AN ABSTRACT OF THE THESIS OF

Eric Ashbaker for the degree of Master of Science in Radiation Health Physics presented on June 24, 2005

Characterizing the Neutron Spectra in Various Irradiation Facilities within the Oregon State University TRIGA® Reactor

Abstract approved: Redacted for privacy

Steve Reese

The Oregon State University TRIGA® Reactor (OSTR) has a number of irradiation facilities providing a wide range of neutron energies and fluxes. These facilities include a pneumatic transfer tube, a rotating rack, a thermal column, four beam ports, in-core irradiation tubes, a cryogenic gas transfer system and a large vault radiography facility. Until now, the neutron energy spectra in these various facilities were not precisely known. The spectra were, depending on location, assumed to resemble a thermal Maxwellian distribution or a Watt fission spectrum. Two recent changes have made knowledge of the neutron energy spectrum in the irradiation facilities a necessity. First, the 1 MeV equivalent neutron damage factor has become increasingly important to researchers interested in using the OSTR for materials science/radiation damage testing. Precise knowledge of the spectrum is needed in order to calculate this factor. Second, changes to the configuration of beam port shielding and the increased use of neutron beams makes it prudent to have a better knowledge of the neutron energy spectrum for calculating dose in the event of an accidental overexposure. To resolve this, the OSTR was modeled using the Monte-Carlo N-Particle (MCNP) transport code. Activation foils, with activation cross sections that covered a wide and overlapping range of energies, were irradiated in various irradiation facilities. Data from the foils were used to adjust the calculated MCNP spectrum using the dosimetry unfolding code STAY'SL. STAY'SL is a least-squares adjustment code system which provides the best fit to the neutron flux spectrum as well as uncertainties in the group fluxes due to the uncertainties in the activation data, dosimetry cross sections, and input group fluxes. Results indicate that the MCNP model may underestimate the thermal neutron contribution by as much as a factor of four. However, the calculations are in excellent agreement with the activation data for the epithermal and fast neutrons.

©Copyright by Eric Ashbaker
June 24, 2005
All Rights Reserved

Characterizing the Neutron Spectra in Various Irradiation Facilities within the Oregon State University TRIGA® Reactor

by

Eric Ashbaker

A THESIS

submitted to

Oregon State University

In partial fulfillment of

the requirements for the

degree of

Master of Science

Presented June 24, 2005

Commencement June 2006

Master of Science thesis of Eric Ashbaker presented on June 24, 2005

APPROVED: Redacted for privacy

Major Professor, representing Radiation Health Physics

Redacted for privacy

Head of the Department of Nuclear Engineering and Radiation Health Physics

Redacted for privacy

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to reader upon request.

Redacted for privacy

Eric Ashbaker, Author

ACKNOWLEDGMENTS

I would like to begin thanking the person that is responsible for planting the seed in me that started this journey on the road to a Masters in Radiation Health Physics. Dr. Brosing taught a modern physics class at Pacific University that dramatically influenced my future.

I would like to thank Dr Steve Reese, my thesis advisor, for bringing the topic of my thesis to my attention. Dr Reese has really allowed me to work on this project at my own pace and has been quite patient with me. Dr Reese is a wonderful teacher. He really understands that the best way to learn is to force the student to struggle a little before offering suggestions. I enjoyed my time here at Oregon State University under the guidance of Dr. Reese and appreciate all that he did for me personally, academically, and financially.

I would also like to thank Dr. Larry Greenwood of Pacific Northwest National Laboratory for his collaboration on this project. His expertise was crucial to the success of this project.

I appreciate and would like to thank the other members of my committee: Dr. Hamby, Dr. Palmer, and Dr. Istok, for their participation in my education process. Drs. Palmer and Hamby are wonderful professors. They were always available to answer questions and brought a little humor to the OSU Radiation Center.

I wouldn't have been able to collect my data had it not been for the OSTR personnel. I really appreciate their time and willingness to guide me through the neutron activation process. Dr. Menn especially deserves my thanks for sacrificing life and limb to ensure that my samples were available to me. Shirley Campbell went beyond the call of duty to ensure that I had my activation supplies.

The other graduate students in my office really made for an enjoyable experience. From study groups to gummy bear experiments, the friendships that developed will last a lifetime.

Finally and most importantly, my family has been quite patient with me in my academic endeavors. Therefore, I must thank my wife Tiffany and my three boys: Kory, Kiel, and Kaleb for their support. Only they truly know my shortcomings and have decided to love me anyway.

TABLE OF CONTENTS

Page

1 INTRODUCTION 1

1.1 Purpose 1

1.2 TRIGA Reactors 2

1.2.1 The Rotating Rack (Lazy Susan) 3

1.2.2 Pneumatic Transfer System (Rabbit) 4

1.2.3 In-core Irradiation Tubes ((CL)ICIT) 7

1.2.4 Thermal Column 8

1.3 Neutron Energy Spectra 9

1.3.1 Fast 9

1.3.2 Epi-thermal 10

1.3.3 Thermal 10

1.4 Neutron Activation Analysis 11

1.5 Monte Carlo Technique 12

1.6 STAY'SL 13

1.7 Neutron Self-Shielding Adjustments 16

2 LITERATURE REVIEW 18

3 METHODS AND PROCEDURES 22

3.1 MCNP Flux Determination 22

3.1.1 OSTR Irradiation Facilities 22

3.2 Neutron Activation Analysis 23

3.2.1 Foil Selection 23

TABLE OF CONTENTS (CONTINUED)

Page

3.2.2 Irradiations 24

3.2.3 Neutron Self-Shielding 25

3.2.4 Foil Counting 26

3.3 Calculating $\sigma\phi$ (STAY'SL input) 26

3.3.1 Derivation 26

3.4 Sample Preparation 28

3.4.1 Lazy Susan 28

3.4.2 Rabbit 28

3.4.3 (CL)ICIT 29

3.4.4 Thermal Column 29

4 RESULTS 30

4.1 Lazy Susan 30

4.1.1 MCNP Flux Distribution in the Lazy Susan 30

4.1.2 NAA Results in the Lazy Susan 30

4.1.3 Calculating $\sigma\phi$ for STAY'SL input in the Lazy Susan 32

4.1.4 STAY'SL Results in the Lazy Susan 32

4.1.4.1 Maxwellian Fit to thermal region in the Lazy Susan 32

4.1.4.2 Normalization factor (AK1) in the Lazy Susan 34

4.1.4.3 Lazy Susan Spectra Results 35

4.1.4.4 Regional Flux Values in the Lazy Susan 38

TABLE OF CONTENTS (CONTINUED)

Page

4.2 ICIT 38

4.2.1 MCNP Flux Determination in the ICIT 38

4.2.2 NAA Results in the ICIT 39

4.2.3 Calculating $\sigma\phi$ for STAY'SL input in the ICIT 40

4.2.4 STAY'SL Results in the ICIT 40

4.2.4.1 Maxwellian Fit to thermal region in the ICIT 40

4.2.4.2 Normalization Factor (AK1) in the ICIT 41

4.2.4.3 ICIT STAY'SL Results 42

4.2.4.4 Regional Flux Values in the ICIT 46

4.3 CLICIT 46

4.3.1 MCNP Flux Distribution in the CLICIT 46

4.3.2 NAA Results in the CLICIT 47

4.3.3 Calculating $\sigma\phi$ for STAY'SL input in the CLICIT 48

4.3.4 STAY'SL Results in the CLICIT 49

4.3.4.1 Normalization Factor (AK1) in the CLICIT 49

4.3.4.2 CLICIT STAY'SL Results 49

4.3.4.3 Regional Flux Values in the CLICIT 51

4.4 Rabbit 51

4.4.1 MCNP Flux Distribution in the Rabbit 51

4.4.2 NAA Results in the Rabbit 52

4.4.3 Calculating $\sigma\phi$ for STAY'SL input in the Rabbit 53

TABLE OF CONTENTS (CONTINUED)

Page

4.4.4 Rabbit STAY'SL Results 54

4.4.4.1 Maxwellian Fit to thermal region in the Rabbit 54

4.4.4.2 Normalization Factor (AK1) in the Rabbit 56

4.4.4.3 Rabbit STAY'SL Results 56

4.4.4.4 Regional Flux Values in the Rabbit 57

4.5 Thermal Column 57

4.5.1 MCNP Flux Determination in the Thermal Column 57

4.5.2 NAA Results in the Thermal Column 58

4.5.3 Calculating $\sigma\phi$ for STAY'SL input in the Thermal Column 59

4.5.4 Regional Flux Values in the Thermal Column 59

5 DISCUSSION 60

6 CONCLUSION 62

BIBLIOGRAPHY 63

APPENDICIES 65

APPENDIX A: MCNP INPUT DECKS 66

CLICIT Core 66

TABLE OF CONTENTS (CONTINUED)

Page

ICIT Core 107

APPENDIX B: ENERGY & EFFICIENCY CALIBRATION EQUATIONS FROM GAMMAVISION® 149

APPENDIX C: OPERATING STAY'SL 151

LIST OF FIGURES

Figure Page

1.1 Cutout view of a TRIGA® core....3

1.2 Lazy Susan....4

1.3 Upper Grid Plate....5

1.4 Cross-sectional view of the Rabbit terminus....6

1.5 (CL)ICIT Terminus and tube specifications....7

1.6 Top view of OSTR....8

1.7 Fast Neutron Spectrum....10

1.8 Thermal Neutron Spectrum....11

2.1 Flux/Lethargy plot for the TRIGA® reactor in Vienna....18

2.2 Neutron Energy Spectrum....20

3.1 MCNP model of OSTR irradiation facilities....23

3.2 Sensor Response....24

3.3 Activity Plot....27

4.1.1 MCNP Modeled Flux Distribution in the Lazy Susan....30

4.1.2 Energy Dependent Flux in the Lazy Susan without Maxwellian Correction....33

4.1.3 Energy Dependent Flux in the Lazy Susan with Maxwellian Correction....34

4.1.4 AK1 Determination in the Lazy Susan....35

4.1.5 χ^2 Comparison for Lazy Susan....36

4.1.6 Energy Dependent Flux in the Lazy Susan with Maxwellian Correction and bare cobalt reaction removed....37

LIST OF FIGURES (CONTINUED)

Figure Page

4.2.1 MCNP Modeled Flux Distribution in the ICIT 38

4.2.2 Energy Dependent Flux in the ICIT without Maxwellian Correction 41

4.2.3 AK1 Determination in the ICIT 42

4.2.4 Energy Dependent Flux in the ICIT with Maxwellian Correction 43

4.2.5 χ^2 Comparison for ICIT 44

4.2.6 Energy Dependent Flux in the ICIT with Maxwellian Correction and Co Bare removed 45

4.3.1 MCNP Modeled Flux Distribution in the CLICIT 47

4.3.2 AK1 Determination in the CLICIT 49

4.3.3 χ^2 Comparison for CLICIT 50

4.3.4 Energy Dependent Flux in the CLICIT 51

4.4.1 MCNP Modeled Flux Distribution in the Rabbit 52

4.4.2 Energy Dependent Flux in the Rabbit without Maxwellian Correction 55

4.4.3 Energy Dependent Flux in the Rabbit 56

4.4.4 χ^2 Comparison for Rabbit 57

4.5.1 MCNP Modeled Distribution in the Thermal Column 58

LIST OF TABLES

Table — Page

2.1 Neutron Flux Summary 19

2.2 STAY'SL spectral adjustment for the Fast Flux Test Facility (FFTF) 21

3.1 Summary of Irradiation Times 25

4.1.2 Summary of EOB activities calculated in the Lazy Susan 31

4.1.3 Summary of $\sigma\phi$ values for the Lazy Susan 32

4.1.4 Summary of the ratios between measured and calculated reaction rates in the Lazy Susan 37

4.1.5 Regional Flux Values for the Lazy Susan 38

4.2.2 Summary of EOB activities for the ICIT 39

4.2.3 Summary of $\sigma\phi$ values for the ICIT 40

4.2.4 Summary of the ratios between measured and calculated reaction rates in the ICIT 45

4.2.5 Regional Flux Values for the ICIT 46

4.3.2 Summary of EOB activities in the CLICIT 48

4.3.3 Summary of $\sigma\phi$ values for the CLICIT 48

4.3.4 Summary of the ratios between measured and calculated reaction rates in the CLICIT 50

4.3.5 Regional Flux Values for the CLICIT 51

4.4.2 Summary of EOB activities in the Rabbit 53

4.4.3 Summary of $\sigma\phi$ values for the Rabbit 54

LIST OF TABLES

Table Page

4.4.4 Summary of the ratios between measured and calculated reaction rates in the Rabbit 55

4.4.5 Regional Flux Values for the Rabbit 57

4.5.2 Summary of EOB activities in the Thermal Column 59

4.5.3 Summary of $\sigma\phi$ values for the Thermal Column 59

1. INTRODUCTION

This thesis discusses and implements the techniques used to characterize the neutron energy spectra in the Oregon State University TRIGA® Reactor (OSTR). The OSTR has a number of irradiation facilities. The facilities considered in this paper include a pneumatic transfer tube, a rotating rack, a thermal column, and in-core irradiation tubes. Until now, the neutron energy spectra in these facilities were not precisely known.

Determination of the neutron energy spectra within a research reactor like the OSTR can be accomplished by "adjusting" an input neutron spectrum using a multiple activation technique. The OSTR was modeled using the Monte-Carlo N-Particle (MCNP) transport code. Activation foils, along with activation cross sections that cover a wide and overlapping range of energies were also used. The computer code STAY'SL can take a calculated neutron spectrum and activities obtained from Neutron Activation Analysis (NAA) and perform a least-squares-fit, minimizing chi-squared and thereby "adjusting" the modeled spectra.

1.1 Purpose

The purpose of this work is to determine the neutron energy spectra in various irradiation facilities in the OSTR. Applications include using the OSTR for radiation damage testing and calculating neutron dose in the event of an accidental overexposure.

Radiation damage testing looks at the effects of neutron irradiations on materials and depends on the neutron spectra and the length of time the material is irradiated. A nuclear reactor core is subject to intensive bombardment by nuclear radiation to which the materials of the core are exposed. Over a period of time, such radiation can alter the properties of these materials. For example, metals will become brittle and swell and corrosion is enhanced. The 1 MeV equivalent damage factor is a standard method for comparing the irradiations between different reactor facilities by characterizing a neutron flux in terms of an equivalent monoenergetic neutron flux (ASTM E 722).

Another reason for precisely knowing the neutron energy spectra in the OSTR is to calculate neutron dose in the event of an accidental overexposure. The amount of dose someone receives from neutrons depends on the number of neutrons present at a given energy.

1.2 TRIGA® Reactors

Training, Research, Isotope production, General Atomic (TRIGA®) reactors were developed by General Atomic Inc. to be utilized by universities, medical institutions, and other research facilities to provide services as indicated by their name. TRIGA® reactors were designed with two primary intrinsic safety features to reduce the probability of a nuclear accident (Simnad, M. T. et al. 1976). When the reaction rate increases in a reactor, the temperature of the reactor also increases. If water is used as the moderator, its density decreases with increasing temperature, and becomes a less effective moderator. This property naturally creates negative reactivity. General Atomic incorporated some additional intrinsic physical properties into the fuel itself that would aid in the shut down of the reactor or limit its power level to a safe value. This unique fuel consists of a solid homogenous alloy of uranium fuel and zirconium-hydride moderator. This fuel also includes erbium, which has two large resonances in its cross section. Adding hydrogen and erbium to the fuel element enhances its prompt negative temperature coefficient. This large negative coefficient of reactivity allows the TRIGA® to be pulsed to high power levels without the use of any mechanical control devices to return the reactor to safe operating levels.

The Oregon State TRIGA® Reactor (OSTR) is a water-cooled, swimming pool type research reactor that uses uranium/zirconium hydride fuel elements that are arranged in a circular grid. The reactor core is surrounded by a graphite reflector and is located at the bottom of a 22-foot deep water-filled tank.

The OSTR has a number of irradiation facilities including a pneumatic transfer tube (called "The Rabbit"), a rotating rack (called "The Lazy Susan"), a thermal column, four neutron beam ports, an in-core irradiation tube (ICIT), and a cadmium-lined in-core irradiation tube (CLICIT) that offer many options for experimentation. Figure 1.1 shows a cutout picture of the OSTR core.

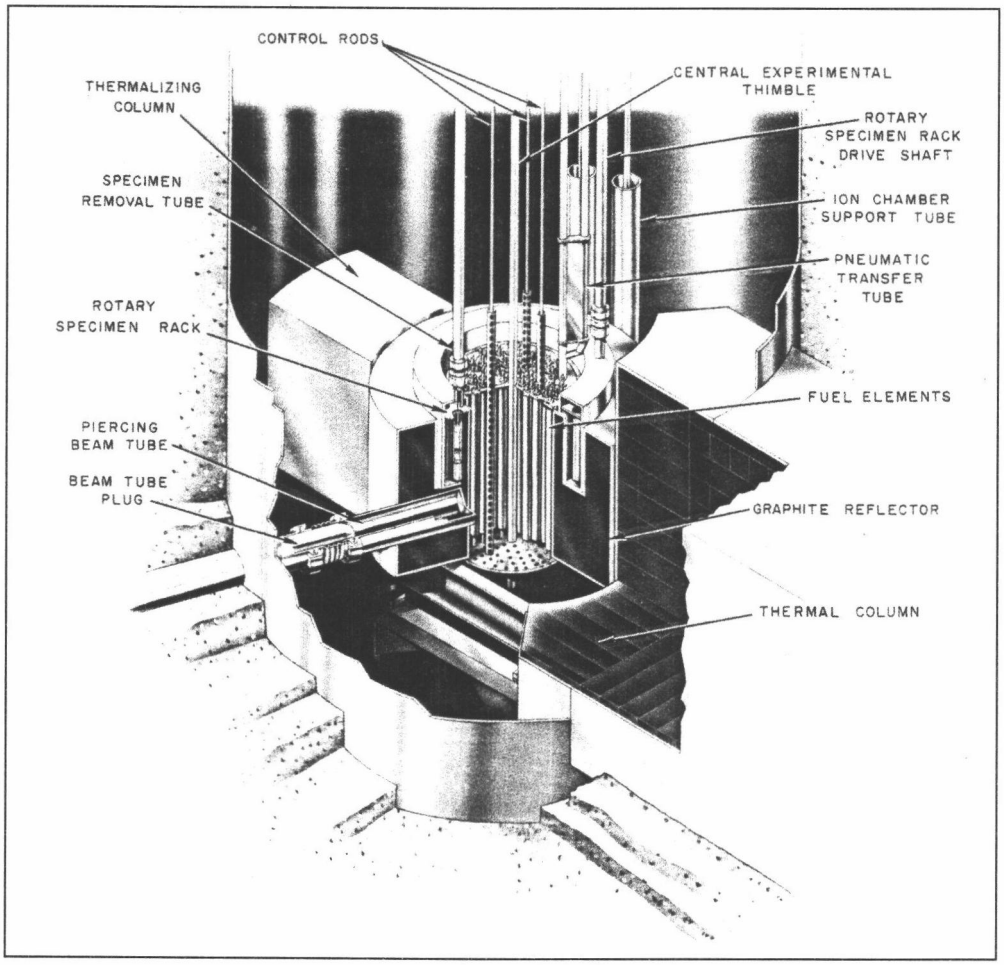

Figure 1.1 Cutout view of a TRIGA® core – This graphic illustrates to location of the irradiation facilities. It is difficult to see the (CL)ICIT due to its proximity to the central thimble (Anderson et al 1990).

1.2.1 The Rotating Rack (Lazy Susan)

The Lazy Susan is an aluminum can surrounding the upper section of the core that contains an internal rack consisting of 40 evenly-spaced tubular aluminum containers (see Figure 1.1). These containers can be rotated about the core to achieve a uniform irradiation flux. Samples are inserted and removed via a tube running from the Lazy Susan to the reactor top.

Figure 1.2 illustrates the Lazy Susan and shows how the 40 sample positions are located within a watertight aluminum housing. The rack is rotated from a drive system on top of the reactor. Rotation is accomplished through a drive shaft system located inside a thin wall pipe housing, which then turns the specimen rack with a sprocket–and-chain (Anderson et al. 1990).

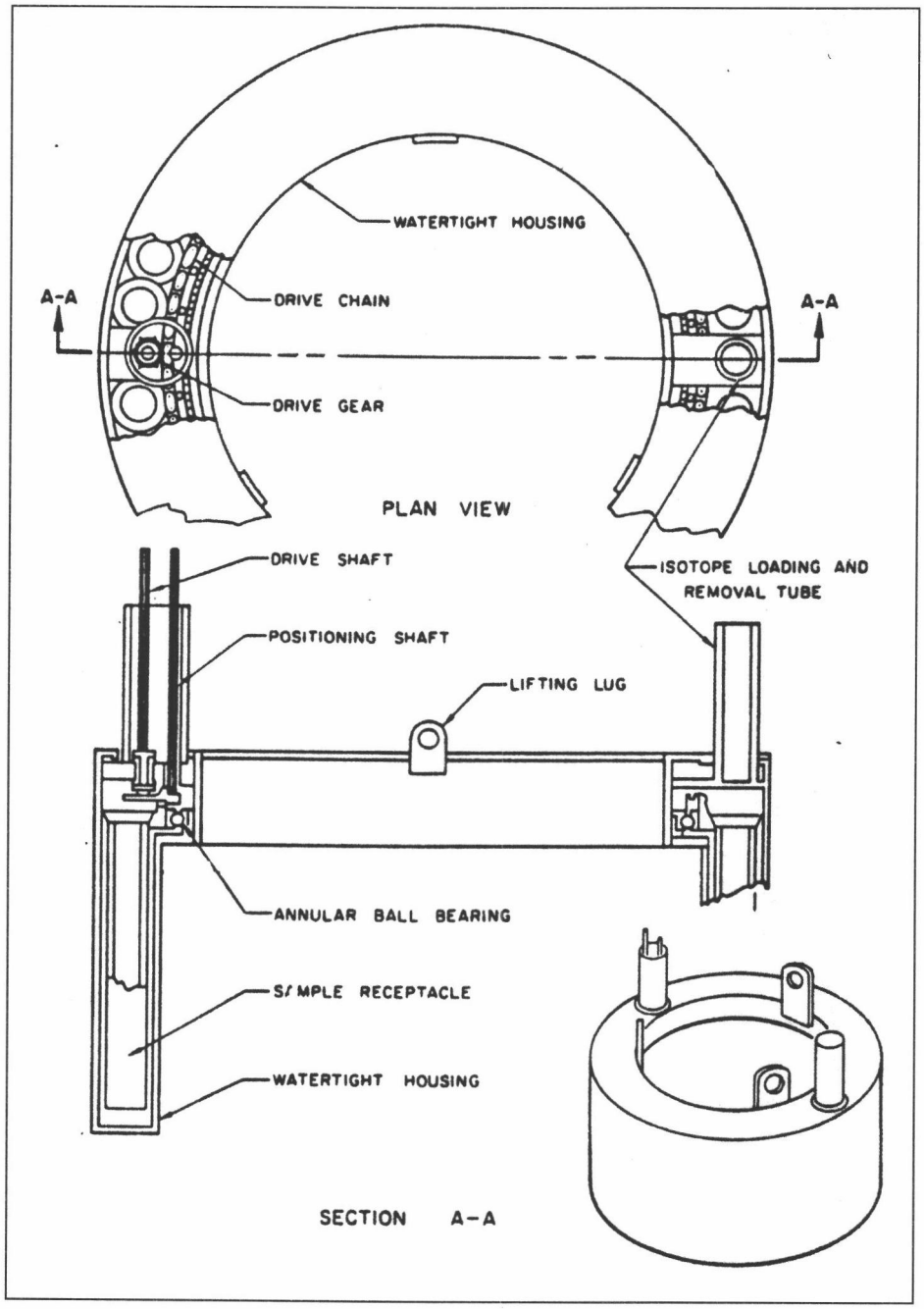

Figure 1.2 Lazy Susan. Schematic drawing of the rotating rack including a top view, side view, and 3-D view of the outer canister (Anderson et al., pg. 62).

1.2.2 Pneumatic Transfer System (Rabbit)

Radioisotopes with very short half-lives (half-lives on the order of seconds to a few minutes) can be examined using the Rabbit. This pneumatic system rapidly moves samples from the core to a counting laboratory that is near the reactor bay. Short-lived samples are

able to be counted before decaying away due to the Rabbit's fast sample transfer time. The Rabbit facility is located on the outer ring of the reactor core in position G-2 (see Figures 1.1 and 1.3)

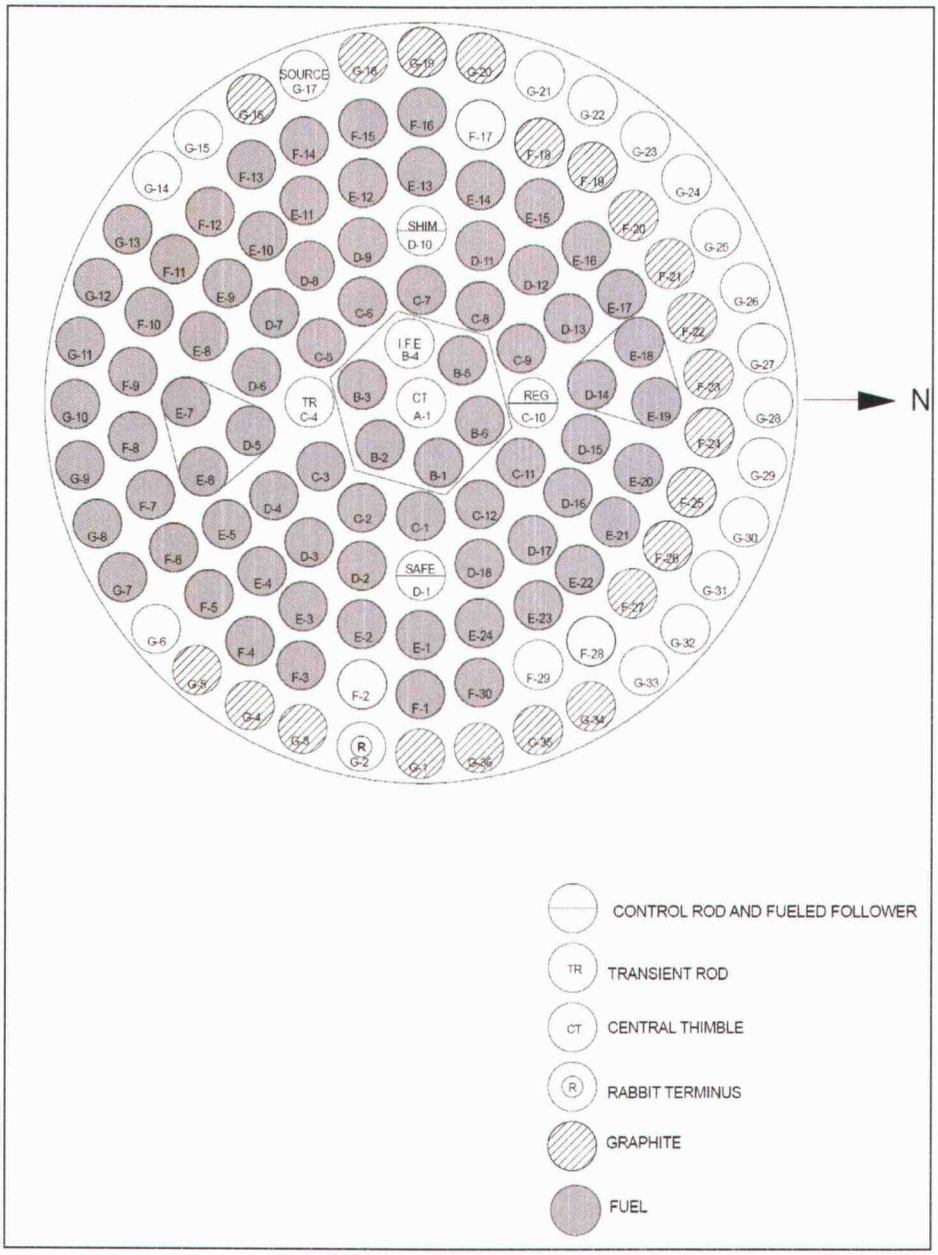

Figure 1.3 Upper Grid Plate – This graphic illustrates the position of the Rabbit in the outer core ring in position G-2. (Not the current core configuration; only used to illustrate position of the Rabbit).

This pneumatic system is controlled from a receiving area (Room D-102) and may be operated either manually or automatically. Analyses of samples irradiated for short times may

have some increased error because it does take time for the sample to move from core to counting room (~5 seconds). The sample is positioned at the core centerline to ensure that the sample receives the highest flux (see Figure 1.4).

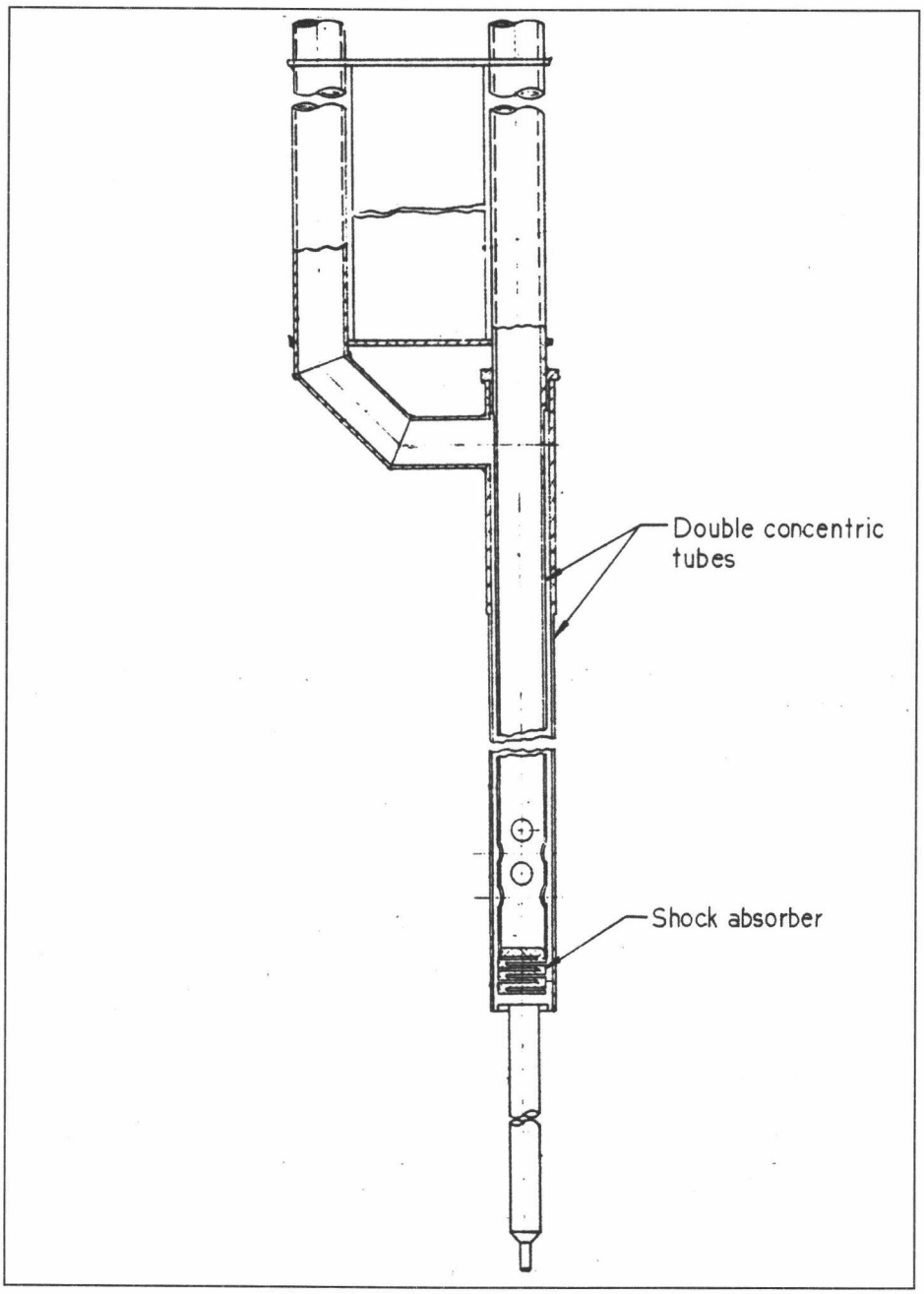

Figure 1.4 Cross-sectional view of the Rabbit terminus – Sample transport can be quite violent to the sample. The shock absorber reduces movement of the sample within the Rabbit tube (Anderson et al., pg. 78).

The system operates on a pneumatic pressure differential, drawing the Rabbit tube in and out of the core by vacuum. Thus, the system is always under a negative pressure so that leakage is always into the tubing system. The air is filtered before being exhausted to the environment (Anderson et al. 1990).

1.2.3 In-core Irradiation Tubes ((CL)ICIT)

The ICIT is designed to irradiate samples within the reactor core at the position of highest flux. The tube may be inserted and removed from position B-1 within the core grid plate (see Figure 1.3). A spacer is placed within such that samples are irradiated at the flux centerline (see Figure 1.5). The tube is offset by 16" to eliminate radiation from streaming to the reactor top.

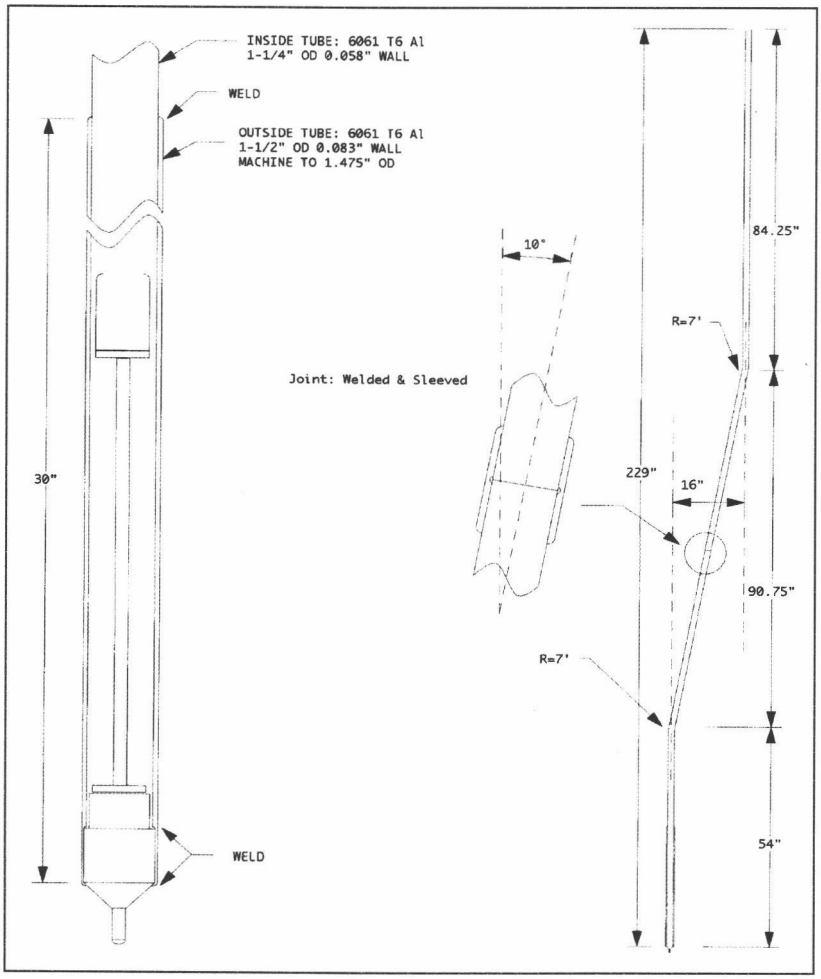

Figure 1.5 (CL)ICIT Terminus and tube specifications – The sample rests on the spacer to the left. The curve in the tube ensures that a neutron beam does not exit the reactor top.

The CLICIT is identical to the ICIT facility with the exception of a layer of cadmium surrounding the tube. It is designed to irradiate samples in the reactor core using neutrons that have energies greater than the cadmium cutoff (> 0.5 eV). The cadmium is placed between two concentric layers of aluminum in the tube wall and is 20 mils thick (1 mil = 1/1000 inch).

1.2.4 Thermal Column

The thermal column is a large, boral-lined (boral is an aluminum boron carbide alloy used as a shield against thermal neutrons), graphite-filled aluminum container. It is located within the concrete mass surrounding the reactor core and is ideal for experiments requiring a nearly pure thermal neutron flux. The graphite, being an effective moderator, slows the fast neutrons down by means of elastic collision.

Samples are inserted into the facility by removing a 4"x4"x4' graphite block and placing samples at various distances from the core. Figure 1.6 shows a cross-sectional illustration of the OSTR and indicates the position of the thermal column.

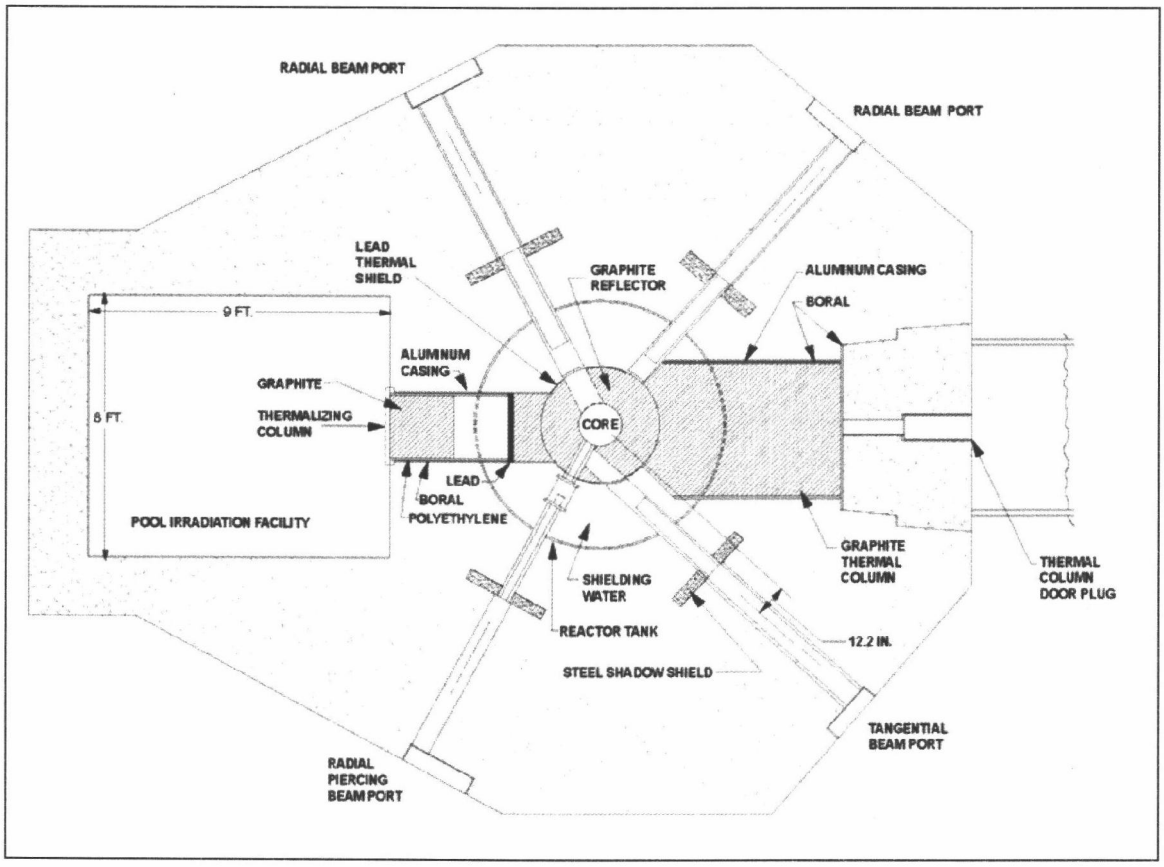

Figure 1.6 Top view of OSTR - Top view of the OSTR to illustrate the position of the thermal column.

1.3 Neutron Energy Spectra

Neutrons are generally classified according to their energy. Neutrons with energies less than 0.5 eV are classified as thermal neutrons. Neutrons with energies between 0.5 eV and 1.0 MeV are classified as epi-thermal neutrons. Neutrons with energies greater than 1.0 MeV are classified as fast neutrons.

All neutrons, at the time of their birth (from a fission event) are fast. Fast neutrons lose energy by colliding elastically with atoms within their environment. These neutrons eventually lose kinetic energy to a point where they are in thermal equilibrium with the surrounding gas molecules and are then considered to be "thermalized." Once "thermalized," these neutrons have a high likelihood of being captured by absorbing nuclei. If the neutrons are absorbed by the reactor fuel additional fission events will occur. This relationship can be exploited by choosing specific targets for the neutrons to bombard. Often the capture of a thermal neutron is followed by the emission of a gamma ray at a specific energy. In addition, reactions with fast neutrons can result in the emission of other nuclear particles (Cember 1996).

1.3.1 Fast

The neutrons produced by fission emerge with a distribution of energies, with the average fission neutron energy being roughly 2 MeV and a most probable neutron energy of 0.7 MeV (Cember 1996). Fast neutrons are often modeled using an energy distribution that can be represented by the Watt-fission spectrum (see Figure 1.7): (Duderstadt 1976)

$$\chi(E) = 0.453e^{-1.036}\sinh(\sqrt{2.29E}) \tag{1.1}$$

where

$\chi(E)$ is the fractional number of neutrons.

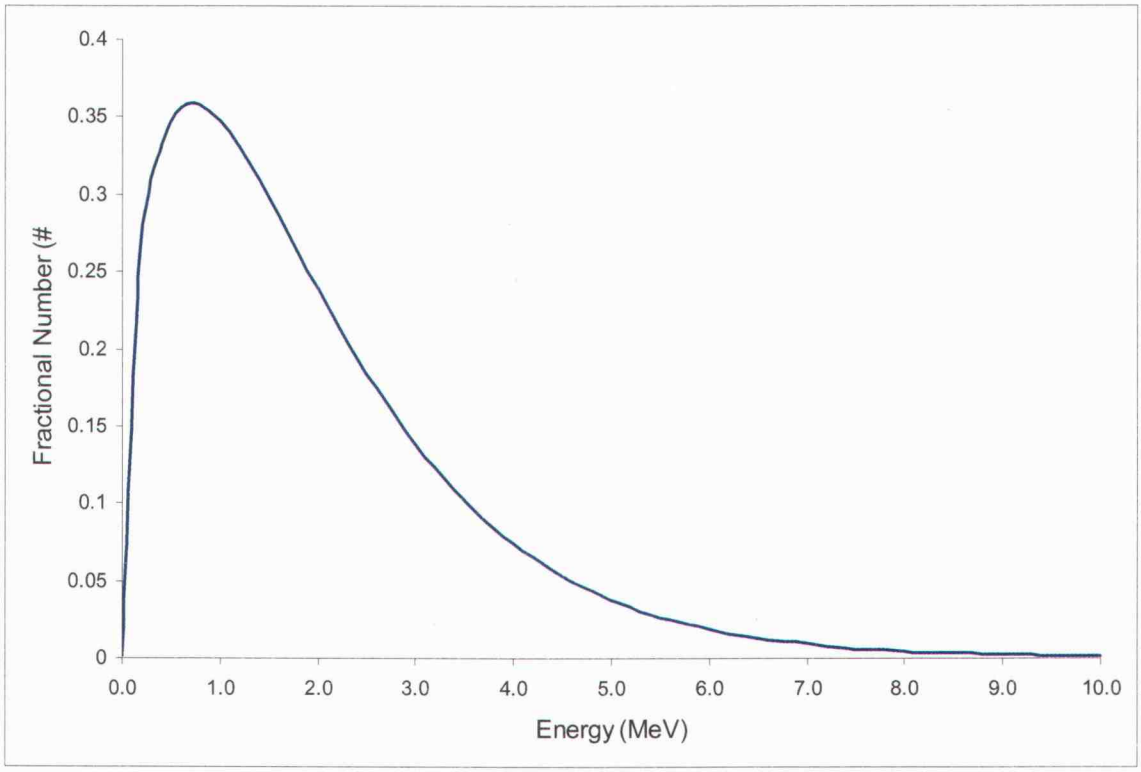

Figure 1.7 Fast Neutron Spectrum - Fission Spectrum for fast neutrons from U-235

1.3.2 Epi-thermal Neutrons

Fission neutrons are born fast; however, neutrons need to be thermalized to cause more fission events. The OSTR is a water-moderated reactor and thermalizes neutrons by forcing neutrons to collide with the similar-sized hydrogen atoms that exist in water.

The scattering cross section for hydrogen is much higher than its absorption cross section $\left(\sigma_a^H / \sigma_s^H \sim 0.014\right)$; therefore, neutron scatter is the dominant mechanism for neutron interaction with hydrogen. In the absence cross sectional resonances within the fuel meat, an epi-thermal neutron flux assumes a 1/E form. (Duderstadt 1976)

1.3.3 Thermal

The kinetic energies of gas molecules are related to temperature by the Maxwell-Boltzmann distribution (see Figure 1.8) and described by the following equation: (Cember 1996)

$$f(E) = \frac{2\pi}{(\pi kT)^{3/2}} e^{-\frac{E}{kT}} \sqrt{E} \tag{1.2}$$

where

$f(E)$ is the fractional differential energy spectrum,

k is the Boltzmann constant (8.6E-05 eV/K),

T is the absolute temperature of the gas in Kelvin.

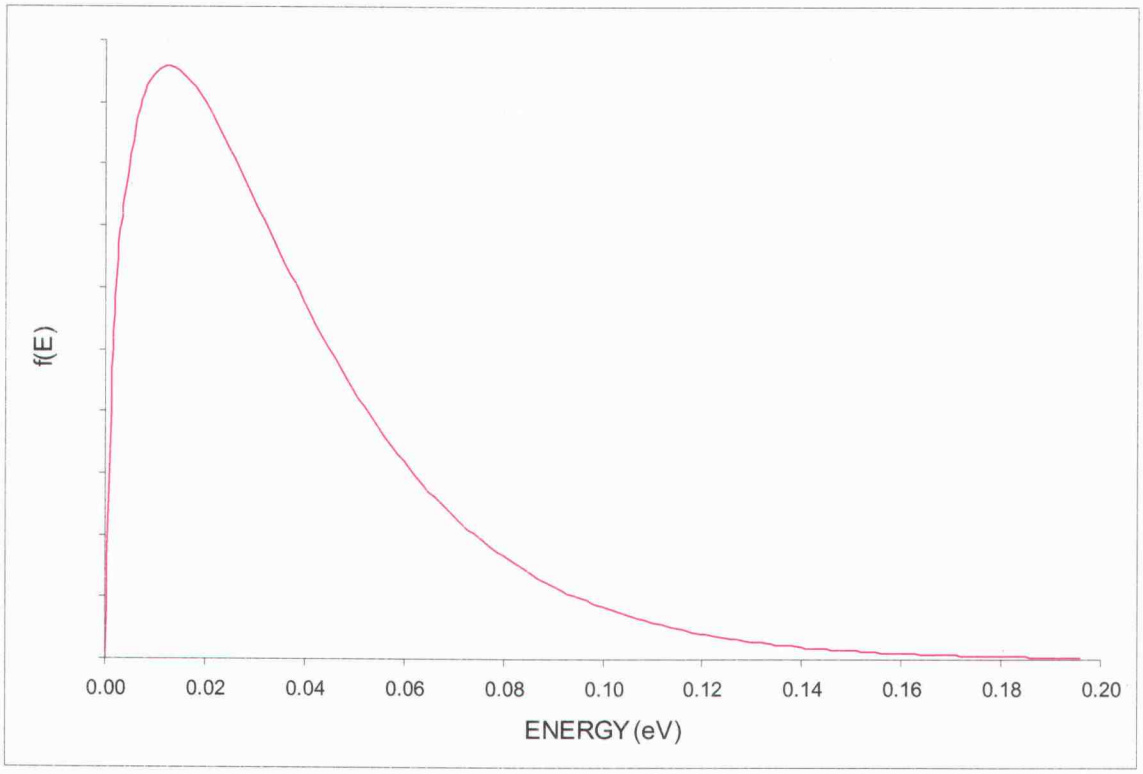

Figure 1.8 Thermal Neutron Spectrum - Maxwell-Boltzmann Distribution of kinetic energies for the molecules of an ideal gas.

1.4 Neutron Activation Analysis

The characteristic gamma rays created by neutron capture can be examined with a process called Neutron Activation Analysis (NAA). When a target sample is placed in a neutron flux, additional radionuclides are produced through the absorption of neutrons. As these radionuclides decay their characteristic gamma rays can be counted using High-Purity Germanium (HPGe) detection systems to display these gamma rays as a function of energy. The activity of the radionuclide produced can be calculated by the following equation:

$$A = \frac{CR_{net}}{\varepsilon f_{\gamma}} \tag{1.3}$$

where

ε is the detection efficiency of the detection system,

f_γ is the probability of gamma emission (also called branching ratio),

CR_{net} is the net count rate from each photopeak collected by the detector.

This activity decays over time; therefore, in order to determine the total number of disintegrations for a given photopeak, the activity must be integrated over the counting live time.

1.5 Monte Carlo Technique

The Monte Carlo technique is a numerical analysis technique based on using random numbers to sample from probability distributions describing an empirical situation. It is like making a decision about a population based on what the individuals do. The fate of individuals is determined by a random number. Results approximate an actual situation as the number of "histories" increases, where a "history" is defined as the events describing the lifetime of a particle (neutron) from its birth to its death.

The Monte Carlo N-Particle (MCNP) is a general purpose transport code for tracking neutrons, photons, and electrons. The primary interest in all reactors is that of fast neutrons created due to fission events in the reactor core and all of their (neutron) interactions until death.

The user creates an input file that is subsequently read by MCNP. This input file contains the following information: (Briesmeister 1997)

- The specific geometry in 3-dimensions.
- Material constituents and cross-section information.
- Source information.
- Desired tally information (cell, surface, etc.).
- Variance reduction information (energy cutoff, etc.).

The source information for a criticality problem, such as a reactor, is introduced to MCNP using a *ksrc* (k-source) card to specify the initial spatial fission distribution. The *ksrc* card simply provides a position in the core where a fission event will occur. As many source points as needed can be placed within the reactor geometry (usually within the fuel meat).

Nuclear criticality pertains to the reactor's ability to create more neutrons than are being consumed. A critical reactor is able to sustain a chain reaction and is characterized by a multiplication factor k, which is the ratio between the number of neutrons in successive generations created by fission events. A critical reactor has a $k = 1$, which corresponds to a neutron created for every neutron destroyed. Sub-critical reactors have a $k < 1$, which corresponds to more neutrons being destroyed than created. A supercritical reactor has a $k > 1$ and the number of fission events will increase with time.

All criticality calculations must have a *kcode* card. The *kcode* card tells MCNP the number of neutrons in each generation, an initial guess for k_{eff}, and the total number of generations that the user wants to run. In addition, the user can specify the number of generations to skip before accumulating data.

1.6 STAY'SL

STAY'SL is a least-squares dosimetry unfolding code created at Oak Ridge National Laboratory and managed by Lockheed Martin Energy Research Corporation for the U.S. Department of Energy (DOE). STAY'SL allows the user to input a flux distribution, activation data, and cross sectional information and performs a least-squares-fit based on minimizing the chi-squared value. Uncertainties can also be input into STAY'SL. The user must consider error in the activation measurements as well as error in the input spectrum and the cross sectional data. The user must input error for each activation reaction rate. The error for the input spectrum can be input for each of the 100 energy bins or by broad energy groups. Error for the dosimetry cross sections are already in the cross sectional library that STAY'SL accesses.

STAY'SL uses a least-squares method to obtain its solution. The input neutron flux data is multiplied by cross sectional data for a particular reaction to obtain reaction rates that can be compared to the reaction rates from the activation data. A linear regression is performed to determine a variance for the input flux data and the activation data. Because the three different types of input are assumed to be independent, the solution only requires the inversion of a matrix of dimensions equal to the number of activation measurements. The ratio of these variances for each reaction should be close to unity if the fit is good.

The method of least-squares used by STAY'SL begins by looking at the residuals in the regression model: (Martin 1971)

$$S = \sum_{i=1}^{n} (y_i - \hat{\eta}_i)^2 = \sum_{i=1}^{n} r_i^2 \tag{1.4}$$

where

$$\hat{\eta}_i = f\left(x_{1i}, x_{2i}, ..., x_{ki}; \hat{\theta}_1, ...\hat{\theta}_p\right) \quad i = 1, 2, ..., n \tag{1.5}$$

and $y_i, x_{1i}, x_{2i}, ..., x_{ki}$ denote the ith set of observations on $(k + 1)$ variables, of which only y_i is random. The relation

$$\hat{\eta} = f\left(x_1, x_2, ..., x_k; \hat{\theta}_1, ...\hat{\theta}_p\right) \tag{1.6}$$

is the function that represents the best fit for the regression curve. The observations are subject to experimental error e_i. If n observations y_i depend linearly on p parameters then the observational equations may be expressed as the following: (Martin 1971)

$$y_i = \sum_{k=1}^{p} \theta_k \phi_k(x_i) + e_i, \qquad i = 1, 2, ..., n \tag{1.7}$$

where $\phi_k(x)$ are any linearly independent functions of x. The Matrix notation of Equation 1.7 is as follows: (Martin 1971)

$$Y = \Phi\Theta + E, \tag{1.8}$$

where Y and E are $(n \times 1)$ column vectors,

Θ is the $(p \times 1)$ column vector, and

Φ is the $(n \times p)$ matrix (often called the design matrix).

If the number of observations is equal to the number of parameters then a solution can be found by a simple matrix inversion. In some cases, however, the number of observations is greater than the number of parameters, which means there are more unknowns than equations to solve them (called overdetermined). There is no unique solution for this situation; therefore, a best average solution is desired. The experimental observations are approximated to be the following: (Martin 1976)

$$f_i \equiv \sum_{k=1}^{p} \theta_k \phi_k(x_i). \tag{1.9}$$

The experimental errors are considered to be normally distributed with zero mean and have an associated variance matrix: (Martin 1976)

$$V_{ij} = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \cdots & \sigma_{1n} \\ \sigma_{12} & \sigma_2^2 & \cdots & \sigma_{2n} \\ \vdots & \vdots & & \vdots \\ \sigma_{1n} & \sigma_{2n} & \cdots & \sigma_n^2 \end{pmatrix}, \tag{1.10}$$

where $\sigma_i^2 = \mathrm{var}(y_i)$ and $\sigma_{ij} = \mathrm{cov}(y_i, y_j)$. The residuals from Equation 1.4 are then replaced by the following: (Martin 1976)

$$r_i \equiv y_i - \hat{f}_i = y_i - \sum_{k=1}^{p} \theta_k \phi_k(x_i). \tag{1.11}$$

Equation 1.4 becomes the following: (Martin 1976)

$$S = \sum_{i=1}^{n} \sum_{j=1}^{n} r_i r_j V_{ij}^{-1} = R^T V^{-1} R \tag{1.12}$$

where R is an $(n \times 1)$ column vector of residuals. It is assumed that y_i is normally distributed about f_i. In this case, S is distributed as χ^2 with $n - p$ degrees of freedom.

Chi-squared (χ^2) is a statistical parameter calculated from experimental data and is given by the following equation: (Martin 1971)

$$\chi^2 = \sum_{i=1}^{n} \left[\frac{x_i - \mu_i}{\sigma_i} \right]^2 \tag{1.13}$$

where

σ_i^2 is the expected variance,

μ_i is the experimental mean,

n is the sample number, and

x_i are the individual observations summed from $i = 1$ to N.

The chi-squared test is a way of determining if the variability in observed data is a close fit to the expected values. The degree at which the χ^2 deviates from unity is a direct measure of the extent to which the observed sample variance differs from the expected variance. A χ_R^2 with approximately 15 degrees of freedom is considered to be a good fit between 0.3 and

2.0 (Perey 1977). This range varies depending on the degrees of freedom but the probability of having χ_R^2 outside this range is not statistically likely.

STAY'SL requires that the input flux data be fairly accurate in order to obtain an accurate adjustment of the neutron energy spectra. If there is significant error in the input flux data, then the spectral unfolding code is not as affective.

Typically, thermal neutron flux calculations are unreliable, so STAY'SL allows the user to fit the thermal neutron region with a Maxwellian distribution if the flux data has significant error. This requires the user to choose a 1/E joining energy value where the Maxwellian correction ends. The spectra at energies less than the 1/E joining value are fit to a Maxwellian distribution.

STAY'SL outputs an adjusted energy dependent flux that can be numerically integrated over specific energy regions to obtain thermal, epi-thermal, and fast neutron flux values..

1.7 Neutron Self-Shielding Adjustments

When making neutron spectral adjustments, it is important to consider neutron self-shielding, which causes a depression in the flux density in the inner part of a sample (foil) due to absorption in the outer layers of the sample. Prior to adjusting the spectra, corrections to the neutron cross sections need to be applied for self-shielded or covered reactions. Such corrections are essential and, if ignored, may result in significant errors in the calculated reaction rates, especially for thermal and epi-thermal reactions.

Ideally, neutron transport computer codes are used to determine the neutron self-shielding and cover corrections for a given material. These lengthy transport calculations may not be required when the neutron mean free paths for neutron scattering are larger than the dimensions of the sample.

The following equation is a useful approximation for the attenuation of neutrons through covered foils in a mono-directional neutron beam: (Bersillon et al. 2002)

$$F = e^{-N\sigma_t t} \tag{1.14}$$

where N is the neutron number density,

σ_t is the total neutron absorption cross section, and

t is the thickness of the covered foil.

For an isotropic neutron flux, Equation 1.14 can be integrated over all angles to get the following: (Bersillon et al. 2002)

$$G = \frac{(1 - 2E_3)}{2N\sigma_t a} \tag{1.15}$$

where G is the self-shielding factor and

E_3 is the third exponential integral of $N\sigma_t a$

The mean length a, is defined as 2V/S, where V is the foil volume and S is the foil surface area. As the size of the foil increases, a approaches the thickness of the foil (Bersillon et al. 2002).

2. LITERATURE REVIEW

Similar reactor characterization was accomplished for a similar reactor located in Vienna in the mid 1980s in order to examine the change of material properties due to fast neutron irradiation; specifically, to study radiation damage effects in materials being considered for fusion reactor applications (Weber et al. 1986). This research was accomplished using fission reactors since no actual fusion neutron spectra are available.

In order to examine the neutron energy spectra in the core of the TRIGA® Mark II, the central thimble irradiation facility was characterized using STAY'SL. The central irradiation thimble is a water filled tube located in the center of the reactor core. Reaction rates from multiple neutron activation experiments were determined for 16 nuclides in order to adjust estimated neutron flux values determined by the manufacturer, General Atomics. The work in Vienna was performed at a power level of 250 kW and with a different core configuration.

STAY'SL can present flux in several different units: energy dependent flux or lethargy dependent flux. They are essentially two different methods for looking at the same information. Weber chose to look at flux per lethargy (see Figure 2.1).

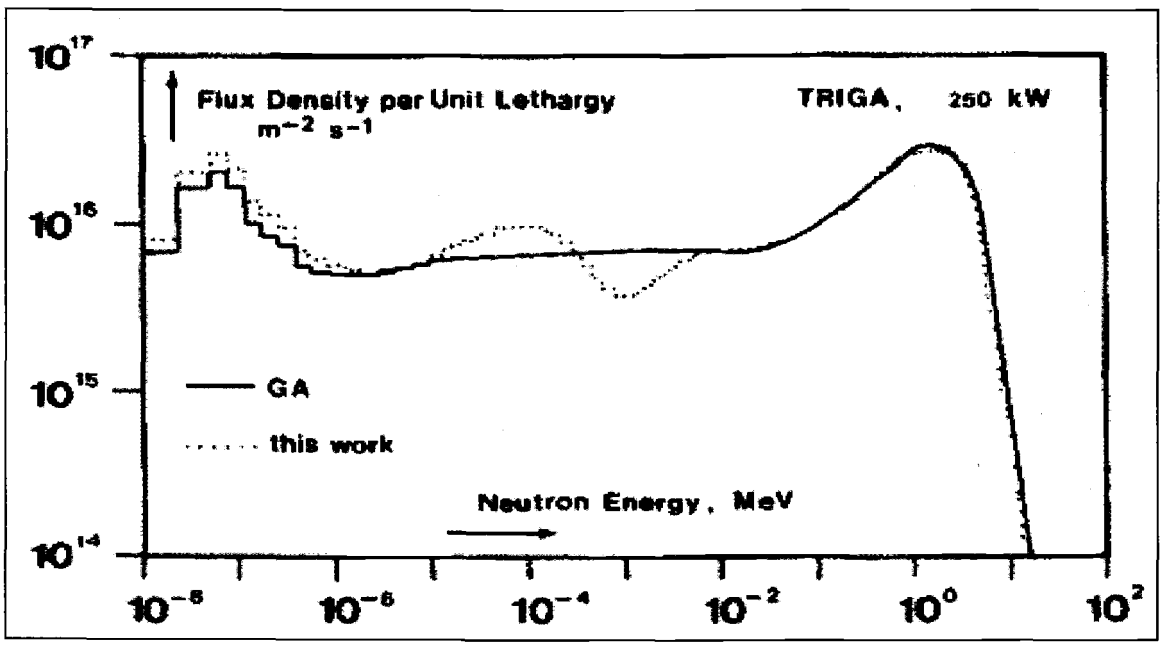

Figure 2.1 Flux/Lethargy plot for the TRIGA® reactor in Vienna. The solid line is the input spectra based on calculations from General Atomics. The dashed line in the STAY'SL outputted corrected spectra (Weber 1986).

A flux per lethargy plot is visually appealing because it illustrates the three classic spectra: Maxwellian thermal region, 1/E epi-thermal region, and the fission-dominated fast region. The interesting S-shape in the STAY'SL result is speculated to be caused by resonances in the fuel and structural materials of the core configuration analyzed.

Results of interest from Weber's work consist of a total flux over the entire neutron energy range (1E-10 MeV $< E <$ 20 MeV), a thermal neutron flux ($E <$ 5.5E-07 MeV), an epi-thermal neutron flux ($E >$ 0.1 MeV), and a fast neutron flux ($E >$ 1 MeV). The results are summarized in the Table 2.1.

Table 2.1 Neutron Flux Summary – Summary of the neutron flux densities and selected broad group flux densities for the TRIGA® reactor at a power level of 250 kW

Energy Range	Flux Density (m^{-2} s^{-1})	Standard Deviation (%)
Total	2.1E+17	± 5.7
Thermal (E < 0.55 eV)	6.1E+16	± 5.1
Fast (E > 0.1 MeV)	7.6E+16	± 11.6
(E > 1 MeV)	4.0E+16	± 11.8

The multiple activation process was also presented for the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory to examine the effects of neutron irradiations on materials (Greenwood 1994). There was interest in comparing effects on materials produced by different fission and accelerator type facilities. The emphasis of this work was on characterizing neutron irradiation facilities using multiple foil activation techniques and computer codes for spectral adjustment and radiation damage calculations.

Figure 2.2 illustrates two methods for representing flux on the same plot. The dashed line represents the unadjusted group input flux. The dotted line represents the adjusted lethargy dependent flux. The solid line represents the adjusted energy dependent flux (Greenwood 1994).

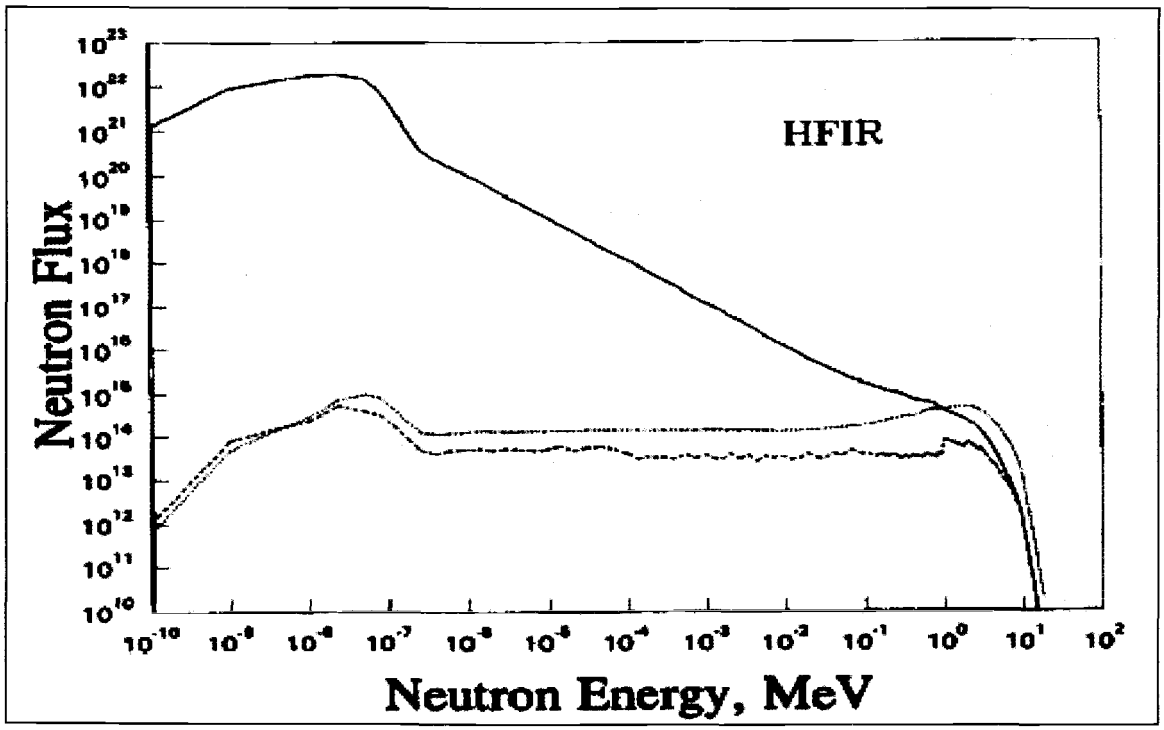

Figure 2.2 Neutron Energy Spectra - Results of multiple activation process with HFIR. The dashed line represents the unadjusted group flux. The dotted line is the group flux times energy (flux/lethargy). The solid line represents the energy dependent flux (Greenwood 1994).

A fundamental objective of characterizing the OSTR is to obtain regional neutron flux values that indicate the total thermal, epi-thermal, and fast flux in various irradiation facilities within the OSTR. The adjusted energy dependent or lethargy dependent STAY'SL output distributions can be integrated numerically in order to obtain these regional group flux values. Although it is not always possible to obtain accurate information about the details of a neutron spectrum, the multiple activation technique does provide accurate integral values by keeping track of all the uncertainties associated with the starting spectrum, activation data, and cross sectional information.

Table 2.2 summarizes the STAY'SL results for the HFIR, comparing the activation measurements with the input spectrum and the STAY'SL adjusted spectrum for several reactions. Table 2.2 also provides the reduced chi-squared value (0.45) - a measure of the quality of the spectral adjustment.

Table 2.2 STAY'SL spectral adjustment for the Fast Flux Test Facility (FFTF).

STAY'SL spectral adjustments for FFTF/MOTA-1G Position: −1.1 cm, χ^2 = 0.45. Comparison of reaction rates (at/at s)								
Measured	±1%	Calculated	Diff. (%)	STAY'SL	Diff. (%)	Reaction	Energy range (MeV)	
2.32E − 10	5	5.03E − 10	117	2.32E − 10	0.0	^{59}Co(n, γ)^{60}Co	1.00E − 04	3.60E − 01
3.92E − 11	5	5.36E − 11	37	3.96E − 11	1.2	^{58}Fe(n, γ)^{59}Fe	2.80E − 04	5.50E − 01
8.33E − 10	5	9.94E − 10	19	8.35E − 10	0.3	^{93}Nb(n, γ)^{94}Nb	5.75E − 04	5.00E − 01
3.81E − 11	5	3.68E − 11	−3	3.62E − 11	−5.1	^{54}Fe(n, p)^{54}Mn	2.00E + 00	6.70E + 00
1.88E − 13	5	2.07E − 13	10	1.75E − 13	−7.2	^{63}Cu(n, α)^{60}Co	4.50E + 00	1.10E + 01
4.36E − 11	8	4.97E − 11	14	4.96E − 11	13.8	^{58}Ni(n, p)^{58}Co	1.60E + 00	6.70E + 00
7.44E − 13	10	1.04E − 12	40	8.68E − 13	16.6	^{60}Ni(n, p)^{60}Co	4.50E + 00	1.00E + 01
3.39E − 12	5	4.39E − 12	30	3.75E − 12	10.7	^{46}Ti(n, p)^{46}Sc	3.30E + 00	9.00E + 00
1.95E − 09	7	1.72E − 09	−12	1.92E − 09	−1.8	^{237}Np(n, fission)	3.60E − 01	3.30E + 00
7.92E − 09	6	8.77E − 09	11	8.11E − 09	2.3	^{239}Pu(n, fission)	7.60E − 04	2.00E + 00
8.12E − 09	6	8.92E − 09	10	7.98E − 09	−1.7	^{235}U(n, fission)	5.75E − 04	1.60E + 00
Standard deviation, %			43		8.2			

Other computer codes have been used to characterize neutron energy spectra. SANDS II is an example of an iterative adjustment code. The code employs a mild perturbation method that reduces spurious structure in the output spectrum. Measured activities determined from foil activation are compared to an input spectrum. Like STAY'SL it is important that the input spectrum be an accurate estimate of the actual spectrum in order to yield accurate results (ASTM E 721).

SANDS II does not propagate errors from the input spectrum, cross sections, or activation measurements like STAY'SL does. This is a major limitation and is the primary motivation for using STAY'SL.

3. METHODS AND PROCEDURES

3.1 MCNP Flux Determination

The model of the OSTR used in this work was benchmarked using MCNP (Tiyapun 1997). The original model was modified by creating tally cells where samples would be positioned. Each irradiation facility was segmented into 1-cm high volumes. These small volumes were used as flux tally cells. Usually there was a specific tally cell of interest per irradiation facility (the cell containing the greatest flux); however, adjacent cells were tallied as well to obtain the spatial flux distribution in each facility. The MCNP fluxes are a result of an MCNP *kcode* card that followed 10000 neutrons through 5000 cycles with an initial *k-eff* of 1.0. Flux tallies were determined for an ICIT core and a CLICIT core. These two input decks are found in Appendix A.

3.1.1 OSTR Irradiation Facilities

To determine the flux in the rotating rack, each of the 40-irradiation positions were axially divided into 1 cm segments (see Figure 3.1). Tallies were performed in the bottom 1 cm segment in all 40 positions. The data from all 40 tallies were then averaged to produce flux and spectral data for the Lazy Susan. The average value for all these positions is appropriate because samples typically rest at the bottom of each position and the entire facility is rotating during irradiation.

The in-core facilities extend from the bottom of the core grid plate position B-1 to the reactor top and have an inner diameter of 1.134 inches (see Figure 3.1). To determine the flux in these facilities, the tubes were axially divided into 1 cm high compartments. The samples in these facilities are placed on a spacer that raises the sample approximately 10 inches off the bottom grid plate (see Figure 1.5) where the flux is the highest. The tally cell was modeled at this height.

Like the in-core facilities, the Rabbit was axially divided into 1 cm-high compartments. Samples in the Rabbit rest on a shock absorber at the core centerline to ensure they receive the maximum flux in that region of the core (approximately 10 cm from the core grid plate). The Rabbit is located in the outer ring of the core in position G-2 (see Figure 3.1).

In the thermal column, samples are placed against the inside face, as indicated by Figure 3.1. A small section of the void, where the graphite block is removed, was divided into 1 cm^3 cells. Tallies were collected in the innermost cells where the samples are placed.

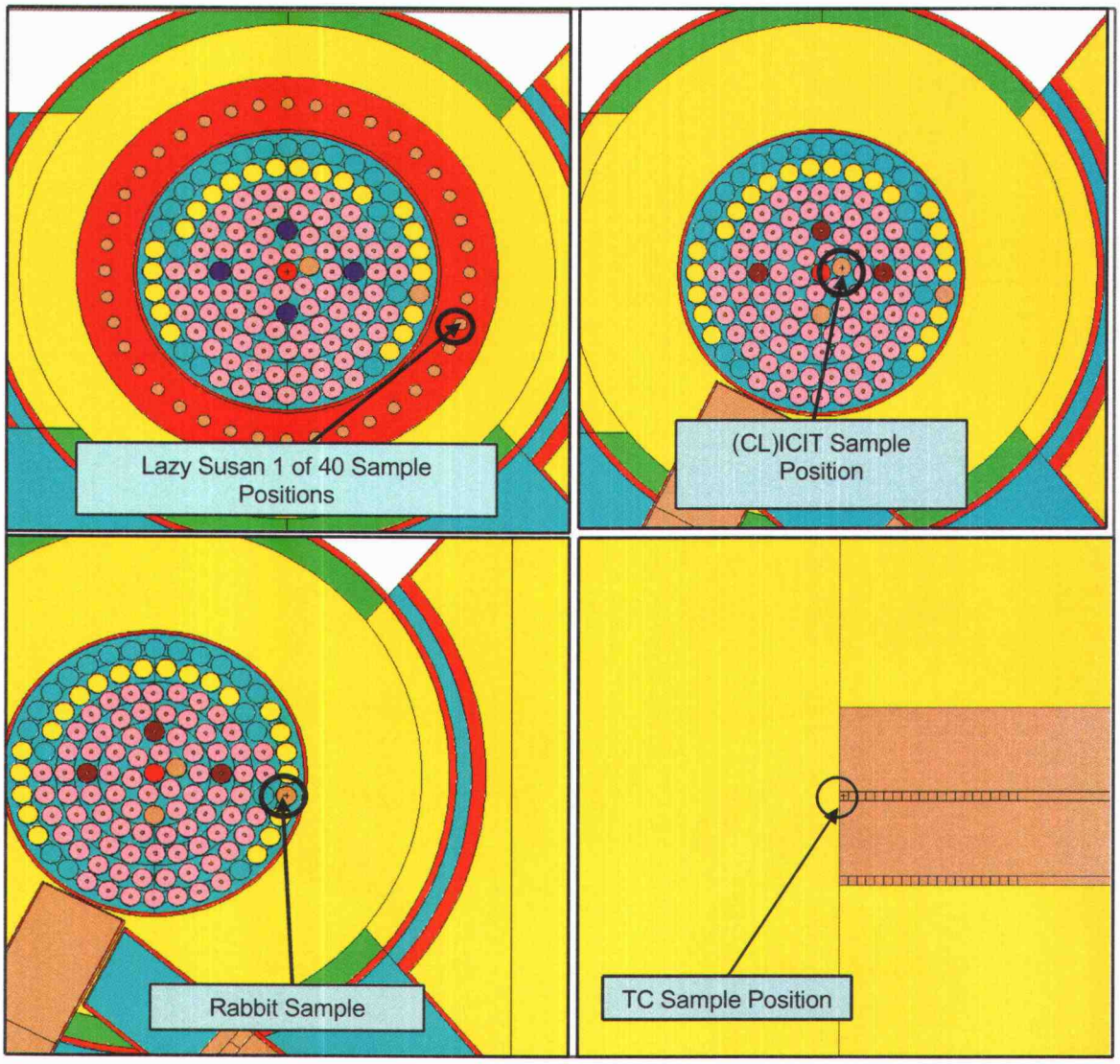

Figure 3.1 MCNP model of OSTR irradiation facilities - Visual Editor 5.0 plot of the Lazy Susan, (CL)ICIT, Rabbit, and thermal column to illustrate the location of the flux tally cell

3.2 Neutron Activation Analysis

3.2.1 Foil Selection

A combination of thermal, epi-thermal, and fast reactions were chosen with each reaction covering a portion of the energy spectrum. Cadmium covers were used for some foils to obtain information from reactions in the epi-thermal region.

Figure 3.2 illustrates the portion of the energy spectrum covered by these specific reactions. Activation foils were selected to utilize the reactions listed in Figure 3.2 in each irradiation facility. These regions represent the energy range encompassed by 90% of the cross section data for each reaction. The energy range for the bottom and top 5% are not shown.

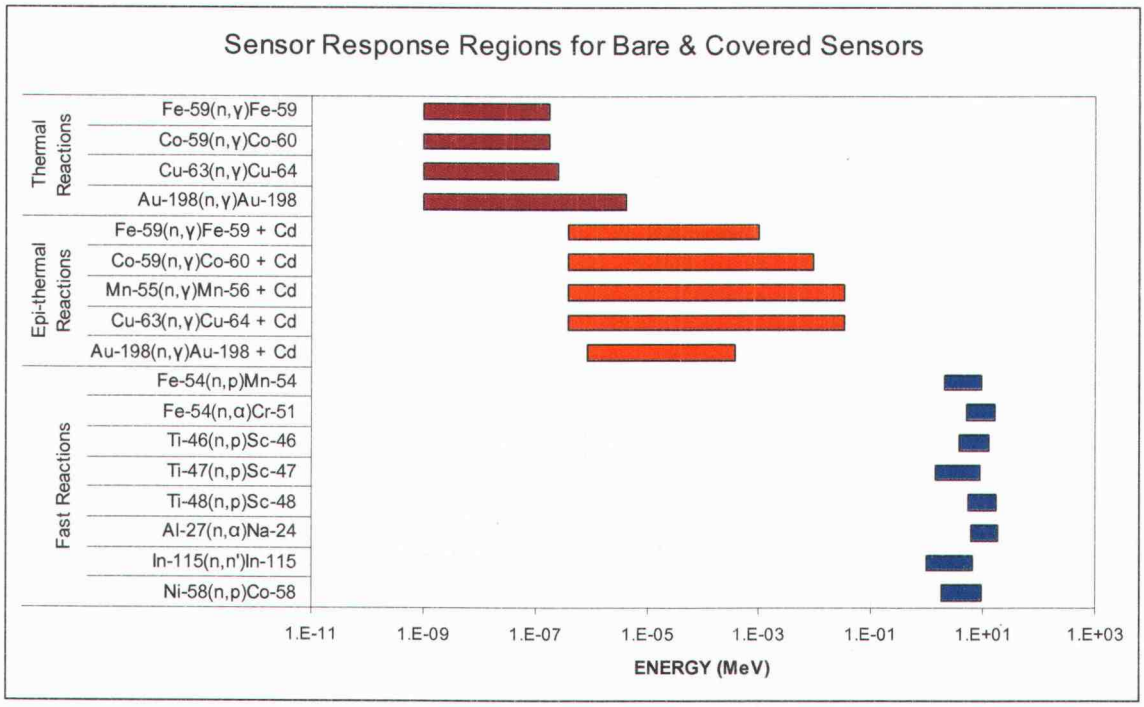

Figure 3.2 Sensor Response - Regions of response from activation reactions. This graph was created using the 90% cross section energy range from the Lazy Susan STAY'SL output file.

3.2.2 Irradiations

Table 3.1 shows the irradiation times used for all the facilities in the OSTR. All of the irradiations were performed at a reactor power level of 1 MW. Times varied depending on the neutron flux in that facility. In-core facilities had short irradiation times due to high neutron fluxes, while facilities outside the core had longer irradiation times due to lower neutron fluxes. The goal was to have comparable activities and similar counting times. Foils were chosen based on the energy range they cover as well as their availability. No cadmium covered foils were irradiated in the CLICIT because this facility is already wrapped in 0.02 inches of cadmium.

Due to the lack of neutrons seen in the MCNP model of the thermal column, only two foils were irradiated to determine gross flux numbers. No attempt was made to determine the spectrum in this facility.

Table 3.1 Summary of Irradiation Times – The irradiation times (min) based on distance from the core to achieve similar activities.

Irradiation Times (min) for irradiation facilities in the OSTR at 1 MW					
Material	Lazy Susan	ICIT	CLICIT	Rabbit	Thermal Column
Cobalt	5	1	1	0.5	-
Gold	5	1	-	-	-
Nickel	5	1	1	0.5	-
Titanium	60	5	1	0.5	-
Iron	60	5	1	0.5	-
Mn-Cu	60	5	-	-	-
Indium	60	5	1	0.5	-
Aluminum	60	5	-	-	-
Al-Au	-	-	1	0.5	60
Copper	-	-	1	0.5	-
Cobalt + Cd	5	1	-	0.5	-
Gold + Cd	5	1	-	-	-
Iron + Cd	60	5	-	0.5	-
Mn-Cu + Cd	60	5	-	-	-
Al-Au +Cd	-	-	-	0.5	60
Copper + Cd	-	-	-	0.5	-

3.2.3 Neutron Self-Shielding

Considering neutron self-shielding for the thermal and epi-thermal reactions was essential. Self-shielding factors can be input into STAY'SL in order to adjust the cross section data. Calculations of the self-shielding factors were performed for each reaction using Equation 1.15. These factors were then entered into a self-shielding file read by STAY'SL. Before STAY'SL adjusts the neutron energy spectra, the cross sections for each energy bin are multiplied by these self-shielding factors.

STAY'SL will also take into account self-shielding due to a covered activation foil. This is done when inputting activation reaction rates into STAY'SL by indicating the shielding file as well as indicating the type and thickness of the cover.

3.2.4 Foil Counting

The foils were counted and analyzed on an HPGe detection system using GammaVision®. Specific photopeaks were examined that correspond to the activation products of interest. The net counts were used to calculate the saturation activity of the activation products.

Two calibrations were performed for Lazy Susan irradiations in June 2004. Since there was a considerable amount of time (9 months) between when the Lazy Susan data and the remaining data were collected, the calibrations were repeated. The calibrations were done using a multi-nuclide source that contained various photopeaks that cover an energy range from approximately 90 keV to 1300 keV. Calibrations were performed for sample positions 2 cm and 20 cm above the detector. Energy and efficiency calibration equations were obtained from GammaVision®. See Appendix B for the calibration equations. The information collected from GammaVision® included the counting start time and date, live time, net counts in each desired photopeak, and the error in the net counts.

3.3 Calculating $\sigma\phi$ (STAY'SL input)

3.3.1 Derivation

The buildup of radionuclides due to neutron activation can be predicted by the following buildup equation: (see Figure 3.3)

$$A_{EOB} = N\sigma\phi\left(1 - e^{-\lambda T_I}\right) \tag{3.3}$$

where

$N\sigma\phi$ is the saturation activity (made up of the number of target atoms N, the target microscopic absorption cross section σ, and the incident neutron flux ϕ),

T_I is the irradiation time, and

λ is the decay constant for the radionuclide.

Figure 3.3 illustrates the activation buildup of a radionuclide and the decay that occurs once the sample is removed from the neutron flux.

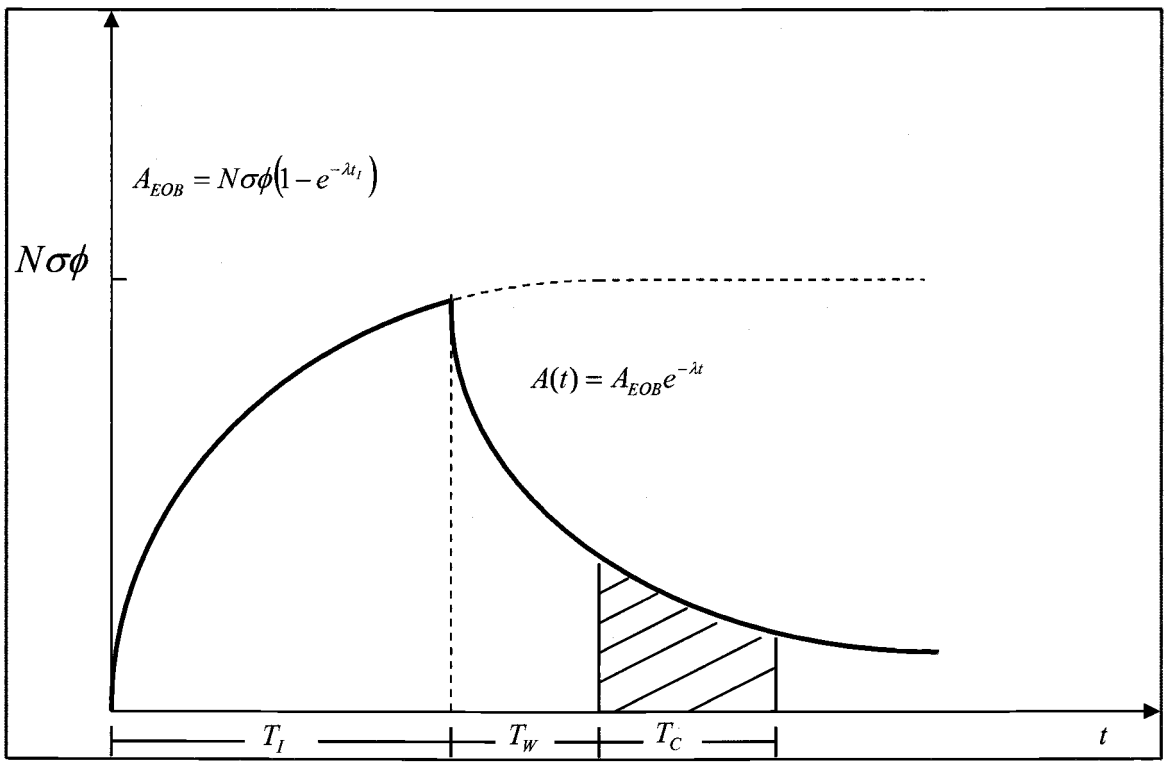

Figure 3.3 Activity Plot - Activity vs. time for irradiation time and decay

Once the target is removed from the incident neutron flux, it will decay for some amount of time T_W until the sample is counted. The equation for radioactive decay is the following:

$$A(t) = A_{EOB}e^{-\lambda t} \tag{3.4}$$

where

A_{EOB} is the activity at the End Of Bombardment (EOB), and

λ is the radioactive decay constant for the radionuclide that was created.

In order to get the total number of disintegrations from counting the target foil, Equation 3.4 must be integrated over the counting time. The resulting equation can be expressed in terms of the net counts for a particular photopeak by including the detection efficiency and branching ratio:

$$C = \frac{A_{EOB}\varepsilon f_\gamma}{\lambda e^{\lambda T_w}}\left(1 - e^{-\lambda T_c}\right) \tag{3.5}$$

where

C is the net number of counts for a particular photopeak (GammaVision® subtracts background counts by averaging the first three channels of the Region Of Interest (ROI) on both sides of the peak. These two points form a straight line. The counts below that line are subtracted as background.),

ε is the absolute efficiency of the detector,

f_γ is the branching ratio for a particular photopeak,

$T_C = T_f - T_s$, (T_f is the final counting time and T_s is the stating counting time), and

T_w is the decay time between the EOB and the counting start time.

The solution for $\sigma\phi$ may be determined by eliminating A_{EOB} from Equations 3.3 and 3.5:

$$\sigma\phi = \frac{C\lambda e^{\lambda T_w}}{N\varepsilon f_\gamma \left(1 - e^{-\lambda T_c}\right)\left(1 - e^{-\lambda T_i}\right)}. \tag{3.6}$$

This quantity is the reaction rate per target atom.

3.4 Sample Preparation

3.4.1 Lazy Susan

Twelve foils were irradiated in the Lazy Susan (See Table 3.1 for specific foils used). Each sample was placed in a sealed 2 dram polyethylene TRIGA® tube. A dram is a unit of volume that is approximately equal to 3.7 milliliters. Foils with cadmium covers were packed in 4 dram vials with Styrofoam peanuts to ensure that the covers would stay in place during the irradiation process. Styrofoam was used because it is non-reactant and does not activate when placed in a neutron flux. After the irradiation, the samples were given time to decay and then transferred to a new, clean 2 dram vial for counting. This is done to reduce detector dead time and ensure that activation products in the encapsulation material do not interfere with detecting radiation from the foils.

3.4.2 Rabbit

Eleven foils were irradiated in the Rabbit. Encapsulation became an issue for the Rabbit foils because the tubes are smaller than the cadmium covers. Covered foils were first wrapped in aluminum foil to keep the covers in place. Aluminum was used as filler because its absorption and scattering cross sections are low and its half-life is short ($T_{1/2} = 2.25\,\text{min}$).

The remainder of the space inside the vial was filled with aluminum foil to ensure that the covered foil would not slide during transfer. Bare foils were also wrapped in aluminum foil for consistency and placed vertically in 2 dram vials. Two dram polyethylene vials were just small enough to fit inside the Rabbit tube and hold the bare foils but were too small for the cadmium covers. They, therefore, were placed vertically into 2 dram vials. All foils were then transferred to a clean 2 dram vial for counting.

3.4.3 (CL)ICIT

Twelve foils were irradiated in the ICIT. Each sample was encapsulated in an aluminum TRIGA® tube. Foils with cadmium covers were wrapped in aluminum foil to ensure the cover would remain in place. After the irradiation, the samples were allowed to decay and then transferred to a clean 2 dram polyethylene vial for counting.

Seven foils were irradiated in the CLICIT. No covered foils were used since this facility is already lined with cadmium. The samples were encapsulated in the same manner as those used in the ICIT.

3.4.4 Thermal Column

Two foils were irradiated at the center face of the thermal column. Due to the lack of neutrons tallied in the MCNP model, correcting this model using STAY'SL was not appropriate. However, thermal and epi-thermal group fluxes were determined using covered and bare gold foils. The foils were encapsulated in sealed polyethylene TRIGA® tubes (bare in 2 dram, covered in 4 dram).

4. RESULTS

4.1 Lazy Susan

4.1.1 MCNP Flux Determination in the Lazy Susan

The statistical error in the MCNP model appears as error bars on Figure 4.1.1. The error is quite small (≤ 1%); however, the error at the extremes is high (1.0E-10 MeV = 47%, 16 MeV = 91%).

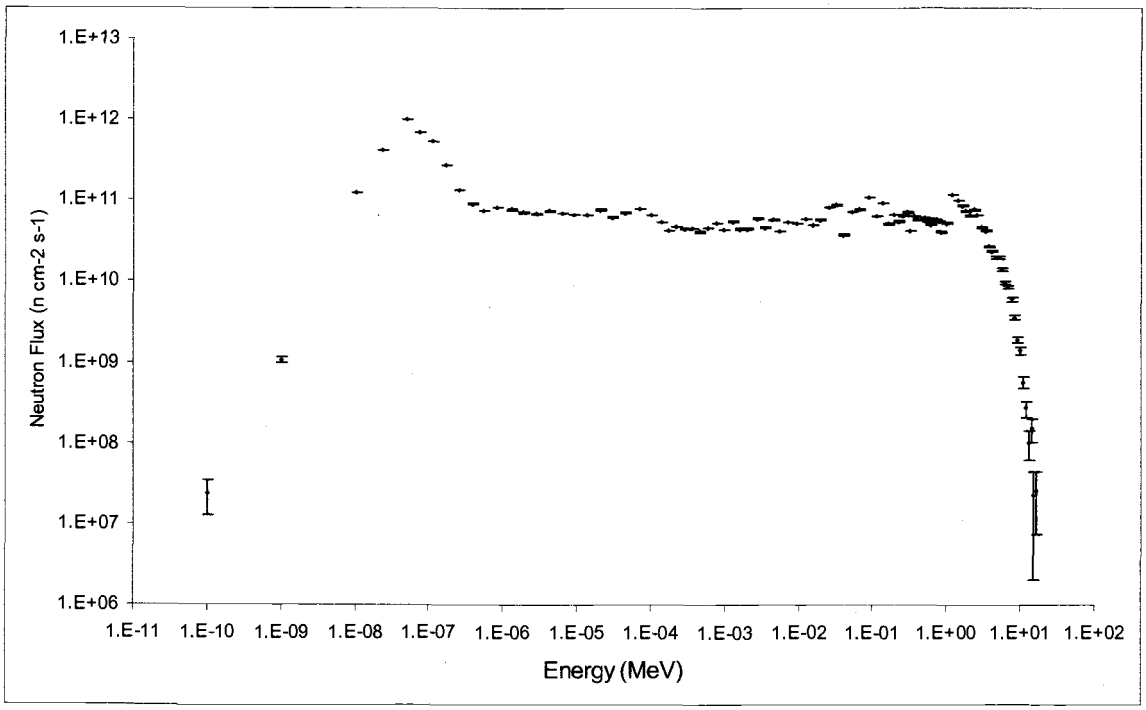

Figure 4.1.1 MCNP Modeled Flux Distribution in the Lazy Susan - Neutron flux distribution in the Lazy Susan determined from MCNP flux tallies

Initial examination of the MCNP neutron flux distribution shows that no neutrons have energies greater than 16 MeV. Therefore, the last three neutron energy groups were truncated changing the number of energy groups from 100 to 97.

4.1.2 NAA Results in the Lazy Susan

For each foil, the saturation activity was calculated for each photopeak. This was accomplished using Equation 3.6. Saturation activity should be the same for each photopeak of a given reaction. For example, the two most prominent peaks for the thermal reaction Fe-58(n,γ)Fe-59 exist at 1099.25 keV and 1291.6 keV. The saturation activities calculated from

these photopeaks were 345.7 ± 6.8 Bq and 345.4 ± 6.9 Bq, respectively. The activities are summarized in Table 4.1.2.

Table 4.1.2 Summary of EOB activities in the Lazy Susan.

Foil	Reactions	Energy (keV)	Saturation Activity (Bq)
Covered Iron	Fe-58(n,γ)Fe-59	1099.3	3.46E+02 ± 6.80E+00
		1291.6	3.45E+02 ± 6.87E+00
	Fe-54(n,p)Mn-54	834.8	3.90E+02 ± 7.57E+00
	Fe-54(n,α)Cr-51	320.1	5.48E+01 ± 2.02E+00
Bare Iron	Fe-58(n,γ)Fe-59	1099.3	1.05E+04 ± 2.49E+02
		1291.6	1.07E+04 ± 2.51E+02
	Fe-54(n,p)Mn-54	834.8	3.89E+02 ± 7.55E+00
	Fe-54(n,α)Cr-51	320.1	5.95E+01 ± 3.13E+00
Co Covered	Co-59(n,γ)Co-60	1173.2	3.54E+03 ± 1.14E+02
		1332.5	3.63E+03 ± 1.17E+02
Co Bare	Co-59(n,γ)Co-60	1173.2	1.59E+05 ± 5.01E+03
		1332.5	1.65E+05 ± 5.20E+03
MnCu Covered	Mn-55(n,γ)Mn-56	846.8	1.22E+08 ± 2.40E+06
	Mn-55(n,2n)Mn-54	834.8	9.44E+00 ± 7.03E-01
	Cu-63(n,γ)Cu-64	1345.8	1.60E+06 ± 3.13E+04
MnCu Bare	Mn-55(n,γ)Mn-56	846.8	9.19E+08 ± 2.93E+08
	Mn-55(n,2n)Mn-54	834.8	-
	Cu-63(n,γ)Cu-64	1345.8	4.34E+07 ± 8.58E+05
Gold Covered	Au-197(n,γ)Au-198	411.8	1.07E+07 ± 3.28E+05
Gold Bare	Au-197(n,γ)Au-198	411.8	6.89E+07 ± 2.13E+06
Ti Bare	Ti-46(n,p)Sc-46	889.3	3.82E+02 ± 9.05E+00
		1120.5	3.96E+02 ± 9.30E+00
	Ti-47(n,p)Sc-47	159.4	1.33E+04 ± 2.56E+02
	Ti-48(n,p)Sc-48	983.5	4.48E+03 ± 8.84E+01
		1312.1	4.44E+03 ± 8.82E+01
		1037.5	4.35E+03 ± 8.64E+01
		175.4	4.32E+03 ± 9.29E+01
Al Bare	Al-27(n,α)Na-24	1368.6	1.15E+05 ± 3.61E+03
		2754.0	1.34E+05 ± 4.23E+03
In Bare	In-115(n,n')In-115	336.2	8.81E+06 ± 2.78E+05
Ni Bare	Ni-58(n,p)Co-58	810.8	3.70E+03 ± 1.17E+02

The Mn (n,2n) reaction and the bare Mn (n,γ) reaction were dropped due to the inability to observe counts in the photopeak of interest. This is due to low probability of a gamma emitted from a decay event.

4.1.3 Calculating $\sigma\phi$ for STAY'SL input in the Lazy Susan.

STAY'SL requires the reaction rate to be expressed as $\sigma\phi$. This is calculated by dividing the saturation activity by the number of atoms (taking into account the mass of the foil, the purity of the foil, the isotopic abundance for that reaction, and the atomic weight of the foil). Table 4.1.3 summarizes the $\sigma\phi$ values for the OSTR Lazy Susan.

Table 4.1.3 Summary of $\sigma\phi$ values for the Lazy Susan - Averaged for each reaction.

Reactions	sigma-phi (atoms/atoms/s)
Fe-58(n,g)Fe-59	3.91E-12 ± 5.47E-14
Fe-58(n,g)Fe-59+Cd	1.29E-13 ± 1.76E-15
Fe-54(n,p)Mn-54	4.89E-14 ± 9.49E-16
Ni-58(n,p)Co-58	5.24E-14 ± 1.66E-15
Ti-46(n,p)Sc-46	6.94E-15 ± 1.16E-16
Ti-47(n,p)Sc-47	1.08E-14 ± 2.07E-16
Ti-48(n,p)Sc-48	1.92E-16 ± 1.95E-18
Fe-54(n,a)Cr-51	6.33E-16 ± 2.83E-17
Al-27(n,a)Na-24	4.84E-16 ± 1.09E-17
In-115(n,n')In-115m	1.05E-13 ± 3.30E-15
Cu-63(n,g)Cu-64	1.37E-11 ± 2.71E-13
Mn-55(n,g)Mn-56+Cd	1.16E-12 ± 2.28E-14
Cu-63(n,g)Cu-64+Cd	4.89E-13 ± 9.58E-15
Co-59(n,g)Co-60	1.97E-10 ± 4.39E-12
Co-59(n,g)Co-60+Cd	4.43E-12 ± 1.01E-13
Au-197(n,g)Au-198	2.93E-10 ± 9.06E-12
Au-197(n,g)Au-198+Cd	4.38E-11 ± 1.34E-12

4.1.4 STAY'SL Results in the Lazy Susan

4.1.4.1 Maxwellian Fit to thermal region in the Lazy Susan

Initial runs on the Lazy Susan show that the MCNP model in the Lazy Susan underestimates the thermal spectra by a factor of 2 and overestimates the epi-region by a factor of 2 based on the neutron activation data (see Figure 4.1.2).

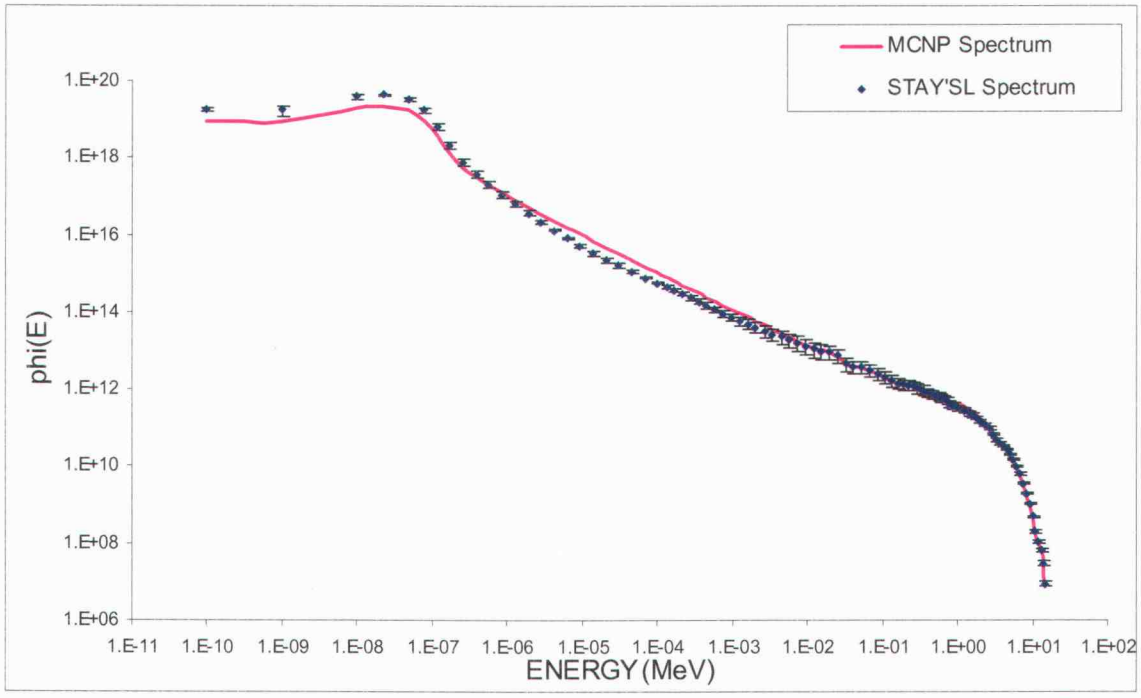

Figure 4.1.2 Energy Dependent Flux in the Lazy Susan without Maxwellian Correction – MCNP appears to under estimate the thermal region. Chi2 = 14.5.

STAY'SL has a feature that allows the user to truncate thermal energy groups and fit the input flux to a Maxwellian distribution. The user must decide the appropriate number of groups to truncate. This is convenient for situations where the thermal spectrum is not well known or defined. For a more complete description of the parameters in STAY'SL, see Appendix C.

Several STAY'SL runs were completed to examine the shape of the thermal spectra as neutron energy groups were truncated because the shape changes considerably depending on the number of groups removed. Figure 4.1.3 shows the Lazy Susan spectra with the Maxwellian correction to the first four energy groups.

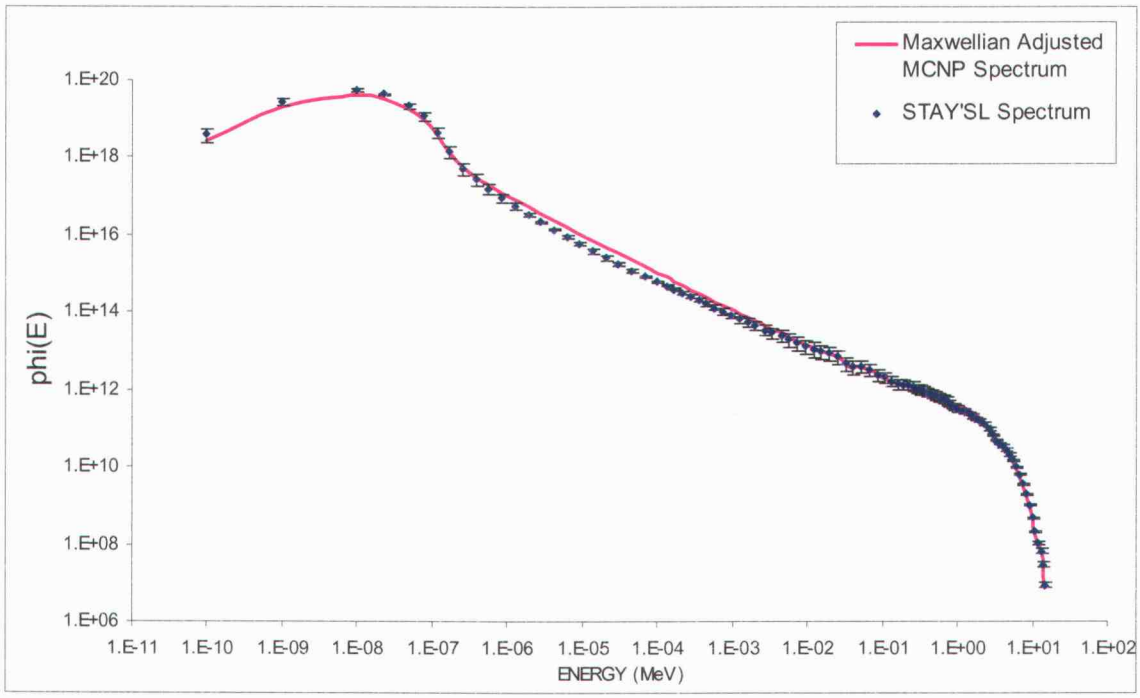

Figure 4.1.3 Energy Dependent Flux in the Lazy Susan with Maxwellian Correction – There is better agreement to the thermal region when the Maxwellian correction is applied. Chi2 = 13.9

4.1.4.2 Normalization factor (AK1) in the Lazy Susan

The AK1 parameter in STAY'SL is a normalization factor that shifts the adjusted spectra up or down to match the modeled data. This allows the user to visually compare the two spectra. If AK1 = 0, the spectrum is normalized based on the input data. If AK1 = 1, the spectrum is forced to be normalized to 1. The AK1 value can also be fixed to a value specified by the user.

AK1 was set to zero and run for only the fast reactions in order to determine the AK1 value that would be used when adjusting the entire modeled spectrum. This normalizes the spectrum to the fast region, forcing the two spectra to lie on top of each other. Once the AK1 value was determined from the fast reactions, then that value is used for the rest of the Lazy Susan STAY'SL runs.

For example, the fast reactions for the Lazy Susan were run in STAY'SL to determine the AK1 value. The following plot shows the fast reaction fit.

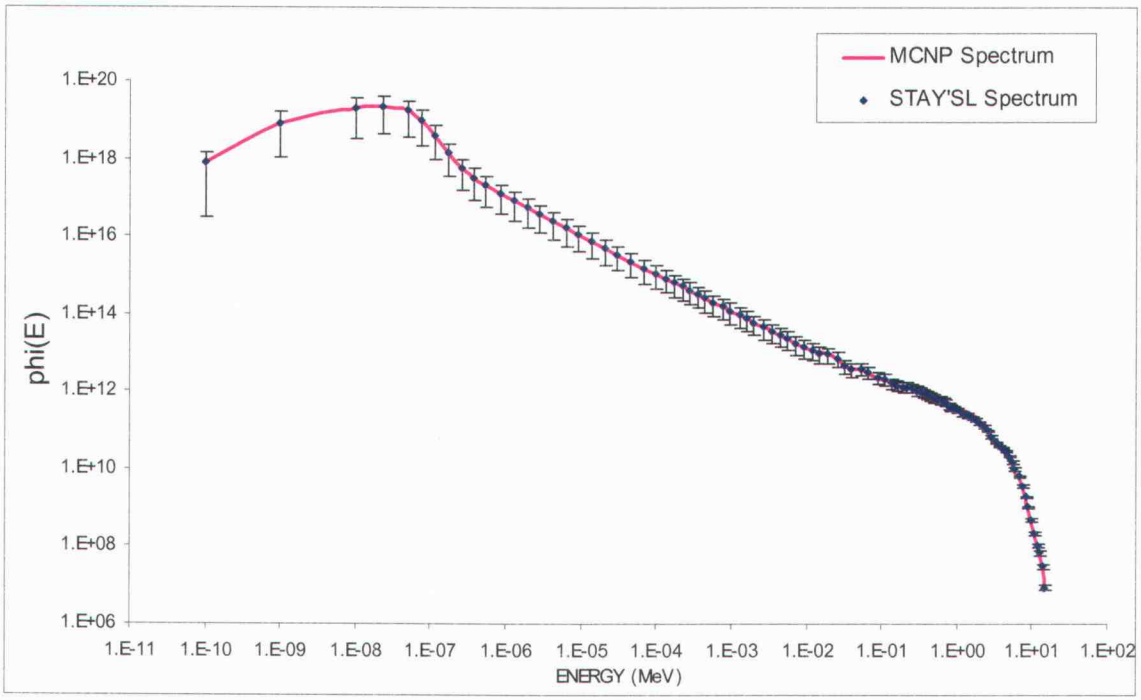

Figure 4.1.4 AK1 Determination in the Lazy Susan. Fast reactions were fit by STAY'SL to determine the normalization factor for use later. (AK1 = 0.689).

The normalization factor was determined to be 0.689 for the Lazy Susan. This value was then fixed in subsequent STAY'SL runs.

4.1.4.3 Lazy Susan Spectral Results

Examining the individual χ^2 values for reactions in the Lazy Susan reveals that the bare cobalt foil does not fit as well as the other reactions (see Figure 4.1.5). There is no obvious reason for this discrepancy. When the bare cobalt reaction was removed from the STAY'SL input, χ^2_R reduces to approximately 1.5.

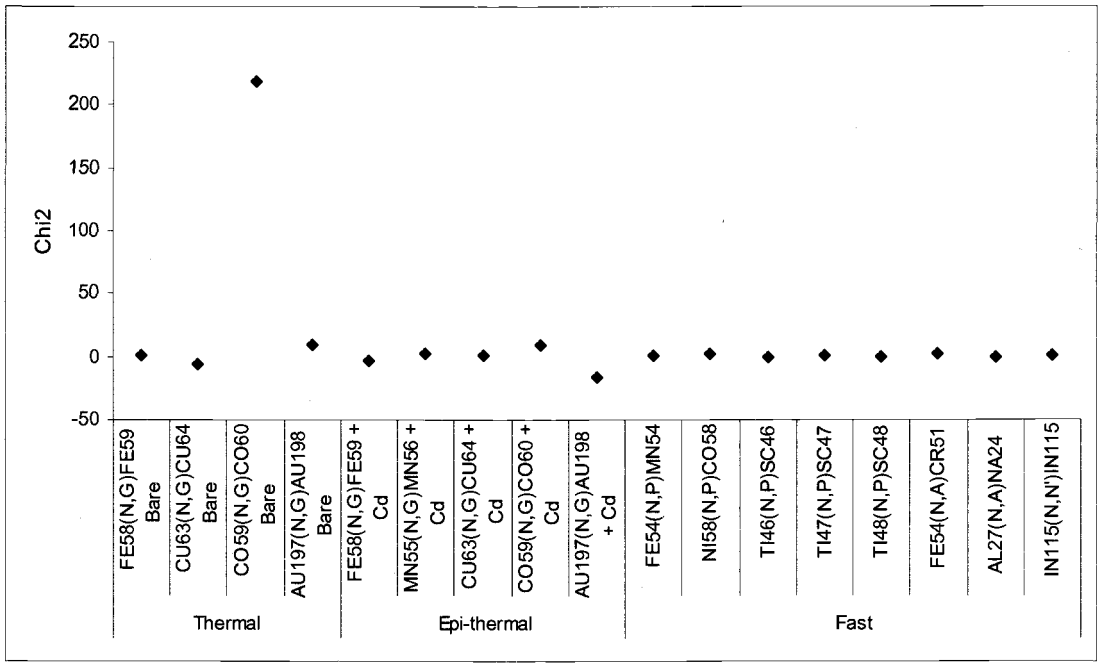

Figure 4.1.5 χ^2 Comparison for Lazy Susan - Individual χ^2 values for reactions in the Lazy Susan

It appears that the modeled MCNP group fluxes overestimate the epi-thermal region (illustrated by the dip below the MCNP spectrum in Figure 4.1.6). The rest of the spectrum shows good agreement.

Table 4.1.4 lists the measured and calculated reaction rates in the Lazy Susan to show the degree at which the two reaction rates differed before the STAY'SL adjustment.

Table 4.1.4 Summary of the ratios between measured and calculated reaction rates in the Lazy Susan

	Reactions	Measured Reaction Rates (at/at/s)	Calculated Reaction Rates based on MCNP input	% Diff
Thermal	FE58(N,G)FE59	3.91E+12	3.16E+12	-19.28
	CU63(N,G)CU64	1.37E+13	1.25E+13	-8.94
	AU197(N,G)AU198	2.93E+14	3.19E+14	8.89
Epi-thermal	FE58(N,G)FE59 CADM	1.29E+11	1.69E+11	30.75
	CU63(N,G)CU64 CADM	4.89E+11	6.92E+11	41.58
	CO59(N,G)CO60 CADM	4.43E+12	7.42E+12	67.48
	AU197(N,G)AU198 CADM	4.38E+13	6.88E+13	57.32
	MN55(N,G)MN56 CADM	1.16E+12	1.79E+12	54.23
Fast	FE54(N,P)MN54	4.89E+10	4.75E+10	-2.83
	NI58(N,P)CO58	5.24E+10	6.29E+10	20.13
	TI46(N,P)SC46	6.94E+09	6.48E+09	-6.62
	TI47(N,P)SC47	1.08E+10	1.28E+10	18.82
	TI48(N,P)SC48	1.92E+08	1.77E+08	-8.07
	FE54(N,A)CR51	6.33E+08	4.68E+08	-26.04
	AL27(N,A)NA24	4.84E+08	4.52E+08	-6.61
	IN115(N,N')IN115	1.05E+11	1.35E+11	28.62

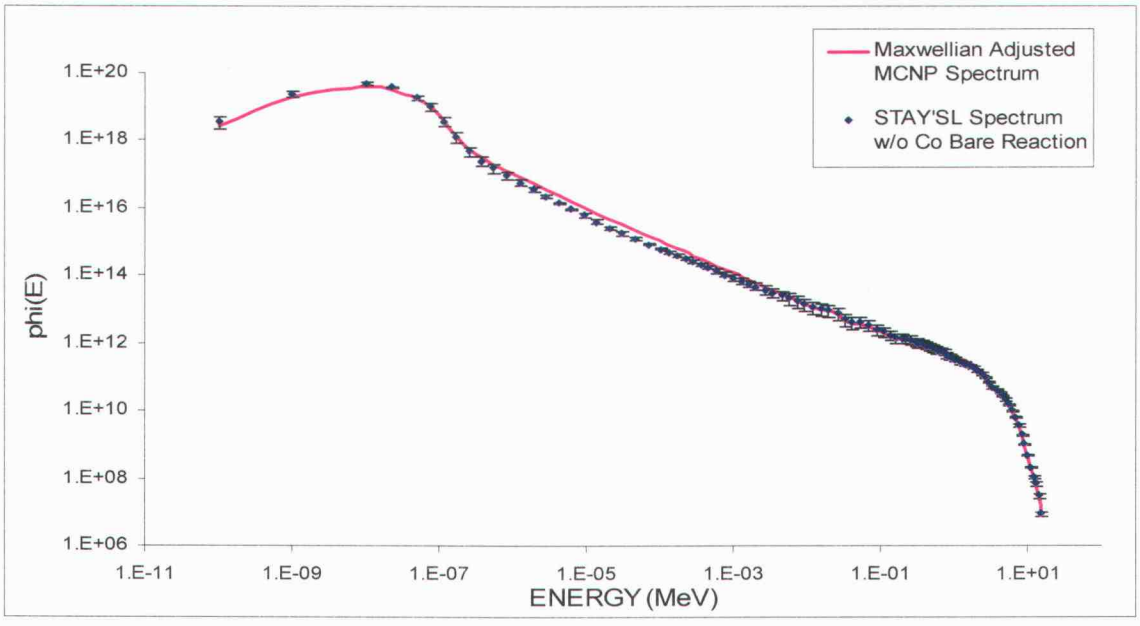

Figure 4.1.6 Energy Dependent Flux in the Lazy Susan with Maxwellian Correction and bare cobalt bare reaction removed. Chi2 = 1.5.

4.1.4.4 Regional Flux Values in the Lazy Susan

The energy dependent spectra with and without the bare cobalt reactions were numerically integrated over their respective energy ranges using the trapezoidal rule. The following table lists the regional flux values for the thermal, epi-thermal, and fast regions.

Table 4.1.5 Regional Flux Values for the Lazy Susan

LS flux w/o Co bare	
Region	Flux (n cm^-2 s^-1)
thermal	2.6E+12 ± 3.8E+11
epi-thermal	1.9E+12 ± 4.7E+11
fast	4.4E+11 ± 4.6E+10
LS flux all reactions	
thermal	3.0E+12 ± 4.3E+11
epi-thermal	1.8E+12 ± 4.6E+11
fast	4.4E+11 ± 4.6E+10

4.2 ICIT

4.2.1 MCNP Flux Determination in the ICIT

The ICIT flux was determined from an MCNP flux tally in the cell that represents the position in the ICIT where samples are located (see Figure 4.2.1). This position is located at the flux peak for the core.

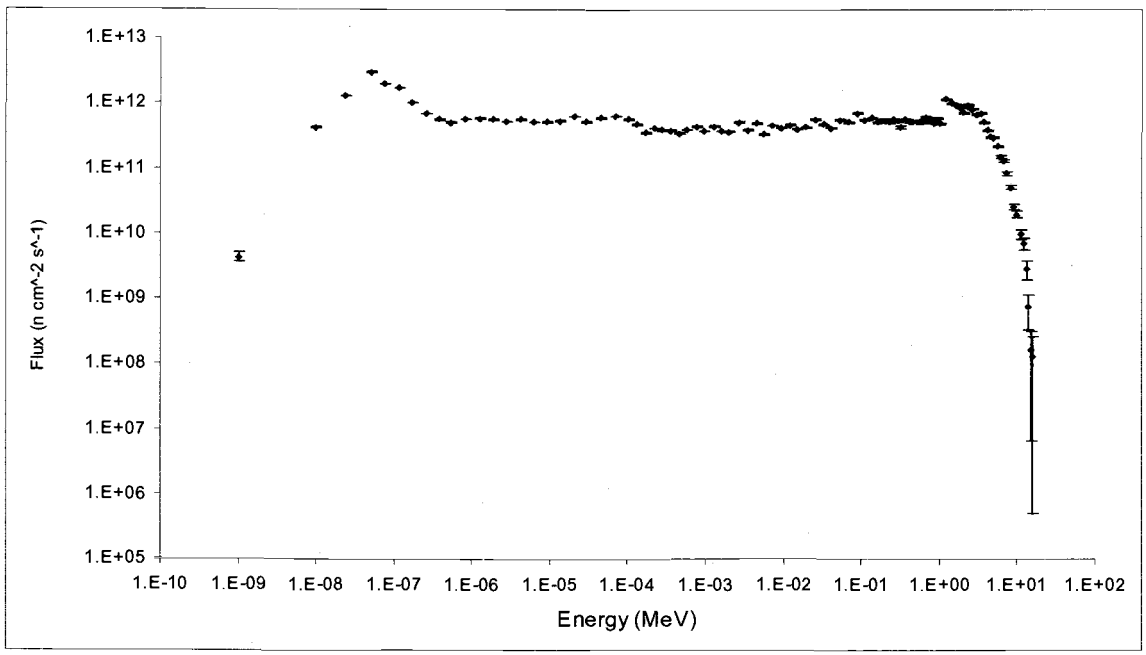

Figure 4.2.1 MCNP Modeled Flux Distribution in the ICIT - Neutron flux distribution in the ICIT determined from MCNP flux tallies at the position of highest flux.

Once again the spectra could not be resolved above 16 MeV because the error was greater than 100%. Therefore, the last 3 energy groups were truncated (from 100 to 97).

4.2.2 NAA Results in the ICIT

Table 4.2.2 Summary of EOB activities in the ICIT

Foil	Reactions	Energy (keV)	Saturation Activity (Bq)
Covered Iron	Fe-58(n,γ)Fe-59	1099.3	4.25E+02 ± 9.32E+00
		1291.6	4.44E+02 ± 1.00E+01
	Fe-54(n,p)Mn-54	834.8	7.36E+02 ± 1.43E+01
	Fe-54(n,α)Cr-51	320.1	8.99E+01 ± 6.16E+00
Bare Iron	Fe-58(n,γ)Fe-59	1099.3	2.95E+03 ± 7.00E+01
		1291.6	3.01E+03 ± 7.08E+01
	Fe-54(n,p)Mn-54	834.8	7.54E+02 ± 1.46E+01
	Fe-54(n,α)Cr-51	320.1	8.70E+01 ± 1.06E+01
Co Covered	Co-59(n,γ)Co-60	1173.2	1.32E+04 ± 4.24E+02
		1332.5	1.34E+04 ± 4.31E+02
Co Bare	Co-59(n,γ)Co-60	1173.2	1.33E+05 ± 4.19E+03
		1332.5	1.38E+05 ± 4.36E+03
MnCu Covered	Mn-55(n,γ)Mn-56	846.8	1.53E+08 ± 4.60E+06
	Mn-55(n,2n)Mn-54	834.8	-
	Cu-63(n,γ)Cu-64	1345.8	1.86E+6 ± 7.44E+04
MnCu Bare	Mn-55(n,γ)Mn-56	846.8	1.05E+09 ± 3.14E+07
	Mn-55(n,2n)Mn-54	834.8	-
	Cu-63(n,γ)Cu-64	1345.8	1.15E+07 ± 4.58E+05
Gold Covered	Au-197(n,γ)Au-198	411.8	2.72E+07 ± 8.36E+05
Gold Bare	Au-197(n,γ)Au-198	411.8	6.14E+07 ± 1.90E+06
Ti Bare	Ti-46(n,p)Sc-46	889.3	7.05E+02 ± 1.67E+01
		1120.5	7.23E+02 ± 1.70E+01
	Ti-47(n,p)Sc-47	159.4	3.18E+04 ± 6.14E+02
	Ti-48(n,p)Sc-48	983.5	7.80E+03 ± 1.54E+02
		1312.1	8.20E+03 ± 1.63E+02
		1037.5	7.88E+03 ± 1.56E+02
		175.4	9.37E+03 ± 2.02E+02
Al Bare	Al-27(n,α)Na-24	1368.6	2.20E+05 ± 6.90E+03
		2754.0	2.65E+05 ± 8.51E+03
In Bare	In-115(n,n')In-115	336.2	2.04E+07 ± 6.43E+05
Ni Bare	Ni-58(n,p)Co-58	810.8	5.75E+03 ± 1.15E+02

The irradiation times for foils placed in the ICIT were reduced because of the higher flux in that facility. The 5 minute irradiations in the Lazy Susan were shortened to 1 minute in

the ICIT. The 60 minute irradiations from the Lazy Susan were reduced to 5 minute irradiations in the ICIT. This allowed for comparable activities and reasonable counting times.

Activities were calculated for each photopeak. Table 4.2.1 summarizes the activities determined from neutron activation and lists their absolute error based on counting error and error in detection efficiency. These activities were then averaged over the reactions to determine $\sigma\phi$.

4.2.3 Calculating $\sigma\phi$ for STAY'SL input in the ICIT

The values of $\sigma\phi$ used in STAY'SL for the ICIT are summarized in Table 4.2.3.

Table 4.2.3 Summary of $\sigma\phi$ values for the ICIT

Reactions	sigma-phi (atoms/atoms/s)
Fe-58(n,g)Fe-59	1.33E-11 ± 1.33E-13
Fe-58(n,g)Fe-59+Cd	1.95E-12 ± 3.89E-14
Fe-54(n,p)Mn-54	1.13E-12 ± 1.13E-14
Ni-58(n,p)Co-58	1.46E-12 ± 2.92E-14
Ti-46(n,p)Sc-46	1.53E-13 ± 3.06E-15
Ti-47(n,p)Sc-47	3.08E-13 ± 6.16E-15
Ti-48(n,p)Sc-48	4.33E-15 ± 8.67E-17
Fe-54(n,a)Cr-51	1.18E-14 ± 8.29E-16
Al-27(n,a)Na-24	1.11E-14 ± 2.21E-16
In-115(n,n')In-115m	2.72E-12 ± 8.15E-14
Cu-63(n,g)Cu-64	4.24E-11 ± 1.69E-12
Mn-55(n,g)Mn-56+Cd	1.55E-11 ± 4.65E-13
Cu-63(n,g)Cu-64+Cd	6.67E-12 ± 2.67E-13
Co-59(n,g)Co-60	8.30E-10 ± 1.66E-11
Co-59(n,g)Co-60+Cd	8.46E-11 ± 1.69E-12
Au-197(n,g)Au-198	1.31E-09 ± 3.92E-11
Au-197(n,g)Au-198+Cd	5.58E-10 ± 1.67E-11

4.2.4 STAYSL Results in the ICIT

4.2.4.1 Maxwellian Fit to thermal region in the ICIT

As with the Lazy Susan, the MCNP model for the ICIT appears to underestimate the thermal flux distribution by a factor of 2 (see Figure 4.2.2). A truncation sensitivity test was performed to determine the number of thermal energy groups to fit using a Maxwellian distribution. Similar to the Lazy Susan, the best Maxwellian correction appears to occur when truncating 4 thermal energy groups (see Figure 4.2.4).

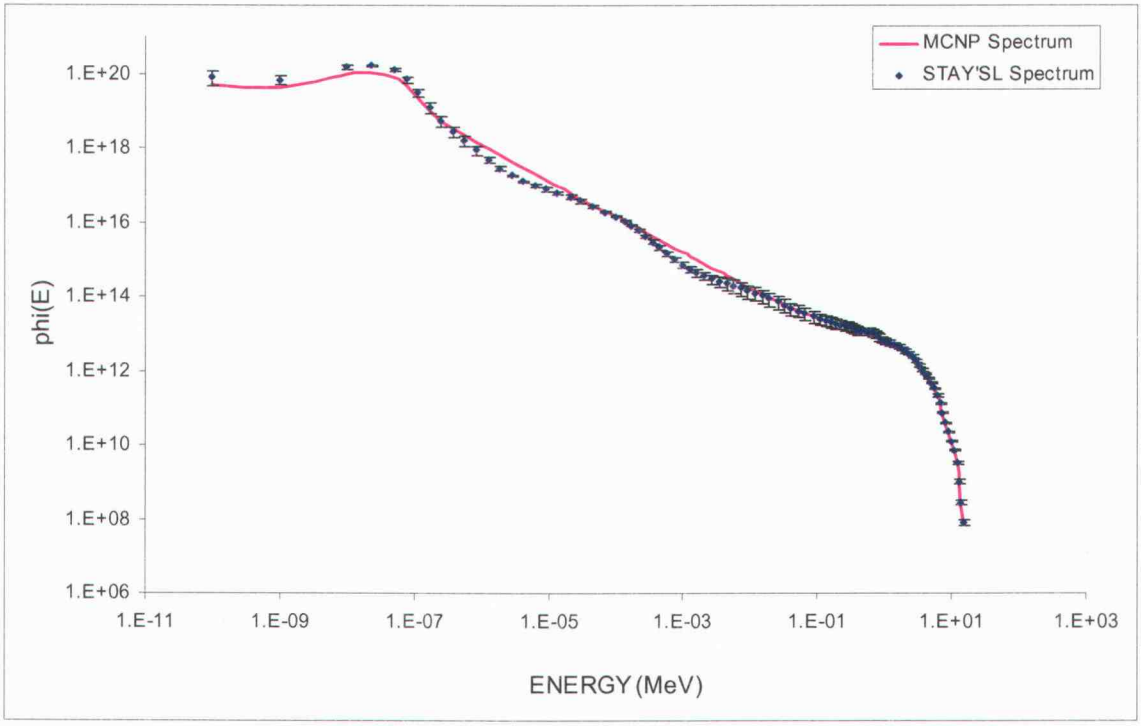

Figure 4.2.2 Energy Dependent Flux in the ICIT without Maxwellian correction. Chi2 = 27.2

4.2.4.2 Normalization Factor (AK1) in the ICIT

The fast reactions were analyzed with STAY'SL to determine the spectral normalization factor to ensure that the modeled spectra lines up with the adjusted spectra. Figure 4.2.3 shows the neutron energy spectra for the ICIT that determined the AK1 value by normalizing the fast reactions to the input spectrum. The normalization factor (AK1) determined from this fit was 1.1047 and was fixed for all other ICIT STAY'SL runs.

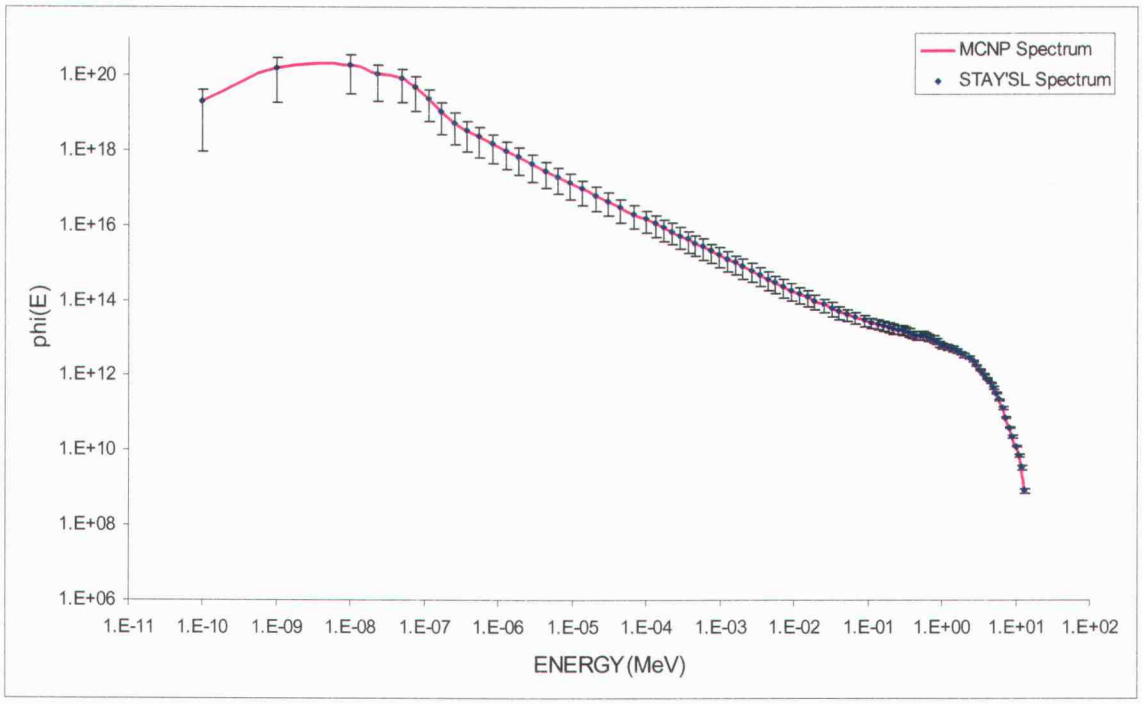

Figure 4.2.3 AK1 Determination in the ICIT - Fast reactions were fit by STAY'SL to determine the normalization factor for use later. AK1 = 1.1047, Chi2 = 0.1

4.2.4.3 ICIT STAY'SL Results

As with the Lazy Susan, 4 energy groups were fit to a Maxwellian distribution (see Figure 4.2.4). Appling the Maxwellian correction improved the spectral adjustment only slightly (χ_R^2 decreased from 27.2 to 26.5). The dips in the epi-thermal region were unaffected by the Maxwellian correction.

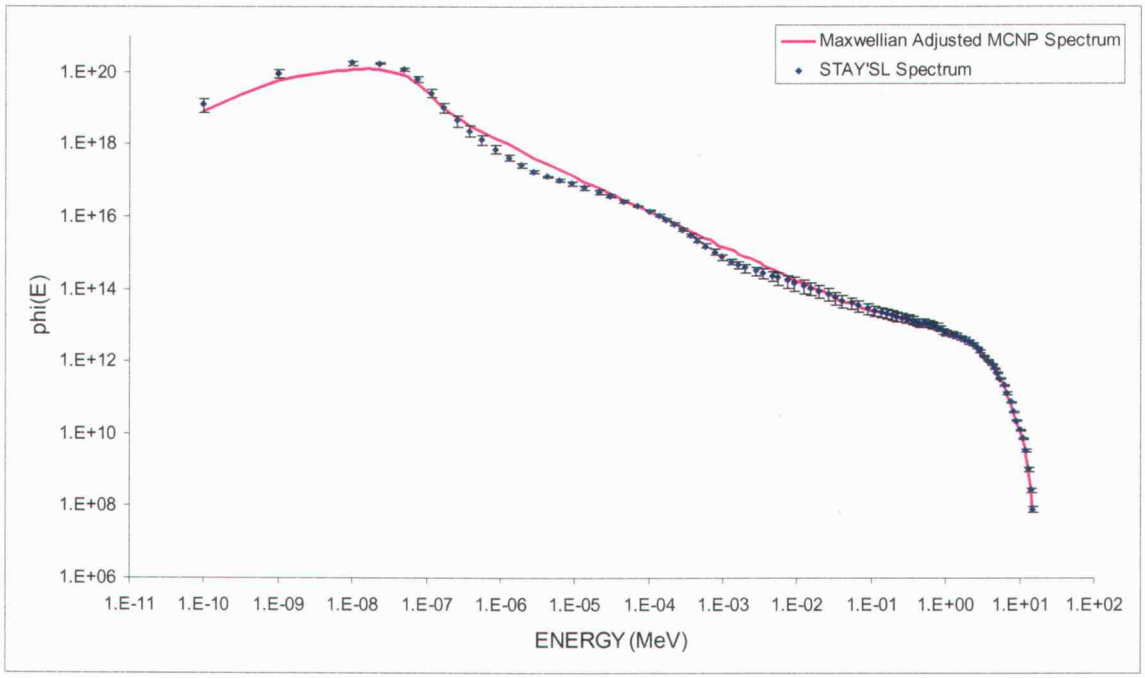

Figure 4.2.4 Energy Dependent Flux in the ICIT with Maxwellian Correction - There is better agreement in the thermal region when the Maxwellian correction is applied. Chi2 = 26.5.

Shown in Figure 4.2.5, a review of the individual χ^2 values for the reactions in the ICIT once again shows that the activity calculated from the bare cobalt irradiation was not a good fit.

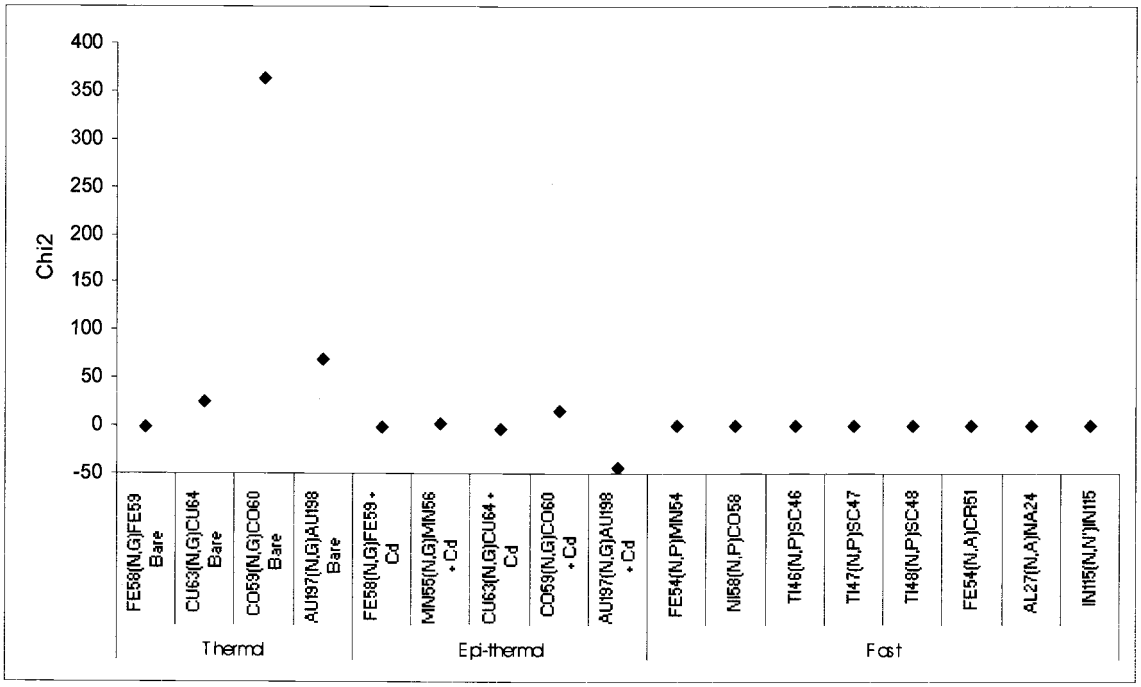

Figure 4.2.5 χ^2 Comparison for ICIT - Individual χ^2 values for reactions in the OSTR ICIT.

Removing the cobalt bare reaction improves

Table 4.2.4 Summary of the ratios between measured and calculated reaction rates in the ICIT

	Reactions	Measured Reaction Rates (at/at/s)	Calculated Reaction Rates based on MCNP input	% Diff
Thermal	FE58(N,G)FE59	1.33E+13	1.29E+13	-3.01
	CU63(N,G)CU64	6.67E+12	8.84E+12	32.46
	AU197(N,G)AU198	1.31E+15	1.75E+15	34.12
Epi-thermal	MN55(N,G)MN56 CADM	1.55E+13	2.27E+13	46.4
	FE58(N,G)FE59 CADM	1.95E+12	2.15E+12	10.31
	CU63(N,G)CU64 CADM	6.67E+12	8.84E+12	32.46
	CO59(N,G)CO60 CADM	8.20E+13	9.66E+13	17.83
	AU197(N,G)AU198 CADM	5.58E+14	8.36E+14	49.79
Fast	FE54(N,P)MN54	1.13E+12	1.14E+12	1.24
	NI58(N,P)CO58	1.46E+12	1.49E+12	1.63
	TI46(N,P)SC46	1.53E+11	1.56E+11	1.96
	TI47(N,P)SC47	3.08E+11	2.87E+11	-6.91
	TI48(N,P)SC48	4.33E+09	4.20E+09	-3.18
	FE54(N,A)CR51	1.18E+10	1.11E+10	-6.61
	AL27(N,A)NA24	1.11E+10	1.07E+10	-3.39
	IN115(N,N')IN115	2.72E+12	2.75E+12	1.35

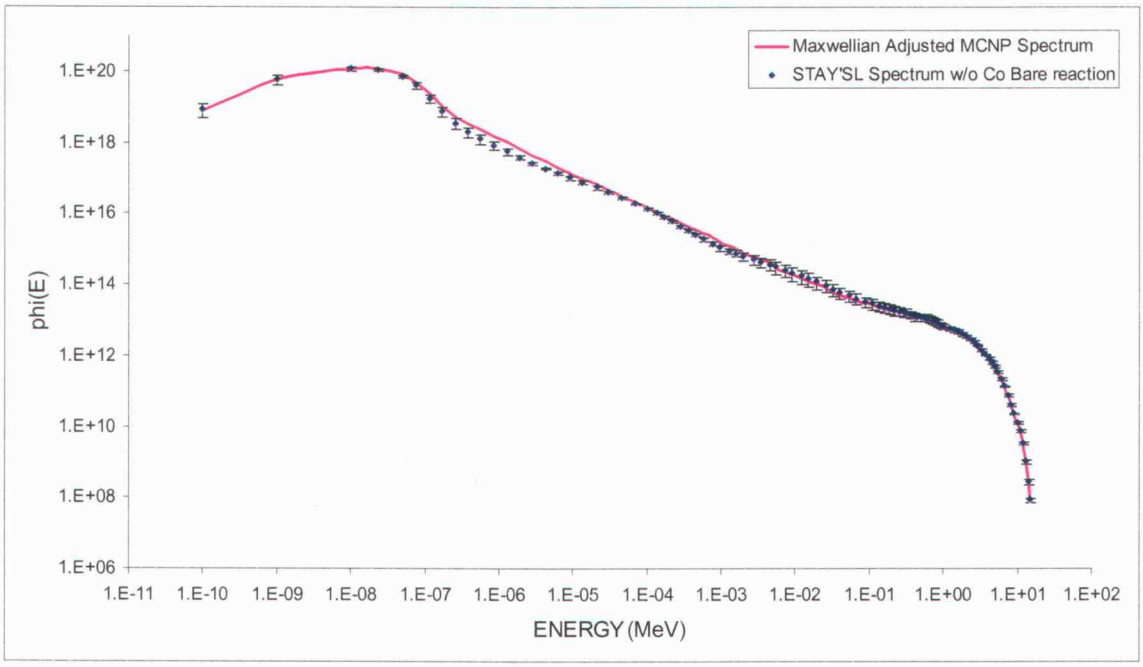

Figure 4.2.6 Energy Dependent Flux in the ICIT with Maxwellian Correction and Co Bare removed. Chi2 = 0.9

4.2.4.4 Regional Flux Values in the ICIT

The energy dependent spectra, with and without the bare cobalt reaction, were numerically integrated using the trapezoidal rule. The following table lists the regional flux values in the OSTR ICIT for the thermal, epi-thermal, and fast regions.

Table 4.2.5 Regional Flux Values for the ICIT

ICIT flux w/o Co bare	
Region	Flux (n cm^-2 s^-1)
thermal	9.0E+12 ± 1.4E+12
epi-thermal	2.8E+13 ± 6.8E+12
fast	1.0E+13 ± 1.1E+12
ICIT flux all reactions	
thermal	1.4E+13 ± 2.2E+12
epi-thermal	2.5E+13 ± 5.9E+12
fast	9.9E+12 ± 1.0E+12

4.3 CLICIT

4.3.1 MCNP Flux Distribution in the CLICIT

The thermal region of the neutron flux distribution in the CLICIT is suppressed significantly due to the cadmium lining in the facility. In the model, few thermal neutrons reached the tally cell, significantly increasing the error in that cell. As in the other facilities, the error in the fast region above 10 MeV was quite high (see Figure 4.3.1).

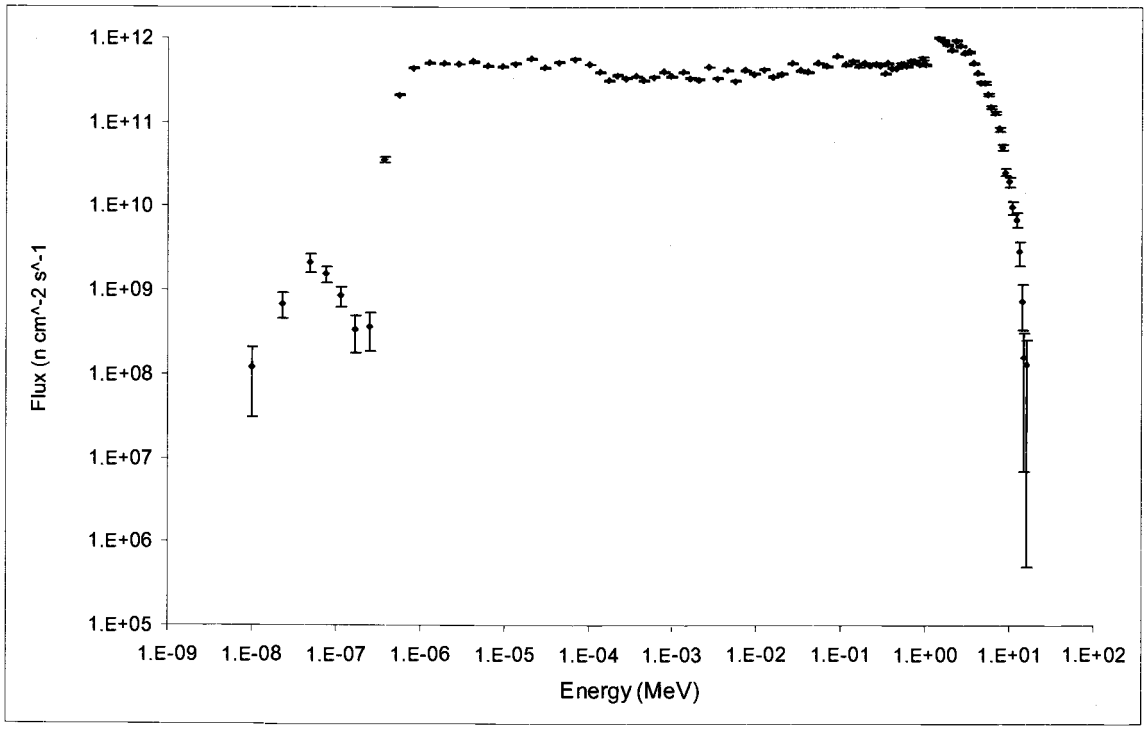

Figure 4.3.1 Modeled Flux Distribution in the CLICIT - Neutron flux distribution in the CLICIT determined from MCNP flux tallies at the position of highest flux.

The last 4 energy groups as well as the first 2 energy groups had error greater than 100%; therefore, these energy groups were truncated.

4.3.2 NAA Results in the CLICIT

Table 4.3.2 summarizes the activities determined from neutron activation and lists their absolute error based on counting error and error in detection efficiency. These activities were then averaged over the reactions to determine $\sigma\phi$.

Table 4.3.2 Summary of EOB activities in the CLICIT

Foil	Reactions	Energy (keV)	Saturation Activity (Bq)
Iron Bare	Fe-58(n,γ)Fe-59	1099.3	7.33E+01 ± 1.64E+00
		1291.6	7.53E+01 ± 1.74E+00
		192.4	7.12E+01 ± 4.68E+00
	Fe-54(n,p)Mn-54	834.8	1.59E+02 ± 3.27E+00
	Fe-54(n,α)Cr-51	320.1	1.76E+01 ± 2.08E+00
Co Bare	Co-59(n,γ)Co-60	1173.2	1.01E+04 ± 2.29E+02
		1332.5	1.05E+04 ± 2.39E+02
Cu Bare	Cu-63(n,γ)Cu-64	1345.8	3.83E+06 ± 1.34E+05
Al-Au Bare	Al-27(n,α)Na-24	1368.6	7.19E+03 ± 1.55E+02
		2754.0	8.09E+03 ± 1.85E+02
	Au-197(n,γ)Au-198	411.8	4.97E+04 ± 1.01E+03
Ti Bare	Ti-46(n,p)Sc-46	889.3	1.21E+02 ± 3.00E+00
		1120.5	1.28E+02 ± 3.20E+00
	Ti-47(n,p)Sc-47	159.4	5.29E+03 ± 1.08E+02
	Ti-48(n,p)Sc-48	983.5	1.35E+03 ± 2.78E+01
		1312.1	1.43E+03 ± 2.96E+01
		1037.5	1.37E+03 ± 2.84E+01
		175.4	1.61E+03 ± 3.46E+01
In Bare	In-115(n,n')In-115	336.2	6.15E+06 ± 2.14E+05
Ni Bare	Ni-58(n,p)Co-58	810.8	4.89E+03 ± 1.07E+02

4.3.3 Calculating $\sigma\phi$ for STAY'SL input in the CLICIT

The data from Table 4.3.2 was used to calculate the neutron reaction rate ($\sigma\phi$). Table 4.3.3 summarizes the reaction rates that were averaged from that saturation activity data and input into STAY'SL.

Table 4.3.3 Summary of $\sigma\phi$ values for the CLICIT

Reactions	sigma-phi (atoms/atoms/s)
Fe-58(n,g)Fe-59	1.87E-12 ± 3.74E-14
Fe-54(n,p)Mn-54	1.35E-12 ± 2.70E-14
Ni-58(n,p)Co-58	1.25E-12 ± 2.49E-14
Ti-46(n,p)Sc-46	1.35E-13 ± 2.37E-15
Ti-47(n,p)Sc-47	2.58E-13 ± 5.25E-15
Ti-48(n,p)Sc-48	3.78E-15 ± 3.97E-17
Fe-54(n,a)Cr-51	1.33E-14 ± 1.57E-15
Al-27(n,a)Na-24	9.23E-15 ± 1.85E-16
In-115(n,n')In-115m	2.20E-12 ± 6.61E-14
Cu-63(n,g)Cu-64	5.71E-12 ± 2.28E-13
Co-59(n,g)Co-60	6.47E-11 ± 1.29E-12
Au-197(n,g)Au-198	1.41E-09 ± 2.83E-11

4.3.4 STAY'SL Results in the CLICIT.

4.3.4.1 Normalization Factor (AK1) in the CLICIT

No Maxwellian correction was applied to the CLICIT data because there is no thermal adjustment in this facility. The fast reactions were run in STAY'SL to determine the spectral normalization factor. Figure 4.3.2 show the fit to the fast reactions only with AK1 = 0.986.

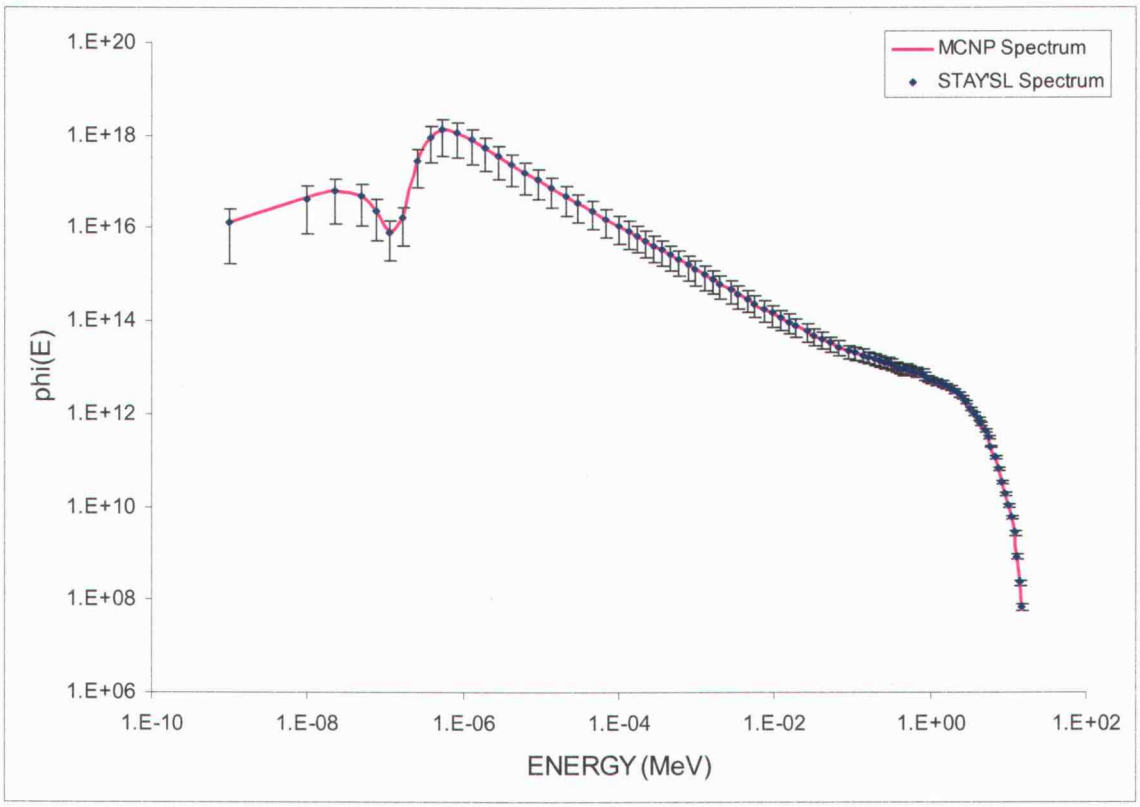

Figure 4.3.2 AK1 Determination in the CLICIT - Fast reactions were fit by STAY'SL to determine the normalization factor for use later. AK1 = 0.986, Chi2 = 1.1.

4.3.4.2 CLICIT STAY'SL Results

Examining the individual χ^2 values for the CLICIT reactions (Figure 4.3.3) reveal that Fe54(n,p) reaction had a significantly high χ^2 value, ($\chi^2 = 5.3$). The χ^2_R , however, was 1.1, which indicates that activation data adequately fits the input spectrum (see Figure 4.3.4). There does appear to be a depression in the epi-region, similar to the other facilities.

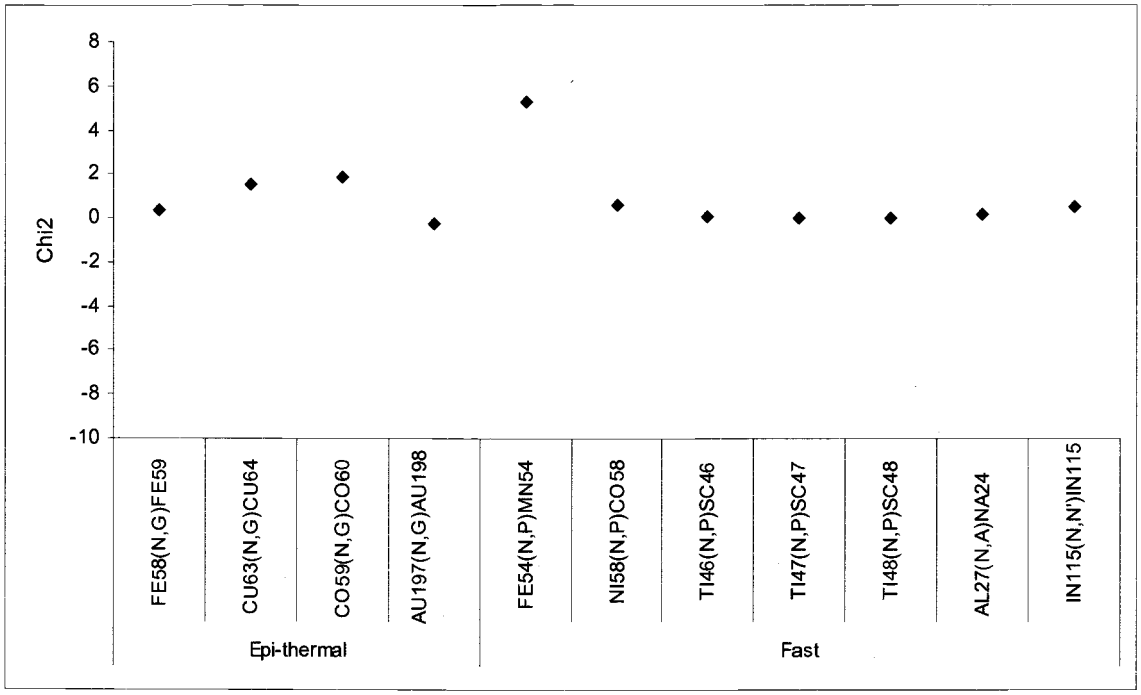

Figure 4.3.3 χ^2 Comparison for CLICIT - Individual χ^2 values for reactions in the OSTR CLICIT.

Table 4.3.4 lists the measured and calculated reaction rates in the CLICIT to show the degree at which the two reaction rates differed before the STAY'SL adjustment.

Table 4.3.4 Summary of the ratios between measured and calculated reaction rates in the CLICIT

	Reactions	Measured Reaction Rates (at/at/s)	Calculated Reaction Rates based on MCNP input	% Diff
Epi-thermal	FE58(N,G)FE59	1.87E+12	1.83E+12	-2.16
	CU63(N,G)CU64	5.71E+12	6.89E+12	20.58
	CO59(N,G)CO60	6.47E+13	8.50E+13	31.49
	AU197(N,G)AU198	1.41E+15	1.80E+15	27.56
Fast	FE54(N,P)MN54	1.35E+12	1.02E+12	-24.5
	NI58(N,P)CO58	1.25E+12	1.33E+12	6.8
	TI46(N,P)SC46	1.35E+11	1.40E+11	3.73
	TI47(N,P)SC47	2.58E+11	2.57E+11	-0.44
	TI48(N,P)SC48	3.78E+09	3.76E+09	-0.46
	AL27(N,A)NA24	9.23E+09	9.57E+09	3.63
	IN115(N,N')IN115	2.20E+12	2.46E+12	11.78

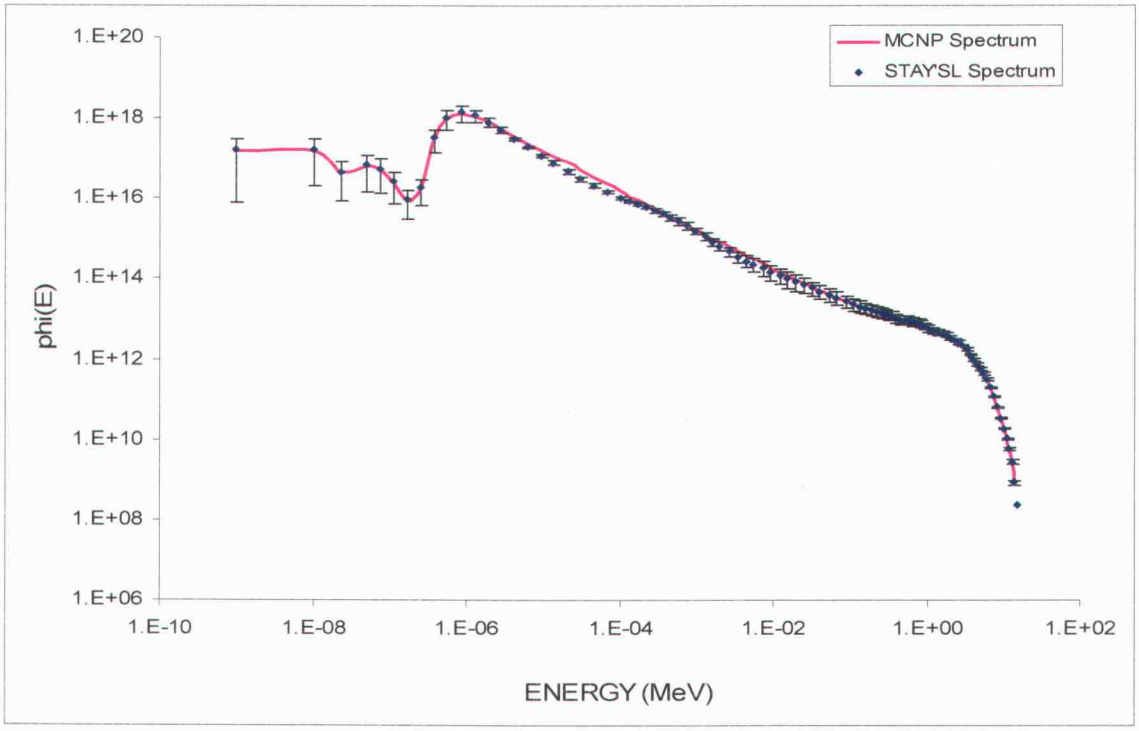

Figure 4.3.4 Energy Dependent Flux in the CLICIT. Chi2 = 1.1

4.3.4.3 Regional Flux Values in the CLICIT

The energy dependent spectrum was numerically integrated using the trapezoidal rule. The following table lists the regional flux values in the OSTR CLICIT for the thermal, epi-thermal, and fast regions. The group flux number for the thermal region is fairly meaningless since no thermal adjustment was done.

Table 4.3.5 Regional Flux Values for the CLICIT

CLICIT flux all reactions (n cm^-2 s^-1)	
thermal	3.1E+11 ± 1.5E+11
epi-thermal	2.2E+13 ± 5.5E+12
fast	8.8E+12 ± 9.8E+11

4.4 Rabbit

4.4.1 MCNP Flux Distribution in the Rabbit

Like the other facilities, the error in the flux within the Rabbit was greatest at the extremities (see Figure 4.4.1).

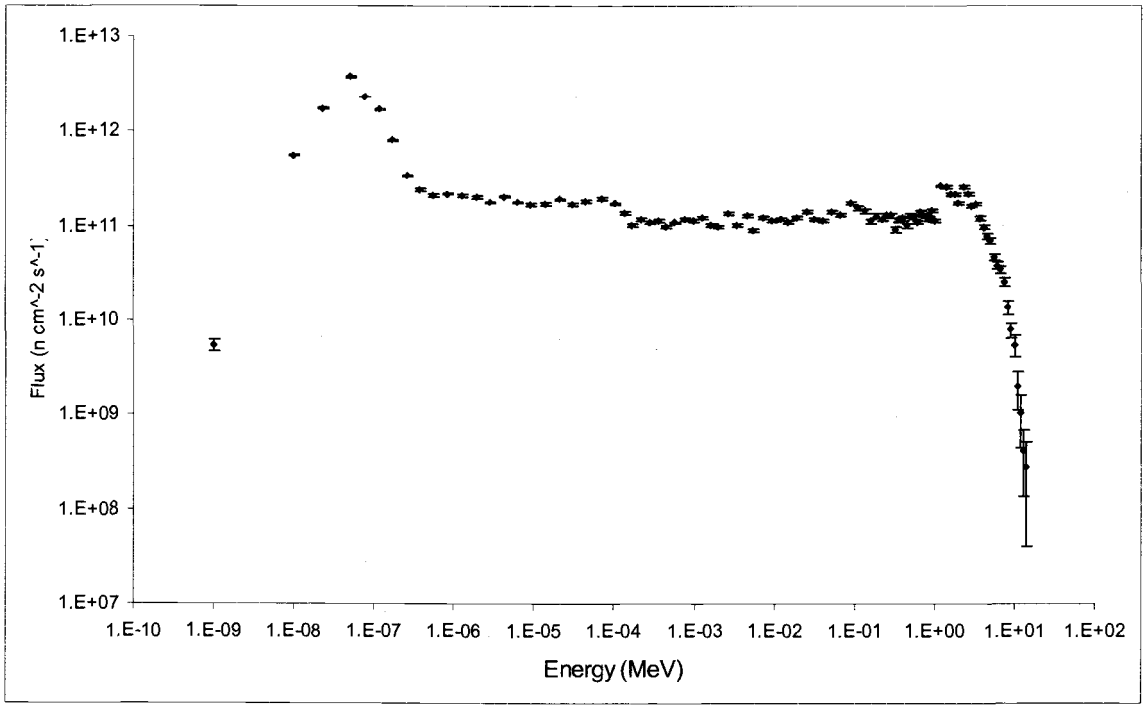

Figure 4.4.1 MCNP Modeled Flux Distribution in the Rabbit - Neutron flux distribution in the Rabbit determined from MCNP flux tallies at the position of highest flux.

The error in the last five energy groups and the first energy group had error greater than 100%; therefore, these groups were truncated.

4.4.2 NAA Results in the Rabbit

All of the irradiation times in the Rabbit were reduced to 30 seconds. This was done to minimize radiation exposure to personnel. Counting times increased as a result.

Table 4.4.2 summarizes the activities determined from neutron activation and lists their absolute error based on counting error and error in detection efficiency. These activities were then averaged over the reactions to determine $\sigma\phi$.

Table 4.4.2 Summary of EOB activities in the Rabbit

Foil	Reactions	Energy (keV)	Saturation Activity (Bq)
Covered Iron	Fe-58(n,γ)Fe-59	1099.3	9.86E+00 ± 2.69E-01
		1291.6	1.00E+01 ± 2.65E-01
		192.4	9.31E+00 ± 6.85E-01
	Fe-54(n,p)Mn-54	834.8	1.25E+01 ± 2.69E-01
	Fe-54(n,α)Cr-51	320.1	-
Bare Iron	Fe-58(n,γ)Fe-59	1099.3	2.72E+02 ± 5.92E+00
		1291.6	2.86E+02 ± 6.32E+00
		192.4	2.79E+02 ± 8.81E+00
	Fe-54(n,p)Mn-54	834.8	2.71E+01 ± 7.89E-01
	Fe-54(n,α)Cr-51	320.1	-
Co Covered	Co-59(n,γ)Co-60	1173.2	2.02E+03 ± 7.04E+01
		1332.5	2.08E+03 ± 7.26E+01
Co Bare	Co-59(n,γ)Co-60	1173.2	2.82E+04 ± 9.68E+02
		1332.5	2.89E+04 ± 9.93E+02
Cu Covered	Cu-63(n,γ)Cu-64	1345.8	6.21E+05 ± 2.16E+04
Cu Bare	Cu-63(n,γ)Cu-64	1345.8	1.68E+07 ± 6.03E+05
Al-Au Covered	Al-27(n,α)Na-24	1368.6	8.72E+02 ± 1.90E+01
		2754.0	1.01E+03 ± 2.32E+01
	Au-197(n,γ)Au-198	411.8	7.88E+03 ± 1.77E+02
Al-Au Bare	Al-27(n,α)Na-24	1368.6	9.17E+02 ± 1.99E+01
		2754.0	1.05E+03 ± 2.39E+01
	Au-197(n,γ)Au-198	411.8	2.21E+04 ± 4.82E+02
Ti Bare	Ti-46(n,p)Sc-46	889.3	1.34E+01 ± 3.32E-01
		1120.5	1.41E+01 ± 3.57E-01
	Ti-47(n,p)Sc-47	159.4	5.81E+02 ± 1.18E+01
	Ti-48(n,p)Sc-48	983.5	1.55E+02 ± 3.28E+00
		1312.1	1.61E+02 ± 3.41E+00
		1037.5	1.55E+02 ± 3.27E+00
		175.4	1.82E+02 ± 4.14E+00
In Bare	In-115(n,n')In-115	336.2	7.54E+05 ± 2.58E+04
Ni Bare	Ni-58(n,p)Co-58	810.8	5.67E+02 ± 1.29E+01

The number of counts observed from the Fe-54(n,α)Cr-51 reaction were insignificant due to a small branching ratio; therefore, this reaction was not included in STAY'SL.

4.4.3 Calculating $\sigma\phi$ for STAY'SL input in the Rabbit

The data from Table 4.4.2 was used to calculate the neutron reaction rate ($\sigma\phi$). The following table (Table 4.4.3) summarizes the reaction rates that were averaged from activity data and input into STAY'SL.

Table 4.4.3 Summary of $\sigma\phi$ values for the Rabbit

Reactions	sigma-phi (atoms/atoms/s)
Fe-58(n,g)Fe-59	1.42E-11 ± 2.09E-13
Fe-58(n,g)Fe-59+Cd	4.87E-13 ± 1.30E-14
Fe-54(n,p)Mn-54	2.14E-13 ± 4.62E-15
Ni-58(n,p)Co-58	2.86E-13 ± 6.50E-15
Ti-46(n,p)Sc-46	3.01E-14 ± 5.45E-16
Ti-47(n,p)Sc-47	5.63E-14 ± 1.15E-15
Ti-48(n,p)Sc-48	8.52E-16 ± 9.31E-18
Al-27(n,a)Na-24	2.40E-15 ± 3.82E-17
In-115(n,n')In-115m	5.56E-13 ± 1.90E-14
Cu-63(n,g)Cu-64	4.96E-11 ± 1.79E-12
Cu-63(n,g)Cu-64+Cd	1.86E-12 ± 6.46E-14
Co-59(n,g)Co-60	3.71E-10 ± 9.01E-12
Co-59(n,g)Co-60+Cd	2.55E-11 ± 6.26E-13
Au-197(n,g)Au-198	1.30E-09 ± 2.65E-11
Au-197(n,g)Au-198+Cd	4.70E-10 ± 9.55E-12

4.4.4 STAY'SL Results in the Rabbit

4.4.4.1 Maxwellian Fit to thermal region in the Rabbit

Table 4.4.4 lists the ratios of measured to calculated reaction rates in the Rabbit to show that the initial reaction rates in the Rabbit are in fairly good agreement even before the STAY'SL adjustment. Figure 4.4.2 visually illustrates this result.

All of the reactions were input into STAY'SL to determine if a Maxwellian correction should be made to fit the thermal energy groups. Initially, there appeared to be a slight depression in the epi-thermal range; however, the thermal energy range appears to be a reasonable fit (see Figure 4.4.2). Table 4.4.4 lists the measured and calculated reaction rates in the Rabbit to show the degree at which the two reaction rates differed before the STAY'SL adjustment.

Table 4.4.4 Summary of the ratios between measured and calculated reaction rates in the Rabbit

	Reactions	Measured Reaction Rates (at/at/s)	Calculated Reaction Rates based on MCNP input	% Diff
Thermal	FE58(N,G)FE59	1.42E+13	9.38E+12	-33.83
	CU63(N,G)CU64	4.96E+13	3.65E+13	-26.46
	CO59(N,G)CO60	3.71E+14	3.02E+14	-18.71
	AU197(N,G)AU198	1.30E+15	1.37E+15	5.49
Epi-thermal	FE58(N,G)FE59 CADM	4.87E+11	5.30E+11	8.93
	CU63(N,G)CU64 CADM	1.86E+12	1.95E+12	5.12
	CO59(N,G)CO60 CADM	2.55E+13	2.40E+13	-6.02
	AU197(N,G)AU198 CADM	4.70E+14	5.94E+14	26.33
Fast	FE54(N,P)MN54	2.14E+11	2.24E+11	4.59
	NI58(N,P)CO58	2.86E+11	2.92E+11	2.24
	TI46(N,P)SC46	3.01E+10	3.12E+10	3.78
	TI47(N,P)SC47	5.63E+10	5.66E+10	0.57
	TI48(N,P)SC48	8.52E+08	8.46E+08	-0.65
	AL27(N,A)NA24	2.40E+09	2.19E+09	-8.78
	IN115(N,N')IN115	5.56E+11	5.44E+11	-2.2

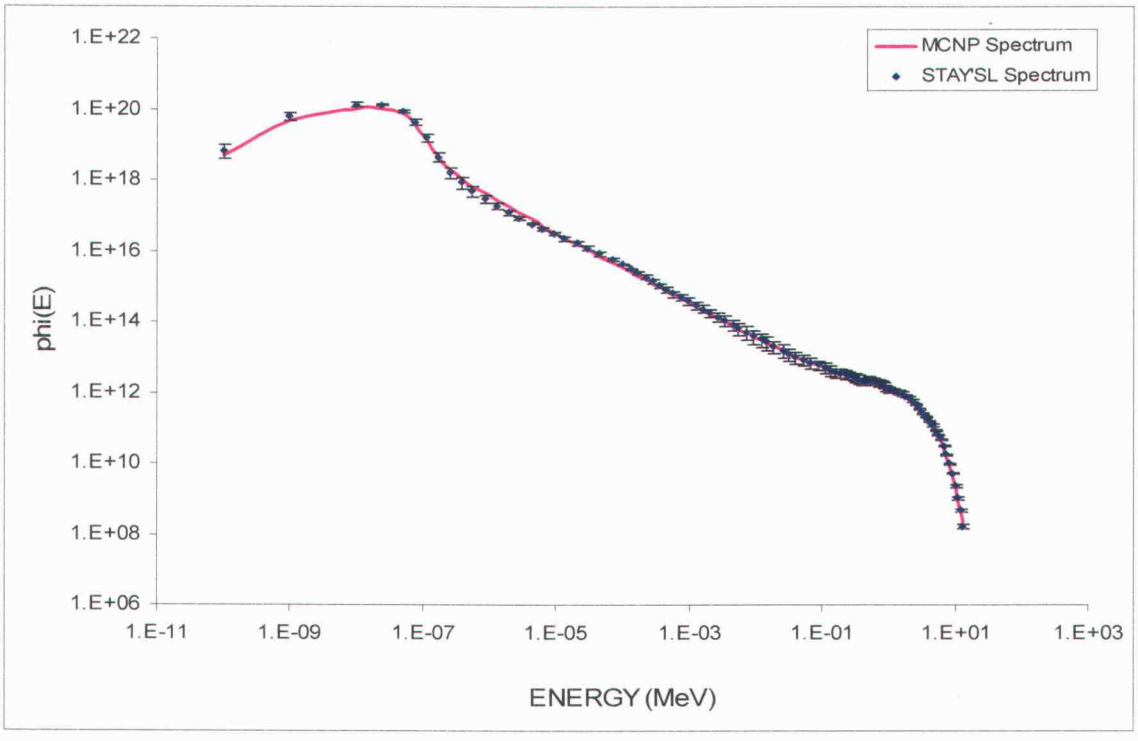

Figure 4.4.2 Energy Dependent Flux in the Rabbit without Maxwellian Correction. Chi2 = 1.779

A Maxwellian correction was applied to the Rabbit data to see if the correction improved χ_R^2. The Maxwellian correction did not improve the fit to the Rabbit spectra because χ_R^2 changed very little, which suggests that the MCNP model is quite good.

4.4.4.2 Normalization Factor (AK1) in the Rabbit

The fast reactions were run in STAY'SL to determine the spectral normalization factor. The AK1 value determined from STAY'SL was 0.871 (see Figure 4.4.3).

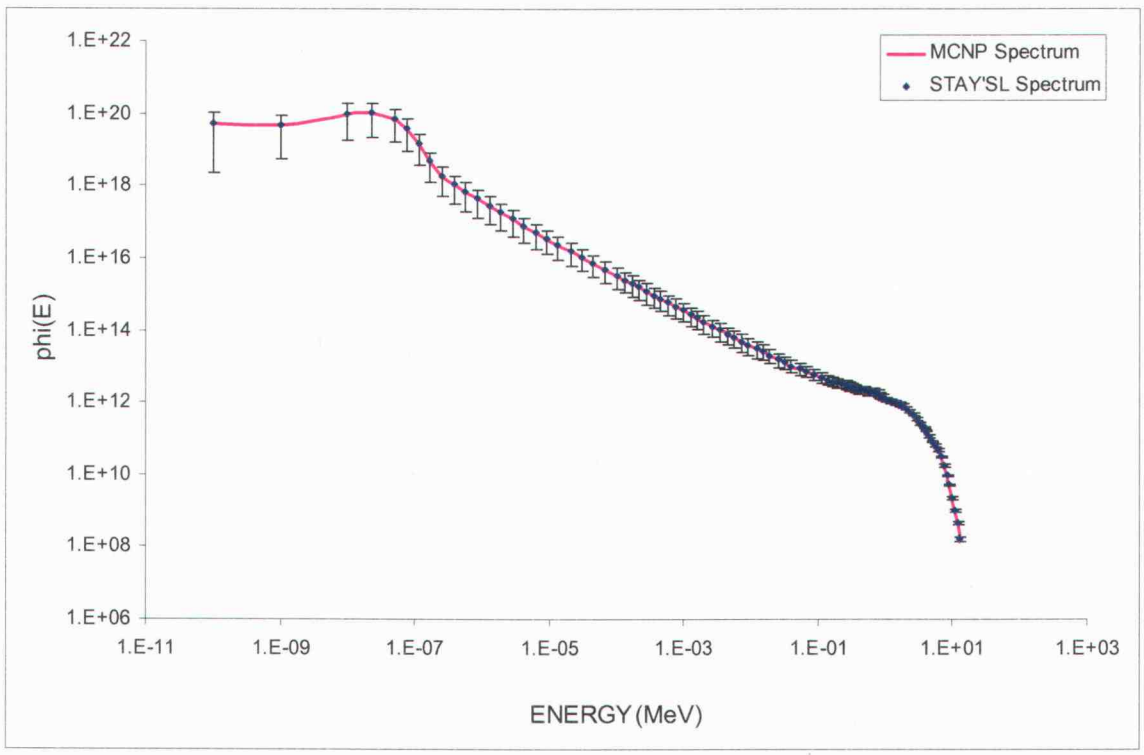

Figure 4.4.3 AK1 Determination in the Rabbit - Fast reactions were fit by STAY'SL to determine the normalization factor (AK1) for use later.

4.4.4.3 Rabbit STAY'SL Results

Examining the individual χ^2 values for the Rabbit reactions reveal that the covered Au197(n,γ) reaction and the Fe58(n,γ) bare reaction have significantly high χ^2 values compared to the rest of the reactions (see Figure 4.4.4). The χ_R^2 , however, was 1.8, which indicates that activation data is adequately predicted by the input spectrum (see Figure 4.4.4).

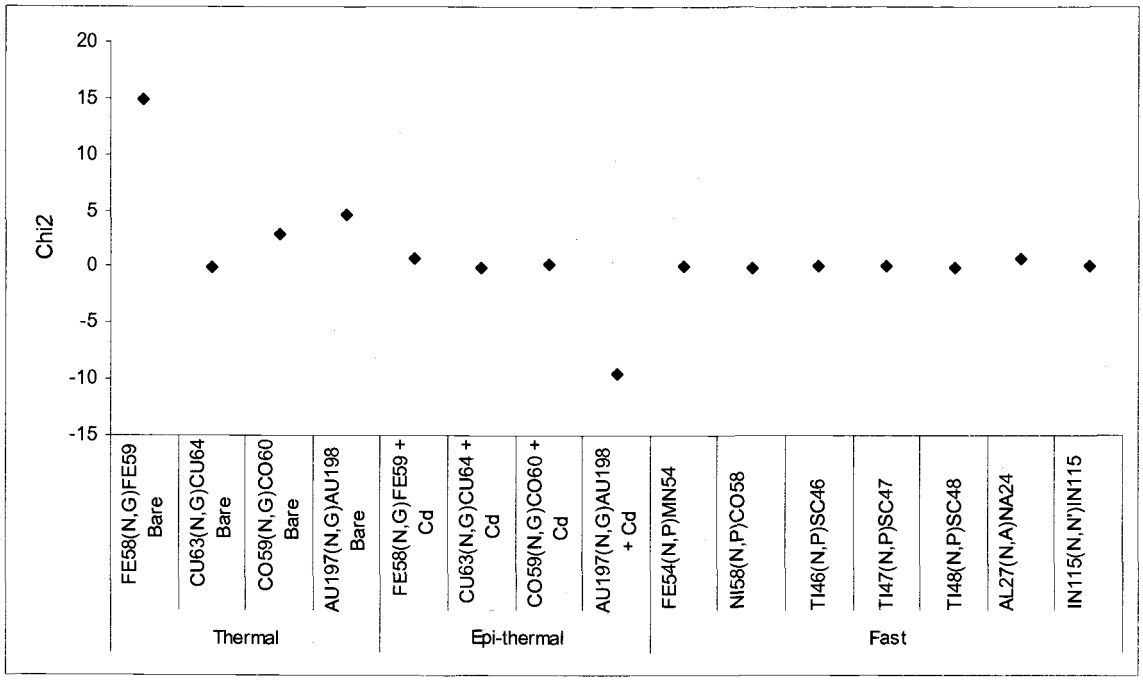

Figure 4.4.4 χ^2 Comparison for Rabbit - Individual χ^2 values for reactions in the OSTR Rabbit.

4.4.4.4 Regional Flux Values in the Rabbit

The energy dependent spectrum was numerically integrated using the trapezoidal rule. The following table lists the regional flux values in the OSTR Rabbit for the thermal, epi-thermal, and fast regions.

Table 4.4.5: Regional Flux Values for the Rabbit

RABBIT flux all reactions	
thermal	9.6E+12 ± 1.4E+12
epi-thermal	6.4E+12 ± 1.5E+12
fast	1.9E+12 ± 2.0E+11

4.5 Thermal Column

4.5.1 MCNP Flux Determination in the Thermal Column

Because of the significant amount of graphite between the core and the sample location, the parameters used in the *kcode* input card, and a lack of variance reduction techniques employed, the number of neutrons reaching the sample location was insufficient to determine the spectrum adequately. The error in this model was essentially infinite in the tally

bins of energy above 2.55E-07 MeV. Most energy bins above this energy saw only one neutron. (see Figure 4.5.1)

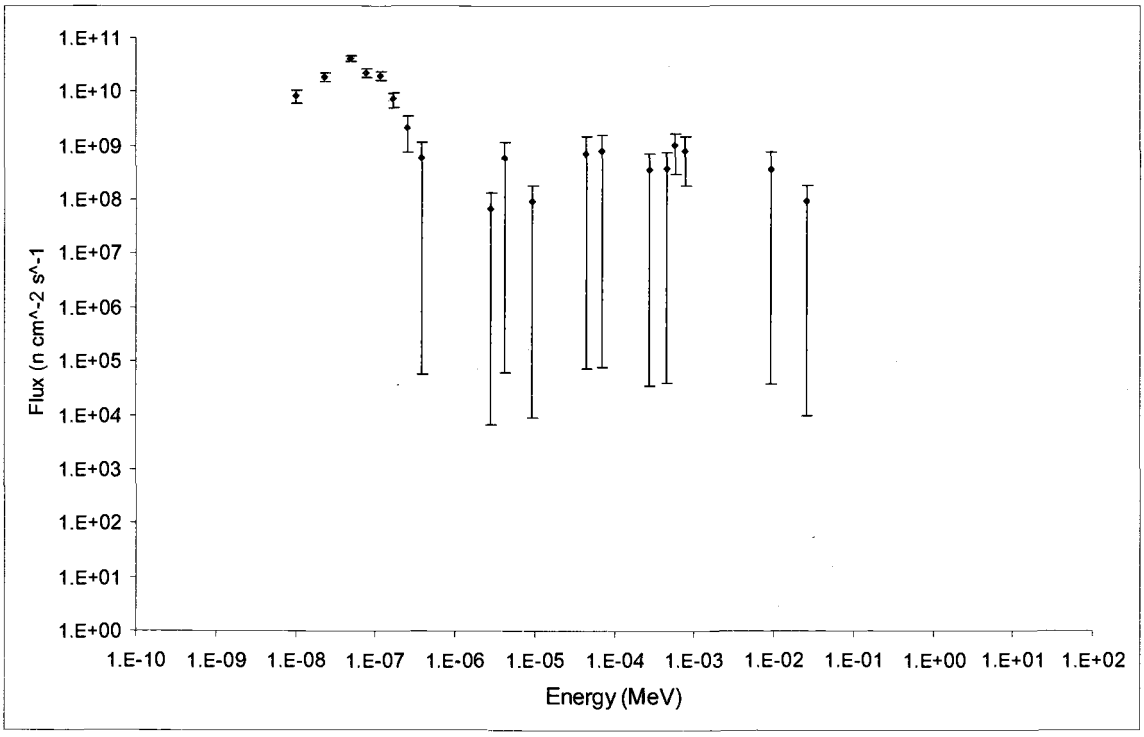

Figure 4.5.1 Modeled Flux Distribution in the Thermal Column - Neutron flux distribution in the thermal column determined from MCNP flux tallies at the face.

Since there were no neutrons tallied throughout most of the flux distribution, adjusting it was inappropriate.

4.5.2 NAA Results in the Thermal Column

Because the flux in the thermal column was lower than the other facilities, irradiation times had to be increased to 1 hour to ensure enough activity for counting. There is significant error associated with irradiating samples in the thermal column because the reactor has to be shutdown to load samples, brought up to power (takes 5 to 10 min), and then shutdown again to remove the samples. The sample is continually exposed during these transitional periods, adding to the incident flux seen by the activation foils. Longer irradiation times in the thermal column decrease the relative importance of the error introduced by the transitional periods.

Table 4.5.2 summarizes the activities determined from neutron activation and lists their absolute error based on counting error and error in detection efficiency.

Table 4.5.2 Summary of EOB activities in the Thermal Column.

Foil	Reactions	Energy (keV)	Saturation Activity (Bq)
Al-Au Covered	Au-197(n,γ)Au-198	411.8	6.96E+02 ± 1.56E+01
Al-Au Bare	Au-197(n,γ)Au-198	411.8	1.16E+04 ± 2.42E+02

4.5.3 Calculating $\sigma\phi$ for STAY'SL input in the Thermal Column

The data from Table 4.5.2 were used to calculate the neutron reaction rate ($\sigma\phi$). The following table (Table 4.5.3) summarizes these reaction rates. This data was not used in STAY'SL, however, due to the uncertainty in the modeled group fluxes. The $\sigma\phi$ values were simply used to determine gross regional flux values for the thermal and epi-thermal energy regions.

Table 4.5.3 Summary of $\sigma\phi$ values compute from the activity of the Au foils at the end of bombardment

Reactions	sigma-phi (atoms/atoms/s)
Au-197(n,g)Au-198	5.86E-12 ± 1.22E-13
Au-197(n,g)Au-198+Cd	3.48E-13 ± 7.80E-15

4.5.4 Regional Flux Values in the Thermal Column

Regional flux values for the thermal and epi-thermal neutrons can be estimated by dividing $\sigma\phi$ by the corresponding thermal and epi-thermal cross sections. The thermal flux value was determined to be 6.7E+10 ± 1.4E+09 n cm^{-2} s^{-1}. The epi-thermal flux component in the thermal column was determined to be 2.2E+08 ± 5.0E+06 n cm^{-2} s^{-1}.

5. DISCUSSION

The results obtained from STAY'SL are slightly subjective because the spectra produced are only as good as the uncertainties considered for the input spectra and activation data. Determining the correct amount of error associated with these quantities is difficult. For example, the uncertainty associated with the input spectra determined by MCNP was input into STAY'SL in four broad energy groups: one for extremely low energies (< 1E-10 MeV), one for thermal energies (< 10 keV), one for epi-thermal energies (< 1.5 MeV), and one for fast energies (< 20 MeV). How does one consider the error in these regions? One could simply enter the statistical error from the MCNP tally cells. However, this does not seem sufficient due to other errors in the model that may exist, such as incorrect material representation, error in geometry, cross sectional data discrepancies, etc. The uncertainty chosen for this work considered error in the MCNP model to be 100% for neutron energies less than 1E-10 MeV, 50 % for neutron energies less than 10 keV, 20% for neutron energies less than 1.5 MeV, and 20% for neutron energies less than 20 MeV. These values essentially say that MCNP models fast neutrons better than thermal. Other choices for uncertainty levels can significantly change the spectra; therefore, the user must be cautious in predicting these values.

Uncertainty in the activation data was determined by considering counting error and error in the detection efficiency. One must consider if there is other error that should be associated with the activation data.

Another important item should be mentioned. Figures, 4.1.5, 4.2.5, 4.3.3, and 4.4.5 show individual comparisons of the χ^2 values for each reaction. Notice that in each of these figures, there are reactions that have negative χ^2 values. In a linear least-squares calculation, this would be incorrect. STAY'SL, however, is performing a generalized least-squares-fit, where all of the parameters get adjusted according to the variance-covariance matrix (see Equation 1.10). STAY'SL only displays the least-squares adjustment to the flux spectrum; however, it is actually adjusting everything including the cross sections and activity measurements while taking into account the covariance. The negative values appear to be cases where the flux spectrum starts out being higher than the measured activity before

adjustment and lower after the adjustment (or vice versa). This would result in a negative covariance and subsequently a negative χ^2. (Larsen 1986)

The relative errors at the extremities of each MCNP flux distributions are expected due to the low number of neutrons at those energies. Low energy neutrons (1E-10 MeV) have great difficulty getting to the flux tally volumes set up in MCNP due to attenuation through material. High energy neutrons have difficulty interacting in such a small tally cell; therefore, fewer neutrons interact in the tally volume.

6. CONCLUSION

The objective of this project was to show that the neutron energy spectra in various irradiation facilities within the OSTR can be characterized using STAY'SL and MCNP. MCNP was used to model the OSTR and produce a spectrum in each facility. The reaction rate data from NAA and cross-sectional data from LANL were used to adjust the modeled flux data. The energy dependent flux from STAY'SL was numerically integrated over specific regions to obtain total neutron flux values for the thermal, epi-thermal, and fast regions of the neutron spectra.

Future work could include redoing the measurements done in this project using a different neutron transport code (possibly ATTILLA). The neutron activation data should be verified with new foils to determine why some reactions did not agree with the rest. The MCNP model of the thermal column can be improved by increasing the number of neutrons tracked and by applying variance reduction techniques to improve the error in the flux tallies. More time should be taken to consider the uncertainties input into STAY'SL.

BIBLIOGRAPHY

Anderson, T. V., *Oregon State TRIGA ® Reactor Training Manual*, Volume 1, 3rd Edition, (1990)

Bersillion, O. et al., *Neutron Self-Shielding, Cover Reactions, and Burnup Corrections for Reactor Dosimetry Applications*, IAEA IDRF-2002 Appendix II (2002)

Briesmeister, J. F., (Ed), 1997. MCNP – A General Monte Carlo N-Particle Transport Code (Version 4C), RSIC# CCC-700, Oak Ridge National Laboratory.

Carter, A. H., *Classical and Statistical Thermodynamics*, Prentice-Hill Inc., NJ, (2001)

Cember, H., *Introduction to Health Physics*, 3rd Edition, McGraw-Hill Pub., New York, (1996)

Duderstadt, J. J., Hamilton, L. J., *Nuclear Reactor Analysis*, John Wiley & Sons, Inc. (1976).

E 721 *Standard Guide for Determining Neutron Energy Spectra from Neutron Sensors for Radiation Hardness Testing of Electronics*[1].

E 722 *Standard Practice for Characterizing Neutron Energy Fluence Spectra in Terms of an Equivalent Monoenergetic Neutron Fluence for Radiation Hardness Testing of Electronics*[1].

GammaVision® V2.4, Gamma-Ray Spectrum Analysis and MCA Emulation. A66-BI Software User's Manual. (1996) 102 – 104.

Greenwood, L. R., J. Nucl. Mater. 216 (1994) pp. 29-44.

Knoll, G. F., *Radiation Detection and Measurement*, 3rd Edition, John Wiley & Sons, Inc. New York. (2000).

Larsen, R. J., Marx, M. L., *An Introduction to Mathematical Statistics and Its Applications*, 2nd Edition, Prentice-Hill Inc., NJ, (1986).

Martin, B. R., *Statistics for Physicists*, Academic Press, New York (1971)

Perey, F.G., *Least squares dosimetry unfolding*: the program STAY'SL. ORNL/TM-6062 (1977); modified by Greenwood, L. R., ANL (1979)

Simnad, M. T. et al., Nuclear Technology. 28 (1976) 31 - 56.

Tipler, P. A., Llewellyn, R. A., *Modern Physics*, 3rd Edition, W. H. Freeman and Company, New York, (2000).

Tiyapun, K., *Epithermal Neutron Beam Design at te Oregon State University TRIGA Mark-II Reactor (OSTR) Based on Monte Carlo Methods*, (1997).

Weber, H. W. et al., J. Nucl. Mater. 137 (1986) 236 - 240

APPENDICIES

APPENDIX A: MCNP INPUT DECKS

CLICIT CORE

```
1 OSU TRIGA Reactor flux in clicit, lazy susan, rabbit, and thermal column
c void
13000   0 1 $ void outside reactor
13001   0 -1 601 $ void above reactor
13002   0 -1 -606 $ void below reactor
13003   0 -1 -1000 -858 606 -601 $ void outside bp4
13005   0 877 -617 890 -601 606 886 -1 $ right side outside reactor
13006   0 -877 882 -601 871 890 -617 886 $ above thermalizing column
13007   0 -877 882 -876 606 890 -617 886 $ below thermalizing column
13008   0 -882 -617 890 -601 606 886 1041 902 $ left side outside reactor
13010   0 -1 -886 902 -601 606 $ left of thermalizing column
13012   0 -612 617 890 1042 -601 606 -848 -618 $ left side outside reactor
13013   0 607 617 -618 890 -601 606 -1 $ right side outside reactor
13014   0 -612 848 1044 -858 617 -618 -601 606 1000 $ outside reactor bp3
13015   0 -902 1043 1000 -617 -601 606 -1 $ outside reactor bp4
13016   0 618 612 -607 -601 606 -1 $ outside TC
13017   0 618 607 -601 606 -1 $ outside TC
13018   0 618 -612 1044 -858 617 -601 606 -1 $ around bp3
c 13011   0 -1 -5020 858 -601 606 $  air south of slab
c 13100   0 -1 5019 858 -601 606 -612 $ air north of slab
20004   0 701 -889 617 -615 -601 606 $ 1st quadrant
20006   0 701 -889 -617 877 -601 606 $ 2nd quadrant
1052    0 -800 -903 904 $ steel plate bp4
1053    0 -800 -904 905 $ steel pipe bp4
1054    0 -800 -905 906 $ steel pipe bp4
1055    0 -800 -906 907 $ steel pipe bp4
1056    0 -800 -907 908 $ steel pipe bp4
1057    0 -800 -908 909 $ steel pipe bp4
2051    0 800 -801  -902 903 $ steel cladding bp4
2053    0 800 -801  -904 905 $ steel cladding bp4
2054    0 800 -801  -905 906 $ steel cladding bp4
2055    0 800 -801  -906 907 $ steel cladding bp4
2056    0 800 -801  -907 908 $ steel cladding bp4
2057    0 800 -801  -908 909 $ steel cladding bp4
14003   0 801 -1043 -904 905 -617 $ concrete around steel clad bp4
14004   0 801 -1043 -905 906 -617 $ concrete around steel clad bp4
14005   0 801 -1043 -906 907 -617 $ concrete around steel clad bp4
14006   0 801 -1043 -907 908 -617 $ concrete around steel clad bp4
14007   0 801 -1043 -908 909 -617 $ concrete around steel clad bp4
1058    0 -800 -909 1000 $ end of steel pipe bp4
2058    0 800 -801  -909 1000 $ end of steel cladding bp4
14008   0 801 -1043 -909 1000 -617 $ end of concrete around clad bp4
c 50008   0 -5007 -1 5003 5002 -601 606 $ volume behind slab
c 50009   0 -5004 5008 5002 -1 -601 606 $ volume behind slab
c 50003   0 5006 -1 -5003 5004 -601 606 $ back air
c 50026   0 5015 -1 5007 -5019 -601 606 $ north (back) side air
c 50029   0 5015 -1 5020 -5008 -601 606 $ south (back) side air
50030   0 858 -1 606 -601 -612 $ outside bp3
c 16013   0 619 -618 -609 610 -603 604 $ graphite thermal column
c Al cladding
15000   1 -2.7 -5 4 2 -3 #15003 vol=7302.0827 $ core vessel
```

```
15001   1 -2.7 -7 9 13 -701 -615 877 $ right side of reactor
15004   1 -2.7 -7 9 13 -701 -877 882 -617 $ in front of thermalizing column
15005   1 -2.7 -7 9 13 -701 -882 -613 #(-835 13 -701) #(-838 13 -701) $ between TC and Th column
15006   1 -2.7 -7 9 13 -701 613 615 617 $ in front of TC
15002   1 -2.7 -601 606 -890 889 #(-607 612 -601 606 889 -890 617)
        #(-877 882 -871 876 889 -890 -617) #(889 -890 -835 -617)
        #(889 -890 -838 617) $ around reactor tank
15003   1 -2.7 -617 2 -3 -835 vol=142.20728 $ disk at core vessel in front of bp4
c thermal column
16000   6 -1.0 701 -702 615 613 -601 606 617 $ water gap
16001   1 -2.7 702 -703 615 613 -601 606 617 vol=31514.3997 $ front Al cladding
16002   1 -2.7 615 -616 703 -607 -601 606 617 vol=3843.197 $ right angle
16003   1 -2.7 613 -614 703 612 -601 606 617 vol=3843.197 $ left angle
16004   1 -2.7 616 -618 -607 608 -601 606 $ right
16005   1 -2.7 614 -618 -611 612 -601 606 $ left
16006   1 -2.7 703 616 614 -608 611 -618 -601 602 $ top
16007   1 -2.7 703 616 614 -608 611 -618 -605 606 $ bottom
16008   10 -2.48 703 616 614 -609 610 -618 -602 603 $b4c top
16009   10 -2.48 703 616 614 -609 610 -618 -604 605 $ b4c bottom
16010   10 -2.48 616 -618 -608 609 -602 605 $ b4c right
16011   10 -2.48 614 -618 -610 611 -602 605 $ b4c left
16012   4 0.085205 703 616 614 -609 610 -619 -603 604 $ graphite
16013   4 0.085205 619 -620 -609 610 -603 604 $ graphite thermal column
16014   4 0.085205 620 -618 -609 610 624 -603 $ TC
16015   4 0.085205 620 -618 -623 604 -609 610 $ TC
16016   4 0.085205 620 -618 -622 610 -624 623 $ TC
16017   4 0.085205 620 -618 623 -624 -609 621 $ TC
c 16018   19 -1.029e-3 620 -625 623 -624 -621 622 $ TC void where sample is placed
16019   19 -1.029e-3 620 -618 -621 622 -624 648 $ TC void top section
16020   19 -1.029e-3 620 -618 -621 622 623 -649 $ TC void bottom section
16021   19 -1.029e-3 620 -625 -646 647 -648 649 $ First sample position from back of TC void
16022   19 -1.029e-3 625 -626 -646 647 -648 649 $ Second sample position from back of TC void
16023   19 -1.029e-3 626 -627 -646 647 -648 649 $ Third sample position from back of TC void
16024   19 -1.029e-3 627 -628 -646 647 -648 649 $ Fourth sample position from back of TC void
16025   19 -1.029e-3 628 -629 -646 647 -648 649 $ Fifth sample position from back of TC void
16026   19 -1.029e-3 629 -630 -646 647 -648 649 $ Sixth sample position from back of TC void
16027   19 -1.029e-3 630 -631 -646 647 -648 649 $ Seventh sample position from back of TC void
16028   19 -1.029e-3 631 -632 -646 647 -648 649 $ Eighth sample position from back of TC void
16029   19 -1.029e-3 632 -633 -646 647 -648 649 $ Ninth sample position from back of TC void
16030   19 -1.029e-3 633 -634 -646 647 -648 649 $ Tenth sample position from back of TC void
16031   19 -1.029e-3 634 -635 -646 647 -648 649 $ 11th sample position from back of TC void
16032   19 -1.029e-3 635 -636 -646 647 -648 649 $ 12th sample position from back of TC void
16033   19 -1.029e-3 636 -637 -646 647 -648 649 $ 13th sample position from back of TC void
16034   19 -1.029e-3 637 -638 -646 647 -648 649 $ 14th sample position from back of TC void
16035   19 -1.029e-3 638 -639 -646 647 -648 649 $ 15th sample position from back of TC void
16036   19 -1.029e-3 639 -640 -646 647 -648 649 $ 16th sample position from back of TC void
16037   19 -1.029e-3 640 -641 -646 647 -648 649 $ 17th sample position from back of TC void
16038   19 -1.029e-3 641 -642 -646 647 -648 649 $ 18th sample position from back of TC void
16039   19 -1.029e-3 642 -643 -646 647 -648 649 $ 19th sample position from back of TC void
16040   19 -1.029e-3 643 -644 -646 647 -648 649 $ 20th sample position from back of TC void
16041   19 -1.029e-3 644 -618 -646 647 -648 649 $ rest of void from back of TC void
16042   19 -1.029e-3 620 -618 646 -621 -648 649 $ void not part of sample
16043   19 -1.029e-3 620 -618 -647 650 -648 649 $ void not part od sample
16044   19 -1.029e-3 620 -625 -650 622 -648 649 $ First sample position from back of TC void wall
16045   19 -1.029e-3 625 -626 -650 622 -648 649 $ Second sample position from back of TC void wall
16046   19 -1.029e-3 626 -627 -650 622 -648 649 $ Third sample position from back of TC void wall
```

```
16047   19 -1.029e-3 627 -628 -650 622 -648 649 $ Fourth sample position from back of TC void wall
16048   19 -1.029e-3 628 -629 -650 622 -648 649 $ Fifth sample position from back of TC void wall
16049   19 -1.029e-3 629 -630 -650 622 -648 649 $ Sixth sample position from back of TC void wall
16050   19 -1.029e-3 630 -631 -650 622 -648 649 $ Seventh sample position from back of TC void wall
16051   19 -1.029e-3 631 -632 -650 622 -648 649 $ Eighth sample position from back of TC void wall
16052   19 -1.029e-3 632 -633 -650 622 -648 649 $ Ninth sample position from back of TC void wall
16053   19 -1.029e-3 633 -634 -650 622 -648 649 $ Tenth sample position from back of TC void wall
16054   19 -1.029e-3 634 -635 -650 622 -648 649 $ 11th sample position from back of TC void wall
16055   19 -1.029e-3 635 -636 -650 622 -648 649 $ 12th sample position from back of TC void wall
16056   19 -1.029e-3 636 -637 -650 622 -648 649 $ 13th sample position from back of TC void wall
16057   19 -1.029e-3 637 -638 -650 622 -648 649 $ 14th sample position from back of TC void wall
16058   19 -1.029e-3 638 -639 -650 622 -648 649 $ 15th sample position from back of TC void wall
16059   19 -1.029e-3 639 -640 -650 622 -648 649 $ 16th sample position from back of TC void wall
16060   19 -1.029e-3 640 -641 -650 622 -648 649 $ 17th sample position from back of TC void wall
16061   19 -1.029e-3 641 -642 -650 622 -648 649 $ 18th sample position from back of TC void wall
16062   19 -1.029e-3 642 -643 -650 622 -648 649 $ 19th sample position from back of TC void wall
16063   19 -1.029e-3 643 -644 -650 622 -648 649 $ 20th sample position from back of TC void wall
16064   19 -1.029e-3 644 -618 -650 622 -648 649 $ rest of void from back of TC void wall
17000   6 -1.0 701 -702 -877 882 -601 606 -617 vol=20828.981 $ water gap
17001   1 -2.7 702 -703 -877 882 -871 876 -617 vol=9943.8022 $ front Al
17002   1 -2.7 703 -877 878 -871 876 886 -617 vol=4229.17498 $ right Al
17003   1 -2.7 703 -881 882 -871 876 886 -617 vol=4229.17498 $ left Al
17004   1 -2.7 703 886 -617 -871 872 -878 881 vol=4367.551 $ top Al
17005   1 -2.7 703 886 -617 -875 876 -878 881 vol=4367.551 $ bottom Al
17006   10 -2.48 703 886 -617 -878 879 -872 875 vol=1059.7933 $ b4c right
17007   10 -2.48 703 886 -617 -880 881 -872 875 vol=1059.7933 $ b4c left
17008   10 -2.48 703 886 -617 -879 880 -872 873 vol=1062.5544 $ b4c top
17009   10 -2.48 703 886 -617 -879 880 -874 875 vol=1062.5544 $ b4c bottom
17010   4 0.085205 703 883 -873 874 -879 880 -617 vol=61012.553 $ graphite
17011   5 -11.4 -883 884 -873 874 -879 880 $ lead
17012   19 -1.029e-3 -884 885 -873 874 -879 880 $ air
17013   4 0.085205 -885 886 -873 874 -879 880 $ graphite
c core internals
18000   1 -2.7 -5 6 -2 vol=3597.67 $ top grid
18001   1 -2.7 -8 4 -2 vol=4268.05 $ bottom grid
18002   2 0.0958666 -6 7 -2 vol=6681.39 $ top end fittings
18003   2 0.0958666 -9 8 -2 vol=14368.3 $ bottom end fittings
c reflector region
19000   1 -2.7 -7 11 3 -10 1001 1002 1003 1004 1005 1006
        1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017
        1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028
        1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040
        vol=41415.67284 $ around lazy susan
19001   4 0.085205 -7 11 10 -12 vol=118198.5445 $ graphite around lazy susan
19002   4 0.085205 -11 9 3 -12 #(-833 -835 -13) #(834 -838 -13) $ graphite
19003   4 0.085205 12 -13 -7 9 613 615 617 $ graphite in TC lead
19004   4 0.085205 12 -13 -7 9 -877 882 -617 $ graphite in Th. colum
19005   5 -11.4 12 -13 -615 617 -7 9 $ lead 1st quadrant
19006   5 -11.4 12 -13 877 -617 -7 9 $ lead 2nd quadrant
19007   5 -11.4 12 -13 -882 -617 -7 9 #(-835 12 -13 -868)
        #(-838 12 -13 -868) $ lead 3rd quadrant
19008   5 -11.4 12 -13 -613 617 -7 9 #(-838 12 -13 -868) $ lead 4th quadrant
c water region
20000   6 -1.0 -3 -601 5 $ above core
20001   6 -1.0 -3 606 -4 $ below core
20002   6 -1.0 -701 3 -601 7 $ above reflector
```

```
20003   6 -1.0 -701 3 606 -9 $ below reflector
20005   6 -1.0 -889 615 607 -601 606 $ corner 1st quadrant
20007   6 -1.0 701 -889 -617 -882 -601 606 835 838 $ 3rd quadrant
20008   6 -1.0 701 -889 617 -613 -601 606 838 $ 4th quadrant
20009   6 -1.0 -889 613 -612 -601 606 $ corner 4th quadrant
20010   6 -1.0 702 -889 -877 882 -601 871 -617 $ above thermalizing column
20011   6 -1.0 702 -889 -877 882 606 -876 -617 $ below thermalizing column
c inside core rods and moderator
17      6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner core
        79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
        -18 17 -19 -617
18      6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner top reflector region
        79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133 -7
        18 -19 -617
19      6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner bottom reflector region
        79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
        -17 9 -19 -617
20      6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer core 1
        127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
        175 178 181 184 187 190 193 196 199 202 205 -18 17 19 -20 -617
21      6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer top reflector 1
        127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
        175 178 181 184 187 190 193 196 199 202 205 -7 18 19 -20 -617
22      6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124  $ bottom reflector region 1
        127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
        175 178 181 184 187 190 193 196 199 202 205 -17 9 19 -20 -617
23      6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer core 2
        178 181 184 187 190 193 196 199 202 205 -18 17 20 -21 -617
24      6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer top reflector 2
        178 181 184 187 190 193 196 199 202 205 -7 18 20 -21 -617
25      6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ bottom reflector region 2
        178 181 184 187 190 193 196 199 202 205 -17 9 20 -21 -617
26      6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer core 3
        181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
        230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
        274 277 278 281 293 296 -18 17 21 -22 -617
27      6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer top reflector 3
        181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
        230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
        274 277 278 281 293 296 -7 18 21 -22 -617
28      6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ bottom reflector region 3
        181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
        230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
        274 277 278 281 293 296 -17 9 21 -22 -617
29      6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer core 4
        246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
        298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
        324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
        349 351 353 355 -18 17 22 -23 -617
30      6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer top reflector 4
        246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
        298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
        324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
        349 351 353 355 -7 18 22 -23 -617
31      6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ bottom reflector region 4
        246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
```

```
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -17 9 22 -23 -617
32     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319 $ outer core 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 23 -24 -617
33     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 23 -24 -617
34     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 23 -24 -617
35     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer core 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 24 -2 -617
36     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 24 -2 -617
37     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 24 -2 -617
11017  6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner core
      79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
      -18 17 -19 617
11018  6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner top reflector region
      79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133 -7
      18 -19 617
11019  6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner bottom reflector region
      79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
      -17 9 -19 617
11020  6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer core 1
      127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
      175 178 181 184 187 190 193 196 199 202 205 -18 17 19 -20 617
11021  6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer top reflector 1
      127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
      175 178 181 184 187 190 193 196 199 202 205 -7 18 19 -20 617
11022  6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124  $ bottom reflector region 1
      127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
      175 178 181 184 187 190 193 196 199 202 205 -17 9 19 -20 617
11023  6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer core 2
      178 181 184 187 190 193 196 199 202 205 -18 17 20 -21 617
11024  6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer top reflector 2
      178 181 184 187 190 193 196 199 202 205 -7 18 20 -21 617
11025  6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ bottom reflector region 2
      178 181 184 187 190 193 196 199 202 205 -17 9 20 -21 617
11026  6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer core 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
      274 277 278 281 293 296 -18 17 21 -22 617
11027  6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer top reflector 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
      274 277 278 281 293 296 -7 18 21 -22 617
11028  6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ bottom reflector region 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
```

```
      274 277 278 281 293 296 -17 9 21 -22 617
11029   6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer core 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -18 17 22 -23 617
11030   6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer top reflector 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -7 18 22 -23 617
11031   6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ bottom reflector region 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -17 9 22 -23 617
11032   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319 $ outer core 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 23 -24 617
11033   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 23 -24 617
11034   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 23 -24 617
11035   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer core 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 24 -2 617
11036   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 24 -2 617
11037   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 24 -2 617
38      1 -2.7 -7 9 -25  vol=580.666  $ aluminium central thimble -#a1
39      7 0.085755 -7 9 25 -26  vol=32.8228  $ cladding central thimble -#a1
c 40      20 -8.642 -7 9 -28 vol=31.2503 $ cadmium shell in CLICIT
c 40      8 0.042234 -18 17 -27  vol=12.066  $ central zr rod ss-#b1
c 40      19 -1.029e-3 -7 9 -28  vol=613.489  $ (cl)icit void -#b1
c 41      19 -1.029e-3 -7 9 -28  vol=568.6  $ fueled region ss-#b1
c 42      4 0.080193 -7 18 -28  vol=91.1953  $ gr reflector ss-#b1
c 43      4 0.080193 -17 9 -28  vol=91.9257  $ gr reflector ss-#b1
44      20 -8.642 -7 9 28 -29  vol=31.2503  $ cd shell for clicit void-#b1
45      8 0.042234 -18 17 -30  vol=12.066  $ central zr rod ss-#b2
46      9 0.0928308 -18 17 30 -31  vol=385.479  $ fueled region ss-#b2
47      4 0.080193 -7 18 -31  vol=91.1953  $ gr reflector ss-#b2
48      4 0.080193 -17 9 -31  vol=91.9257  $ gr reflector ss-#b2
49      7 0.085755 -7 9 31 -32  vol=32.8228  $ cladding ss-#b2
50      8 0.042234 -18 17 -33  vol=12.066  $ central zr rod ss-#b3
51      9 0.0928308 -18 17 33 -34  vol=385.479  $ fueled region ss-#b3
52      4 0.080193 -7 18 -34  vol=91.1953  $ gr reflector ss-#b3
53      4 0.080193 -17 9 -34  vol=91.9257  $ gr reflector ss-#b3
54      7 0.085755 -7 9 34 -35  vol=32.8228  $ cladding ss-#b3
55      8 0.042234 -18 17 -36  vol=12.066  $ central zr rod ss-#b4
56      9 0.0928308 -18 17 36 -37  vol=385.479  $ fueled region ss-#b4
57      4 0.080193 -7 18 -37  vol=91.1953  $ gr reflector ss-#b4
```

```
58    4 0.080193 -17 9 -37  vol=91.9257  $ gr reflector ss-#b4
59    7 0.085755 -7 9 37 -38  vol=32.8228  $ cladding ss-#b4
60    8 0.042234 -18 17 -39  vol=12.066  $ central zr rod ss-#b5
61    9 0.0928308 -18 17 39 -40  vol=385.479  $ fueled region ss-#b5
62    4 0.080193 -7 18 -40  vol=91.1953  $ gr reflector ss-#b5
63    4 0.080193 -17 9 -40  vol=91.9257  $ gr reflector ss-#b5
64    7 0.085755 -7 9 40 -41  vol=32.8228  $ cladding ss-#b5
65    8 0.042234 -18 17 -42  vol=12.066  $ central zr rod ss-#b6
66    9 0.0928308 -18 17 42 -43  vol=385.479  $ fueled region ss-#b6
67    4 0.080193 -7 18 -43  vol=91.1953  $ gr reflector ss-#b6
68    4 0.080193 -17 9 -43  vol=91.9257  $ gr reflector ss-#b6
69    7 0.085755 -7 9 43 -44  vol=32.8228  $ cladding ss-#b6
70    8 0.042234 -18 17 -45  vol=12.066  $ central zr rod ss-#c1
71    9 0.0928308 -18 17 45 -46  vol=385.479  $ fueled region ss-#c1
72    4 0.080193 -7 18 -46  vol=91.1953  $ gr reflector ss-#c1
73    4 0.080193 -17 9 -46  vol=91.9257  $ gr reflector ss-#c1
74    7 0.085755 -7 9 46 -47  vol=32.8228  $ cladding ss-#c1
75    8 0.042234 -18 17 -48  vol=12.066  $ central zr rod ss-#c2
76    9 0.0928308 -18 17 48 -49  vol=385.479  $ fueled region ss-#c2
77    4 0.080193 -7 18 -49  vol=91.1953  $ gr reflector ss-#c2
78    4 0.080193 -17 9 -49  vol=91.9257  $ gr reflector ss-#c2
79    7 0.085755 -7 9 49 -50  vol=32.8228  $ cladding ss-#c2
80    8 0.042234 -18 17 -51  vol=12.066  $ central zr rod ss-#c3
81    9 0.0928308 -18 17 51 -52  vol=385.479  $ fueled region ss-#c3
82    4 0.080193 -7 18 -52  vol=91.1953  $ gr reflector ss-#c3
83    4 0.080193 -17 9 -52  vol=91.9257  $ gr reflector ss-#c3
84    7 0.085755 -7 9 52 -53  vol=32.8228  $ cladding ss-#c3
85    10 -2.48 -7 1090 -54  vol=296.4494  $ control rod poison control w/o fuel-#c4
86    19 -1.029e-3 -1090 9 -54  vol=283.7991  $ air region control w/o fuel-#c4
87    7 0.085755 -7 9 54 -55  vol=42.0765  $ cladding control w/o fuel-#c4
88    8 0.042234 -18 17 -56  vol=12.066  $ central zr rod ss-#c5
89    9 0.0928308 -18 17 56 -57  vol=385.479  $ fueled region ss-#c5
90    4 0.080193 -7 18 -57  vol=91.1953  $ gr reflector ss-#c5
91    4 0.080193 -17 9 -57  vol=91.9257  $ gr reflector ss-#c5
92    7 0.085755 -7 9 57 -58  vol=32.8228  $ cladding ss-#c5
93    8 0.042234 -18 17 -59  vol=12.066  $ central zr rod ss-#c6
94    9 0.0928308 -18 17 59 -60  vol=385.479  $ fueled region ss-#c6
95    4 0.080193 -7 18 -60  vol=91.1953  $ gr reflector ss-#c6
96    4 0.080193 -17 9 -60  vol=91.9257  $ gr reflector ss-#c6
97    7 0.085755 -7 9 60 -61  vol=32.8228  $ cladding ss-#c6
98    8 0.042234 -18 17 -62  vol=12.066  $ central zr rod ss-#c7
99    9 0.0928308 -18 17 62 -63  vol=385.479  $ fueled region ss-#c7
100    4 0.080193 -7 18 -63  vol=91.1953  $ gr reflector ss-#c7
101    4 0.080193 -17 9 -63  vol=91.9257  $ gr reflector ss-#c7
102    7 0.085755 -7 9 63 -64  vol=32.8228  $ cladding ss-#c7
103    8 0.042234 -18 17 -65  vol=12.066  $ central zr rod ss-#c8
104    9 0.0928308 -18 17 65 -66  vol=385.479  $ fueled region ss-#c8
105    4 0.080193 -7 18 -66  vol=91.1953  $ gr reflector ss-#c8
106    4 0.080193 -17 9 -66  vol=91.9257  $ gr reflector ss-#c8
107    7 0.085755 -7 9 66 -67  vol=32.8228  $ cladding ss-#c8
108    8 0.042234 -18 17 -68  vol=12.066  $ central zr rod ss-#c9
109    9 0.0928308 -18 17 68 -69  vol=385.479  $ fueled region ss-#c9
110    4 0.080193 -7 18 -69  vol=91.1953  $ gr reflector ss-#c9
111    4 0.080193 -17 9 -69  vol=91.9257  $ gr reflector ss-#c9
112    7 0.085755 -7 9 69 -70  vol=32.8228  $ cladding ss-#c9
113    10 -2.48 -7 1093 -71  vol=273.3329  $ control rod poison con w/fuel-#c10
```

```
114   8 0.042234 -1093 9 -72  vol=9.315264  $ central zr rod con w/fuel-#c10
115   12 -5.0 -1093 9 72 -71  vol=209.2916  $ fueled region con w/fuel-#c10
116   7 0.085755 -7 9 71 -73  vol=32.8228  $ cladding con w/fuel-#c10
117   8 0.042234 -18 17 -74  vol=12.066  $ central zr rod ss-#c11
118   9 0.0928308 -18 17 74 -75  vol=385.479  $ fueled region ss-#c11
119   4 0.080193 -7 18 -75  vol=91.1953  $ gr reflector ss-#c11
120   4 0.080193 -17 9 -75  vol=91.9257  $ gr reflector ss-#c11
121   7 0.085755 -7 9 75 -76  vol=32.8228  $ cladding ss-#c11
122   8 0.042234 -18 17 -77  vol=12.066  $ central zr rod ss-#c12
123   9 0.0928308 -18 17 77 -78  vol=385.479  $ fueled region ss-#c12
124   4 0.080193 -7 18 -78  vol=91.1953  $ gr reflector ss-#c12
125   4 0.080193 -17 9 -78  vol=91.9257  $ gr reflector ss-#c12
126   7 0.085755 -7 9 78 -79  vol=32.8228  $ cladding ss-#c12
127   10 -2.48 -7 1092 -80  vol=286.9684  $ control rod poison con w/fuel-#d1
128   8 0.042234 -1092 9 -81  vol=8.901409  $ central zr rod con w/fuel-#d1
129   12 -5.0 -1092 9 81 -80  vol=199.9933  $ fueled region con w/fuel-#d1
130   7 0.085755 -7 9 80 -82  vol=32.8228  $ cladding con w/fuel-#d1
131   8 0.042234 -18 17 -83  vol=12.066  $ central zr rod ss-#d2
132   9 0.0928308 -18 17 83 -84  vol=385.479  $ fueled region ss-#d2
133   4 0.080193 -7 18 -84  vol=91.1953  $ gr reflector ss-#d2
134   4 0.080193 -17 9 -84  vol=91.9257  $ gr reflector ss-#d2
135   7 0.085755 -7 9 84 -85  vol=32.8228  $ cladding ss-#d2
136   8 0.042234 -18 17 -86  vol=12.066  $ central zr rod ss-#d3
137   9 0.0928308 -18 17 86 -87  vol=385.479  $ fueled region ss-#d3
138   4 0.080193 -7 18 -87  vol=91.1953  $ gr reflector ss-#d3
139   4 0.080193 -17 9 -87  vol=91.9257  $ gr reflector ss-#d3
140   7 0.085755 -7 9 87 -88  vol=32.8228  $ cladding ss-#d3
141   8 0.042234 -18 17 -89  vol=12.066  $ central zr rod ss-#d4
142   9 0.0928308 -18 17 89 -90  vol=385.479  $ fueled region ss-#d4
143   4 0.080193 -7 18 -90  vol=91.1953  $ gr reflector ss-#d4
144   4 0.080193 -17 9 -90  vol=91.9257  $ gr reflector ss-#d4
145   7 0.085755 -7 9 90 -91  vol=32.8228  $ cladding ss-#d4
146   8 0.042234 -18 17 -92  vol=12.066  $ central zr rod ss-#d5
147   9 0.0928308 -18 17 92 -93  vol=385.479  $ fueled region ss-#d5
148   4 0.080193 -7 18 -93  vol=91.1953  $ gr reflector ss-#d5
149   4 0.080193 -17 9 -93  vol=91.9257  $ gr reflector ss-#d5
150   7 0.085755 -7 9 93 -94  vol=32.8228  $ cladding ss-#d5
151   8 0.042234 -18 17 -95  vol=12.066  $ central zr rod ss-#d6
152   9 0.0928308 -18 17 95 -96  vol=385.479  $ fueled region ss-#d6
153   4 0.080193 -7 18 -96  vol=91.1953  $ gr reflector ss-#d6
154   4 0.080193 -17 9 -96  vol=91.9257  $ gr reflector ss-#d6
155   7 0.085755 -7 9 96 -97  vol=32.8228  $ cladding ss-#d6
156   8 0.042234 -18 17 -98  vol=12.066  $ central zr rod ss-#d7
157   9 0.0928308 -18 17 98 -99  vol=385.479  $ fueled region ss-#d7
158   4 0.080193 -7 18 -99  vol=91.1953  $ gr reflector ss-#d7
159   4 0.080193 -17 9 -99  vol=91.9257  $ gr reflector ss-#d7
160   7 0.085755 -7 9 99 -100  vol=32.8228  $ cladding ss-#d7
161   8 0.042234 -18 17 -101  vol=12.066  $ central zr rod ss-#d8
162   9 0.0928308 -18 17 101 -102  vol=385.479  $ fueled region ss-#d8
163   4 0.080193 -7 18 -102  vol=91.1953  $ gr reflector ss-#d8
164   4 0.080193 -17 9 -102  vol=91.9257  $ gr reflector ss-#d8
165   7 0.085755 -7 9 102 -103  vol=32.8228  $ cladding ss-#d8
166   8 0.042234 -18 17 -104  vol=12.066  $ central zr rod ss-#d9
167   9 0.0928308 -18 17 104 -105  vol=385.479  $ fueled region ss-#d9
168   4 0.080193 -7 18 -105  vol=91.1953  $ gr reflector ss-#d9
169   4 0.080193 -17 9 -105  vol=91.9257  $ gr reflector ss-#d9
```

```
170   7 0.085755 -7 9 105 -106  vol=32.8228  $ cladding ss-#d9
171   10 -2.48 -7 1091 -107  vol=285.0122  $ control rod poison con w/fuel-#d10
172   8 0.042234 -1091 9 -108  vol=8.960783  $ central zr rod con w/fuel-#d10
173   12 -5.0 -1091 9 108 -107  vol=201.3273  $ fueled region con w/fuel-#d10
174   7 0.085755 -7 9 107 -109  vol=32.8228  $ cladding con w/fuel-#d10
175   8 0.042234 -18 17 -110  vol=12.066  $ central zr rod ss-#d11
176   9 0.0928308 -18 17 110 -111  vol=385.479  $ fueled region ss-#d11
177   4 0.080193 -7 18 -111  vol=91.1953  $ gr reflector ss-#d11
178   4 0.080193 -17 9 -111  vol=91.9257  $ gr reflector ss-#d11
179   7 0.085755 -7 9 111 -112  vol=32.8228  $ cladding ss-#d11
180   8 0.042234 -18 17 -113  vol=12.066  $ central zr rod ss-#d12
181   9 0.0928308 -18 17 113 -114  vol=385.479  $ fueled region ss-#d12
182   4 0.080193 -7 18 -114  vol=91.1953  $ gr reflector ss-#d12
183   4 0.080193 -17 9 -114  vol=91.9257  $ gr reflector ss-#d12
184   7 0.085755 -7 9 114 -115  vol=32.8228  $ cladding ss-#d12
185   8 0.042234 -18 17 -116  vol=12.066  $ central zr rod ss-#d13
186   9 0.0928308 -18 17 116 -117  vol=385.479  $ fueled region ss-#d13
187   4 0.080193 -7 18 -117  vol=91.1953  $ gr reflector ss-#d13
188   4 0.080193 -17 9 -117  vol=91.9257  $ gr reflector ss-#d13
189   7 0.085755 -7 9 117 -118  vol=32.8228  $ cladding ss-#d13
190   8 0.042234 -18 17 -119  vol=12.066  $ central zr rod ss-#d14
191   9 0.0928308 -18 17 119 -120  vol=385.479  $ fueled region ss-#d14
192   4 0.080193 -7 18 -120  vol=91.1953  $ gr reflector ss-#d14
193   4 0.080193 -17 9 -120  vol=91.9257  $ gr reflector ss-#d14
194   7 0.085755 -7 9 120 -121  vol=32.8228  $ cladding ss-#d14
195   8 0.042234 -18 17 -122  vol=12.066  $ central zr rod ss-#d15
196   9 0.0928308 -18 17 122 -123  vol=385.479  $ fueled region ss-#d15
197   4 0.080193 -7 18 -123  vol=91.1953  $ gr reflector ss-#d15
198   4 0.080193 -17 9 -123  vol=91.9257  $ gr reflector ss-#d15
199   7 0.085755 -7 9 123 -124  vol=32.8228  $ cladding ss-#d15
200   8 0.042234 -18 17 -125  vol=12.066  $ central zr rod ss-#d16
201   9 0.0928308 -18 17 125 -126  vol=385.479  $ fueled region ss-#d16
202   4 0.080193 -7 18 -126  vol=91.1953  $ gr reflector ss-#d16
203   4 0.080193 -17 9 -126  vol=91.9257  $ gr reflector ss-#d16
204   7 0.085755 -7 9 126 -127  vol=32.8228  $ cladding ss-#d16
205   8 0.042234 -18 17 -128  vol=12.066  $ central zr rod ss-#d17
206   9 0.0928308 -18 17 128 -129  vol=385.479  $ fueled region ss-#d17
207   4 0.080193 -7 18 -129  vol=91.1953  $ gr reflector ss-#d17
208   4 0.080193 -17 9 -129  vol=91.9257  $ gr reflector ss-#d17
209   7 0.085755 -7 9 129 -130  vol=32.8228  $ cladding ss-#d17
210   8 0.042234 -18 17 -131  vol=12.066  $ central zr rod ss-#d18
211   9 0.0928308 -18 17 131 -132  vol=385.479  $ fueled region ss-#d18
212   4 0.080193 -7 18 -132  vol=91.1953  $ gr reflector ss-#d18
213   4 0.080193 -17 9 -132  vol=91.9257  $ gr reflector ss-#d18
214   7 0.085755 -7 9 132 -133  vol=32.8228  $ cladding ss-#d18
215   8 0.042234 -18 17 -134  vol=12.066  $ central zr rod ss-#e1
216   9 0.0928308 -18 17 134 -135  vol=385.479  $ fueled region ss-#e1
217   4 0.080193 -7 18 -135  vol=91.1953  $ gr reflector ss-#e1
218   4 0.080193 -17 9 -135  vol=91.9257  $ gr reflector ss-#e1
219   7 0.085755 -7 9 135 -136  vol=32.8228  $ cladding ss-#e1
220   8 0.042234 -18 17 -137  vol=12.066  $ central zr rod ss-#e2
221   9 0.0928308 -18 17 137 -138  vol=385.479  $ fueled region ss-#e2
222   4 0.080193 -7 18 -138  vol=91.1953  $ gr reflector ss-#e2
223   4 0.080193 -17 9 -138  vol=91.9257  $ gr reflector ss-#e2
224   7 0.085755 -7 9 138 -139  vol=32.8228  $ cladding ss-#e2
225   8 0.042234 -18 17 -140  vol=12.066  $ central zr rod ss-#e3
```

```
226   9 0.0928308 -18 17 140 -141  vol=385.479  $ fueled region ss-#e3
227   4 0.080193 -7 18 -141  vol=91.1953  $ gr reflector ss-#e3
228   4 0.080193 -17 9 -141  vol=91.9257  $ gr reflector ss-#e3
229   7 0.085755 -7 9 141 -142  vol=32.8228  $ cladding ss-#e3
230   8 0.042234 -18 17 -143  vol=12.066  $ central zr rod ss-#e4
231   9 0.0928308 -18 17 143 -144  vol=385.479  $ fueled region ss-#e4
232   4 0.080193 -7 18 -144  vol=91.1953  $ gr reflector ss-#e4
233   4 0.080193 -17 9 -144  vol=91.9257  $ gr reflector ss-#e4
234   7 0.085755 -7 9 144 -145  vol=32.8228  $ cladding ss-#e4
235   8 0.042234 -18 17 -146  vol=12.066  $ central zr rod ss-#e5
236   9 0.0928308 -18 17 146 -147  vol=385.479  $ fueled region ss-#e5
237   4 0.080193 -7 18 -147  vol=91.1953  $ gr reflector ss-#e5
238   4 0.080193 -17 9 -147  vol=91.9257  $ gr reflector ss-#e5
239   7 0.085755 -7 9 147 -148  vol=32.8228  $ cladding ss-#e5
240   8 0.042234 -18 17 -149  vol=12.066  $ central zr rod ss-#e6
241   9 0.0928308 -18 17 149 -150  vol=385.479  $ fueled region ss-#e6
242   4 0.080193 -7 18 -150  vol=91.1953  $ gr reflector ss-#e6
243   4 0.080193 -17 9 -150  vol=91.9257  $ gr reflector ss-#e6
244   7 0.085755 -7 9 150 -151  vol=32.8228  $ cladding ss-#e6
245   8 0.042234 -18 17 -152  vol=12.066  $ central zr rod ss-#e7
246   9 0.0928308 -18 17 152 -153  vol=385.479  $ fueled region ss-#e7
247   4 0.080193 -7 18 -153  vol=91.1953  $ gr reflector ss-#e7
248   4 0.080193 -17 9 -153  vol=91.9257  $ gr reflector ss-#e7
249   7 0.085755 -7 9 153 -154  vol=32.8228  $ cladding ss-#e7
250   8 0.042234 -18 17 -155  vol=12.066  $ central zr rod ss-#e8
251   9 0.0928308 -18 17 155 -156  vol=385.479  $ fueled region ss-#e8
252   4 0.080193 -7 18 -156  vol=91.1953  $ gr reflector ss-#e8
253   4 0.080193 -17 9 -156  vol=91.9257  $ gr reflector ss-#e8
254   7 0.085755 -7 9 156 -157  vol=32.8228  $ cladding ss-#e8
255   8 0.042234 -18 17 -158  vol=12.066  $ central zr rod ss-#e9
256   9 0.0928308 -18 17 158 -159  vol=385.479  $ fueled region ss-#e9
257   4 0.080193 -7 18 -159  vol=91.1953  $ gr reflector ss-#e9
258   4 0.080193 -17 9 -159  vol=91.9257  $ gr reflector ss-#e9
259   7 0.085755 -7 9 159 -160  vol=32.8228  $ cladding ss-#e9
260   8 0.042234 -18 17 -161  vol=12.066  $ central zr rod ss-#e10
261   9 0.0928308 -18 17 161 -162  vol=385.479  $ fueled region ss-#e10
262   4 0.080193 -7 18 -162  vol=91.1953  $ gr reflector ss-#e10
263   4 0.080193 -17 9 -162  vol=91.9257  $ gr reflector ss-#e10
264   7 0.085755 -7 9 162 -163  vol=32.8228  $ cladding ss-#e10
265   8 0.042234 -18 17 -164  vol=12.066  $ central zr rod ss-#e11
266   9 0.0928308 -18 17 164 -165  vol=385.479  $ fueled region ss-#e11
267   4 0.080193 -7 18 -165  vol=91.1953  $ gr reflector ss-#e11
268   4 0.080193 -17 9 -165  vol=91.9257  $ gr reflector ss-#e11
269   7 0.085755 -7 9 165 -166  vol=32.8228  $ cladding ss-#e11
270   8 0.042234 -18 17 -167  vol=12.066  $ central zr rod ss-#e12
271   9 0.0928308 -18 17 167 -168  vol=385.479  $ fueled region ss-#e12
272   4 0.080193 -7 18 -168  vol=91.1953  $ gr reflector ss-#e12
273   4 0.080193 -17 9 -168  vol=91.9257  $ gr reflector ss-#e12
274   7 0.085755 -7 9 168 -169  vol=32.8228  $ cladding ss-#e12
275   8 0.042234 -18 17 -170  vol=12.066  $ central zr rod ss-#e13
276   9 0.0928308 -18 17 170 -171  vol=385.479  $ fueled region ss-#e13
277   4 0.080193 -7 18 -171  vol=91.1953  $ gr reflector ss-#e13
278   4 0.080193 -17 9 -171  vol=91.9257  $ gr reflector ss-#e13
279   7 0.085755 -7 9 171 -172  vol=32.8228  $ cladding ss-#e13
280   8 0.042234 -18 17 -173  vol=12.066  $ central zr rod ss-#e14
281   9 0.0928308 -18 17 173 -174  vol=385.479  $ fueled region ss-#e14
```

```
282   4 0.080193 -7 18 -174  vol=91.1953  $ gr reflector ss-#e14
283   4 0.080193 -17 9 -174  vol=91.9257  $ gr reflector ss-#e14
284   7 0.085755 -7 9 174 -175  vol=32.8228  $ cladding ss-#e14
285   8 0.042234 -18 17 -176  vol=12.066  $ central zr rod ss-#e15
286   9 0.0928308 -18 17 176 -177  vol=385.479  $ fueled region ss-#e15
287   4 0.080193 -7 18 -177  vol=91.1953  $ gr reflector ss-#e15
288   4 0.080193 -17 9 -177  vol=91.9257  $ gr reflector ss-#e15
289   7 0.085755 -7 9 177 -178  vol=32.8228  $ cladding ss-#e15
290   8 0.042234 -18 17 -179  vol=12.066  $ central zr rod ss-#e16
291   9 0.0928308 -18 17 179 -180  vol=385.479  $ fueled region ss-#e16
292   4 0.080193 -7 18 -180  vol=91.1953  $ gr reflector ss-#e16
293   4 0.080193 -17 9 -180  vol=91.9257  $ gr reflector ss-#e16
294   7 0.085755 -7 9 180 -181  vol=32.8228  $ cladding ss-#e16
295   8 0.042234 -18 17 -182  vol=12.066  $ central zr rod ss-#e17
296   9 0.0928308 -18 17 182 -183  vol=385.479  $ fueled region ss-#e17
297   4 0.080193 -7 18 -183  vol=91.1953  $ gr reflector ss-#e17
298   4 0.080193 -17 9 -183  vol=91.9257  $ gr reflector ss-#e17
299   7 0.085755 -7 9 183 -184  vol=32.8228  $ cladding ss-#e17
300   8 0.042234 -18 17 -185  vol=12.066  $ central zr rod ss-#e18
301   9 0.0928308 -18 17 185 -186  vol=385.479  $ fueled region ss-#e18
302   4 0.080193 -7 18 -186  vol=91.1953  $ gr reflector ss-#e18
303   4 0.080193 -17 9 -186  vol=91.9257  $ gr reflector ss-#e18
304   7 0.085755 -7 9 186 -187  vol=32.8228  $ cladding ss-#e18
305   8 0.042234 -18 17 -188  vol=12.066  $ central zr rod ss-#e19
306   9 0.0928308 -18 17 188 -189  vol=385.479  $ fueled region ss-#e19
307   4 0.080193 -7 18 -189  vol=91.1953  $ gr reflector ss-#e19
308   4 0.080193 -17 9 -189  vol=91.9257  $ gr reflector ss-#e19
309   7 0.085755 -7 9 189 -190  vol=32.8228  $ cladding ss-#e19
310   8 0.042234 -18 17 -191  vol=12.066  $ central zr rod ss-#e20
311   9 0.0928308 -18 17 191 -192  vol=385.479  $ fueled region ss-#e20
312   4 0.080193 -7 18 -192  vol=91.1953  $ gr reflector ss-#e20
313   4 0.080193 -17 9 -192  vol=91.9257  $ gr reflector ss-#e20
314   7 0.085755 -7 9 192 -193  vol=32.8228  $ cladding ss-#e20
315   8 0.042234 -18 17 -194  vol=12.066  $ central zr rod ss-#e21
316   9 0.0928308 -18 17 194 -195  vol=385.479  $ fueled region ss-#e21
317   4 0.080193 -7 18 -195  vol=91.1953  $ gr reflector ss-#e21
318   4 0.080193 -17 9 -195  vol=91.9257  $ gr reflector ss-#e21
319   7 0.085755 -7 9 195 -196  vol=32.8228  $ cladding ss-#e21
320   8 0.042234 -18 17 -197  vol=12.066  $ central zr rod ss-#e22
321   9 0.0928308 -18 17 197 -198  vol=385.479  $ fueled region ss-#e22
322   4 0.080193 -7 18 -198  vol=91.1953  $ gr reflector ss-#e22
323   4 0.080193 -17 9 -198  vol=91.9257  $ gr reflector ss-#e22
324   7 0.085755 -7 9 198 -199  vol=32.8228  $ cladding ss-#e22
325   8 0.042234 -18 17 -200  vol=12.066  $ central zr rod ss-#e23
326   9 0.0928308 -18 17 200 -201  vol=385.479  $ fueled region ss-#e23
327   4 0.080193 -7 18 -201  vol=91.1953  $ gr reflector ss-#e23
328   4 0.080193 -17 9 -201  vol=91.9257  $ gr reflector ss-#e23
329   7 0.085755 -7 9 201 -202  vol=32.8228  $ cladding ss-#e23
330   8 0.042234 -18 17 -203  vol=12.066  $ central zr rod ss-#e24
331   9 0.0928308 -18 17 203 -204  vol=385.479  $ fueled region ss-#e24
332   4 0.080193 -7 18 -204  vol=91.1953  $ gr reflector ss-#e24
333   4 0.080193 -17 9 -204  vol=91.9257  $ gr reflector ss-#e24
334   7 0.085755 -7 9 204 -205  vol=32.8228  $ cladding ss-#e24
335   8 0.042234 -18 17 -206  vol=12.066  $ central zr rod ss-#f1
336   9 0.0928308 -18 17 206 -207  vol=385.479  $ fueled region ss-#f1
337   4 0.080193 -7 18 -207  vol=91.1953  $ gr reflector ss-#f1
```

```
338    4 0.080193 -17 9 -207  vol=91.9257  $ gr reflector ss-#f1
339    7 0.085755 -7 9 207 -208  vol=32.8228  $ cladding ss-#f1
655    6 -1.0 -7 9 -211  vol=613.489  $ water water -#f2
345    8 0.042234 -18 17 -212  vol=12.066  $ central zr rod ss-#f3
346    9 0.0928308 -18 17 212 -213  vol=385.479  $ fueled region ss-#f3
347    4 0.080193 -7 18 -213  vol=91.1953  $ gr reflector ss-#f3
348    4 0.080193 -17 9 -213  vol=91.9257  $ gr reflector ss-#f3
349    7 0.085755 -7 9 213 -214  vol=32.8228  $ cladding ss-#f3
350    8 0.042234 -18 17 -215  vol=12.066  $ central zr rod ss-#f4
351    9 0.0928308 -18 17 215 -216  vol=385.479  $ fueled region ss-#f4
352    4 0.080193 -7 18 -216  vol=91.1953  $ gr reflector ss-#f4
353    4 0.080193 -17 9 -216  vol=91.9257  $ gr reflector ss-#f4
354    7 0.085755 -7 9 216 -217  vol=32.8228  $ cladding ss-#f4
600    8 0.042234 -18 17 -400  vol=12.066  $ central zr rod ss-#f5
601    9 0.0928308 -18 17 400 -401  vol=385.479  $ fueled region ss-#f5
602    4 0.080193 -7 18 -401  vol=91.1953  $ gr reflector ss-#f5
603    4 0.080193 -17 9 -401  vol=91.9257  $ gr reflector ss-#f5
604    7 0.085755 -7 9 401 -218  vol=32.8228  $ cladding ss-#f5
356    8 0.042234 -18 17 -219  vol=12.066  $ central zr rod ss-#f6
357    9 0.0928308 -18 17 219 -220  vol=385.479  $ fueled region ss-#f6
358    4 0.080193 -7 18 -220  vol=91.1953  $ gr reflector ss-#f6
359    4 0.080193 -17 9 -220  vol=91.9257  $ gr reflector ss-#f6
360    7 0.085755 -7 9 220 -221  vol=32.8228  $ cladding ss-#f6
361    8 0.042234 -18 17 -222  vol=12.066  $ central zr rod ss-#f7
362    9 0.0928308 -18 17 222 -223  vol=385.479  $ fueled region ss-#f7
363    4 0.080193 -7 18 -223  vol=91.1953  $ gr reflector ss-#f7
364    4 0.080193 -17 9 -223  vol=91.9257  $ gr reflector ss-#f7
365    7 0.085755 -7 9 223 -224  vol=32.8228  $ cladding ss-#f7
366    8 0.042234 -18 17 -225  vol=12.066  $ central zr rod ss-#f8
367    9 0.0928308 -18 17 225 -226  vol=385.479  $ fueled region ss-#f8
368    4 0.080193 -7 18 -226  vol=91.1953  $ gr reflector ss-#f8
369    4 0.080193 -17 9 -226  vol=91.9257  $ gr reflector ss-#f8
370    7 0.085755 -7 9 226 -227  vol=32.8228  $ cladding ss-#f8
371    8 0.042234 -18 17 -228  vol=12.066  $ central zr rod ss-#f9
372    9 0.0928308 -18 17 228 -229  vol=385.479  $ fueled region ss-#f9
373    4 0.080193 -7 18 -229  vol=91.1953  $ gr reflector ss-#f9
374    4 0.080193 -17 9 -229  vol=91.9257  $ gr reflector ss-#f9
375    7 0.085755 -7 9 229 -230  vol=32.8228  $ cladding ss-#f9
376    8 0.042234 -18 17 -231  vol=12.066  $ central zr rod ss-#f10
377    9 0.0928308 -18 17 231 -232  vol=385.479  $ fueled region ss-#f10
378    4 0.080193 -7 18 -232  vol=91.1953  $ gr reflector ss-#f10
379    4 0.080193 -17 9 -232  vol=91.9257  $ gr reflector ss-#f10
380    7 0.085755 -7 9 232 -233  vol=32.8228  $ cladding ss-#f10
381    8 0.042234 -18 17 -234  vol=12.066  $ central zr rod ss-#f11
382    9 0.0928308 -18 17 234 -235  vol=385.479  $ fueled region ss-#f11
383    4 0.080193 -7 18 -235  vol=91.1953  $ gr reflector ss-#f11
384    4 0.080193 -17 9 -235  vol=91.9257  $ gr reflector ss-#f11
385    7 0.085755 -7 9 235 -236  vol=32.8228  $ cladding ss-#f11
605    8 0.042234 -18 17 -402  vol=12.066  $ central zr rod ss-#f12
606    9 0.0928308 -18 17 402 -403  vol=385.479  $ fueled region ss-#f12
607    4 0.080193 -7 18 -403  vol=91.1953  $ gr reflector ss-#f12
608    4 0.080193 -17 9 -403  vol=91.9257  $ gr reflector ss-#f12
609    7 0.085755 -7 9 403 -237  vol=32.8228  $ cladding ss-#f12
387    8 0.042234 -18 17 -238  vol=12.066  $ central zr rod ss-#f13
388    9 0.0928308 -18 17 238 -239  vol=385.479  $ fueled region ss-#f13
389    4 0.080193 -7 18 -239  vol=91.1953  $ gr reflector ss-#f13
```

```
390     4 0.080193 -17 9 -239  vol=91.9257  $ gr reflector ss-#f13
391     7 0.085755 -7 9 239 -240  vol=32.8228  $ cladding ss-#f13
392     8 0.042234 -18 17 -241  vol=12.066  $ central zr rod ss-#f14
393     9 0.0928308 -18 17 241 -242  vol=385.479  $ fueled region ss-#f14
394     4 0.080193 -7 18 -242  vol=91.1953  $ gr reflector ss-#f14
395     4 0.080193 -17 9 -242  vol=91.9257  $ gr reflector ss-#f14
396     7 0.085755 -7 9 242 -243  vol=32.8228  $ cladding ss-#f14
397     8 0.042234 -18 17 -244  vol=12.066  $ central zr rod ss-#f15
398     9 0.0928308 -18 17 244 -245  vol=385.479  $ fueled region ss-#f15
399     4 0.080193 -7 18 -245  vol=91.1953  $ gr reflector ss-#f15
400     4 0.080193 -17 9 -245  vol=91.9257  $ gr reflector ss-#f15
401     7 0.085755 -7 9 245 -246  vol=32.8228  $ cladding ss-#f15
402     8 0.042234 -18 17 -247  vol=12.066  $ central zr rod ss-#f16
403     9 0.0928308 -18 17 247 -248  vol=385.479  $ fueled region ss-#f16
404     4 0.080193 -7 18 -248  vol=91.1953  $ gr reflector ss-#f16
405     4 0.080193 -17 9 -248  vol=91.9257  $ gr reflector ss-#f16
406     7 0.085755 -7 9 248 -249  vol=32.8228  $ cladding ss-#f16
407     6 -1.0 -7 9 -252  vol=613.489  $ water water -#f17
c 407     8 0.042234 -18 17 -250  vol=12.066  $ central zr rod ss-#f17
c 408     9 0.0928308 -18 17 250 -251  vol=385.479  $ fueled region ss-#f17
c 409     4 0.080193 -7 18 -251  vol=91.1953  $ gr reflector ss-#f17
c 410     4 0.080193 -17 9 -251  vol=91.9257  $ gr reflector ss-#f17
c 411     7 0.085755 -7 9 251 -252  vol=32.8228  $ cladding ss-#f17
412     4 0.080193 -7 9 -254  vol=580.666  $ graphite region gr-#f18
413     7 0.085755 -7 9 254 -255  vol=32.8228  $ cladding gr-#f18
414     4 0.080193 -7 9 -257  vol=580.666  $ graphite region gr-#f19
415     7 0.085755 -7 9 257 -258  vol=32.8228  $ cladding gr-#f19
610     4 0.080193 -7 9 -405  vol=580.666  $ graphite region gr-#f20
611     7 0.085755 -7 9 405 -259  vol=32.8228  $ cladding gr-#f20
663     4 0.080193 -7 9 -261  vol=580.666  $ graphite region gr-#f21
427     7 0.085755 -7 9 261 -262  vol=32.8228  $ cladding ss-#f21
664     4 0.080193 -7 9 -264  vol=580.666  $ graphite region gr-#f22
432     7 0.085755 -7 9 264 -265  vol=32.8228  $ cladding ss-#f22
665     4 0.080193 -7 9 -267  vol=580.666  $ graphite region gr-#f23
437     7 0.085755 -7 9 267 -268  vol=32.8228  $ cladding ss-#f23
666     4 0.080193 -7 9 -270  vol=580.666  $ graphite region gr-#f24
442     7 0.085755 -7 9 270 -271  vol=32.8228  $ cladding ss-#f24
667     4 0.080193 -7 9 -273  vol=580.666  $ graphite region gr-#f25
447     7 0.085755 -7 9 273 -274  vol=32.8228  $ cladding ss-#f25
668     4 0.080193 -7 9 -276  vol=580.666  $ graphite region gr-#f26
452     7 0.085755 -7 9 276 -277  vol=32.8228  $ cladding ss-#f26
669     4 0.080193 -7 9 -407  vol=580.666  $ graphite region gr-#f27
619     7 0.085755 -7 9 407 -278  vol=32.8228  $ cladding ss-#f27
454     6 -1.0 -7 9 -281  vol=613.489  $ water water -#f28
c 454     8 0.042234 -18 17 -279  vol=12.066  $ central zr rod ss-#f28
c 455     4 0.080193 -7 18 -280  vol=91.1953  $ gr reflector ss-#f28
c 456     4 0.080193 -17 9 -280  vol=91.9257  $ gr reflector ss-#f28
c 457     7 0.085755 -7 9 280 -281  vol=32.8228  $ cladding ss-#f28
c 458     9 0.0928308 -18 282 279 -280  vol=38.5479  $ segment top ss-#f28
c 459     9 0.0928308 -282 283 279 -280  vol=38.5479  $ segment2 ss-#f28
c 460     9 0.0928308 -283 284 279 -280  vol=38.5479  $ segment3 ss-#f28
c 461     9 0.0928308 -284 285 279 -280  vol=38.5479  $ segment4 ss-#f28
c 462     9 0.0928308 -285 286 279 -280  vol=38.5479  $ segment5 ss-#f28
c 463     9 0.0928308 -286 287 279 -280  vol=38.5479  $ segment6 ss-#f28
c 464     9 0.0928308 -287 288 279 -280  vol=38.5479  $ segment7 ss-#f28
c 465     9 0.0928308 -288 289 279 -280  vol=38.5479  $ segment8 ss-#f28
```

```
c 466    9 0.0928308 -289 290 279 -280  vol=38.5479  $ segment9 ss-#f28
c 467    9 0.0928308 -290 17 279 -280  vol=38.5479  $ segment bottom ss-#f28
468    6 -1.0 -7 9 -293  vol=613.489  $ water water -#29
c 468    8 0.042234 -18 17 -291  vol=12.066  $ central zr rod ss-#f29
c 469    9 0.0928308 -18 17 291 -292  vol=385.479  $ fueled region ss-#f29
c 470    4 0.080193 -7 18 -292  vol=91.1953  $ gr reflector ss-#f29
c 471    4 0.080193 -17 9 -292  vol=91.9257  $ gr reflector ss-#f29
c 472    7 0.085755 -7 9 292 -293  vol=32.8228  $ cladding ss-#f29
473    8 0.042234 -18 17 -294  vol=12.066  $ central zr rod ss-#f30
474    9 0.0928308 -18 17 294 -295  vol=385.479  $ fueled region ss-#f30
475    4 0.080193 -7 18 -295  vol=91.1953  $ gr reflector ss-#f30
476    4 0.080193 -17 9 -295  vol=91.9257  $ gr reflector ss-#f30
477    7 0.085755 -7 9 295 -296  vol=32.8228  $ cladding ss-#f30
478    4 0.080193 -7 9 -297  vol=580.666  $ graphite region gr-#g1
479    7 0.085755 -7 9 297 -298  vol=32.8228  $ cladding gr-#g1
c 480    19 -1.029e-3 -7 830 -299 $ void of rabbit-#g2
c 670    19 -1.029e-3 -830 831 -299 $ void of rabbit-#g2
c 671    19 -1.029e-3 -831 9 -299 $ void of rabbit-#g2
481    1 -2.7 -7 9 299 -300  vol=32.8228  $ cladding gr-#g2
482    4 0.080193 -7 9 -301  vol=580.666  $ graphite region gr-#g3
483    7 0.085755 -7 9 301 -302  vol=32.8228  $ cladding gr-#g3
484    4 0.080193 -7 9 -303  vol=580.666  $ graphite region gr-#g4
485    7 0.085755 -7 9 303 -304  vol=32.8228  $ cladding gr-#g4
486    4 0.080193 -7 9 -305  vol=580.666  $ graphite region gr-#g5
487    7 0.085755 -7 9 305 -306  vol=32.8228  $ cladding gr-#g5
488    6 -1.0 -7 9 -308  vol=613.489  $ water water -#g6
c 488    4 0.080193 -7 9 -307  vol=580.666  $ graphite region gr-#g6
c 489    7 0.085755 -7 9 307 -308  vol=32.8228  $ cladding gr-#g6
490    8 0.042234 -18 17 -309  vol=12.066  $ central zr rod ss-#g7
491    9 0.0928308 -18 17 309 -10000  vol=385.479  $ fueled region ss-#g7
492    4 0.080193 -7 18 -10000  vol=91.1953  $ gr reflector ss-#g7
493    4 0.080193 -17 9 -10000  vol=91.9257  $ gr reflector ss-#g7
494    7 0.085755 -7 9 10000 -310  vol=32.8228  $ cladding ss-#g7
495    8 0.042234 -18 17 -311  vol=12.066  $ central zr rod ss-#g8
496    9 0.0928308 -18 17 311 -10001  vol=385.479  $ fueled region ss-#g8
497    4 0.080193 -7 18 -10001  vol=91.1953  $ gr reflector ss-#g8
498    4 0.080193 -17 9 -10001  vol=91.9257  $ gr reflector ss-#g8
499    7 0.085755 -7 9 10001 -312  vol=32.8228  $ cladding ss-#g8
500    8 0.042234 -18 17 -313  vol=12.066  $ central zr rod ss-#g9
501    9 0.0928308 -18 17 313 -10002  vol=385.479  $ fueled region ss-#g9
502    4 0.080193 -7 18 -10002  vol=91.1953  $ gr reflector ss-#g9
503    4 0.080193 -17 9 -10002  vol=91.9257  $ gr reflector ss-#g9
504    7 0.085755 -7 9 10002 -314  vol=32.8228  $ cladding ss-#g9
620    8 0.042234 -18 17 -408  vol=12.066  $ central zr rod ss-#g10
621    9 0.0928308 -18 17 408 -409  vol=385.479  $ fueled region ss-#g10
622    4 0.080193 -7 18 -409  vol=91.1953  $ gr reflector ss-#g10
623    4 0.080193 -17 9 -409  vol=91.9257  $ gr reflector ss-#g10
624    7 0.085755 -7 9 409 -315  vol=32.8228  $ cladding ss-#g10
625    8 0.042234 -18 17 -410  vol=12.066  $ central zr rod ss-#g11
626    9 0.0928308 -18 17 410 -411  vol=385.479  $ fueled region ss-#g11
627    4 0.080193 -7 18 -411  vol=91.1953  $ gr reflector ss-#g11
628    4 0.080193 -17 9 -411  vol=91.9257  $ gr reflector ss-#g11
629    7 0.085755 -7 9 411 -316  vol=32.8228  $ cladding ss-#g11
630    8 0.042234 -18 17 -412  vol=12.066  $ central zr rod ss-#g12
631    9 0.0928308 -18 17 412 -413  vol=385.479  $ fueled region ss-#g12
632    4 0.080193 -7 18 -413  vol=91.1953  $ gr reflector ss-#g12
```

```
633     4 0.080193 -17 9 -413  vol=91.9257  $ gr reflector ss-#g12
634     7 0.085755 -7 9 413 -317  vol=32.8228  $ cladding ss-#g12
635     8 0.042234 -18 17 -414  vol=12.066  $ central zr rod ss-#g13
636     9 0.0928308 -18 17 414 -415  vol=385.479  $ fueled region ss-#g13
637     4 0.080193 -7 18 -415  vol=91.1953  $ gr reflector ss-#g13
638     4 0.080193 -17 9 -415  vol=91.9257  $ gr reflector ss-#g13
639     7 0.085755 -7 9 415 -318  vol=32.8228  $ cladding ss-#g13
640     6 -1.0 -7 9 -319  vol=613.489  $ water water -#g6
c 640     8 0.042234 -18 17 -416  vol=12.066  $ central zr rod ss-#g14
c 641     9 0.0928308 -18 17 416 -417  vol=385.479  $ fueled region ss-#g14
c 642     4 0.080193 -7 18 -417  vol=91.1953  $ gr reflector ss-#g14
c 643     4 0.080193 -17 9 -417  vol=91.9257  $ gr reflector ss-#g14
c 644     7 0.085755 -7 9 417 -319  vol=32.8228  $ cladding ss-#g14
645     6 -1.0 -7 9 -320  vol=613.489  $ water water -#g15
c 645     8 0.042234 -18 17 -418  vol=12.066  $ central zr rod ss-#g15
c 646     9 0.0928308 -18 17 418 -419  vol=385.479  $ fueled region ss-#g15
c 647     4 0.080193 -7 18 -419  vol=91.1953  $ gr reflector ss-#g15
c 648     4 0.080193 -17 9 -419  vol=91.9257  $ gr reflector ss-#g15
c 649     7 0.085755 -7 9 419 -320  vol=32.8228  $ cladding ss-#g15
650     4 0.080193 -7 9 -321  vol=580.666  $ graphite region gr-#g16
651     7 0.085755 -7 9 321 -322  vol=32.8228  $ cladding gr-#g16
505     4 0.080193 -7 9 -323  vol=580.666  $ graphite region gr-#g17
506     7 0.085755 -7 9 323 -324  vol=32.8228  $ cladding gr-#g17
507     4 0.080193 -7 9 -325  vol=580.666  $ graphite region gr-#g18
508     7 0.085755 -7 9 325 -326  vol=32.8228  $ cladding gr-#g18
509     4 0.080193 -7 9 -327  vol=580.666  $ graphite region gr-#g19
510     7 0.085755 -7 9 327 -328  vol=32.8228  $ cladding gr-#g19
511     4 0.080193 -7 9 -329  vol=580.666  $ graphite region gr-#g20
512     7 0.085755 -7 9 329 -330  vol=32.8228  $ cladding gr-#g20
c 513     4 0.080193 -7 9 -331  vol=580.666  $ graphite region gr-#g21
c 514     7 0.085755 -7 9 331 -332  vol=32.8228  $ cladding gr-#g21
513     6 -1.0 -7 9 -332  vol=613.489  $ water water -#g21
515     6 -1.0 -7 9 -333  vol=613.489  $ water water -#g22
516     6 -1.0 -7 9 -334  vol=613.489  $ water water -#g23
517     6 -1.0 -7 9 -335  vol=613.489  $ water water -#g24
518     6 -1.0 -7 9 -336  vol=613.489  $ water water -#g25
519     6 -1.0 -7 9 -337  vol=613.489  $ water water -#g26
520     6 -1.0 -7 9 -338  vol=613.489  $ water water -#g27
521     6 -1.0 -7 9 -339  vol=613.489  $ water water -#g28
656     6 -1.0 -7 9 -341  vol=613.489  $ water water -#g29
657     6 -1.0 -7 9 -343  vol=613.489  $ water water -#g30
658     6 -1.0 -7 9 -345  vol=613.489  $ water water -#g31
659     6 -1.0 -7 9 -347  vol=613.489  $ water water -#g32
660     6 -1.0 -7 9 -349  vol=613.489  $ water water -#g33
661     4 0.080193 -7 9 -350  vol=580.666  $ graphite region gr-#g34
662     7 0.085755 -7 9 350 -351  vol=32.8228  $ cladding gr-#g34
612     4 0.080193 -7 9 -352  vol=580.666  $ graphite region gr-#g35
613     7 0.085755 -7 9 352 -353  vol=32.8228  $ cladding gr-#g35
c 2003     6 -1.0 -7 1045 -353 vol=474.36507 $ 1st segment of rabbit #g35
c 2004     6 -1.0 9 -1046 -353 vol=128.09951 $ 2nd segment of rabbit #g35
c 2005     6 -1.0 -1045 1046 -353 vol=11.024055 $ 1cm above the bottom of rabbit
535     4 0.080193 -7 9 -354  vol=580.666  $ graphite region gr-#g36
536     7 0.085755 -7 9 354 -355  vol=32.8228  $ cladding gr-#g36
c lazy susan rack segment
5001    19 -1.029e-3 -7 1056 -1001 vol=89.299973
5002    19 -1.029e-3 -7 1056 -1002 vol=89.299973
```

```
5003    19 -1.029e-3 -7 1056 -1003 vol=89.299973
5004    19 -1.029e-3 -7 1056 -1004 vol=89.299973
5005    19 -1.029e-3 -7 1056 -1005 vol=89.299973
5006    19 -1.029e-3 -7 1056 -1006 vol=89.299973
5007    19 -1.029e-3 -7 1056 -1007 vol=89.299973
5008    19 -1.029e-3 -7 1056 -1008 vol=89.299973
5009    19 -1.029e-3 -7 1056 -1009 vol=89.299973
5010    19 -1.029e-3 -7 1056 -1010 vol=89.299973
5011    19 -1.029e-3 -7 1056 -1011 vol=89.299973
5012    19 -1.029e-3 -7 1056 -1012 vol=89.299973
5013    19 -1.029e-3 -7 1056 -1013 vol=89.299973
5014    19 -1.029e-3 -7 1056 -1014 vol=89.299973
5015    19 -1.029e-3 -7 1056 -1015 vol=89.299973
5016    19 -1.029e-3 -7 1056 -1016 vol=89.299973
5017    19 -1.029e-3 -7 1056 -1017 vol=89.299973
5018    19 -1.029e-3 -7 1056 -1018 vol=89.299973
5019    19 -1.029e-3 -7 1056 -1019 vol=89.299973
5020    19 -1.029e-3 -7 1056 -1020 vol=89.299973
5021    19 -1.029e-3 -7 1056 -1021 vol=89.299973
5022    19 -1.029e-3 -7 1056 -1022 vol=89.299973
5023    19 -1.029e-3 -7 1056 -1023 vol=89.299973
5024    19 -1.029e-3 -7 1056 -1024 vol=89.299973
5025    19 -1.029e-3 -7 1056 -1025 vol=89.299973
5026    19 -1.029e-3 -7 1056 -1026 vol=89.299973
5027    19 -1.029e-3 -7 1056 -1027 vol=89.299973
5028    19 -1.029e-3 -7 1056 -1028 vol=89.299973
5029    19 -1.029e-3 -7 1056 -1029 vol=89.299973
5030    19 -1.029e-3 -7 1056 -1030 vol=89.299973
5031    19 -1.029e-3 -7 1056 -1031 vol=89.299973
5032    19 -1.029e-3 -7 1056 -1032 vol=89.299973
5033    19 -1.029e-3 -7 1056 -1033 vol=89.299973
5034    19 -1.029e-3 -7 1056 -1034 vol=89.299973
5035    19 -1.029e-3 -7 1056 -1035 vol=89.299973
5036    19 -1.029e-3 -7 1056 -1036 vol=89.299973
5037    19 -1.029e-3 -7 1056 -1037 vol=89.299973
5038    19 -1.029e-3 -7 1056 -1038 vol=89.299973
5039    19 -1.029e-3 -7 1056 -1039 vol=89.299973
5040    19 -1.029e-3 -7 1056 -1040 vol=89.299973
c cell bottom position for each lazy susan position
6000    19 -1.029e-3 11  -1047 -1040 vol=4.10433
6001    19 -1.029e-3 11  -1047 -1039 vol=4.10433
6002    19 -1.029e-3 11  -1047 -1038 vol=4.10433
6003    19 -1.029e-3 11  -1047 -1037 vol=4.10433
6004    19 -1.029e-3 11  -1047 -1036 vol=4.10433
6005    19 -1.029e-3 11  -1047 -1035 vol=4.10433
6006    19 -1.029e-3 11  -1047 -1034 vol=4.10433
6007    19 -1.029e-3 11  -1047 -1033 vol=4.10433
6008    19 -1.029e-3 11  -1047 -1032 vol=4.10433
6009    19 -1.029e-3 11  -1047 -1031 vol=4.10433
6010    19 -1.029e-3 11  -1047 -1030 vol=4.10433
6011    19 -1.029e-3 11  -1047 -1029 vol=4.10433
6012    19 -1.029e-3 11  -1047 -1028 vol=4.10433
6013    19 -1.029e-3 11  -1047 -1027 vol=4.10433
6014    19 -1.029e-3 11  -1047 -1026 vol=4.10433
6015    19 -1.029e-3 11  -1047 -1025 vol=4.10433
6016    19 -1.029e-3 11  -1047 -1024 vol=4.10433
```

```
6017    19 -1.029e-3 11  -1047 -1023 vol=4.10433
6018    19 -1.029e-3 11  -1047 -1022 vol=4.10433
6019    19 -1.029e-3 11  -1047 -1021 vol=4.10433
6020    19 -1.029e-3 11  -1047 -1020 vol=4.10433
6021    19 -1.029e-3 11  -1047 -1019 vol=4.10433
6022    19 -1.029e-3 11  -1047 -1018 vol=4.10433
6023    19 -1.029e-3 11  -1047 -1017 vol=4.10433
6024    19 -1.029e-3 11  -1047 -1016 vol=4.10433
6025    19 -1.029e-3 11  -1047 -1015 vol=4.10433
6026    19 -1.029e-3 11  -1047 -1014 vol=4.10433
6027    19 -1.029e-3 11  -1047 -1013 vol=4.10433
6028    19 -1.029e-3 11  -1047 -1012 vol=4.10433
6029    19 -1.029e-3 11  -1047 -1011 vol=4.10433
6030    19 -1.029e-3 11  -1047 -1010 vol=4.10433
6031    19 -1.029e-3 11  -1047 -1009 vol=4.10433
6032    19 -1.029e-3 11  -1047 -1008 vol=4.10433
6033    19 -1.029e-3 11  -1047 -1007 vol=4.10433
6034    19 -1.029e-3 11  -1047 -1006 vol=4.10433
6035    19 -1.029e-3 11  -1047 -1005 vol=4.10433
6036    19 -1.029e-3 11  -1047 -1004 vol=4.10433
6037    19 -1.029e-3 11  -1047 -1003 vol=4.10433
6038    19 -1.029e-3 11  -1047 -1002 vol=4.10433
6039    19 -1.029e-3 11  -1047 -1001 vol=4.10433
c cell 2nd position for bottom lazy susan
6040    19 -1.029e-3 1047 -1048 -1040 vol=4.10433
6041    19 -1.029e-3 1047 -1048 -1039 vol=4.10433
6042    19 -1.029e-3 1047 -1048 -1038 vol=4.10433
6043    19 -1.029e-3 1047 -1048 -1037 vol=4.10433
6044    19 -1.029e-3 1047 -1048 -1036 vol=4.10433
6045    19 -1.029e-3 1047 -1048 -1035 vol=4.10433
6046    19 -1.029e-3 1047 -1048 -1034 vol=4.10433
6047    19 -1.029e-3 1047 -1048 -1033 vol=4.10433
6048    19 -1.029e-3 1047 -1048 -1032 vol=4.10433
6049    19 -1.029e-3 1047 -1048 -1031 vol=4.10433
6050    19 -1.029e-3 1047 -1048 -1030 vol=4.10433
6051    19 -1.029e-3 1047 -1048 -1029 vol=4.10433
6052    19 -1.029e-3 1047 -1048 -1028 vol=4.10433
6053    19 -1.029e-3 1047 -1048 -1027 vol=4.10433
6054    19 -1.029e-3 1047 -1048 -1026 vol=4.10433
6055    19 -1.029e-3 1047 -1048 -1025 vol=4.10433
6056    19 -1.029e-3 1047 -1048 -1024 vol=4.10433
6057    19 -1.029e-3 1047 -1048 -1023 vol=4.10433
6058    19 -1.029e-3 1047 -1048 -1022 vol=4.10433
6059    19 -1.029e-3 1047 -1048 -1021 vol=4.10433
6060    19 -1.029e-3 1047 -1048 -1020 vol=4.10433
6061    19 -1.029e-3 1047 -1048 -1019 vol=4.10433
6062    19 -1.029e-3 1047 -1048 -1018 vol=4.10433
6063    19 -1.029e-3 1047 -1048 -1017 vol=4.10433
6064    19 -1.029e-3 1047 -1048 -1016 vol=4.10433
6065    19 -1.029e-3 1047 -1048 -1015 vol=4.10433
6066    19 -1.029e-3 1047 -1048 -1014 vol=4.10433
6067    19 -1.029e-3 1047 -1048 -1013 vol=4.10433
6068    19 -1.029e-3 1047 -1048 -1012 vol=4.10433
6069    19 -1.029e-3 1047 -1048 -1011 vol=4.10433
6070    19 -1.029e-3 1047 -1048 -1010 vol=4.10433
6071    19 -1.029e-3 1047 -1048 -1009 vol=4.10433
```

```
6072    19 -1.029e-3 1047 -1048 -1008 vol=4.10433
6073    19 -1.029e-3 1047 -1048 -1007 vol=4.10433
6074    19 -1.029e-3 1047 -1048 -1006 vol=4.10433
6075    19 -1.029e-3 1047 -1048 -1005 vol=4.10433
6076    19 -1.029e-3 1047 -1048 -1004 vol=4.10433
6077    19 -1.029e-3 1047 -1048 -1003 vol=4.10433
6078    19 -1.029e-3 1047 -1048 -1002 vol=4.10433
6079    19 -1.029e-3 1047 -1048 -1001 vol=4.10433
c cell 3rd position for bottom lazy susan
6080    19 -1.029e-3 1048 -1049 -1040 vol=4.10433
6081    19 -1.029e-3 1048 -1049 -1039 vol=4.10433
6082    19 -1.029e-3 1048 -1049 -1038 vol=4.10433
6083    19 -1.029e-3 1048 -1049 -1037 vol=4.10433
6084    19 -1.029e-3 1048 -1049 -1036 vol=4.10433
6085    19 -1.029e-3 1048 -1049 -1035 vol=4.10433
6086    19 -1.029e-3 1048 -1049 -1034 vol=4.10433
6087    19 -1.029e-3 1048 -1049 -1033 vol=4.10433
6088    19 -1.029e-3 1048 -1049 -1032 vol=4.10433
6089    19 -1.029e-3 1048 -1049 -1031 vol=4.10433
6090    19 -1.029e-3 1048 -1049 -1030 vol=4.10433
6091    19 -1.029e-3 1048 -1049 -1029 vol=4.10433
6092    19 -1.029e-3 1048 -1049 -1028 vol=4.10433
6093    19 -1.029e-3 1048 -1049 -1027 vol=4.10433
6094    19 -1.029e-3 1048 -1049 -1026 vol=4.10433
6095    19 -1.029e-3 1048 -1049 -1025 vol=4.10433
6096    19 -1.029e-3 1048 -1049 -1024 vol=4.10433
6097    19 -1.029e-3 1048 -1049 -1023 vol=4.10433
6098    19 -1.029e-3 1048 -1049 -1022 vol=4.10433
6099    19 -1.029e-3 1048 -1049 -1021 vol=4.10433
6100    19 -1.029e-3 1048 -1049 -1020 vol=4.10433
6101    19 -1.029e-3 1048 -1049 -1019 vol=4.10433
6102    19 -1.029e-3 1048 -1049 -1018 vol=4.10433
6103    19 -1.029e-3 1048 -1049 -1017 vol=4.10433
6104    19 -1.029e-3 1048 -1049 -1016 vol=4.10433
6105    19 -1.029e-3 1048 -1049 -1015 vol=4.10433
6106    19 -1.029e-3 1048 -1049 -1014 vol=4.10433
6107    19 -1.029e-3 1048 -1049 -1013 vol=4.10433
6108    19 -1.029e-3 1048 -1049 -1012 vol=4.10433
6109    19 -1.029e-3 1048 -1049 -1011 vol=4.10433
6110    19 -1.029e-3 1048 -1049 -1010 vol=4.10433
6111    19 -1.029e-3 1048 -1049 -1009 vol=4.10433
6112    19 -1.029e-3 1048 -1049 -1008 vol=4.10433
6113    19 -1.029e-3 1048 -1049 -1007 vol=4.10433
6114    19 -1.029e-3 1048 -1049 -1006 vol=4.10433
6115    19 -1.029e-3 1048 -1049 -1005 vol=4.10433
6116    19 -1.029e-3 1048 -1049 -1004 vol=4.10433
6117    19 -1.029e-3 1048 -1049 -1003 vol=4.10433
6118    19 -1.029e-3 1048 -1049 -1002 vol=4.10433
6119    19 -1.029e-3 1048 -1049 -1001 vol=4.10433
c cell 4th position for bottom lazy susan
6120    19 -1.029e-3 1049 -1050 -1040 vol=4.10433
6121    19 -1.029e-3 1049 -1050 -1039 vol=4.10433
6122    19 -1.029e-3 1049 -1050 -1038 vol=4.10433
6123    19 -1.029e-3 1049 -1050 -1037 vol=4.10433
6124    19 -1.029e-3 1049 -1050 -1036 vol=4.10433
6125    19 -1.029e-3 1049 -1050 -1035 vol=4.10433
```

```
6126    19 -1.029e-3 1049 -1050 -1034 vol=4.10433
6127    19 -1.029e-3 1049 -1050 -1033 vol=4.10433
6128    19 -1.029e-3 1049 -1050 -1032 vol=4.10433
6129    19 -1.029e-3 1049 -1050 -1031 vol=4.10433
6130    19 -1.029e-3 1049 -1050 -1030 vol=4.10433
6131    19 -1.029e-3 1049 -1050 -1029 vol=4.10433
6132    19 -1.029e-3 1049 -1050 -1028 vol=4.10433
6133    19 -1.029e-3 1049 -1050 -1027 vol=4.10433
6134    19 -1.029e-3 1049 -1050 -1026 vol=4.10433
6135    19 -1.029e-3 1049 -1050 -1025 vol=4.10433
6136    19 -1.029e-3 1049 -1050 -1024 vol=4.10433
6137    19 -1.029e-3 1049 -1050 -1023 vol=4.10433
6138    19 -1.029e-3 1049 -1050 -1022 vol=4.10433
6139    19 -1.029e-3 1049 -1050 -1021 vol=4.10433
6140    19 -1.029e-3 1049 -1050 -1020 vol=4.10433
6141    19 -1.029e-3 1049 -1050 -1019 vol=4.10433
6142    19 -1.029e-3 1049 -1050 -1018 vol=4.10433
6143    19 -1.029e-3 1049 -1050 -1017 vol=4.10433
6144    19 -1.029e-3 1049 -1050 -1016 vol=4.10433
6145    19 -1.029e-3 1049 -1050 -1015 vol=4.10433
6146    19 -1.029e-3 1049 -1050 -1014 vol=4.10433
6147    19 -1.029e-3 1049 -1050 -1013 vol=4.10433
6148    19 -1.029e-3 1049 -1050 -1012 vol=4.10433
6149    19 -1.029e-3 1049 -1050 -1011 vol=4.10433
6150    19 -1.029e-3 1049 -1050 -1010 vol=4.10433
6151    19 -1.029e-3 1049 -1050 -1009 vol=4.10433
6152    19 -1.029e-3 1049 -1050 -1008 vol=4.10433
6153    19 -1.029e-3 1049 -1050 -1007 vol=4.10433
6154    19 -1.029e-3 1049 -1050 -1006 vol=4.10433
6155    19 -1.029e-3 1049 -1050 -1005 vol=4.10433
6156    19 -1.029e-3 1049 -1050 -1004 vol=4.10433
6157    19 -1.029e-3 1049 -1050 -1003 vol=4.10433
6158    19 -1.029e-3 1049 -1050 -1002 vol=4.10433
6159    19 -1.029e-3 1049 -1050 -1001 vol=4.10433
c cell 5th position for bottom lazy susan
6160    19 -1.029e-3 1050 -1051 -1040 vol=4.10433
6161    19 -1.029e-3 1050 -1051 -1039 vol=4.10433
6162    19 -1.029e-3 1050 -1051 -1038 vol=4.10433
6163    19 -1.029e-3 1050 -1051 -1037 vol=4.10433
6164    19 -1.029e-3 1050 -1051 -1036 vol=4.10433
6165    19 -1.029e-3 1050 -1051 -1035 vol=4.10433
6166    19 -1.029e-3 1050 -1051 -1034 vol=4.10433
6167    19 -1.029e-3 1050 -1051 -1033 vol=4.10433
6168    19 -1.029e-3 1050 -1051 -1032 vol=4.10433
6169    19 -1.029e-3 1050 -1051 -1031 vol=4.10433
6170    19 -1.029e-3 1050 -1051 -1030 vol=4.10433
6171    19 -1.029e-3 1050 -1051 -1029 vol=4.10433
6172    19 -1.029e-3 1050 -1051 -1028 vol=4.10433
6173    19 -1.029e-3 1050 -1051 -1027 vol=4.10433
6174    19 -1.029e-3 1050 -1051 -1026 vol=4.10433
6175    19 -1.029e-3 1050 -1051 -1025 vol=4.10433
6176    19 -1.029e-3 1050 -1051 -1024 vol=4.10433
6177    19 -1.029e-3 1050 -1051 -1023 vol=4.10433
6178    19 -1.029e-3 1050 -1051 -1022 vol=4.10433
6179    19 -1.029e-3 1050 -1051 -1021 vol=4.10433
6180    19 -1.029e-3 1050 -1051 -1020 vol=4.10433
```

6181 19 -1.029e-3 1050 -1051 -1019 vol=4.10433
6182 19 -1.029e-3 1050 -1051 -1018 vol=4.10433
6183 19 -1.029e-3 1050 -1051 -1017 vol=4.10433
6184 19 -1.029e-3 1050 -1051 -1016 vol=4.10433
6185 19 -1.029e-3 1050 -1051 -1015 vol=4.10433
6186 19 -1.029e-3 1050 -1051 -1014 vol=4.10433
6187 19 -1.029e-3 1050 -1051 -1013 vol=4.10433
6188 19 -1.029e-3 1050 -1051 -1012 vol=4.10433
6189 19 -1.029e-3 1050 -1051 -1011 vol=4.10433
6190 19 -1.029e-3 1050 -1051 -1010 vol=4.10433
6191 19 -1.029e-3 1050 -1051 -1009 vol=4.10433
6192 19 -1.029e-3 1050 -1051 -1008 vol=4.10433
6193 19 -1.029e-3 1050 -1051 -1007 vol=4.10433
6194 19 -1.029e-3 1050 -1051 -1006 vol=4.10433
6195 19 -1.029e-3 1050 -1051 -1005 vol=4.10433
6196 19 -1.029e-3 1050 -1051 -1004 vol=4.10433
6197 19 -1.029e-3 1050 -1051 -1003 vol=4.10433
6198 19 -1.029e-3 1050 -1051 -1002 vol=4.10433
6199 19 -1.029e-3 1050 -1051 -1001 vol=4.10433
c cell 6th position for bottom lazy susan
6200 19 -1.029e-3 1051 -1052 -1040 vol=4.10433
6201 19 -1.029e-3 1051 -1052 -1039 vol=4.10433
6202 19 -1.029e-3 1051 -1052 -1038 vol=4.10433
6203 19 -1.029e-3 1051 -1052 -1037 vol=4.10433
6204 19 -1.029e-3 1051 -1052 -1036 vol=4.10433
6205 19 -1.029e-3 1051 -1052 -1035 vol=4.10433
6206 19 -1.029e-3 1051 -1052 -1034 vol=4.10433
6207 19 -1.029e-3 1051 -1052 -1033 vol=4.10433
6208 19 -1.029e-3 1051 -1052 -1032 vol=4.10433
6209 19 -1.029e-3 1051 -1052 -1031 vol=4.10433
6210 19 -1.029e-3 1051 -1052 -1030 vol=4.10433
6211 19 -1.029e-3 1051 -1052 -1029 vol=4.10433
6212 19 -1.029e-3 1051 -1052 -1028 vol=4.10433
6213 19 -1.029e-3 1051 -1052 -1027 vol=4.10433
6214 19 -1.029e-3 1051 -1052 -1026 vol=4.10433
6215 19 -1.029e-3 1051 -1052 -1025 vol=4.10433
6216 19 -1.029e-3 1051 -1052 -1024 vol=4.10433
6217 19 -1.029e-3 1051 -1052 -1023 vol=4.10433
6218 19 -1.029e-3 1051 -1052 -1022 vol=4.10433
6219 19 -1.029e-3 1051 -1052 -1021 vol=4.10433
6220 19 -1.029e-3 1051 -1052 -1020 vol=4.10433
6221 19 -1.029e-3 1051 -1052 -1019 vol=4.10433
6222 19 -1.029e-3 1051 -1052 -1018 vol=4.10433
6223 19 -1.029e-3 1051 -1052 -1017 vol=4.10433
6224 19 -1.029e-3 1051 -1052 -1016 vol=4.10433
6225 19 -1.029e-3 1051 -1052 -1015 vol=4.10433
6226 19 -1.029e-3 1051 -1052 -1014 vol=4.10433
6227 19 -1.029e-3 1051 -1052 -1013 vol=4.10433
6228 19 -1.029e-3 1051 -1052 -1012 vol=4.10433
6229 19 -1.029e-3 1051 -1052 -1011 vol=4.10433
6230 19 -1.029e-3 1051 -1052 -1010 vol=4.10433
6231 19 -1.029e-3 1051 -1052 -1009 vol=4.10433
6232 19 -1.029e-3 1051 -1052 -1008 vol=4.10433
6233 19 -1.029e-3 1051 -1052 -1007 vol=4.10433
6234 19 -1.029e-3 1051 -1052 -1006 vol=4.10433
6235 19 -1.029e-3 1051 -1052 -1005 vol=4.10433

6236 19 -1.029e-3 1051 -1052 -1004 vol=4.10433
6237 19 -1.029e-3 1051 -1052 -1003 vol=4.10433
6238 19 -1.029e-3 1051 -1052 -1002 vol=4.10433
6239 19 -1.029e-3 1051 -1052 -1001 vol=4.10433
c cell 7th position for bottom lazy susan
6240 19 -1.029e-3 1052 -1053 -1040 vol=4.10433
6241 19 -1.029e-3 1052 -1053 -1039 vol=4.10433
6242 19 -1.029e-3 1052 -1053 -1038 vol=4.10433
6243 19 -1.029e-3 1052 -1053 -1037 vol=4.10433
6244 19 -1.029e-3 1052 -1053 -1036 vol=4.10433
6245 19 -1.029e-3 1052 -1053 -1035 vol=4.10433
6246 19 -1.029e-3 1052 -1053 -1034 vol=4.10433
6247 19 -1.029e-3 1052 -1053 -1033 vol=4.10433
6248 19 -1.029e-3 1052 -1053 -1032 vol=4.10433
6249 19 -1.029e-3 1052 -1053 -1031 vol=4.10433
6250 19 -1.029e-3 1052 -1053 -1030 vol=4.10433
6251 19 -1.029e-3 1052 -1053 -1029 vol=4.10433
6252 19 -1.029e-3 1052 -1053 -1028 vol=4.10433
6253 19 -1.029e-3 1052 -1053 -1027 vol=4.10433
6254 19 -1.029e-3 1052 -1053 -1026 vol=4.10433
6255 19 -1.029e-3 1052 -1053 -1025 vol=4.10433
6256 19 -1.029e-3 1052 -1053 -1024 vol=4.10433
6257 19 -1.029e-3 1052 -1053 -1023 vol=4.10433
6258 19 -1.029e-3 1052 -1053 -1022 vol=4.10433
6259 19 -1.029e-3 1052 -1053 -1021 vol=4.10433
6260 19 -1.029e-3 1052 -1053 -1020 vol=4.10433
6261 19 -1.029e-3 1052 -1053 -1019 vol=4.10433
6262 19 -1.029e-3 1052 -1053 -1018 vol=4.10433
6263 19 -1.029e-3 1052 -1053 -1017 vol=4.10433
6264 19 -1.029e-3 1052 -1053 -1016 vol=4.10433
6265 19 -1.029e-3 1052 -1053 -1015 vol=4.10433
6266 19 -1.029e-3 1052 -1053 -1014 vol=4.10433
6267 19 -1.029e-3 1052 -1053 -1013 vol=4.10433
6268 19 -1.029e-3 1052 -1053 -1012 vol=4.10433
6269 19 -1.029e-3 1052 -1053 -1011 vol=4.10433
6270 19 -1.029e-3 1052 -1053 -1010 vol=4.10433
6271 19 -1.029e-3 1052 -1053 -1009 vol=4.10433
6272 19 -1.029e-3 1052 -1053 -1008 vol=4.10433
6273 19 -1.029e-3 1052 -1053 -1007 vol=4.10433
6274 19 -1.029e-3 1052 -1053 -1006 vol=4.10433
6275 19 -1.029e-3 1052 -1053 -1005 vol=4.10433
6276 19 -1.029e-3 1052 -1053 -1004 vol=4.10433
6277 19 -1.029e-3 1052 -1053 -1003 vol=4.10433
6278 19 -1.029e-3 1052 -1053 -1002 vol=4.10433
6279 19 -1.029e-3 1052 -1053 -1001 vol=4.10433
c cell 8th position for bottom lazy susan
6280 19 -1.029e-3 1053 -1054 -1040 vol=4.10433
6281 19 -1.029e-3 1053 -1054 -1039 vol=4.10433
6282 19 -1.029e-3 1053 -1054 -1038 vol=4.10433
6283 19 -1.029e-3 1053 -1054 -1037 vol=4.10433
6284 19 -1.029e-3 1053 -1054 -1036 vol=4.10433
6285 19 -1.029e-3 1053 -1054 -1035 vol=4.10433
6286 19 -1.029e-3 1053 -1054 -1034 vol=4.10433
6287 19 -1.029e-3 1053 -1054 -1033 vol=4.10433
6288 19 -1.029e-3 1053 -1054 -1032 vol=4.10433
6289 19 -1.029e-3 1053 -1054 -1031 vol=4.10433

6290 19 -1.029e-3 1053 -1054 -1030 vol=4.10433
6291 19 -1.029e-3 1053 -1054 -1029 vol=4.10433
6292 19 -1.029e-3 1053 -1054 -1028 vol=4.10433
6293 19 -1.029e-3 1053 -1054 -1027 vol=4.10433
6294 19 -1.029e-3 1053 -1054 -1026 vol=4.10433
6295 19 -1.029e-3 1053 -1054 -1025 vol=4.10433
6296 19 -1.029e-3 1053 -1054 -1024 vol=4.10433
6297 19 -1.029e-3 1053 -1054 -1023 vol=4.10433
6298 19 -1.029e-3 1053 -1054 -1022 vol=4.10433
6299 19 -1.029e-3 1053 -1054 -1021 vol=4.10433
6300 19 -1.029e-3 1053 -1054 -1020 vol=4.10433
6301 19 -1.029e-3 1053 -1054 -1019 vol=4.10433
6302 19 -1.029e-3 1053 -1054 -1018 vol=4.10433
6303 19 -1.029e-3 1053 -1054 -1017 vol=4.10433
6304 19 -1.029e-3 1053 -1054 -1016 vol=4.10433
6305 19 -1.029e-3 1053 -1054 -1015 vol=4.10433
6306 19 -1.029e-3 1053 -1054 -1014 vol=4.10433
6307 19 -1.029e-3 1053 -1054 -1013 vol=4.10433
6308 19 -1.029e-3 1053 -1054 -1012 vol=4.10433
6309 19 -1.029e-3 1053 -1054 -1011 vol=4.10433
6310 19 -1.029e-3 1053 -1054 -1010 vol=4.10433
6311 19 -1.029e-3 1053 -1054 -1009 vol=4.10433
6312 19 -1.029e-3 1053 -1054 -1008 vol=4.10433
6313 19 -1.029e-3 1053 -1054 -1007 vol=4.10433
6314 19 -1.029e-3 1053 -1054 -1006 vol=4.10433
6315 19 -1.029e-3 1053 -1054 -1005 vol=4.10433
6316 19 -1.029e-3 1053 -1054 -1004 vol=4.10433
6317 19 -1.029e-3 1053 -1054 -1003 vol=4.10433
6318 19 -1.029e-3 1053 -1054 -1002 vol=4.10433
6319 19 -1.029e-3 1053 -1054 -1001 vol=4.10433
c cell 9th position for bottom lazy susan
6320 19 -1.029e-3 1054 -1055 -1040 vol=4.10433
6321 19 -1.029e-3 1054 -1055 -1039 vol=4.10433
6322 19 -1.029e-3 1054 -1055 -1038 vol=4.10433
6323 19 -1.029e-3 1054 -1055 -1037 vol=4.10433
6324 19 -1.029e-3 1054 -1055 -1036 vol=4.10433
6325 19 -1.029e-3 1054 -1055 -1035 vol=4.10433
6326 19 -1.029e-3 1054 -1055 -1034 vol=4.10433
6327 19 -1.029e-3 1054 -1055 -1033 vol=4.10433
6328 19 -1.029e-3 1054 -1055 -1032 vol=4.10433
6329 19 -1.029e-3 1054 -1055 -1031 vol=4.10433
6330 19 -1.029e-3 1054 -1055 -1030 vol=4.10433
6331 19 -1.029e-3 1054 -1055 -1029 vol=4.10433
6332 19 -1.029e-3 1054 -1055 -1028 vol=4.10433
6333 19 -1.029e-3 1054 -1055 -1027 vol=4.10433
6334 19 -1.029e-3 1054 -1055 -1026 vol=4.10433
6335 19 -1.029e-3 1054 -1055 -1025 vol=4.10433
6336 19 -1.029e-3 1054 -1055 -1024 vol=4.10433
6337 19 -1.029e-3 1054 -1055 -1023 vol=4.10433
6338 19 -1.029e-3 1054 -1055 -1022 vol=4.10433
6339 19 -1.029e-3 1054 -1055 -1021 vol=4.10433
6340 19 -1.029e-3 1054 -1055 -1020 vol=4.10433
6341 19 -1.029e-3 1054 -1055 -1019 vol=4.10433
6342 19 -1.029e-3 1054 -1055 -1018 vol=4.10433
6343 19 -1.029e-3 1054 -1055 -1017 vol=4.10433
6344 19 -1.029e-3 1054 -1055 -1016 vol=4.10433

6345 19 -1.029e-3 1054 -1055 -1015 vol=4.10433
6346 19 -1.029e-3 1054 -1055 -1014 vol=4.10433
6347 19 -1.029e-3 1054 -1055 -1013 vol=4.10433
6348 19 -1.029e-3 1054 -1055 -1012 vol=4.10433
6349 19 -1.029e-3 1054 -1055 -1011 vol=4.10433
6350 19 -1.029e-3 1054 -1055 -1010 vol=4.10433
6351 19 -1.029e-3 1054 -1055 -1009 vol=4.10433
6352 19 -1.029e-3 1054 -1055 -1008 vol=4.10433
6353 19 -1.029e-3 1054 -1055 -1007 vol=4.10433
6354 19 -1.029e-3 1054 -1055 -1006 vol=4.10433
6355 19 -1.029e-3 1054 -1055 -1005 vol=4.10433
6356 19 -1.029e-3 1054 -1055 -1004 vol=4.10433
6357 19 -1.029e-3 1054 -1055 -1003 vol=4.10433
6358 19 -1.029e-3 1054 -1055 -1002 vol=4.10433
6359 19 -1.029e-3 1054 -1055 -1001 vol=4.10433
c cell 10th position for bottom lazy susan
6360 19 -1.029e-3 1055 -1056 -1040 vol=4.10433
6361 19 -1.029e-3 1055 -1056 -1039 vol=4.10433
6362 19 -1.029e-3 1055 -1056 -1038 vol=4.10433
6363 19 -1.029e-3 1055 -1056 -1037 vol=4.10433
6364 19 -1.029e-3 1055 -1056 -1036 vol=4.10433
6365 19 -1.029e-3 1055 -1056 -1035 vol=4.10433
6366 19 -1.029e-3 1055 -1056 -1034 vol=4.10433
6367 19 -1.029e-3 1055 -1056 -1033 vol=4.10433
6368 19 -1.029e-3 1055 -1056 -1032 vol=4.10433
6369 19 -1.029e-3 1055 -1056 -1031 vol=4.10433
6370 19 -1.029e-3 1055 -1056 -1030 vol=4.10433
6371 19 -1.029e-3 1055 -1056 -1029 vol=4.10433
6372 19 -1.029e-3 1055 -1056 -1028 vol=4.10433
6373 19 -1.029e-3 1055 -1056 -1027 vol=4.10433
6374 19 -1.029e-3 1055 -1056 -1026 vol=4.10433
6375 19 -1.029e-3 1055 -1056 -1025 vol=4.10433
6376 19 -1.029e-3 1055 -1056 -1024 vol=4.10433
6377 19 -1.029e-3 1055 -1056 -1023 vol=4.10433
6378 19 -1.029e-3 1055 -1056 -1022 vol=4.10433
6379 19 -1.029e-3 1055 -1056 -1021 vol=4.10433
6380 19 -1.029e-3 1055 -1056 -1020 vol=4.10433
6381 19 -1.029e-3 1055 -1056 -1019 vol=4.10433
6382 19 -1.029e-3 1055 -1056 -1018 vol=4.10433
6383 19 -1.029e-3 1055 -1056 -1017 vol=4.10433
6384 19 -1.029e-3 1055 -1056 -1016 vol=4.10433
6385 19 -1.029e-3 1055 -1056 -1015 vol=4.10433
6386 19 -1.029e-3 1055 -1056 -1014 vol=4.10433
6387 19 -1.029e-3 1055 -1056 -1013 vol=4.10433
6388 19 -1.029e-3 1055 -1056 -1012 vol=4.10433
6389 19 -1.029e-3 1055 -1056 -1011 vol=4.10433
6390 19 -1.029e-3 1055 -1056 -1010 vol=4.10433
6391 19 -1.029e-3 1055 -1056 -1009 vol=4.10433
6392 19 -1.029e-3 1055 -1056 -1008 vol=4.10433
6393 19 -1.029e-3 1055 -1056 -1007 vol=4.10433
6394 19 -1.029e-3 1055 -1056 -1006 vol=4.10433
6395 19 -1.029e-3 1055 -1056 -1005 vol=4.10433
6396 19 -1.029e-3 1055 -1056 -1004 vol=4.10433
6397 19 -1.029e-3 1055 -1056 -1003 vol=4.10433
6398 19 -1.029e-3 1055 -1056 -1002 vol=4.10433
6399 19 -1.029e-3 1055 -1056 -1001 vol=4.10433

```
c cell 41 (#b1 (CL)ICIT divided into 40 1 cm segments from the bottom
c 41     19 -1.029e-3 -7 9 -28  vol=567.8696  $ fueled region ss-#b1
c 7      pz 27.79 $ top of rod
c 9      pz -27.86 $ bottom of rod
c 28     c/z 1.04648 3.91414 1.82245 $ fuel...going to asuume that's x y r,
8001   19 -1.029e-3 9    -4000 -28 vol=10.4342
8002   19 -1.029e-3 4000 -4001 -28 vol=10.4342
8003   19 -1.029e-3 4001 -4002 -28 vol=10.4342
8004   19 -1.029e-3 4002 -4003 -28 vol=10.4342
8005   19 -1.029e-3 4003 -4004 -28 vol=10.4342
8006   19 -1.029e-3 4004 -4005 -28 vol=10.4342
8007   19 -1.029e-3 4005 -4006 -28 vol=10.4342
8008   19 -1.029e-3 4006 -4007 -28 vol=10.4342
8009   19 -1.029e-3 4007 -4008 -28 vol=10.4342
8010   19 -1.029e-3 4008 -4009 -28 vol=10.4342
8011   19 -1.029e-3 4009 -4010 -28 vol=10.4342
8012   19 -1.029e-3 4010 -4011 -28 vol=10.4342
8013   19 -1.029e-3 4011 -4012 -28 vol=10.4342
8014   19 -1.029e-3 4012 -4013 -28 vol=10.4342
8015   19 -1.029e-3 4013 -4014 -28 vol=10.4342
8016   19 -1.029e-3 4014 -4015 -28 vol=10.4342
8017   19 -1.029e-3 4015 -4016 -28 vol=10.4342
8018   19 -1.029e-3 4016 -4017 -28 vol=10.4342
8019   19 -1.029e-3 4017 -4018 -28 vol=10.4342
8020   19 -1.029e-3 4018 -4019 -28 vol=10.4342
8021   19 -1.029e-3 4019 -4020 -28 vol=10.4342
8022   19 -1.029e-3 4020 -4021 -28 vol=10.4342
8023   19 -1.029e-3 4021 -4022 -28 vol=10.4342
8024   19 -1.029e-3 4022 -4023 -28 vol=10.4342
8025   19 -1.029e-3 4023 -4024 -28 vol=10.4342
8026   19 -1.029e-3 4024 -4025 -28 vol=10.4342
8027   19 -1.029e-3 4025 -4026 -28 vol=10.4342
8028   19 -1.029e-3 4026 -4027 -28 vol=10.4342
8029   19 -1.029e-3 4027 -4028 -28 vol=10.4342
8030   19 -1.029e-3 4028 -4029 -28 vol=10.4342
8031   19 -1.029e-3 4029 -4030 -28 vol=10.4342
8032   19 -1.029e-3 4030 -4031 -28 vol=10.4342
8033   19 -1.029e-3 4031 -4032 -28 vol=10.4342
8034   19 -1.029e-3 4032 -4033 -28 vol=10.4342
8035   19 -1.029e-3 4033 -4034 -28 vol=10.4342
8036   19 -1.029e-3 4034 -4035 -28 vol=10.4342
8037   19 -1.029e-3 4035 -4036 -28 vol=10.4342
8038   19 -1.029e-3 4036 -4037 -28 vol=10.4342
8039   19 -1.029e-3 4037 -4038 -28 vol=10.4342
8040   19 -1.029e-3 4038 -4039 -28 vol=10.4342
8041   19 -1.029e-3 4039 -7   -28 vol=163.2952
c #g2 rabbit divided into 40 1 cm segments from the bottom
9001   19 -1.029e-3 9    -4000 -299 vol=10.4342
9002   19 -1.029e-3 4000 -4001 -299 vol=10.4342
9003   19 -1.029e-3 4001 -4002 -299 vol=10.4342
9004   19 -1.029e-3 4002 -4003 -299 vol=10.4342
9005   19 -1.029e-3 4003 -4004 -299 vol=10.4342
9006   19 -1.029e-3 4004 -4005 -299 vol=10.4342
9007   19 -1.029e-3 4005 -4006 -299 vol=10.4342
9008   19 -1.029e-3 4006 -4007 -299 vol=10.4342
9009   19 -1.029e-3 4007 -4008 -299 vol=10.4342
```

```
9010    19 -1.029e-3 4008 -4009 -299 vol=10.4342
9011    19 -1.029e-3 4009 -4010 -299 vol=10.4342
9012    19 -1.029e-3 4010 -4011 -299 vol=10.4342
9013    19 -1.029e-3 4011 -4012 -299 vol=10.4342
9014    19 -1.029e-3 4012 -4013 -299 vol=10.4342
9015    19 -1.029e-3 4013 -4014 -299 vol=10.4342
9016    19 -1.029e-3 4014 -4015 -299 vol=10.4342
9017    19 -1.029e-3 4015 -4016 -299 vol=10.4342
9018    19 -1.029e-3 4016 -4017 -299 vol=10.4342
9019    19 -1.029e-3 4017 -4018 -299 vol=10.4342
9020    19 -1.029e-3 4018 -4019 -299 vol=10.4342
9021    19 -1.029e-3 4019 -4020 -299 vol=10.4342
9022    19 -1.029e-3 4020 -4021 -299 vol=10.4342
9023    19 -1.029e-3 4021 -4022 -299 vol=10.4342
9024    19 -1.029e-3 4022 -4023 -299 vol=10.4342
9025    19 -1.029e-3 4023 -4024 -299 vol=10.4342
9026    19 -1.029e-3 4024 -4025 -299 vol=10.4342
9027    19 -1.029e-3 4025 -4026 -299 vol=10.4342
9028    19 -1.029e-3 4026 -4027 -299 vol=10.4342
9029    19 -1.029e-3 4027 -4028 -299 vol=10.4342
9030    19 -1.029e-3 4028 -4029 -299 vol=10.4342
9031    19 -1.029e-3 4029 -4030 -299 vol=10.4342
9032    19 -1.029e-3 4030 -4031 -299 vol=10.4342
9033    19 -1.029e-3 4031 -4032 -299 vol=10.4342
9034    19 -1.029e-3 4032 -4033 -299 vol=10.4342
9035    19 -1.029e-3 4033 -4034 -299 vol=10.4342
9036    19 -1.029e-3 4034 -4035 -299 vol=10.4342
9037    19 -1.029e-3 4035 -4036 -299 vol=10.4342
9038    19 -1.029e-3 4036 -4037 -299 vol=10.4342
9039    19 -1.029e-3 4037 -4038 -299 vol=10.4342
9040    19 -1.029e-3 4038 -4039 -299 vol=10.4342
9041    19 -1.029e-3 4039 -7   -299 vol=163.2952
c beam port 43
1047    1 -2.7 -836 -833 899 $ al plate bp4
1048    19 -1.029e-3 -836 -899 900 $ al pipe bp4
1049    19 -1.029e-3 -836 -900 901 $ al pipe bp4
1050    19 -1.029e-3 -836 -901 902 $ end of al pipe bp4
1051    1 -2.7 -800 -902 903 $ al plate bp4
c al and steel cladding bp4
2047    1 -2.7 -835 836 -833 899 $ al claddingbp4
2048    1 -2.7 -835 836 -899 900 $ al cladding bp4
2049    1 -2.7 -835 836 -900 901 $ al cladding bp4
2050    1 -2.7 -835 836 -901 902 $ end of al cladding bp4
2052    16 -7.86 800 -801  -903 904 $ steel cladding bp4
c concrete surrounded al cladding bp4
14000   18 -2.3 835 -1041 890 902 -882 -617 $ concrete surrounded bp4
c concrete surrounded steel cladding bp4
14001   18 -2.3 801 -1043 -902 903 -617 $ concrete around steel clad bp4
14002   18 -2.3 801 -1043 -903 904 -617 $ concrete around steel clad bp4
c beam port 3
1010    19 -1.029e-3 -837 865 -896 617 vol=420.00983 $ vol next to water
1011    1 -2.7 -837 834 -842 vol=57.91666 $ al plate bp3
1012    6 -1.0 -837 842 -865 vol=2779.99991 $ Flooded portion of BP3
1090    19 -1.029e-3 -837 895 896 -843 $ Boron Carbide appature
1091    19 -1.029e-3 -895 896 -843 $ Boron Carbide appature hole
1013    19 -1.029e-3 -837 843 -844 $ al pipe bp3
```

```
1014    19 -1.029e-3 -837 844 -845 $ al pipe bp3
1015    19 -1.029e-3 -837 845 -846 $ al pipe bp3
1016    19 -1.029e-3 -837 846 -847 $ al pipe bp3
1017    19 -1.029e-3 -837 847 -848 $ end of al pipe bp3
1018    1 -2.7 -839 848 -849 $ al plate bp3
1019    16 -7.86 -839 849 -850 $ steel plate bp3
1030    19 -1.029e-3 -839 850 -860 $ Bi filter
1020    19 -1.029e-3 -839 860 -851 $ steel pipe bp3
1021    19 -1.029e-3 -839 851 -852 $ steel pipe bp3
1022    19 -1.029e-3 -839 852 -853 $ steel pipe bp3
1023    19 -1.029e-3 -839 853 -854 $ steel pipe bp3
1024    19 -1.029e-3 -839 854 -855 $ steel pipe bp3
1025    19 -1.029e-3 -839 855 -856 $ steel pipe bp3
1026    19 -1.029e-3 -839 856 -857 $ steel pipe bp3
1027    19 -1.029e-3 -839 857 -858 $ end of steel pipe bp3
c al and steel cladding bp3
2011    1 -2.7 837 -838 834 -842 $ al cladding bp3
2012    1 -2.7 837 -838 842 -843 $ al cladding bp3
2013    1 -2.7 837 -838 843 -844 $ al cladding bp3
2014    1 -2.7 837 -838 844 -845 $ al cladding bp3
2015    1 -2.7 837 -838 845 -846 $ al cladding bp3
2016    1 -2.7 837 -838 846 -847 $ al cladding bp3
2017    1 -2.7 837 -838 847 -848 $ end of al cladding bp3
2018    16 -7.86 839 -840 848 -849 $ steel cladding bp3
2019    16 -7.86 839 -840 849 -850 $ steel cladding bp3
2020    16 -7.86 839 -840 850 -851 $ steel cladding bp3
2021    16 -7.86 839 -840 851 -852 $ steel cladding bp3
2022    16 -7.86 839 -840 852 -853 $ steel cladding bp3
2023    16 -7.86 839 -840 853 -854 $ steel cladding bp3
2024    16 -7.86 839 -840 854 -855 $ steel cladding bp3
2025    16 -7.86 839 -840 855 -856 $ steel cladding bp3
2026    16 -7.86 839 -840 856 -857 $ steel cladding bp3
2027    16 -7.86 839 -840 857 -858 $ end of steel cladding bp3
c concrete surrounded al cladding bp3
14009   18 -2.3 838 -1042 890 -846 617 -612 $ concrete around al clad bp3
14010   18 -2.3 838 -1042 846 -847 617 -612 $ concrete around al clad bp3
14011   18 -2.3 838 -1042 847 -848 617 -612 $ concrete around al clad bp3
c concrete surrounded steel cladding bp3
14012   18 -2.3 840 -1044 617 -612 848 -849 $ concrete around steel clad bp3
14013   18 -2.3 840 -1044 617 -612 849 -850 $ concrete around steel clad bp3
14014   18 -2.3 840 -1044 617 -612 850 -851 $ concrete around steel clad bp3
14015   18 -2.3 840 -1044 617 -612 851 -852 $ concrete around steel clad bp3
14016   18 -2.3 840 -1044 617 -612 852 -853 $ concrete around steel clad bp3
14017   18 -2.3 840 -1044 617 -612 853 -854 $ concrete around steel clad bp3
14018   18 -2.3 840 -1044 617 -612 854 -855 $ concrete around steel clad bp3
14019   18 -2.3 840 -1044 617 -612 855 -856 $ concrete around steel clad bp3
14020   18 -2.3 840 -1044 617 -612 856 -857 $ concrete around steel clad bp3
14021   18 -2.3 840 -1044 617 -612 857 -858 $ end of concrete around clad bp3
c volume cards for slab
c 50000   5 -11.4 -5003 5004 -601 606 5000 -5001 $ lead slab
c 50001   18 -2.3 5001 -5002 -5003 5004 -601 606 $ concrete slab
c 50002   19 -1.029e-3 858 -5021 -5003 5004 -601 606 $ front air
c 50005   19 -1.029e-3 -5003 5004 -601 606 -5006 5002 $ back detector
c 50006   18 -2.3 858 -5002 -5007 5003 -601 606 $ north wall
c 50007   18 -2.3 858 -5002 -5004 5008 -601 606 $ south wall
c 50010   5 -11.4 5009 -5003 -5000 5011 -601 606 $ north lead
```

```
c 50011   5 -11.4 5004 -5010 -5000 5011 -601 606 $ south lead
c 50012   19 -1.029e-3 -5015 -5016 5018 5017 -601 606 $ air space
c 50013   5 -11.4 5011 -5012 -5009 5013 -601 606 $ north lead lip
c 50014   5 -11.4 5011 -5012 -5014 5010 -601 606 $ south lead lip
c 50015   19 -1.029e-3 5011 -5018 -5013 5014 -601 606 $ lip air
c 50016   6 -1.0 -5000 5015 -5009 5010 -601 606 $ masonite block (water)
c 50017   6 -1.0 -5009 5016 5012 -5015 -601 606 $ north masonite
c 50018   6 -1.0 5010 -5017 5012 -5015 -601 606 $ south masonite
c 50019   6 -1.0 -5016 5013 5012 -5018 -601 606 $ north masonite lip
c 50020   6 -1.0 5017 -5014 5012 -5018 -601 606 $ south masonite lip
c 50021   19 -1.029e-3 -5014 5004 5021 -5011 -601 606 $ south front air
c 50022   19 -1.029e-3 5021 -5011 5014 -5013 -601 606 $ middle front air
c 50023   19 -1.029e-3 5021 -5011 5013 -5003 -601 606 $ north front air
c 50024   19 -1.029e-3 858 -5018 5007 -5019 -601 606 $ north (front) side air
c 50025   19 -1.029e-3 5018 -5015 5007 -5019 -601 606 $ north (middle) side air
c 50027   19 -1.029e-3 858 -5018 5020 -5008 -601 606 $ south (front) side air
c 50028   19 -1.029e-3 5018 -5015 5020 -5008 -601 606 $ south (middle) side air

1     so 1000  $ infinity
2     cz 26.67 $ cylinder of water
3     cz 27.31 $ cylinder of vessel
4     pz -36.2 $ bottom of reflector
5     pz 32.39 $ top of water
6     pz 30.78 $ bottom of upper grid plate
7     pz 27.79 $ top of rod
8     pz -34.29 $ top of lower grid plate
9     pz -27.86 $ bottom of rod
10     cz 37.47 $ cylinder of lazy susan
11     pz 6.0325 $ bottom of lazy susan
12     cz 47.63 $ cylinder of graphite
13     cz 52.55 $ cylinder of lead
c 14     pz -46.2 $ bottom of water
c 15     pz 42.39 $ top of water
c 16     cz 62.71 $ cylinder of water
17     pz -19.05 $ bottom of fuel
18     pz 19.05 $ top of fuel
19     cz 10.0803 $ region 0 core
20     cz 14.2557 $ region 1 core
21     cz 17.4596 $ region 2 core
22     cz 20.1606 $ region 3 core
23     cz 22.5403 $ region 4 core
24     cz 24.6916 $ region 5 core
25     cz 1.82245 $ graph
26     cz 1.87325 $ cladding central thimble -#a1
c 27     c/z 1.04648 3.91414 0.3175 $ zr rod
c 28     c/z 1.04648 3.91414 1.82245 $ fuel
28     c/z 1.04648 3.91414 1.82245 $ air
29     c/z 1.04648 3.91414 1.87325 $ cladding cd-#b1
30     c/z -2.86766 2.86766 0.3175 $ zr rod
31     c/z -2.86766 2.86766 1.82245 $ fuel
32     c/z -2.86766 2.86766 1.87325 $ cladding ss-#b2
33     c/z -3.91414 -1.04648 0.3175 $ zr rod
34     c/z -3.91414 -1.04648 1.82245 $ fuel
35     c/z -3.91414 -1.04648 1.87325 $ cladding ss-#b3
36     c/z -1.04648 -3.91414 0.3175 $ zr rod
37     c/z -1.04648 -3.91414 1.82245 $ fuel
```

```
38    c/z -1.04648 -3.91414 1.87325 $ cladding ss-#b4
39    c/z 2.86766 -2.86766 0.3175 $ zr rod
40    c/z 2.86766 -2.86766 1.82245 $ fuel
41    c/z 2.86766 -2.86766 1.87325 $ cladding ss-#b5
42    c/z 3.91414 1.04648 0.3175 $ zr rod
43    c/z 3.91414 1.04648 1.82245 $ fuel
44    c/z 3.91414 1.04648 1.87325 $ cladding ss-#b6
45    c/z 0.0 7.98068 0.3175 $ zr rod
46    c/z 0.0 7.98068 1.82245 $ fuel
47    c/z 0.0 7.98068 1.87325 $ cladding ss-#c1
48    c/z -3.99034 6.91134 0.3175 $ zr rod
49    c/z -3.99034 6.91134 1.82245 $ fuel
50    c/z -3.99034 6.91134 1.87325 $ cladding ss-#c2
51    c/z -6.91134 3.99034 0.3175 $ zr rod
52    c/z -6.91134 3.99034 1.82245 $ fuel
53    c/z -6.91134 3.99034 1.87325 $ cladding ss-#c3
54    c/z -7.98068 0.0 1.82245 $ fuel
55    c/z -7.98068 0.0 1.88733 $ cladding control w/o fuel-#c4
56    c/z -6.91134 -3.99034 0.3175 $ zr rod
57    c/z -6.91134 -3.99034 1.82245 $ fuel
58    c/z -6.91134 -3.99034 1.87325 $ cladding ss-#c5
59    c/z -3.99034 -6.91134 0.3175 $ zr rod
60    c/z -3.99034 -6.91134 1.82245 $ fuel
61    c/z -3.99034 -6.91134 1.87325 $ cladding ss-#c6
62    c/z 0.0 -7.98068 0.3175 $ zr rod
63    c/z 0.0 -7.98068 1.82245 $ fuel
64    c/z 0.0 -7.98068 1.87325 $ cladding ss-#c7
65    c/z 3.99034 -6.91134 0.3175 $ zr rod
66    c/z 3.99034 -6.91134 1.82245 $ fuel
67    c/z 3.99034 -6.91134 1.87325 $ cladding ss-#c8
68    c/z 6.91134 -3.99034 0.3175 $ zr rod
69    c/z 6.91134 -3.99034 1.82245 $ fuel
70    c/z 6.91134 -3.99034 1.87325 $ cladding ss-#c9
71    c/z 7.98068 0.0 1.82245 $ fuel
72    c/z 7.98068 0.0 0.3175 $ zr rod
73    c/z 7.98068 0.0 1.87325 $ cladding con w/fuel-#c10
74    c/z 6.91134 3.99034 0.3175 $ zr rod
75    c/z 6.91134 3.99034 1.82245 $ fuel
76    c/z 6.91134 3.99034 1.87325 $ cladding ss-#c11
77    c/z 3.99034 6.91134 0.3175 $ zr rod
78    c/z 3.99034 6.91134 1.82245 $ fuel
79    c/z 3.99034 6.91134 1.87325 $ cladding ss-#c12
80    c/z 0.0 11.9456 1.82245 $ fuel
81    c/z 0.0 11.9456 0.3175 $ zr rod
82    c/z 0.0 11.9456 1.87325 $ cladding con w/fuel-#d1
83    c/z -4.08432 11.2243 0.3175 $ zr rod
84    c/z -4.08432 11.2243 1.82245 $ fuel
85    c/z -4.08432 11.2243 1.87325 $ cladding ss-#d2
86    c/z -7.67842 9.15162 0.3175 $ zr rod
87    c/z -7.67842 9.15162 1.82245 $ fuel
88    c/z -7.67842 9.15162 1.87325 $ cladding ss-#d3
89    c/z -10.3454 5.97408 0.3175 $ zr rod
90    c/z -10.3454 5.97408 1.82245 $ fuel
91    c/z -10.3454 5.97408 1.87325 $ cladding ss-#d4
92    c/z -11.7653 2.2225 0.3175 $ zr rod
93    c/z -11.7653 2.2225 1.82245 $ fuel
```

```
94    c/z -11.7653 2.2225 1.87325 $ cladding ss-#d5
95    c/z -11.303 -2.07264 0.3175 $ zr rod
96    c/z -11.303 -2.07264 1.82245 $ fuel
97    c/z -11.303 -2.07264 1.87325 $ cladding ss-#d6
98    c/z -10.3454 -5.97408 0.3175 $ zr rod
99    c/z -10.3454 -5.97408 1.82245 $ fuel
100   c/z -10.3454 -5.97408 1.87325 $ cladding ss-#d7
101   c/z -7.67842 -9.15162 0.3175 $ zr rod
102   c/z -7.67842 -9.15162 1.82245 $ fuel
103   c/z -7.67842 -9.15162 1.87325 $ cladding ss-#d8
104   c/z -4.08432 -11.2243 0.3175 $ zr rod
105   c/z -4.08432 -11.2243 1.82245 $ fuel
106   c/z -4.08432 -11.2243 1.87325 $ cladding ss-#d9
107   c/z 0.0 -11.9456 1.82245 $ fuel
108   c/z 0.0 -11.9456 0.3175 $ zr rod
109   c/z 0.0 -11.9456 1.87325 $ cladding con w/fuel-#d10
110   c/z 4.08432 -11.2243 0.3175 $ zr rod
111   c/z 4.08432 -11.2243 1.82245 $ fuel
112   c/z 4.08432 -11.2243 1.87325 $ cladding ss-#d11
113   c/z 7.67842 -9.15162 0.3175 $ zr rod
114   c/z 7.67842 -9.15162 1.82245 $ fuel
115   c/z 7.67842 -9.15162 1.87325 $ cladding ss-#d12
116   c/z 10.3454 -5.97408 0.3175 $ zr rod
117   c/z 10.3454 -5.97408 1.82245 $ fuel
118   c/z 10.3454 -5.97408 1.87325 $ cladding ss-#d13
119   c/z 11.7653 -2.2225 0.3175 $ zr rod
120   c/z 11.7653 -2.2225 1.82245 $ fuel
121   c/z 11.7653 -2.2225 1.87325 $ cladding ss-#d14
122   c/z 11.303 2.07264 0.3175 $ zr rod
123   c/z 11.303 2.07264 1.82245 $ fuel
124   c/z 11.303 2.07264 1.87325 $ cladding ss-#d15
125   c/z 10.3454 5.97408 0.3175 $ zr rod
126   c/z 10.3454 5.97408 1.82245 $ fuel
127   c/z 10.3454 5.97408 1.87325 $ cladding ss-#d16
128   c/z 7.67842 9.15162 0.3175 $ zr rod
129   c/z 7.67842 9.15162 1.82245 $ fuel
130   c/z 7.67842 9.15162 1.87325 $ cladding ss-#d17
131   c/z 4.08432 11.2243 0.3175 $ zr rod
132   c/z 4.08432 11.2243 1.82245 $ fuel
133   c/z 4.08432 11.2243 1.87325 $ cladding ss-#d18
134   c/z 0.0 15.9156 0.3175 $ zr rod
135   c/z 0.0 15.9156 1.82245 $ fuel
136   c/z 0.0 15.9156 1.87325 $ cladding ss-#e1
137   c/z -4.11988 15.3721 0.3175 $ zr rod
138   c/z -4.11988 15.3721 1.82245 $ fuel
139   c/z -4.11988 15.3721 1.87325 $ cladding ss-#e2
140   c/z -7.95782 13.782 0.3175 $ zr rod
141   c/z -7.95782 13.782 1.82245 $ fuel
142   c/z -7.95782 13.782 1.87325 $ cladding ss-#e3
143   c/z -11.2547 11.2547 0.3175 $ zr rod
144   c/z -11.2547 11.2547 1.82245 $ fuel
145   c/z -11.2547 11.2547 1.87325 $ cladding ss-#e4
146   c/z -13.782 7.95782 0.3175 $ zr rod
147   c/z -13.782 7.95782 1.82245 $ fuel
148   c/z -13.782 7.95782 1.87325 $ cladding ss-#e5
149   c/z -15.2019 4.20624 0.3175 $ zr rod
```

```
150   c/z -15.2019 4.20624 1.82245 $ fuel
151   c/z -15.2019 4.20624 1.87325 $ cladding ss-#e6
152   c/z -15.2019 0.2413 0.3175 $ zr rod
153   c/z -15.2019 0.2413 1.82245 $ fuel
154   c/z -15.2019 0.2413 1.87325 $ cladding ss-#e7
155   c/z -15.3721 -4.11988 0.3175 $ zr rod
156   c/z -15.3721 -4.11988 1.82245 $ fuel
157   c/z -15.3721 -4.11988 1.87325 $ cladding ss-#e8
158   c/z -13.782 -7.95782 0.3175 $ zr rod
159   c/z -13.782 -7.95782 1.82245 $ fuel
160   c/z -13.782 -7.95782 1.87325 $ cladding ss-#e9
161   c/z -11.2547 -11.2547 0.3175 $ zr rod
162   c/z -11.2547 -11.2547 1.82245 $ fuel
163   c/z -11.2547 -11.2547 1.87325 $ cladding ss-#e10
164   c/z -7.95782 -13.782 0.3175 $ zr rod
165   c/z -7.95782 -13.782 1.82245 $ fuel
166   c/z -7.95782 -13.782 1.87325 $ cladding ss-#e11
167   c/z -4.11988 -15.3721 0.3175 $ zr rod
168   c/z -4.11988 -15.3721 1.82245 $ fuel
169   c/z -4.11988 -15.3721 1.87325 $ cladding ss-#e12
170   c/z 0.0 -15.9156 0.3175 $ zr rod
171   c/z 0.0 -15.9156 1.82245 $ fuel
172   c/z 0.0 -15.9156 1.87325 $ cladding ss-#e13
173   c/z 4.11988 -15.3721 0.3175 $ zr rod
174   c/z 4.11988 -15.3721 1.82245 $ fuel
175   c/z 4.11988 -15.3721 1.87325 $ cladding ss-#e14
176   c/z 7.95782 -13.782 0.3175 $ zr rod
177   c/z 7.95782 -13.782 1.82245 $ fuel
178   c/z 7.95782 -13.782 1.87325 $ cladding ss-#e15
179   c/z 11.2547 -11.2547 0.3175 $ zr rod
180   c/z 11.2547 -11.2547 1.82245 $ fuel
181   c/z 11.2547 -11.2547 1.87325 $ cladding ss-#e16
182   c/z 13.782 -7.95782 0.3175 $ zr rod
183   c/z 13.782 -7.95782 1.82245 $ fuel
184   c/z 13.782 -7.95782 1.87325 $ cladding ss-#e17
185   c/z 15.2019 -4.20624 0.3175 $ zr rod
186   c/z 15.2019 -4.20624 1.82245 $ fuel
187   c/z 15.2019 -4.20624 1.87325 $ cladding ss-#e18
188   c/z 15.2019 -0.2413 0.3175 $ zr rod
189   c/z 15.2019 -0.2413 1.82245 $ fuel
190   c/z 15.2019 -0.2413 1.87325 $ cladding ss-#e19
191   c/z 15.3721 4.11988 0.3175 $ zr rod
192   c/z 15.3721 4.11988 1.82245 $ fuel
193   c/z 15.3721 4.11988 1.87325 $ cladding ss-#e20
194   c/z 13.782 7.95782 0.3175 $ zr rod
195   c/z 13.782 7.95782 1.82245 $ fuel
196   c/z 13.782 7.95782 1.87325 $ cladding ss-#e21
197   c/z 11.2547 11.2547 0.3175 $ zr rod
198   c/z 11.2547 11.2547 1.82245 $ fuel
199   c/z 11.2547 11.2547 1.87325 $ cladding ss-#e22
200   c/z 7.95782 13.782 0.3175 $ zr rod
201   c/z 7.95782 13.782 1.82245 $ fuel
202   c/z 7.95782 13.782 1.87325 $ cladding ss-#e23
203   c/z 4.11988 15.3721 0.3175 $ zr rod
204   c/z 4.11988 15.3721 1.82245 $ fuel
205   c/z 4.11988 15.3721 1.87325 $ cladding ss-#e24
```

```
206     c/z 0.0 19.8196 0.3175 $ zr rod
207     c/z 0.0 19.8196 1.82245 $ fuel
208     c/z 0.0 19.8196 1.87325 $ cladding ss-#f1
211     c/z -4.13512 19.4539 1.87325 $ cladding ss-#f2
212     c/z -8.0899 18.1686 0.3175 $ zr rod
213     c/z -8.0899 18.1686 1.82245 $ fuel
214     c/z -8.0899 18.1686 1.87325 $ cladding ss-#f3
215     c/z -11.6916 16.0909 0.3175 $ zr rod
216     c/z -11.6916 16.0909 1.82245 $ fuel
217     c/z -11.6916 16.0909 1.87325 $ cladding ss-#f4
400     c/z -14.7803 13.3071 0.3175 $ zr rod
401     c/z -14.7803 13.3071 1.82245 $ fuel
218     c/z -14.7803 13.3071 1.87325 $ cladding water -#f5
219     c/z -17.1323 10.1194 0.3175 $ zr rod
220     c/z -17.1323 10.1194 1.82245 $ fuel
221     c/z -17.1323 10.1194 1.87325 $ cladding ss-#f6
222     c/z -18.9154 6.1468 0.3175 $ zr rod
223     c/z -18.9154 6.1468 1.82245 $ fuel
224     c/z -18.9154 6.1468 1.87325 $ cladding ss-#f7
225     c/z -19.9898 2.07772 0.3175 $ zr rod
226     c/z -19.9898 2.07772 1.82245 $ fuel
227     c/z -19.9898 2.07772 1.87325 $ cladding ss-#f8
228     c/z -19.9898 -2.07772 0.3175 $ zr rod
229     c/z -19.9898 -2.07772 1.82245 $ fuel
230     c/z -19.9898 -2.07772 1.87325 $ cladding ss-#f9
231     c/z -18.9154 -6.1468 0.3175 $ zr rod
232     c/z -18.9154 -6.1468 1.82245 $ fuel
233     c/z -18.9154 -6.1468 1.87325 $ cladding ss-#f10
234     c/z -17.4523 -9.9441 0.3175 $ zr rod
235     c/z -17.4523 -9.9441 1.82245 $ fuel
236     c/z -17.4523 -9.9441 1.87325 $ cladding ss-#f11
402     c/z -14.7803 -13.3071 0.3175 $ zr rod
403     c/z -14.7803 -13.3071 1.82245 $ fuel
237     c/z -14.7803 -13.3071 1.87325 $ cladding water -#f12
238     c/z -11.6916 -16.0909 0.3175 $ zr rod
239     c/z -11.6916 -16.0909 1.82245 $ fuel
240     c/z -11.6916 -16.0909 1.87325 $ cladding ss-#f13
241     c/z -8.0899 -18.1686 0.3175 $ zr rod
242     c/z -8.0899 -18.1686 1.82245 $ fuel
243     c/z -8.0899 -18.1686 1.87325 $ cladding ss-#f14
244     c/z -4.13512 -19.4539 0.3175 $ zr rod
245     c/z -4.13512 -19.4539 1.82245 $ fuel
246     c/z -4.13512 -19.4539 1.87325 $ cladding ss-#f15
247     c/z 0.0 -19.8882 0.3175 $ zr rod
248     c/z 0.0 -19.8882 1.82245 $ fuel
249     c/z 0.0 -19.8882 1.87325 $ cladding ss-#f16
c 250     c/z 4.13512 -19.4539 0.3175 $ zr rod
c 251     c/z 4.13512 -19.4539 1.82245 $ fuel
252     c/z 4.13512 -19.4539 1.87325 $ h20-#f17
c 253     c/z 8.0899 -18.1686 0.3175 $ zr rod
254     c/z 8.0899 -18.1686 1.82245 $ fuel
255     c/z 8.0899 -18.1686 1.87325 $ cladding ss-#f18
c 256     c/z 11.6916 -16.0909 0.3175 $ zr rod
257     c/z 11.6916 -16.0909 1.82245 $ fuel
258     c/z 11.6916 -16.0909 1.87325 $ cladding ss-#f19
405     c/z 14.7803 -13.3071 1.82245 $ fuel
```

```
259     c/z 14.7803 -13.3071 1.87325 $ cladding water -#f20
261     c/z 17.1323 -10.1194 1.82245 $ fuel
262     c/z 17.1323 -10.1194 1.87325 $ cladding ss-#f21
264     c/z 18.9154 -6.1468 1.82245 $ fuel
265     c/z 18.9154 -6.1468 1.87325 $ cladding ss-#f22
267     c/z 19.9898 -2.07772 1.82245 $ fuel
268     c/z 19.9898 -2.07772 1.87325 $ cladding ss-#f23
c 269     c/z 19.9898 2.07772 0.3175 $ zr rod
270     c/z 19.9898 2.07772 1.82245 $ fuel
271     c/z 19.9898 2.07772 1.87325 $ cladding ss-#f24
273     c/z 18.9154 6.1468 1.82245 $ fuel
274     c/z 18.9154 6.1468 1.87325 $ cladding ss-#f25
276     c/z 17.4523 9.9441 1.82245 $ fuel
277     c/z 17.4523 9.9441 1.87325 $ cladding ss-#f26
407     c/z 14.7803 13.3071 1.82245 $ fuel
278     c/z 14.7803 13.3071 1.87325 $ cladding water -#f27
c 279     c/z 11.6916 16.0909 0.3175 $ zr rod
c 280     c/z 11.6916 16.0909 1.82245 $ fuel
281     c/z 11.6916 16.0909 1.87325 $ h20-#f28
c 282     pz 15.24 $ segment bottom1
c 283     pz 11.43 $ segment bottom2
c 284     pz 7.62 $ segment bottom3
c 285     pz 3.81 $ segment bottom4
c 286     pz 0.0 $ segment bottom5
c 287     pz -3.81 $ segment bottom6
c 288     pz -7.62 $ segment bottom7
c 289     pz -11.43 $ segment bottom8
c 290     pz -15.24 $ segment bottom9
c 291     c/z 8.0899 18.1686 0.3175 $ zr rod
c 292     c/z 8.0899 18.1686 1.82245 $ fuel
293     c/z 8.0899 18.1686 1.87325 $ h20-#f29
294     c/z 4.13512 19.4539 0.3175 $ zr rod
295     c/z 4.13512 19.4539 1.82245 $ fuel
296     c/z 4.13512 19.4539 1.87325 $ cladding ss-#f30
297     c/z 0.0 23.8608 1.82245 $ graph
298     c/z 0.0 23.8608 1.87325 $ cladding gr-#g1
299     c/z -4.14274 23.4975 1.82245 $ graph
300     c/z -4.14274 23.4975 1.87325 $ cladding gr-#g2
301     c/z -8.16102 22.4206 1.82245 $ graph
302     c/z -8.16102 22.4206 1.87325 $ cladding gr-#g3
303     c/z -11.9304 20.6654 1.82245 $ graph
304     c/z -11.9304 20.6654 1.87325 $ cladding gr-#g4
305     c/z -15.3365 18.2778 1.82245 $ graph
306     c/z -15.3365 18.2778 1.87325 $ cladding gr-#g5
307     c/z -18.2778 15.3365 1.82245 $ graph
308     c/z -18.2778 15.3365 1.87325 $ h20-#g6
c 308     c/z -18.2778 15.3365 1.87325 $ cladding gr-#g6
c 309     c/z -20.6654 11.9304 1.82245 $ graph
309     c/z -20.6654 11.9304 0.3175 $ zr rod
c 310     c/z -20.6654 11.9304 1.87325 $ cladding gr-#g7
10000   c/z -20.6654 11.9304 1.82245 $ fuel
310     c/z -20.6654 11.9304 1.87325 $ cladding water -#g7
c 311     c/z -22.606 8.0772 1.82245 $ graph
311     c/z -22.606 8.0772 0.3175 $ zr rod
10001   c/z -22.606 8.0772 1.82245 $ fuel
312     c/z -22.606 8.0772 1.87325 $ cladding gr-#g8
```

```
313     c/z -23.4975 4.14274 0.3175 $ zr rod
10002    c/z -23.4975 4.14274 1.82245 $ fuel
314     c/z -23.4975 4.14274 1.87325 $ cladding gr-#g9
408     c/z -23.8608 0.0 0.3175 $ zr rod
409     c/z -23.8608 0.0 1.82245 $ fuel
315     c/z -23.8608 0.0 1.87325 $ cladding water -#g10
410     c/z -23.4975 -4.14274 0.3175 $ zr rod
411     c/z -23.4975 -4.14274 1.82245 $ fuel
316     c/z -23.4975 -4.14274 1.87325 $ cladding water -#g11
412     c/z -22.4206 -8.16102 0.3175 $ zr rod
413     c/z -22.4206 -8.16102 1.82245 $ fuel
317     c/z -22.4206 -8.16102 1.87325 $ cladding water -#g12
414     c/z -20.6654 -11.9304 0.3175 $ zr rod
415     c/z -20.6654 -11.9304 1.82245 $ fuel
318     c/z -20.6654 -11.9304 1.87325 $ cladding water -#g13
c 416    c/z -18.2778 -15.3365 0.3175 $ zr rod
c 417    c/z -18.2778 -15.3365 1.82245 $ fuel
319     c/z -18.2778 -15.3365 1.87325 $ h20 -#g14
c 418    c/z -15.3365 -18.2778 0.3175 $ zr rod
c 419    c/z -15.3365 -18.2778 1.82245 $ fuel
320     c/z -15.3365 -18.2778 1.87325 $ h20 -#g15
c 420    c/z -11.9304 -20.6654 0.3175 $ zr rod
321     c/z -11.9304 -20.6654 1.82245 $ graph
322     c/z -11.9304 -20.6654 1.87325 $ cladding gr-#g16
323     c/z -7.93242 -22.4206 1.82245 $ graph
324     c/z -7.93242 -22.4206 1.87325 $ cladding gr-#g17
325     c/z -4.14274 -23.4975 1.82245 $ graph
326     c/z -4.14274 -23.4975 1.87325 $ cladding gr-#g18
327     c/z 0.0 -23.8608 1.82245 $ graph
328     c/z 0.0 -23.8608 1.87325 $ cladding gr-#g19
329     c/z 4.14274 -23.4975 1.82245 $ graph
330     c/z 4.14274 -23.4975 1.87325 $ cladding gr-#g20
c 331    c/z 8.16102 -22.4206 1.82245 $ graph
332     c/z 8.16102 -22.4206 1.87325 $ h20-#g21
333     c/z 11.9304 -20.6654 1.87325 $ cladding water -#g22
334     c/z 15.3365 -18.2778 1.87325 $ cladding water -#g23
335     c/z 18.2778 -15.3365 1.87325 $ cladding water -#g24
336     c/z 20.6654 -11.9304 1.87325 $ cladding water -#g25
337     c/z 22.606 -8.0772 1.87325 $ cladding water -#g26
338     c/z 23.4975 -4.14274 1.87325 $ cladding water -#g27
339     c/z 23.8608 0.0 1.87325 $ cladding water -#g28
341     c/z 23.4975 4.14274 1.87325 $ cladding gr-#g29
343     c/z 22.4206 8.16102 1.87325 $ cladding gr-#g30
345     c/z 20.6654 11.9304 1.87325 $ cladding gr-#g31
347     c/z 18.2778 15.3365 1.87325 $ cladding gr-#g32
349     c/z 15.3365 18.2778 1.87325 $ cladding gr-#g33
350     c/z 11.9304 20.6654 1.82245 $ graph
351     c/z 11.9304 20.6654 1.87325 $ cladding gr-#g34
352     c/z 7.93242 22.4206 1.82245 $ graph
353     c/z 7.93242 22.4206 1.87325 $ cladding gr-#g35
354     c/z 4.14274 23.4975 1.82245 $ graph
355     c/z 4.14274 23.4975 1.87325 $ cladding gr-#g36
701     cz 53.815 $ water gap
702     cz 56.46 $ cylinder of Al
703     cz 59.0 $ outer cylinder of Al
601     pz 60.96 $ top of TC
```

```
602   pz 59.691 $ b4c top of TC
603   pz 59.373 $ Al top of TC
604   pz -59.373 $ Al bottom of TC
605   pz -59.691 $ b4c bottom of TC
606   pz -60.96 $ bottom of TC
607   px 60.96 $ right side of TC
608   px 59.691 $ b4c right of TC
609   px 59.373 $ Al right of TC
610   px -59.373 $ Al left of TC
611   px -59.691 $ b4c left of TC
612   px -60.96 $ left side of TC
613   p 0 13.38 0 0 13.38 1 -60.96 63.623 0 $ left outer angle of TC
614   p 0 13.8 0 0 13.8 1 -59.373 63.623 0 $ left inner angle of TC
615   p 0 13.38 0 0 13.38 1 60.96 63.623 0 $ right outer angle of TC
616   p 0 13.8 0 0 13.8 1 59.373 63.623 0 $ right inner angle of TC
617   py 0.0 $ center line
618   py 219.405 $ front of region N
619   py 63.623 $ back of region A
620   py 97.485 $ back of TC void
621   px 10.160 $ side of TC void
622   px -10.160 $ side of TC void
623   pz -10.160 $ bottom of TC void
624   pz 10.160 $ top of TC void
625   py 98.485 $ Sample position for TC
626   py 99.485 $ Sample position for TC
627   py 100.485 $ Sample position for TC
628   py 101.485 $ Sample position for TC
629   py 102.485 $ Sample position for TC
630   py 103.485 $ Sample position for TC
631   py 104.485 $ Sample position for TC
632   py 105.485 $ Sample position for TC
633   py 106.485 $ Sample position for TC
634   py 107.485 $ Sample position for TC
635   py 108.485 $ Sample position for TC
636   py 109.485 $ Sample position for TC
637   py 110.485 $ Sample position for TC
638   py 111.485 $ Sample position for TC
639   py 112.485 $ Sample position for TC
640   py 113.485 $ Sample position for TC
641   py 114.485 $ Sample position for TC
642   py 115.485 $ Sample position for TC
643   py 116.485 $ Sample position for TC
644   py 117.485 $ Sample position for TC
646   px 0.5 $ side of sample voids
647   px -0.5 $ side of sample voids
648   pz 0.5 $ top of sample voids
649   pz -0.5 $ bottom osample voids
650   px -9.160 $ 1 cm from TC void wall
830   pz 5.08 $ top of inner region
831   pz -5.08 $ bottom of inner region
833   1 px -27.4105 $ al pipe bp4
834   1 py 8.7313 $ al pipe bp3
835   1 cx 8.4138 $ outer radius al pipe bp4
838   2 cy 8.4138 $ outer radius al pipe bp3
868   px 0 $ center line
871   pz 30.48 $ top of thermalizing column
```

```
872    pz 29.211 $ b4c top of thermalizing column
873    pz 28.893 $ Al top of thermalizing column
874    pz -28.893 $ Al bottom of thermalizing column
875    pz -29.211 $ b4c bottom of thermalizing column
876    pz -30.48 $ bottom of thermalizing column
877    px 30.48 $ right side of thermalizing column
878    px 29.211 $ b4c right of thermalizing column
879    px 28.893 $ Al right of thermalizing column
880    px -28.893 $ Al left of thermalizing column
881    px -29.211 $ b4c left of thermalizing column
882    px -30.48 $ left side of thermalizing column
883    py -67.95 $ front lead block in thermalizing column
884    py -73.03 $ back lead block in thermalizing column
885    py -93.35 $ air block in thermalzing column
886    py -113.67 $ end of graphite in thermalizing column
889    cz 98.425 $ inner radius of reactor tank
890    cz 99.06 $ outer radius of reactor tank
837    2 cy 7.62 $ inner radius al pipe bp3
839    2 cy 10.16 $ inner radius steel pipe bp3
840    2 cy 10.9538 $ outer radius steel pipe bp3
895    2 cy 4.0 $ appature hole
842    1 py 9.0488 $ al pipe bp3
865    2 py 24.2888 $ plane for water flooding
896    2 py 26.8288 $ plane for appature
843    2 py 29.1313 $ al pipe bp3
844    2 py 49.5313 $ al pipe bp3
845    2 py 69.9313 $ al pipe bp3
846    2 py 90.3313 $ al pipe bp3
847    2 py 110.7313 $ al pipe bp3
848    2 py 131.1313 $ end of al pipe bp3
849    2 py 131.7663 $ al plate bp3
850    2 py 132.4013 $ steel plate bp3
860    2 py 136.9413 $ Bi filter
851    2 py 152.6813 $ steel pipe bp3
852    2 py 172.9613 $ steel pipe bp3
853    2 py 193.2413 $ steel pipe bp3
854    2 py 213.5213 $ steel pipe bp3
855    2 py 233.8013 $ steel pipe bp3
856    2 py 254.0813 $ steel pipe bp3
857    2 py 274.3613 $ steel pipe bp3
858    2 py 294.6413 $ end of steel pipe bp3
836    1 cx 8.02 $ inner radius Al pipe bp4
800    1 cx 10.16 $ inner radius steel pipe bp4
801    1 cx 10.9538 $ outer radius steel pipe bp4
899    1 px -27.628 $ Al pipe bp4
900    1 px -53.9276 $ Al pipe bp4
901    1 px -80.2272 $ Al pipe bp4
902    1 px -105.8918 $ end of Al pipe bp4
903    1 px -106.5268 $ Al plate of bp4
904    1 px -107.1618 $ steel plate bp4
905    1 px -132.8793 $ steel pipe bp4
906    1 px -158.5968 $ steel pipe bp4
907    1 px -184.3143 $ steel pipe bp4
908    1 px -210.0318 $ steel pipe bp4
909    1 px -235.7493 $ steel pipe bp4
1000   1 px -261.4668 $ end of steel pipe bp4
```

```
1001    c/z 5.06691 31.99123 1.143 $ lazy susan rack
1002    c/z 10.00906 30.80472 1.143 $ lazy susan rack
1003    c/z 14.70475 28.8597 1.143 $ lazy susan rack
1004    c/z 19.03836 26.20406 1.143 $ lazy susan rack
1005    c/z 22.90319 22.90319 1.143 $ lazy susan rack
1006    c/z 26.20406 19.03836 1.143 $ lazy susan rack
1007    c/z 28.8597 14.70475 1.143 $ lazy susan rack
1008    c/z 30.80472 10.00906 1.143 $ lazy susan rack
1009    c/z 31.99123 5.066912 1.143 $ lazy susan rack
1010    c/z 32.39 0 1.143 $ lazy susan rack
1011    c/z 31.99123 -5.06691 1.143 $ lazy susan rack
1012    c/z 30.80472 -10.0091 1.143 $ lazy susan rack
1013    c/z 28.8597 -14.7048 1.143 $ lazy susan rack
1014    c/z 26.20406 -19.0384 1.143 $ lazy susan rack
1015    c/z 22.90319 -22.9032 1.143 $ lazy susan rack
1016    c/z 19.03836 -26.2041 1.143 $ lazy susan rack
1017    c/z 14.70475 -28.8597 1.143 $ lazy susan rack
1018    c/z 10.00906 -30.8047 1.143 $ lazy susan rack
1019    c/z 5.066912 -31.9912 1.143 $ lazy susan rack
1020    c/z 0 -32.39 1.143 $ lazy susan rack
1021    c/z -5.06691 -31.9912 1.143 $ lazy susan rack
1022    c/z -10.0091 -30.8047 1.143 $ lazy susan rack
1023    c/z -14.7048 -28.8597 1.143 $ lazy susan rack
1024    c/z -19.0384 -26.2041 1.143 $ lazy susan rack
1025    c/z -22.9032 -22.9032 1.143 $ lazy susan rack
1026    c/z -26.2041 -19.0384 1.143 $ lazy susan rack
1027    c/z -28.8597 -14.7048 1.143 $ lazy susan rack
1028    c/z -30.8047 -10.0091 1.143 $ lazy susan rack
1029    c/z -31.9912 -5.06691 1.143 $ lazy susan rack
1030    c/z -32.39 0 1.143 $ lazy susan rack
1031    c/z -31.9912 5.066912 1.143 $ lazy susan rack
1032    c/z -30.8047 10.00906 1.143 $ lazy susan rack
1033    c/z -28.8597 14.70475 1.143 $ lazy susan rack
1034    c/z -26.2041 19.03836 1.143 $ lazy susan rack
1035    c/z -22.9032 22.90319 1.143 $ lazy susan rack
1036    c/z -19.0384 26.20406 1.143 $ lazy susan rack
1037    c/z -14.7048 28.8597 1.143 $ lazy susan rack
1038    c/z -10.0091 30.80472 1.143 $ lazy susan rack
1039    c/z -5.06691 31.99123 1.143 $ lazy susan rack
1040    c/z 0 32.39 1.143 $ lazy susan rack
1041    1 cx 18.4138 $ concrete surrounded al clad bp4
1042    2 cy 18.4138 $ concrete surrounded al clad bp3
1043    1 cx 20.9538 $ concrete surrounded steel clad bp4
1044    2 cy 20.9538 $ concrete surrouned steel clad bp3
1045    pz -15.24 $ 1 cm above the bottom of rabbit sample position
1046    pz -16.24 $ bottom of rabbit sample position
c --------added surfaces for 1 cm segments in the lazy susan----------
1047    pz 7.0325 $ 1 cm above the bottom of the lazy susan sample position
1048    pz 8.0325 $ 2 cm above the bottom of the lazy susan
1049    pz 9.0325 $ 3 cm above the bottom of the lazy susan
1050    pz 10.0325 $ 4 cm above the bottom of the lazy susan
1051    pz 11.0325 $ 5 cm above the bottom of the lazy susan
1052    pz 12.0325 $ 6 cm above the bottom of the lazy susan
1053    pz 13.0325 $ 7 cm above the bottom of the lazy susan
1054    pz 14.0325 $ 8 cm above the bottom of the lazy susan
1055    pz 15.0325 $ 9 cm above the bottom of the lazy susan
```

```
1056    pz 16.0325 $ 10 cm above the bottom of the lazy susan
c ---------------------------------------------------------
1090    pz -0.6212 $ transient rod position
1091    pz 0.47493 $ shim rod position
1092    pz 0.28745 $ safety rod position
1093    pz 1.59426 $ regulating rod position
c --------added surfaces HHL ----------------------------
2000    pz 8.070375 $ plane for lazy susan axial segment
2001    pz 9.10825
2002    pz 10.14613
2003    pz 11.184
2004    pz 12.22188
2005    pz 13.25975
2006    pz 14.29763
2007    pz 15.3355
2008    pz 16.37338
2009    pz 17.41125
2010    pz 18.44913
2011    pz 19.487
2012    pz 20.52488
2013    pz 21.56275
2014    pz 22.60063
2015    pz 23.6385
2016    pz 24.67638
2017    pz 25.71425
2018    pz 26.75213
c --------add radial segment for Lazy Susan-------------------
3000    c/z 32.39 0 0.05715
3001    c/z 32.39 0 0.11430
3002    c/z 32.39 0 0.17145
3003    c/z 32.39 0 0.22860
3004    c/z 32.39 0 0.28575
3005    c/z 32.39 0 0.34290
3006    c/z 32.39 0 0.40005
3007    c/z 32.39 0 0.45720
3008    c/z 32.39 0 0.51435
3009    c/z 32.39 0 0.57150
3010    c/z 32.39 0 0.62865
3011    c/z 32.39 0 0.68580
3012    c/z 32.39 0 0.74295
3013    c/z 32.39 0 0.80010
3014    c/z 32.39 0 0.85725
3015    c/z 32.39 0 0.91440
3016    c/z 32.39 0 0.97155
3017    c/z 32.39 0 1.02870
3018    c/z 32.39 0 1.08585
c added surfaces to divide #b1 into 1 cm axial segments
4000    pz -26.86
4001    pz -25.86
4002    pz -24.86
4003    pz -23.86
4004    pz -22.86
4005    pz -21.86
4006    pz -20.86
4007    pz -19.86
4008    pz -18.86
```

```
4009    pz -17.86
4010    pz -16.86
4011    pz -15.86
4012    pz -14.86
4013    pz -13.86
4014    pz -12.86
4015    pz -11.86
4016    pz -10.86
4017    pz -09.86
4018    pz -08.86
4019    pz -07.86
4020    pz -06.86
4021    pz -05.86
4022    pz -04.86
4023    pz -03.86
4024    pz -02.86
4025    pz -01.86
4026    pz -00.86
4027    pz 00.14
4028    pz 01.14
4029    pz 02.14
4030    pz 03.14
4031    pz 04.14
4032    pz 05.14
4033    pz 06.14
4034    pz 07.14
4035    pz 08.14
4036    pz 09.14
4037    pz 10.14
4038    pz 11.14
4039    pz 12.14
c surface cards for lead block
5000    2 py 478.0 $ start of lead
5001    2 py 508.48 $ end of lead
5002    2 py 630.4 $ end of concrete
5003    2 px 40.0 $ right side of slab
5004    2 px -40.0 $ left side of slab
5005    2 py 472.0 $ front of detector volume
5006    2 py 636.4 $ back of detector volume
5007    2 px 161.92 $ north side of shield
5008    2 px -161.92 $ south side of shield
5009    2 px 29.84 $ north lead
5010    2 px -29.84 $ south lead
5011    2 py 396.72 $ start of lead
5012    2 py 406.88 $ lead lip
5013    2 px 9.52 $ north lead lip
5014    2 px -9.52 $ south lead lip
5015    2 py 447.52 $ start of masonite
5016    2 px 19.68 $ north masonite
5017    2 px -19.68 $ south masonite
5018    2 py 417.04 $ masonite lip
5019    2 px 167.0 $ north detectors
5020    2 px -167.0 $ south detectors
5021    2 py 391.64 $ front detector

*tr1    0 0 -6.985 27 63 90 117 27 90 90 90 0
```

```
*tr2    -36.49 -9.37 -6.985 40 50 90 130 40 90 90 90 0
m1      13027 1.0 $ al
m2      6012 0.00009456 24000 0.005187 28000 0.00241866 26000  $ steel/h2o
        0.0180264 1001 0.04676 8016 0.02338
m4      6012 1.0 $ graphite
mt4     grph.01t $ graphite  salphabeta card
m5      82000 1.0 $ lead
m6      1001 0.6667 8016 0.3333 $ h2o
mt6     lwtr.01t $ h2o  salphabeta card
m7      6012 0.00031519 24000 0.01729 28000 0.0080622 26000 0.060088 $ steel
m8      40000.35c 1.0 $ zr
m9      1001 0.0561382 40000.35c 0.0350864  92235 0.000892797 92238  $ uzrh-full
        0.000378151 68166 0.000258324  68167 0.0000769439
mt9     h/zr.01t zr/h.01t $ uzrh-full  salphabeta card
m10     5010 0.15824 5011 0.64176 6012 0.2 $ b4c
m12     1001 0.04666 40000.35c 0.02916 92235 0.000753 92238 0.000323  $ uzrh-partial
        68166 0.000267 68167 0.000080
mt12    h/zr.01t zr/h.01t $ uzrh-partial  salphabeta card
c m13     83209 1.0  $ Bi
c m14     1001 2.0 6012 1.0 $ CH2
c m15     79197 1.0
m16     26000 1.0 $ steel
m18     1001 -0.010 8016 -0.529 11023 -0.016 12000 -0.002
        13027 -0.034 14000 -0.337 19000 -0.013 20000 -0.044
        26000 -0.014 6012 -0.001 $ concrete
m19     7014 0.79 8016 0.21 $ air
m20     48000 1.0 $ natural cad
c m21     79197.60c 1.0 $ gold
ksrc    4.24164 1.37398 0.0 3.19516 -2.54016 0.0 -0.71898 -3.58664 0.0
       -3.58664 -0.71898 0.0 -2.54016 3.19516 0.0 1.37398 4.24164 0.0
        8.30818 0.3275 0.0 7.23884 -3.66284 0.0 4.31784 -6.58384 0.0
       -3.66284 -6.58384 0.0 -6.58384 -3.66284 0.0 -7.65318 0.3275 0.0
       -6.58384 4.31784 0.0 -3.66284 7.23884 0.0 0.3275 8.30818 -4.405
        4.31784 7.23884 0.0 7.23884 4.31784 0.0 12.2731 0.3275 -4.405
        11.5518 -3.75682 0.0 9.47912 -7.35092 0.0 6.30158 -10.0179 0.0
        2.55 -11.4378 0.0 -1.74514 -10.9755 0.0 -5.64658 -10.0179 0.0
       -8.82412 -7.35092 0.0 -10.8968 -3.75682 0.0 -11.6181 0.3275
       -4.405 -10.8968 4.41182 0.0 -8.82412 8.00592 0.0 -5.64658
        10.6729 0.0 -1.895 12.0928 0.0 2.40014 11.6305 0.0 6.30158
        10.6729 0.0 9.47912 8.00592 0.0 11.5518 4.41182 0.0 16.2431
        0.3275 0.0 15.6996 -3.79238 0.0 14.1095 -7.63032 0.0 11.5822
       -10.9272 0.0 8.28532 -13.4545 0.0 4.53374 -14.8744 0.0 0.5688
       -14.8744 0.0 -3.79238 -15.0446 0.0 -7.63032 -13.4545 0.0
       -10.9272 -10.9272 0.0 -13.4545 -7.63032 0.0 -15.0446 -3.79238
        0.0 -15.5881 0.3275 0.0 -15.0446 4.44738 0.0 -13.4545 8.28532
        0.0 -10.9272 11.5822 0.0 -7.63032 14.1095 0.0 -3.87874 15.5294
        0.0 0.0862 15.5294 0.0 4.44738 15.6996 0.0 8.28532 14.1095 0.0
        11.5822 11.5822 0.0 14.1095 8.28532 0.0 15.6996 4.44738 0.0
        20.1471 0.3275 0.0 19.7814 -3.80762 0.0 18.4961 -7.7624 0.0
        16.4184 -11.3641 0.0 10.4469 -16.8048 0.0 6.4743 -18.5879 0.0
        2.40522 -19.6623 0.0 -1.75022 -19.6623 0.0 -5.8193 -18.5879 0.0
       -9.6166 -17.1248 0.0 -15.7634 -11.3641 0.0 -17.8411 -7.7624 0.0
       -19.1264 -3.80762 0.0 -19.5607 0.3275 0.0 -19.1264 4.46262 0.0
       -17.8411 8.4174 0.0 -15.7634 12.0191 0.0 -9.79186 17.4598 0.0
       -5.8193 19.2429 0.0 -1.75022 20.3173 0.0 2.40522 20.3173 0.0
        6.4743 19.2429 0.0 10.2716 17.7798 0.0 18.4961 8.4174 0.0
```

```
      19.7814 4.46262 0.0 -15.1803 13.3071 0.0 -15.1803 -13.3071 0.0
      -24.2608 0.0 0.0 -23.8975 -4.14274 0.0 -21.0654 -11.9304 0.0
      -18.6778 -15.3365 0.0 -15.8365 -18.2778 0.0 -12.3304 -20.6654 0.0
mode    n p $  card
kcode   10000 1.0 50 5000 $ kcode card
c ssw    847 (-1016)
dbcn    12j 764585 4j $ random number stride is 5 time of 152917 (default)
esplt:n  2 0.1 2 0.001 2 0.0001 2 0.000001 0.75 5e-7 $ split energy
c -----------Tally for lazy susan in 1 cm segment at the bottom--------
c f2:n    843 844 900 901 $ surface tally around 1013 and 1049
c f4:n    1013 1049 $ flux in BP3 and BP4
c f4:n    1027 50022 50005 50025 50028
c f14:p   1027 50022 50005 50025 50028
c f14:n   5001 38i 5040 T $ dose over lazy susan cells
c -----------Tally for lazy susan in axial and radial segment------
c f24:n     8001 38i 8040 T $ Activity in #b1
f34:n   6000 38i 6039 T $ flux in LS bottom
f144:n  6040 38i 6079 T $ flux 1 cm from bottom
f154:n  6080 38i 6119 T $ flux 1 cm from bottom
f164:n  6120 38i 6159 T $ flux 1 cm from bottom
f174:n  6160 38i 6199 T $ flux 1 cm from bottom
f184:n  6200 38i 6239 T $ flux 1 cm from bottom
f194:n  6240 38i 6279 T $ flux 1 cm from bottom
f204:n  6280 38i 6319 T $ flux 1 cm from bottom
f214:n  6320 38i 6359 T $ flux 1 cm from bottom
f224:n  6360 38i 6399 T $ flux 1 cm from bottom
c f44:n   7001 18i 7020 T $ radial flux in lazy susan----------HHL
c f54:n   7001 18i 7020 T $ radial dose in lazy susan----------HHL
c ------------Tally for beam port 3 and beam port 4----------------
c f64:n   1011 5i 1017 T $ flux in beamport 3 cells
c f74:n   1011 5i 1017 T $ dose in beamport 3 cells
c f4:n    1016 1017 1020 1021 $ flux in beamport 3 cells
c f14:n   1016 1017 1020 1021 $ dose in beamport 3 cells
c f24:p   1016 1017 1020 1021 $ flux in beamport 3 cells
c f34:p   1016 1017 1020 1021 $ dose in beamport 3 cells
c ------------Tally Thermal Column---------------------------------
f104:n  16021 18i 16040 T $ axial flux through center of TC void
f114:n  16044 18i 16063 T $ axial flux along TC void wall
c ------------Tally for clicit-------------------------------------
f124:n  8001 38i 8040 T $ radial flux through the icit
c ------------Tally for Rabbit-------------------------------------
f134:n  9010 29i 9040 T $ radial flux through Rabbit
c -------------Area card-------------------------------------------
area    380j 222.39972 222.39972 5598.01919 6932.31709 19j
      6278.28760 10438.01448 11253.53573 182.41469 182.41469 182.41469
      182.41469 182.41469 182.41469 182.41469
      324.29279 324.29279 324.29279 324.29279 324.29279
      324.29279 324.29279 324.29279 324.29279 324.29279
      5336.00917 9931.46659 10707.41129
      202.06849 202.06849 202.06849 202.06849
      324.29279 324.29279 324.29279 324.29279
      324.29279 324.29279 324.29279 324.29279
      40j 790.42093 3710.56338 20482.47683 21527.17202 3j
      325.3307 312.7792 314.9260 299.9619 19j 19j
c -------- same neutron spectrum in LAZY SUSAN--------------------------
e0      1.000e-10 1.000e-09 1.000e-08 2.300e-08 5.000e-08 7.600e-08
```

```
      1.150e-07 1.700e-07 2.550e-07 3.800e-07 5.500e-07 8.400e-07
      1.275e-06 1.900e-06 2.800e-06 4.250e-06 6.300e-06 9.200e-06
      1.350e-05 2.100e-05 3.000e-05 4.500e-05 6.900e-05 1.000e-04
      1.350e-04 1.700e-04 2.200e-04 2.800e-04 3.600e-04 4.500e-04
      5.750e-04 7.600e-04 9.600e-04 1.275e-03 1.600e-03 2.000e-03
      2.700e-03 3.400e-03 4.500e-03 5.500e-03 7.200e-03 9.200e-03
      1.200e-02 1.500e-02 1.900e-02 2.550e-02 3.200e-02 4.000e-02
      5.250e-02 6.600e-02 8.800e-02 1.100e-01 1.350e-01 1.600e-01
      1.900e-01 2.200e-01 2.550e-01 2.900e-01 3.200e-01 3.600e-01
      4.000e-01 4.500e-01 5.000e-01 5.500e-01 6.000e-01 6.600e-01
      7.200e-01 7.800e-01 8.400e-01 9.200e-01 1.000e+00 1.200e+00
      1.400e+00 1.600e+00 1.800e+00 2.000e+00 2.300e+00 2.600e+00
      2.900e+00 3.300e+00 3.700e+00 4.100e+00 4.500e+00 5.000e+00
      5.500e+00 6.000e+00 6.700e+00 7.400e+00 8.200e+00 9.000e+00
      1.000e+01 1.100e+01 1.200e+01 1.300e+01 1.400e+01 1.500e+01
      1.600e+01 1.700e+01 1.800e+01 1.900e+01
c -------dose conversion for axial and radial distribution of the lazy susan
c de14    2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1
c       5.0e-1 1 2.0 5.0 10.0 20.0
c df14    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6
c       2.08e-5 7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de34   0.01 0.03 0.05 0.07 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55
c      0.6 0.65 0.7 0.8 1.0 1.4 1.8 2.2 2.6 2.8 3.25 3.75 4.25 4.75 5.0
c      5.25 5.75 6.25 6.75 7.5 9.0 11.0 13.0 15.0
c df34   3.96e-6 5.82e-7 2.9e-7 2.58e-7 2.83e-7 3.79e-7 5.01e-7 6.31e-7
c     7.59e-7 8.78e-7 9.85e-7 1.08e-6 1.17e-6 1.27e-6 1.36e-6 1.44e-6
c      1.52e-6 1.68e-6 1.98e-6 2.51e-6 2.99e-6 3.42e-6 3.82e-6 4.01e-6
c      4.41e-6 4.83e-6 5.23e-6 5.6e-6 5.8e-6 6.01e-6 6.37e-6 6.74e-6
c      7.11e-6 7.66e-6 8.77e-6 1.03e-5 1.18e-5 1.33e-5
c de34    2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
c      2.0   5.0   10.0   20.0
c df34    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c       7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de54    2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
c      2.0   5.0   10.0   20.0
c df54    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c      7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de74    2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
c      2.0   5.0   10.0   20.0
c df74    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c      7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de94    2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
c      2.0   5.0   10.0   20.0
c df94    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c      7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c ---------------------------------------------------------------------
c fm2     8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm4     8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm14    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm24      (6.76166e8 21 -2) $ multiplier card (normalize factor)
c fm24    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm34    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
```

```
c fm54    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm64    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm74    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm84    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm94    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm104   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm114   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm124   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm134   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm144   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm154   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm164   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm174   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm184   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm194   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm204   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm214   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm224   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
cut:n   j 0
c print
prdmp   0 -30 1 1
imp:n   0 38r 1 1208r
```

ICIT CORE

```
1 OSU TRIGA Reactor flux in icit, lazy susan, rabbit, and thermal column
c void
13000   0 1 $ void outside reactor
13001   0 -1 601 $ void above reactor
13002   0 -1 -606 $ void below reactor
13003   0 -1 -1000 -858 606 -601 $ void outside bp4
13005   0 877 -617 890 -601 606 886 -1 $ right side outside reactor
13006   0 -877 882 -601 871 890 -617 886 $ above thermalizing column
13007   0 -877 882 -876 606 890 -617 886 $ below thermalizing column
13008   0 -882 -617 890 -601 606 886 1041 902 $ left side outside reactor
13010   0 -1 -886 902 -601 606 $ left of thermalizing column
13012   0 -612 617 890 1042 -601 606 -848 -618 $ left side outside reactor
13013   0 607 617 -618 890 -601 606 -1 $ right side outside reactor
13014   0 -612 848 1044 -858 617 -618 -601 606 1000 $ outside reactor bp3
13015   0 -902 1043 1000 -617 -601 606 -1 $ outside reactor bp4
13016   0 618 612 -607 -601 606 -1 $ outside TC
13017   0 618 607 -601 606 -1 $ outside TC
13018   0 618 -612 1044 -858 617 -601 606 -1 $ around bp3
c 13011   0 -1 -5020 858 -601 606 $  air south of slab
c 13100   0 -1 5019 858 -601 606 -612 $ air north of slab
20004   0 701 -889 617 -615 -601 606 $ 1st quadrant
20006   0 701 -889 -617 877 -601 606 $ 2nd quadrant
1052    0 -800 -903 904 $ steel plate bp4
1053    0 -800 -904 905 $ steel pipe bp4
1054    0 -800 -905 906 $ steel pipe bp4
1055    0 -800 -906 907 $ steel pipe bp4
1056    0 -800 -907 908 $ steel pipe bp4
1057    0 -800 -908 909 $ steel pipe bp4
2051    0 800 -801  -902 903 $ steel cladding bp4
2053    0 800 -801  -904 905 $ steel cladding bp4
```

```
2054    0 800 -801  -905 906 $ steel cladding bp4
2055    0 800 -801  -906 907 $ steel cladding bp4
2056    0 800 -801  -907 908 $ steel cladding bp4
2057    0 800 -801  -908 909 $ steel cladding bp4
14003   0 801 -1043 -904 905 -617 $ concrete around steel clad bp4
14004   0 801 -1043 -905 906 -617 $ concrete around steel clad bp4
14005   0 801 -1043 -906 907 -617 $ concrete around steel clad bp4
14006   0 801 -1043 -907 908 -617 $ concrete around steel clad bp4
14007   0 801 -1043 -908 909 -617 $ concrete around steel clad bp4
1058    0 -800 -909 1000 $ end of steel pipe bp4
2058    0 800 -801  -909 1000 $ end of steel cladding bp4
14008   0 801 -1043 -909 1000 -617 $ end of concrete around clad bp4
c 50008   0 -5007 -1 5003 5002 -601 606 $ volume behind slab
c 50009   0 -5004 5008 5002 -1 -601 606 $ volume behind slab
c 50003   0 5006 -1 -5003 5004 -601 606 $ back air
c 50026   0 5015 -1 5007 -5019 -601 606 $ north (back) side air
c 50029   0 5015 -1 5020 -5008 -601 606 $ south (back) side air
50030   0 858 -1 606 -601 -612 $ outside bp3
c 16013   0 619 -618 -609 610 -603 604 $ graphite thermal column
c Al cladding
15000   1 -2.7 -5 4 2 -3 #15003 vol=7302.0827 $ core vessel
15001   1 -2.7 -7 9 13 -701 -615 877 $ right side of reactor
15004   1 -2.7 -7 9 13 -701 -877 882 -617 $ in front of thermalizing column
15005   1 -2.7 -7 9 13 -701 -882 -613 #(-835 13 -701) #(-838 13 -701) $ between TC and Th column
15006   1 -2.7 -7 9 13 -701 613 615 617 $ in front of TC
15002   1 -2.7 -601 606 -890 889 #(-607 612 -601 606 889 -890 617)
        #(-877 882 -871 876 889 -890 -617) #(889 -890 -835 -617)
        #(889 -890 -838 617) $ around reactor tank
15003   1 -2.7 -617 2 -3 -835 vol=142.20728 $ disk at core vessel in front of bp4
c thermal column
16000   6 -1.0 701 -702 615 613 -601 606 617 $ water gap
16001   1 -2.7 702 -703 615 613 -601 606 617 vol=31514.3997 $ front Al cladding
16002   1 -2.7 615 -616 703 -607 -601 606 617 vol=3843.197 $ right angle
16003   1 -2.7 613 -614 703 612 -601 606 617 vol=3843.197 $ left angle
16004   1 -2.7 616 -618 -607 608 -601 606 $ right
16005   1 -2.7 614 -618 -611 612 -601 606 $ left
16006   1 -2.7 703 616 614 -608 611 -618 -601 602 $ top
16007   1 -2.7 703 616 614 -608 611 -618 -605 606 $ bottom
16008   10 -2.48 703 616 614 -609 610 -618 -602 603 $b4c top
16009   10 -2.48 703 616 614 -609 610 -618 -604 605 $ b4c bottom
16010   10 -2.48 616 -618 -608 609 -602 605 $ b4c right
16011   10 -2.48 614 -618 -610 611 -602 605 $ b4c left
16012   4 0.085205 703 616 614 -609 610 -619 -603 604 $ graphite
16013   4 0.085205 619 -620 -609 610 -603 604 $ graphite thermal column
16014   4 0.085205 620 -618 -609 610 624 -603 $ TC
16015   4 0.085205 620 -618 -623 604 -609 610 $ TC
16016   4 0.085205 620 -618 -622 610 -624 623 $ TC
16017   4 0.085205 620 -618 623 -624 -609 621 $ TC
c 16018   19 -1.029e-3 620 -625 623 -624 -621 622 $ TC void where sample is placed
16019   19 -1.029e-3 620 -618 -621 622 -624 648 $ TC void top section
16020   19 -1.029e-3 620 -618 -621 622 623 -649 $ TC void bottom section
16021   19 -1.029e-3 620 -625 -646 647 -648 649 $ First sample position from back of TC void
16022   19 -1.029e-3 625 -626 -646 647 -648 649 $ Second sample position from back of TC void
16023   19 -1.029e-3 626 -627 -646 647 -648 649 $ Third sample position from back of TC void
16024   19 -1.029e-3 627 -628 -646 647 -648 649 $ Fourth sample position from back of TC void
16025   19 -1.029e-3 628 -629 -646 647 -648 649 $ Fifth sample position from back of TC void
```

```
16026   19 -1.029e-3 629 -630 -646 647 -648 649 $ Sixth sample position from back of TC void
16027   19 -1.029e-3 630 -631 -646 647 -648 649 $ Seventh sample position from back of TC void
16028   19 -1.029e-3 631 -632 -646 647 -648 649 $ Eighth sample position from back of TC void
16029   19 -1.029e-3 632 -633 -646 647 -648 649 $ Ninth sample position from back of TC void
16030   19 -1.029e-3 633 -634 -646 647 -648 649 $ Tenth sample position from back of TC void
16031   19 -1.029e-3 634 -635 -646 647 -648 649 $ 11th sample position from back of TC void
16032   19 -1.029e-3 635 -636 -646 647 -648 649 $ 12th sample position from back of TC void
16033   19 -1.029e-3 636 -637 -646 647 -648 649 $ 13th sample position from back of TC void
16034   19 -1.029e-3 637 -638 -646 647 -648 649 $ 14th sample position from back of TC void
16035   19 -1.029e-3 638 -639 -646 647 -648 649 $ 15th sample position from back of TC void
16036   19 -1.029e-3 639 -640 -646 647 -648 649 $ 16th sample position from back of TC void
16037   19 -1.029e-3 640 -641 -646 647 -648 649 $ 17th sample position from back of TC void
16038   19 -1.029e-3 641 -642 -646 647 -648 649 $ 18th sample position from back of TC void
16039   19 -1.029e-3 642 -643 -646 647 -648 649 $ 19th sample position from back of TC void
16040   19 -1.029e-3 643 -644 -646 647 -648 649 $ 20th sample position from back of TC void
16041   19 -1.029e-3 644 -618 -646 647 -648 649 $ rest of void from back of TC void
16042   19 -1.029e-3 620 -618 646 -621 -648 649 $ void not part of sample
16043   19 -1.029e-3 620 -618 -647 650 -648 649 $ void not part od sample
16044   19 -1.029e-3 620 -625 -650 622 -648 649 $ First sample position from back of TC void wall
16045   19 -1.029e-3 625 -626 -650 622 -648 649 $ Second sample position from back of TC void wall
16046   19 -1.029e-3 626 -627 -650 622 -648 649 $ Third sample position from back of TC void wall
16047   19 -1.029e-3 627 -628 -650 622 -648 649 $ Fourth sample position from back of TC void wall
16048   19 -1.029e-3 628 -629 -650 622 -648 649 $ Fifth sample position from back of TC void wall
16049   19 -1.029e-3 629 -630 -650 622 -648 649 $ Sixth sample position from back of TC void wall
16050   19 -1.029e-3 630 -631 -650 622 -648 649 $ Seventh sample position from back of TC void wall
16051   19 -1.029e-3 631 -632 -650 622 -648 649 $ Eighth sample position from back of TC void wall
16052   19 -1.029e-3 632 -633 -650 622 -648 649 $ Ninth sample position from back of TC void wall
16053   19 -1.029e-3 633 -634 -650 622 -648 649 $ Tenth sample position from back of TC void wall
16054   19 -1.029e-3 634 -635 -650 622 -648 649 $ 11th sample position from back of TC void wall
16055   19 -1.029e-3 635 -636 -650 622 -648 649 $ 12th sample position from back of TC void wall
16056   19 -1.029e-3 636 -637 -650 622 -648 649 $ 13th sample position from back of TC void wall
16057   19 -1.029e-3 637 -638 -650 622 -648 649 $ 14th sample position from back of TC void wall
16058   19 -1.029e-3 638 -639 -650 622 -648 649 $ 15th sample position from back of TC void wall
16059   19 -1.029e-3 639 -640 -650 622 -648 649 $ 16th sample position from back of TC void wall
16060   19 -1.029e-3 640 -641 -650 622 -648 649 $ 17th sample position from back of TC void wall
16061   19 -1.029e-3 641 -642 -650 622 -648 649 $ 18th sample position from back of TC void wall
16062   19 -1.029e-3 642 -643 -650 622 -648 649 $ 19th sample position from back of TC void wall
16063   19 -1.029e-3 643 -644 -650 622 -648 649 $ 20th sample position from back of TC void wall
16064   19 -1.029e-3 644 -618 -650 622 -648 649 $ rest of void from back of TC void wall
17000   6 -1.0 701 -702 -877 882 -601 606 -617 vol=20828.981 $ water gap
17001   1 -2.7 702 -703 -877 882 -871 876 -617 vol=9943.8022 $ front Al
17002   1 -2.7 703 -877 878 -871 876 886 -617 vol=4229.17498 $ right Al
17003   1 -2.7 703 -881 882 -871 876 886 -617 vol=4229.17498 $ left Al
17004   1 -2.7 703 886 -617 -871 872 -878 881 vol=4367.551 $ top Al
17005   1 -2.7 703 886 -617 -875 876 -878 881 vol=4367.551 $ bottom Al
17006   10 -2.48 703 886 -617 -878 879 -872 875 vol=1059.7933 $ b4c right
17007   10 -2.48 703 886 -617 -880 881 -872 875 vol=1059.7933 $ b4c left
17008   10 -2.48 703 886 -617 -879 880 -872 873 vol=1062.5544 $ b4c top
17009   10 -2.48 703 886 -617 -879 880 -874 875 vol=1062.5544 $ b4c bottom
17010   4 0.085205 703 883 -873 874 -879 880 -617 vol=61012.553 $ graphite
17011   5 -11.4 -883 884 -873 874 -879 880 $ lead
17012   19 -1.029e-3 -884 885 -873 874 -879 880 $ air
17013   4 0.085205 -885 886 -873 874 -879 880 $ graphite
c core internals
18000   1 -2.7 -5 6 -2 vol=3597.67 $ top grid
18001   1 -2.7 -8 4 -2 vol=4268.05 $ bottom grid
```

```
18002   2 0.0958666 -6 7 -2 vol=6681.39 $ top end fittings
18003   2 0.0958666 -9 8 -2 vol=14368.3 $ bottom end fittings
c reflector region
19000   1 -2.7 -7 11 3 -10 1001 1002 1003 1004 1005 1006
        1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017
        1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028
        1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040
        vol=41415.67284 $ around lazy susan
19001   4 0.085205 -7 11 10 -12 vol=118198.5445 $ graphite around lazy susan
19002   4 0.085205 -11 9 3 -12 #(-833 -835 -13) #(834 -838 -13) $ graphite
19003   4 0.085205 12 -13 -7 9 613 615 617 $ graphite in TC lead
19004   4 0.085205 12 -13 -7 9 -877 882 -617 $ graphite in Th. colum
19005   5 -11.4 12 -13 -615 617 -7 9 $ lead 1st quadrant
19006   5 -11.4 12 -13 877 -617 -7 9 $ lead 2nd quadrant
19007   5 -11.4 12 -13 -882 -617 -7 9 #(-835 12 -13 -868)
        #(-838 12 -13 -868) $ lead 3rd quadrant
19008   5 -11.4 12 -13 -613 617 -7 9 #(-838 12 -13 -868) $ lead 4th quadrant
c water region
20000   6 -1.0 -3 -601 5 $ above core
20001   6 -1.0 -3 606 -4 $ below core
20002   6 -1.0 -701 3 -601 7 $ above reflector
20003   6 -1.0 -701 3 606 -9 $ below reflector
20005   6 -1.0 -889 615 607 -601 606 $ corner 1st quadrant
20007   6 -1.0 701 -889 -617 -882 -601 606 835 838 $ 3rd quadrant
20008   6 -1.0 701 -889 617 -613 -601 606 838 $ 4th quadrant
20009   6 -1.0 -889 613 -612 -601 606 $ corner 4th quadrant
20010   6 -1.0 702 -889 -877 882 -601 871 -617 $ above thermalizing column
20011   6 -1.0 702 -889 -877 882 606 -876 -617 $ below thermalizing column
c inside core rods and moderator
17      6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner core
        79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
        -18 17 -19 -617
18      6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner top reflector region
        79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133 -7
        18 -19 -617
19      6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner bottom reflector region
        79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
        -17 9 -19 -617
20      6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer core 1
        127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
        175 178 181 184 187 190 193 196 199 202 205 -18 17 19 -20 -617
21      6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer top reflector 1
        127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
        175 178 181 184 187 190 193 196 199 202 205 -7 18 19 -20 -617
22      6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124  $ bottom reflector region 1
        127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
        175 178 181 184 187 190 193 196 199 202 205 -17 9 19 -20 -617
23      6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer core 2
        178 181 184 187 190 193 196 199 202 205 -18 17 20 -21 -617
24      6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer top reflector 2
        178 181 184 187 190 193 196 199 202 205 -7 18 20 -21 -617
25      6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ bottom reflector region 2
        178 181 184 187 190 193 196 199 202 205 -17 9 20 -21 -617
26      6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer core 3
        181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
        230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
```

```
      274 277 278 281 293 296 -18 17 21 -22 -617
27     6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer top reflector 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
      274 277 278 281 293 296 -7 18 21 -22 -617
28     6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ bottom reflector region 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
      274 277 278 281 293 296 -17 9 21 -22 -617
29     6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer core 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -18 17 22 -23 -617
30     6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer top reflector 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -7 18 22 -23 -617
31     6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ bottom reflector region 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -17 9 22 -23 -617
32     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319 $ outer core 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 23 -24 -617
33     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 23 -24 -617
34     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 23 -24 -617
35     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer core 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 24 -2 -617
36     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 24 -2 -617
37     6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 24 -2 -617
11017  6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner core
      79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
      -18 17 -19 617
11018  6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner top reflector region
      79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133 -7
      18 -19 617
11019  6 -1.0 26 29 32 35 38 41 44 47 50 53 55 58 61 64 67 70 73 76  $ inner bottom reflector region
      79 82 85 88 91 97 100 103 106 109 112 115 118 124 127 130 133
      -17 9 -19 617
11020  6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer core 1
      127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
      175 178 181 184 187 190 193 196 199 202 205 -18 17 19 -20 617
11021  6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 $ outer top reflector 1
      127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
```

```
      175 178 181 184 187 190 193 196 199 202 205 -7 18 19 -20 617
11022   6 -1.0 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124  $ bottom reflector region 1
      127 130 133 136 139 142 145 148 151 154 157 160 163 166 169 172
      175 178 181 184 187 190 193 196 199 202 205 -17 9 19 -20 617
11023   6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer core 2
      178 181 184 187 190 193 196 199 202 205 -18 17 20 -21 617
11024   6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ outer top reflector 2
      178 181 184 187 190 193 196 199 202 205 -7 18 20 -21 617
11025   6 -1.0 136 139 142 145 148 151 154 157 160 163 166 169 172 175 $ bottom reflector region 2
      178 181 184 187 190 193 196 199 202 205 -17 9 20 -21 617
11026   6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer core 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
      274 277 278 281 293 296 -18 17 21 -22 617
11027   6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ outer top reflector 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
      274 277 278 281 293 296 -7 18 21 -22 617
11028   6 -1.0 136 139 142 145 148 151 157 160 163 166 169 172 175 178 $ bottom reflector region 3
      181 184 187 193 196 199 202 205 208 211 214 217 218 221 224 227
      230 233 236 237 240 243 246 249 252 255 258 259 262 265 268 271
      274 277 278 281 293 296 -17 9 21 -22 617
11029   6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer core 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -18 17 22 -23 617
11030   6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ outer top reflector 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -7 18 22 -23 617
11031   6 -1.0 208 211 214 217 218 221 224 227 230 233 236 237 240 243 $ bottom reflector region 4
      246 249 252 255 258 259 262 265 268 271 274 277 278 281 293 296
      298 300 302 304 306 308 310 312 314 315 316 317 318 319 320 322
      324 326 328 330 332 333 334 335 336 337 338 339 341 343 345 347
      349 351 353 355 -17 9 22 -23 617
11032   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319 $ outer core 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 23 -24 617
11033   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 23 -24 617
11034   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 5
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 23 -24 617
11035   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer core 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -18 17 24 -2 617
11036   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ outer top reflector 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -7 18 24 -2 617
11037   6 -1.0 298 300 302 304 306 308 310 312 314 315 316 317 318 319  $ bottom reflector region 6
      320 322 324 326 328 330 332 333 334 335 336 337 338 339 341 343
      345 347 349 351 353 355 -17 9 24 -2 617
38      1 -2.7 -7 9 -25  vol=580.666  $ aluminium central thimble -#a1
```

```
39    7 0.085755 -7 9 25 -26  vol=32.8228  $ cladding central thimble -#a1
c 40    8 0.042234 -18 17 -27  vol=12.066  $ central zr rod ss-#b1
c 40    19 -1.029e-3 -7 9 -28  vol=613.489  $ (cl)icit void -#b1
c 41    19 -1.029e-3 -7 9 -28  vol=568.6  $ fueled region ss-#b1
c 42    4 0.080193 -7 18 -28  vol=91.1953  $ gr reflector ss-#b1
c 43    4 0.080193 -17 9 -28  vol=91.9257  $ gr reflector ss-#b1
44    1 -2.7 -7 9 28 -29  vol=32.8228  $ cladding al-#b1
45    8 0.042234 -18 17 -30  vol=12.066  $ central zr rod ss-#b2
46    9 0.0928308 -18 17 30 -31  vol=385.479  $ fueled region ss-#b2
47    4 0.080193 -7 18 -31  vol=91.1953  $ gr reflector ss-#b2
48    4 0.080193 -17 9 -31  vol=91.9257  $ gr reflector ss-#b2
49    7 0.085755 -7 9 31 -32  vol=32.8228  $ cladding ss-#b2
50    8 0.042234 -18 17 -33  vol=12.066  $ central zr rod ss-#b3
51    9 0.0928308 -18 17 33 -34  vol=385.479  $ fueled region ss-#b3
52    4 0.080193 -7 18 -34  vol=91.1953  $ gr reflector ss-#b3
53    4 0.080193 -17 9 -34  vol=91.9257  $ gr reflector ss-#b3
54    7 0.085755 -7 9 34 -35  vol=32.8228  $ cladding ss-#b3
55    8 0.042234 -18 17 -36  vol=12.066  $ central zr rod ss-#b4
56    9 0.0928308 -18 17 36 -37  vol=385.479  $ fueled region ss-#b4
57    4 0.080193 -7 18 -37  vol=91.1953  $ gr reflector ss-#b4
58    4 0.080193 -17 9 -37  vol=91.9257  $ gr reflector ss-#b4
59    7 0.085755 -7 9 37 -38  vol=32.8228  $ cladding ss-#b4
60    8 0.042234 -18 17 -39  vol=12.066  $ central zr rod ss-#b5
61    9 0.0928308 -18 17 39 -40  vol=385.479  $ fueled region ss-#b5
62    4 0.080193 -7 18 -40  vol=91.1953  $ gr reflector ss-#b5
63    4 0.080193 -17 9 -40  vol=91.9257  $ gr reflector ss-#b5
64    7 0.085755 -7 9 40 -41  vol=32.8228  $ cladding ss-#b5
65    8 0.042234 -18 17 -42  vol=12.066  $ central zr rod ss-#b6
66    9 0.0928308 -18 17 42 -43  vol=385.479  $ fueled region ss-#b6
67    4 0.080193 -7 18 -43  vol=91.1953  $ gr reflector ss-#b6
68    4 0.080193 -17 9 -43  vol=91.9257  $ gr reflector ss-#b6
69    7 0.085755 -7 9 43 -44  vol=32.8228  $ cladding ss-#b6
70    8 0.042234 -18 17 -45  vol=12.066  $ central zr rod ss-#c1
71    9 0.0928308 -18 17 45 -46  vol=385.479  $ fueled region ss-#c1
72    4 0.080193 -7 18 -46  vol=91.1953  $ gr reflector ss-#c1
73    4 0.080193 -17 9 -46  vol=91.9257  $ gr reflector ss-#c1
74    7 0.085755 -7 9 46 -47  vol=32.8228  $ cladding ss-#c1
75    8 0.042234 -18 17 -48  vol=12.066  $ central zr rod ss-#c2
76    9 0.0928308 -18 17 48 -49  vol=385.479  $ fueled region ss-#c2
77    4 0.080193 -7 18 -49  vol=91.1953  $ gr reflector ss-#c2
78    4 0.080193 -17 9 -49  vol=91.9257  $ gr reflector ss-#c2
79    7 0.085755 -7 9 49 -50  vol=32.8228  $ cladding ss-#c2
80    8 0.042234 -18 17 -51  vol=12.066  $ central zr rod ss-#c3
81    9 0.0928308 -18 17 51 -52  vol=385.479  $ fueled region ss-#c3
82    4 0.080193 -7 18 -52  vol=91.1953  $ gr reflector ss-#c3
83    4 0.080193 -17 9 -52  vol=91.9257  $ gr reflector ss-#c3
84    7 0.085755 -7 9 52 -53  vol=32.8228  $ cladding ss-#c3
85    10 -2.48 -7 1090 -54  vol=296.4494  $ control rod poison control w/o fuel-#c4
86    19 -1.029e-3 -1090 9 -54  vol=283.7991  $ air region control w/o fuel-#c4
87    7 0.085755 -7 9 54 -55  vol=42.0765  $ cladding control w/o fuel-#c4
88    8 0.042234 -18 17 -56  vol=12.066  $ central zr rod ss-#c5
89    9 0.0928308 -18 17 56 -57  vol=385.479  $ fueled region ss-#c5
90    4 0.080193 -7 18 -57  vol=91.1953  $ gr reflector ss-#c5
91    4 0.080193 -17 9 -57  vol=91.9257  $ gr reflector ss-#c5
92    7 0.085755 -7 9 57 -58  vol=32.8228  $ cladding ss-#c5
93    8 0.042234 -18 17 -59  vol=12.066  $ central zr rod ss-#c6
```

```
94    9 0.0928308 -18 17 59 -60  vol=385.479  $ fueled region ss-#c6
95    4 0.080193 -7 18 -60  vol=91.1953  $ gr reflector ss-#c6
96    4 0.080193 -17 9 -60  vol=91.9257  $ gr reflector ss-#c6
97    7 0.085755 -7 9 60 -61  vol=32.8228  $ cladding ss-#c6
98    8 0.042234 -18 17 -62  vol=12.066  $ central zr rod ss-#c7
99    9 0.0928308 -18 17 62 -63  vol=385.479  $ fueled region ss-#c7
100    4 0.080193 -7 18 -63  vol=91.1953  $ gr reflector ss-#c7
101    4 0.080193 -17 9 -63  vol=91.9257  $ gr reflector ss-#c7
102    7 0.085755 -7 9 63 -64  vol=32.8228  $ cladding ss-#c7
103    8 0.042234 -18 17 -65  vol=12.066  $ central zr rod ss-#c8
104    9 0.0928308 -18 17 65 -66  vol=385.479  $ fueled region ss-#c8
105    4 0.080193 -7 18 -66  vol=91.1953  $ gr reflector ss-#c8
106    4 0.080193 -17 9 -66  vol=91.9257  $ gr reflector ss-#c8
107    7 0.085755 -7 9 66 -67  vol=32.8228  $ cladding ss-#c8
108    8 0.042234 -18 17 -68  vol=12.066  $ central zr rod ss-#c9
109    9 0.0928308 -18 17 68 -69  vol=385.479  $ fueled region ss-#c9
110    4 0.080193 -7 18 -69  vol=91.1953  $ gr reflector ss-#c9
111    4 0.080193 -17 9 -69  vol=91.9257  $ gr reflector ss-#c9
112    7 0.085755 -7 9 69 -70  vol=32.8228  $ cladding ss-#c9
113    10 -2.48 -7 1093 -71  vol=273.3329  $ control rod poison con w/fuel-#c10
114    8 0.042234 -1093 9 -72  vol=9.315264  $ central zr rod con w/fuel-#c10
115    12 -5.0 -1093 9 72 -71  vol=209.2916  $ fueled region con w/fuel-#c10
116    7 0.085755 -7 9 71 -73  vol=32.8228  $ cladding con w/fuel-#c10
117    8 0.042234 -18 17 -74  vol=12.066  $ central zr rod ss-#c11
118    9 0.0928308 -18 17 74 -75  vol=385.479  $ fueled region ss-#c11
119    4 0.080193 -7 18 -75  vol=91.1953  $ gr reflector ss-#c11
120    4 0.080193 -17 9 -75  vol=91.9257  $ gr reflector ss-#c11
121    7 0.085755 -7 9 75 -76  vol=32.8228  $ cladding ss-#c11
122    8 0.042234 -18 17 -77  vol=12.066  $ central zr rod ss-#c12
123    9 0.0928308 -18 17 77 -78  vol=385.479  $ fueled region ss-#c12
124    4 0.080193 -7 18 -78  vol=91.1953  $ gr reflector ss-#c12
125    4 0.080193 -17 9 -78  vol=91.9257  $ gr reflector ss-#c12
126    7 0.085755 -7 9 78 -79  vol=32.8228  $ cladding ss-#c12
127    10 -2.48 -7 1092 -80  vol=286.9684  $ control rod poison con w/fuel-#d1
128    8 0.042234 -1092 9 -81  vol=8.901409  $ central zr rod con w/fuel-#d1
129    12 -5.0 -1092 9 81 -80  vol=199.9933  $ fueled region con w/fuel-#d1
130    7 0.085755 -7 9 80 -82  vol=32.8228  $ cladding con w/fuel-#d1
131    8 0.042234 -18 17 -83  vol=12.066  $ central zr rod ss-#d2
132    9 0.0928308 -18 17 83 -84  vol=385.479  $ fueled region ss-#d2
133    4 0.080193 -7 18 -84  vol=91.1953  $ gr reflector ss-#d2
134    4 0.080193 -17 9 -84  vol=91.9257  $ gr reflector ss-#d2
135    7 0.085755 -7 9 84 -85  vol=32.8228  $ cladding ss-#d2
136    8 0.042234 -18 17 -86  vol=12.066  $ central zr rod ss-#d3
137    9 0.0928308 -18 17 86 -87  vol=385.479  $ fueled region ss-#d3
138    4 0.080193 -7 18 -87  vol=91.1953  $ gr reflector ss-#d3
139    4 0.080193 -17 9 -87  vol=91.9257  $ gr reflector ss-#d3
140    7 0.085755 -7 9 87 -88  vol=32.8228  $ cladding ss-#d3
141    8 0.042234 -18 17 -89  vol=12.066  $ central zr rod ss-#d4
142    9 0.0928308 -18 17 89 -90  vol=385.479  $ fueled region ss-#d4
143    4 0.080193 -7 18 -90  vol=91.1953  $ gr reflector ss-#d4
144    4 0.080193 -17 9 -90  vol=91.9257  $ gr reflector ss-#d4
145    7 0.085755 -7 9 90 -91  vol=32.8228  $ cladding ss-#d4
146    8 0.042234 -18 17 -92  vol=12.066  $ central zr rod ss-#d5
147    9 0.0928308 -18 17 92 -93  vol=385.479  $ fueled region ss-#d5
148    4 0.080193 -7 18 -93  vol=91.1953  $ gr reflector ss-#d5
149    4 0.080193 -17 9 -93  vol=91.9257  $ gr reflector ss-#d5
```

```
150   7 0.085755 -7 9 93 -94  vol=32.8228  $ cladding ss-#d5
151   8 0.042234 -18 17 -95  vol=12.066  $ central zr rod ss-#d6
152   9 0.0928308 -18 17 95 -96  vol=385.479  $ fueled region ss-#d6
153   4 0.080193 -7 18 -96  vol=91.1953  $ gr reflector ss-#d6
154   4 0.080193 -17 9 -96  vol=91.9257  $ gr reflector ss-#d6
155   7 0.085755 -7 9 96 -97  vol=32.8228  $ cladding ss-#d6
156   8 0.042234 -18 17 -98  vol=12.066  $ central zr rod ss-#d7
157   9 0.0928308 -18 17 98 -99  vol=385.479  $ fueled region ss-#d7
158   4 0.080193 -7 18 -99  vol=91.1953  $ gr reflector ss-#d7
159   4 0.080193 -17 9 -99  vol=91.9257  $ gr reflector ss-#d7
160   7 0.085755 -7 9 99 -100  vol=32.8228  $ cladding ss-#d7
161   8 0.042234 -18 17 -101  vol=12.066  $ central zr rod ss-#d8
162   9 0.0928308 -18 17 101 -102  vol=385.479  $ fueled region ss-#d8
163   4 0.080193 -7 18 -102  vol=91.1953  $ gr reflector ss-#d8
164   4 0.080193 -17 9 -102  vol=91.9257  $ gr reflector ss-#d8
165   7 0.085755 -7 9 102 -103  vol=32.8228  $ cladding ss-#d8
166   8 0.042234 -18 17 -104  vol=12.066  $ central zr rod ss-#d9
167   9 0.0928308 -18 17 104 -105  vol=385.479  $ fueled region ss-#d9
168   4 0.080193 -7 18 -105  vol=91.1953  $ gr reflector ss-#d9
169   4 0.080193 -17 9 -105  vol=91.9257  $ gr reflector ss-#d9
170   7 0.085755 -7 9 105 -106  vol=32.8228  $ cladding ss-#d9
171   10 -2.48 -7 1091 -107  vol=285.0122  $ control rod poison con w/fuel-#d10
172   8 0.042234 -1091 9 -108  vol=8.960783  $ central zr rod con w/fuel-#d10
173   12 -5.0 -1091 9 108 -107  vol=201.3273  $ fueled region con w/fuel-#d10
174   7 0.085755 -7 9 107 -109  vol=32.8228  $ cladding con w/fuel-#d10
175   8 0.042234 -18 17 -110  vol=12.066  $ central zr rod ss-#d11
176   9 0.0928308 -18 17 110 -111  vol=385.479  $ fueled region ss-#d11
177   4 0.080193 -7 18 -111  vol=91.1953  $ gr reflector ss-#d11
178   4 0.080193 -17 9 -111  vol=91.9257  $ gr reflector ss-#d11
179   7 0.085755 -7 9 111 -112  vol=32.8228  $ cladding ss-#d11
180   8 0.042234 -18 17 -113  vol=12.066  $ central zr rod ss-#d12
181   9 0.0928308 -18 17 113 -114  vol=385.479  $ fueled region ss-#d12
182   4 0.080193 -7 18 -114  vol=91.1953  $ gr reflector ss-#d12
183   4 0.080193 -17 9 -114  vol=91.9257  $ gr reflector ss-#d12
184   7 0.085755 -7 9 114 -115  vol=32.8228  $ cladding ss-#d12
185   8 0.042234 -18 17 -116  vol=12.066  $ central zr rod ss-#d13
186   9 0.0928308 -18 17 116 -117  vol=385.479  $ fueled region ss-#d13
187   4 0.080193 -7 18 -117  vol=91.1953  $ gr reflector ss-#d13
188   4 0.080193 -17 9 -117  vol=91.9257  $ gr reflector ss-#d13
189   7 0.085755 -7 9 117 -118  vol=32.8228  $ cladding ss-#d13
190   8 0.042234 -18 17 -119  vol=12.066  $ central zr rod ss-#d14
191   9 0.0928308 -18 17 119 -120  vol=385.479  $ fueled region ss-#d14
192   4 0.080193 -7 18 -120  vol=91.1953  $ gr reflector ss-#d14
193   4 0.080193 -17 9 -120  vol=91.9257  $ gr reflector ss-#d14
194   7 0.085755 -7 9 120 -121  vol=32.8228  $ cladding ss-#d14
195   8 0.042234 -18 17 -122  vol=12.066  $ central zr rod ss-#d15
196   9 0.0928308 -18 17 122 -123  vol=385.479  $ fueled region ss-#d15
197   4 0.080193 -7 18 -123  vol=91.1953  $ gr reflector ss-#d15
198   4 0.080193 -17 9 -123  vol=91.9257  $ gr reflector ss-#d15
199   7 0.085755 -7 9 123 -124  vol=32.8228  $ cladding ss-#d15
200   8 0.042234 -18 17 -125  vol=12.066  $ central zr rod ss-#d16
201   9 0.0928308 -18 17 125 -126  vol=385.479  $ fueled region ss-#d16
202   4 0.080193 -7 18 -126  vol=91.1953  $ gr reflector ss-#d16
203   4 0.080193 -17 9 -126  vol=91.9257  $ gr reflector ss-#d16
204   7 0.085755 -7 9 126 -127  vol=32.8228  $ cladding ss-#d16
205   8 0.042234 -18 17 -128  vol=12.066  $ central zr rod ss-#d17
```

```
206   9 0.0928308 -18 17 128 -129  vol=385.479  $ fueled region ss-#d17
207   4 0.080193 -7 18 -129  vol=91.1953  $ gr reflector ss-#d17
208   4 0.080193 -17 9 -129  vol=91.9257  $ gr reflector ss-#d17
209   7 0.085755 -7 9 129 -130  vol=32.8228  $ cladding ss-#d17
210   8 0.042234 -18 17 -131  vol=12.066  $ central zr rod ss-#d18
211   9 0.0928308 -18 17 131 -132  vol=385.479  $ fueled region ss-#d18
212   4 0.080193 -7 18 -132  vol=91.1953  $ gr reflector ss-#d18
213   4 0.080193 -17 9 -132  vol=91.9257  $ gr reflector ss-#d18
214   7 0.085755 -7 9 132 -133  vol=32.8228  $ cladding ss-#d18
215   8 0.042234 -18 17 -134  vol=12.066  $ central zr rod ss-#e1
216   9 0.0928308 -18 17 134 -135  vol=385.479  $ fueled region ss-#e1
217   4 0.080193 -7 18 -135  vol=91.1953  $ gr reflector ss-#e1
218   4 0.080193 -17 9 -135  vol=91.9257  $ gr reflector ss-#e1
219   7 0.085755 -7 9 135 -136  vol=32.8228  $ cladding ss-#e1
220   8 0.042234 -18 17 -137  vol=12.066  $ central zr rod ss-#e2
221   9 0.0928308 -18 17 137 -138  vol=385.479  $ fueled region ss-#e2
222   4 0.080193 -7 18 -138  vol=91.1953  $ gr reflector ss-#e2
223   4 0.080193 -17 9 -138  vol=91.9257  $ gr reflector ss-#e2
224   7 0.085755 -7 9 138 -139  vol=32.8228  $ cladding ss-#e2
225   8 0.042234 -18 17 -140  vol=12.066  $ central zr rod ss-#e3
226   9 0.0928308 -18 17 140 -141  vol=385.479  $ fueled region ss-#e3
227   4 0.080193 -7 18 -141  vol=91.1953  $ gr reflector ss-#e3
228   4 0.080193 -17 9 -141  vol=91.9257  $ gr reflector ss-#e3
229   7 0.085755 -7 9 141 -142  vol=32.8228  $ cladding ss-#e3
230   8 0.042234 -18 17 -143  vol=12.066  $ central zr rod ss-#e4
231   9 0.0928308 -18 17 143 -144  vol=385.479  $ fueled region ss-#e4
232   4 0.080193 -7 18 -144  vol=91.1953  $ gr reflector ss-#e4
233   4 0.080193 -17 9 -144  vol=91.9257  $ gr reflector ss-#e4
234   7 0.085755 -7 9 144 -145  vol=32.8228  $ cladding ss-#e4
235   8 0.042234 -18 17 -146  vol=12.066  $ central zr rod ss-#e5
236   9 0.0928308 -18 17 146 -147  vol=385.479  $ fueled region ss-#e5
237   4 0.080193 -7 18 -147  vol=91.1953  $ gr reflector ss-#e5
238   4 0.080193 -17 9 -147  vol=91.9257  $ gr reflector ss-#e5
239   7 0.085755 -7 9 147 -148  vol=32.8228  $ cladding ss-#e5
240   8 0.042234 -18 17 -149  vol=12.066  $ central zr rod ss-#e6
241   9 0.0928308 -18 17 149 -150  vol=385.479  $ fueled region ss-#e6
242   4 0.080193 -7 18 -150  vol=91.1953  $ gr reflector ss-#e6
243   4 0.080193 -17 9 -150  vol=91.9257  $ gr reflector ss-#e6
244   7 0.085755 -7 9 150 -151  vol=32.8228  $ cladding ss-#e6
245   8 0.042234 -18 17 -152  vol=12.066  $ central zr rod ss-#e7
246   9 0.0928308 -18 17 152 -153  vol=385.479  $ fueled region ss-#e7
247   4 0.080193 -7 18 -153  vol=91.1953  $ gr reflector ss-#e7
248   4 0.080193 -17 9 -153  vol=91.9257  $ gr reflector ss-#e7
249   7 0.085755 -7 9 153 -154  vol=32.8228  $ cladding ss-#e7
250   8 0.042234 -18 17 -155  vol=12.066  $ central zr rod ss-#e8
251   9 0.0928308 -18 17 155 -156  vol=385.479  $ fueled region ss-#e8
252   4 0.080193 -7 18 -156  vol=91.1953  $ gr reflector ss-#e8
253   4 0.080193 -17 9 -156  vol=91.9257  $ gr reflector ss-#e8
254   7 0.085755 -7 9 156 -157  vol=32.8228  $ cladding ss-#e8
255   8 0.042234 -18 17 -158  vol=12.066  $ central zr rod ss-#e9
256   9 0.0928308 -18 17 158 -159  vol=385.479  $ fueled region ss-#e9
257   4 0.080193 -7 18 -159  vol=91.1953  $ gr reflector ss-#e9
258   4 0.080193 -17 9 -159  vol=91.9257  $ gr reflector ss-#e9
259   7 0.085755 -7 9 159 -160  vol=32.8228  $ cladding ss-#e9
260   8 0.042234 -18 17 -161  vol=12.066  $ central zr rod ss-#e10
261   9 0.0928308 -18 17 161 -162  vol=385.479  $ fueled region ss-#e10
```

```
262   4 0.080193 -7 18 -162  vol=91.1953  $ gr reflector ss-#e10
263   4 0.080193 -17 9 -162  vol=91.9257  $ gr reflector ss-#e10
264   7 0.085755 -7 9 162 -163  vol=32.8228  $ cladding ss-#e10
265   8 0.042234 -18 17 -164  vol=12.066  $ central zr rod ss-#e11
266   9 0.0928308 -18 17 164 -165  vol=385.479  $ fueled region ss-#e11
267   4 0.080193 -7 18 -165  vol=91.1953  $ gr reflector ss-#e11
268   4 0.080193 -17 9 -165  vol=91.9257  $ gr reflector ss-#e11
269   7 0.085755 -7 9 165 -166  vol=32.8228  $ cladding ss-#e11
270   8 0.042234 -18 17 -167  vol=12.066  $ central zr rod ss-#e12
271   9 0.0928308 -18 17 167 -168  vol=385.479  $ fueled region ss-#e12
272   4 0.080193 -7 18 -168  vol=91.1953  $ gr reflector ss-#e12
273   4 0.080193 -17 9 -168  vol=91.9257  $ gr reflector ss-#e12
274   7 0.085755 -7 9 168 -169  vol=32.8228  $ cladding ss-#e12
275   8 0.042234 -18 17 -170  vol=12.066  $ central zr rod ss-#e13
276   9 0.0928308 -18 17 170 -171  vol=385.479  $ fueled region ss-#e13
277   4 0.080193 -7 18 -171  vol=91.1953  $ gr reflector ss-#e13
278   4 0.080193 -17 9 -171  vol=91.9257  $ gr reflector ss-#e13
279   7 0.085755 -7 9 171 -172  vol=32.8228  $ cladding ss-#e13
280   8 0.042234 -18 17 -173  vol=12.066  $ central zr rod ss-#e14
281   9 0.0928308 -18 17 173 -174  vol=385.479  $ fueled region ss-#e14
282   4 0.080193 -7 18 -174  vol=91.1953  $ gr reflector ss-#e14
283   4 0.080193 -17 9 -174  vol=91.9257  $ gr reflector ss-#e14
284   7 0.085755 -7 9 174 -175  vol=32.8228  $ cladding ss-#e14
285   8 0.042234 -18 17 -176  vol=12.066  $ central zr rod ss-#e15
286   9 0.0928308 -18 17 176 -177  vol=385.479  $ fueled region ss-#e15
287   4 0.080193 -7 18 -177  vol=91.1953  $ gr reflector ss-#e15
288   4 0.080193 -17 9 -177  vol=91.9257  $ gr reflector ss-#e15
289   7 0.085755 -7 9 177 -178  vol=32.8228  $ cladding ss-#e15
290   8 0.042234 -18 17 -179  vol=12.066  $ central zr rod ss-#e16
291   9 0.0928308 -18 17 179 -180  vol=385.479  $ fueled region ss-#e16
292   4 0.080193 -7 18 -180  vol=91.1953  $ gr reflector ss-#e16
293   4 0.080193 -17 9 -180  vol=91.9257  $ gr reflector ss-#e16
294   7 0.085755 -7 9 180 -181  vol=32.8228  $ cladding ss-#e16
295   8 0.042234 -18 17 -182  vol=12.066  $ central zr rod ss-#e17
296   9 0.0928308 -18 17 182 -183  vol=385.479  $ fueled region ss-#e17
297   4 0.080193 -7 18 -183  vol=91.1953  $ gr reflector ss-#e17
298   4 0.080193 -17 9 -183  vol=91.9257  $ gr reflector ss-#e17
299   7 0.085755 -7 9 183 -184  vol=32.8228  $ cladding ss-#e17
300   8 0.042234 -18 17 -185  vol=12.066  $ central zr rod ss-#e18
301   9 0.0928308 -18 17 185 -186  vol=385.479  $ fueled region ss-#e18
302   4 0.080193 -7 18 -186  vol=91.1953  $ gr reflector ss-#e18
303   4 0.080193 -17 9 -186  vol=91.9257  $ gr reflector ss-#e18
304   7 0.085755 -7 9 186 -187  vol=32.8228  $ cladding ss-#e18
305   8 0.042234 -18 17 -188  vol=12.066  $ central zr rod ss-#e19
306   9 0.0928308 -18 17 188 -189  vol=385.479  $ fueled region ss-#e19
307   4 0.080193 -7 18 -189  vol=91.1953  $ gr reflector ss-#e19
308   4 0.080193 -17 9 -189  vol=91.9257  $ gr reflector ss-#e19
309   7 0.085755 -7 9 189 -190  vol=32.8228  $ cladding ss-#e19
310   8 0.042234 -18 17 -191  vol=12.066  $ central zr rod ss-#e20
311   9 0.0928308 -18 17 191 -192  vol=385.479  $ fueled region ss-#e20
312   4 0.080193 -7 18 -192  vol=91.1953  $ gr reflector ss-#e20
313   4 0.080193 -17 9 -192  vol=91.9257  $ gr reflector ss-#e20
314   7 0.085755 -7 9 192 -193  vol=32.8228  $ cladding ss-#e20
315   8 0.042234 -18 17 -194  vol=12.066  $ central zr rod ss-#e21
316   9 0.0928308 -18 17 194 -195  vol=385.479  $ fueled region ss-#e21
317   4 0.080193 -7 18 -195  vol=91.1953  $ gr reflector ss-#e21
```

```
318    4 0.080193 -17 9 -195  vol=91.9257  $ gr reflector ss-#e21
319    7 0.085755 -7 9 195 -196  vol=32.8228  $ cladding ss-#e21
320    8 0.042234 -18 17 -197  vol=12.066  $ central zr rod ss-#e22
321    9 0.0928308 -18 17 197 -198  vol=385.479  $ fueled region ss-#e22
322    4 0.080193 -7 18 -198  vol=91.1953  $ gr reflector ss-#e22
323    4 0.080193 -17 9 -198  vol=91.9257  $ gr reflector ss-#e22
324    7 0.085755 -7 9 198 -199  vol=32.8228  $ cladding ss-#e22
325    8 0.042234 -18 17 -200  vol=12.066  $ central zr rod ss-#e23
326    9 0.0928308 -18 17 200 -201  vol=385.479  $ fueled region ss-#e23
327    4 0.080193 -7 18 -201  vol=91.1953  $ gr reflector ss-#e23
328    4 0.080193 -17 9 -201  vol=91.9257  $ gr reflector ss-#e23
329    7 0.085755 -7 9 201 -202  vol=32.8228  $ cladding ss-#e23
330    8 0.042234 -18 17 -203  vol=12.066  $ central zr rod ss-#e24
331    9 0.0928308 -18 17 203 -204  vol=385.479  $ fueled region ss-#e24
332    4 0.080193 -7 18 -204  vol=91.1953  $ gr reflector ss-#e24
333    4 0.080193 -17 9 -204  vol=91.9257  $ gr reflector ss-#e24
334    7 0.085755 -7 9 204 -205  vol=32.8228  $ cladding ss-#e24
335    8 0.042234 -18 17 -206  vol=12.066  $ central zr rod ss-#f1
336    9 0.0928308 -18 17 206 -207  vol=385.479  $ fueled region ss-#f1
337    4 0.080193 -7 18 -207  vol=91.1953  $ gr reflector ss-#f1
338    4 0.080193 -17 9 -207  vol=91.9257  $ gr reflector ss-#f1
339    7 0.085755 -7 9 207 -208  vol=32.8228  $ cladding ss-#f1
655    6 -1.0 -7 9 -211  vol=613.489  $ water water -#f2
345    8 0.042234 -18 17 -212  vol=12.066  $ central zr rod ss-#f3
346    9 0.0928308 -18 17 212 -213  vol=385.479  $ fueled region ss-#f3
347    4 0.080193 -7 18 -213  vol=91.1953  $ gr reflector ss-#f3
348    4 0.080193 -17 9 -213  vol=91.9257  $ gr reflector ss-#f3
349    7 0.085755 -7 9 213 -214  vol=32.8228  $ cladding ss-#f3
350    8 0.042234 -18 17 -215  vol=12.066  $ central zr rod ss-#f4
351    9 0.0928308 -18 17 215 -216  vol=385.479  $ fueled region ss-#f4
352    4 0.080193 -7 18 -216  vol=91.1953  $ gr reflector ss-#f4
353    4 0.080193 -17 9 -216  vol=91.9257  $ gr reflector ss-#f4
354    7 0.085755 -7 9 216 -217  vol=32.8228  $ cladding ss-#f4
600    8 0.042234 -18 17 -400  vol=12.066  $ central zr rod ss-#f5
601    9 0.0928308 -18 17 400 -401  vol=385.479  $ fueled region ss-#f5
602    4 0.080193 -7 18 -401  vol=91.1953  $ gr reflector ss-#f5
603    4 0.080193 -17 9 -401  vol=91.9257  $ gr reflector ss-#f5
604    7 0.085755 -7 9 401 -218  vol=32.8228  $ cladding ss-#f5
356    8 0.042234 -18 17 -219  vol=12.066  $ central zr rod ss-#f6
357    9 0.0928308 -18 17 219 -220  vol=385.479  $ fueled region ss-#f6
358    4 0.080193 -7 18 -220  vol=91.1953  $ gr reflector ss-#f6
359    4 0.080193 -17 9 -220  vol=91.9257  $ gr reflector ss-#f6
360    7 0.085755 -7 9 220 -221  vol=32.8228  $ cladding ss-#f6
361    8 0.042234 -18 17 -222  vol=12.066  $ central zr rod ss-#f7
362    9 0.0928308 -18 17 222 -223  vol=385.479  $ fueled region ss-#f7
363    4 0.080193 -7 18 -223  vol=91.1953  $ gr reflector ss-#f7
364    4 0.080193 -17 9 -223  vol=91.9257  $ gr reflector ss-#f7
365    7 0.085755 -7 9 223 -224  vol=32.8228  $ cladding ss-#f7
366    8 0.042234 -18 17 -225  vol=12.066  $ central zr rod ss-#f8
367    9 0.0928308 -18 17 225 -226  vol=385.479  $ fueled region ss-#f8
368    4 0.080193 -7 18 -226  vol=91.1953  $ gr reflector ss-#f8
369    4 0.080193 -17 9 -226  vol=91.9257  $ gr reflector ss-#f8
370    7 0.085755 -7 9 226 -227  vol=32.8228  $ cladding ss-#f8
371    8 0.042234 -18 17 -228  vol=12.066  $ central zr rod ss-#f9
372    9 0.0928308 -18 17 228 -229  vol=385.479  $ fueled region ss-#f9
373    4 0.080193 -7 18 -229  vol=91.1953  $ gr reflector ss-#f9
```

```
374     4 0.080193 -17 9 -229  vol=91.9257  $ gr reflector ss-#f9
375     7 0.085755 -7 9 229 -230  vol=32.8228  $ cladding ss-#f9
376     8 0.042234 -18 17 -231  vol=12.066  $ central zr rod ss-#f10
377     9 0.0928308 -18 17 231 -232  vol=385.479  $ fueled region ss-#f10
378     4 0.080193 -7 18 -232  vol=91.1953  $ gr reflector ss-#f10
379     4 0.080193 -17 9 -232  vol=91.9257  $ gr reflector ss-#f10
380     7 0.085755 -7 9 232 -233  vol=32.8228  $ cladding ss-#f10
381     8 0.042234 -18 17 -234  vol=12.066  $ central zr rod ss-#f11
382     9 0.0928308 -18 17 234 -235  vol=385.479  $ fueled region ss-#f11
383     4 0.080193 -7 18 -235  vol=91.1953  $ gr reflector ss-#f11
384     4 0.080193 -17 9 -235  vol=91.9257  $ gr reflector ss-#f11
385     7 0.085755 -7 9 235 -236  vol=32.8228  $ cladding ss-#f11
605     8 0.042234 -18 17 -402  vol=12.066  $ central zr rod ss-#f12
606     9 0.0928308 -18 17 402 -403  vol=385.479  $ fueled region ss-#f12
607     4 0.080193 -7 18 -403  vol=91.1953  $ gr reflector ss-#f12
608     4 0.080193 -17 9 -403  vol=91.9257  $ gr reflector ss-#f12
609     7 0.085755 -7 9 403 -237  vol=32.8228  $ cladding ss-#f12
387     8 0.042234 -18 17 -238  vol=12.066  $ central zr rod ss-#f13
388     9 0.0928308 -18 17 238 -239  vol=385.479  $ fueled region ss-#f13
389     4 0.080193 -7 18 -239  vol=91.1953  $ gr reflector ss-#f13
390     4 0.080193 -17 9 -239  vol=91.9257  $ gr reflector ss-#f13
391     7 0.085755 -7 9 239 -240  vol=32.8228  $ cladding ss-#f13
392     8 0.042234 -18 17 -241  vol=12.066  $ central zr rod ss-#f14
393     9 0.0928308 -18 17 241 -242  vol=385.479  $ fueled region ss-#f14
394     4 0.080193 -7 18 -242  vol=91.1953  $ gr reflector ss-#f14
395     4 0.080193 -17 9 -242  vol=91.9257  $ gr reflector ss-#f14
396     7 0.085755 -7 9 242 -243  vol=32.8228  $ cladding ss-#f14
397     8 0.042234 -18 17 -244  vol=12.066  $ central zr rod ss-#f15
398     9 0.0928308 -18 17 244 -245  vol=385.479  $ fueled region ss-#f15
399     4 0.080193 -7 18 -245  vol=91.1953  $ gr reflector ss-#f15
400     4 0.080193 -17 9 -245  vol=91.9257  $ gr reflector ss-#f15
401     7 0.085755 -7 9 245 -246  vol=32.8228  $ cladding ss-#f15
402     8 0.042234 -18 17 -247  vol=12.066  $ central zr rod ss-#f16
403     9 0.0928308 -18 17 247 -248  vol=385.479  $ fueled region ss-#f16
404     4 0.080193 -7 18 -248  vol=91.1953  $ gr reflector ss-#f16
405     4 0.080193 -17 9 -248  vol=91.9257  $ gr reflector ss-#f16
406     7 0.085755 -7 9 248 -249  vol=32.8228  $ cladding ss-#f16
407     6 -1.0 -7 9 -252  vol=613.489  $ water water -#f17
c 407     8 0.042234 -18 17 -250  vol=12.066  $ central zr rod ss-#f17
c 408     9 0.0928308 -18 17 250 -251  vol=385.479  $ fueled region ss-#f17
c 409     4 0.080193 -7 18 -251  vol=91.1953  $ gr reflector ss-#f17
c 410     4 0.080193 -17 9 -251  vol=91.9257  $ gr reflector ss-#f17
c 411     7 0.085755 -7 9 251 -252  vol=32.8228  $ cladding ss-#f17
412     4 0.080193 -7 9 -254  vol=580.666  $ graphite region gr-#f18
413     7 0.085755 -7 9 254 -255  vol=32.8228  $ cladding gr-#f18
414     4 0.080193 -7 9 -257  vol=580.666  $ graphite region gr-#f19
415     7 0.085755 -7 9 257 -258  vol=32.8228  $ cladding gr-#f19
610     4 0.080193 -7 9 -405  vol=580.666  $ graphite region gr-#f20
611     7 0.085755 -7 9 405 -259  vol=32.8228  $ cladding gr-#f20
663     4 0.080193 -7 9 -261  vol=580.666  $ graphite region gr-#f21
427     7 0.085755 -7 9 261 -262  vol=32.8228  $ cladding ss-#f21
664     4 0.080193 -7 9 -264  vol=580.666  $ graphite region gr-#f22
432     7 0.085755 -7 9 264 -265  vol=32.8228  $ cladding ss-#f22
665     4 0.080193 -7 9 -267  vol=580.666  $ graphite region gr-#f23
437     7 0.085755 -7 9 267 -268  vol=32.8228  $ cladding ss-#f23
666     4 0.080193 -7 9 -270  vol=580.666  $ graphite region gr-#f24
```

```
442     7 0.085755 -7 9 270 -271  vol=32.8228  $ cladding ss-#f24
667     4 0.080193 -7 9 -273  vol=580.666  $ graphite region gr-#f25
447     7 0.085755 -7 9 273 -274  vol=32.8228  $ cladding ss-#f25
668     4 0.080193 -7 9 -276  vol=580.666  $ graphite region gr-#f26
452     7 0.085755 -7 9 276 -277  vol=32.8228  $ cladding ss-#f26
669     4 0.080193 -7 9 -407  vol=580.666  $ graphite region gr-#f27
619     7 0.085755 -7 9 407 -278  vol=32.8228  $ cladding ss-#f27
454     6 -1.0 -7 9 -281  vol=613.489  $ water water -#f28
c 454     8 0.042234 -18 17 -279  vol=12.066  $ central zr rod ss-#f28
c 455     4 0.080193 -7 18 -280  vol=91.1953  $ gr reflector ss-#f28
c 456     4 0.080193 -17 9 -280  vol=91.9257  $ gr reflector ss-#f28
c 457     7 0.085755 -7 9 280 -281  vol=32.8228  $ cladding ss-#f28
c 458     9 0.0928308 -18 282 279 -280  vol=38.5479  $ segment top ss-#f28
c 459     9 0.0928308 -282 283 279 -280  vol=38.5479  $ segment2 ss-#f28
c 460     9 0.0928308 -283 284 279 -280  vol=38.5479  $ segment3 ss-#f28
c 461     9 0.0928308 -284 285 279 -280  vol=38.5479  $ segment4 ss-#f28
c 462     9 0.0928308 -285 286 279 -280  vol=38.5479  $ segment5 ss-#f28
c 463     9 0.0928308 -286 287 279 -280  vol=38.5479  $ segment6 ss-#f28
c 464     9 0.0928308 -287 288 279 -280  vol=38.5479  $ segment7 ss-#f28
c 465     9 0.0928308 -288 289 279 -280  vol=38.5479  $ segment8 ss-#f28
c 466     9 0.0928308 -289 290 279 -280  vol=38.5479  $ segment9 ss-#f28
c 467     9 0.0928308 -290 17 279 -280  vol=38.5479  $ segment bottom ss-#f28
468     6 -1.0 -7 9 -293  vol=613.489  $ water water -#29
c 468     8 0.042234 -18 17 -291  vol=12.066  $ central zr rod ss-#f29
c 469     9 0.0928308 -18 17 291 -292  vol=385.479  $ fueled region ss-#f29
c 470     4 0.080193 -7 18 -292  vol=91.1953  $ gr reflector ss-#f29
c 471     4 0.080193 -17 9 -292  vol=91.9257  $ gr reflector ss-#f29
c 472     7 0.085755 -7 9 292 -293  vol=32.8228  $ cladding ss-#f29
473     8 0.042234 -18 17 -294  vol=12.066  $ central zr rod ss-#f30
474     9 0.0928308 -18 17 294 -295  vol=385.479  $ fueled region ss-#f30
475     4 0.080193 -7 18 -295  vol=91.1953  $ gr reflector ss-#f30
476     4 0.080193 -17 9 -295  vol=91.9257  $ gr reflector ss-#f30
477     7 0.085755 -7 9 295 -296  vol=32.8228  $ cladding ss-#f30
478     4 0.080193 -7 9 -297  vol=580.666  $ graphite region gr-#g1
479     7 0.085755 -7 9 297 -298  vol=32.8228  $ cladding gr-#g1
c 480     19 -1.029e-3 -7 830 -299 $ void of rabbit-#g2
c 670     19 -1.029e-3 -830 831 -299 $ void of rabbit-#g2
c 671     19 -1.029e-3 -831 9 -299 $ void of rabbit-#g2
481     1 -2.7 -7 9 299 -300  vol=32.8228  $ cladding gr-#g2
482     4 0.080193 -7 9 -301  vol=580.666  $ graphite region gr-#g3
483     7 0.085755 -7 9 301 -302  vol=32.8228  $ cladding gr-#g3
484     4 0.080193 -7 9 -303  vol=580.666  $ graphite region gr-#g4
485     7 0.085755 -7 9 303 -304  vol=32.8228  $ cladding gr-#g4
486     4 0.080193 -7 9 -305  vol=580.666  $ graphite region gr-#g5
487     7 0.085755 -7 9 305 -306  vol=32.8228  $ cladding gr-#g5
488     6 -1.0 -7 9 -308  vol=613.489  $ water water -#g6
c 488     4 0.080193 -7 9 -307  vol=580.666  $ graphite region gr-#g6
c 489     7 0.085755 -7 9 307 -308  vol=32.8228  $ cladding gr-#g6
490     8 0.042234 -18 17 -309  vol=12.066  $ central zr rod ss-#g7
491     9 0.0928308 -18 17 309 -10000  vol=385.479  $ fueled region ss-#g7
492     4 0.080193 -7 18 -10000  vol=91.1953  $ gr reflector ss-#g7
493     4 0.080193 -17 9 -10000  vol=91.9257  $ gr reflector ss-#g7
494     7 0.085755 -7 9 10000 -310  vol=32.8228  $ cladding ss-#g7
495     8 0.042234 -18 17 -311  vol=12.066  $ central zr rod ss-#g8
496     9 0.0928308 -18 17 311 -10001  vol=385.479  $ fueled region ss-#g8
497     4 0.080193 -7 18 -10001  vol=91.1953  $ gr reflector ss-#g8
```

```
498     4 0.080193 -17 9 -10001  vol=91.9257  $ gr reflector ss-#g8
499     7 0.085755 -7 9 10001 -312  vol=32.8228  $ cladding ss-#g8
500     8 0.042234 -18 17 -313  vol=12.066  $ central zr rod ss-#g9
501     9 0.0928308 -18 17 313 -10002  vol=385.479  $ fueled region ss-#g9
502     4 0.080193 -7 18 -10002  vol=91.1953  $ gr reflector ss-#g9
503     4 0.080193 -17 9 -10002  vol=91.9257  $ gr reflector ss-#g9
504     7 0.085755 -7 9 10002 -314  vol=32.8228  $ cladding ss-#g9
620     8 0.042234 -18 17 -408  vol=12.066  $ central zr rod ss-#g10
621     9 0.0928308 -18 17 408 -409  vol=385.479  $ fueled region ss-#g10
622     4 0.080193 -7 18 -409  vol=91.1953  $ gr reflector ss-#g10
623     4 0.080193 -17 9 -409  vol=91.9257  $ gr reflector ss-#g10
624     7 0.085755 -7 9 409 -315  vol=32.8228  $ cladding ss-#g10
625     8 0.042234 -18 17 -410  vol=12.066  $ central zr rod ss-#g11
626     9 0.0928308 -18 17 410 -411  vol=385.479  $ fueled region ss-#g11
627     4 0.080193 -7 18 -411  vol=91.1953  $ gr reflector ss-#g11
628     4 0.080193 -17 9 -411  vol=91.9257  $ gr reflector ss-#g11
629     7 0.085755 -7 9 411 -316  vol=32.8228  $ cladding ss-#g11
630     8 0.042234 -18 17 -412  vol=12.066  $ central zr rod ss-#g12
631     9 0.0928308 -18 17 412 -413  vol=385.479  $ fueled region ss-#g12
632     4 0.080193 -7 18 -413  vol=91.1953  $ gr reflector ss-#g12
633     4 0.080193 -17 9 -413  vol=91.9257  $ gr reflector ss-#g12
634     7 0.085755 -7 9 413 -317  vol=32.8228  $ cladding ss-#g12
635     8 0.042234 -18 17 -414  vol=12.066  $ central zr rod ss-#g13
636     9 0.0928308 -18 17 414 -415  vol=385.479  $ fueled region ss-#g13
637     4 0.080193 -7 18 -415  vol=91.1953  $ gr reflector ss-#g13
638     4 0.080193 -17 9 -415  vol=91.9257  $ gr reflector ss-#g13
639     7 0.085755 -7 9 415 -318  vol=32.8228  $ cladding ss-#g13
640     6 -1.0 -7 9 -319  vol=613.489  $ water water -#g6
c 640     8 0.042234 -18 17 -416  vol=12.066  $ central zr rod ss-#g14
c 641     9 0.0928308 -18 17 416 -417  vol=385.479  $ fueled region ss-#g14
c 642     4 0.080193 -7 18 -417  vol=91.1953  $ gr reflector ss-#g14
c 643     4 0.080193 -17 9 -417  vol=91.9257  $ gr reflector ss-#g14
c 644     7 0.085755 -7 9 417 -319  vol=32.8228  $ cladding ss-#g14
645     6 -1.0 -7 9 -320  vol=613.489  $ water water -#g15
c 645     8 0.042234 -18 17 -418  vol=12.066  $ central zr rod ss-#g15
c 646     9 0.0928308 -18 17 418 -419  vol=385.479  $ fueled region ss-#g15
c 647     4 0.080193 -7 18 -419  vol=91.1953  $ gr reflector ss-#g15
c 648     4 0.080193 -17 9 -419  vol=91.9257  $ gr reflector ss-#g15
c 649     7 0.085755 -7 9 419 -320  vol=32.8228  $ cladding ss-#g15
650     4 0.080193 -7 9 -321  vol=580.666  $ graphite region gr-#g16
651     7 0.085755 -7 9 321 -322  vol=32.8228  $ cladding gr-#g16
505     4 0.080193 -7 9 -323  vol=580.666  $ graphite region gr-#g17
506     7 0.085755 -7 9 323 -324  vol=32.8228  $ cladding gr-#g17
507     4 0.080193 -7 9 -325  vol=580.666  $ graphite region gr-#g18
508     7 0.085755 -7 9 325 -326  vol=32.8228  $ cladding gr-#g18
509     4 0.080193 -7 9 -327  vol=580.666  $ graphite region gr-#g19
510     7 0.085755 -7 9 327 -328  vol=32.8228  $ cladding gr-#g19
511     4 0.080193 -7 9 -329  vol=580.666  $ graphite region gr-#g20
512     7 0.085755 -7 9 329 -330  vol=32.8228  $ cladding gr-#g20
c 513     4 0.080193 -7 9 -331  vol=580.666  $ graphite region gr-#g21
c 514     7 0.085755 -7 9 331 -332  vol=32.8228  $ cladding gr-#g21
513     6 -1.0 -7 9 -332  vol=613.489  $ water water -#g21
515     6 -1.0 -7 9 -333  vol=613.489  $ water water -#g22
516     6 -1.0 -7 9 -334  vol=613.489  $ water water -#g23
517     6 -1.0 -7 9 -335  vol=613.489  $ water water -#g24
518     6 -1.0 -7 9 -336  vol=613.489  $ water water -#g25
```

```
519     6 -1.0 -7 9 -337  vol=613.489  $ water water -#g26
520     6 -1.0 -7 9 -338  vol=613.489  $ water water -#g27
521     6 -1.0 -7 9 -339  vol=613.489  $ water water -#g28
656     6 -1.0 -7 9 -341  vol=613.489  $ water water -#g29
657     6 -1.0 -7 9 -343  vol=613.489  $ water water -#g30
658     6 -1.0 -7 9 -345  vol=613.489  $ water water -#g31
659     6 -1.0 -7 9 -347  vol=613.489  $ water water -#g32
660     6 -1.0 -7 9 -349  vol=613.489  $ water water -#g33
661     4 0.080193 -7 9 -350  vol=580.666  $ graphite region gr-#g34
662     7 0.085755 -7 9 350 -351  vol=32.8228  $ cladding gr-#g34
612     4 0.080193 -7 9 -352  vol=580.666  $ graphite region gr-#g35
613     7 0.085755 -7 9 352 -353  vol=32.8228  $ cladding gr-#g35
c 2003    6 -1.0 -7 1045 -353 vol=474.36507 $ 1st segment of rabbit #g35
c 2004    6 -1.0 9 -1046 -353 vol=128.09951 $ 2nd segment of rabbit #g35
c 2005    6 -1.0 -1045 1046 -353 vol=11.024055 $ 1cm above the bottom of rabbit
535     4 0.080193 -7 9 -354  vol=580.666  $ graphite region gr-#g36
536     7 0.085755 -7 9 354 -355  vol=32.8228  $ cladding gr-#g36
c lazy susan rack segment
5001    19 -1.029e-3 -7 1056 -1001 vol=89.299973
5002    19 -1.029e-3 -7 1056 -1002 vol=89.299973
5003    19 -1.029e-3 -7 1056 -1003 vol=89.299973
5004    19 -1.029e-3 -7 1056 -1004 vol=89.299973
5005    19 -1.029e-3 -7 1056 -1005 vol=89.299973
5006    19 -1.029e-3 -7 1056 -1006 vol=89.299973
5007    19 -1.029e-3 -7 1056 -1007 vol=89.299973
5008    19 -1.029e-3 -7 1056 -1008 vol=89.299973
5009    19 -1.029e-3 -7 1056 -1009 vol=89.299973
5010    19 -1.029e-3 -7 1056 -1010 vol=89.299973
5011    19 -1.029e-3 -7 1056 -1011 vol=89.299973
5012    19 -1.029e-3 -7 1056 -1012 vol=89.299973
5013    19 -1.029e-3 -7 1056 -1013 vol=89.299973
5014    19 -1.029e-3 -7 1056 -1014 vol=89.299973
5015    19 -1.029e-3 -7 1056 -1015 vol=89.299973
5016    19 -1.029e-3 -7 1056 -1016 vol=89.299973
5017    19 -1.029e-3 -7 1056 -1017 vol=89.299973
5018    19 -1.029e-3 -7 1056 -1018 vol=89.299973
5019    19 -1.029e-3 -7 1056 -1019 vol=89.299973
5020    19 -1.029e-3 -7 1056 -1020 vol=89.299973
5021    19 -1.029e-3 -7 1056 -1021 vol=89.299973
5022    19 -1.029e-3 -7 1056 -1022 vol=89.299973
5023    19 -1.029e-3 -7 1056 -1023 vol=89.299973
5024    19 -1.029e-3 -7 1056 -1024 vol=89.299973
5025    19 -1.029e-3 -7 1056 -1025 vol=89.299973
5026    19 -1.029e-3 -7 1056 -1026 vol=89.299973
5027    19 -1.029e-3 -7 1056 -1027 vol=89.299973
5028    19 -1.029e-3 -7 1056 -1028 vol=89.299973
5029    19 -1.029e-3 -7 1056 -1029 vol=89.299973
5030    19 -1.029e-3 -7 1056 -1030 vol=89.299973
5031    19 -1.029e-3 -7 1056 -1031 vol=89.299973
5032    19 -1.029e-3 -7 1056 -1032 vol=89.299973
5033    19 -1.029e-3 -7 1056 -1033 vol=89.299973
5034    19 -1.029e-3 -7 1056 -1034 vol=89.299973
5035    19 -1.029e-3 -7 1056 -1035 vol=89.299973
5036    19 -1.029e-3 -7 1056 -1036 vol=89.299973
5037    19 -1.029e-3 -7 1056 -1037 vol=89.299973
5038    19 -1.029e-3 -7 1056 -1038 vol=89.299973
```

```
5039    19 -1.029e-3 -7 1056 -1039 vol=89.299973
5040    19 -1.029e-3 -7 1056 -1040 vol=89.299973
c cell bottom position for each lazy susan position
6000    19 -1.029e-3 11  -1047 -1040 vol=4.10433
6001    19 -1.029e-3 11  -1047 -1039 vol=4.10433
6002    19 -1.029e-3 11  -1047 -1038 vol=4.10433
6003    19 -1.029e-3 11  -1047 -1037 vol=4.10433
6004    19 -1.029e-3 11  -1047 -1036 vol=4.10433
6005    19 -1.029e-3 11  -1047 -1035 vol=4.10433
6006    19 -1.029e-3 11  -1047 -1034 vol=4.10433
6007    19 -1.029e-3 11  -1047 -1033 vol=4.10433
6008    19 -1.029e-3 11  -1047 -1032 vol=4.10433
6009    19 -1.029e-3 11  -1047 -1031 vol=4.10433
6010    19 -1.029e-3 11  -1047 -1030 vol=4.10433
6011    19 -1.029e-3 11  -1047 -1029 vol=4.10433
6012    19 -1.029e-3 11  -1047 -1028 vol=4.10433
6013    19 -1.029e-3 11  -1047 -1027 vol=4.10433
6014    19 -1.029e-3 11  -1047 -1026 vol=4.10433
6015    19 -1.029e-3 11  -1047 -1025 vol=4.10433
6016    19 -1.029e-3 11  -1047 -1024 vol=4.10433
6017    19 -1.029e-3 11  -1047 -1023 vol=4.10433
6018    19 -1.029e-3 11  -1047 -1022 vol=4.10433
6019    19 -1.029e-3 11  -1047 -1021 vol=4.10433
6020    19 -1.029e-3 11  -1047 -1020 vol=4.10433
6021    19 -1.029e-3 11  -1047 -1019 vol=4.10433
6022    19 -1.029e-3 11  -1047 -1018 vol=4.10433
6023    19 -1.029e-3 11  -1047 -1017 vol=4.10433
6024    19 -1.029e-3 11  -1047 -1016 vol=4.10433
6025    19 -1.029e-3 11  -1047 -1015 vol=4.10433
6026    19 -1.029e-3 11  -1047 -1014 vol=4.10433
6027    19 -1.029e-3 11  -1047 -1013 vol=4.10433
6028    19 -1.029e-3 11  -1047 -1012 vol=4.10433
6029    19 -1.029e-3 11  -1047 -1011 vol=4.10433
6030    19 -1.029e-3 11  -1047 -1010 vol=4.10433
6031    19 -1.029e-3 11  -1047 -1009 vol=4.10433
6032    19 -1.029e-3 11  -1047 -1008 vol=4.10433
6033    19 -1.029e-3 11  -1047 -1007 vol=4.10433
6034    19 -1.029e-3 11  -1047 -1006 vol=4.10433
6035    19 -1.029e-3 11  -1047 -1005 vol=4.10433
6036    19 -1.029e-3 11  -1047 -1004 vol=4.10433
6037    19 -1.029e-3 11  -1047 -1003 vol=4.10433
6038    19 -1.029e-3 11  -1047 -1002 vol=4.10433
6039    19 -1.029e-3 11  -1047 -1001 vol=4.10433
c cell 2nd position for bottom lazy susan
6040    19 -1.029e-3 1047 -1048 -1040 vol=4.10433
6041    19 -1.029e-3 1047 -1048 -1039 vol=4.10433
6042    19 -1.029e-3 1047 -1048 -1038 vol=4.10433
6043    19 -1.029e-3 1047 -1048 -1037 vol=4.10433
6044    19 -1.029e-3 1047 -1048 -1036 vol=4.10433
6045    19 -1.029e-3 1047 -1048 -1035 vol=4.10433
6046    19 -1.029e-3 1047 -1048 -1034 vol=4.10433
6047    19 -1.029e-3 1047 -1048 -1033 vol=4.10433
6048    19 -1.029e-3 1047 -1048 -1032 vol=4.10433
6049    19 -1.029e-3 1047 -1048 -1031 vol=4.10433
6050    19 -1.029e-3 1047 -1048 -1030 vol=4.10433
6051    19 -1.029e-3 1047 -1048 -1029 vol=4.10433
```

```
6052    19 -1.029e-3 1047 -1048 -1028 vol=4.10433
6053    19 -1.029e-3 1047 -1048 -1027 vol=4.10433
6054    19 -1.029e-3 1047 -1048 -1026 vol=4.10433
6055    19 -1.029e-3 1047 -1048 -1025 vol=4.10433
6056    19 -1.029e-3 1047 -1048 -1024 vol=4.10433
6057    19 -1.029e-3 1047 -1048 -1023 vol=4.10433
6058    19 -1.029e-3 1047 -1048 -1022 vol=4.10433
6059    19 -1.029e-3 1047 -1048 -1021 vol=4.10433
6060    19 -1.029e-3 1047 -1048 -1020 vol=4.10433
6061    19 -1.029e-3 1047 -1048 -1019 vol=4.10433
6062    19 -1.029e-3 1047 -1048 -1018 vol=4.10433
6063    19 -1.029e-3 1047 -1048 -1017 vol=4.10433
6064    19 -1.029e-3 1047 -1048 -1016 vol=4.10433
6065    19 -1.029e-3 1047 -1048 -1015 vol=4.10433
6066    19 -1.029e-3 1047 -1048 -1014 vol=4.10433
6067    19 -1.029e-3 1047 -1048 -1013 vol=4.10433
6068    19 -1.029e-3 1047 -1048 -1012 vol=4.10433
6069    19 -1.029e-3 1047 -1048 -1011 vol=4.10433
6070    19 -1.029e-3 1047 -1048 -1010 vol=4.10433
6071    19 -1.029e-3 1047 -1048 -1009 vol=4.10433
6072    19 -1.029e-3 1047 -1048 -1008 vol=4.10433
6073    19 -1.029e-3 1047 -1048 -1007 vol=4.10433
6074    19 -1.029e-3 1047 -1048 -1006 vol=4.10433
6075    19 -1.029e-3 1047 -1048 -1005 vol=4.10433
6076    19 -1.029e-3 1047 -1048 -1004 vol=4.10433
6077    19 -1.029e-3 1047 -1048 -1003 vol=4.10433
6078    19 -1.029e-3 1047 -1048 -1002 vol=4.10433
6079    19 -1.029e-3 1047 -1048 -1001 vol=4.10433
c cell 3rd position for bottom lazy susan
6080    19 -1.029e-3 1048 -1049 -1040 vol=4.10433
6081    19 -1.029e-3 1048 -1049 -1039 vol=4.10433
6082    19 -1.029e-3 1048 -1049 -1038 vol=4.10433
6083    19 -1.029e-3 1048 -1049 -1037 vol=4.10433
6084    19 -1.029e-3 1048 -1049 -1036 vol=4.10433
6085    19 -1.029e-3 1048 -1049 -1035 vol=4.10433
6086    19 -1.029e-3 1048 -1049 -1034 vol=4.10433
6087    19 -1.029e-3 1048 -1049 -1033 vol=4.10433
6088    19 -1.029e-3 1048 -1049 -1032 vol=4.10433
6089    19 -1.029e-3 1048 -1049 -1031 vol=4.10433
6090    19 -1.029e-3 1048 -1049 -1030 vol=4.10433
6091    19 -1.029e-3 1048 -1049 -1029 vol=4.10433
6092    19 -1.029e-3 1048 -1049 -1028 vol=4.10433
6093    19 -1.029e-3 1048 -1049 -1027 vol=4.10433
6094    19 -1.029e-3 1048 -1049 -1026 vol=4.10433
6095    19 -1.029e-3 1048 -1049 -1025 vol=4.10433
6096    19 -1.029e-3 1048 -1049 -1024 vol=4.10433
6097    19 -1.029e-3 1048 -1049 -1023 vol=4.10433
6098    19 -1.029e-3 1048 -1049 -1022 vol=4.10433
6099    19 -1.029e-3 1048 -1049 -1021 vol=4.10433
6100    19 -1.029e-3 1048 -1049 -1020 vol=4.10433
6101    19 -1.029e-3 1048 -1049 -1019 vol=4.10433
6102    19 -1.029e-3 1048 -1049 -1018 vol=4.10433
6103    19 -1.029e-3 1048 -1049 -1017 vol=4.10433
6104    19 -1.029e-3 1048 -1049 -1016 vol=4.10433
6105    19 -1.029e-3 1048 -1049 -1015 vol=4.10433
6106    19 -1.029e-3 1048 -1049 -1014 vol=4.10433
```

```
6107    19 -1.029e-3 1048 -1049 -1013 vol=4.10433
6108    19 -1.029e-3 1048 -1049 -1012 vol=4.10433
6109    19 -1.029e-3 1048 -1049 -1011 vol=4.10433
6110    19 -1.029e-3 1048 -1049 -1010 vol=4.10433
6111    19 -1.029e-3 1048 -1049 -1009 vol=4.10433
6112    19 -1.029e-3 1048 -1049 -1008 vol=4.10433
6113    19 -1.029e-3 1048 -1049 -1007 vol=4.10433
6114    19 -1.029e-3 1048 -1049 -1006 vol=4.10433
6115    19 -1.029e-3 1048 -1049 -1005 vol=4.10433
6116    19 -1.029e-3 1048 -1049 -1004 vol=4.10433
6117    19 -1.029e-3 1048 -1049 -1003 vol=4.10433
6118    19 -1.029e-3 1048 -1049 -1002 vol=4.10433
6119    19 -1.029e-3 1048 -1049 -1001 vol=4.10433
c cell 4th position for bottom lazy susan
6120    19 -1.029e-3 1049 -1050 -1040 vol=4.10433
6121    19 -1.029e-3 1049 -1050 -1039 vol=4.10433
6122    19 -1.029e-3 1049 -1050 -1038 vol=4.10433
6123    19 -1.029e-3 1049 -1050 -1037 vol=4.10433
6124    19 -1.029e-3 1049 -1050 -1036 vol=4.10433
6125    19 -1.029e-3 1049 -1050 -1035 vol=4.10433
6126    19 -1.029e-3 1049 -1050 -1034 vol=4.10433
6127    19 -1.029e-3 1049 -1050 -1033 vol=4.10433
6128    19 -1.029e-3 1049 -1050 -1032 vol=4.10433
6129    19 -1.029e-3 1049 -1050 -1031 vol=4.10433
6130    19 -1.029e-3 1049 -1050 -1030 vol=4.10433
6131    19 -1.029e-3 1049 -1050 -1029 vol=4.10433
6132    19 -1.029e-3 1049 -1050 -1028 vol=4.10433
6133    19 -1.029e-3 1049 -1050 -1027 vol=4.10433
6134    19 -1.029e-3 1049 -1050 -1026 vol=4.10433
6135    19 -1.029e-3 1049 -1050 -1025 vol=4.10433
6136    19 -1.029e-3 1049 -1050 -1024 vol=4.10433
6137    19 -1.029e-3 1049 -1050 -1023 vol=4.10433
6138    19 -1.029e-3 1049 -1050 -1022 vol=4.10433
6139    19 -1.029e-3 1049 -1050 -1021 vol=4.10433
6140    19 -1.029e-3 1049 -1050 -1020 vol=4.10433
6141    19 -1.029e-3 1049 -1050 -1019 vol=4.10433
6142    19 -1.029e-3 1049 -1050 -1018 vol=4.10433
6143    19 -1.029e-3 1049 -1050 -1017 vol=4.10433
6144    19 -1.029e-3 1049 -1050 -1016 vol=4.10433
6145    19 -1.029e-3 1049 -1050 -1015 vol=4.10433
6146    19 -1.029e-3 1049 -1050 -1014 vol=4.10433
6147    19 -1.029e-3 1049 -1050 -1013 vol=4.10433
6148    19 -1.029e-3 1049 -1050 -1012 vol=4.10433
6149    19 -1.029e-3 1049 -1050 -1011 vol=4.10433
6150    19 -1.029e-3 1049 -1050 -1010 vol=4.10433
6151    19 -1.029e-3 1049 -1050 -1009 vol=4.10433
6152    19 -1.029e-3 1049 -1050 -1008 vol=4.10433
6153    19 -1.029e-3 1049 -1050 -1007 vol=4.10433
6154    19 -1.029e-3 1049 -1050 -1006 vol=4.10433
6155    19 -1.029e-3 1049 -1050 -1005 vol=4.10433
6156    19 -1.029e-3 1049 -1050 -1004 vol=4.10433
6157    19 -1.029e-3 1049 -1050 -1003 vol=4.10433
6158    19 -1.029e-3 1049 -1050 -1002 vol=4.10433
6159    19 -1.029e-3 1049 -1050 -1001 vol=4.10433
c cell 5th position for bottom lazy susan
6160    19 -1.029e-3 1050 -1051 -1040 vol=4.10433
```

```
6161    19 -1.029e-3 1050 -1051 -1039 vol=4.10433
6162    19 -1.029e-3 1050 -1051 -1038 vol=4.10433
6163    19 -1.029e-3 1050 -1051 -1037 vol=4.10433
6164    19 -1.029e-3 1050 -1051 -1036 vol=4.10433
6165    19 -1.029e-3 1050 -1051 -1035 vol=4.10433
6166    19 -1.029e-3 1050 -1051 -1034 vol=4.10433
6167    19 -1.029e-3 1050 -1051 -1033 vol=4.10433
6168    19 -1.029e-3 1050 -1051 -1032 vol=4.10433
6169    19 -1.029e-3 1050 -1051 -1031 vol=4.10433
6170    19 -1.029e-3 1050 -1051 -1030 vol=4.10433
6171    19 -1.029e-3 1050 -1051 -1029 vol=4.10433
6172    19 -1.029e-3 1050 -1051 -1028 vol=4.10433
6173    19 -1.029e-3 1050 -1051 -1027 vol=4.10433
6174    19 -1.029e-3 1050 -1051 -1026 vol=4.10433
6175    19 -1.029e-3 1050 -1051 -1025 vol=4.10433
6176    19 -1.029e-3 1050 -1051 -1024 vol=4.10433
6177    19 -1.029e-3 1050 -1051 -1023 vol=4.10433
6178    19 -1.029e-3 1050 -1051 -1022 vol=4.10433
6179    19 -1.029e-3 1050 -1051 -1021 vol=4.10433
6180    19 -1.029e-3 1050 -1051 -1020 vol=4.10433
6181    19 -1.029e-3 1050 -1051 -1019 vol=4.10433
6182    19 -1.029e-3 1050 -1051 -1018 vol=4.10433
6183    19 -1.029e-3 1050 -1051 -1017 vol=4.10433
6184    19 -1.029e-3 1050 -1051 -1016 vol=4.10433
6185    19 -1.029e-3 1050 -1051 -1015 vol=4.10433
6186    19 -1.029e-3 1050 -1051 -1014 vol=4.10433
6187    19 -1.029e-3 1050 -1051 -1013 vol=4.10433
6188    19 -1.029e-3 1050 -1051 -1012 vol=4.10433
6189    19 -1.029e-3 1050 -1051 -1011 vol=4.10433
6190    19 -1.029e-3 1050 -1051 -1010 vol=4.10433
6191    19 -1.029e-3 1050 -1051 -1009 vol=4.10433
6192    19 -1.029e-3 1050 -1051 -1008 vol=4.10433
6193    19 -1.029e-3 1050 -1051 -1007 vol=4.10433
6194    19 -1.029e-3 1050 -1051 -1006 vol=4.10433
6195    19 -1.029e-3 1050 -1051 -1005 vol=4.10433
6196    19 -1.029e-3 1050 -1051 -1004 vol=4.10433
6197    19 -1.029e-3 1050 -1051 -1003 vol=4.10433
6198    19 -1.029e-3 1050 -1051 -1002 vol=4.10433
6199    19 -1.029e-3 1050 -1051 -1001 vol=4.10433
c cell 6th position for bottom lazy susan
6200    19 -1.029e-3 1051 -1052 -1040 vol=4.10433
6201    19 -1.029e-3 1051 -1052 -1039 vol=4.10433
6202    19 -1.029e-3 1051 -1052 -1038 vol=4.10433
6203    19 -1.029e-3 1051 -1052 -1037 vol=4.10433
6204    19 -1.029e-3 1051 -1052 -1036 vol=4.10433
6205    19 -1.029e-3 1051 -1052 -1035 vol=4.10433
6206    19 -1.029e-3 1051 -1052 -1034 vol=4.10433
6207    19 -1.029e-3 1051 -1052 -1033 vol=4.10433
6208    19 -1.029e-3 1051 -1052 -1032 vol=4.10433
6209    19 -1.029e-3 1051 -1052 -1031 vol=4.10433
6210    19 -1.029e-3 1051 -1052 -1030 vol=4.10433
6211    19 -1.029e-3 1051 -1052 -1029 vol=4.10433
6212    19 -1.029e-3 1051 -1052 -1028 vol=4.10433
6213    19 -1.029e-3 1051 -1052 -1027 vol=4.10433
6214    19 -1.029e-3 1051 -1052 -1026 vol=4.10433
6215    19 -1.029e-3 1051 -1052 -1025 vol=4.10433
```

6216 19 -1.029e-3 1051 -1052 -1024 vol=4.10433
6217 19 -1.029e-3 1051 -1052 -1023 vol=4.10433
6218 19 -1.029e-3 1051 -1052 -1022 vol=4.10433
6219 19 -1.029e-3 1051 -1052 -1021 vol=4.10433
6220 19 -1.029e-3 1051 -1052 -1020 vol=4.10433
6221 19 -1.029e-3 1051 -1052 -1019 vol=4.10433
6222 19 -1.029e-3 1051 -1052 -1018 vol=4.10433
6223 19 -1.029e-3 1051 -1052 -1017 vol=4.10433
6224 19 -1.029e-3 1051 -1052 -1016 vol=4.10433
6225 19 -1.029e-3 1051 -1052 -1015 vol=4.10433
6226 19 -1.029e-3 1051 -1052 -1014 vol=4.10433
6227 19 -1.029e-3 1051 -1052 -1013 vol=4.10433
6228 19 -1.029e-3 1051 -1052 -1012 vol=4.10433
6229 19 -1.029e-3 1051 -1052 -1011 vol=4.10433
6230 19 -1.029e-3 1051 -1052 -1010 vol=4.10433
6231 19 -1.029e-3 1051 -1052 -1009 vol=4.10433
6232 19 -1.029e-3 1051 -1052 -1008 vol=4.10433
6233 19 -1.029e-3 1051 -1052 -1007 vol=4.10433
6234 19 -1.029e-3 1051 -1052 -1006 vol=4.10433
6235 19 -1.029e-3 1051 -1052 -1005 vol=4.10433
6236 19 -1.029e-3 1051 -1052 -1004 vol=4.10433
6237 19 -1.029e-3 1051 -1052 -1003 vol=4.10433
6238 19 -1.029e-3 1051 -1052 -1002 vol=4.10433
6239 19 -1.029e-3 1051 -1052 -1001 vol=4.10433
c cell 7th position for bottom lazy susan
6240 19 -1.029e-3 1052 -1053 -1040 vol=4.10433
6241 19 -1.029e-3 1052 -1053 -1039 vol=4.10433
6242 19 -1.029e-3 1052 -1053 -1038 vol=4.10433
6243 19 -1.029e-3 1052 -1053 -1037 vol=4.10433
6244 19 -1.029e-3 1052 -1053 -1036 vol=4.10433
6245 19 -1.029e-3 1052 -1053 -1035 vol=4.10433
6246 19 -1.029e-3 1052 -1053 -1034 vol=4.10433
6247 19 -1.029e-3 1052 -1053 -1033 vol=4.10433
6248 19 -1.029e-3 1052 -1053 -1032 vol=4.10433
6249 19 -1.029e-3 1052 -1053 -1031 vol=4.10433
6250 19 -1.029e-3 1052 -1053 -1030 vol=4.10433
6251 19 -1.029e-3 1052 -1053 -1029 vol=4.10433
6252 19 -1.029e-3 1052 -1053 -1028 vol=4.10433
6253 19 -1.029e-3 1052 -1053 -1027 vol=4.10433
6254 19 -1.029e-3 1052 -1053 -1026 vol=4.10433
6255 19 -1.029e-3 1052 -1053 -1025 vol=4.10433
6256 19 -1.029e-3 1052 -1053 -1024 vol=4.10433
6257 19 -1.029e-3 1052 -1053 -1023 vol=4.10433
6258 19 -1.029e-3 1052 -1053 -1022 vol=4.10433
6259 19 -1.029e-3 1052 -1053 -1021 vol=4.10433
6260 19 -1.029e-3 1052 -1053 -1020 vol=4.10433
6261 19 -1.029e-3 1052 -1053 -1019 vol=4.10433
6262 19 -1.029e-3 1052 -1053 -1018 vol=4.10433
6263 19 -1.029e-3 1052 -1053 -1017 vol=4.10433
6264 19 -1.029e-3 1052 -1053 -1016 vol=4.10433
6265 19 -1.029e-3 1052 -1053 -1015 vol=4.10433
6266 19 -1.029e-3 1052 -1053 -1014 vol=4.10433
6267 19 -1.029e-3 1052 -1053 -1013 vol=4.10433
6268 19 -1.029e-3 1052 -1053 -1012 vol=4.10433
6269 19 -1.029e-3 1052 -1053 -1011 vol=4.10433
6270 19 -1.029e-3 1052 -1053 -1010 vol=4.10433

```
6271    19 -1.029e-3 1052 -1053 -1009 vol=4.10433
6272    19 -1.029e-3 1052 -1053 -1008 vol=4.10433
6273    19 -1.029e-3 1052 -1053 -1007 vol=4.10433
6274    19 -1.029e-3 1052 -1053 -1006 vol=4.10433
6275    19 -1.029e-3 1052 -1053 -1005 vol=4.10433
6276    19 -1.029e-3 1052 -1053 -1004 vol=4.10433
6277    19 -1.029e-3 1052 -1053 -1003 vol=4.10433
6278    19 -1.029e-3 1052 -1053 -1002 vol=4.10433
6279    19 -1.029e-3 1052 -1053 -1001 vol=4.10433
c cell 8th position for bottom lazy susan
6280    19 -1.029e-3 1053 -1054 -1040 vol=4.10433
6281    19 -1.029e-3 1053 -1054 -1039 vol=4.10433
6282    19 -1.029e-3 1053 -1054 -1038 vol=4.10433
6283    19 -1.029e-3 1053 -1054 -1037 vol=4.10433
6284    19 -1.029e-3 1053 -1054 -1036 vol=4.10433
6285    19 -1.029e-3 1053 -1054 -1035 vol=4.10433
6286    19 -1.029e-3 1053 -1054 -1034 vol=4.10433
6287    19 -1.029e-3 1053 -1054 -1033 vol=4.10433
6288    19 -1.029e-3 1053 -1054 -1032 vol=4.10433
6289    19 -1.029e-3 1053 -1054 -1031 vol=4.10433
6290    19 -1.029e-3 1053 -1054 -1030 vol=4.10433
6291    19 -1.029e-3 1053 -1054 -1029 vol=4.10433
6292    19 -1.029e-3 1053 -1054 -1028 vol=4.10433
6293    19 -1.029e-3 1053 -1054 -1027 vol=4.10433
6294    19 -1.029e-3 1053 -1054 -1026 vol=4.10433
6295    19 -1.029e-3 1053 -1054 -1025 vol=4.10433
6296    19 -1.029e-3 1053 -1054 -1024 vol=4.10433
6297    19 -1.029e-3 1053 -1054 -1023 vol=4.10433
6298    19 -1.029e-3 1053 -1054 -1022 vol=4.10433
6299    19 -1.029e-3 1053 -1054 -1021 vol=4.10433
6300    19 -1.029e-3 1053 -1054 -1020 vol=4.10433
6301    19 -1.029e-3 1053 -1054 -1019 vol=4.10433
6302    19 -1.029e-3 1053 -1054 -1018 vol=4.10433
6303    19 -1.029e-3 1053 -1054 -1017 vol=4.10433
6304    19 -1.029e-3 1053 -1054 -1016 vol=4.10433
6305    19 -1.029e-3 1053 -1054 -1015 vol=4.10433
6306    19 -1.029e-3 1053 -1054 -1014 vol=4.10433
6307    19 -1.029e-3 1053 -1054 -1013 vol=4.10433
6308    19 -1.029e-3 1053 -1054 -1012 vol=4.10433
6309    19 -1.029e-3 1053 -1054 -1011 vol=4.10433
6310    19 -1.029e-3 1053 -1054 -1010 vol=4.10433
6311    19 -1.029e-3 1053 -1054 -1009 vol=4.10433
6312    19 -1.029e-3 1053 -1054 -1008 vol=4.10433
6313    19 -1.029e-3 1053 -1054 -1007 vol=4.10433
6314    19 -1.029e-3 1053 -1054 -1006 vol=4.10433
6315    19 -1.029e-3 1053 -1054 -1005 vol=4.10433
6316    19 -1.029e-3 1053 -1054 -1004 vol=4.10433
6317    19 -1.029e-3 1053 -1054 -1003 vol=4.10433
6318    19 -1.029e-3 1053 -1054 -1002 vol=4.10433
6319    19 -1.029e-3 1053 -1054 -1001 vol=4.10433
c cell 9th position for bottom lazy susan
6320    19 -1.029e-3 1054 -1055 -1040 vol=4.10433
6321    19 -1.029e-3 1054 -1055 -1039 vol=4.10433
6322    19 -1.029e-3 1054 -1055 -1038 vol=4.10433
6323    19 -1.029e-3 1054 -1055 -1037 vol=4.10433
6324    19 -1.029e-3 1054 -1055 -1036 vol=4.10433
```

```
6325    19 -1.029e-3 1054 -1055 -1035 vol=4.10433
6326    19 -1.029e-3 1054 -1055 -1034 vol=4.10433
6327    19 -1.029e-3 1054 -1055 -1033 vol=4.10433
6328    19 -1.029e-3 1054 -1055 -1032 vol=4.10433
6329    19 -1.029e-3 1054 -1055 -1031 vol=4.10433
6330    19 -1.029e-3 1054 -1055 -1030 vol=4.10433
6331    19 -1.029e-3 1054 -1055 -1029 vol=4.10433
6332    19 -1.029e-3 1054 -1055 -1028 vol=4.10433
6333    19 -1.029e-3 1054 -1055 -1027 vol=4.10433
6334    19 -1.029e-3 1054 -1055 -1026 vol=4.10433
6335    19 -1.029e-3 1054 -1055 -1025 vol=4.10433
6336    19 -1.029e-3 1054 -1055 -1024 vol=4.10433
6337    19 -1.029e-3 1054 -1055 -1023 vol=4.10433
6338    19 -1.029e-3 1054 -1055 -1022 vol=4.10433
6339    19 -1.029e-3 1054 -1055 -1021 vol=4.10433
6340    19 -1.029e-3 1054 -1055 -1020 vol=4.10433
6341    19 -1.029e-3 1054 -1055 -1019 vol=4.10433
6342    19 -1.029e-3 1054 -1055 -1018 vol=4.10433
6343    19 -1.029e-3 1054 -1055 -1017 vol=4.10433
6344    19 -1.029e-3 1054 -1055 -1016 vol=4.10433
6345    19 -1.029e-3 1054 -1055 -1015 vol=4.10433
6346    19 -1.029e-3 1054 -1055 -1014 vol=4.10433
6347    19 -1.029e-3 1054 -1055 -1013 vol=4.10433
6348    19 -1.029e-3 1054 -1055 -1012 vol=4.10433
6349    19 -1.029e-3 1054 -1055 -1011 vol=4.10433
6350    19 -1.029e-3 1054 -1055 -1010 vol=4.10433
6351    19 -1.029e-3 1054 -1055 -1009 vol=4.10433
6352    19 -1.029e-3 1054 -1055 -1008 vol=4.10433
6353    19 -1.029e-3 1054 -1055 -1007 vol=4.10433
6354    19 -1.029e-3 1054 -1055 -1006 vol=4.10433
6355    19 -1.029e-3 1054 -1055 -1005 vol=4.10433
6356    19 -1.029e-3 1054 -1055 -1004 vol=4.10433
6357    19 -1.029e-3 1054 -1055 -1003 vol=4.10433
6358    19 -1.029e-3 1054 -1055 -1002 vol=4.10433
6359    19 -1.029e-3 1054 -1055 -1001 vol=4.10433
c cell 10th position for bottom lazy susan
6360    19 -1.029e-3 1055 -1056 -1040 vol=4.10433
6361    19 -1.029e-3 1055 -1056 -1039 vol=4.10433
6362    19 -1.029e-3 1055 -1056 -1038 vol=4.10433
6363    19 -1.029e-3 1055 -1056 -1037 vol=4.10433
6364    19 -1.029e-3 1055 -1056 -1036 vol=4.10433
6365    19 -1.029e-3 1055 -1056 -1035 vol=4.10433
6366    19 -1.029e-3 1055 -1056 -1034 vol=4.10433
6367    19 -1.029e-3 1055 -1056 -1033 vol=4.10433
6368    19 -1.029e-3 1055 -1056 -1032 vol=4.10433
6369    19 -1.029e-3 1055 -1056 -1031 vol=4.10433
6370    19 -1.029e-3 1055 -1056 -1030 vol=4.10433
6371    19 -1.029e-3 1055 -1056 -1029 vol=4.10433
6372    19 -1.029e-3 1055 -1056 -1028 vol=4.10433
6373    19 -1.029e-3 1055 -1056 -1027 vol=4.10433
6374    19 -1.029e-3 1055 -1056 -1026 vol=4.10433
6375    19 -1.029e-3 1055 -1056 -1025 vol=4.10433
6376    19 -1.029e-3 1055 -1056 -1024 vol=4.10433
6377    19 -1.029e-3 1055 -1056 -1023 vol=4.10433
6378    19 -1.029e-3 1055 -1056 -1022 vol=4.10433
6379    19 -1.029e-3 1055 -1056 -1021 vol=4.10433
```

```
6380    19 -1.029e-3 1055 -1056 -1020 vol=4.10433
6381    19 -1.029e-3 1055 -1056 -1019 vol=4.10433
6382    19 -1.029e-3 1055 -1056 -1018 vol=4.10433
6383    19 -1.029e-3 1055 -1056 -1017 vol=4.10433
6384    19 -1.029e-3 1055 -1056 -1016 vol=4.10433
6385    19 -1.029e-3 1055 -1056 -1015 vol=4.10433
6386    19 -1.029e-3 1055 -1056 -1014 vol=4.10433
6387    19 -1.029e-3 1055 -1056 -1013 vol=4.10433
6388    19 -1.029e-3 1055 -1056 -1012 vol=4.10433
6389    19 -1.029e-3 1055 -1056 -1011 vol=4.10433
6390    19 -1.029e-3 1055 -1056 -1010 vol=4.10433
6391    19 -1.029e-3 1055 -1056 -1009 vol=4.10433
6392    19 -1.029e-3 1055 -1056 -1008 vol=4.10433
6393    19 -1.029e-3 1055 -1056 -1007 vol=4.10433
6394    19 -1.029e-3 1055 -1056 -1006 vol=4.10433
6395    19 -1.029e-3 1055 -1056 -1005 vol=4.10433
6396    19 -1.029e-3 1055 -1056 -1004 vol=4.10433
6397    19 -1.029e-3 1055 -1056 -1003 vol=4.10433
6398    19 -1.029e-3 1055 -1056 -1002 vol=4.10433
6399    19 -1.029e-3 1055 -1056 -1001 vol=4.10433
c cell 41 (#b1 (CL)ICIT divided into 40 1 cm segments from the bottom
c 41     19 -1.029e-3 -7 9 -28  vol=567.8696  $ fueled region ss-#b1
c 7      pz 27.79 $ top of rod
c 9      pz -27.86 $ bottom of rod
c 28      c/z 1.04648 3.91414 1.82245 $ fuel...going to asuume that's x y r,
8001    19 -1.029e-3 9    -4000 -28 vol=10.4342
8002    19 -1.029e-3 4000 -4001 -28 vol=10.4342
8003    19 -1.029e-3 4001 -4002 -28 vol=10.4342
8004    19 -1.029e-3 4002 -4003 -28 vol=10.4342
8005    19 -1.029e-3 4003 -4004 -28 vol=10.4342
8006    19 -1.029e-3 4004 -4005 -28 vol=10.4342
8007    19 -1.029e-3 4005 -4006 -28 vol=10.4342
8008    19 -1.029e-3 4006 -4007 -28 vol=10.4342
8009    19 -1.029e-3 4007 -4008 -28 vol=10.4342
8010    19 -1.029e-3 4008 -4009 -28 vol=10.4342
8011    19 -1.029e-3 4009 -4010 -28 vol=10.4342
8012    19 -1.029e-3 4010 -4011 -28 vol=10.4342
8013    19 -1.029e-3 4011 -4012 -28 vol=10.4342
8014    19 -1.029e-3 4012 -4013 -28 vol=10.4342
8015    19 -1.029e-3 4013 -4014 -28 vol=10.4342
8016    19 -1.029e-3 4014 -4015 -28 vol=10.4342
8017    19 -1.029e-3 4015 -4016 -28 vol=10.4342
8018    19 -1.029e-3 4016 -4017 -28 vol=10.4342
8019    19 -1.029e-3 4017 -4018 -28 vol=10.4342
8020    19 -1.029e-3 4018 -4019 -28 vol=10.4342
8021    19 -1.029e-3 4019 -4020 -28 vol=10.4342
8022    19 -1.029e-3 4020 -4021 -28 vol=10.4342
8023    19 -1.029e-3 4021 -4022 -28 vol=10.4342
8024    19 -1.029e-3 4022 -4023 -28 vol=10.4342
8025    19 -1.029e-3 4023 -4024 -28 vol=10.4342
8026    19 -1.029e-3 4024 -4025 -28 vol=10.4342
8027    19 -1.029e-3 4025 -4026 -28 vol=10.4342
8028    19 -1.029e-3 4026 -4027 -28 vol=10.4342
8029    19 -1.029e-3 4027 -4028 -28 vol=10.4342
8030    19 -1.029e-3 4028 -4029 -28 vol=10.4342
8031    19 -1.029e-3 4029 -4030 -28 vol=10.4342
```

```
8032    19 -1.029e-3 4030 -4031 -28 vol=10.4342
8033    19 -1.029e-3 4031 -4032 -28 vol=10.4342
8034    19 -1.029e-3 4032 -4033 -28 vol=10.4342
8035    19 -1.029e-3 4033 -4034 -28 vol=10.4342
8036    19 -1.029e-3 4034 -4035 -28 vol=10.4342
8037    19 -1.029e-3 4035 -4036 -28 vol=10.4342
8038    19 -1.029e-3 4036 -4037 -28 vol=10.4342
8039    19 -1.029e-3 4037 -4038 -28 vol=10.4342
8040    19 -1.029e-3 4038 -4039 -28 vol=10.4342
8041    19 -1.029e-3 4039 -7   -28 vol=163.2952
c #g2 rabbit divided into 40 1 cm segments from the bottom
9001    19 -1.029e-3 9    -4000 -299 vol=10.4342
9002    19 -1.029e-3 4000 -4001 -299 vol=10.4342
9003    19 -1.029e-3 4001 -4002 -299 vol=10.4342
9004    19 -1.029e-3 4002 -4003 -299 vol=10.4342
9005    19 -1.029e-3 4003 -4004 -299 vol=10.4342
9006    19 -1.029e-3 4004 -4005 -299 vol=10.4342
9007    19 -1.029e-3 4005 -4006 -299 vol=10.4342
9008    19 -1.029e-3 4006 -4007 -299 vol=10.4342
9009    19 -1.029e-3 4007 -4008 -299 vol=10.4342
9010    19 -1.029e-3 4008 -4009 -299 vol=10.4342
9011    19 -1.029e-3 4009 -4010 -299 vol=10.4342
9012    19 -1.029e-3 4010 -4011 -299 vol=10.4342
9013    19 -1.029e-3 4011 -4012 -299 vol=10.4342
9014    19 -1.029e-3 4012 -4013 -299 vol=10.4342
9015    19 -1.029e-3 4013 -4014 -299 vol=10.4342
9016    19 -1.029e-3 4014 -4015 -299 vol=10.4342
9017    19 -1.029e-3 4015 -4016 -299 vol=10.4342
9018    19 -1.029e-3 4016 -4017 -299 vol=10.4342
9019    19 -1.029e-3 4017 -4018 -299 vol=10.4342
9020    19 -1.029e-3 4018 -4019 -299 vol=10.4342
9021    19 -1.029e-3 4019 -4020 -299 vol=10.4342
9022    19 -1.029e-3 4020 -4021 -299 vol=10.4342
9023    19 -1.029e-3 4021 -4022 -299 vol=10.4342
9024    19 -1.029e-3 4022 -4023 -299 vol=10.4342
9025    19 -1.029e-3 4023 -4024 -299 vol=10.4342
9026    19 -1.029e-3 4024 -4025 -299 vol=10.4342
9027    19 -1.029e-3 4025 -4026 -299 vol=10.4342
9028    19 -1.029e-3 4026 -4027 -299 vol=10.4342
9029    19 -1.029e-3 4027 -4028 -299 vol=10.4342
9030    19 -1.029e-3 4028 -4029 -299 vol=10.4342
9031    19 -1.029e-3 4029 -4030 -299 vol=10.4342
9032    19 -1.029e-3 4030 -4031 -299 vol=10.4342
9033    19 -1.029e-3 4031 -4032 -299 vol=10.4342
9034    19 -1.029e-3 4032 -4033 -299 vol=10.4342
9035    19 -1.029e-3 4033 -4034 -299 vol=10.4342
9036    19 -1.029e-3 4034 -4035 -299 vol=10.4342
9037    19 -1.029e-3 4035 -4036 -299 vol=10.4342
9038    19 -1.029e-3 4036 -4037 -299 vol=10.4342
9039    19 -1.029e-3 4037 -4038 -299 vol=10.4342
9040    19 -1.029e-3 4038 -4039 -299 vol=10.4342
9041    19 -1.029e-3 4039 -7   -299 vol=163.2952
c beam port 43
1047     1 -2.7 -836 -833 899 $ al plate bp4
1048     19 -1.029e-3 -836 -899 900 $ al pipe bp4
1049     19 -1.029e-3 -836 -900 901 $ al pipe bp4
```

```
1050    19 -1.029e-3 -836 -901 902 $ end of al pipe bp4
1051    1 -2.7 -800 -902 903 $ al plate bp4
c al and steel cladding bp4
2047    1 -2.7 -835 836 -833 899 $ al claddingbp4
2048    1 -2.7 -835 836 -899 900 $ al cladding bp4
2049    1 -2.7 -835 836 -900 901 $ al cladding bp4
2050    1 -2.7 -835 836 -901 902 $ end of al cladding bp4
2052    16 -7.86 800 -801  -903 904 $ steel cladding bp4
c concrete surrounded al cladding bp4
14000   18 -2.3 835 -1041 890 902 -882 -617 $ concrete surrounded bp4
c concrete surrounded steel cladding bp4
14001   18 -2.3 801 -1043 -902 903 -617 $ concrete around steel clad bp4
14002   18 -2.3 801 -1043 -903 904 -617 $ concrete around steel clad bp4
c beam port 3
1010    19 -1.029e-3 -837 865 -896 617 vol=420.00983 $ vol next to water
1011    1 -2.7 -837 834 -842 vol=57.91666 $ al plate bp3
1012    6 -1.0 -837 842 -865 vol=2779.99991 $ Flooded portion of BP3
1090    19 -1.029e-3 -837 895 896 -843 $ Boron Carbide appature
1091    19 -1.029e-3 -895 896 -843 $ Boron Carbide appature hole
1013    19 -1.029e-3 -837 843 -844 $ al pipe bp3
1014    19 -1.029e-3 -837 844 -845 $ al pipe bp3
1015    19 -1.029e-3 -837 845 -846 $ al pipe bp3
1016    19 -1.029e-3 -837 846 -847 $ al pipe bp3
1017    19 -1.029e-3 -837 847 -848 $ end of al pipe bp3
1018    1 -2.7 -839 848 -849 $ al plate bp3
1019    16 -7.86 -839 849 -850 $ steel plate bp3
1030    19 -1.029e-3 -839 850 -860 $ Bi filter
1020    19 -1.029e-3 -839 860 -851 $ steel pipe bp3
1021    19 -1.029e-3 -839 851 -852 $ steel pipe bp3
1022    19 -1.029e-3 -839 852 -853 $ steel pipe bp3
1023    19 -1.029e-3 -839 853 -854 $ steel pipe bp3
1024    19 -1.029e-3 -839 854 -855 $ steel pipe bp3
1025    19 -1.029e-3 -839 855 -856 $ steel pipe bp3
1026    19 -1.029e-3 -839 856 -857 $ steel pipe bp3
1027    19 -1.029e-3 -839 857 -858 $ end of steel pipe bp3
c al and steel cladding bp3
2011    1 -2.7 837 -838 834 -842 $ al cladding bp3
2012    1 -2.7 837 -838 842 -843 $ al cladding bp3
2013    1 -2.7 837 -838 843 -844 $ al cladding bp3
2014    1 -2.7 837 -838 844 -845 $ al cladding bp3
2015    1 -2.7 837 -838 845 -846 $ al cladding bp3
2016    1 -2.7 837 -838 846 -847 $ al cladding bp3
2017    1 -2.7 837 -838 847 -848 $ end of al cladding bp3
2018    16 -7.86 839 -840 848 -849 $ steel cladding bp3
2019    16 -7.86 839 -840 849 -850 $ steel cladding bp3
2020    16 -7.86 839 -840 850 -851 $ steel cladding bp3
2021    16 -7.86 839 -840 851 -852 $ steel cladding bp3
2022    16 -7.86 839 -840 852 -853 $ steel cladding bp3
2023    16 -7.86 839 -840 853 -854 $ steel cladding bp3
2024    16 -7.86 839 -840 854 -855 $ steel cladding bp3
2025    16 -7.86 839 -840 855 -856 $ steel cladding bp3
2026    16 -7.86 839 -840 856 -857 $ steel cladding bp3
2027    16 -7.86 839 -840 857 -858 $ end of steel cladding bp3
c concrete surrounded al cladding bp3
14009   18 -2.3 838 -1042 890 -846 617 -612 $ concrete around al clad bp3
14010   18 -2.3 838 -1042 846 -847 617 -612 $ concrete around al clad bp3
```

```
14011   18 -2.3 838 -1042 847 -848 617 -612 $ concrete around al clad bp3
c concrete surrounded steel cladding bp3
14012   18 -2.3 840 -1044 617 -612 848 -849 $ concrete around steel clad bp3
14013   18 -2.3 840 -1044 617 -612 849 -850 $ concrete around steel clad bp3
14014   18 -2.3 840 -1044 617 -612 850 -851 $ concrete around steel clad bp3
14015   18 -2.3 840 -1044 617 -612 851 -852 $ concrete around steel clad bp3
14016   18 -2.3 840 -1044 617 -612 852 -853 $ concrete around steel clad bp3
14017   18 -2.3 840 -1044 617 -612 853 -854 $ concrete around steel clad bp3
14018   18 -2.3 840 -1044 617 -612 854 -855 $ concrete around steel clad bp3
14019   18 -2.3 840 -1044 617 -612 855 -856 $ concrete around steel clad bp3
14020   18 -2.3 840 -1044 617 -612 856 -857 $ concrete around steel clad bp3
14021   18 -2.3 840 -1044 617 -612 857 -858 $ end of concrete around clad bp3
c volume cards for slab
c 50000   5 -11.4 -5003 5004 -601 606 5000 -5001 $ lead slab
c 50001   18 -2.3 5001  -5002 -5003 5004 -601 606 $ concrete slab
c 50002   19 -1.029e-3 858 -5021 -5003 5004 -601 606 $ front air
c 50005   19 -1.029e-3 -5003 5004 -601 606 -5006 5002 $ back detector
c 50006   18 -2.3 858 -5002 -5007 5003 -601 606 $ north wall
c 50007   18 -2.3 858 -5002 -5004 5008 -601 606 $ south wall
c 50010   5 -11.4 5009 -5003 -5000 5011 -601 606 $ north lead
c 50011   5 -11.4 5004 -5010 -5000 5011 -601 606 $ south lead
c 50012   19 -1.029e-3 -5015 -5016 5018 5017 -601 606 $ air space
c 50013   5 -11.4 5011 -5012 -5009 5013 -601 606 $ north lead lip
c 50014   5 -11.4 5011 -5012 -5014 5010 -601 606 $ south lead lip
c 50015   19 -1.029e-3 5011 -5018 -5013 5014 -601 606 $ lip air
c 50016   6 -1.0 -5000 5015 -5009 5010 -601 606 $ masonite block (water)
c 50017   6 -1.0 -5009 5016 5012 -5015 -601 606 $ north masonite
c 50018   6 -1.0 5010 -5017 5012 -5015 -601 606 $ south masonite
c 50019   6 -1.0 -5016 5013 5012 -5018 -601 606 $ north masonite lip
c 50020   6 -1.0 5017 -5014 5012 -5018 -601 606 $ south masonite lip
c 50021   19 -1.029e-3 -5014 5004 5021 -5011 -601 606 $ south front air
c 50022   19 -1.029e-3 5021 -5011 5014 -5013 -601 606 $ middle front air
c 50023   19 -1.029e-3 5021 -5011 5013 -5003 -601 606 $ north front air
c 50024   19 -1.029e-3 858 -5018 5007 -5019 -601 606 $ north (front) side air
c 50025   19 -1.029e-3 5018 -5015 5007 -5019 -601 606 $ north (middle) side air
c 50027   19 -1.029e-3 858 -5018 5020 -5008 -601 606 $ south (front) side air
c 50028   19 -1.029e-3 5018 -5015 5020 -5008 -601 606 $ south (middle) side air

1     so 1000  $ infinity
2     cz 26.67 $ cylinder of water
3     cz 27.31 $ cylinder of vessel
4     pz -36.2 $ bottom of reflector
5     pz 32.39 $ top of water
6     pz 30.78 $ bottom of upper grid plate
7     pz 27.79 $ top of rod
8     pz -34.29 $ top of lower grid plate
9     pz -27.86 $ bottom of rod
10     cz 37.47 $ cylinder of lazy susan
11     pz 6.0325 $ bottom of lazy susan
12     cz 47.63 $ cylinder of graphite
13     cz 52.55 $ cylinder of lead
c 14     pz -46.2 $ bottom of water
c 15     pz 42.39 $ top of water
c 16     cz 62.71 $ cylinder of water
17     pz -19.05 $ bottom of fuel
18     pz 19.05 $ top of fuel
```

```
19    cz 10.0803 $ region 0 core
20    cz 14.2557 $ region 1 core
21    cz 17.4596 $ region 2 core
22    cz 20.1606 $ region 3 core
23    cz 22.5403 $ region 4 core
24    cz 24.6916 $ region 5 core
25    cz 1.82245 $ graph
26    cz 1.87325 $ cladding central thimble -#a1
c 27    c/z 1.04648 3.91414 0.3175 $ zr rod
c 28    c/z 1.04648 3.91414 1.82245 $ fuel
28    c/z 1.04648 3.91414 1.82245 $ air
29    c/z 1.04648 3.91414 1.87325 $ cladding al-#b1
30    c/z -2.86766 2.86766 0.3175 $ zr rod
31    c/z -2.86766 2.86766 1.82245 $ fuel
32    c/z -2.86766 2.86766 1.87325 $ cladding ss-#b2
33    c/z -3.91414 -1.04648 0.3175 $ zr rod
34    c/z -3.91414 -1.04648 1.82245 $ fuel
35    c/z -3.91414 -1.04648 1.87325 $ cladding ss-#b3
36    c/z -1.04648 -3.91414 0.3175 $ zr rod
37    c/z -1.04648 -3.91414 1.82245 $ fuel
38    c/z -1.04648 -3.91414 1.87325 $ cladding ss-#b4
39    c/z 2.86766 -2.86766 0.3175 $ zr rod
40    c/z 2.86766 -2.86766 1.82245 $ fuel
41    c/z 2.86766 -2.86766 1.87325 $ cladding ss-#b5
42    c/z 3.91414 1.04648 0.3175 $ zr rod
43    c/z 3.91414 1.04648 1.82245 $ fuel
44    c/z 3.91414 1.04648 1.87325 $ cladding ss-#b6
45    c/z 0.0 7.98068 0.3175 $ zr rod
46    c/z 0.0 7.98068 1.82245 $ fuel
47    c/z 0.0 7.98068 1.87325 $ cladding ss-#c1
48    c/z -3.99034 6.91134 0.3175 $ zr rod
49    c/z -3.99034 6.91134 1.82245 $ fuel
50    c/z -3.99034 6.91134 1.87325 $ cladding ss-#c2
51    c/z -6.91134 3.99034 0.3175 $ zr rod
52    c/z -6.91134 3.99034 1.82245 $ fuel
53    c/z -6.91134 3.99034 1.87325 $ cladding ss-#c3
54    c/z -7.98068 0.0 1.82245 $ fuel
55    c/z -7.98068 0.0 1.88733 $ cladding control w/o fuel-#c4
56    c/z -6.91134 -3.99034 0.3175 $ zr rod
57    c/z -6.91134 -3.99034 1.82245 $ fuel
58    c/z -6.91134 -3.99034 1.87325 $ cladding ss-#c5
59    c/z -3.99034 -6.91134 0.3175 $ zr rod
60    c/z -3.99034 -6.91134 1.82245 $ fuel
61    c/z -3.99034 -6.91134 1.87325 $ cladding ss-#c6
62    c/z 0.0 -7.98068 0.3175 $ zr rod
63    c/z 0.0 -7.98068 1.82245 $ fuel
64    c/z 0.0 -7.98068 1.87325 $ cladding ss-#c7
65    c/z 3.99034 -6.91134 0.3175 $ zr rod
66    c/z 3.99034 -6.91134 1.82245 $ fuel
67    c/z 3.99034 -6.91134 1.87325 $ cladding ss-#c8
68    c/z 6.91134 -3.99034 0.3175 $ zr rod
69    c/z 6.91134 -3.99034 1.82245 $ fuel
70    c/z 6.91134 -3.99034 1.87325 $ cladding ss-#c9
71    c/z 7.98068 0.0 1.82245 $ fuel
72    c/z 7.98068 0.0 0.3175 $ zr rod
73    c/z 7.98068 0.0 1.87325 $ cladding con w/fuel-#c10
```

```
74    c/z 6.91134 3.99034 0.3175 $ zr rod
75    c/z 6.91134 3.99034 1.82245 $ fuel
76    c/z 6.91134 3.99034 1.87325 $ cladding ss-#c11
77    c/z 3.99034 6.91134 0.3175 $ zr rod
78    c/z 3.99034 6.91134 1.82245 $ fuel
79    c/z 3.99034 6.91134 1.87325 $ cladding ss-#c12
80    c/z 0.0 11.9456 1.82245 $ fuel
81    c/z 0.0 11.9456 0.3175 $ zr rod
82    c/z 0.0 11.9456 1.87325 $ cladding con w/fuel-#d1
83    c/z -4.08432 11.2243 0.3175 $ zr rod
84    c/z -4.08432 11.2243 1.82245 $ fuel
85    c/z -4.08432 11.2243 1.87325 $ cladding ss-#d2
86    c/z -7.67842 9.15162 0.3175 $ zr rod
87    c/z -7.67842 9.15162 1.82245 $ fuel
88    c/z -7.67842 9.15162 1.87325 $ cladding ss-#d3
89    c/z -10.3454 5.97408 0.3175 $ zr rod
90    c/z -10.3454 5.97408 1.82245 $ fuel
91    c/z -10.3454 5.97408 1.87325 $ cladding ss-#d4
92    c/z -11.7653 2.2225 0.3175 $ zr rod
93    c/z -11.7653 2.2225 1.82245 $ fuel
94    c/z -11.7653 2.2225 1.87325 $ cladding ss-#d5
95    c/z -11.303 -2.07264 0.3175 $ zr rod
96    c/z -11.303 -2.07264 1.82245 $ fuel
97    c/z -11.303 -2.07264 1.87325 $ cladding ss-#d6
98    c/z -10.3454 -5.97408 0.3175 $ zr rod
99    c/z -10.3454 -5.97408 1.82245 $ fuel
100   c/z -10.3454 -5.97408 1.87325 $ cladding ss-#d7
101   c/z -7.67842 -9.15162 0.3175 $ zr rod
102   c/z -7.67842 -9.15162 1.82245 $ fuel
103   c/z -7.67842 -9.15162 1.87325 $ cladding ss-#d8
104   c/z -4.08432 -11.2243 0.3175 $ zr rod
105   c/z -4.08432 -11.2243 1.82245 $ fuel
106   c/z -4.08432 -11.2243 1.87325 $ cladding ss-#d9
107   c/z 0.0 -11.9456 1.82245 $ fuel
108   c/z 0.0 -11.9456 0.3175 $ zr rod
109   c/z 0.0 -11.9456 1.87325 $ cladding con w/fuel-#d10
110   c/z 4.08432 -11.2243 0.3175 $ zr rod
111   c/z 4.08432 -11.2243 1.82245 $ fuel
112   c/z 4.08432 -11.2243 1.87325 $ cladding ss-#d11
113   c/z 7.67842 -9.15162 0.3175 $ zr rod
114   c/z 7.67842 -9.15162 1.82245 $ fuel
115   c/z 7.67842 -9.15162 1.87325 $ cladding ss-#d12
116   c/z 10.3454 -5.97408 0.3175 $ zr rod
117   c/z 10.3454 -5.97408 1.82245 $ fuel
118   c/z 10.3454 -5.97408 1.87325 $ cladding ss-#d13
119   c/z 11.7653 -2.2225 0.3175 $ zr rod
120   c/z 11.7653 -2.2225 1.82245 $ fuel
121   c/z 11.7653 -2.2225 1.87325 $ cladding ss-#d14
122   c/z 11.303 2.07264 0.3175 $ zr rod
123   c/z 11.303 2.07264 1.82245 $ fuel
124   c/z 11.303 2.07264 1.87325 $ cladding ss-#d15
125   c/z 10.3454 5.97408 0.3175 $ zr rod
126   c/z 10.3454 5.97408 1.82245 $ fuel
127   c/z 10.3454 5.97408 1.87325 $ cladding ss-#d16
128   c/z 7.67842 9.15162 0.3175 $ zr rod
129   c/z 7.67842 9.15162 1.82245 $ fuel
```

```
130   c/z 7.67842 9.15162 1.87325 $ cladding ss-#d17
131   c/z 4.08432 11.2243 0.3175 $ zr rod
132   c/z 4.08432 11.2243 1.82245 $ fuel
133   c/z 4.08432 11.2243 1.87325 $ cladding ss-#d18
134   c/z 0.0 15.9156 0.3175 $ zr rod
135   c/z 0.0 15.9156 1.82245 $ fuel
136   c/z 0.0 15.9156 1.87325 $ cladding ss-#e1
137   c/z -4.11988 15.3721 0.3175 $ zr rod
138   c/z -4.11988 15.3721 1.82245 $ fuel
139   c/z -4.11988 15.3721 1.87325 $ cladding ss-#e2
140   c/z -7.95782 13.782 0.3175 $ zr rod
141   c/z -7.95782 13.782 1.82245 $ fuel
142   c/z -7.95782 13.782 1.87325 $ cladding ss-#e3
143   c/z -11.2547 11.2547 0.3175 $ zr rod
144   c/z -11.2547 11.2547 1.82245 $ fuel
145   c/z -11.2547 11.2547 1.87325 $ cladding ss-#e4
146   c/z -13.782 7.95782 0.3175 $ zr rod
147   c/z -13.782 7.95782 1.82245 $ fuel
148   c/z -13.782 7.95782 1.87325 $ cladding ss-#e5
149   c/z -15.2019 4.20624 0.3175 $ zr rod
150   c/z -15.2019 4.20624 1.82245 $ fuel
151   c/z -15.2019 4.20624 1.87325 $ cladding ss-#e6
152   c/z -15.2019 0.2413 0.3175 $ zr rod
153   c/z -15.2019 0.2413 1.82245 $ fuel
154   c/z -15.2019 0.2413 1.87325 $ cladding ss-#e7
155   c/z -15.3721 -4.11988 0.3175 $ zr rod
156   c/z -15.3721 -4.11988 1.82245 $ fuel
157   c/z -15.3721 -4.11988 1.87325 $ cladding ss-#e8
158   c/z -13.782 -7.95782 0.3175 $ zr rod
159   c/z -13.782 -7.95782 1.82245 $ fuel
160   c/z -13.782 -7.95782 1.87325 $ cladding ss-#e9
161   c/z -11.2547 -11.2547 0.3175 $ zr rod
162   c/z -11.2547 -11.2547 1.82245 $ fuel
163   c/z -11.2547 -11.2547 1.87325 $ cladding ss-#e10
164   c/z -7.95782 -13.782 0.3175 $ zr rod
165   c/z -7.95782 -13.782 1.82245 $ fuel
166   c/z -7.95782 -13.782 1.87325 $ cladding ss-#e11
167   c/z -4.11988 -15.3721 0.3175 $ zr rod
168   c/z -4.11988 -15.3721 1.82245 $ fuel
169   c/z -4.11988 -15.3721 1.87325 $ cladding ss-#e12
170   c/z 0.0 -15.9156 0.3175 $ zr rod
171   c/z 0.0 -15.9156 1.82245 $ fuel
172   c/z 0.0 -15.9156 1.87325 $ cladding ss-#e13
173   c/z 4.11988 -15.3721 0.3175 $ zr rod
174   c/z 4.11988 -15.3721 1.82245 $ fuel
175   c/z 4.11988 -15.3721 1.87325 $ cladding ss-#e14
176   c/z 7.95782 -13.782 0.3175 $ zr rod
177   c/z 7.95782 -13.782 1.82245 $ fuel
178   c/z 7.95782 -13.782 1.87325 $ cladding ss-#e15
179   c/z 11.2547 -11.2547 0.3175 $ zr rod
180   c/z 11.2547 -11.2547 1.82245 $ fuel
181   c/z 11.2547 -11.2547 1.87325 $ cladding ss-#e16
182   c/z 13.782 -7.95782 0.3175 $ zr rod
183   c/z 13.782 -7.95782 1.82245 $ fuel
184   c/z 13.782 -7.95782 1.87325 $ cladding ss-#e17
185   c/z 15.2019 -4.20624 0.3175 $ zr rod
```

```
186   c/z 15.2019 -4.20624 1.82245 $ fuel
187   c/z 15.2019 -4.20624 1.87325 $ cladding ss-#e18
188   c/z 15.2019 -0.2413 0.3175 $ zr rod
189   c/z 15.2019 -0.2413 1.82245 $ fuel
190   c/z 15.2019 -0.2413 1.87325 $ cladding ss-#e19
191   c/z 15.3721 4.11988 0.3175 $ zr rod
192   c/z 15.3721 4.11988 1.82245 $ fuel
193   c/z 15.3721 4.11988 1.87325 $ cladding ss-#e20
194   c/z 13.782 7.95782 0.3175 $ zr rod
195   c/z 13.782 7.95782 1.82245 $ fuel
196   c/z 13.782 7.95782 1.87325 $ cladding ss-#e21
197   c/z 11.2547 11.2547 0.3175 $ zr rod
198   c/z 11.2547 11.2547 1.82245 $ fuel
199   c/z 11.2547 11.2547 1.87325 $ cladding ss-#e22
200   c/z 7.95782 13.782 0.3175 $ zr rod
201   c/z 7.95782 13.782 1.82245 $ fuel
202   c/z 7.95782 13.782 1.87325 $ cladding ss-#e23
203   c/z 4.11988 15.3721 0.3175 $ zr rod
204   c/z 4.11988 15.3721 1.82245 $ fuel
205   c/z 4.11988 15.3721 1.87325 $ cladding ss-#e24
206   c/z 0.0 19.8196 0.3175 $ zr rod
207   c/z 0.0 19.8196 1.82245 $ fuel
208   c/z 0.0 19.8196 1.87325 $ cladding ss-#f1
211   c/z -4.13512 19.4539 1.87325 $ cladding ss-#f2
212   c/z -8.0899 18.1686 0.3175 $ zr rod
213   c/z -8.0899 18.1686 1.82245 $ fuel
214   c/z -8.0899 18.1686 1.87325 $ cladding ss-#f3
215   c/z -11.6916 16.0909 0.3175 $ zr rod
216   c/z -11.6916 16.0909 1.82245 $ fuel
217   c/z -11.6916 16.0909 1.87325 $ cladding ss-#f4
400   c/z -14.7803 13.3071 0.3175 $ zr rod
401   c/z -14.7803 13.3071 1.82245 $ fuel
218   c/z -14.7803 13.3071 1.87325 $ cladding water -#f5
219   c/z -17.1323 10.1194 0.3175 $ zr rod
220   c/z -17.1323 10.1194 1.82245 $ fuel
221   c/z -17.1323 10.1194 1.87325 $ cladding ss-#f6
222   c/z -18.9154 6.1468 0.3175 $ zr rod
223   c/z -18.9154 6.1468 1.82245 $ fuel
224   c/z -18.9154 6.1468 1.87325 $ cladding ss-#f7
225   c/z -19.9898 2.07772 0.3175 $ zr rod
226   c/z -19.9898 2.07772 1.82245 $ fuel
227   c/z -19.9898 2.07772 1.87325 $ cladding ss-#f8
228   c/z -19.9898 -2.07772 0.3175 $ zr rod
229   c/z -19.9898 -2.07772 1.82245 $ fuel
230   c/z -19.9898 -2.07772 1.87325 $ cladding ss-#f9
231   c/z -18.9154 -6.1468 0.3175 $ zr rod
232   c/z -18.9154 -6.1468 1.82245 $ fuel
233   c/z -18.9154 -6.1468 1.87325 $ cladding ss-#f10
234   c/z -17.4523 -9.9441 0.3175 $ zr rod
235   c/z -17.4523 -9.9441 1.82245 $ fuel
236   c/z -17.4523 -9.9441 1.87325 $ cladding ss-#f11
402   c/z -14.7803 -13.3071 0.3175 $ zr rod
403   c/z -14.7803 -13.3071 1.82245 $ fuel
237   c/z -14.7803 -13.3071 1.87325 $ cladding water -#f12
238   c/z -11.6916 -16.0909 0.3175 $ zr rod
239   c/z -11.6916 -16.0909 1.82245 $ fuel
```

```
240     c/z -11.6916 -16.0909 1.87325 $ cladding ss-#f13
241     c/z -8.0899 -18.1686 0.3175 $ zr rod
242     c/z -8.0899 -18.1686 1.82245 $ fuel
243     c/z -8.0899 -18.1686 1.87325 $ cladding ss-#f14
244     c/z -4.13512 -19.4539 0.3175 $ zr rod
245     c/z -4.13512 -19.4539 1.82245 $ fuel
246     c/z -4.13512 -19.4539 1.87325 $ cladding ss-#f15
247     c/z 0.0 -19.8882 0.3175 $ zr rod
248     c/z 0.0 -19.8882 1.82245 $ fuel
249     c/z 0.0 -19.8882 1.87325 $ cladding ss-#f16
c 250     c/z 4.13512 -19.4539 0.3175 $ zr rod
c 251     c/z 4.13512 -19.4539 1.82245 $ fuel
252     c/z 4.13512 -19.4539 1.87325 $ h20-#f17
c 253     c/z 8.0899 -18.1686 0.3175 $ zr rod
254     c/z 8.0899 -18.1686 1.82245 $ fuel
255     c/z 8.0899 -18.1686 1.87325 $ cladding ss-#f18
c 256     c/z 11.6916 -16.0909 0.3175 $ zr rod
257     c/z 11.6916 -16.0909 1.82245 $ fuel
258     c/z 11.6916 -16.0909 1.87325 $ cladding ss-#f19
405     c/z 14.7803 -13.3071 1.82245 $ fuel
259     c/z 14.7803 -13.3071 1.87325 $ cladding water -#f20
261     c/z 17.1323 -10.1194 1.82245 $ fuel
262     c/z 17.1323 -10.1194 1.87325 $ cladding ss-#f21
264     c/z 18.9154 -6.1468 1.82245 $ fuel
265     c/z 18.9154 -6.1468 1.87325 $ cladding ss-#f22
267     c/z 19.9898 -2.07772 1.82245 $ fuel
268     c/z 19.9898 -2.07772 1.87325 $ cladding ss-#f23
c 269     c/z 19.9898 2.07772 0.3175 $ zr rod
270     c/z 19.9898 2.07772 1.82245 $ fuel
271     c/z 19.9898 2.07772 1.87325 $ cladding ss-#f24
273     c/z 18.9154 6.1468 1.82245 $ fuel
274     c/z 18.9154 6.1468 1.87325 $ cladding ss-#f25
276     c/z 17.4523 9.9441 1.82245 $ fuel
277     c/z 17.4523 9.9441 1.87325 $ cladding ss-#f26
407     c/z 14.7803 13.3071 1.82245 $ fuel
278     c/z 14.7803 13.3071 1.87325 $ cladding water -#f27
c 279     c/z 11.6916 16.0909 0.3175 $ zr rod
c 280     c/z 11.6916 16.0909 1.82245 $ fuel
281     c/z 11.6916 16.0909 1.87325 $ h20-#f28
c 282     pz 15.24 $ segment bottom1
c 283     pz 11.43 $ segment bottom2
c 284     pz 7.62 $ segment bottom3
c 285     pz 3.81 $ segment bottom4
c 286     pz 0.0 $ segment bottom5
c 287     pz -3.81 $ segment bottom6
c 288     pz -7.62 $ segment bottom7
c 289     pz -11.43 $ segment bottom8
c 290     pz -15.24 $ segment bottom9
c 291     c/z 8.0899 18.1686 0.3175 $ zr rod
c 292     c/z 8.0899 18.1686 1.82245 $ fuel
293     c/z 8.0899 18.1686 1.87325 $ h20-#f29
294     c/z 4.13512 19.4539 0.3175 $ zr rod
295     c/z 4.13512 19.4539 1.82245 $ fuel
296     c/z 4.13512 19.4539 1.87325 $ cladding ss-#f30
297     c/z 0.0 23.8608 1.82245 $ graph
298     c/z 0.0 23.8608 1.87325 $ cladding gr-#g1
```

```
299     c/z -4.14274 23.4975 1.82245 $ graph
300     c/z -4.14274 23.4975 1.87325 $ cladding gr-#g2
301     c/z -8.16102 22.4206 1.82245 $ graph
302     c/z -8.16102 22.4206 1.87325 $ cladding gr-#g3
303     c/z -11.9304 20.6654 1.82245 $ graph
304     c/z -11.9304 20.6654 1.87325 $ cladding gr-#g4
305     c/z -15.3365 18.2778 1.82245 $ graph
306     c/z -15.3365 18.2778 1.87325 $ cladding gr-#g5
307     c/z -18.2778 15.3365 1.82245 $ graph
308     c/z -18.2778 15.3365 1.87325 $ h20-#g6
c 308     c/z -18.2778 15.3365 1.87325 $ cladding gr-#g6
c 309     c/z -20.6654 11.9304 1.82245 $ graph
309     c/z -20.6654 11.9304 0.3175 $ zr rod
c 310     c/z -20.6654 11.9304 1.87325 $ cladding gr-#g7
10000   c/z -20.6654 11.9304 1.82245 $ fuel
310     c/z -20.6654 11.9304 1.87325 $ cladding water -#g7
c 311     c/z -22.606 8.0772 1.82245 $ graph
311     c/z -22.606 8.0772 0.3175 $ zr rod
10001   c/z -22.606 8.0772 1.82245 $ fuel
312     c/z -22.606 8.0772 1.87325 $ cladding gr-#g8
313     c/z -23.4975 4.14274 0.3175 $ zr rod
10002   c/z -23.4975 4.14274 1.82245 $ fuel
314     c/z -23.4975 4.14274 1.87325 $ cladding gr-#g9
408     c/z -23.8608 0.0 0.3175 $ zr rod
409     c/z -23.8608 0.0 1.82245 $ fuel
315     c/z -23.8608 0.0 1.87325 $ cladding water -#g10
410     c/z -23.4975 -4.14274 0.3175 $ zr rod
411     c/z -23.4975 -4.14274 1.82245 $ fuel
316     c/z -23.4975 -4.14274 1.87325 $ cladding water -#g11
412     c/z -22.4206 -8.16102 0.3175 $ zr rod
413     c/z -22.4206 -8.16102 1.82245 $ fuel
317     c/z -22.4206 -8.16102 1.87325 $ cladding water -#g12
414     c/z -20.6654 -11.9304 0.3175 $ zr rod
415     c/z -20.6654 -11.9304 1.82245 $ fuel
318     c/z -20.6654 -11.9304 1.87325 $ cladding water -#g13
c 416     c/z -18.2778 -15.3365 0.3175 $ zr rod
c 417     c/z -18.2778 -15.3365 1.82245 $ fuel
319     c/z -18.2778 -15.3365 1.87325 $ h20 -#g14
c 418     c/z -15.3365 -18.2778 0.3175 $ zr rod
c 419     c/z -15.3365 -18.2778 1.82245 $ fuel
320     c/z -15.3365 -18.2778 1.87325 $ h20 -#g15
c 420     c/z -11.9304 -20.6654 0.3175 $ zr rod
321     c/z -11.9304 -20.6654 1.82245 $ graph
322     c/z -11.9304 -20.6654 1.87325 $ cladding gr-#g16
323     c/z -7.93242 -22.4206 1.82245 $ graph
324     c/z -7.93242 -22.4206 1.87325 $ cladding gr-#g17
325     c/z -4.14274 -23.4975 1.82245 $ graph
326     c/z -4.14274 -23.4975 1.87325 $ cladding gr-#g18
327     c/z 0.0 -23.8608 1.82245 $ graph
328     c/z 0.0 -23.8608 1.87325 $ cladding gr-#g19
329     c/z 4.14274 -23.4975 1.82245 $ graph
330     c/z 4.14274 -23.4975 1.87325 $ cladding gr-#g20
c 331     c/z 8.16102 -22.4206 1.82245 $ graph
332     c/z 8.16102 -22.4206 1.87325 $ h20-#g21
333     c/z 11.9304 -20.6654 1.87325 $ cladding water -#g22
334     c/z 15.3365 -18.2778 1.87325 $ cladding water -#g23
```

```
335   c/z 18.2778 -15.3365 1.87325 $ cladding water -#g24
336   c/z 20.6654 -11.9304 1.87325 $ cladding water -#g25
337   c/z 22.606 -8.0772 1.87325 $ cladding water -#g26
338   c/z 23.4975 -4.14274 1.87325 $ cladding water -#g27
339   c/z 23.8608 0.0 1.87325 $ cladding water -#g28
341   c/z 23.4975 4.14274 1.87325 $ cladding gr-#g29
343   c/z 22.4206 8.16102 1.87325 $ cladding gr-#g30
345   c/z 20.6654 11.9304 1.87325 $ cladding gr-#g31
347   c/z 18.2778 15.3365 1.87325 $ cladding gr-#g32
349   c/z 15.3365 18.2778 1.87325 $ cladding gr-#g33
350   c/z 11.9304 20.6654 1.82245 $ graph
351   c/z 11.9304 20.6654 1.87325 $ cladding gr-#g34
352   c/z 7.93242 22.4206 1.82245 $ graph
353   c/z 7.93242 22.4206 1.87325 $ cladding gr-#g35
354   c/z 4.14274 23.4975 1.82245 $ graph
355   c/z 4.14274 23.4975 1.87325 $ cladding gr-#g36
701  cz 53.815 $ water gap
702  cz 56.46 $ cylinder of Al
703  cz 59.0 $ outer cylinder of Al
601  pz 60.96 $ top of TC
602  pz 59.691 $ b4c top of TC
603  pz 59.373 $ Al top of TC
604  pz -59.373 $ Al bottom of TC
605  pz -59.691 $ b4c bottom of TC
606  pz -60.96 $ bottom of TC
607  px 60.96 $ right side of TC
608  px 59.691 $ b4c right of TC
609  px 59.373 $ Al right of TC
610  px -59.373 $ Al left of TC
611  px -59.691 $ b4c left of TC
612  px -60.96 $ left side of TC
613  p 0 13.38 0 0 13.38 1 -60.96 63.623 0 $ left outer angle of TC
614  p 0 13.8 0 0 13.8 1 -59.373 63.623 0 $ left inner angle of TC
615  p 0 13.38 0 0 13.38 1 60.96 63.623 0 $ right outer angle of TC
616  p 0 13.8 0 0 13.8 1 59.373 63.623 0 $ right inner angle of TC
617  py 0.0 $ center line
618  py 219.405 $ front of region N
619  py 63.623 $ back of region A
620  py 97.485 $ back of TC void
621  px 10.160 $ side of TC void
622  px -10.160 $ side of TC void
623  pz -10.160 $ bottom of TC void
624  pz 10.160 $ top of TC void
625  py 98.485 $ Sample position for TC
626  py 99.485 $ Sample position for TC
627  py 100.485 $ Sample position for TC
628  py 101.485 $ Sample position for TC
629  py 102.485 $ Sample position for TC
630  py 103.485 $ Sample position for TC
631  py 104.485 $ Sample position for TC
632  py 105.485 $ Sample position for TC
633  py 106.485 $ Sample position for TC
634  py 107.485 $ Sample position for TC
635  py 108.485 $ Sample position for TC
636  py 109.485 $ Sample position for TC
637  py 110.485 $ Sample position for TC
```

```
638   py 111.485 $ Sample position for TC
639   py 112.485 $ Sample position for TC
640   py 113.485 $ Sample position for TC
641   py 114.485 $ Sample position for TC
642   py 115.485 $ Sample position for TC
643   py 116.485 $ Sample position for TC
644   py 117.485 $ Sample position for TC
646   px 0.5 $ side of sample voids
647   px -0.5 $ side of sample voids
648   pz 0.5 $ top of sample voids
649   pz -0.5 $ bottom osample voids
650   px -9.160 $ 1 cm from TC void wall
830   pz 5.08 $ top of inner region
831   pz -5.08 $ bottom of inner region
833   1 px -27.4105 $ al pipe bp4
834   1 py 8.7313 $ al pipe bp3
835   1 cx 8.4138 $ outer radius al pipe bp4
838   2 cy 8.4138 $ outer radius al pipe bp3
868   px 0 $ center line
871   pz 30.48 $ top of thermalizing column
872   pz 29.211 $ b4c top of thermalizing column
873   pz 28.893 $ Al top of thermalizing column
874   pz -28.893 $ Al bottom of thermalizing column
875   pz -29.211 $ b4c bottom of thermalizing column
876   pz -30.48 $ bottom of thermalizing column
877   px 30.48 $ right side of thermalizing column
878   px 29.211 $ b4c right of thermalizing column
879   px 28.893 $ Al right of thermalizing column
880   px -28.893 $ Al left of thermalizing column
881   px -29.211 $ b4c left of thermalizing column
882   px -30.48 $ left side of thermalizing column
883   py -67.95 $ front lead block in thermalizing column
884   py -73.03 $ back lead block in thermalizing column
885   py -93.35 $ air block in thermalzing column
886   py -113.67 $ end of graphite in thermalizing column
889   cz 98.425 $ inner radius of reactor tank
890   cz 99.06 $ outer radius of reactor tank
837   2 cy 7.62 $ inner radius al pipe bp3
839   2 cy 10.16 $ inner radius steel pipe bp3
840   2 cy 10.9538 $ outer radius steel pipe bp3
895   2 cy 4.0 $ appature hole
842   1 py 9.0488 $ al pipe bp3
865   2 py 24.2888 $ plane for water flooding
896   2 py 26.8288 $ plane for appature
843   2 py 29.1313 $ al pipe bp3
844   2 py 49.5313 $ al pipe bp3
845   2 py 69.9313 $ al pipe bp3
846   2 py 90.3313 $ al pipe bp3
847   2 py 110.7313 $ al pipe bp3
848   2 py 131.1313 $ end of al pipe bp3
849   2 py 131.7663 $ al plate bp3
850   2 py 132.4013 $ steel plate bp3
860   2 py 136.9413 $ Bi filter
851   2 py 152.6813 $ steel pipe bp3
852   2 py 172.9613 $ steel pipe bp3
853   2 py 193.2413 $ steel pipe bp3
```

```
854   2 py 213.5213 $ steel pipe bp3
855   2 py 233.8013 $ steel pipe bp3
856   2 py 254.0813 $ steel pipe bp3
857   2 py 274.3613 $ steel pipe bp3
858   2 py 294.6413 $ end of steel pipe bp3
836   1 cx 8.02 $ inner radius Al pipe bp4
800   1 cx 10.16 $ inner radius steel pipe bp4
801   1 cx 10.9538 $ outer radius steel pipe bp4
899   1 px -27.628 $ Al pipe bp4
900   1 px -53.9276 $ Al pipe bp4
901   1 px -80.2272 $ Al pipe bp4
902   1 px -105.8918 $ end of Al pipe bp4
903   1 px -106.5268 $ Al plate of bp4
904   1 px -107.1618 $ steel plate bp4
905   1 px -132.8793 $ steel pipe bp4
906   1 px -158.5968 $ steel pipe bp4
907   1 px -184.3143 $ steel pipe bp4
908   1 px -210.0318 $ steel pipe bp4
909   1 px -235.7493 $ steel pipe bp4
1000  1 px -261.4668 $ end of steel pipe bp4
1001   c/z 5.06691 31.99123 1.143 $ lazy susan rack
1002   c/z 10.00906 30.80472 1.143 $ lazy susan rack
1003   c/z 14.70475 28.8597 1.143 $ lazy susan rack
1004   c/z 19.03836 26.20406 1.143 $ lazy susan rack
1005   c/z 22.90319 22.90319 1.143 $ lazy susan rack
1006   c/z 26.20406 19.03836 1.143 $ lazy susan rack
1007   c/z 28.8597 14.70475 1.143 $ lazy susan rack
1008   c/z 30.80472 10.00906 1.143 $ lazy susan rack
1009   c/z 31.99123 5.066912 1.143 $ lazy susan rack
1010   c/z 32.39 0 1.143 $ lazy susan rack
1011   c/z 31.99123 -5.06691 1.143 $ lazy susan rack
1012   c/z 30.80472 -10.0091 1.143 $ lazy susan rack
1013   c/z 28.8597 -14.7048 1.143 $ lazy susan rack
1014   c/z 26.20406 -19.0384 1.143 $ lazy susan rack
1015   c/z 22.90319 -22.9032 1.143 $ lazy susan rack
1016   c/z 19.03836 -26.2041 1.143 $ lazy susan rack
1017   c/z 14.70475 -28.8597 1.143 $ lazy susan rack
1018   c/z 10.00906 -30.8047 1.143 $ lazy susan rack
1019   c/z 5.066912 -31.9912 1.143 $ lazy susan rack
1020   c/z 0 -32.39 1.143 $ lazy susan rack
1021   c/z -5.06691 -31.9912 1.143 $ lazy susan rack
1022   c/z -10.0091 -30.8047 1.143 $ lazy susan rack
1023   c/z -14.7048 -28.8597 1.143 $ lazy susan rack
1024   c/z -19.0384 -26.2041 1.143 $ lazy susan rack
1025   c/z -22.9032 -22.9032 1.143 $ lazy susan rack
1026   c/z -26.2041 -19.0384 1.143 $ lazy susan rack
1027   c/z -28.8597 -14.7048 1.143 $ lazy susan rack
1028   c/z -30.8047 -10.0091 1.143 $ lazy susan rack
1029   c/z -31.9912 -5.06691 1.143 $ lazy susan rack
1030   c/z -32.39 0 1.143 $ lazy susan rack
1031   c/z -31.9912 5.066912 1.143 $ lazy susan rack
1032   c/z -30.8047 10.00906 1.143 $ lazy susan rack
1033   c/z -28.8597 14.70475 1.143 $ lazy susan rack
1034   c/z -26.2041 19.03836 1.143 $ lazy susan rack
1035   c/z -22.9032 22.90319 1.143 $ lazy susan rack
1036   c/z -19.0384 26.20406 1.143 $ lazy susan rack
```

```
1037    c/z -14.7048 28.8597 1.143 $ lazy susan rack
1038    c/z -10.0091 30.80472 1.143 $ lazy susan rack
1039    c/z -5.06691 31.99123 1.143 $ lazy susan rack
1040    c/z 0 32.39 1.143 $ lazy susan rack
1041    1 cx 18.4138 $ concrete surrounded al clad bp4
1042    2 cy 18.4138 $ concrete surrounded al clad bp3
1043    1 cx 20.9538 $ concrete surrounded steel clad bp4
1044    2 cy 20.9538 $ concrete surrouned steel clad bp3
1045    pz -15.24 $ 1 cm above the bottom of rabbit sample position
1046    pz -16.24 $ bottom of rabbit sample position
c --------added surfaces for 1 cm segments in the lazy susan----------
1047    pz 7.0325 $ 1 cm above the bottom of the lazy susan sample position
1048    pz 8.0325 $ 2 cm above the bottom of the lazy susan
1049    pz 9.0325 $ 3 cm above the bottom of the lazy susan
1050    pz 10.0325 $ 4 cm above the bottom of the lazy susan
1051    pz 11.0325 $ 5 cm above the bottom of the lazy susan
1052    pz 12.0325 $ 6 cm above the bottom of the lazy susan
1053    pz 13.0325 $ 7 cm above the bottom of the lazy susan
1054    pz 14.0325 $ 8 cm above the bottom of the lazy susan
1055    pz 15.0325 $ 9 cm above the bottom of the lazy susan
1056    pz 16.0325 $ 10 cm above the bottom of the lazy susan
c ------------------------------------------------------------
1090    pz -0.6212 $ transient rod position
1091    pz 0.47493 $ shim rod position
1092    pz 0.28745 $ safety rod position
1093    pz 1.59426 $ regulating rod position
c --------added surfaces HHL ----------------------------
2000    pz 8.070375 $ plane for lazy susan axial segment
2001    pz 9.10825
2002    pz 10.14613
2003    pz 11.184
2004    pz 12.22188
2005    pz 13.25975
2006    pz 14.29763
2007    pz 15.3355
2008    pz 16.37338
2009    pz 17.41125
2010    pz 18.44913
2011    pz 19.487
2012    pz 20.52488
2013    pz 21.56275
2014    pz 22.60063
2015    pz 23.6385
2016    pz 24.67638
2017    pz 25.71425
2018    pz 26.75213
c --------add radial segment for Lazy Susan----------
3000    c/z 32.39 0 0.05715
3001    c/z 32.39 0 0.11430
3002    c/z 32.39 0 0.17145
3003    c/z 32.39 0 0.22860
3004    c/z 32.39 0 0.28575
3005    c/z 32.39 0 0.34290
3006    c/z 32.39 0 0.40005
3007    c/z 32.39 0 0.45720
3008    c/z 32.39 0 0.51435
```

```
3009    c/z 32.39 0 0.57150
3010    c/z 32.39 0 0.62865
3011    c/z 32.39 0 0.68580
3012    c/z 32.39 0 0.74295
3013    c/z 32.39 0 0.80010
3014    c/z 32.39 0 0.85725
3015    c/z 32.39 0 0.91440
3016    c/z 32.39 0 0.97155
3017    c/z 32.39 0 1.02870
3018    c/z 32.39 0 1.08585
c added surfaces to divide #b1 into 1 cm axial segments
4000    pz -26.86
4001    pz -25.86
4002    pz -24.86
4003    pz -23.86
4004    pz -22.86
4005    pz -21.86
4006    pz -20.86
4007    pz -19.86
4008    pz -18.86
4009    pz -17.86
4010    pz -16.86
4011    pz -15.86
4012    pz -14.86
4013    pz -13.86
4014    pz -12.86
4015    pz -11.86
4016    pz -10.86
4017    pz -09.86
4018    pz -08.86
4019    pz -07.86
4020    pz -06.86
4021    pz -05.86
4022    pz -04.86
4023    pz -03.86
4024    pz -02.86
4025    pz -01.86
4026    pz -00.86
4027    pz 00.14
4028    pz 01.14
4029    pz 02.14
4030    pz 03.14
4031    pz 04.14
4032    pz 05.14
4033    pz 06.14
4034    pz 07.14
4035    pz 08.14
4036    pz 09.14
4037    pz 10.14
4038    pz 11.14
4039    pz 12.14
c surface cards for lead block
5000    2 py 478.0 $ start of lead
5001    2 py 508.48 $ end of lead
5002    2 py 630.4 $ end of concrete
5003    2 px 40.0 $ right side of slab
```

```
5004    2 px -40.0 $ left side of slab
5005    2 py 472.0 $ front of detector volume
5006    2 py 636.4 $ back of detector volume
5007    2 px 161.92 $ north side of shield
5008    2 px -161.92 $ south side of shield
5009    2 px 29.84 $ north lead
5010    2 px -29.84 $ south lead
5011    2 py 396.72 $ start of lead
5012    2 py 406.88 $ lead lip
5013    2 px 9.52 $ north lead lip
5014    2 px -9.52 $ south lead lip
5015    2 py 447.52 $ start of masonite
5016    2 px 19.68 $ north masonite
5017    2 px -19.68 $ south masonite
5018    2 py 417.04 $ masonite lip
5019    2 px 167.0 $ north detectors
5020    2 px -167.0 $ south detectors
5021    2 py 391.64 $ front detector

*tr1    0 0 -6.985 27 63 90 117 27 90 90 90 0
*tr2    -36.49 -9.37 -6.985 40 50 90 130 40 90 90 90 0
m1      13027 1.0 $ al
m2      6012 0.00009456 24000 0.005187 28000 0.00241866 26000  $ steel/h2o
      0.0180264 1001 0.04676 8016 0.02338
m4      6012 1.0 $ graphite
mt4     grph.01t $ graphite  salphabeta card
m5      82000 1.0 $ lead
m6      1001 0.6667 8016 0.3333 $ h2o
mt6     lwtr.01t $ h2o  salphabeta card
m7      6012 0.00031519 24000 0.01729 28000 0.0080622 26000 0.060088 $ steel
m8      40000.35c 1.0 $ zr
m9      1001 0.0561382 40000.35c 0.0350864  92235 0.000892797 92238  $ uzrh-full
      0.000378151 68166 0.000258324  68167 0.0000769439
mt9     h/zr.01t zr/h.01t $ uzrh-full  salphabeta card
m10     5010 0.15824 5011 0.64176 6012 0.2 $ b4c
m12     1001 0.04666 40000.35c 0.02916 92235 0.000753 92238 0.000323  $ uzrh-partial
      68166 0.000267 68167 0.000080
mt12    h/zr.01t zr/h.01t $ uzrh-partial  salphabeta card
c m13     83209 1.0  $ Bi
c m14     1001 2.0 6012 1.0 $ CH2
c m15     79197 1.0
m16     26000 1.0 $ steel
m18     1001 -0.010 8016 -0.529 11023 -0.016 12000 -0.002
      13027 -0.034 14000 -0.337 19000 -0.013 20000 -0.044
      26000 -0.014 6012 -0.001 $ concrete
m19     7014 0.79 8016 0.21 $ air
c m20     48000 1.0 $ natural cad
c m21     79197.60c 1.0 $ gold
ksrc    4.24164 1.37398 0.0 3.19516 -2.54016 0.0 -0.71898 -3.58664 0.0
     -3.58664 -0.71898 0.0 -2.54016 3.19516 0.0 1.37398 4.24164 0.0
      8.30818 0.3275 0.0 7.23884 -3.66284 0.0 4.31784 -6.58384 0.0
     -3.66284 -6.58384 0.0 -6.58384 -3.66284 0.0 -7.65318 0.3275 0.0
     -6.58384 4.31784 0.0 -3.66284 7.23884 0.0 0.3275 8.30818 -4.405
      4.31784 7.23884 0.0 7.23884 4.31784 0.0 12.2731 0.3275 -4.405
      11.5518 -3.75682 0.0 9.47912 -7.35092 0.0 6.30158 -10.0179 0.0
      2.55 -11.4378 0.0 -1.74514 -10.9755 0.0 -5.64658 -10.0179 0.0
```

```
        -8.82412 -7.35092 0.0 -10.8968 -3.75682 0.0 -11.6181 0.3275
        -4.405 -10.8968 4.41182 0.0 -8.82412 8.00592 0.0 -5.64658
        10.6729 0.0 -1.895 12.0928 0.0 2.40014 11.6305 0.0 6.30158
        10.6729 0.0 9.47912 8.00592 0.0 11.5518 4.41182 0.0 16.2431
        0.3275 0.0 15.6996 -3.79238 0.0 14.1095 -7.63032 0.0 11.5822
        -10.9272 0.0 8.28532 -13.4545 0.0 4.53374 -14.8744 0.0 0.5688
        -14.8744 0.0 -3.79238 -15.0446 0.0 -7.63032 -13.4545 0.0
        -10.9272 -10.9272 0.0 -13.4545 -7.63032 0.0 -15.0446 -3.79238
        0.0 -15.5881 0.3275 0.0 -15.0446 4.44738 0.0 -13.4545 8.28532
        0.0 -10.9272 11.5822 0.0 -7.63032 14.1095 0.0 -3.87874 15.5294
        0.0 0.0862 15.5294 0.0 4.44738 15.6996 0.0 8.28532 14.1095 0.0
        11.5822 11.5822 0.0 14.1095 8.28532 0.0 15.6996 4.44738 0.0
        20.1471 0.3275 0.0 19.7814 -3.80762 0.0 18.4961 -7.7624 0.0
        16.4184 -11.3641 0.0 10.4469 -16.8048 0.0 6.4743 -18.5879 0.0
        2.40522 -19.6623 0.0 -1.75022 -19.6623 0.0 -5.8193 -18.5879 0.0
        -9.6166 -17.1248 0.0 -15.7634 -11.3641 0.0 -17.8411 -7.7624 0.0
        -19.1264 -3.80762 0.0 -19.5607 0.3275 0.0 -19.1264 4.46262 0.0
        -17.8411 8.4174 0.0 -15.7634 12.0191 0.0 -9.79186 17.4598 0.0
        -5.8193 19.2429 0.0 -1.75022 20.3173 0.0 2.40522 20.3173 0.0
        6.4743 19.2429 0.0 10.2716 17.7798 0.0 18.4961 8.4174 0.0
        19.7814 4.46262 0.0 -15.1803 13.3071 0.0 -15.1803 -13.3071 0.0
        -24.2608 0.0 0.0 -23.8975 -4.14274 0.0 -21.0654 -11.9304 0.0
        -18.6778 -15.3365 0.0 -15.8365 -18.2778 0.0 -12.3304 -20.6654 0.0
mode    n p $  card
kcode   10000 1.0 50 5000 $ kcode card
c ssw    847 (-1016)
dbcn    12j 764585 4j $ random number stride is 5 time of 152917 (default)
esplt:n  2 0.1 2 0.001 2 0.0001 2 0.000001 0.75 5e-7 $ split energy
c ----------Tally for lazy susan in 1 cm segment at the bottom--------
c f2:n    843 844 900 901 $ surface tally around 1013 and 1049
c f4:n    1013 1049 $ flux in BP3 and BP4
c f4:n    1027 50022 50005 50025 50028
c f14:p   1027 50022 50005 50025 50028
c f14:n   5001 38i 5040 T $ dose over lazy susan cells
c ----------Tally for lazy susan in axial and radial segment------
c f24:n     8001 38i 8040 T $ Activity in #b1
f34:n   6000 38i 6039 T $ flux in LS bottom
f144:n  6040 38i 6079 T $ flux 1 cm from bottom
f154:n  6080 38i 6119 T $ flux 1 cm from bottom
f164:n  6120 38i 6159 T $ flux 1 cm from bottom
f174:n  6160 38i 6199 T $ flux 1 cm from bottom
f184:n  6200 38i 6239 T $ flux 1 cm from bottom
f194:n  6240 38i 6279 T $ flux 1 cm from bottom
f204:n  6280 38i 6319 T $ flux 1 cm from bottom
f214:n  6320 38i 6359 T $ flux 1 cm from bottom
f224:n  6360 38i 6399 T $ flux 1 cm from bottom
c f44:n   7001 18i 7020 T $ radial flux in lazy susan----------HHL
c f54:n   7001 18i 7020 T $ radial dose in lazy susan----------HHL
c ----------Tally for beam port 3 and beam port 4----------
c f64:n   1011 5i 1017 T $ flux in beamport 3 cells
c f74:n   1011 5i 1017 T $ dose in beamport 3 cells
c f4:n    1016 1017 1020 1021 $ flux in beamport 3 cells
c f14:n   1016 1017 1020 1021 $ dose in beamport 3 cells
c f24:p   1016 1017 1020 1021 $ flux in beamport 3 cells
c f34:p   1016 1017 1020 1021 $ dose in beamport 3 cells
c ----------Tally Thermal Column----------
```

```
f104:n  16021 18i 16040 T $ axial flux through center of TC void
f114:n  16044 18i 16063 T $ axial flux along TC void wall
c ------------Tally for icit----------------------------------------
f124:n  8001 38i 8040 T $ radial flux through the icit
c ------------Tally for Rabbit-------------------------------------
f134:n  9010 29i 9040 T $ radial flux through Rabbit
c -------------Area card-------------------------------------------
area    380j 222.39972 222.39972 5598.01919 6932.31709 19j
        6278.28760 10438.01448 11253.53573 182.41469 182.41469 182.41469
        182.41469 182.41469 182.41469 182.41469
        324.29279 324.29279 324.29279 324.29279 324.29279
        324.29279 324.29279 324.29279 324.29279 324.29279
        5336.00917 9931.46659 10707.41129
        202.06849 202.06849 202.06849 202.06849
        324.29279 324.29279 324.29279 324.29279
        324.29279 324.29279 324.29279 324.29279
        40j 790.42093 3710.56338 20482.47683 21527.17202 3j
        325.3307 312.7792 314.9260 299.9619 19j 19j
c -------- same neutron spectrum in LAZY SUSAN----------------------------
e0      1.000e-10 1.000e-09 1.000e-08 2.300e-08 5.000e-08 7.600e-08
        1.150e-07 1.700e-07 2.550e-07 3.800e-07 5.500e-07 8.400e-07
        1.275e-06 1.900e-06 2.800e-06 4.250e-06 6.300e-06 9.200e-06
        1.350e-05 2.100e-05 3.000e-05 4.500e-05 6.900e-05 1.000e-04
        1.350e-04 1.700e-04 2.200e-04 2.800e-04 3.600e-04 4.500e-04
        5.750e-04 7.600e-04 9.600e-04 1.275e-03 1.600e-03 2.000e-03
        2.700e-03 3.400e-03 4.500e-03 5.500e-03 7.200e-03 9.200e-03
        1.200e-02 1.500e-02 1.900e-02 2.550e-02 3.200e-02 4.000e-02
        5.250e-02 6.600e-02 8.800e-02 1.100e-01 1.350e-01 1.600e-01
        1.900e-01 2.200e-01 2.550e-01 2.900e-01 3.200e-01 3.600e-01
        4.000e-01 4.500e-01 5.000e-01 5.500e-01 6.000e-01 6.600e-01
        7.200e-01 7.800e-01 8.400e-01 9.200e-01 1.000e+00 1.200e+00
        1.400e+00 1.600e+00 1.800e+00 2.000e+00 2.300e+00 2.600e+00
        2.900e+00 3.300e+00 3.700e+00 4.100e+00 4.500e+00 5.000e+00
        5.500e+00 6.000e+00 6.700e+00 7.400e+00 8.200e+00 9.000e+00
        1.000e+01 1.100e+01 1.200e+01 1.300e+01 1.400e+01 1.500e+01
        1.600e+01 1.700e+01 1.800e+01 1.900e+01
c -------dose conversion for axial and radial distribution of the lazy susan
c de14   2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1
c       5.0e-1 1 2.0 5.0 10.0 20.0
c df14   3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6
c       2.08e-5 7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de34   0.01 0.03 0.05 0.07 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55
c       0.6 0.65 0.7 0.8 1.0 1.4 1.8 2.2 2.6 2.8 3.25 3.75 4.25 4.75 5.0
c       5.25 5.75 6.25 6.75 7.5 9.0 11.0 13.0 15.0
c df34   3.96e-6 5.82e-7 2.9e-7 2.58e-7 2.83e-7 3.79e-7 5.01e-7 6.31e-7
c      7.59e-7 8.78e-7 9.85e-7 1.08e-6 1.17e-6 1.27e-6 1.36e-6 1.44e-6
c       1.52e-6 1.68e-6 1.98e-6 2.51e-6 2.99e-6 3.42e-6 3.82e-6 4.01e-6
c       4.41e-6 4.83e-6 5.23e-6 5.6e-6 5.8e-6 6.01e-6 6.37e-6 6.74e-6
c       7.11e-6 7.66e-6 8.77e-6 1.03e-5 1.18e-5 1.33e-5
c de34   2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
c       2.0   5.0   10.0   20.0
c df34   3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c       7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de54   2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
```

```
c       2.0   5.0   10.0  20.0
c df54    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c       7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de74    2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
c       2.0   5.0   10.0  20.0
c df74    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c       7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c de94    2.5e-8 1.0e-7 1.0e-6 1.0e-5 1.0e-4 1.0e-3 1.0e-2 1.0e-1 5.0e-1
c 1
c       2.0   5.0   10.0  20.0
c df94    3.85e-6 4.17e-6 4.55e-6 4.35e-6 4.17e-6 3.70e-6 3.57e-6 2.08e-5
c       7.14e-5 1.18e-4 1.43e-4 1.47e-4 1.47e-4 1.54e-4
c ---------------------------------------------------------------------
c fm2     8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm4     8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm14    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm24      (6.76166e8 21 -2) $ multiplier card (normalize factor)
c fm24    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm34    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm54    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm64    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm74    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm84    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
c fm94    8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm104   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm114   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm124   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm134   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm144   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm154   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm164   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm174   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm184   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm194   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm204   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm214   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
fm224   8.296523e16 $ multiplier card (normalize factor for 1 MW reactor)
cut:n   j 0
c print
prdmp   0 -30 1 1
imp:n   0 38r 1 1208r
```

APPENDIX B: ENERGY & EFFICIENCY CALIBRATION EQUATIONS FROM GAMMAVISION®

Lazy Susan Equations:

Shelf 2 Calibrations:

Energy Calibration Fit
Energy = -0.3762 +0.199956*Channel +2.94935e-008*Channel**2
FWHM = 5.2815 +0.000922*Channel -2.64784e-008*Channel**2

Efficiency Calibration Fit
Knee Energy = 150.00 keV
Above the Knee: Quadratic Uncertainty = 1.9257 %
Ln(Eff) = 1.5214 -0.829909*Ln(Eng) -0.011472*(Ln(Eng))**2
Below the Knee: Quadratic Uncertainty = 1.0903 %
Ln(Eff) = -4.0537 +0.071146*Ln(Eng) +0.030458*(Ln(Eng))**2

Shelf 20 Calibrations:

Energy Calibration Fit
Energy = 0.3021 +0.199990*Channel +5.14726e-008*Channel**2
FWHM = 4.0852 +0.000961*Channel -3.87658e-008*Channel**2

Efficiency Calibration Fit
Knee Energy = 150.00 keV
Above the Knee: Quadratic Uncertainty = 3.0623 %
Ln(Eff) = -5.1876 +0.341169*Ln(Eng) -0.100399*(Ln(Eng))**2

Below the Knee: Quadratic Uncertainty = 2.3468 %
Ln(Eff) = -40.8376 +14.046212*Ln(Eng) -1.4172*(Ln(Eng))**2

(CL)ICIT, Rabbit, & Thermal Column:

Shelf 2 Calibrations:

Energy Calibration Fit
Energy = 0.0049 +0.200038*Channel +5.27178e-009*Channel**2
FWHM = 3.2896 +0.000875*Channel -1.72326e-009*Channel**2

Efficiency Calibration Fit
Knee Energy = 120.00 keV
Above the Knee: Quadratic Uncertainty = 2.0318 %
Ln(Eff) = -2.6046 +0.417005*Ln(Eng) -0.105399*(Ln(Eng))**2
Below the Knee: Quadratic Uncertainty = 0.0000 %
Ln(Eff) = -18.4932 +6.141115*Ln(Eng) -0.607819*(Ln(Eng))**2

Top Shelf Calibrations

Energy Calibration Fit
Energy = 0.1140 +0.199904*Channel +2.13345e-008*Channel**2
FWHM = 2.8370 +0.001339*Channel -8.77994e-008*Channel**2

Efficiency Calibration Fit
Knee Energy = 120.00 keV
Above the Knee: Quadratic Uncertainty = 3.3491 %
Ln(Eff) = -7.0782 +0.796364*Ln(Eng) -0.132548*(Ln(Eng))**2
Below the Knee: Quadratic Uncertainty = 0.0000 %
Ln(Eff) = -11.8003 +1.148137*Ln(Eng) +0*(Ln(Eng))**2

APPENDIX C: OPERATING STAY'SL

The first line in the STAY'SL input deck is the title card. Line 2 consists of several parameters: NGROUP, NFOIL, IPNT, IACT, and KQT.

NGROUP = The number of neutron energy groups (usually 100)

NFOIL = The number of foil reactions

IPNT = 1 to suppress the output of cross section data

= 2 to suppress the output of covariance matrices (IPNT was 2 for our purposes)

= 3 to print sig-phi file

= 4 to print cover factors

IACT = 0 for spectral adjustment (IACT was 0 for our purposes)

= 1 for activity run

= 2 for cross section adjustment

KQT = 0 for differential flux input

= 1for group flux input (KQT was 1 because the MCNP model outputs group flux information)

= 2 for flux/lethargy (E*PHI) input

Line 4 lists some important spectral adjustment parameters: AK1, NOR, ILOG, and TIME.

AK1 = 0.0 for free floating normalization of input flux. (AK1 was set to 0 when fitting the fast reactions to obtain an AK1 value that could be used for all reactions).

= 1.0 for absolute fixed input flux

= x.x for renormalization to stated value x.x. (AK1 was set to a particular value that was determined from a fit to the fast reactions. Ex for the Lazy Susan AK1 = 0.689)

NOR = 0 for flux renormalization by chi-square (NOR was 0 for our purposes)

= 1 for flux renormalization by standard deviation

ILOG = 0 for logarithmic flux changes (ILOG was 0 for our purposes)

= 1 for linear flux changes (caution – flux < 0 possible)

TIME = The length of irradiation time in seconds. This can be used to compute fluence values but was not utilized for our purposes.

The next section of the STAY'SL input deck has the user input the reaction, the reaction rate calculated from the saturation activity, and the relative uncertainty in the reaction rate. If the foil is covered, then the user would include the type of cover by typing the first four letters of that cover and indicate whether the cover is in an isotropic or beam flux. By adding a separate file the user can adjust for self-shielding as well.

Another important section of the STAY'SL input is where the user inputs the flux spectrum. Before the title card there is one parameter that acts as a switch (ITHERM). This is the parameter that toggles whether or not you apply a fit to the activity data with a Maxwellian distribution. If ITHERM is 0, then no fit is performed. If ITHERM is 1, then the Maxwellian fit is performed and the following parameters become important: INGP, TNORM, TEMP, and ETE.

INGP = the number of input flux energy groups that are left after the Maxwellian fit is applied. For Example, if the user has 100 energy groups but wants to apply the Maxwellian fit to the first 6 energy group, then the user would enter 94 groups for this parameter.

TNORM = a normalization factor that for our purposes was 1.

TEMP = the temperature of the Maxwellian (usually 20 C)

ETE = the 1/E joining energy.

After deciding on these values the user would then enter the values for the energy groups followed by the modeled flux spectrum, which in our case was determined by an MCNP model of the OSTR.

STAY'SL outputs a corrected and uncorrected energy dependent flux. It calculates the ratio of the corrected to uncorrected spectra as well as their percent standard deviations. STAY'SL also outputs a column of integrated flux that is summed from high energy to low, meaning that the number at the top of the column corresponds to the lowest energy group but is the total flux for the entire spectra. The running sum integral flux is calculated by using numerical integration, specifically the rectangular rule. This column was not a useful feature for representing the integral flux because a total spectral flux is not needed; however, group values for thermal, epi-thermal, and fast region were desired. Therefore, the energy dependent spectrum from STAY'SL was integrated in EXCEL using the trapazoidal numerical method to

determine the three regional flux values. The thermal region was considered to be from the lowest energy (1e-10 MeV) to the cadmium cutoff (0.5 eV). The epi-thermal region was considered to be above thermal to 1 MeV, and the fast region was determined to be all energies above 1 MeV.