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HOMOGENIZED CROSS SECTION DETERMINATION USING MONTE CARLO SIMULATION

by

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B.S., Hacettepe University, Turkey (1987)
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Submitted to the Department of Nuclear Engineering
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ABSTRACT

This thesis is an application of Monte Carlo simulation techniques to homogenized cross section determination. MCNP Monte Carlo code was used for obtaining homogenized node cross sections for QUARTZ triangular-z nodal code model of MITR-II (MIT research reactor). According to specifically developed original scheme, three different MCNP models of MITR-II were generated. These models were used in several MCNP runs to obtain cell fluxes and reaction rates. These results were processed using a homogenization scheme to generate homogenized total, absorption, fission and elastic scattering cross sections and diffusion coefficients for two energy groups. The accuracy of the specifically developed cross section processing programs were tested. Axial and radial distributions of the results were investigated. The general accuracy of the procedure was evaluated and possible sources of error were identified. A simple problem which is a portion of a MITR-II fuel element was modeled and used for demonstrating the suggested one-MCNP-run procedure. The computer facility requirements were evaluated and some projections about the future requirements were discussed.

Three major outcomes of this thesis are : (1) three new MCNP models of MITR-II, (2) two group reaction rate and flux data for every cell represented in the MCNP model of MITR-II, (3) Triangular-z nodal homogenized cross sections for two groups.

Thesis Supervisor: Prof. Allan F. Henry
Thesis Reader : Prof. David D. Lanning

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CHAPTER 1

INTRODUCTION

1.1. THESIS OBJECTIVE

This thesis is an integrated part of the department wide effort to obtain tools for real time transient analysis of nuclear rectors. The real time determination of spatial power distribution in the core and the total core reactivity is the key issue to improve the safety and control of the nuclear reactors. The real time calculations and analysis requires accurate and faster methods to determine reactor physics parameters. The theoretical, and experimental nodal synthesis methods are the promising candidates for this task. Recently , a quadratic nodal code for triangular-z geometry (QUARTZ) is developed by T.F. DeLorey [D-1] and tested against several static and transient benchmark cases. Application of QUARTZ to calculation of a real reactor for the first time, requires homogenized cross section data for every node in its defined mesh. The thesis project of W.S. Kuo [K-1] involves this kind of application of QUARTZ to Massachusetts Institute of Technology Research Reactor (MITR-II), therefore the homogenized cross sections for triangular-z mesh model of MITR-II for QUARTZ are required. The main objective of this thesis is to generate the required cross section data by using a Monte Carlo simulation. The MCNP Monte Carlo code developed at the Los Alamos National Laboratory is chosen for this job, it being the only readily available code that can provide enough flexibility to obtain satisfactory results. Some unique characteristics of the MITR-II makes reactor analysis impossible without using a Monte Carlo simulation. During the course of this thesis work, a *consistent and original* approach was developed by the author and Kuo. Since the application of the procedure by one person was impossible to complete within the time limitations, the task was divided between the author and Kuo. The task division and the approach will be discussed in the next chapter.

Sections 1.2 through 1.4 briefly describe MITR-II, MCNP and QUARTZ for the unfamiliar reader. More detail about MITR-II and MCNP is presented as required for the understanding of the related topics. For more information on those topics, references [M-1] and [B-1] are very good sources of information for MITR-II and MCNP, respectively.

1.2. BACKGROUND ON MITR-II

MITR-II is a 5 MWth research reactor at the Massachusetts Institute of Technology which has been in operation since 1975. It serves as an interdepartmental research and education facility. It is a unique design created by MIT Nuclear Engineering Department students, faculty and staff. Figure 1.1 shows the general view of the entire reactor and the associated research facilities.

MITR-II has a very compact core design involving 27 rhomboid assembly locations. These locations can be filled with fuel assemblies, Al-6061 dummy elements or with special experimental apparatus. Each fuel element consists of 15 highly enriched (~93% U-235) UAl_x fuel plates as shown along with dimensions in Figure 1.2 . The Core elements form three separate rings with some parts of the core divided by boron inserts. Figure 1.3 shows the MITR-II fresh Core-2 loading arrangement with 5 dummy elements and 22 fuel assemblies. This is the case for which the homogenized cross sections will be obtained. In this case, the A-ring consists of two dummy elements and a fuel element occupying the small hexagonal section in the middle of the core. The B-ring is a hexagonal ring surrounding the A-ring. It includes 3 dummy and 6 fuel elements. The A-ring and B-ring are divided by a hexagonal structure called a spider which is partly Aluminum, partly water, and some parts of which include boron inserts. The outer ring which includes 15 fuel elements is called as the C-ring. Some elements in B-ring and C-ring are separated by 3 other structures called arms, and some parts of these arms include boron inserts.

The reactor core is surrounded by a hexagonal Aluminum structure in which the control blades, water holes and regulating rod are nested. The six boron control blades are located at the edges of the hexagon. Each corner of the hexagon has a cylindrical hole called a water hole or water vent hole. The main function of the water holes is the ventilation of the water replaced by control blades during the control blade insertion. The water hole on the right corner in Figure 1.3 includes the regulating rod which uses Cadmium as a control material and functions as a mechanism for fine reactivity adjustments and flux shape regulation. All constituents of the core are numbered starting from the position of the regulating rod and numbering in a clockwise direction. For example A-1 is the fuel element in the A-ring nearest the regulating rod where is in water hole 1. MITR-II core is cooled with light water. The core tank which holds the core itself and the coolant, is placed in another tank filled with heavy water which acts as both moderator and reflector. The reflector tank is also surrounded by an approximately 60 cm thick graphite reflector. As can be seen from Figure 1.4, MITR-II core is a very compact design and is neutronically highly coupled.

The MITR-II facility also includes several neutron beam ports, thimbles and pneumatic tubes for both incore and out of core irradiation and a medical therapy facility at the bottom of the reactor. Incore experiments can be conducted by replacing a dummy element with a rhomboid shaped experimental apparatus.

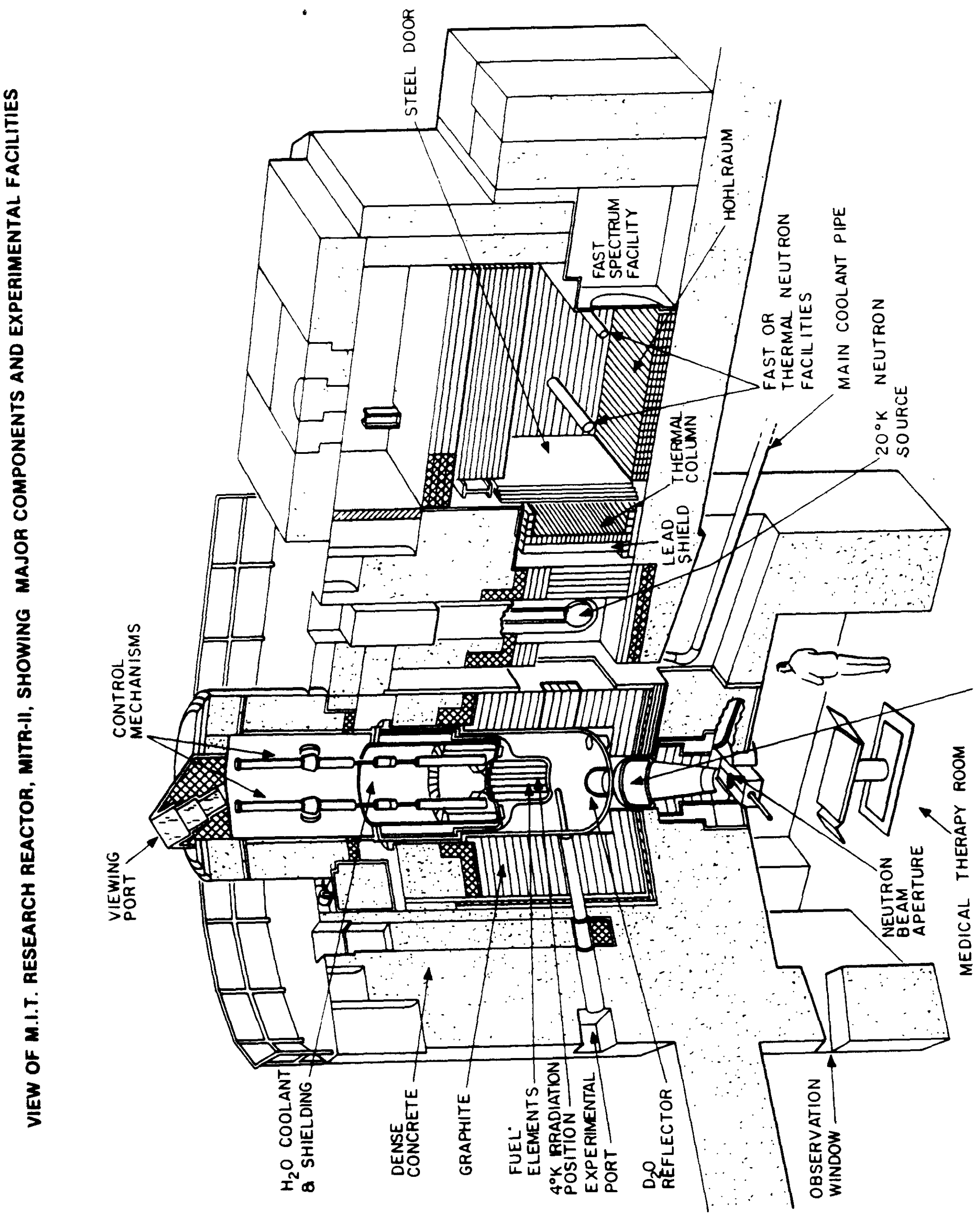


Figure 1.1 Artist's rendering of MITR-II reactor facility (adapted from [M-2])

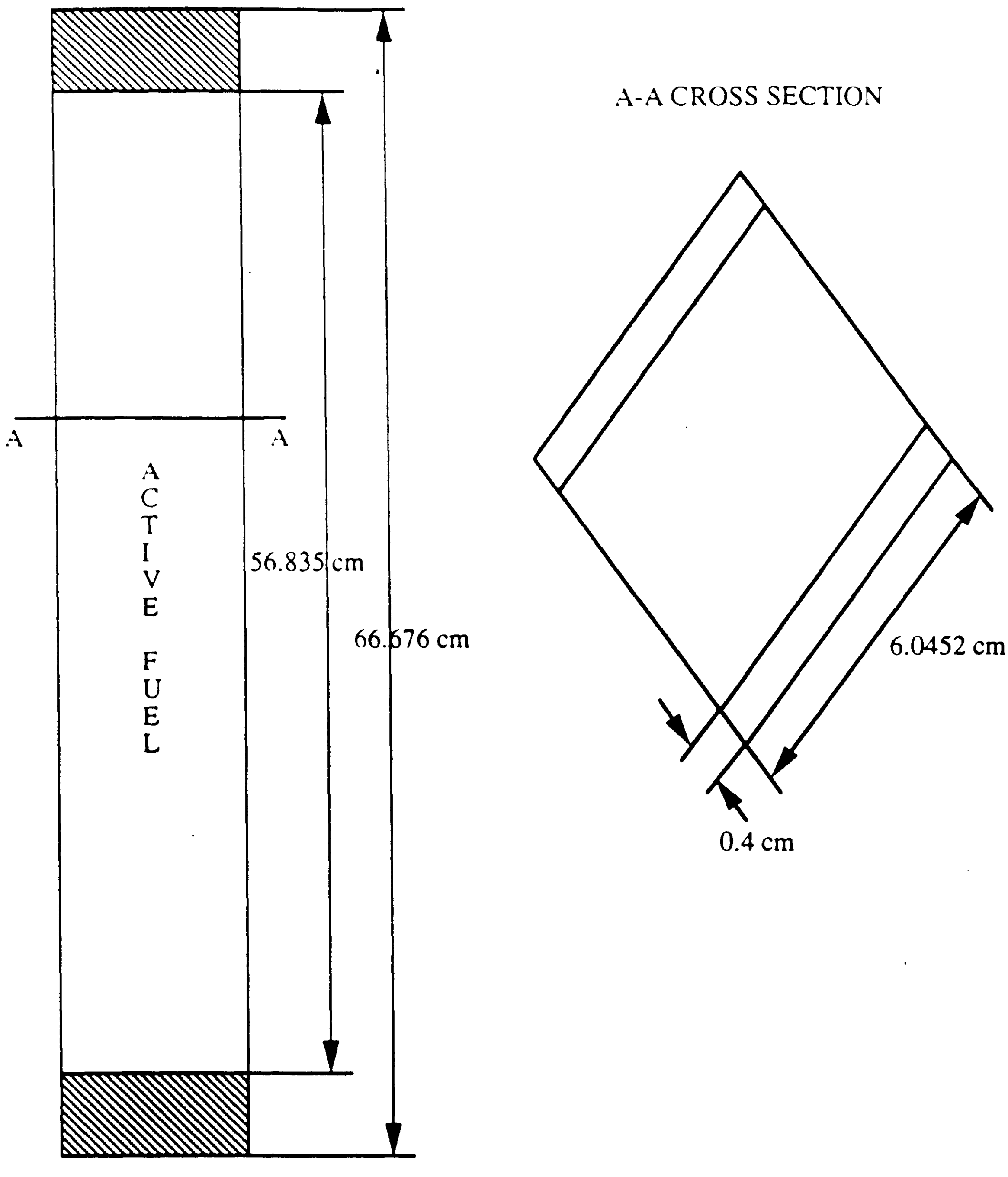
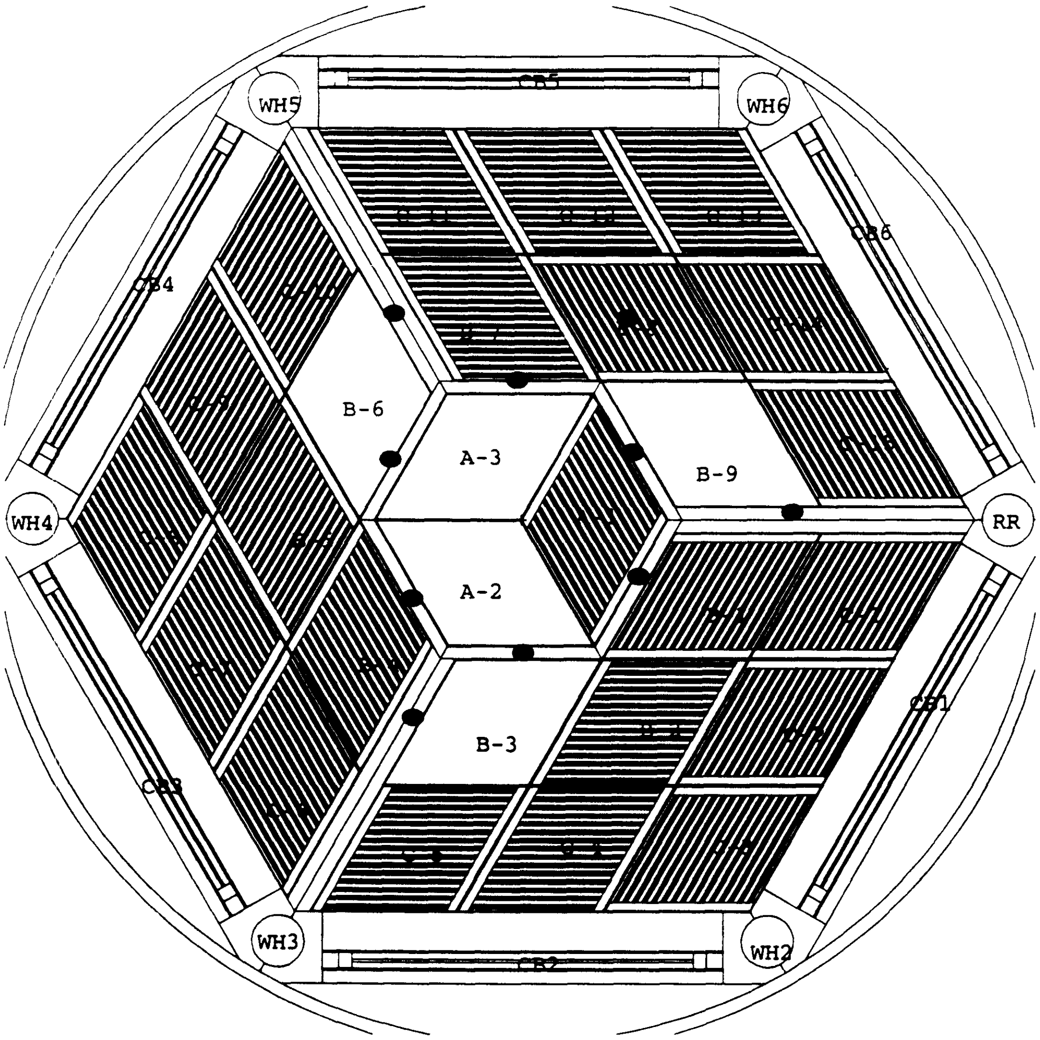


Figure 1.2 MITR-II fuel element with its dimensions



● Absorber Plate

RR : Regulating Rod

CB : Control Blade

WH: Water Hole

Figure 1.3 MITR-II core number 2 loading with 5 dummy and 22 fuel elements

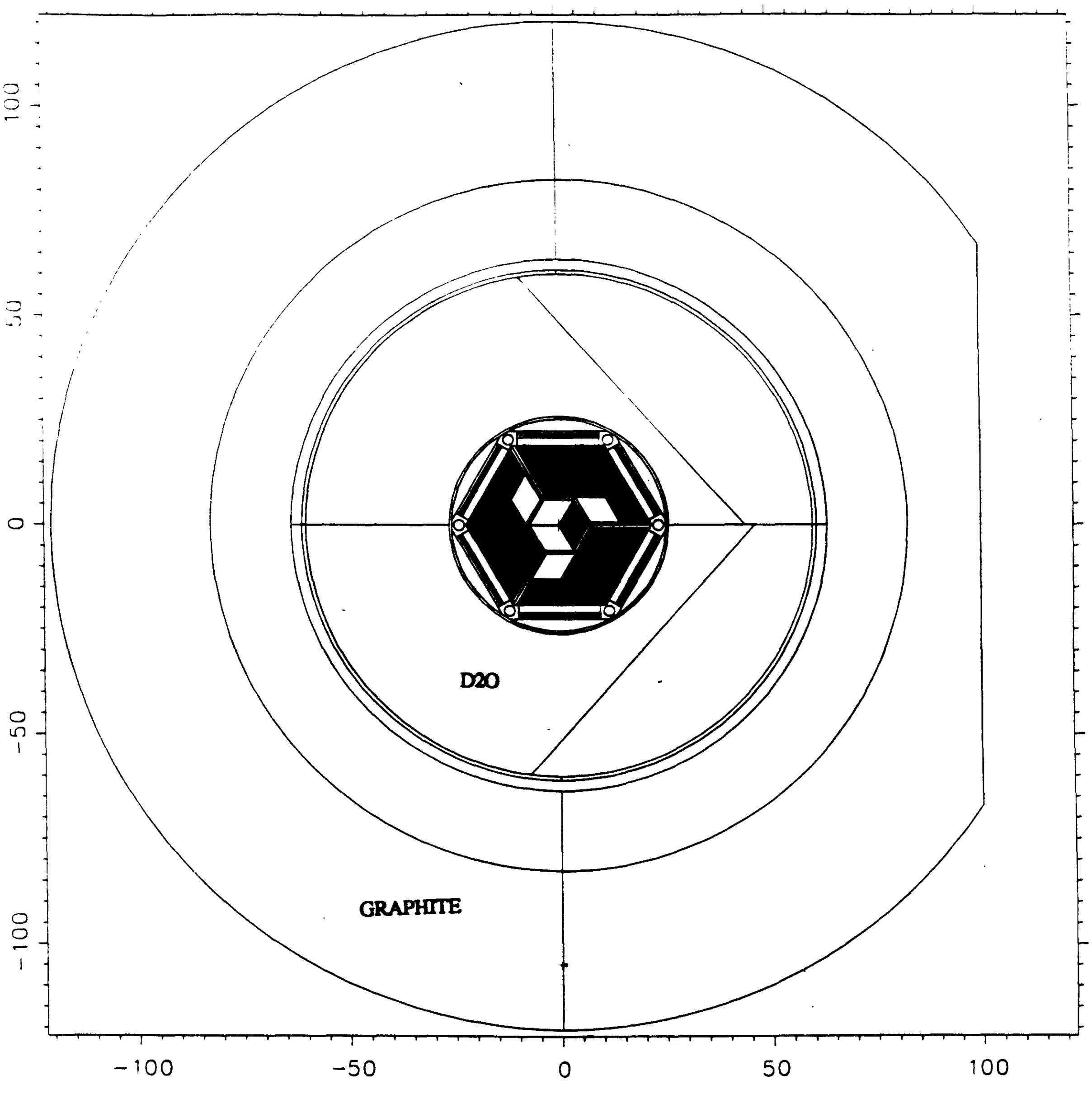


Figure 1.4 Scaled x-y view of MITR-II with reflectors.

1.3. A BRIEF BACKGROUND OF MONTE CARLO SIMULATION AND MCNP

Parts of this paragraph are taken directly from the MCNP Manual [B-1]. Monte Carlo methods are very different from deterministic transport methods. Deterministic methods solve the transport equation for the average particle behavior. By contrast, Monte Carlo does not solve an explicit equation, but rather obtains answers by simulating individual particles and recording some aspects (tallies) of their average behavior. The average behavior of particles in the physical system is then inferred (using the central limit theorem) from the average behavior of the simulated particles. The central limit theorem says that for sampling from almost any distribution, the distribution of the sample mean is approximately normal provided the sample size is large enough [F-1]. Not only are Monte Carlo and deterministic methods very different methods of solving a problem, even what constitutes a solution is different. Deterministic methods typically give fairly complete information (for example, flux) throughout the phase space of the problem, whereas Monte Carlo supplies information only about specific tallies requested by the user. Monte Carlo can be used to theoretically duplicate a statistical process (such as the interaction of nuclear particles with materials) and is particularly useful for complex problems that can not be modeled by computer codes of deterministic methods[B-1].

MCNP is a general-purpose, continuous-energy, generalized-geometry, time-dependent, coupled neutron/photon/electron Monte Carlo transport code. MCNP is widely used and its accuracy has been tested throughout these years of heavy usage. To use the code, the user creates an input file that is subsequently read by MCNP. This file which is referred to as the MCNP model in this thesis, contains information about the problem in areas such as the geometry specification, the description of materials, which cross-section evaluations to use, the location and characteristic of the source, and the type of answers or tallies desired. A more detailed description of MCNP options can be found in User's Manual [B-1] and its supplements [B-2].

Some definitions of the terms used in this thesis related to MCNP are the following.

surface and surface definition : In MCNP input geometry of the model is defined by using surfaces. MCNP has several surface definition tools that can be used to define first- and second-degree surfaces and some special fourth-degree surfaces.

cell and cell definition : Cells are the units that are used to define geometry. They are defined as the volumes bounded by the defined surfaces.

tally and tally definitions : as mentioned earlier, MCNP results are obtained by following histories in the defined geometry. Tallies are the statistical results of that procedure and they can only be obtained for defined surfaces and cells. MCNP can tally seven major quantities. The ones used in this project are F1:surface current, F2:surface flux and F4:track length estimate of cell flux.

source definitions and the criticality run : MCNP has several source definitions to generate the histories and introduce them to the geometry. The ones used are the surface source and the criticality source. The criticality source runs are the ones that starting with the initial source points, create source points for the next group of initiating particles. Each group of particles is called a cycle, and each cycle is introduced at the source points created by the previous one. One can think of source points as the points where the fission events take place. The criticality run gives as a result the eigenvalue (criticality) of the reactor model.

universe-fill and repeated structures definitions : Some repeated structures in the geometry can be defined easily by using the special options of MCNP introduced in the recent versions of the code. The newest and the most frequently used of these options is the universe-fill scheme. In this scheme several cells can be defined as a universe and the universe can be used in some other cell definitions with fill command. These filled cells act as windows that the universe viewed from.

Detailed descriptions of all these definitions can be found in the manual [B-1].

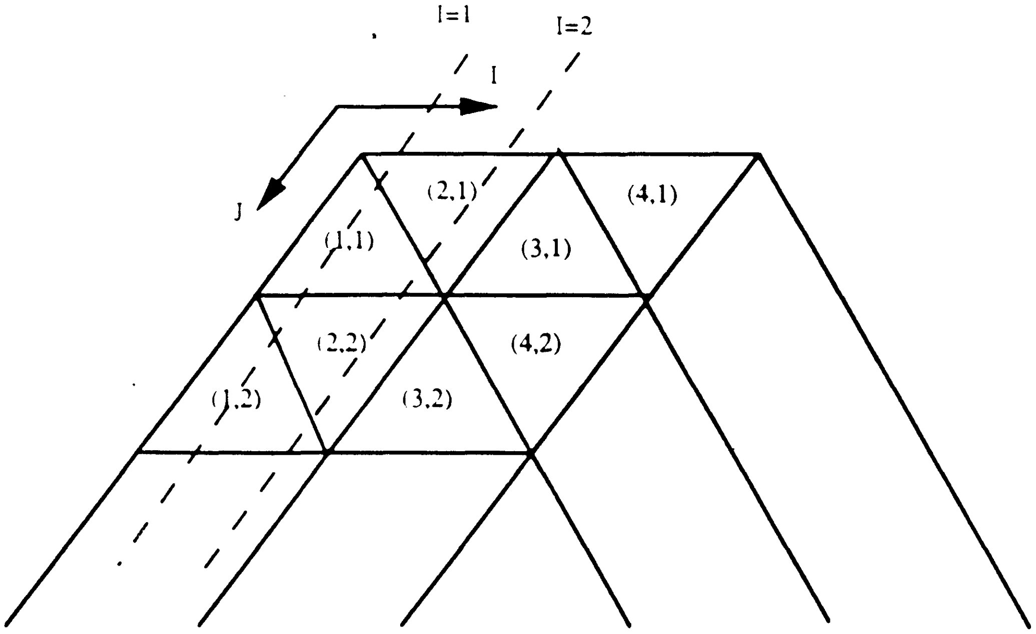
1.4. BACKGROUND ON QUARTZ NODAL CODE

QUARTZ is a QUAdratic polynomial Reactor code for Triangular-Z geometry developed by DeLorey [D-1]. This in-house code solves the quadratic nodal equations using a non-linear iteration scheme, based on the corrected, mesh-centered finite difference equations. These equations are forced to match the quadratic equations by computing discontinuity factors iteratively during the solution [D-1].

QUARTZ uses an equilateral triangle-z geometry. The triangle side length is variable, but the triangle must be equilateral. An example of the nodal mesh geometry of QUARTZ is given in Figure 1.5. This mesh structure is especially suitable to represent the core elements of MITR-II that are rhomboids with equal sides.

More information about QUARTZ can be found in references [D-1],[D-2] and [K-1].

TRIANGULAR MESH :



Z-MESH :

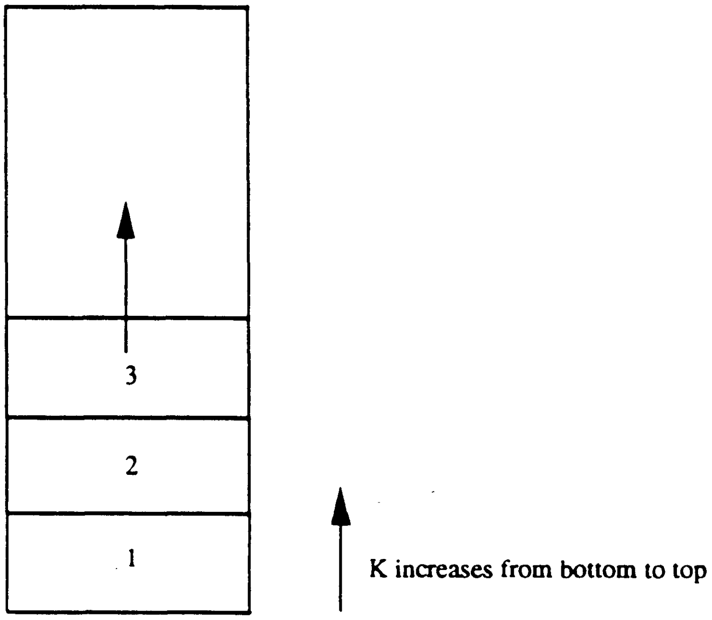


Figure 1.5 QUARTZ triangular-z mesh geometry

1.5. ORGANIZATION OF THE THESIS

After this introduction chapter, in Chapter 2 the overall problem and the approach used for its solution are discussed with respect to the MCNP models created to obtain the data for homogenization.

Chapter 3 gives some information about the pre-processing software written to prepare input data and other data gathering processes. It also discusses the MCNP runs and the homogenization schemes for incore and out of core homogenized cross section calculations, including post-processing procedures and the software written to implement them.

In Chapter 4, results are presented and the procedure for using them in QUARTZ is discussed. The large volume of data obtained is summarized to give the general trends in the forms of tables and graphics.

The thesis conclude with Chapter 5 discussing the validation of the cross section results and evaluation of the general solution scheme. A discussion of computer facility requirements for this kind of job, a summary of the contributions made in this thesis and recommendations for the future work are also given in this chapter.

CHAPTER 2

PROBLEM, SOLUTION STRATEGY AND MCNP MODELS

2.1. WHY MCNP ?

MCNP is the most suitable Monte Carlo code available for the case at hand, as offered, for example KENO Monte Carlo code which has been tested by Kuo was found unsuitable. New versions of MCNP have enough generality for most reactor physics applications. However, we have found no application of MCNP to homogenized cross section generation in the literature. Although the MCNP manual includes some hints, its application to that area requires *creative approaches* and sometimes tricks to fake the code. During the course of this work, among some other tricks tried -such as using the surface source read-write option instead of a criticality run for larger number of histories- the approach discussed in the next section is chosen eventually. It seems to be the best approach possible.

Most of the commercial and research oriented computer codes were developed for commercial nuclear plants, and therefore generally use Cartesian or r-θ-z geometry along with fixed geometrical shapes convenient for the representation of BWR and PWR cores. Since the MITR-II core has a very unique geometry, it is impossible to represent it by these codes without major approximations to the geometry. Calculations for reactor operations for the MITR-II have been done regularly by the reactor staff using the CITATION code [F-1]. But CITATION is in r-θ-z geometry which, as seen in Figure 2.1 does not conform well to the MITR design. On the contrary, MCNP allows the definition of almost any possible geometric shape that can be associated with an open or closed form polynomial function. Such generality is required for a good representation of MITR-II.

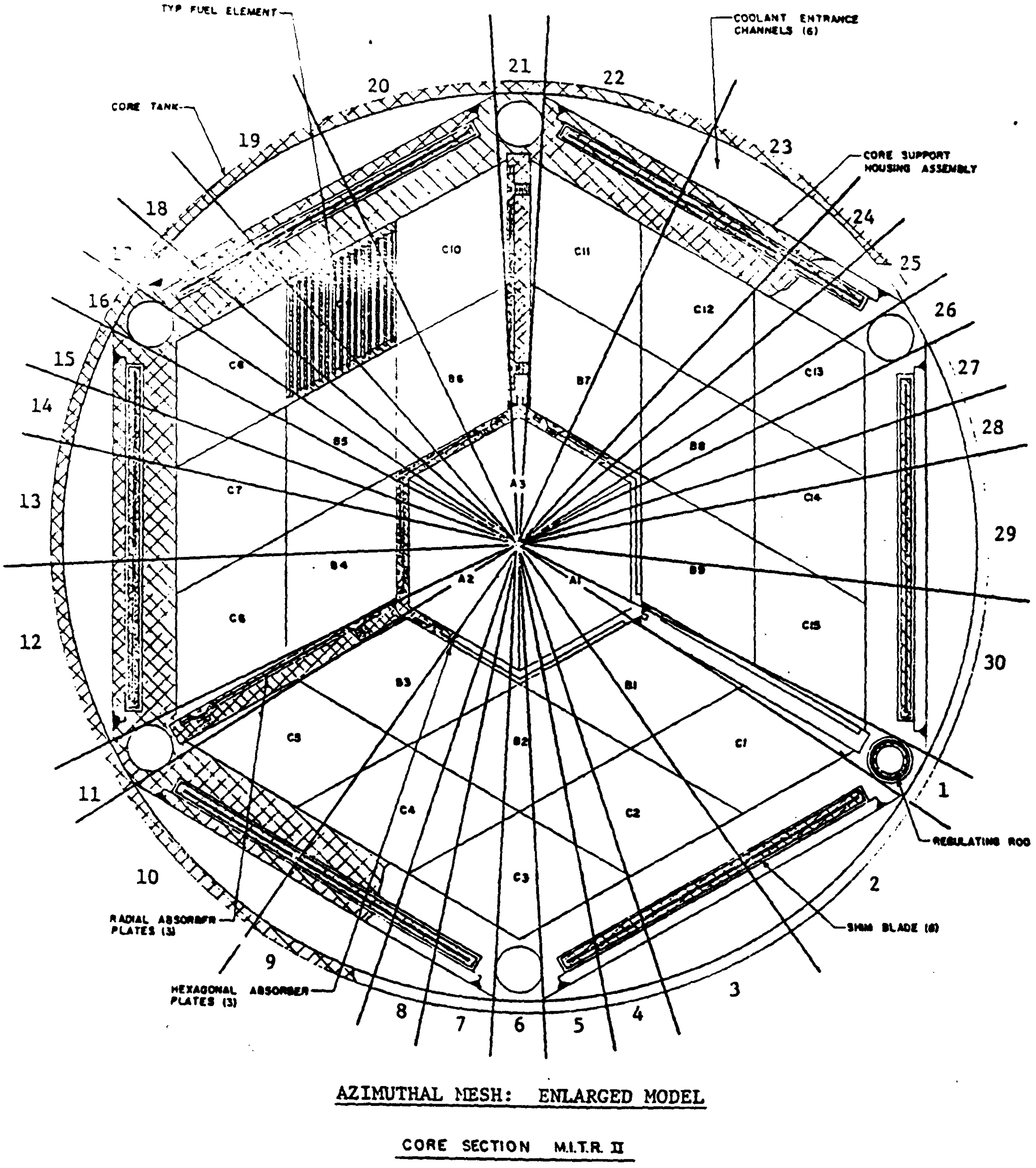


Figure 2.1 Azimuthal enlarged CITATION model of MITR-II

MCNP has some other advantages over deterministic transport codes that can be itemized as :

- It has the inherent characteristic of a Monte Carlo simulation that the accuracy of the results is not limited by any theoretical approximation.
- The continuously-updated, continuous-energy cross section libraries allows calculations to be made without any energy group approximation, and by using the most recent cross section data sets.
- The model geometry plotting tool that comes with the package allows the user to check the model at every step of the development process. Most of the figures included in this thesis were generated by using this tool.

On the other hand, MCNP has some limitations and inconvenient characteristics . The accuracy of MCNP results is limited by the statistical nature of the model. Results can be obtained with any desired statistical certainty, provided that a sufficient number of histories is followed. The larger the number of histories, the better the results, however, also, the longer MCNP runs. Thus to obtain the desired accuracy may be very expensive. MCNP has some variance reduction options for increasing the accuracy without increasing the number of histories. However they are not recommended for the kind of applications associated with this research [B-1].

Some other limitations of MCNP are:

- MCNP can provide only the reaction rates and fluxes for each defined cell in the model. To obtain cross sections, post processing is required.
- Tallying is possible only over the defined cells and surfaces of the model. If the desired cells can not be modeled, the post processing of the data is required.
- MCNP does not provide group-to-group scattering reaction rates. Therefore it is impossible to obtain group-to-group scattering cross sections directly from MCNP results.

Another reason for the selection of MCNP is the existing MCNP model of MITR core number 2 for which the accuracy has been tested originally by Redmond [R-2] and by several users including the author [T-1]. The model is a very detailed representation of MITR-II with its research facilities including the beam ports and the medical therapy room. Since it was originally developed for more general purposes (in particular for BNCT research), it includes some unnecessary portions of the facility when the primary interest is in the core and reflector area. A more detailed description of this model will be given in Section 2.3.1.

2.2. GENERAL STRATEGY AND PROCEDURE

The major goal of the thesis is to represent the triangular-z nodes of the QUARTZ model of MITR-II by an MCNP model and using this MCNP model to obtain required homogenized cross sections for each node of the QUARTZ model.

MCNP calculations raise two major difficulties: long CPU (Central Processing Unit) time, and large computer RAM (Random Access Memory) requirements. These are the major concerns of the present project. As mentioned above the MITR-II model of Redmond is geometrically more detailed than required and includes some parts of the reactor that are not of interest for a core-related reactor physics study. Nevertheless it is reasonable to assume as a starting point, that Redmond's model is a good representation of the MITR-II reactor geometry itself. Its accuracy has been proven several times by both Redmond [R-2][R-3], and the author [T-1]. Its geometric complexity is a drawback with respect to CPU time and RAM, but this complexity is the characteristic of the reactor itself and must be kept as it is, to get reliable results. By keeping the important parts of the model and changing some definitions to simplify the geometric representation of MITR-II, a simplified model was obtained from the original. Taking this simplified model as a basis, a new model consisting of triangular-z cells used for the QUARTZ model of the MITR-II, was developed. More detailed descriptions of these QUARTZ and MCNP models are given in Section 2.2.1 and Section 2.3.

2.2.1. QUARTZ Model of MITR-II

The QUARTZ model of MITR-II includes 600x16 nodes as shown three-dimensionally in Figure 2.2 (adapted from reference [K-1]). The 24 nodes in the center represents the core portion of the reactor, and the outer boundary of the graphite is modeled as a hexagonal prism. The number of axial nodes was originally set as 12 starting from the bottom of the fuel to the top of the fuel. However, initial results showed that a constant albedo boundary condition at the bottom (required by QUARTZ) was not correct because of the D_2O reflector effects, a portion of the bottom reflector (4 more axial layers of nodes) was added to the model.

The energy group structure was set at 2 groups, one from 0 to 0.625 eV and the other from 0.625 eV to 20 MeV.

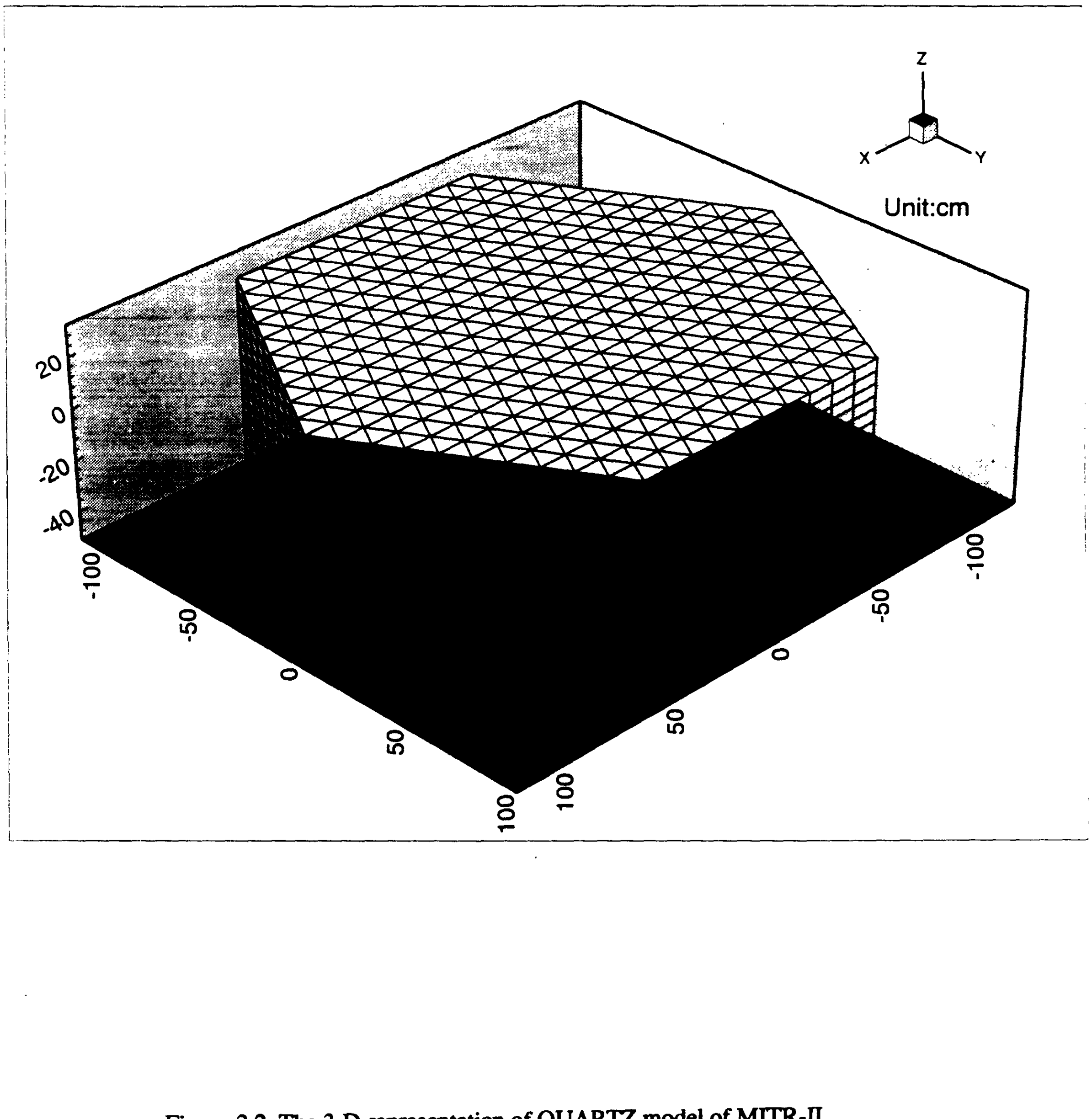


Figure 2.2 The 3-D representation of QUARTZ model of MITR-II.

2.2.2. Organization and Distribution of the Tasks

As mentioned earlier the project was divided between the author and Kuo as shown in Figure 2.3 and Figure 2.4. Details of the division of work are given in the next section. Basically, the node-homogenized cross sections and node-averaged fluxes were obtained by the author, and surface fluxes and currents were obtained by Kuo. Since MCNP does not have the required options to obtain cross section results, the homogenized cross sections were obtained by processing MCNP reaction rates and fluxes by volume-averaging as will be discussed in Section 3.3. However, surface fluxes and surface currents can be obtained from MCNP results directly. Since to obtain the surface currents and surface fluxes is the easier and less time consuming part of the process, Kuo also obtained the group-to-group scattering cross sections and discontinuity factors for each node by putting together the results from both parts of the process. A more detailed description of the portion of the work executed by Kuo can be found in his thesis [K-1].

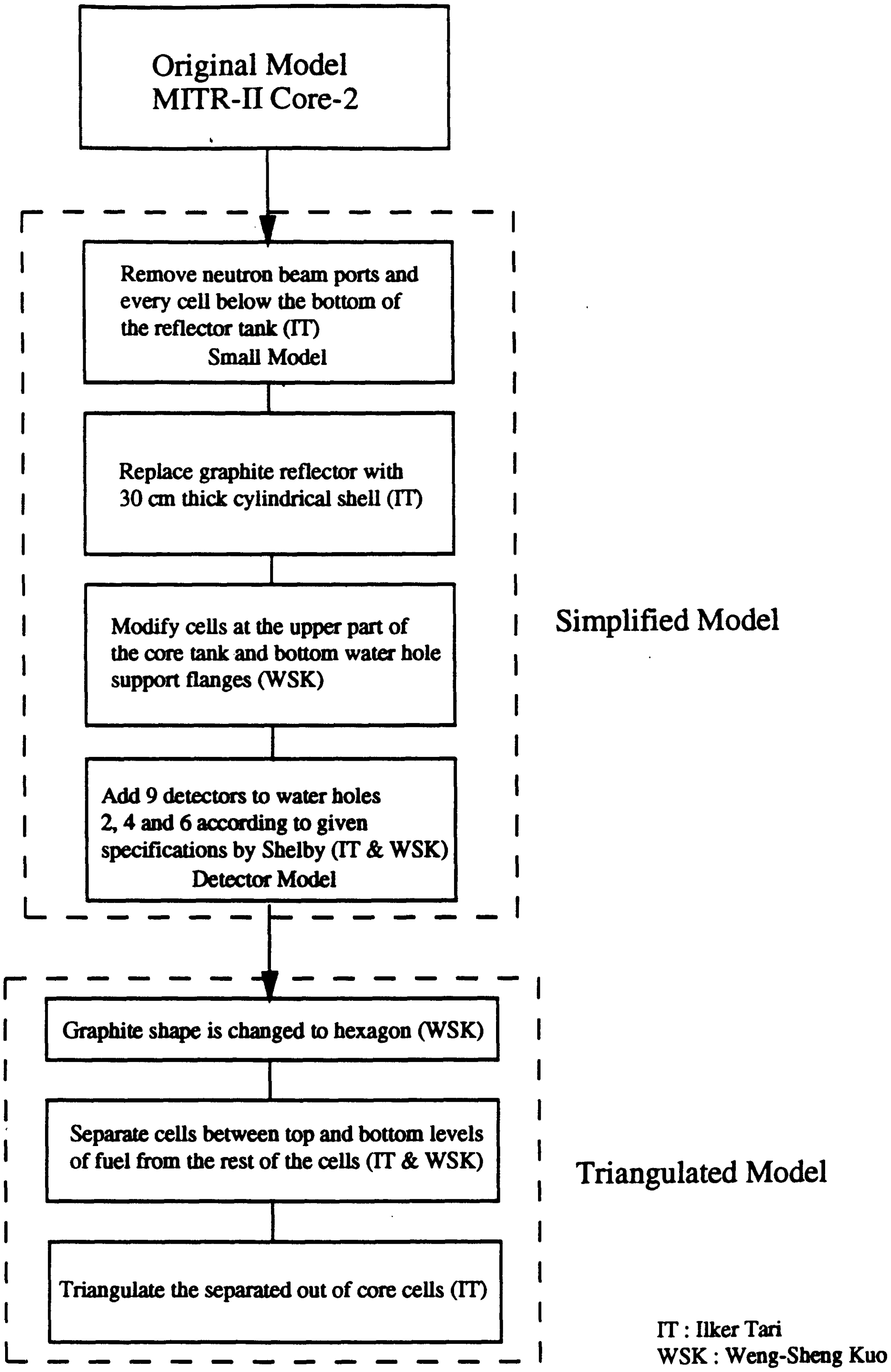
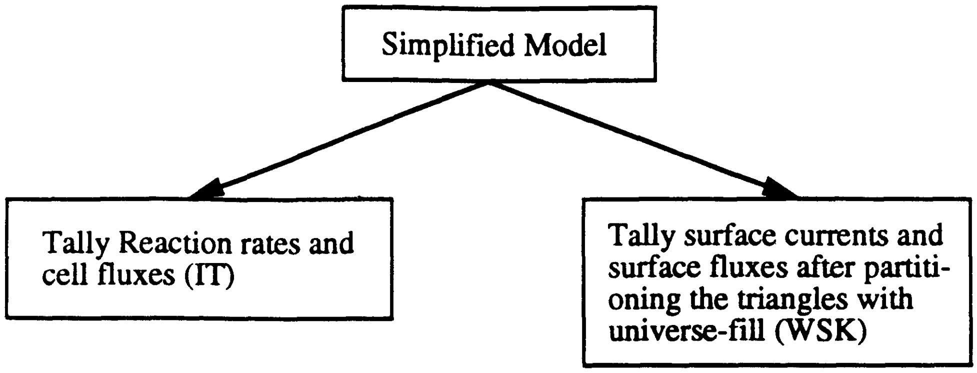
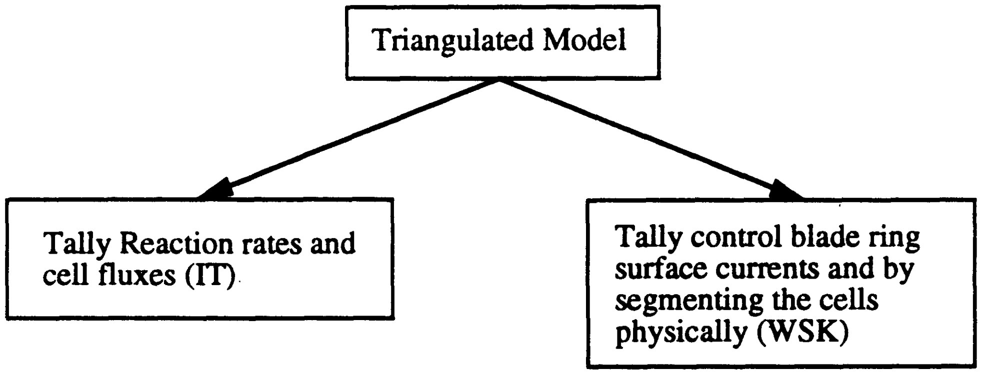


Figure 2.3 The organization of the tasks in the development of MCNP model

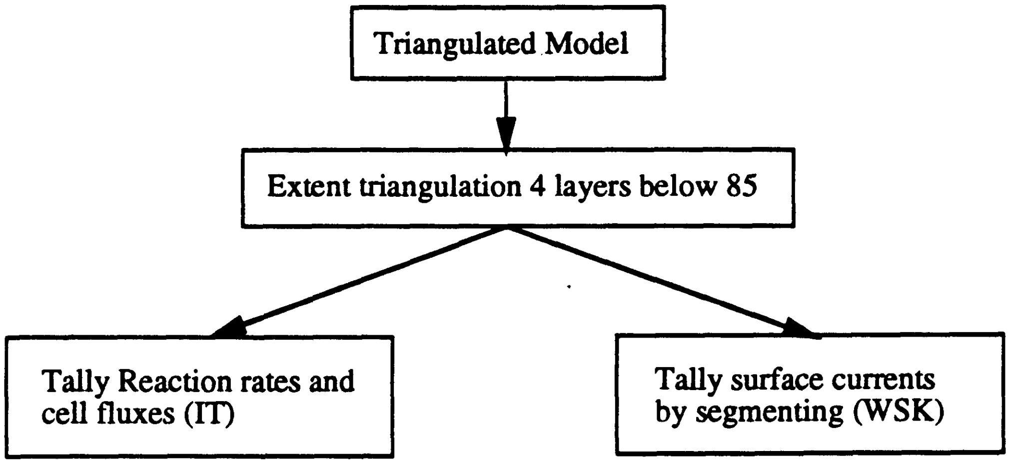
INCORE



OUT-OF-CORE (ABOVE THE BOTTOM OF FUEL)



OUT-OF-CORE (BELOW THE BOTTOM OF FUEL)



IT: Ilker Tari, WSK: Weng-Sheng Kuo

Figure 2.4 The tasks after the model was generated.

2.3. MCNP MODELS AND THEIR EVOLUTION

During the model development stages, *the original model* (Redmond's model) which includes features not needed for present purposes was simplified and then tested for consistency against the original model. Then from *the simplified model* by a triangulation process discussed below, *the triangulated model* was generated. This final model was used for tallying in different ways by both the author and Kuo. A 1/3 triangulated core model developed for a stochastic volume calculation is also discussed below.

2.3.1. Original Model

The Original model as discussed above was developed and tested by Redmond. Details concerning the model and its preparation can be found in references [R-2] and [R-3]. The model represents the fresh core-2 with control blades positioned such that the reactor is critical, therefore MCNP runs of the model give k-effective very close to 1.00. The difference if any is a result of statistics and some minor approximations in the model.

Figure 2.5 and Figure 2.6 shows two different views of the original model.

2.3.2. Simplified Model

Since the present research is concerned only with the parts of the reactor included in the QUARTZ model, the original model of MITR-II includes more detail than needed. By making several simplifications and getting rid of the unnecessary parts, the CPU time requirement can be reduced. The modifications made were the following:

- The beam tubes, medical therapy facility and everything below the reflector tank bottom hemisphere were removed. The resultant model is called the *Small Model*. This model was tested and the results showed that further simplification was possible. By using this model, the difference between reflective and no-incoming-flux boundary conditions was tested. The results from the several runs to obtain cross sections for assemblies A-1, B-4, C-8 and C-11 showed that the reflective boundary condition has little effect on the cross section and criticality results, but increases CPU time as compared to the no-incoming-flux condition. Therefore the boundary condition selected was the no-incoming-flux condition.

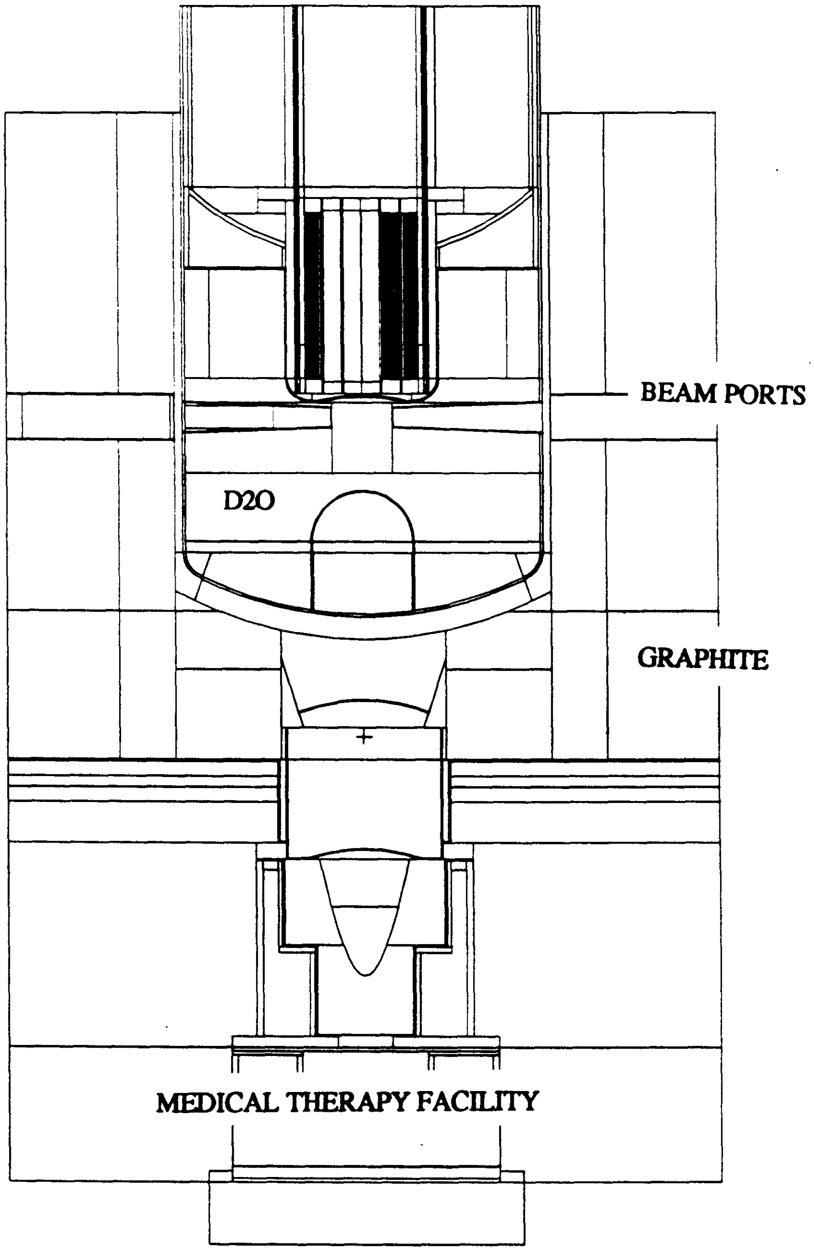


Figure 2.5 Original Model of MITR-II (y-z view)

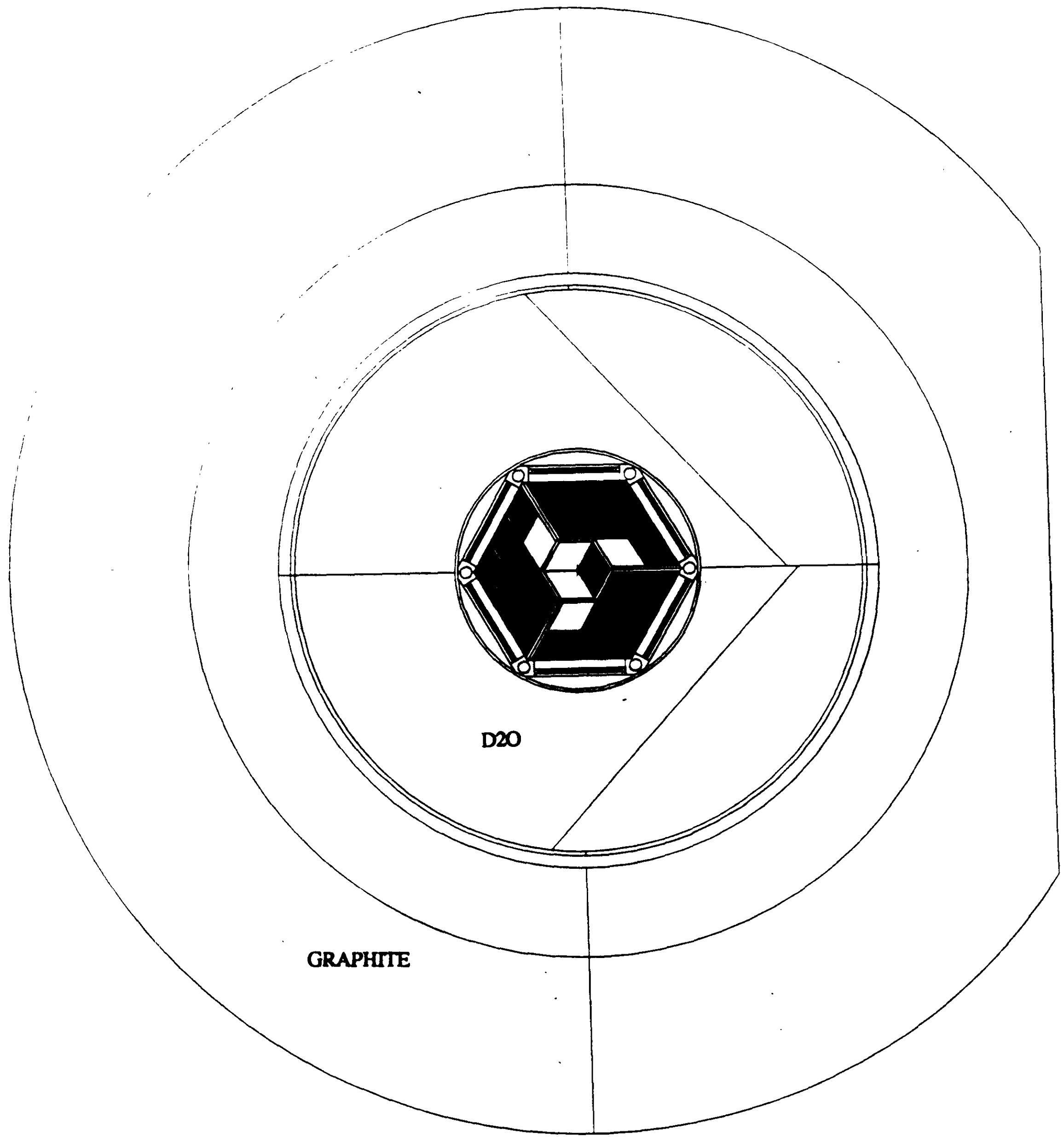


Figure 2.6 Original Model of MITR-II (x-y view)

- As a further simplification the bottom hemisphere of the reflector tank was removed and reflector thickness was reduced by almost half to 30 cm. This model was named the *Simplified Graphite Model* or simply: *Simplified Model*. Tests showed that, without loss of accuracy, the CPU time requirement was reduced ~30% compared to the original model. Table 2.1 shows the findings from criticality runs to obtain fluxes for assemblies C-11, C-8, B-4 and A-1 for 35 cycles of 3000 neutrons and for 205 cycles of 3000 neutrons (no tallies being made for the first 5 cycles). Although the problem is the same in all cases, because of the limitations of the model, a separate run has to be made to edit each individual assembly. The reason for the k-effective difference among the runs for the same model and size is that different source files were used everytime.

Model and number of cycles of 3000 starting particles	*CPU time used (minutes)*	*K-effective*
Original 35 cycles for C-11	322.97	0.98688
Original 35 cycles for C-8	320.72	0.99379
Original 35 cycles for B-4	325.93	0.99427
Original 35 cycles for A-1	329.88	0.99470
Original 205 cycles	1610.36	0.99281
Simplified 35 cycles for C-11	204.50	0.99164
Simplified 35 cycles for B-4	209.79	0.99111
Simplified 35 cycles for A-1	211.88	0.98593
Simplified 205 cycles	1205.72	0.99094
Simplified 205 cycles for WHs	1157.53	0.99338

Table 2.1 The comparison of CPU time and k-effective results for different runs of two models.

The similar eigenvalue and the similar cross section results suggest that the *Simplified* model is as good as the original model. Using this simplified model, the following cell modifications were made by Kuo:

- The corner cells of the control blade hexagon (the Al supporting structure where the control blades are located) and the cells in the curved part of the upper portion of core tank were homogenized as a mixture of the materials originally modeled.

In addition to these modifications the final model includes 9 detectors and placed in the water holes 2,4 and 6 as suggested by Shelby [S-1]. The geometry and material specifications of the detectors were obtained from Shelby's thesis. According to his suggestions, each water hole has 3 detectors axially located in different positions in a guide tube immersed in the water hole. One of the detectors as defined for the model is shown in Figure 2.7. The specifications for these fission chamber detectors can be found in Shelby's thesis [S-1]. After the addition of the detectors, this model is used for incore runs.

For the incore triangular nodes and for out of core nodes, two different paths were followed. For incore nodes, after voiding the repeated structure procedure, cell reaction rates and fluxes were obtained for each cell in the core hexagon. Since the cells of interest are the fuel plates and water channels making up a rhombic assembly, it is necessary to assume that cross sections found from homogenizing a given fuel with its associated moderator are partially constant, then, when a given rhombic element is cut into triangles we can take the cross sections for the portions of a fuel plate belonging to different triangles to be that of the plate itself. The homogenization process is discussed further in Section 3.3. For out of core nodes another model is created.

Figure 2.8 and Figure 2.9 shows two different views of the model after these modifications.

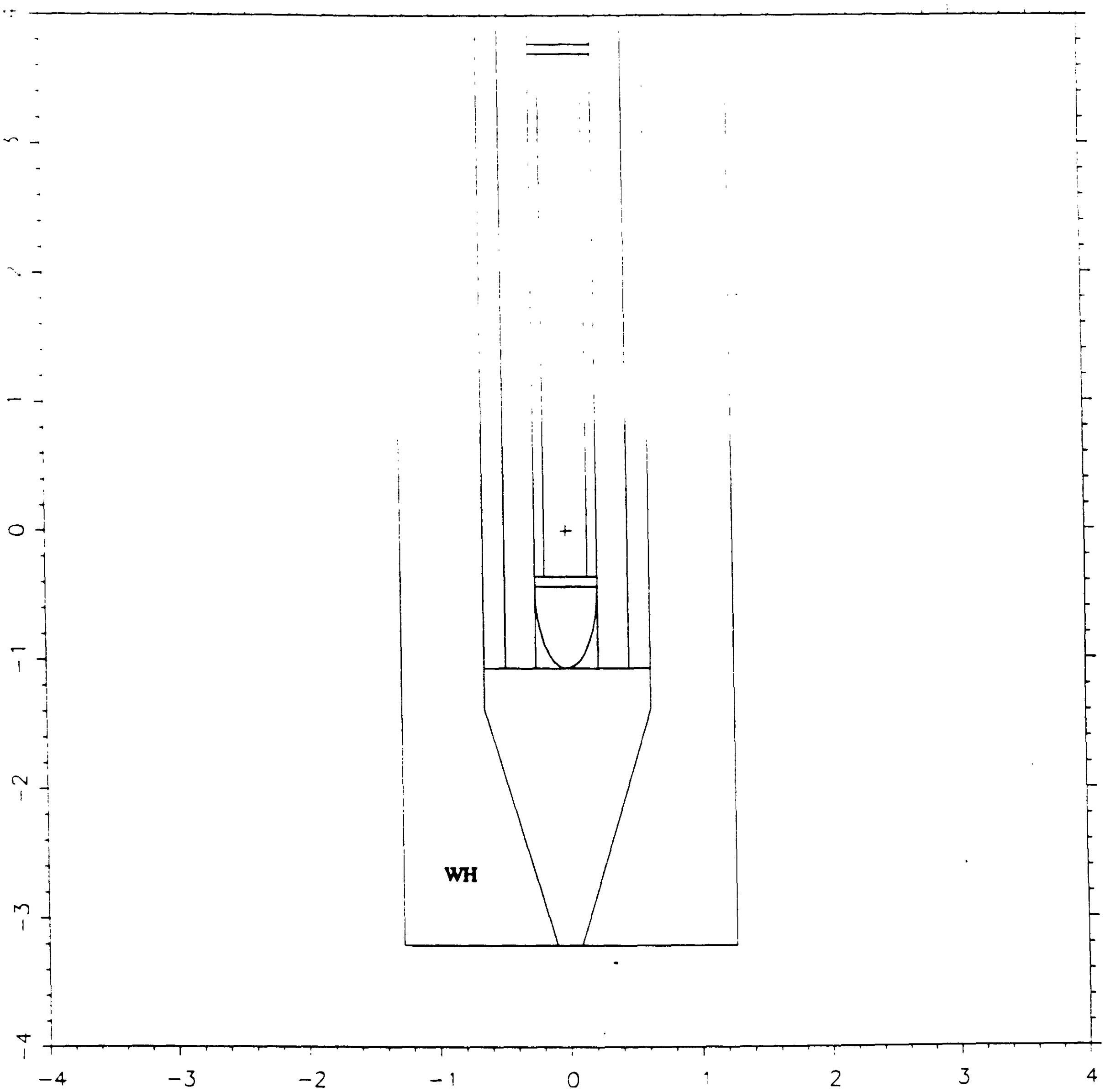


Figure 2.7 One of the bottom detectors in guide tube

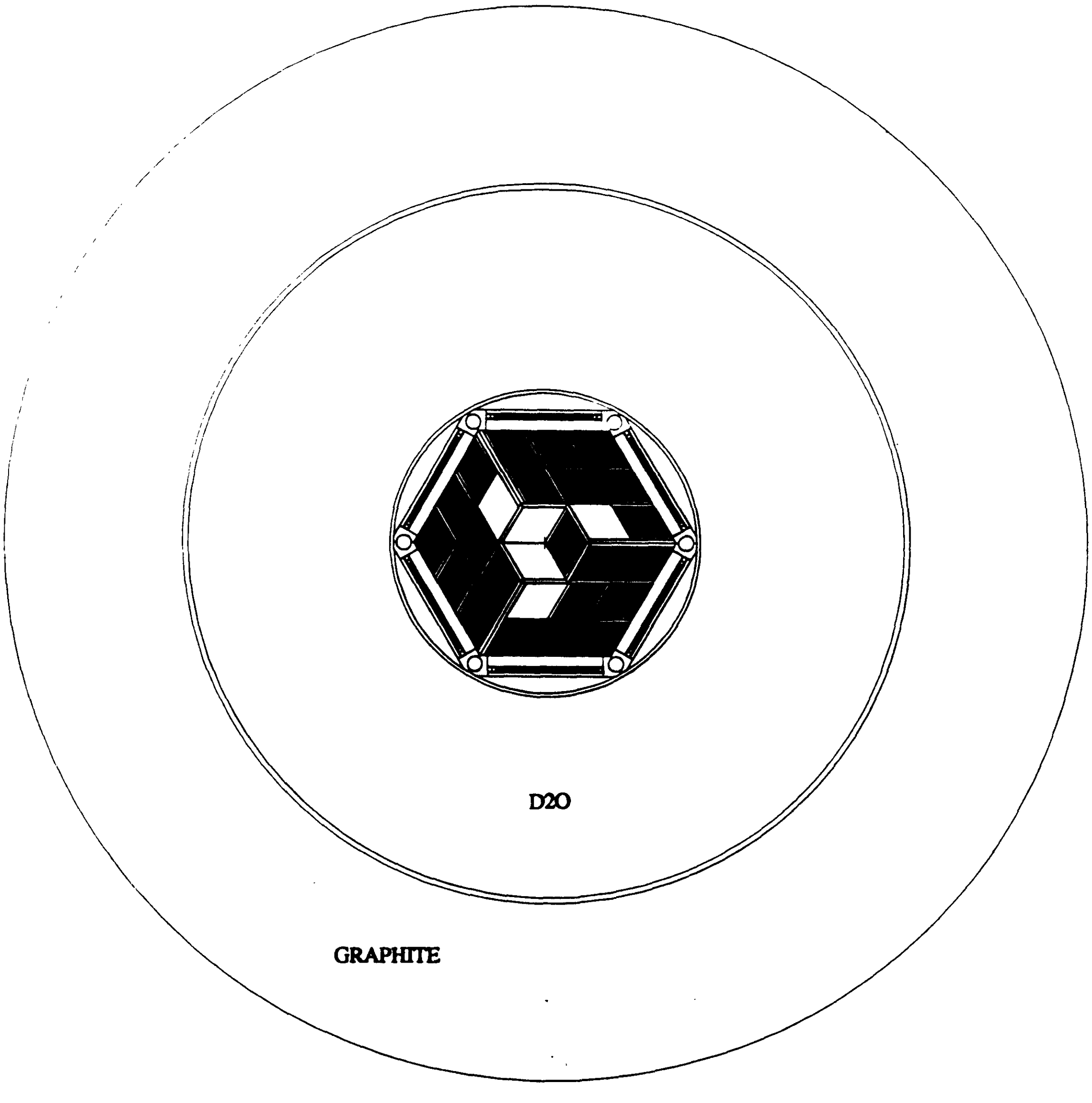


Figure 2.8 Simplified model before graphite reflector changed to hexagonal prism (x-y view)

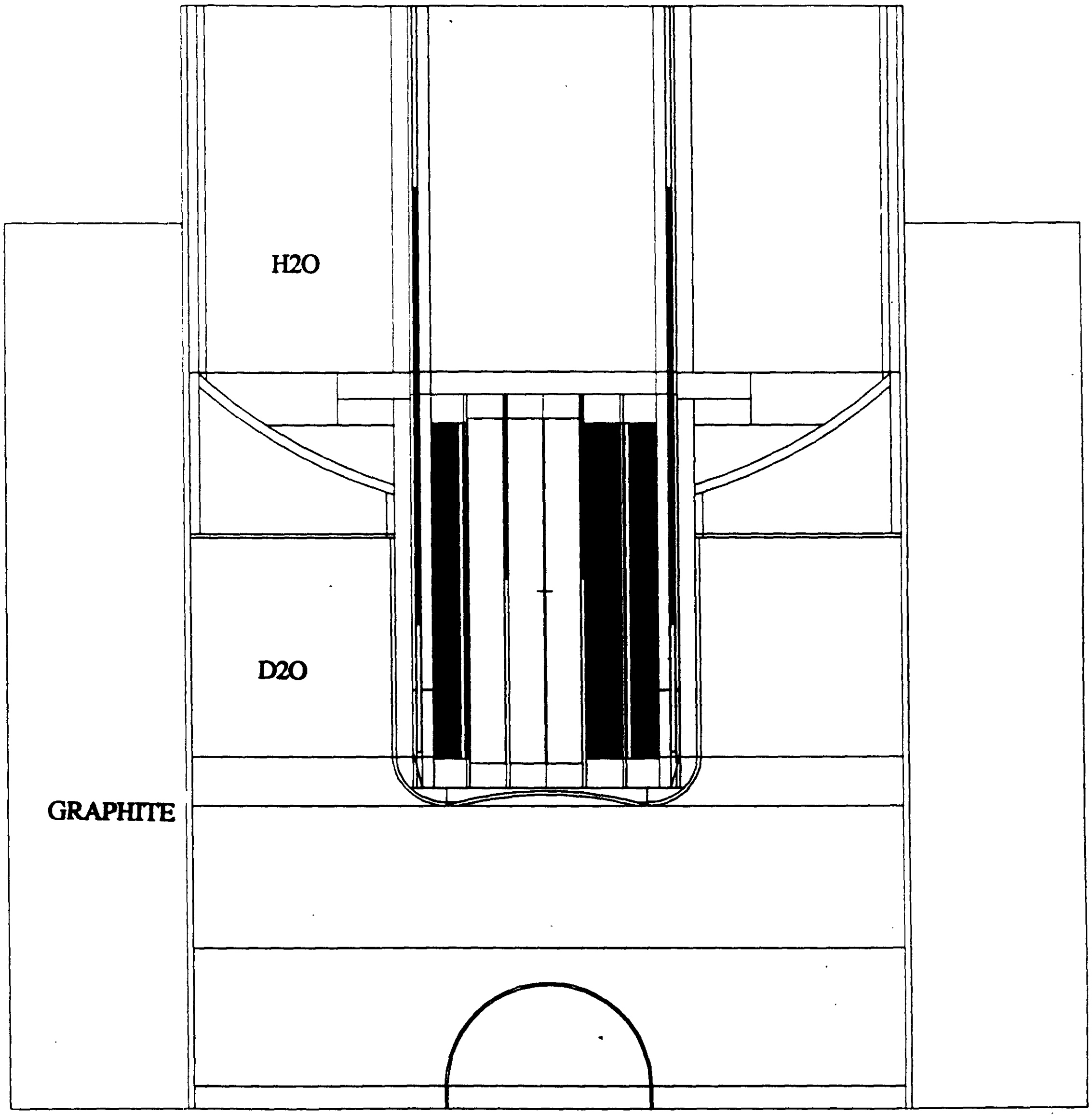


Figure 2.9 Simplified model after graphite reflector changed to hexagonal prism (y-z view)

2.3.3. The Triangulated Model

As mentioned earlier MCNP can not tally energy group cross sections. Rather it can provide energy group cell fluxes by using F4 tallies and cell reaction rates, again by using F4 along with microscopic cross section and atom density multipliers. Atom densities can be obtained from the Table 50 of MCNP output and the multiplier indicators for different microscopic cross sections are given in MCNP manual. Thus, by running MCNP, the reaction rates and fluxes for each cell can be obtained, and then by using these data a homogenization process can be applied to get homogenized cross sections for triangles that include MCNP cells.

To obtain cross sections for triangles, they must be defined in the MCNP model. In the *Simplified Model*, most of the defined cells fall into core hexagon (hexagonal region of 27 elements). That part of the geometry is the most complicated part. The *Simplified Model* incore cells are defined by using repeated structures option. This procedure reduces the number of cell definitions very significantly. However for triangulation, the repeated structures need to be removed, and this removal causes the number of cells in the core to increase by a factor of 12. Since triangulation process also divides the cells, the total effect of triangulation in the core region is to increase the number of cells by a factor of 24. As a result the number of incore cells becomes more than 4000. Since CPU time and RAM requirements increase with increasing number of cells, this kind of triangulation was estimated to be too expensive (if not impossible) to run, because of the RAM limitation of the available computers. Accordingly the triangulation process was applied only to the cells outside the core hexagon.

Before the triangulation of the out of core cells, the graphite definition is changed from cylinder to hexagonal prism as in QUARTZ model. The triangulation of the out of core cells is a very long, and tedious job which required more than 60 hours of work. In this process triangle surfaces defined according to the QUARTZ model and all the out of core cells are redefined by using these definitions, and previous surface definitions of Simplified model. At every stage of the development, geometry integrity checks were done to insure the accuracy and consistency of the model as compared to the Simplified Model. The result is called the *Triangulated Model*; it is a combination of the Simplified model and the QUARTZ model. Figure 2.10 and Figure 2.11 show two different views of the triangulated model. This triangulation was done only for the initial 12 axial segments; four additional axial segments were added to the bottom later on for obtaining the constant albedo at the bottom. Two test were applied to the triangulated model, a geometry test with 100 million histories showed that there is no gap between cell definitions and that all of the cell definitions are correct. In addition, criticality calculation was made and the k-eff obtained was 0.99719 very close to 1.00. These tests support the integrity and accuracy of the model.

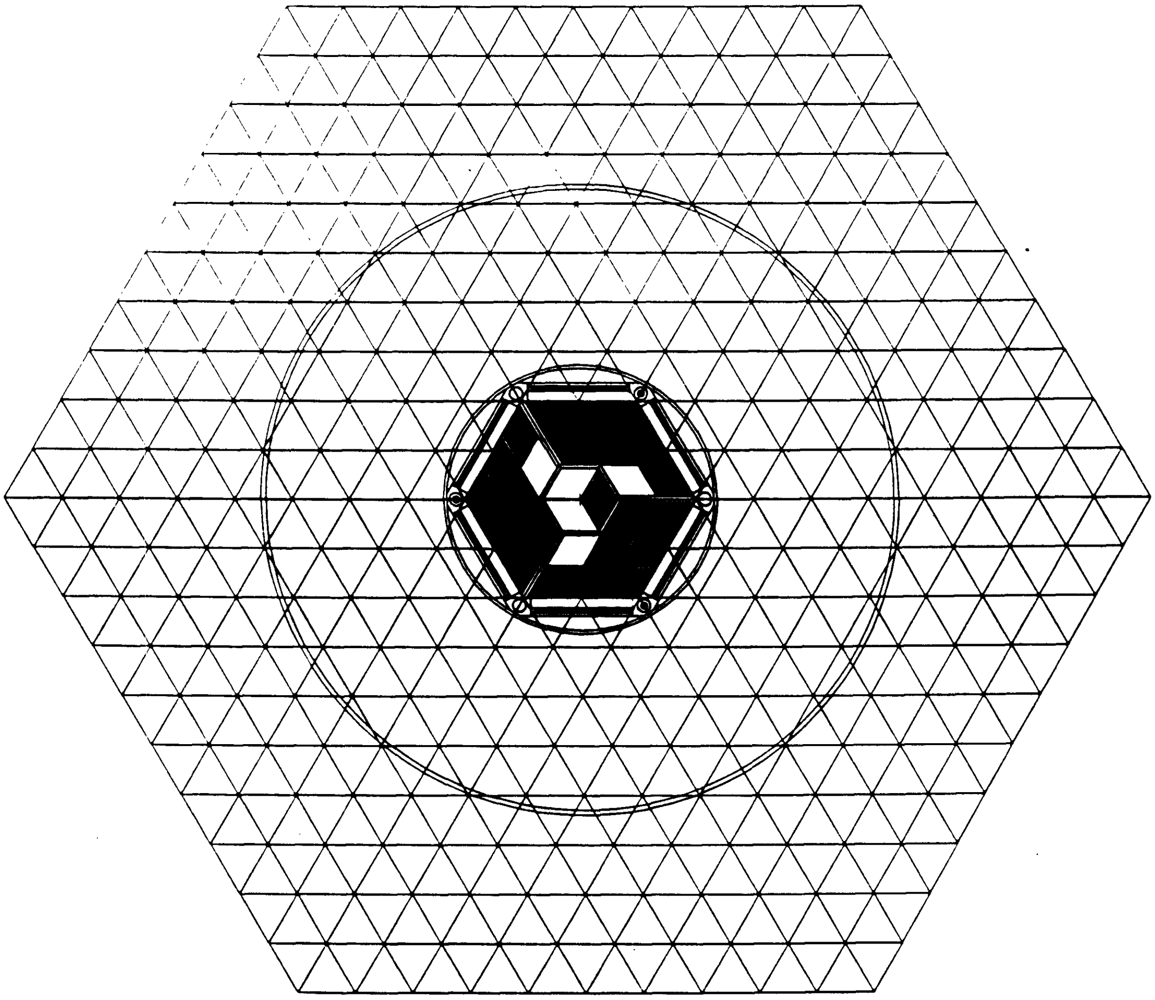


Figure 2.10 Triangulated Model (x-y view)

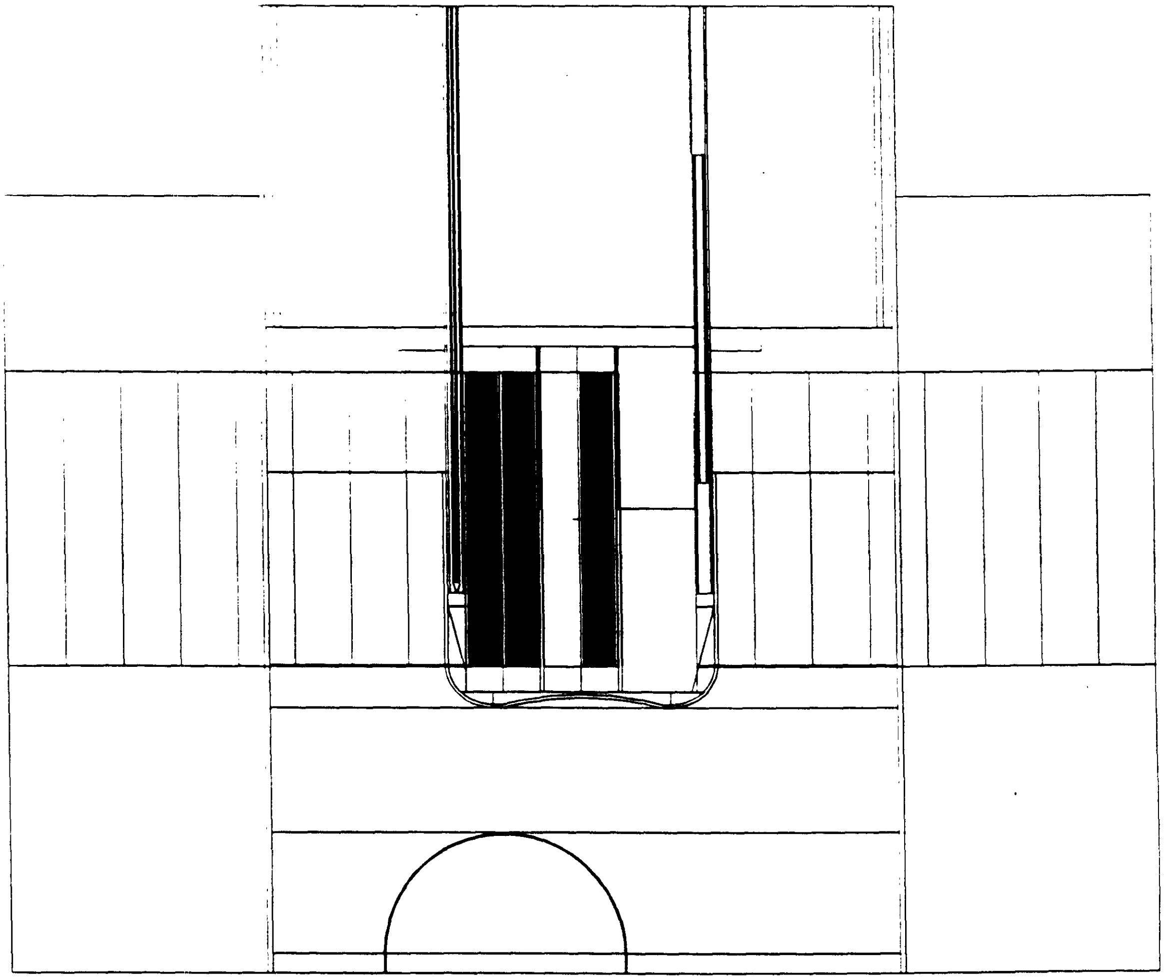


Figure 2.11 Triangulated Model (y-z view)

2.3.4. 1/3 Symmetry Incore Fully Triangulated Model

As mentioned in the previous section, to triangulate incore cells is not an attractive option. As will be discussed in Section 3.3, for incore cross section homogenization, the volume fractions of MCNP model cells falling into each triangle are required and there is only one tractable way to obtain these volumes which is to use the MCNP volume calculation capability and the stochastic volume calculation option after triangulation of the cells. As seen from Figure 2.12 there is almost a 1/3 symmetry for incore triangles. By using this symmetry all the volume fractions can be obtained by triangulating 1/3 of the core. Figure 2.13 shows the 1/3 symmetry triangulated model. In this model every small subregion (portions of fuel plates, water channels etc.) of a triangle is an individual cell. The model was geometry tested for 100000 and 100 million histories and passed both tests.

As will be discussed in Chapter 5, this model is a very promising framework for the future research.

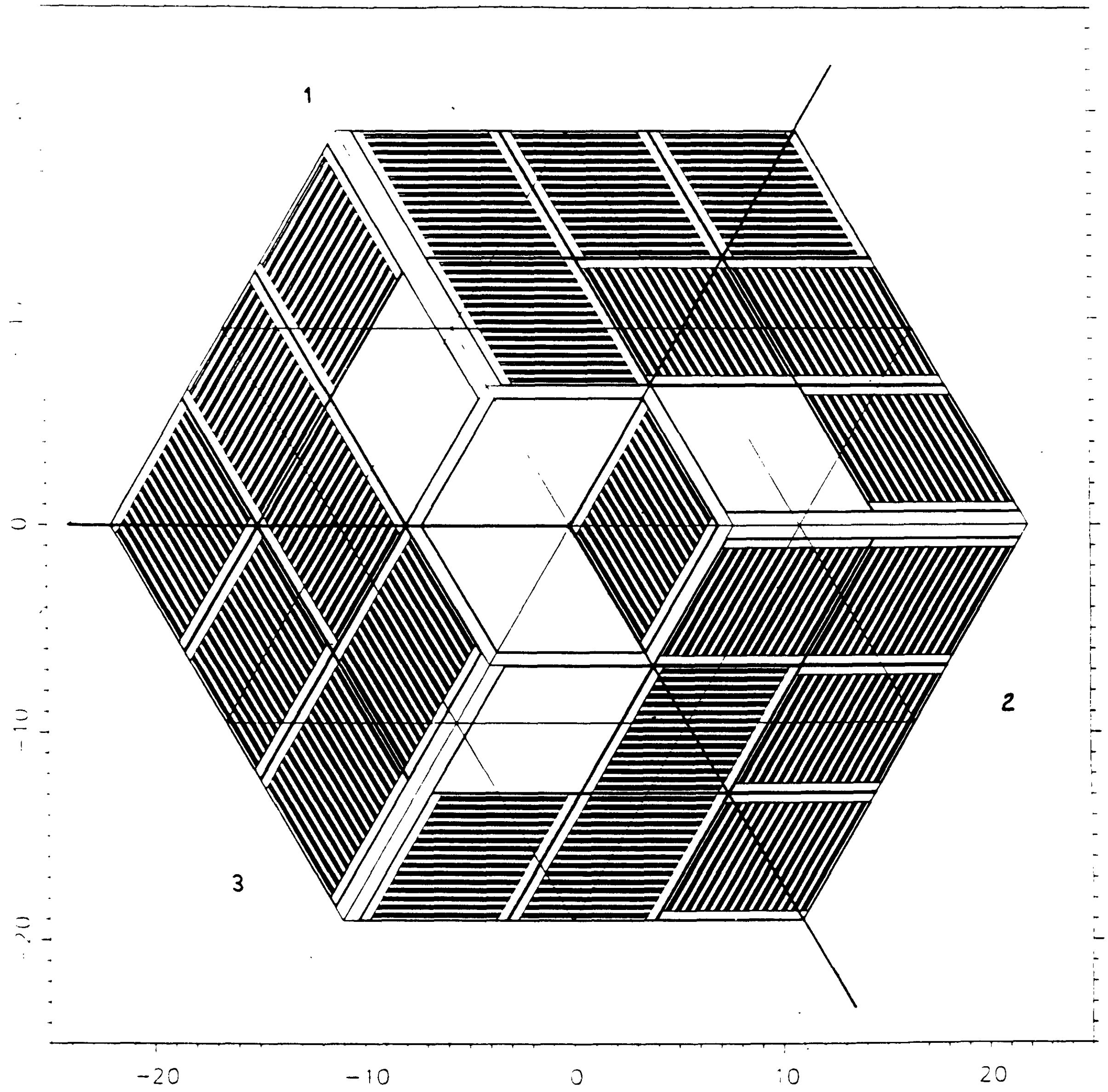


Figure 2.13 The 1/3 symmetry boundaries (note that this is not an exact symmetry because A-ring has only one fuel element and 2 dummy elements)

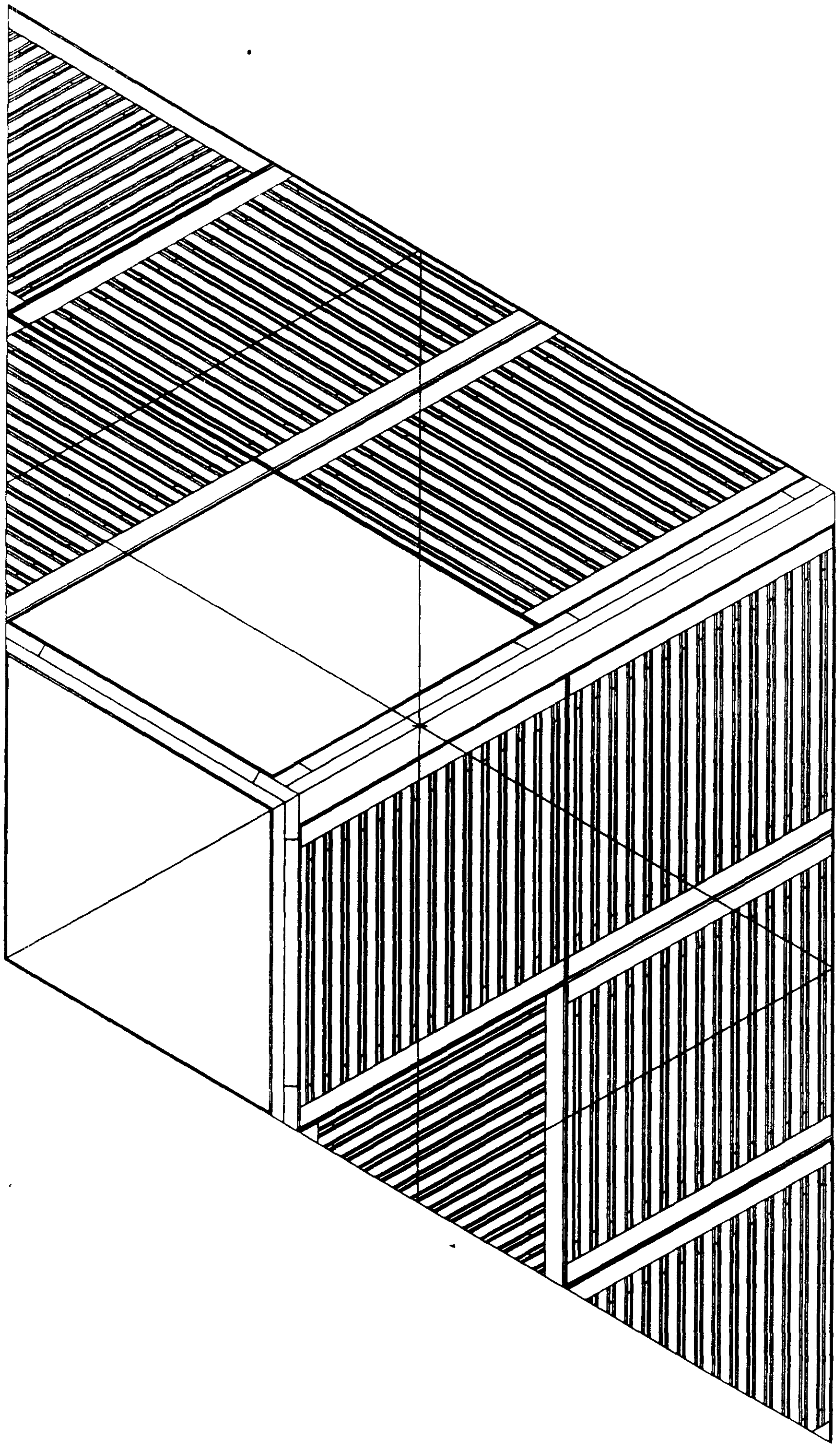


Figure 2.14 The 1/3 symmetry triangulated core model (x-y view)

CHAPTER 3

PRE-PROCESSING, PROCESSING AND POST-PROCESSING

3.1. MCNP INPUT PREPARATION AND PRE-PROCESSING PROGRAMS

MCNP input preparation involves two parts: the model definition and the preparation of tally cards. After the Triangulated Model is generated, it is used in separate ways for cross section generation and tallying of the surface flux and currents. This section discusses the tallying process related to homogenized cross section generation part.

3.1.1. Tally Cards

To tally the required data for homogenization, only the F4 type tally cards of MCNP are used. Without any multipliers, the F4 cards provide the track length estimate of MCNP cell fluxes. For reaction rate tallies the atom density data obtained from the Triangulated Model criticality test run output is also required. By using these atom densities and multipliers for absorption, total, elastic scattering, and fission cross sections, and for $\nu\Sigma_f$, reaction rate tally cards are prepared. To tally for axial nodes over portions of the MCNP cells, tally segmentation cards are used.

3.1.2. Stochastic Volume Calculation using MCNP

MCNP calculates cell volumes and surface areas as one of the first stages of the run, but it cannot calculate the volumes and areas of asymmetric, nonpolyhedron, or infinite cells. Since most of the cells in Triangulated Model are asymmetric, the volumes of this cells are required for F4 tallies. These volumes are found by hand calculations if the geometry is simple, but if not, the stochastic volume estimation of MCNP is used. The stochastic estimation is simply a ray tracing process. The procedure is described in detail in the MCNP manual [B-1]. Since the process is stochastic, the limiting factor on the accuracy of the results of this calculation is the number of histories followed. For the stochastic volume calculations in this thesis 100 million histories were used and less than 2% statistical error was obtained for most of the cell volumes. Since only part of the volumes are obtained this way, this statistical error is not included in the final error calculations described in Section 3.3.2.

3.1.3. Segmentation

As mentioned before, the Triangulated Model is segmented in 12 axial layers, but subsequently changed and 4 more layers added to the bottom of the lower triangle layer. These segmentations and the segmentations for incore tallies are done by using the FS4 tally segmentation cards. The required segment volumes for asymmetric cells are obtained by partitioning the volumes found using the methods discussed in the previous section.

3.2. MCNP RUNS FOR OBTAINING CELL FLUXES AND REACTION RATES

The input files for MCNP runs are ready after the model implementation and preparation of the tally cards. Because of memory limitations, these input files must be used for 8 separate MCNP runs, of which 6 runs are for tallying all the cells in the core hexagon, one for the out of core portion of the original Triangulated Model and one for the four additional layers starting from the bottom of the fuel cells. All MCNP cases were run on the SUN Sparcstation called *mitrsun*, using the same initial source file (SRCTP) to repeat the same simulation a number of times. Since mitrsun is not a dedicated machine for this research, most of the time, the runs were made sharing the time with other jobs running on the machine. This time and memory sharing limits the size of the MCNP jobs in that, if the required RAM is larger than the available RAM at that time, the job cannot be submitted. Also if the time sharing is done without any *nice*ing, time is shared among the submitted jobs equally. This was the case most of the time. Since during all the runs, there was at least one other job, the CPU times given on Table 3.1 must be multiplied by 2 or 3, to get the elapsed time for one run. Table 3.1 shows the resulting CPU times and k-effective values for each MCNP run. As seen, k-effective results for all the incore runs are the same except of Run # 1. During this run the process was interrupted as a result of a power surge, and MCNP used a different source file when the process was restarted.

Model with 260 cycles of 3000 starting particles	*CPU time used (minutes)*	*K-effective*
Incore Run # 1	1978.25	0.99916±0.0011
Incore Run # 2	1979.47	0.99714±0.0011
Incore Run # 3	2183.69	0.99714±0.0011
Incore Run # 4	2099.01	0.99714±0.0011
Incore Run # 5	2103.12	0.99714±0.0011
Incore Run # 6	2003.21	0.99714±0.0011
Out of core run for 12 layers	3196.00	0.99719±0.0012
Run for 4 additional layers	2308.26	0.99524±0.0010

Table 3.1 The comparison of CPU time and k-effective results for 8 MCNP tally runs .

3.3. THE HOMOGENIZATION SCHEME AND POST-PROCESSING PROGRAMS

The node-homogenized cross sections are obtained by flux weighted volume averaging using the computer programs written to process the MCNP tally output files (MCTAL files). For this job, 13 programs to process incore data, and 2 programs to process 12 and 4 segment out of core data were developed. Some of these programs are given in Appendix B.

3.3.1. Homogenization Scheme

The flux weighted volume averaging formula for homogenization can be given as the following:

$$\Sigma_g^j = \frac{\sum_i R_g^i V^{(i,j)}}{\sum_i \phi_g^{(i,j)} V^{(i,j)}}$$

where,

Σ_g^j = homogenized cross section for energy group g and triangular-z node j,

R_g^i = MCNP reaction rate per unit volume for cell i,

$V^{(i,j)}$ = volume of the portion of cell i that is in triangular-z node j

$\phi_g^{(i,j)}$ = MCNP flux density for energy group g and for the portion of cell i in node j.

To find the volumes for incore homogenization, the 1/3 symmetry model of the core was run using the stochastic volume estimation and the resulting values were used as the volumes in the equation above. For the out of core cases, volume values are the segment volumes of the cells given as a part of the input.

The homogenized cross sections computed are the total cross sections(Σ_t), absorption cross sections(Σ_a), fission cross sections(Σ_f) and fission neutron production cross sections ($\nu\Sigma_f$). The edited MCNP absorption cross sections do not include either the fission cross sections or the (n,2n) cross sections. The group-to-group scattering cross sections cannot be tallied. They must be obtained from neutron balance. Details of that procedure can be found in the thesis of Kuo [K-1].

3.3.2. Calculation of the Statistical Errors

Since every MCNP result is accompanied with a statistical error, the calculated cross sections also have statistical errors. Since each MCNP result is a mean value, to calculate the standard deviation associated with the cross sections the following basic formulae [K-2] can be used:

If: $u = x + y$ or $u = x - y$ then $\sigma^2_u = \sigma^2_x + \sigma^2_y$

If: $u = x * y$ or $u = x / y$ then $(\sigma_u / u)^2 = (\sigma_x / x)^2 + (\sigma_y / y)^2$

where x and y are the means of two different quantities having statistical uncertainties and the σ s are the standard deviations. If $u = c * x$ where c is a constant, σ_u can be obtained by multiplying σ_x with the constant c.

CHAPTER 4

RESULTS

The results presented in this chapter are divided into two parts: incore results, and out of core results. To indicate how nodes are identified a 2-D map of the quartz model is shown in Figure 4.1. Indices I and J specify the location of the triangular nodes. The index K specifies the z-location of the nodes (K goes from bottom to top). To be consistent with the results obtained before addition of 4 layers (Appendix C), the nodes above surface 85 are numbered 1-12 starting from that surface and going up. Below surface 85, K is negative and decreases from the surface downward (as -1,-2,-3,-4). The flux results are normalized to one starting particle (fission source) and to obtain the fluxes in units of neutrons/cm^2/sec the MCNP flux results should be multiplied by the number of fission neutrons per second corresponding to the power level of the reactor. That factor is given by:

$$PN = P * (1 / Q) * \nu * (1 / k_{eff})$$

where,

P = Reactor power level (Watts)

Q = Energy generated per fission (J / fission)

ν = Average number of neutrons generated per fission

k_{eff} = Neutron Multiplication Factor.

If both the numerator and denominator of homogenization formula are multiplied with the same constant, the result does not change. Therefore the flux results presented in this chapter are not normalized to power.

4.1. INCORE RESULTS

The incore homogenized cross section results along with the calculated statistical errors for the 12 layers of 24 triangles are obtained by using the scheme discussed previously. The complete set of results are presented in Appendix C under the file name *xchom2n* where group 1 is the fast and group 2 is the thermal group, and group boundaries are 0.625eV to 20MeV and 0 to 0.625eV, respectively, also errors are given as the ratio of error to mean value (the result). These results were obtained by using the specially written programs named as *xcg*.f* and *xcg**.f.* The accuracy of the results and the reliability of the software were tested by ***regenerating the same results*** with an ***entirely different logic*** which is reliable because of its simplicity. The software written for comparison, *sibel.f* and the results labeled *rslts* are given in Appendix B. The results given in *rslts* and those of Appendix C match to at least 5 significant digits after the floating point. This test process is a strong evidence that the processing of the MCNP results is correct.

4.2. OUT OF THE CORE RESULTS

The out of the core results are discussed in two parts: the initial 12 segment Triangulated model results for regions above the bottom level of the fuel and the 4 segment part below the bottom level of fuel (which from this point on will be referred to surface 85 or simply 85 the reference being to its MCNP surface number).

4.2.1. Results for the Nodes Above the Bottom Level of The Fuel (above 85)

This part of the results was obtained by running the program *prohx1n.f* of which listing is given in Appendix B. The complete list of cross section results is extremely long and therefore is not given in this thesis. However the results have been saved in a file named *hx1n.ou* and packed with all the files in the same directory for possible future use.

Some sample results are given in Table 4.1. These results display radial change of the cross sections and flux starting from the graphite reflector, crossing the D2O reflector and core radially, and ending at the other corner of the graphite reflector hexagon at axial node K=6. Statistical errors are given as fractions of the results.

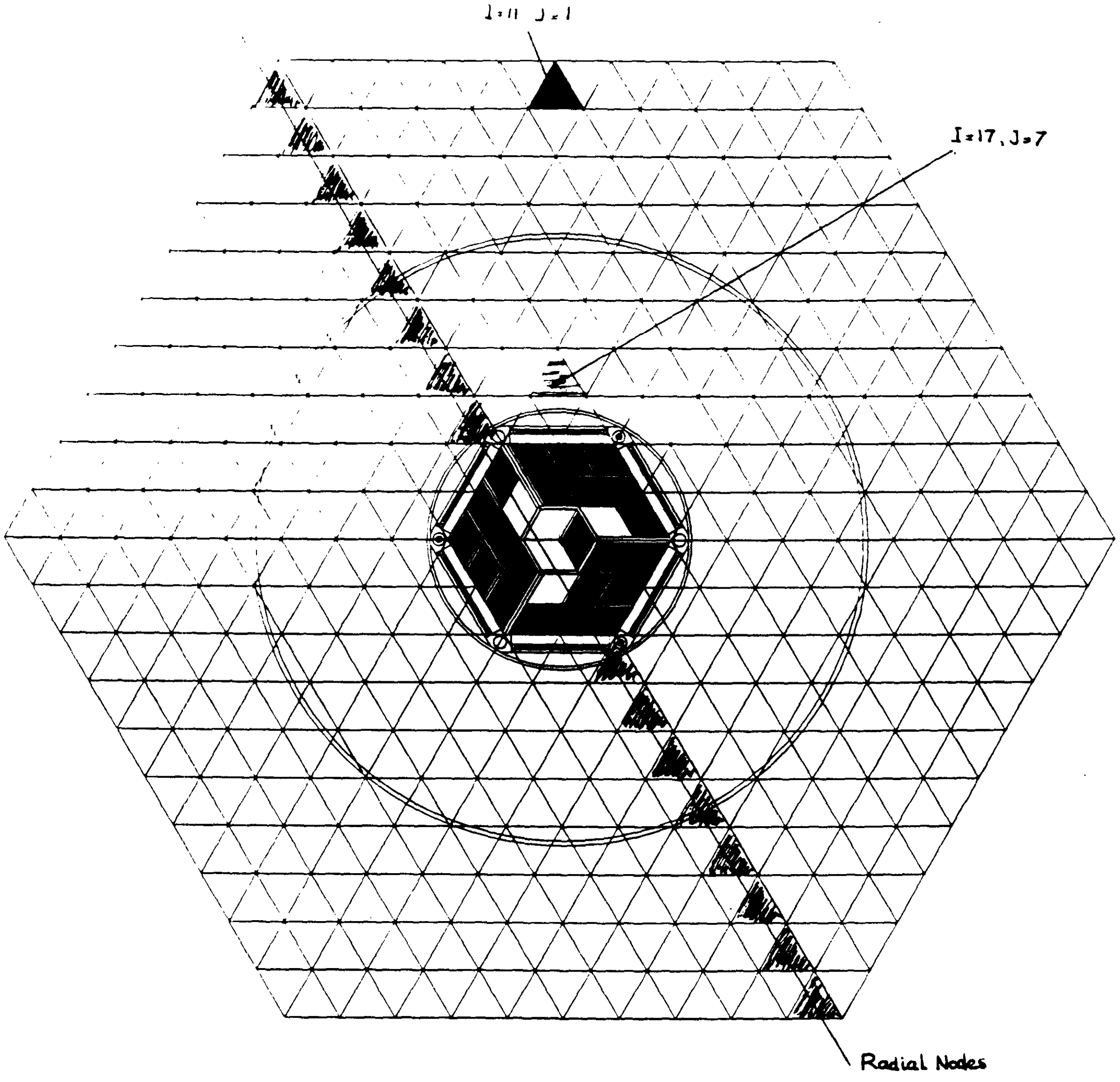


Figure 4.1 2-D nodal map of QUARTZ model showing the I and J indices user in the representation of the results, also K is the index for the z-direction

i	j	k	g	flux	err	diff.coeff.	Tot Xsection	err	Abs.Xsect.	err	nu*Fis Xsec.	err	Fis. Xsect.	err
1	1	6	1	0.00000E+00	0.000	0.00000E+00	0.00000E+00	0.000	0.00000E+00	0.000	0.00000E+00	0.000	0.00000E+00	0.000
			2	2.07020E-06	0.140	8.03067E-01	4.15075E-01	0.200	2.71764E-04	0.221	0.00000E+00	0.000	0.00000E+00	0.000
3	2	6	1	2.46614E-09	1.000	8.18714E-01	4.07142E-01	1.414	4.19210E-05	1.414	0.00000E+00	0.000	0.00000E+00	0.000
			2	9.26605E-06	0.072	7.85597E-01	4.24306E-01	0.102	2.59993E-04	0.105	0.00000E+00	0.000	0.00000E+00	0.000
5	3	6	1	1.67713E-07	0.437	8.31822E-01	4.00727E-01	0.623	2.89893E-05	0.740	0.00000E+00	0.000	0.00000E+00	0.000
			2	2.07684E-05	0.049	7.94325E-01	4.19643E-01	0.070	2.54862E-04	0.072	0.00000E+00	0.000	0.00000E+00	0.000
7	4	6	1	6.27768E-07	0.295	8.95803E-01	3.72106E-01	0.427	1.48909E-05	0.473	0.00000E+00	0.000	0.00000E+00	0.000
			2	3.51586E-05	0.039	7.86446E-01	4.23848E-01	0.056	2.58238E-04	0.058	0.00000E+00	0.000	0.00000E+00	0.000
9	5	6	1	1.82093E-06	0.120	1.04048E+00	3.20364E-01	0.177	2.18258E-04	0.308	0.00000E+00	0.000	0.00000E+00	0.000
			2	5.93599E-05	0.022	8.34871E-01	3.99263E-01	0.033	2.09584E-03	0.045	0.00000E+00	0.000	0.00000E+00	0.000
11	6	6	1	5.91833E-06	0.083	9.79575E-01	3.40283E-01	0.119	3.21276E-05	0.494	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.06061E-04	0.024	6.92918E-01	4.81057E-01	0.034	8.20881E-05	0.035	0.00000E+00	0.000	0.00000E+00	0.000
13	7	6	1	3.07632E-05	0.038	9.76061E-01	3.41509E-01	0.053	4.31152E-05	0.243	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.57135E-04	0.020	6.97113E-01	4.78163E-01	0.028	8.05893E-05	0.029	0.00000E+00	0.000	0.00000E+00	0.000
15	8	6	1	1.21032E-04	0.016	8.49796E-01	3.92251E-01	0.023	1.97240E-04	0.038	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.81025E-04	0.016	5.20730E-01	6.40127E-01	0.023	3.08295E-03	0.025	0.00000E+00	0.000	0.00000E+00	0.000
17	9	6	1	4.48169E-04	0.003	6.34556E-01	5.25301E-01	0.005	1.88870E-03	0.022	6.98395E-03	0.015	2.84733E-03	0.015
			2	5.71853E-05	0.009	2.25064E-01	1.48110E+00	0.015	2.59849E-02	0.015	1.96500E-01	0.021	8.06419E-02	0.021
19	10	6	1	5.04999E-04	0.005	8.33841E-01	3.99757E-01	0.008	5.83178E-04	0.015	7.58082E-04	0.037	3.09118E-04	0.038
			2	6.30525E-05	0.014	4.27141E-01	7.80383E-01	0.022	1.29291E-02	0.019	1.80151E-02	0.039	7.39320E-03	0.039
21	11	6	1	5.19091E-04	0.005	8.25860E-01	4.03620E-01	0.008	5.52463E-04	0.013	7.23206E-04	0.025	2.94695E-04	0.025
			2	6.33294E-05	0.014	4.14470E-01	8.04239E-01	0.023	1.31683E-02	0.019	1.92727E-02	0.038	7.90936E-03	0.038
23	12	6	1	5.09739E-04	0.003	5.83724E-01	5.71046E-01	0.005	2.32848E-03	0.014	9.33501E-03	0.011	3.80445E-03	0.011
			2	5.93874E-05	0.008	1.90556E-01	1.74927E+00	0.013	3.13364E-02	0.012	2.73800E-01	0.016	1.12365E-01	0.016
25	13	6	1	1.25541E-04	0.016	8.94956E-01	3.72458E-01	0.022	1.71450E-04	0.037	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.78758E-04	0.016	5.50002E-01	6.06058E-01	0.022	2.86191E-03	0.024	0.00000E+00	0.000	0.00000E+00	0.000
27	14	6	1	3.43998E-05	0.036	9.76754E-01	3.41267E-01	0.051	3.99590E-05	0.220	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.63178E-04	0.019	6.97383E-01	4.77977E-01	0.028	8.04673E-05	0.028	0.00000E+00	0.000	0.00000E+00	0.000
29	15	6	1	7.72221E-06	0.076	9.77237E-01	3.41098E-01	0.107	6.52048E-05	0.514	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.07323E-04	0.024	6.93257E-01	4.80822E-01	0.035	8.20849E-05	0.036	0.00000E+00	0.000	0.00000E+00	0.000
31	16	6	1	2.11737E-06	0.118	9.61165E-01	3.46801E-01	0.173	1.54844E-04	0.253	0.00000E+00	0.000	0.00000E+00	0.000
			2	6.39322E-05	0.022	8.41182E-01	3.96268E-01	0.033	2.26004E-03	0.045	0.00000E+00	0.000	0.00000E+00	0.000
33	17	6	1	6.08455E-07	0.297	8.33416E-01	3.99961E-01	0.423	1.92271E-05	0.491	0.00000E+00	0.000	0.00000E+00	0.000
			2	3.50588E-05	0.039	7.87819E-01	4.23109E-01	0.055	2.53745E-04	0.057	0.00000E+00	0.000	0.00000E+00	0.000
35	18	6	1	5.92642E-08	0.781	8.01048E-01	4.16121E-01	1.104	4.46787E-06	1.040	0.00000E+00	0.000	0.00000E+00	0.000
			2	2.12214E-05	0.052	7.87222E-01	4.23430E-01	0.074	2.49000E-04	0.074	0.00000E+00	0.000	0.00000E+00	0.000
37	19	6	1	9.01566E-08	1.000	8.18181E-01	4.07408E-01	1.414	5.17403E-07	1.414	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.03531E-05	0.071	7.92436E-01	4.20644E-01	0.101	2.70066E-04	0.105	0.00000E+00	0.000	0.00000E+00	0.000
39	20	6	1	8.70529E-09	1.000	9.19843E-01	3.62381E-01	1.414	8.12050E-08	1.414	0.00000E+00	0.000	0.00000E+00	0.000
			2	2.31599E-06	0.123	7.80428E-01	4.27116E-01	0.175	2.25866E-04	0.174	0.00000E+00	0.000	0.00000E+00	0.000

Table 4.1 The sample results for the radial distribution of the cross sections and flux for two energy groups

4.2.2. Results for the Nodes Below the Bottom Level of The Fuel (below 85)

The homogenized cross section results for the nodes below surface 85 (which is the bottom surface of the fuel) are also extremely long. Some sample results are included in Tables 4.2 and 4.3 which show the axial distribution of flux and cross sections for two triangular nodes: *Triangle 1* (I,J) = (11,1).and *Triangle 2* (I,J) = (17,7). (See Figure 4.1)

4.3. SURFACE FLUX AND SURFACE CURRENT RESULTS

The results for surface fluxes and surface currents were obtained by Kuo and the description of the procedure used to obtain these results can be found in his thesis. The results are voluminous and are presented neither here nor in his thesis. The general strategy used to obtain the results was to trick MCNP by filling exactly defined triangle surfaces with the universe of the entire model for incore cells and by tallying the surface fluxes and currents directly for these triangulated portions of the model.

4.4. GROUP TO GROUP SCATTERING

Since MCNP can not provide group-to-group scattering cross sections, they need to be determined from neutron balance. This portion of the data gathering process for QUARTZ was done by Kuo and is presented in his thesis [K-1]. Also CMFD discontinuity factors were found by Kuo. Some difficulties encountered with the group-to-group cross section and discontinuity factor calculations, which for some cases come out negative. The problems and possible causes of these negative results are, as in his thesis :

- Negative fast to thermal group scattering cross sections were found. This phenomenon may be caused by statistical fluctuation in the net currents or the absorption cross sections, or from the failure to include up-scattering and n-2n cross sections in two-group neutron balance equations.

- Negative CMFD discontinuity factors were found. The negative discontinuity factors can result in loss of the diagonal dominance of the matrices used in QUARTZ, which can cause the solution to diverge. One way was found to avoid the negative discontinuity factors, namely to increase arbitrarily the diffusion coefficients so that the factors which cause a match with the reference leakages will be positive.

Some additional discussion of these problems is given in the next section and in Chapter 5.

i	j	k	g	flux	err	diff.coeff.	Tot Xsection	err	Abs.Xsect.	err
17	7	1	1	4.80751E-05	0.029	9.85212E-01	3.38337E-01	0.042	3.53111E-05	0.193
			2	2.02492E-04	0.017	6.98106E-01	4.77482E-01	0.024	8.02910E-05	0.025
17	7	2	1	5.83805E-05	0.028	9.88478E-01	3.37219E-01	0.040	3.44639E-05	0.166
			2	2.09906E-04	0.017	6.98004E-01	4.77552E-01	0.025	8.02678E-05	0.026
17	7	3	1	6.81750E-05	0.025	9.88469E-01	3.37222E-01	0.036	4.09521E-05	0.156
			2	2.20514E-04	0.017	6.96166E-01	4.78813E-01	0.024	8.10194E-05	0.025
17	7	4	1	7.05469E-05	0.025	9.88895E-01	3.37076E-01	0.036	3.08510E-05	0.174
			2	2.22060E-04	0.017	6.96954E-01	4.78272E-01	0.024	8.06687E-05	0.025
17	7	5	1	7.11013E-05	0.025	9.94242E-01	3.35264E-01	0.036	5.47939E-05	0.165
			2	2.12672E-04	0.017	6.96365E-01	4.78676E-01	0.024	8.09110E-05	0.025
17	7	6	1	6.83809E-05	0.026	9.92469E-01	3.35863E-01	0.037	4.45734E-05	0.170
			2	1.91262E-04	0.018	6.99046E-01	4.76840E-01	0.025	8.00546E-05	0.026
17	7	7	1	6.10893E-05	0.027	9.87968E-01	3.37393E-01	0.038	4.97012E-05	0.203
			2	1.76513E-04	0.019	7.00141E-01	4.76095E-01	0.027	7.95409E-05	0.028
17	7	8	1	5.29172E-05	0.028	9.75385E-01	3.41745E-01	0.039	8.00278E-05	0.127
			2	1.49891E-04	0.019	6.70850E-01	4.96882E-01	0.026	5.52782E-04	0.032
17	7	9	1	4.14385E-05	0.032	8.42328E-01	3.95729E-01	0.046	2.56061E-04	0.061
			2	1.20912E-04	0.022	4.58591E-01	7.26864E-01	0.032	5.78627E-03	0.033
17	7	10	1	3.69581E-05	0.035	8.51008E-01	3.91692E-01	0.050	2.56860E-04	0.064
			2	8.87197E-05	0.025	4.60264E-01	7.24221E-01	0.035	5.71981E-03	0.036
17	7	11	1	2.65286E-05	0.038	8.48228E-01	3.92976E-01	0.055	2.60341E-04	0.076
			2	6.65430E-05	0.028	4.59787E-01	7.24973E-01	0.040	5.74762E-03	0.041
17	7	12	1	2.09861E-05	0.045	8.53362E-01	3.90612E-01	0.064	2.70425E-04	0.092
			2	4.80271E-05	0.032	4.59916E-01	7.24770E-01	0.046	5.74382E-03	0.047

Table 4.3. Axial distribution of flux and cross sections for triangular node I=17, J=7 *Triangle 2*.

i	j	k	g	flux	err	diff.coeff.	Tot Xsection	err	Abs.Xsect.	err
11	1	1	1	1.08643E-07	0.673	8.95670E-01	3.72161E-01	0.950	8.47173E-08	0.952
			2	9.89922E-06	0.071	7.89217E-01	4.22360E-01	0.100	2.56452E-04	0.105
11	1	2	1	4.18807E-08	0.716	8.34523E-01	3.99430E-01	1.011	8.33212E-08	1.010
			2	9.72995E-06	0.066	7.99354E-01	4.17003E-01	0.094	2.60729E-04	0.098
11	1	3	1	1.14215E-07	0.590	1.11012E+00	3.00269E-01	0.859	9.46548E-06	1.145
			2	1.03515E-05	0.066	8.03730E-01	4.14733E-01	0.093	2.76491E-04	0.096
11	1	4	1	1.13265E-07	0.598	1.15483E+00	2.88643E-01	0.867	2.57140E-06	1.119
			2	1.05543E-05	0.066	7.88424E-01	4.22784E-01	0.094	2.66419E-04	0.099
11	1	5	1	3.93038E-08	0.718	1.05661E+00	3.15473E-01	1.081	1.15485E-05	1.222
			2	1.08506E-05	0.066	7.90396E-01	4.21730E-01	0.094	2.68377E-04	0.098
11	1	6	1	0.00000E+00	0.000	0.00000E+00	0.00000E+00	0.000	0.00000E+00	0.000
			2	1.04779E-05	0.070	7.88243E-01	4.22882E-01	0.099	2.51189E-04	0.101
11	1	7	1	2.68951E-08	1.000	1.57398E+00	2.11777E-01	1.414	1.46352E-07	1.414
			2	7.82384E-06	0.073	7.89125E-01	4.22409E-01	0.105	2.61372E-04	0.107
11	1	8	1	6.20758E-08	0.708	1.09882E+00	3.03355E-01	1.020	2.64783E-05	1.223
			2	6.31320E-06	0.076	7.94017E-01	4.19806E-01	0.109	2.56010E-04	0.112
11	1	9	1	6.52415E-08	0.938	8.41589E-01	3.96076E-01	1.350	4.61554E-05	1.371
			2	6.92089E-06	0.083	7.92411E-01	4.20657E-01	0.118	2.50141E-04	0.121
11	1	10	1	0.00000E+00	0.000	0.00000E+00	0.00000E+00	0.000	0.00000E+00	0.000
			2	6.02105E-06	0.091	7.94361E-01	4.19624E-01	0.129	2.52745E-04	0.133
11	1	11	1	0.00000E+00	0.000	0.00000E+00	0.00000E+00	0.000	0.00000E+00	0.000
			2	4.68518E-06	0.093	7.96921E-01	4.18276E-01	0.131	2.57183E-04	0.133
11	1	12	1	2.09973E-08	0.755	8.01263E-01	4.16010E-01	1.067	3.44486E-06	1.157
			2	4.45483E-06	0.100	7.91894E-01	4.20932E-01	0.142	2.54519E-04	0.143

Table 4.2. Axial distribution of flux and cross sections for triangular node I=11, J=1 *Triangle 1*.

4.5. NEUTRON BALANCE

The programs to calculate the two group neutron balance were written by Kuo, originally to obtain group to group scattering cross sections. Because of the inconsistency of the results, another program was written to obtain one group cross sections, fluxes, surface fluxes and surface currents from the two-group results and to check neutron balance for one energy-group. The procedure and programs were also tested by the author. For both incore and out of the core results this balance check is failed (Some of the results of this balance check are given in Appendix D). *It is important to recognize that, for incore results, neutron balance should not be expected. The surface fluxes and surface currents were obtained for the surfaces of triangles, but the cross sections and node flux were obtained from a homogenization scheme which uses MCNP flux results for group of cells not bounded by the triangle surfaces.* The lack of balance suggests that either there are invalid approximations involved in the process or that some of the data obtained is either incorrect or includes *too much statistical error*. These possibilities must be investigated for incore and out of the core separately, because the procedures for these two cases have some major differences.

Incore results :

The accuracy of the homogenized cross sections was established by *regenerating* the same results *semi-manually* for an arbitrary triangle using an entirely different programming logic. The results had very low statistical errors. These findings suggest that the error comes from these results it is related to the assumption that the flux distribution is very similar for the neighboring rhomboid core assemblies and does not change much throughout the assembly.

According to Kuo, the processing of his results are also correct, therefore; again only the MCNP results can be questioned. In his tallying process, Kuo had to make several runs for different surfaces of different cells because the universe-fill scheme does not allow him to obtain all the results together from the same run. This might have caused some inconsistency in the neutron balance, because the model is changed slightly for every run. *To expect a neutron balance in the end, all of the separate MCNP runs should be the repetitions of the same simulation, otherwise the results come out irrelevant.*

Out of core results :

Again the models used for the homogenized cross section part and the surface part have some differences. Kuo explicitly divided the cells into segments to obtain node top and bottom surface results while the author used the Triangulated model directly. These differences might have affected the simulation results.

For the cells and surfaces in the graphite nodes, the statistical errors are very high; even zero flux results are obtained for some of the triangles because of lack of sampling. Therefore; it is hard to expect any balance in this region of the core.

4.6. GENERAL TRENDS OF THE CROSS SECTION RESULTS

This section aims to present some portion of the data in a meaningful format and investigate possible causes of failure of the general procedure. The distributions presented in Table 4.1, Table 4.2 and Table 4.3 are represented graphically in Figures from 4.2 through 4.7. Figure 4.1 shows the location of the traverses in the radial direction.

By looking at the results presented in Appendix C, Table 4.1, Table 4.2, Table 4.3, and the figures, some general observations about the triangular node fluxes and homogenized cross sections can be made. They are itemized as the following:

- Incore homogenized cross section results (Appendix C) have very small errors. Average and maximum statistical errors are (the first number is for fast and the second is for thermal group):

	Flux	*Total Xsection*	*Absorb. Xsection*	*Fission Xsection*
Average error	0.5% - 0.9%	0.6% - 1.8%	2.0% - 1.7%	1.8% - 2.9%
Maximum error	0.9% - 1.7%	1.3% - 2.8%	3.1% - 2.6%	4.2% - 5.1%

  The errors for the flux results are very small; because of the high value of fast flux in the core, the percent error for the fast flux is smaller. Statistical errors are higher for the cross sections -especially for fission- due to the fact that sampling is lower for these quantities. The absorption cross section percent errors are lower for the thermal group, because the thermal absorption cross section is higher then the fast absorption cross section. These are the expected results for a very compact core with the boundary between the energy groups set to 0.625eV. Another observation is that most of the total cross section consists of the scattering cross section.

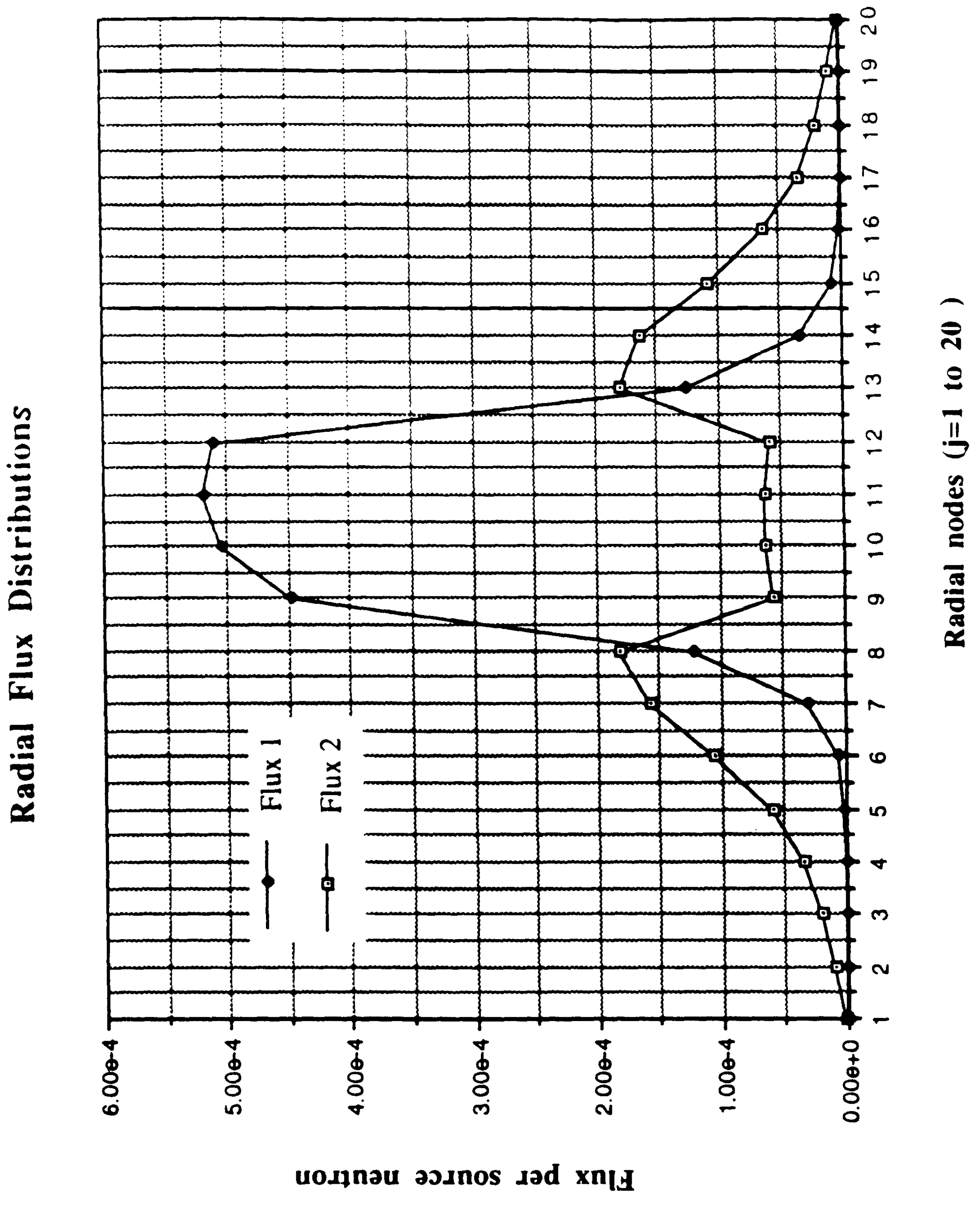


Figure 4.2 Radial flux distributions (axial node K=6).

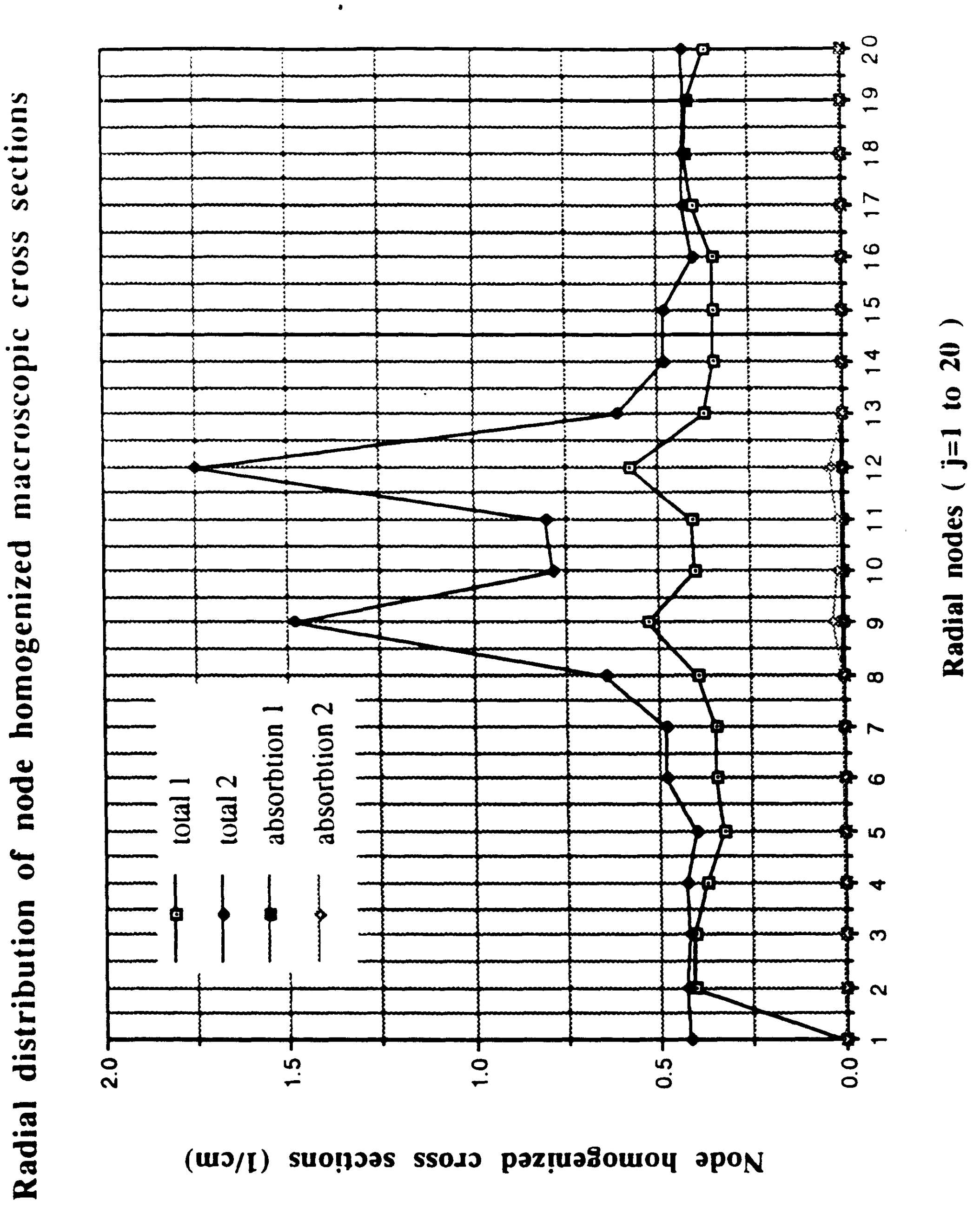


Figure 4.3 The radial distribution of homogenized cross sections (axial node K=6).

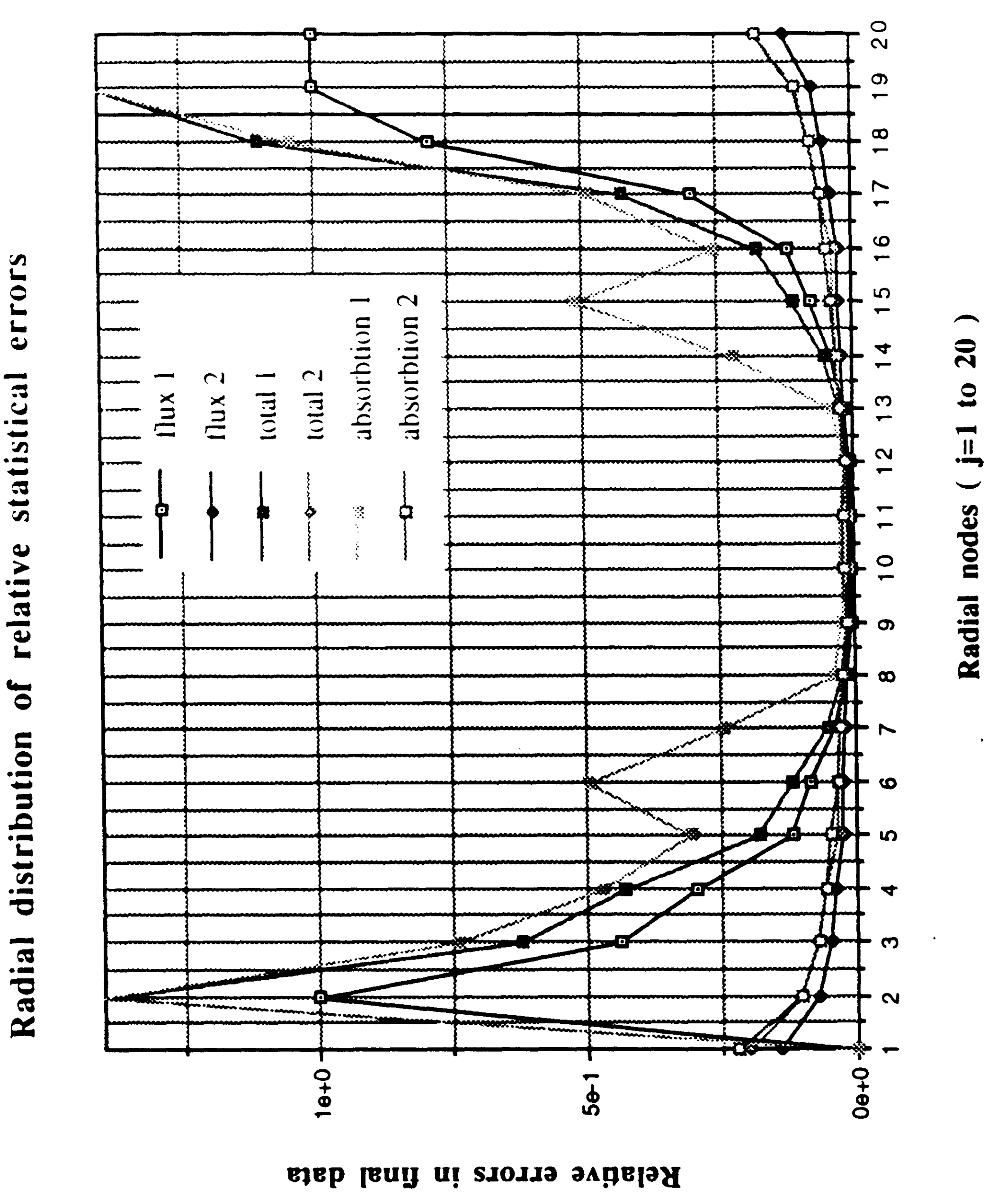


Figure 4.4 The radial distribution of statistical errors (axial node K=6).

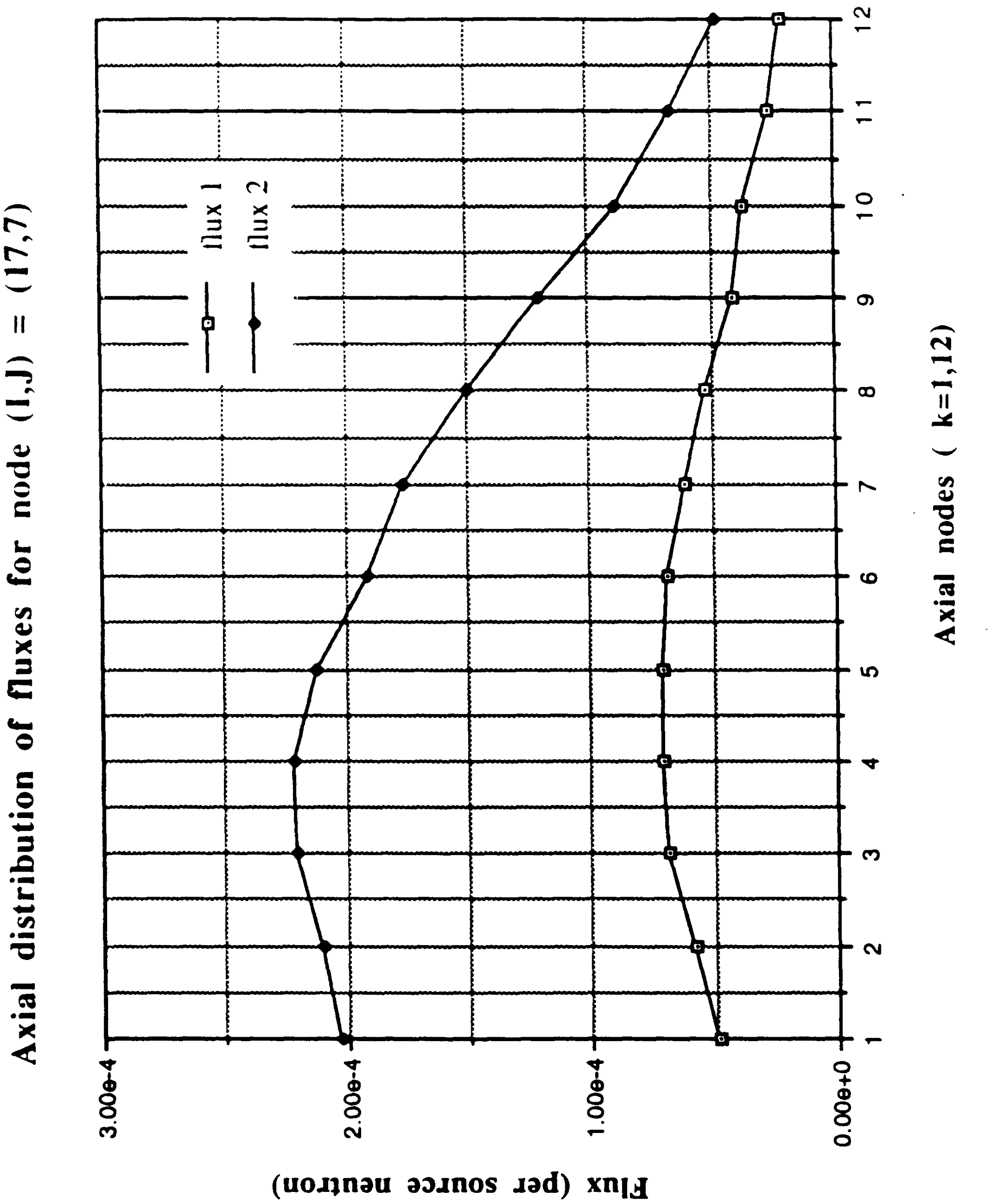


Figure 4.5 The axial distribution of fluxes for the 2 energy groups in node (17,7).

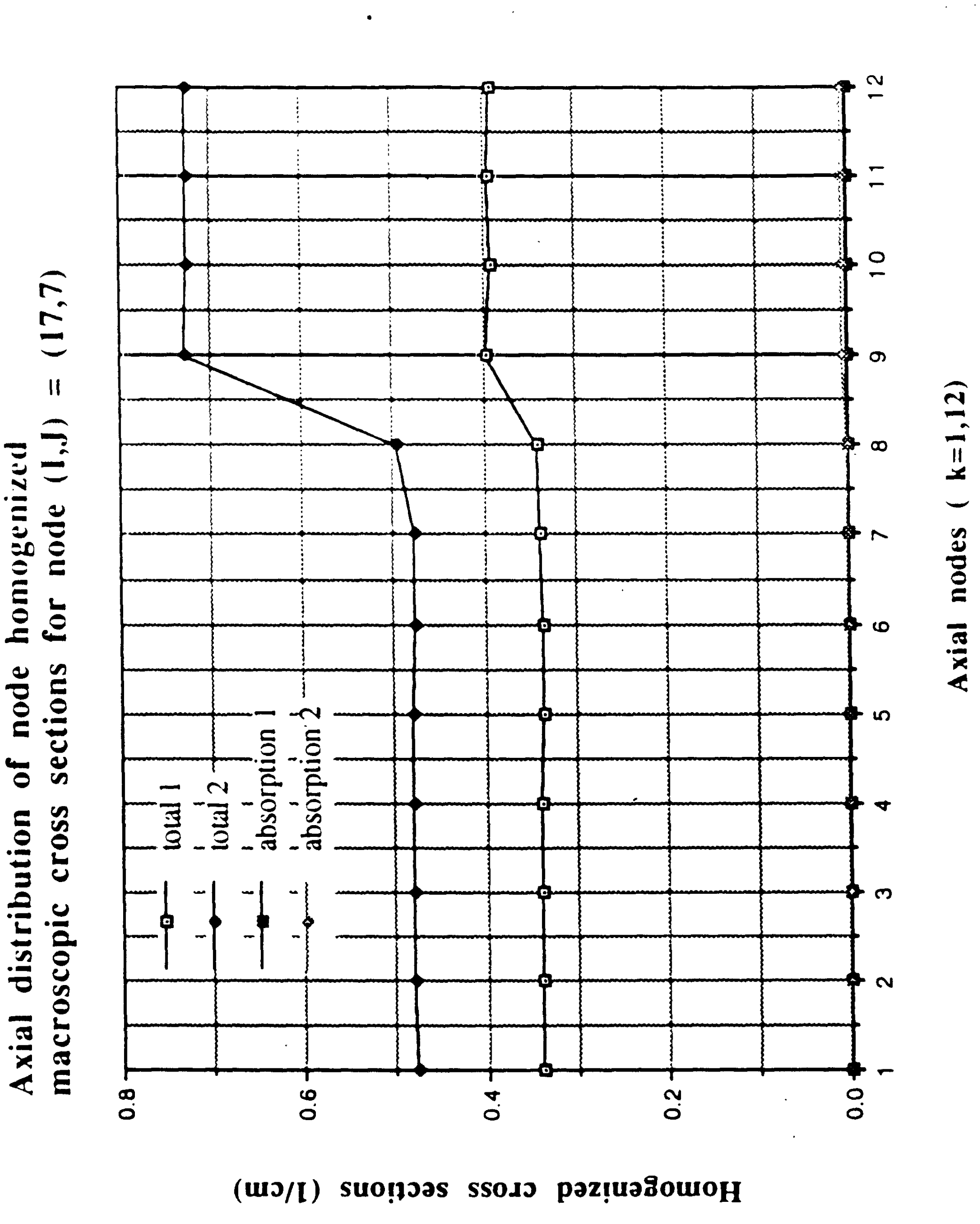


Figure 4.6 The axial distribution of homogenized cross section results for the 2 energy groups in node (17,7).

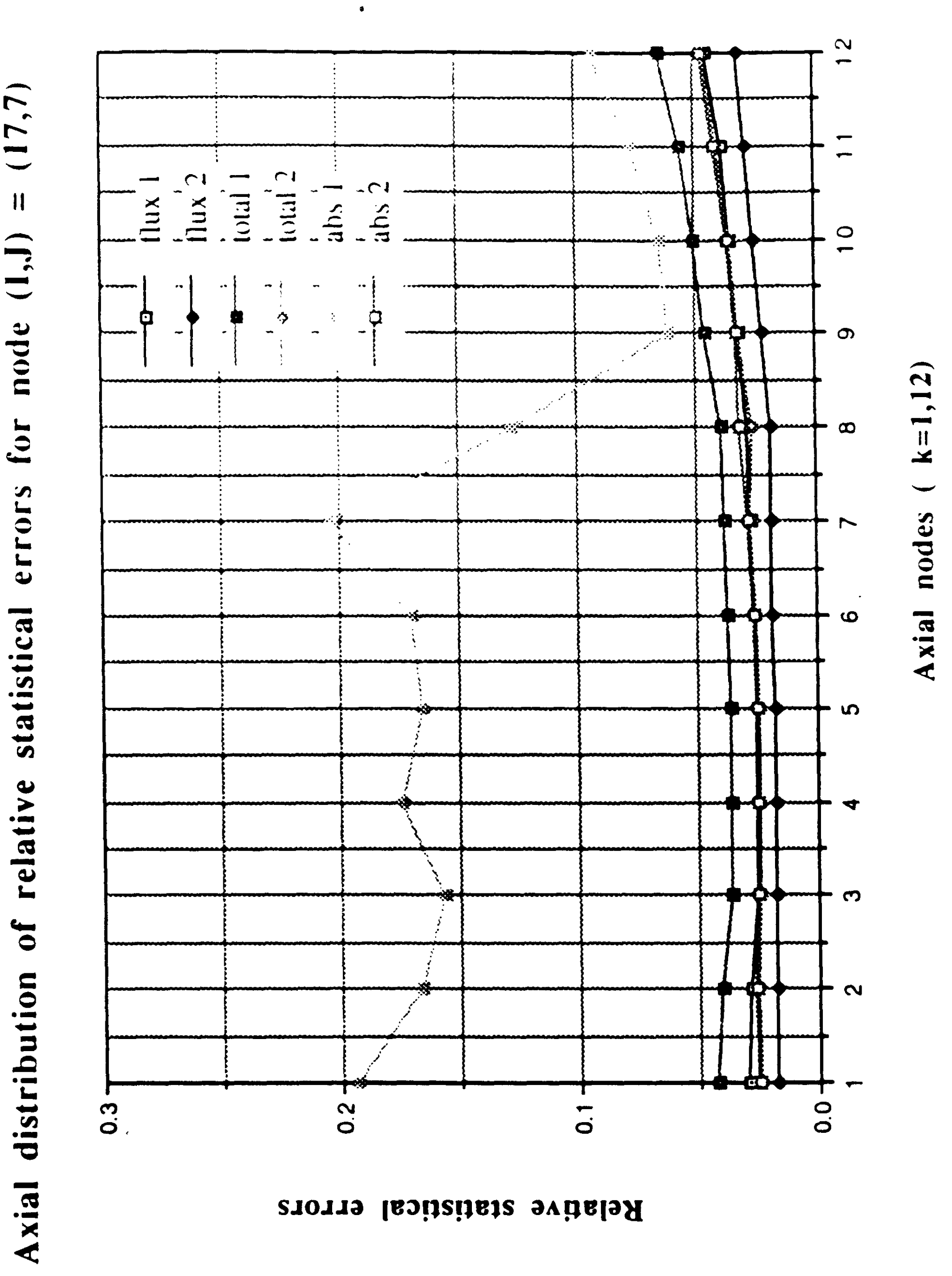


Figure 4.7 The axial distribution of statistical error for the 2 energy groups in node (17,7).

- Table 4.1 shows that the cross sections for graphite -especially the fast group and those for outer triangles- are accompanied with unacceptably large errors. Values of 141% error mean that there are only one or two interactions occurring for the approximately 250*3000 starting particles. Since the flux is low at those areas, they can be used (cautiously) in subsequent calculations. However they can not satisfy the nodal balance. Errors in D_2O region are much lower because of the higher fluxes (especially thermal). The triangle samples from J=8 and J=13 correspond to the *Control Blade Ring* where the control blades and water holes are present in the Al blocks. The errors for this ring are as low as the ones for the incore portion. The gradual increase in the ratio of thermal flux to fast flux with the radius can be seen nicely from Figure 4.4.

- Table 4.2 and Table 4.3 shows the axial distributions for two triangles: the one given as *Triangle 1* (node i=11, j=1 of Table 4.2) is in the outer graphite ring but is on the side of the hexagon so that it sees the core much better than the corner triangles. Hence it has much better statistics than the corner ones. However; the fast energy group results are still unacceptable with their more than 50% error. The thermal energy group results have acceptable errors. The non-zero thermal flux values suggest that there is some leakage from the sides of the graphite which might bring the arbitrary assignment of a hexagonal boundary into question. However the k-effective is not affected, indicating that the coupling of the neutrons in the outer parts of the graphite to the core is negligible. The flux distribution is given in Figure 4.5. It is higher at the bottom and lower at the top nodes, probably because of the higher absorption cross section of the H_2O at the top next to the core hexagon (wider portion of the core tank) comparing to that of D_2O in the reflector tank surrounding the bottom portion of the core tank.

- The other triangle (node i=17, j=7 of Table 4.3) goes through heavy water at the bottom nodes and light water at the top four nodes. Figures 4.5 and 4.6 show axial distribution of fluxes and cross sections. The thermal flux shows a distribution similar to that of *Triangle 1* but drops more significantly because of the light water existing at the top portion. The fast flux is also higher at the bottom. Fast absorption cross sections are much higher in the top 4 nodes (2 to 4 times), although the total cross section is only slightly higher at the top (D_2O balances the effect of H_2O microscopic absorption cross section with its scattering cross section). The thermal total cross section is higher at the top because of two orders of magnitude higher thermal absorption cross section. One thing to remember about the cross section behavior is that the fast group starts at 0.625eV, a rather low cut point.

- The distributions of error for both triangular nodes increase as the flux decreases. Errors in both energy groups for *Triangle 2* are acceptable, also the errors in *Triangle 1* for thermal energy group are acceptable (around 10%). However, again, this kind of error affects neutron balance significantly if all the data is not obtained from the same simulation run.

These observations show that the cross section distributions are consistent and match with the expectations. This is an evidence about their accuracy.

As mentioned, there is a suspicion about the initial assumption that flux shapes among portions of a rhombus shows similar behavior. To test that flux distributions in two different fuel plates of a rhombus and in one of the dummy elements compared with each other. For this comparison, fuel element B-7 and the neighboring dummy element A-3 were selected (both contributes to triangle (I,J)=(4,2) denoted in core coordinates). Figures 4.8 through 4.13 show MCNP axial flux distributions for Aluminum of A-3 and two fuel plates of B-7 of which *Plate 1* is the closest plate to A-3 and it is completely in the selected triangle, *Plate 15* is the farthest fuel plate to A-3 and it is completely out of the triangle. In these figures, according to MCNP convention the segment numbers increase from top to bottom. These figures show that the axial flux distribution differs significantly among the portions of same element, and among the neighboring elements.

After these observations, one other investigation for incore results can be made: Is the assumption that flux distribution is the same throughout a rhomboid shaped element, and the flux distribution does not change significantly between two neighbor incore elements? For these investigations by considering that if there is a significant difference exists, it is between fuel and dummy elements.

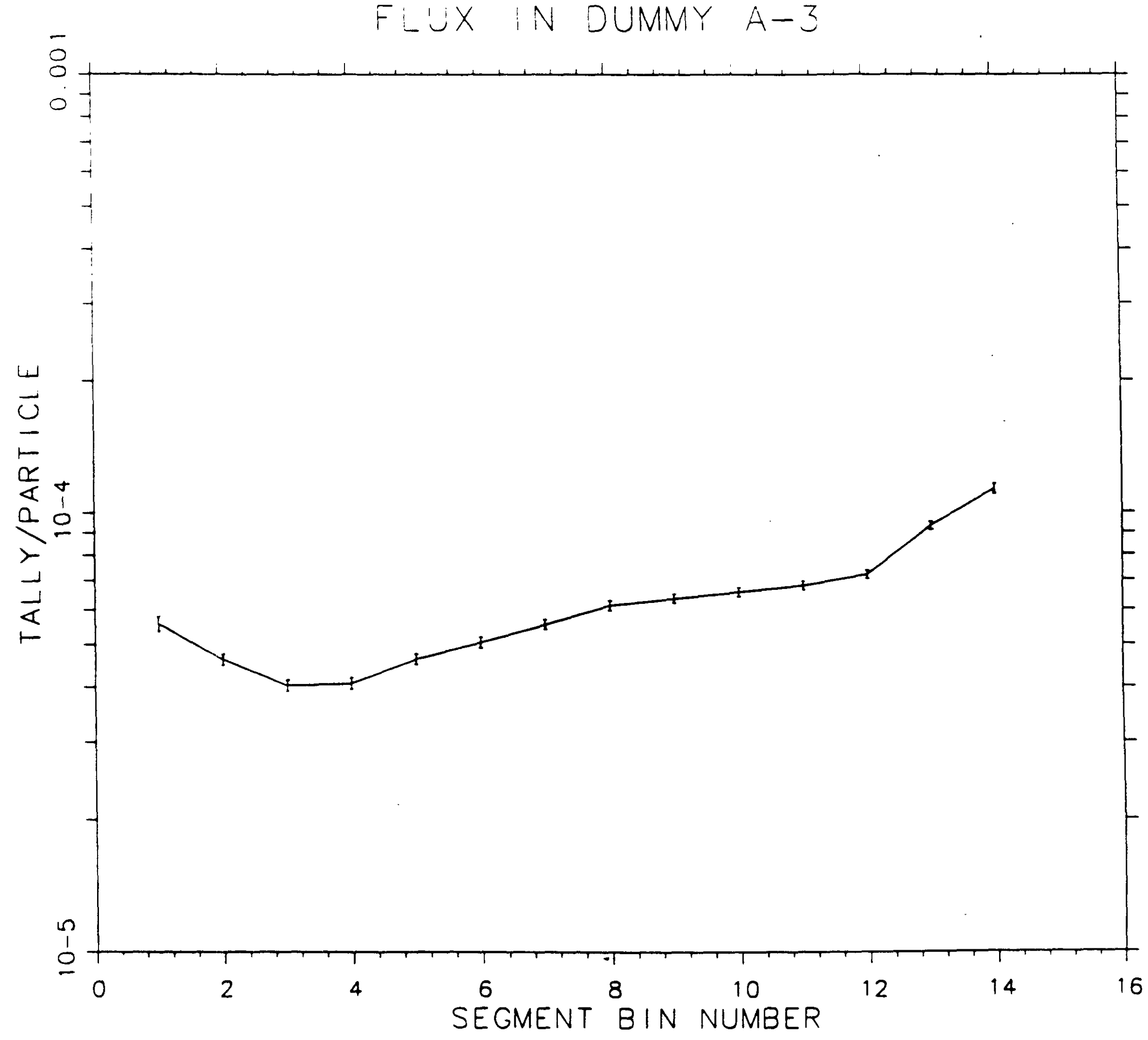


Figure 4.8 MCNP axial thermal flux distribution for Aluminum of A-3 (segments are numbered from top to bottom).

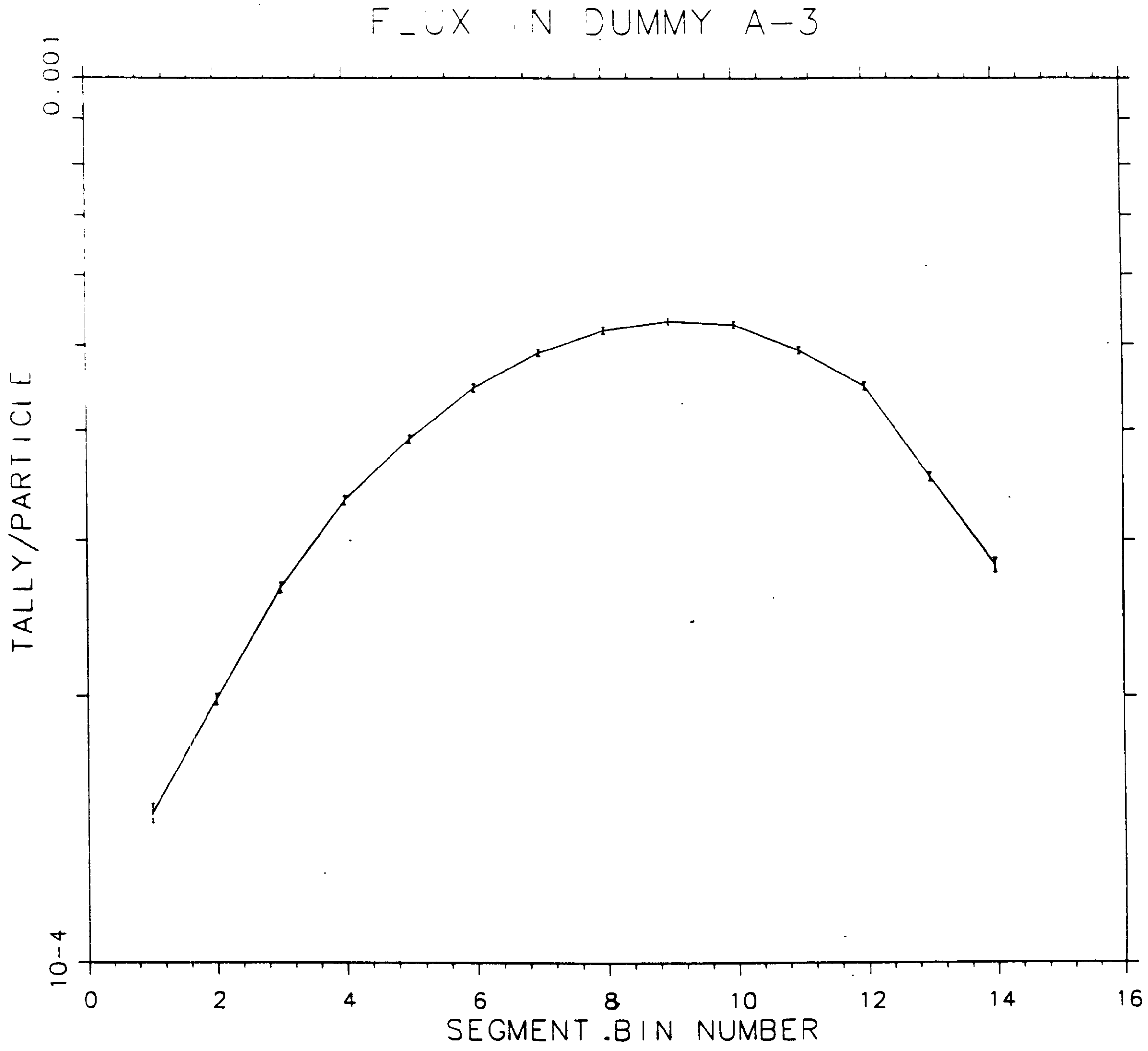


Figure 4.9 MCNP axial fast flux distribution for Aluminum of A-3 (segments are numbered from top to bottom)

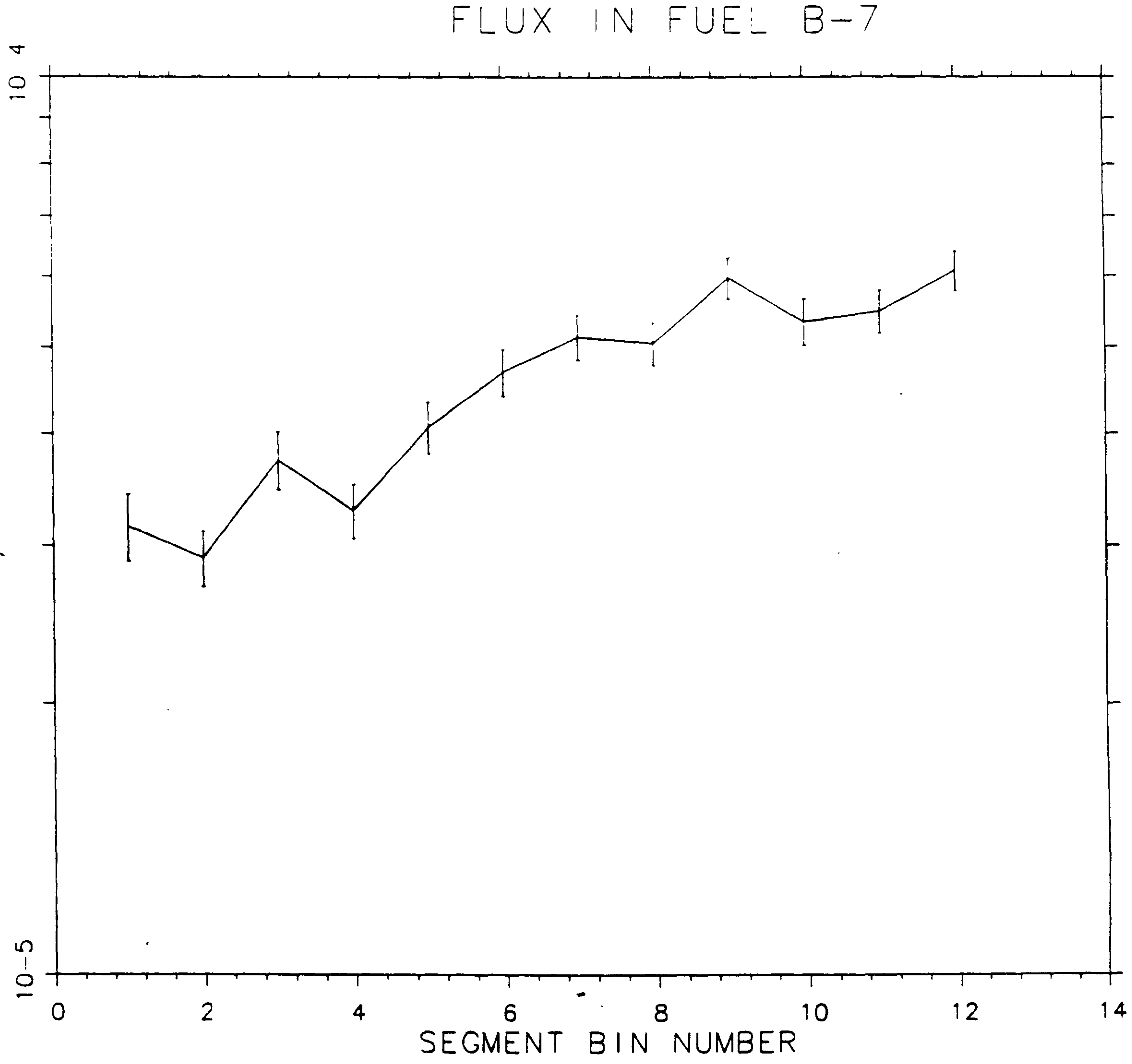


Figure 4.10 MCNP axial thermal flux distribution for Plate 1 of B-7 (the closest fuel plate to A-3)

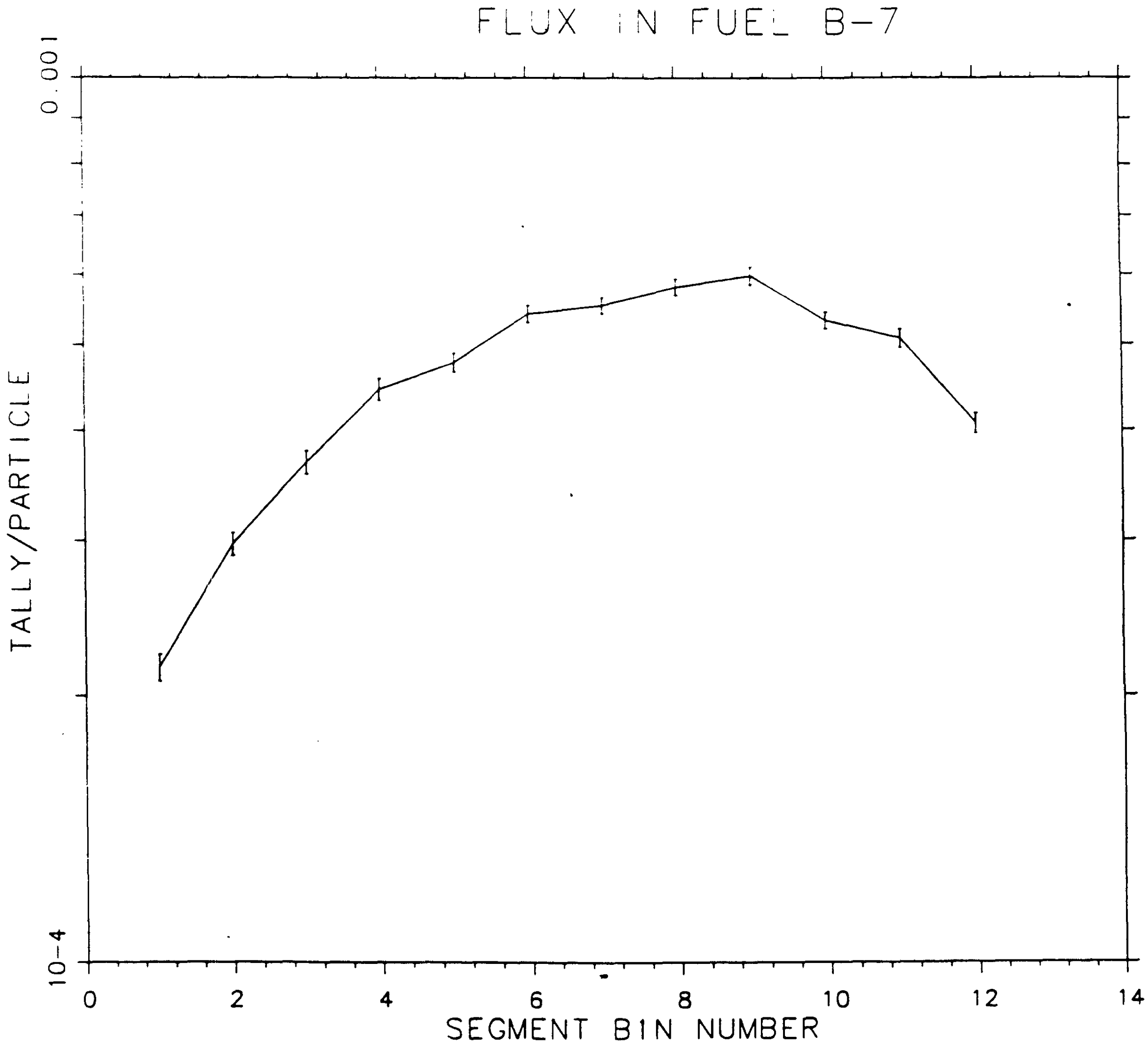


Figure 4.11 MCNP axial fast flux distribution for Plate 1 of B-7 (the closest fuel plate to A-3)

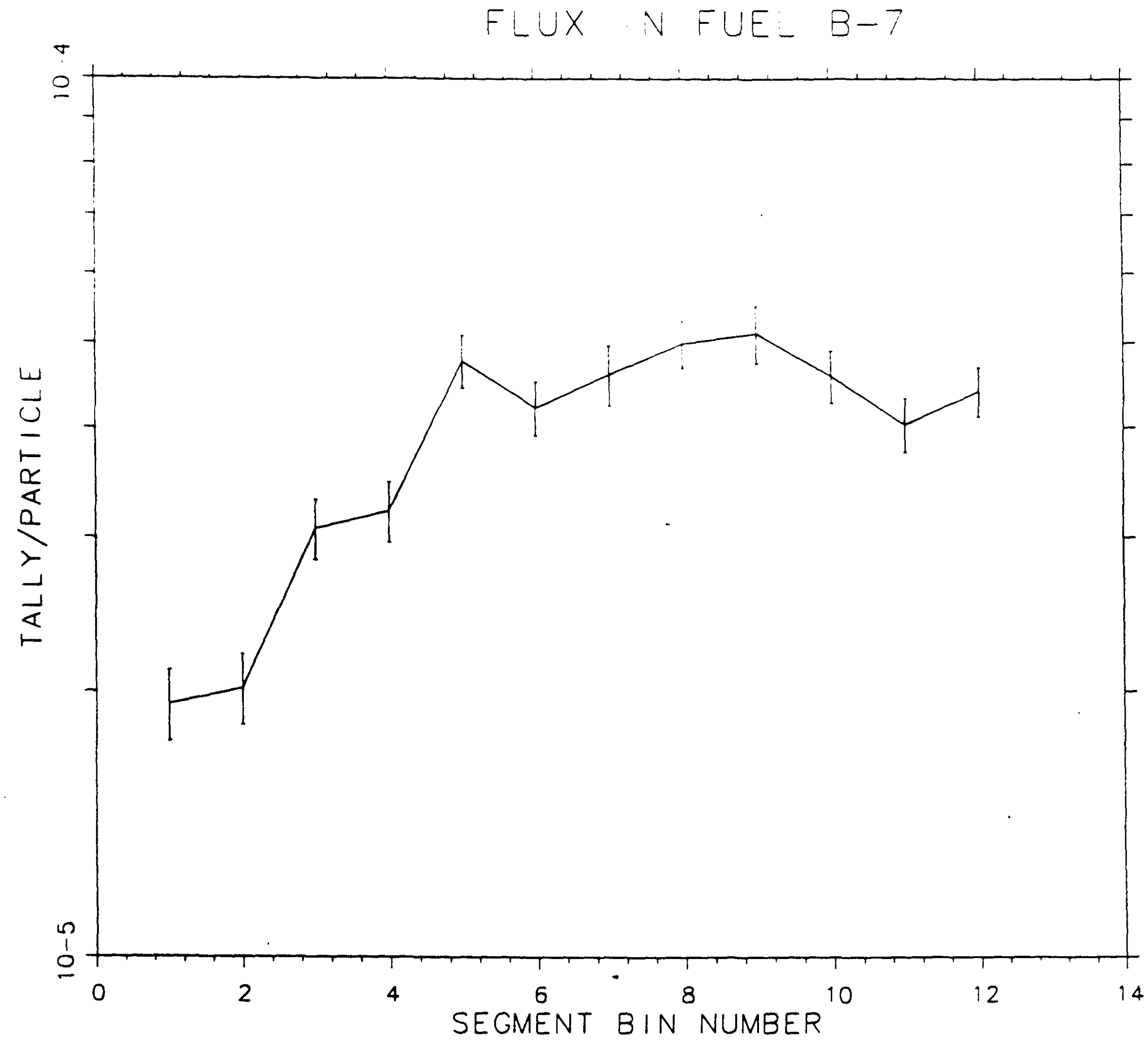


Figure 4.12 MCNP axial thermal flux distribution for Plate 15 of B-7 (the farthest fuel plate to A-3)

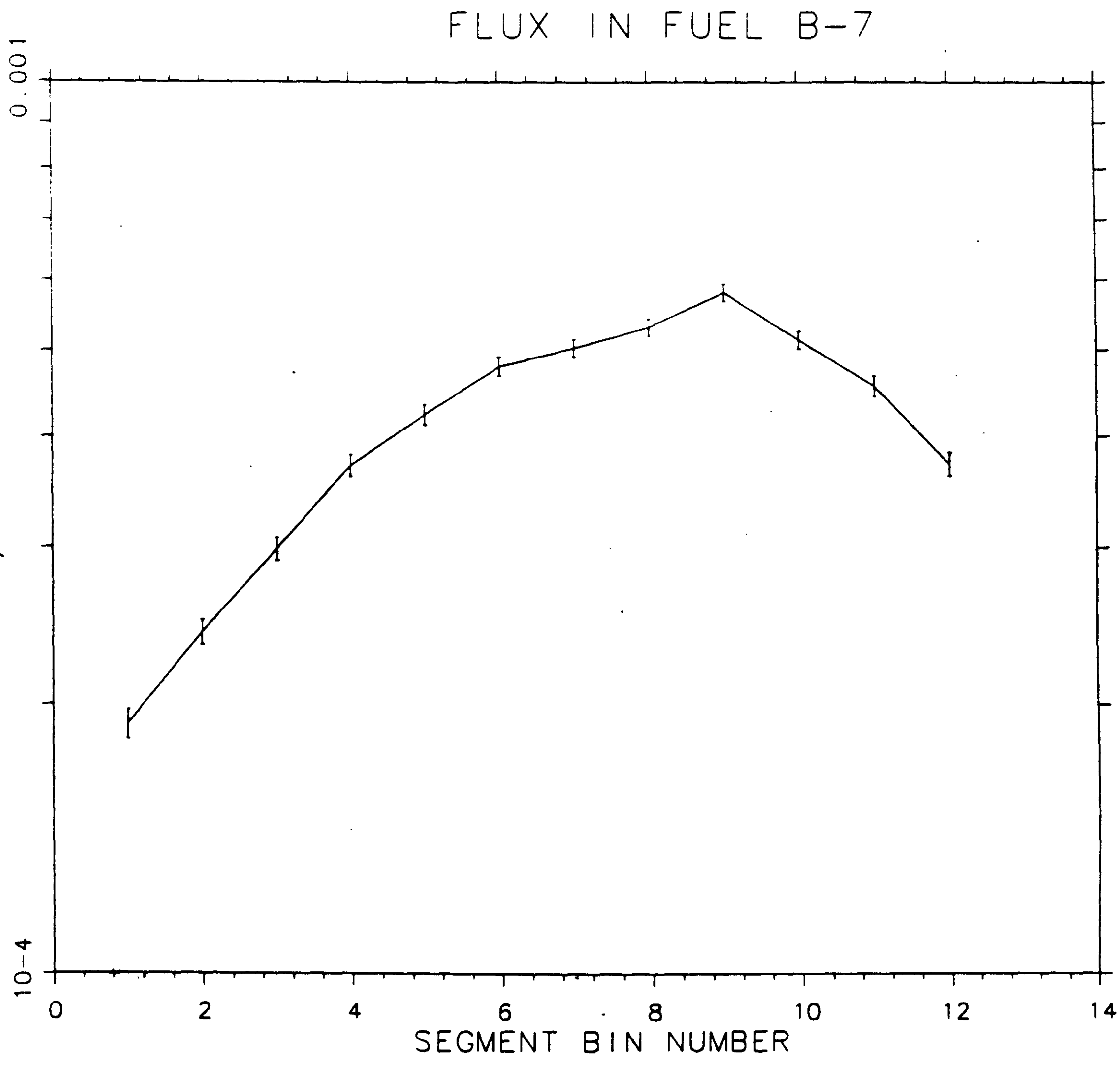


Figure 4.13 MCNP axial fast flux distribution for Plate 15 of B-7 (the farthest fuel plate to A-3)

These observations about axial flux shapes suggests that the assumption was not a good one, but it is the only path that can be followed without triangulating the entire core. On the other hand, without a triangulation, the homogenization process should work for a rhombus providing that the surface currents out of the rhombus can be obtained from the same run. For testing the homogenization scheme, a model consisted of only one fuel element (with smaller length to save from runtime) was created. With only one run surface currents, reaction rates and fluxes were tallied for one energy group and these results were processed to obtain cross sections and leakage out of the rhombus. The MCNP results and the processing program is given in Appendix E. The results of the processing program are:

Average rhombus flux : 1.34163E-02

Absorption cross section : 3.46784E-03

Total cross section : 3.75824E-01

v * sigma fission : 6.14328E-03

Fission cross section : 2.46291E-03

Neutron balance results are:

Total leakage : 2.45090E-03

Total loss : 2.49743E-03

Total source : 2.50364E-03

Therefore, the residual from these was found as:

Residual : 6.21402E-06

The ratio of the residual to total loss and total source are very low:

Residual / Total loss : 2.48817E-03

Residual / Total source : 2.48199E-03

These results are the indication of neutron balance. This shows that the procedure can satisfy neutron balance, if the complete triangulation can be achieved and surface currents can be tallied with the reaction rates in the same run.

CHAPTER 5

CONCLUSION

5.1. GENERAL EVALUATION OF THE RESULTS

In previous chapters, the homogenized cross sections, calculated for each node of triangular-z mesh QUARTZ model of MIT-II, were presented. Comments about the results and their accuracy, and about the unsatisfactory neutron balance results were made. The lack of neutron balance was discussed and some of the mystery surrounding it was removed. The present chapter summarizes these discussions.

Evidence supporting the accuracy of the cross section and node averaged flux results (at least within the limits of the procedure) can be summarized as:

- Past experience with the original model and tests at every step of the model development show that, the *MCNP model (Triangulated Model) represents MITR-II correctly (Section 2.3).*
- *The reliability of the processing software is demonstrated (Section 4.1).*
- The general behavior of both *flux and cross section distributions matches expectations (Section 4.6).*

Despite this evidence, ***nodal neutron balance could not be obtained.*** Since homogenized cross sections and fluxes were obtained from the same group of runs and same proven processing programs, the mismatch must be between them and the surface-current/surface-flux results.

There are several points in the procedure that are believed to be the reason for the mismatch:

- *The model* used *for surface flux and currents differs* in some aspects *from the model* used *for cross sections. Therefore the simulation cannot be repeated exactly (Section 4.5).*
- *For the incore portion, unless flux shapes throughout a given rhombus were flat, exact nodal balance cannot be expected.*

- *Some portions of the out of core results have unacceptably high statistical errors* that can only be fixed by increasing the MCNP simulation run time by at least a factor of 100 *(Section 4.6).*

- Some other portions of the out of core results have moderate errors (5%-10%), but the total effect of these errors and the ones from surface flux/current causes unbalanced results *(Section 4.6).*

Unfortunately the total effect of all these contributors cannot be estimated.

Some other points about the unbalance can be made:

- To repeat a simulation (MCNP run) exactly, the model, the number of histories tracked and the initial source points should be the same. Evidence that some repeated runs were not exact is that the k-effective of the run differed slightly between incore and the out of core runs and also between those and the surface current and surface flux runs. This shows that the use of the same basic model and the same initial source points does not guarantee exact repetition. On the other hand, five incore runs resulted with the same k-effective. Thus simulation can be repeated only by satisfying all of the given conditions. The sampling size (250*3000 = ~ 750000) of starting particles may not have been large enough to compensate for this lack of exact repetition, and balance may have been affected.

- Even if the lack of repetition is only a few percent for each cycle, after a small number of cycles, the simulation become totally different leading to an avalanche effect, since succeeding source points are the outcome of previous cycles.

To get rid of the lack of repetition was not possible with the process used in this thesis. The tallying jobs were done by following the only path found after a careful search and investigation of possible alternatives. Generally, the paths chosen represent the only practical solution (as far as the author and Kuo consider) within the capabilities of MCNP.

To repeat a simulation exactly requires that tallying should be made without modifying any of the cells. However it was necessary to repeat the calculation several times at least by changing the universe numbers. The obvious way to avoid this is to do the simulation only once and to tally everything from this one simulation. Unfortunately this procedure is beyond the capabilities of MCNP at present.

In the following section, computer facility requirements are estimated both to get rid of unacceptable statistical errors, and to complete this kind of MCNP run in a reasonable time.

5.2. COMPUTER FACILITY REQUIREMENTS

The comments about the facility requirements given in this section takes the SUN Sparcstation *mitrsun* as reference. Therefore requirements can be translated as the number of times current capacity.

Table 5.1 shows a summary of the data relevant to the computing resources used during and after each MCNP run. This data is used for making the estimates given in the following subsections. The runs with name *Run#** and *Vol Run* are for incore cells; *mit8c* is for the 1/3 symmetry model; *outhexv, outhxt2* and *outhl0t* are for the out of core cells.

MCNP RUN & run date	*#of cells*	*CPU time (minutes)*	*k-effective*	*OUTPT file size (MB)*	*RUNTPE file size (B)*	*MCTAL file size(B)*
Run #1 (7/7)	913	1978.25	0.99916	2.59	5392939	669872
Run #2 (7/10)	913	1979.47	0.99714	2.58	5392959	669872
Run #3 (7/15)	1210	2183.69	0.99714	5.08	6724855	1586514
Run #4 (7/19)	1210	2099.01	0.99714	5.10	6705367	1565800
Run #5 (7/23)	1210	2103.12	0.99714	5.10	6705367	1565800
Run #6 (7/26)	1012	2003.21	0.99714	3.69	5906727	1051704
Vol Run (8/2)	913	280.11	n/a	Volume run for 10 million particles		
mit8c run (8/8)	1173	3.62	n/a	100000 particle run to check geometry		
outhexv (9/4)	2706	6004.5	n/a	Volume run for 100 million particles		
outhxt2 (9/19)	2706	3196.0	0.99719	13.9	10731259	3314861
outh10t (11/2)	3341	2308.26	0.99524	6.21	9557675	350221

Table 5.1 Summary of the data relevant to the computing resources used during and after each MCNP run.

The following subsections aim to evaluate the computer resources used for this thesis project and to make the required facility estimates for an exactly triangulated model involving 600*16 triangular-z nodes.

5.2.1. Required Memory for MCNP runs

Each incore run used 2,500,000 words of memory and each one of the out of core runs used 5,000,000 words of memory. The total memory available on mitrsun is approximately 15,000,000 words, but experience indicates that, even if only 10,000,000 words of RAM are used, the system starts to create problems and this affects all functions of the system adversely. For example the system may not allow a user to login. The largest size run with approximately 4000 cells were made by Kuo, and this run tied up the machine for about a week. Since it was a 10,000,000-word-run, the upper limit of the RAM may be taken as that value.

The number of cells for the entirely triangulated model may be estimated from the number of cells of 1/3 triangulated incore model and the number of cells of the out of core models. Thus with 913 large incore cells used in the outhxt2 model and 2706 cells used for the rest of the reactor in the model for the lower four layers,

# of incore cells = (# of axial layers)* 3 * (1/3 model cells) = 12 * 3 * 1173 = 42228

# of out of core cells for top 12 layers = 12 * (out of core cells of outhxt2)

= 12 * (outhxt2 cells - 913) = 12 * (2706 - 913) = 21516

# of out of core cells for below 4 layers = 4 *(3341 - 2706) = 2540

Thus the total number of cells required becomes 66248.

The definition and run of that large job is impossible for the available machine. Thus another estimate for a model that gathers the required data with only few runs (2 or 3) by using tally segmentation was made. In this case the number of cells adds up to 3519 + 1793 + 635 = 5947, making it is a very large job by itself. As mentioned a 4000 cell run uses ~10 Mwords of RAM. Assuming linear dependence the required RAM for these 2 or 3 runs becomes around 15 Mwords, which exceeds the RAM capacity of mitrsun. The assumption in this second scenario is that tally segmentation can be done without segmenting the actual cells physically. This is the case for the cell reaction rate and flux runs, but may not work with surface flux and current runs. Methods for accomplishing such segmentations need to be investigated.

5.2.2. Relation between CPU Time and the Number of Cells in the Model

The total CPU time used during the homogenized cross section part alone was approximately 20000 minutes. Since the relation between the number of cells and the CPU time is not linear, being affected by the size of the cells, only a rough estimate for a 260 cycle run with 6000 cells can be made. The result is 8000 minutes based on taking 2.5 times the CPU time of the outhxt2 run. If statistical errors are to be decreased by a factor of 2, the number of cycles must be increased 4 times. Therefore, assuming a linear relation, the CPU time becomes 32000 minutes. As mentioned this run must be repeated at least 2 or 3 times to tally everything, since MCNP has a limit on the number of tally cards that can be used.

5.2.3. Relation between CPU Time and the Tallies in the Model

Present results and past experience suggest that tallying is not the major factor determining CPU time. Obviously it has some effect, but it is negligible compared to the effect of cell definitions.

5.2.4. Storage Space Requirement

During this project MCNP output files (OUTPT), run tracking files (RUNTPE) and tally files (MCTAL) were saved on hard disks. The total storage space for these files for the given runs in Table 5.1 is approximately 113 MB. This storage space requirement may be decreased by file compression. However, since RUNTPE files are binary files, the compression ratio is around 6/5 which is very low, compared to the other text files that have compression ratios around 5. Assuming that the storage space will be the same for a totally triangulated small number of runs, the required space is estimated as 100 MB after compression. If the RUNTPE files were removed, it would drop significantly to 50 MB, but this is not recommended since the RUNTPE files are required for possible restart runs. During the project some space was also used for processing the results. But this was minor compared to the MCNP files. Thus; 200 MB of disk space should be enough for both cross section and surface current runs.

5.3. CONTRIBUTIONS

The contributions of this thesis project can be summarized as the following:

- Although nodal balance for the results could not be obtained (indicating possible errors in nodal fluxes for the triangles), a complete set of homogenized cross section results for the triangular-z nodes were obtained, and in accord with the discussion in Section 4.6, are believed to be acceptably accurate.

- From the MCNP runs of 260 cycles of 3000 neutrons, a tremendous amount of data for the 2 energy groups was obtained. The major portions of that information are:

    i. Flux and reaction rates for every cell (pure material) in the core with 12 equal axial segments. This complete information for the MITR-II model of MCNP was obtained for the first time.

    ii. Flux and cross sections obtained for out of core triangles give valuable information about the distribution of cross sections and fluxes in that portion of the model. (The same kind of information was also obtained for surface flux and currents by Kuo)

    iii. Since all RUNTPE files were saved, statistical errors may be decreased by restarting the MCNP jobs using these files.

- The computer facility requirements were identified, and some estimates for more accurate analysis were given.
- The 1/3 symmetry fully triangulated model is a very good starting point for future research if the triangulation of incore cells is the intention. One might get a feeling about how the triangulation can be done, by looking at the cell definitions for that model. Also that model with some cell additions can be used for tallying and perhaps the recently introduced symmetry boundary condition for MCNP can be used to obtain results with many fewer number of cells.

5.4. RECOMMENDATIONS FOR THE FUTURE WORK

In the future, different approaches should be found to obtain homogenized cross sections, fluxes and surface currents. Some suggestions for these approaches are:

- The use of a smaller triangular mesh including only the D_2O reflector (the flux in graphite reflector is significantly low).
- The triangulation of incore cells with the use of the 1/3 symmetry triangulated incore model.
- The creation of a less detailed model for the MITR-II core, by lumping neighboring cells together through material homogenization.

Also options related to MCNP:

- Apply the recently introduced symmetry boundary condition,
- Make use of the newly added parallel computing capability to reduce run time.

In the future, if MCNP has options for tallying group-to-group scattering reaction rates or tallying homogenized cross sections for groups of cells directly, many inherent problems of this project will be solved automatically.

Other suggestions would be the use of a CRAY for faster runs or the use of a *dedicated* and faster computer.

To write an in-house code especially for MITR-II may not be an option. Developing a code like MCNP requires thousands of man-hours of programming and years of heavy usage testing.

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APPENDIX A

INPUT TALLY CARDS

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e0   0.625e-6 20.0
fq0       e s m
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c         FLUX TALLIES
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f4:n      48145 48149
          49020 49029 49040 49049 49050 49059 49060 49069 49080 49089 49090 49099
          49120 49129 49130 49139 49140 49149 49160 49169 49170 49179
          49200 49209 49210 49219 49220 49229 49240 49249 49250 49259
          49322 49326 49342 49346 49352 49356 49362 49366 49382 49386 49392 49396
          49422 49426 49432 49436 49442 49446 49462 49466 49472 49476
          49502 49506 49512 49516 49522 49526 49542 49546 49552 49556
          49626 49627 49646 49647 49656 49657 49666 49667 49686 49687 49696 49697
          49726 49727 49736 49737 49746 49747 49766 49767 49776 49777
          49806 49807 49816 49817 49826 49827 49846 49847 49856 49857 44403 44404
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          47622 47623 47626 47627 47652 47653 47656 47657 47662 47663 47666 47667
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          20211 20212 20213 20214 20215 20216 20217 20218 20219 20220 20221 20222
          20223 20224 20225 20226 20227 20228 20229 20230 20451 20452 20453 20454
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          20467 20468 20469 20470 20471 20472 20473 20474 20475 20476 20477 20478
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fc4       ** cells without segmentation **
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          46111 46113 46114 46117 46118 46120 46121 46122 46123 46126 46127 46128
          46201 46202 46203 46204 46205 46206 46207 46208 46209 46210
          46211 46212 46213 46214 46215 46216 46217 46218 46219 46220
          46221 46222 46223 46224 46225 46226 46227 46228 46229 46230
          46301 46305 46306 46309
          46314 46315 46318 46319
          46321 46324 46328 46329
          46402 46403 46407 46410
          46412 46413 46416 46417
          46422 46425 46426 46430
fc14      ** segmentation I ** 1(80-85),5(80-1125),12(80-1153)
fs14      204 208 212 216 220 224 228 232 236 240 244
c
f24:n  20351 20352 20353 20354 20355 20356 20357 20358 20359 20360 20361 20362 20363
          20364 20365 20366 20367 20368 20369 20370 20371 20372 20373 20374 20375
          20376 20377 20378 20379 20380
          64750 64751 64752 64753 64754 64755 64756 64775 64776 64777 64778 64784
          64785 64786 64787 64802 64803 64804 64805 64817 64818 64819 64820 64833
          64834 64852 64853 64866 64867 64887 64888 64902 64903 64918 64919 64935
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          65750 65751 65752 65753 65754 65755 65756 65775 65776 65777 65778 65784
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          67949 67950 67951 67952 67953 67954 67955 67956 67957 67958
fc24      ** segmentation I ** 1(80-85),5(80-1125),12(80-1153)
fs24      204 208 212 216 220 224 228 232 236 240 244
sd24      (10.76 10r10.06) (10.76 10r10.06) (59.17 10r 55.31)
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(248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r)  (182.31 11r)
 (226.36 11r)  (98.885 11r)  (208.94 11r)  (98.885 11r)  (226.36 11r)
 (182.31 11r) (248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r)
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(248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r)  (113.32 11r)
 (113.32 11r)    (3.06 11r)    (5.35 11r)    (5.35 11r)    (3.06 11r)
 (113.32 11r)  (113.32 11r) (248.076 11r) (248.076 11r) (248.076 11r)
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(248.076 11r)  (226.36 11r)  (182.31 11r)    (5.35 11r)    (3.06 11r)
   (3.06 11r)    (5.35 11r)  (182.31 11r)  (226.36 11r) (248.076 11r)
(248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r)
(248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r)
(248.076 11r)  (208.94 11r)  (98.885 11r)  (98.885 11r)  (208.94 11r)
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(248.076 11r) (248.076 11r)  (226.36 11r)  (98.885 11r)  (98.885 11r)
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(248.076 11r) (248.076 11r) (248.076 11r) (248.076 11r)  (182.31 11r)
   (5.35 11r)    (5.35 11r)  (182.31 11r) (248.076 11r) (248.076 11r)
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(248.076 11r) (248.076 11r) (248.076 11r)  (113.32 11r)    (3.06 11r)
   (3.06 11r)  (113.32 11r) (248.076 11r) (248.076 11r) (248.076 11r)
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f34:n     48195 48199 48115 48119 48135 48139 48155 48159 48165 48169
          88750 88751 88752 88753 88754 88755 88756
          88775 88776 88777 88778 88779 88780 88781 88782 88783 88784 88785 88786
          88787
          88802 88803 88804 88805 88806 88807 88808 88809 88810 88811 88812 88813
          88814 88815 88816 88817 88818 88819 88820
                           88833 88834 88835 88836 88837 88838 88839 88840
          88841 88842 88843 88844 88845 88846 88847 88848 88849 88850 88851 88852
          88853
          88866 88867 88868 88869 88870 88871 88872 88873 88874 88875 88876 88877
          88878 88879 88880 88881 88882 88883 88884 88885 88886 88887 88888
          88902 88903 88904 88905 88906 88907 88908 88909 88910 88911 88912 88913
          88914 88915 88916 88917 88918 88919
                                             88935 88936 88937 88938 88939 88940
          88941 88942 88943 88944 88945 88946 88947 88948 88949 88950
          89750 89751 89752 89753 89754 89755 89756
          89775 89776 89777 89778 89779 89780 89781 89782 89783 89784 89785 89786
          89787
          89802 89803 89804 89805 89806 89807 89808 89809 89810 89811 89812 89813
          89814 89815 89816 89817 89818 89819 89820
                           89833 89834 89835 89836 89837 89838 89839 89840
          89841 89842 89843 89844 89845 89846 89847 89848 89849 89850 89851 89852
          89853
          89866 89867 89868 89869 89870 89871 89872 89873 89874 89875 89876 89877
          89878 89879 89880 89881 89882 89883 89884 89885 89886 89887 89888
          89902 89903 89904 89905 89906 89907 89908 89909 89910 89911 89912 89913
          89914 89915 89916 89917 89918 89919
                                             89935 89936 89937 89938 89939 89940
          89941 89942 89943 89944 89945 89946 89947 89948 89949 89950
fc34      ** segmentation II ** 2(80-1120),15(80-890),17(80-892)
fs34      204 208 212 216
sd34      (2.81 3r 1.4) (2.81 3r 1.4) (1.94 3r 0.97) (1.94 3r 0.97)
          (1.415 3r 0.326) (1.415 3r 0.326) (2.83 3r 1.41) (2.83 3r 1.41)
          (3.0 3r 1.494) (3.0 3r 1.494)
          (30.26 3r 2.761) (9.26 3r 0.84) (115.2 3r 10.52) (22.18 3r2.01)
          (115.2 3r10.52) (9.26 3r 0.84) (30.26 3r 2.761) (95.16 3r8.67)
          (95.16 3r 8.67) (243.21 3r 22.2) (239.63 3r21.87) (248.075 3r 22.63)
          (248.075 3r 22.63) (248.075 3r 22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (239.63 3r 21.87) (243.21 3r 22.2) (95.16 3r 8.67) (95.16
          3r 8.67) (9.26 3r 0.84) (30.26 3r2.761) (239.63 3r 21.87)
          (243.21 3r 22.2)   (248.075 3r 22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r 22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r 22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r 22.63) (248.075 3r22.63)
          (243.21 3r 22.2) (239.63 3r21.87) (30.26 3r2.761) (9.26 3r 0.84)
          (22.18 3r 2.01) (115.2 3r 10.52)       (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r 22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r 22.63) (248.075 3r22.63)
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          (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (115.2 3r 10.52) (22.18 3r 2.01) (9.26 3r 0.84)
          (115.2 3r10.52)(248.075 3r22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (205.85 3r 18.79) (205.85 3r 18.79) (40.497 3r 3.692)
          (140.5 3r12.8) (40.497 3r3.692) (205.85 3r 18.79) (205.85 3r 18.79)
          (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
          (115.2 3r10.52) (9.26 3r 0.84) (30.26 3r 2.761) (239.63 3r 21.87)
          (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r22.63)
          (140.5 3r12.8) (40.497 3r3.692)  (40.497 3r 3.692) (140.5 3r 12.8)
          (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
          (248.075 3r 22.63) (248.075 3r22.63)
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           (239.63 3r 21.87)
           (30.26 3r 2.761) (95.16 3r8.67) (243.21 3r 22.2)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (205.85 3r 18.79) (40.497 3r 3.692)
           (40.497 3r3.692) (205.85 3r 18.79)(248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (243.21 3r 22.2) (95.16 3r8.67)
           (30.26 3r 2.761) (9.26 3r 0.84) (115.2 3r 10.52) (22.18 3r 2.01)
           (115.2 3r10.52) (9.26 3r 0.84) (30.26 3r 2.761) (95.16 3r 8.67)
           (95.16 3r 8.67) (243.21 3r 22.2) (239.63 3r 21.87) (248.075 3r 22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (239.63 3r 21.87) (243.21 3r 22.2) (95.16 3r 8.67)
           (95.16 3r 8.67) (9.26 3r 0.84) (30.26 3r2.761) (239.63 3r 21.87)
           (243.21 3r 22.2)(248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (243.21 3r 22.2) (239.63 3r 21.87) (30.26 3r 2.761) (9.26 3r 0.84)
           (22.18 3r 2.01) (115.2 3r10.52)(248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
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           (248.075 3r 22.63) (115.2 3r 10.52) (22.18 3r 2.01) (9.26 3r 0.84)
           (115.2 3r10.52)(248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (205.85 3r 18.79) (205.85 3r 18.79) (40.497 3r 3.692)
           (140.5 3r12.8) (40.497 3r3.692) (205.85 3r 18.79) (205.85 3r 18.79)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (115.2 3r10.52) (9.26 3r 0.84) (30.26 3r 2.761) (239.63 3r 21.87)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63)
           (140.5 3r12.8) (40.497 3r3.692)  (40.497 3r 3.692) (140.5 3r 12.8)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63)
           (239.63 3r 21.87)
           (30.26 3r 2.761) (95.16 3r8.67) (243.21 3r 22.2)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (248.075 3r 22.63) (205.85 3r 18.79) (40.497 3r 3.692)
           (40.497 3r3.692) (205.85 3r 18.79)(248.075 3r22.63)
           (248.075 3r 22.63) (248.075 3r22.63) (248.075 3r22.63)
           (243.21 3r 22.2) (95.16 3r8.67)
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f44:n  48280 48289 48384 48385 48482 48486 48582 48581 48686 48687 49010 49019
          49270 49279
          49312 49316
          49572 49576
          49616 49617
          49876 49877
          47314 47315 47318 47319
          47412 47418 47419 47410
          47511 47514 47515 47516
          47612 47613 47616 47617
          47711 47712 47713 47719
          47815 47816 47817 47810
fc44      ** segmentation III ** 6(80-1147),19(80-1147),20(80-5237)
fs44      204 208 212 216 220 224 228 232
sd44      (9.0 7r9.7) (9.0 7r 9.7) (11.999 8r) (11.999 8r)
          (9.0 7r9.7) (9.0 7r 9.7) (11.999 8r) (11.999 8r)
          (9.0 7r9.7) (9.0 7r 9.7)
          (1.357 7r0.743) (1.357 7r 0.743) (1.2186 7r 0.7798) (1.2186 7r 0.7798)
          (1.357 7r0.743) (1.357 7r 0.743) (1.2186 7r 0.7798) (1.2186 7r 0.7798)
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          (1.357 7r0.743) (1.357 7r 0.743) (1.2186 7r 0.7798) (1.2186 7r 0.7798)
          (7.055 7r7.056) (17.31 8r) (7.055 7r 7.056) (17.31 8r)
          (7.055 7r7.056) (7.055 7r 7.056) (17.31 8r) (17.31 8r)
          (7.055 7r7.056) (17.31 8r) (17.31 8r) (7.055 7r 7.056)
          (17.31 8r) (7.055 7r 7.056) (17.31 8r) (7.055 7r 7.056) (17.31 8r)
          (17.31 8r) (7.055 7r 7.056) (7.055 7r 7.056) (7.055 7r7.056) (17.31 8r)
          (17.31 8r) (7.055 7r 7.056)
c
f54:n  20151 20152 20153 20154 20155 20156 20157 20158 20159 20160 20161 20162 20163
          20164 20165 20166 20167 20168 20169 20170 20171 20172 20173 20174 20175
          20176 20177 20178 20179 20180
          68750 68751 68752 68753 68754 68755 68756
          68775 68776 68777 68778 68779 68780 68781 68782 68783 68784 68785 68786
          68787
          68802 68803 68804 68805 68806 68807 68808 68809 68810 68811 68812 68813
          68814 68815 68816 68817 68818 68819 68820
                            68833 68834 68835 68836 68837 68838 68839 68840
          68841 68842 68843 68844 68845 68846 68847 68848 68849 68850 68851 68852
          68853
          68866 68867 68868 68869 68870 68871 68872 68873 68874 68875 68876 68877
          68878 68879 68880 68881 68882 68883 68884 68885 68886 68887 68888
          68902 68903 68904 68905 68906 68907 68908 68909 68910 68911 68912 68913
          68914 68915 68916 68917 68918 68919
                                                68935 68936 68937 68938 68939 68940
          68941 68942 68943 68944 68945 68946 68947 68948 68949 68950
          69750 69751 69752 69753 69754 69755 69756
          69775 69776 69777 69778 69779 69780 69781 69782 69783 69784 69785 69786
          69787
          69802 69803 69804 69805 69806 69807 69808 69809 69810 69811 69812 69813
          69814 69815 69816 69817 69818 69819 69820
                            69833 69834 69835 69836 69837 69838 69839 69840
          69841 69842 69843 69844 69845 69846 69847 69848 69849 69850 69851 69852
          69853
          69866 69867 69868 69869 69870 69871 69872 69873 69874 69875 69876 69877
          69878 69879 69880 69881 69882 69883 69884 69885 69886 69887 69888
          69902 69903 69904 69905 69906 69907 69908 69909 69910 69911 69912 69913
          69914 69915 69916 69917 69918 69919
                                                69935 69936 69937 69938 69939 69940
          69941 69942 69943 69944 69945 69946 69947 69948 69949 69950
fc54      ** segmentation IV ** 4(1120-1125)
fs54      220 224 228 232 236 240 244
sd54      (14.9716.47 5r15.40) (14.97 16.47 5r15.40) (11.69 12.86 5r12.02)
          (20.3122.35 5r20.89) (11.69 12.86 5r12.02) (14.97 16.47 5r15.40)
          (14.9716.47 5r15.40) (20.31 22.35 5r20.89) (11.69 12.86 5r12.02)
          (11.6912.86 5r12.02) (20.31 22.35 5r20.89) (14.97 16.47 5r15.40)
          (11.6912.86 5r12.02) (11.69 12.86 5r12.02) (14.97 16.47 5r15.40)
          (14.9716.47 5r15.40) (11.69 12.86 5r12.02) (11.69 12.86 5r12.02)
          (14.9716.47 5r15.40) (20.31 22.35 5r20.89) (11.69 12.86 5r12.02)
          (11.6912.86 5r12.02) (20.31 22.35 5r 20.89) (14.9716.47 5r 15.40)
          (14.9716.47 5r15.40) (11.69 12.86 5r 12.02) (20.3122.35 5r 20.89)
          (11.6912.86 5r12.02) (14.97 16.47 5r 15.40) (14.9716.47 5r 15.40)
          (27.68 30.46 5r 28.48) (8.47 9.32 5r 8.71) (104.73115.24 5r 107.73)
          (20.0922.1 5r 20.66) (104.73 115.24 5r 107.73) (8.479.32 5r 8.71)
          (27.6830.46 5r28.48) (86.82 95.53 5r 89.3) (86.82 95.53 5r 89.3)
          (220.73 242.89 5r 227.05) (217.3239.12 5r223.52)
          (225.45 248.08 5r 231.9)
          (225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
          (225.45 248.08 5r 231.9)
          (225.45 248.08 5r 231.9) (217.3 239.12 5r 223.52)
          (220.73 242.89 5r 227.05)
          (86.8295.53 5r89.3) (86.82 95.53 5r 89.3) (8.47 9.32 5r 8.71)
          (27.6830.46 5r28.48) (217.3 239.12 5r 223.52)
          (220.73 242.89 5r 227.05)
          (225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
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(225.45 248.08 5r 231.9)
(220.73 242.89 5r 227.05) (217.3239.12 5r223.52)
(27.6830.46 5r28.48) .
(8.47 9.32 5r 8.71) (20.0922.1 5r 20.66) (104.73 115.24 5r 107.73)
(225.45 248.08 5r 231.9)
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(104.73 115.24 5r 107.73) (20.09 22.1 5r 20.66) (8.479.32 5r 8.71)
(104.73 115.24 5r 107.73)
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(225.45 248.08 5r 231.9)
(171.14 188.32 5r 176.04) (171.14 188.32 5r 176.04)
(25.1327.65 5r25.85)
(107.99 118.82 5r 111.08) (25.13 27.65 5r 25.85)
(171.14 188.32 5r 176.04)
(171.14 188.32 5r 176.04)
(225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
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(225.45 248.08 5r 231.9)
(104.73 115.24 5r 107.73) (8.47 9.32 5r 8.71) (27.6830.46 5r 28.48)
(217.3 239.12 5r 223.52)
(225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
(225.45 248.08 5r 231.9)
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(107.99 118.82 5r 111.08) (25.13 27.65 5r 25.85) (25.1327.65 5r25.85)
(107.99 118.82 5r 111.08)
(225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
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(225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
(217.3 239.12 5r 223.52)
(27.6830.46 5r28.48) (86.82 95.53 5r 89.3)
(220.73 242.89 5r 227.05)
(225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
(225.45 248.08 5r 231.9)
(225.45 248.08 5r 231.9) (171.14188.32 5r176.04)
(25.1327.65 5r25.85)
(25.1327.65 5r25.85) (171.14 188.32 5r 176.04)
(225.45 248.08 5r 231.9)
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(225.45 248.08 5r 231.9)
(220.73 242.89 5r 227.05) (86.82 95.53 5r 89.3)
(27.6830.46 5r28.48) (8.47 9.32 5r 8.71) (104.73 115.24 5r 107.73)
(20.0922.1 5r 20.66) (104.73 115.24 5r 107.73) (8.47 9.32 5r 8.71)
(27.6830.46 5r28.48) (86.82 95.53 5r 89.3) (86.82 95.53 5r 89.3)
(220.73 242.89 5r 227.05) (217.3239.12 5r223.52)
(225.45 248.08 5r 231.9)
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(86.8295.53 5r89.3) (86.82 95.53 5r 89.3) (8.47 9.32 5r 8.71)
(27.6830.46 5r28.48) (217.3 239.12 5r 223.52)
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(225.45 248.08 5r 231.9)
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(27.6830.46 5r28.48)
(8.47 9.32 5r 8.71) (20.0922.1 5r 20.66) (104.73 115.24 5r 107.73)
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(225.45 248.08 5r 231.9)
(104.73 115.24 5r 107.73) (20.09 22.1 5r 20.66) (8.47 9.32 5r 8.71)
(104.73 115.24 5r 107.73)
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(171.14 188.32 5r 176.04) (171.14 188.32 5r 176.04)
(25.1327.65 5r25.85)
(107.99 118.82 5r 111.08) (25.13 27.65 5r 25.85)
(171.14 188.32 5r 176.04)
(171.14 188.32 5r 176.04)
(225.45 248.08 5r 231.9) (225.45248.08 5r231.9)
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(104.73 115.24 5r 107.73) (8.47 9.32 5r 8.71) (27.68 30.46 5r 28.48)
(217.3 239.12 5r 223.52)
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(107.99 118.82 5r 111.08) (25.13 27.65 5r 25.85) (25.1327.65 5r25.85)
(107.99 118.82 5r 111.08)
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(225.45248.08 5r231.9) (225.45 248.08 5r231.9)
(217.3 239.12 5r 223.52)
          (27.68 30.46 5r 28.48) (86.82 95.53 5r 89.3)
(220.73242.89 5r227.05)
(225.45248.08 5r231.9) (225.45 248.08 5r231.9)
(225.45248.08 5r231.9)
(225.45248.08 5r231.9) (171.14 188.32 5r176.04)
(25.13 27.65 5r 25.85)
(25.13 27.65 5r 25.85) (171.14188.32 5r 176.04)
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(225.45248.08 5r231.9)
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         (220.73242.89 5r227.05) (86.82 95.53 5r 89.3)
c
f64:n  46503 46504 46505 46508 46509 46510
         46511 46513 46514 46517 46518 46520 46521 46522 46523 46526 46527 46528
         46803 46804 46805 46808 46809 46810 46811 46813 46814 46817 46818 46820
         46821 46822 46823 46826 46827 46828 47103 47104 47105 47108 47109 47110
         47111 47113 47114 47117 47118 47120 47121 47122 47123 47126 47127 47128
fc64     ** segmentation V ** 10(80-872)
fs64     204 208 212 216 220
c
f74:n  46603 46604 46605 46608 46609 46610 46611 46613 46614 46617 46618 46620 46621
         46622 46623 46626 46627 46628
fc74     ** segmentation VI ** 11(872-1153)
fs74     224 228 232 236 240 244
sd74     (1.03 8.35 26.19 27.12 2r 20.3) (0. 1r 7.3629.926 2r 7.43)
         (1.03 8.35 26.19 27.12 2r 20.3) (0. 1r 7.3629.926 2r 7.43)
         (1.03 8.35 26.19 27.12 2r 20.3) (1.03 8.35 26.19 27.12 2r 20.3)
         (0. 1r 7.362 9.926 2r 7.43) (1.03 8.35 26.19 27.12 2r 20.3)
         (1.03 8.35 26.19 27.12 2r 20.3) (1.03 8.35 26.19 27.12 2r 20.3)
         (1.03 8.35 26.19 27.12 2r 20.3) (0. 1r 7.3629.926 2r 7.43)
         (1.03 8.35 26.19 27.12 2r 20.3) (1.03 8.35 26.19 27.12 2r 20.3)
         (0. 1r 7.362 9.926 2r 7.43) (1.03 8.35 26.19 27.12 2r 20.3)
         (0. 1r 7.362 9.926 2r 7.43) (1.03 8.35 26.19 27.12 2r 20.3)
c
f84:n  44103 44104 44105 44108 44109 44110 44111 44113 44114 44117 44118 44120 44121
         44122 44123 44126 44127 44128
         45101 45102 45103 45104 45105 45106 45107 45108 45109 45110 45111 45112
         45113 45114 45115 45116 45117 45118 45119 45120 45121 45122 45123 45124
         45125 45126 45127 45128 45129 45130
fc84     ** segmentation VII ** 13(80-1150)
fs84     204 208 212 216 220 224 228 232 236
c
f94:n  48105 48109
fc94     ** segmentation VIII ** 16(890-1147)
fs94     220 224 228 232
sd94     (6.02 12.0 3r) (6.02 12.0 3r)
c
f104:n 44203 44204 44205 44208 44209 44210 44211 44213 44214 44217 44218 44220 44221
         44222 44223 44226 44227 44228
         44303 44305 44309 44310 44313 44314 44317
         44318 44321 44322 44326 44328
         45201 45202 45203 45204 45205 45206 45207 45208 45209 45210 45211 45212
         45213 45214 45215 45216 45217 45218 45219 45220 45221 45222 45223 45224
         45225 45226 45227 45228 45229 45230 45301 45302 45303 45304 45305 45306
         45307 45308 45309 45310 45311 45312 45313 45314 45315 45316 45317 45318
         45319 45320 45321 45322 45323 45324 45325 45326 45327 45328 45329 45330
         47334 47335 47338 47339 47344 47345 47348 47349
         47432 47438 47439 47430 47442 47448 47449 47440
         47531 47534 47535 47536 47541 47544 47545 47546 47632 47633 47636 47637
         47642 47643 47646 47647 47731 47732 47733 47739 47741 47742 47743 47749
         47835 47836 47837 47830 47845 47846 47847 47840
fc104  ** segmentation X ** 8(1150-1125)
fs104  240 244
sd104 (38.2 82.39 77.02) (4.55 9.82 9.18) (38.282.3977.02) (4.55 9.82 9.18)
        (38.2 82.39 77.02) (38.282.39 77.02) (4.55 9.829.18) (38.282.39 77.02)
        (38.2 82.39 77.02) (38.282.39 77.02) (38.2 82.39 77.02) (4.55 9.82 9.18)
        (38.2 82.39 77.02) (38.282.39 77.02) (4.55 9.829.18) (38.282.39 77.02)
        (4.559.829.18) (38.2 82.39 77.02)
        (0.130.280.27) (0.13 0.280.27) (0.13 0.28 0.27) (0.13 0.280.27)
        (0.130.280.27) (0.13 0.280.27) (0.13 0.28 0.27) (0.13 0.280.27)
        (0.130.280.27) (0.13 0.280.27) (0.13 0.28 0.27) (0.13 0.280.27)
        (0.290.620.58) (0.29 0.620.58) (8.03 17.32 16.18) (5.15 11.11 10.38)
        (8.03 17.32 16.18) (0.29 0.62 0.58) (0.29 0.62 0.58) (5.15 11.11 10.38)
        (8.03 17.32 16.18) (8.0317.32 16.18) (5.15 11.11 10.38) (0.29 0.62 0.58)
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         (8.03 17.32 16.18) (8.0317.32 16.18) (0.29 0.620.58) (0.29 0.62 0.58)
         (8.03 17.32 16.18) (8.0317.32 16.18) (0.29 0.620.58) (5.1511.11 10.38)
         (8.03 17.32 16.18) (8.0317.32 16.18) (5.15 11.11 10.38) (0.29 0.62 0.58)
         (0.290.620.58) (8.03 17.32 16.18) (5.1511.1110.38) (8.0317.32 16.18)
         (0.290.620.58) (0.29 0.620.58)
         (0.440.950.88) (0.44 0.950.88) (2.2 4.74 4.43) (0.071 0.153 0.143)
         (2.2 4.74 4.43) (0.44 0.95 0.88) (0.44 0.95 0.88) (0.071 0.153 0.143)
         (2.2 4.74 4.43) (2.2 4.744.43) (0.071 0.153 0.143) (0.44 0.95 0.88)
         (2.2 4.74 4.43) (2.2 4.744.43) (0.440.950.88) (0.440.95 0.88)
         (2.2 4.74 4.43) (2.2 4.744.43) (0.440.950.88) (0.071 0.1530.143)
         (2.2 4.74 4.43) (2.2 4.744.43) (0.071 0.153 0.143) (0.44 0.95 0.88)
         (0.440.950.88) (2.2 4.74 4.43) (0.071 0.153 0.143) (2.2 4.74 4.43)
         (0.440.950.88) (0.44 0.950.88)
         (3.11 6.71 6.27) (6.55 14.1213.19) (3.116.71 6.27) (6.55 14.1213.19)
         (0.15 0.33 0.31)  (7.2315.614.58) (0.150.33 0.31)  (7.2315.614.58)
         (3.11 6.71 6.27) (3.11 6.71 6.27) (6.55 14.12 13.19) (6.55 14.1213.19)
         (0.15 0.33 0.31) (0.15 0.33 0.31)  (7.2315.6 14.58)  (7.2315.614.58)
         (3.11 6.71 6.27) (6.55 14.1213.19) (6.55 14.12 13.19) (3.116.716.27)
         (0.15 0.33 0.31)  (7.2315.614.58)  (7.23 15.6 14.58) (0.150.330.31)
         (6.55 14.12 13.19) (3.116.716.27) (6.55 14.12 13.19) (3.116.716.27)
         (7.23 15.6 14.58) (0.15 0.33 0.31)  (7.23 15.614.58)  (0.150.330.31)
         (6.55 14.12 13.19) (6.55 14.12 13.19) (3.11 6.71 6.27) (3.116.716.27)
         (7.23 15.6 14.58)(7.23 15.6 14.58) (0.15 0.33 0.31) (0.150.330.31)
         (3.11 6.71 6.27) (6.55 14.1213.19) (6.55 14.12 13.19) (3.116.716.27)
         (0.15 0.33 0.31)  (7.2315.614.58)  (7.23 15.6 14.58) (0.150.330.31)
c
f114:n 49300 49309
         49602 49606
         49906 49907
          46703 46704 46705 46708 46709 46710 46711 46713 46714 46717 46718 46720
          46721 46722 46723 46726 46727 46728 46903 46904 46905 46908 46909 46910
          46911 46913 46914 46917 46918 46920 46921 46922 46923 46926 46927 46928
          47203 47204 47205 47208 47209 47210 47211 47213 47214 47217 47218 47220
          47221 47222 47223 47226 47227 47228
fc114  ** segmentation XI ** 9(872-860),45(5245-5232) fs114  224 228
sd114  (0.076 0.424 0.223) (0.0760.4240.223)
         (0.076 0.424 0.223) (0.0760.4240.223)
         (0.076 0.424 0.223) (0.0760.4240.223)
         (2.53.580.27) (1.14 1.650.27) (2.5 3.58 0.27) (1.14 1.65 0.27)
         (2.53.580.27) (2.5 3.58 0.27) (1.14 1.65 0.27) (2.53.58 0.27)
         (2.53.580.27) (2.5 3.58 0.27) (2.53.580.27) (1.141.65 0.27)
         (2.53.580.27) (2.5 3.58 0.27) (1.14 1.65 0.27) (2.53.58 0.27)
         (1.14 1.65 0.27) (2.5 3.580.27)
         (6.02 8.64 0.8) (3.18 4.570.74) (6.02 8.64 0.8) (3.18 4.57 0.74)
          (6.028.640.8) (6.028.640.8) (3.184.570.74) (6.02 8.64 0.8)
          (6.028.640.8) (6.028.640.8) (6.028.640.8) (3.18 4.570.74)
          (6.028.640.8) (6.028.640.8) (3.184.570.74) (6.02 8.64 0.8)
          (3.184.570.74) (6.02 8.64 0.8)
          (6.459.250.5) (2.633.770.6) (6.459.250.5) (2.63 3.770.6)
          (6.459.250.5) (6.459.250.5) (2.633.770.6) (6.45 9.250.5)
          (6.459.250.5) (6.459.250.5) (6.459.250.5) (2.63 3.770.6)
          (6.459.250.5) (6.459.250.5) (2.633.770.6) (6.45 9.250.5)
          (2.633.770.6) (6.459.250.5)
c
f124:n 49030 49039
          49332 49336
          49636 49637
          49070 49079 49100 49109
          49372 49376 49402 49406
          49676 49677 49706 49707
fc124  ** segmentation XII ** 22(5233-5234),26(5240-5241) fs124  232
sd124  (0.1043 0.0904) (0.10430.0904)
          (0.1043 0.0904) (0.10430.0904)
          (0.1043 0.0904) (0.10430.0904)
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          (1.11e-4 9.6e-5) (1.11e-4 9.6e-5) (0.09 0.078) (0.09 0.078) (1.11e-4 9.6e-5)
          (1.11e-4 9.6e-5) (0.09 0.078) (0.09 0.078) (1.11e-4 9.6e-5) (1.11e-4 9.6e-5)
          (0.09 0.078) (0.09 0.078)
c
f134:n 49110 49119 49150 49159 49180 49189
          49412 49416 49452 49456 49482 49486 49716 49717 49756 49757 49786 49787
fc134  ** segmentation XIII ** 29(5243-5244),33(5250-5251)
fs134  220
sd134  (0.032 0.163) (0.032 0.163) (3.39e-5 1.73e-4) (3.39e-5 1.73e-4) (0.0275 0.1405)
          (0.02750.1405)
          (0.032 0.163) (0.032 0.163) (3.39e-5 1.73e-4) (3.39e-5 1.73e-4) (0.0275
          0.1405) (0.02750.1405)
          (0.032 0.163) (0.032 0.163) (3.39e-5 1.73e-4) (3.39e-5 1.73e-4) (0.0275
          0.1405) (0.02750.1405)
c
f144:n 49190 49199 49230 49239 49260 49269
          49492 49496 49532 49536 49562 49566 49796 49797 49836 49837 49866 49867
fc144  ** segmentation XV ** 36(5253-5254),40(5260-5261)
fs144  212
sd144  (0.187 7.7e-3) (0.1877.7e-3) (1.987e-4 8.26e-6) (1.987e-48.26e-6)
          (0.161 0.007) (0.161 0.007)
          (0.187 7.7e-3) (0.1877.7e-3) (1.987e-4 8.26e-6) (1.987e-48.26e-6)
          (0.161 0.007) (0.161 0.007)
          (0.187 7.7e-3) (0.1877.7e-3) (1.987e-4 8.26e-6) (1.987e-48.26e-6)
          (0.161 0.007) (0.161 0.007)
c
f154:n 49280 49289
          49582 49586
          49886 49887
fc154  ** segmentation XVI ** 43(80-5252)
fs154  204 208
sd154  (0.424 1r 0.069) (0.424 1r0.069)
          (0.424 1r 0.069) (0.424 1r0.069)
          (0.424 1r 0.069) (0.424 1r0.069)
c
f164:n 49290 49299
          49592 49596
          49896 49897
fc164  ** segmentation XVII ** 44(5255-5242)
fs164  216
sd164  (0.3649 0.3578) (0.36490.3578)
          (0.3649 0.3578) (0.36490.3578)
          (0.3649 0.3578) (0.36490.3578)
```

APPENDIX B

PROCESSING PROGRAMS

The following program and file listings are given in this Appendix :

xcg01n.f : incore flux, tally processing program

xcg1n.f : incore homogenized cross section processing program

prohx1n.f : out of core flux and cross section processing program

prohx2n.f : version of prohx1n.f for the cells below surface 85

sibel.f : the program written to prove accuracy of processing programs

rslts : the results of sibel.f

Program : xcg01n.f

```
        character*8 kod,ver
        character*19 probid
        character*79 title
        character*4 ntal,vals
        character*5 tally,kcode
        character*2 f,d,u,s,m,c,e,t
        character*3 tfc
        character*75 fcomment
c
        integer ind1,lupf1,indf,nff
        integer rnr,pbname,ptype,celln,tallyn
        real cellv,xdata,trf
        dimension ebin(3)
        dimension celln(62),tallyn(35),xkeff(3)
        dimension jtf(8)
c
        common/datv/cellv(3659),ind1(3659,5),lupf1(2),indf
        common/datc/nff(35)
        common/datx/xdata(2,35,3,5,14,62)
        common/rslt/trf(2,24,12,3)
c
c       xdata(2,35, 3, 5,14,70)
c             (2,nt,ne,nm,ns,nf)
c           nt  : tally no.
c           ne  : energy bin no.
c           nm  : multiplier no.
c           ns  : segment no.
c           nf  : cell no.
c       trf(2,24,12, 3, 5)
c           (i,ni,ns,ne,nm)
c           ni  : triangle no
c
c
        open(unit=13,file='mcx1',form='formatted',status='old')
        open(unit=19,file='vol7',form='formatted',status='old')
        open(unit=11,file='xc1',form='formatted',status='unknown')
        open(unit=20,file='trr1',form='formatted',status='unknown')
        open(unit=22,file='trf1',form='formatted',status='unknown')
c
c Start to read cell volume data from 'vol' file
c
        ind=0
        do 101 i=1,3659
        read(19,103)(ind1(i,k),k=1,2),cellv(i),(ind1(i,j),j=3,5)
 103         format(i6,x,i6,1pe13.5,3(x,i2))
 101  continue
        read(13,501)kod,ver,probid,knod,nps,rnr
 501  format(2a8,a19,i5,i11,i15)
        write(11,5011)kod,ver,probid,knod,nps,rnr
 5011 format('Tally file:'/,'mcx1',2x,2a8,a19,i5,i11,i15)
c
        read(13,502)title
 502  format(1x,a79)
c
        read(13,503)ntal,nt
 503  format(a4,i6)
c
        read(13,600)(tallyn(i),i=1,nt)
 600  format(16i5)
c
c ***** Start tally loop
c
```

```
      do 100 n=1,nt
        read(13,504)tally,pbname,ptype
 504    format(a5,2i5)
        read(13,505)fcomment
 505  format(5x,a75)
        read(13,506)f,nff(n)
        nf=nff(n)
 506  format(a2,i8)
        read(13,507)(celln(i),i=1,nf)
 507  format(11i7)
        read(13,506)d,idumm
        read(13,506)u,idumm
        read(13,506)s,ns
        read(13,506)m,nm
        if(nm.eq.0)nm=1
        read(13,506)c,nc
        if(nc.eq.0)nc=1
 508  format(a2,i8,i4)
 509  format(1p6e13.5)
        read(13,506)e,ne
        read(13,509)(ebin(i),i=1,ne) read(13,506)t,idumm
        read(13,510)vals
 510  format(a4)
c
c Read list of tally/error data pairs
c
        read(13,511)(((((xdata(it,n,ie,im,is,ic),it=1,2),
     x ie=1,ne),im=1,nm),is=1,ns),ic=1,nf)
 511  format(4(1pe13.5,0pf7.4))
 1025      format(i3,x,i5,1p10e10.3)
c
c Read tally fluctuation data
c
        read(13,512)tfc,nfc,(jtf(i),i=1,8)
 512  format(a3,i5,8i8)
        do 150 j=1,nfc
          read(13,513)nps,xtally,xerr,fom
 513    format(i11,1p3e13.5)
 150  continue
c
c ***** End of tally loop
 100 continue
c
c Read kcode data
c
      read(13,3000,end=999)kcode,ncycle
 3000 format(a5,i5)
c
      do 200 ncy=1,ncycle
      read(13,3010,end=998)(xkeff(k),k=1,3),dummy1,dummy2
 200 continue
 3010 format(1p5e12.5)
c
 998 continue
c
 999 continue
c
c Processing xdata and frac and cellv to get triangle xsections c
c    call parameters (imat,llw,lup,it,itn,calln)
c
c    imat: material number to fetch from cell volume array
c    llw : starting line number cell volume to be found the array
c    lup : final line number to find cell volume
c    it  : order of tally in mcx file no. iu
```

```
c     itn : problem number of tally(only used in if statements)
c     calln: variable to count no of calls from main
c
         indf=1
          call flux(4,1,152,3,24,1)
          call flux(1,1,152,4,34,2)
          call flux(2,1,152,5,44,3)
          call flux(0,153,511,1,4,4)
          call flux(5,155,514,2,14,5)
          call flux(4,292,510,12,124,7)
          call flux(1,292,510,13,134,8)
          call flux(2,292,510,14,144,9)
          call flux(7,2,0,18,194,10)
         do ilk=1,2
         write(22,556)(((trf(ilk,i,j,k),k=1,3),j=1,12),i=1,24)
 555  format(1p5e13.5)
 556  format(1p3e13.5)
         end do
c
         stop
         end
c-------------------------------------------------------------------------
c   SUBROUTINE FOR FLUX CALCULATION
c-------------------------------------------------------------------------
         subroutine flux(imat,llw,lup,it,itn,jale)
c
         integer indl,lupf1,indf,nff
         real cellv,xdata,trf common/datv/cellv(3659),indl(3659,5),lupf1(2),indf
         common/datc/nff(35)
         common/datx/xdata(2,35,3,5,14,62)
         common/rslt/trf(2,24,12,3)
c
         write(11,1001)imat,llw,lup,it,itn,jale
 1001 format(5x,'flux ',6i8)
c
         ic=0
         idmat=1
         iflagd=0
         iflags=0
         nseg=12
         nm=3
c
c --- check for dummy elements that have 14 segments, ignore 1st & last -c
         if(itn.ge.4.and.itn.le.14)iflagd=1
c
c --- check for fuel materials
c
         if(itn.eq.24.or.itn.eq.124)then
             lupf1(indf)=lup
             indf=indf+1
         endif
c
c --- check for aluminum tallies to separate al200, al300, and al600
c
         if(itn.eq.44.or.itn.eq.144)idmat=3
c
c --- check for tally 4 and 14 to separate 2 cells
c
         if(itn.eq.4.or.itn.eq.14)idmat=2
c
c --- check for imat=7 to separate the cells of tally 194
c
         if(imat.eq.7)idmat=llw
c
```

```
                 llup=lup
                 lllw=llw
c
c  do loop to separate cells in same tally
c
         do 500 jj=1,idmat if(imat.eq.7)then
             lup=lupf1(jj)
             llw=lup-12
             if(jj.eq.2)ic=4
         else
         if(idmat.eq.3)then
         if(jj.eq.1)then
                      imat=2
                 endif
         if(jj.eq.2)then
                      imat=3
                      ic=30
                 endif
         if(jj.eq.3)then
                      imat=6
                      ic=60
                 endif
             endif
c
c   if tally4 and 14 then take llw of both cells from call parameters
c
             if(itn.eq.4)then
                 if(jj.eq.1)then
                      lup=lllw+1
                 endif
                 if(jj.eq.2)then
                      ic=1
                      llw=llup
                      lup=llup+2
                 endif
             endif
             if(itn.eq.14)then
                 if(jj.eq.1)then
                      lup=lllw+4
                 endif
                 if(jj.eq.2)then
                      ic=4
                      llw=llup
                      lup=llup+9
                 endif
             endif
         endif
c -----------------------------------------------------------------------c
         CALCULATION OF TRIANGLE FLUX  TOTALS
c -----------------------------------------------------------------------ind=0
         do 410 ii=llw,lup
                 imt=ind1(ii,5)
         if(imat.eq.imt)then
             if(ind.eq.0)then
                 ic=ic+1
                 ni1=ind1(ii,4)
                 ni2=ind1(ii+1,4)
                 ni3=ind1(ii+2,4)
                 nct=ind1(ii,3)
         do 400 ie=1,3
             imn=1
                 do 400 is=1,nseg
c ignore 1st segment ----------------------
                          iss=is
```

```
                          isg=is+iflagd
c fmm = total cellv / segment volume
                          fmm=12.
                          if(iflags.eq.1)then
                              iss=iss+5
                              fmm=6.4357647
if(isg.eq.1)fmm=14.768897
                          endif
                          if(iflags.eq.2)then
                              fmm=5.5642353
if(isg.eq.6)fmm=9.8615507
                          endif
                 cv1=cellv(ii)/fmm
                 cv2=cellv(ii+1)/fmm
                 cv3=cellv(ii+2)/fmm
                      if(nct.eq.0)then
c
          trf(1,ni1,iss,ie)=trf(1,ni1,iss,ie)
       x                             +xdata(1,it,ie,imn,isg,ic)*cv1
          trf(2,ni1,iss,ie)=trf(2,ni1,iss,ie)+
       x  (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv1)**2 c
                          ind=0
                      elseif(nct.eq.1)then
c
          trf(1,ni1,iss,ie)=trf(1,ni1,iss,ie)
       x                             +xdata(1,it,ie,imn,isg,ic)*cv1
          trf(1,ni2,iss,ie)=trf(1,ni2,iss,ie)
       x                             +xdata(1,it,ie,imn,isg,ic)*cv2
          trf(2,ni1,iss,ie)=trf(2,ni1,iss,ie)+
       x  (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv1)**2
          trf(2,ni2,iss,ie)=trf(2,ni2,iss,ie)+
       x  (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv2)**2 c
                          ind=1
                      elseif(nct.eq.2)then
c
          trf(1,ni1,iss,ie)=trf(1,ni1,iss,ie)
       x                             +xdata(1,it,ie,imn,isg,ic)*cv1
          trf(1,ni2,iss,ie)=trf(1,ni2,iss,ie)
       x                             +xdata(1,it,ie,imn,isg,ic)*cv2
          trf(1,ni3,iss,ie)=trf(1,ni3,iss,ie)
       x                             +xdata(1,it,ie,imn,isg,ic)*cv3
          trf(2,ni1,iss,ie)=trf(2,ni1,iss,ie)+
       x  (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv1)**2
          trf(2,ni2,iss,ie)=trf(2,ni2,iss,ie)+
       x  (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv2)**2
          trf(2,ni3,iss,ie)=trf(2,ni3,iss,ie)+
       x  (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv3)**2 c
                          ind=2
                      endif
                      imark=ii+nct
 400  continue
             else
                 ind=ind-1
             endif
        endif
        if(imark.eq.lup.and.jj.eq.2)goto 600
 410  continue
 500  continue
 600  continue
        return
        end
```

Program : xcgln.f

```
        character*8 kod,ver
        character*19 probid
        character*79 title
        character*4 ntal,vals
        character*5 tally,kcode
        character*2 f,d,u,s,m,c,e,t
        character*3 tfc
        character*75 fcomment
c
        integer indl,lupfl,indf,nff
        integer rnr,pbname,ptype,celln,tallyn
        real cellv,xdata,trr
        dimension ebin(3)
        dimension celln(62),tallyn(35),xkeff(3) dimension jtf(8)
c
        common/datv/cellv(3659),indl(3659,5),lupfl(2),indf common/datc/nff(35)
        common/datx/xdata(2,35,3,5,14,62) common/rslt/trr(2,24,12,3,5)
c
c       xdata(2,35, 3, 5,14,70)
c             (2,nt,ne,nm,ns,nf)
c           nt  : tally no.
c           ne  : energy bin no.
c           nm  : multiplier no.
c           ns  : segment no.
c           nf  : cell no.
c       trr(2,24,12, 3, 5)
c          (i,ni,ns,ne,nm)
c            i  : value, stdev pair
c           ni  : triangle no
c
c
        open(unit=13,file='mcxl',form='formatted',status='old')
        open(unit=19,file='vol7',form='formatted',status='old')
        open(unit=11,file='xcl',form='formatted',status='unknown')
        open(unit=20,file='trrl',form='formatted',status='unknown')
c
c Start to read cell volume data from 'vol' file
c
        ind=0
        do 101 i=1,3659 read(19,103)(indl(i,k),k=1,2),cellv(i),(indl(i,j),j=3,5)
 103        format(i6,x,i6,1pe13.5,3(x,i2))
 101   continue
        read(13,501)kod,ver,probid,knod,nps,rnr
 501   format(2a8,a19,i5,i11,i15) write(11,5011)kod,ver,probid,knod,nps,rnr
 5011  format('Tally file:'/,'mcxl',2x,2a8,a19,i5,i11,i15)
c
        read(13,502)title
 502   format(1x,a79)
c
        read(13,503)ntal,nt
 503   format(a4,i6)
c
        read(13,600)(tallyn(i),i=1,nt)
 600   format(16i5)
c
c ***** Start tally loop
c
        do 100 n=1,nt
           read(13,504)tally,pbname,ptype
 504       format(a5,2i5)
           read(13,505)fcomment
 505    format(5x,a75)
           read(13,506)f,nff(n)
```

```
           nf=nff(n)
 506    format(a2,i8)
           read(13,507)(celln(i),i=1,nf)
 507    format(11i7)
           read(13,506)d,idumm
           read(13,506)u,idumm
           read(13,506)s,ns
           read(13,506)m,nm
           if(nm.eq.0)nm=1
           read(13,506)c,nc
           if(nc.eq.0)nc=1
 508    format(a2,i8,i4)
 509    format(1p6e13.5)
           read(13,506)e,ne
           read(13,509)(ebin(i),i=1,ne)
           read(13,506)t,idumm
           read(13,510)vals
 510    format(a4)
c
c Read list of tally/error data pairs
c
           read(13,511)(((((xdata(it,n,ie,im,is,ic),it=1,2),
       x ie=1,ne),im=1,nm),is=1,ns),ic=1,nf)
 511    format(4(1pe13.5,0pf7.4))
 1025        format(i3,x,i5,1p10e10.3)
c
c Read tally fluctuation data
c
           read(13,512)tfc,nfc,(jtf(i),i=1,8)
 512    format(a3,i5,8i8)
           do 150 j=1,nfc
              read(13,513)nps,xtally,xerr,fom
 513       format(i11,1p3e13.5)
 150    continue
c
c ***** End of tally loop
 100   continue
c
c Read kcode data
c
        read(13,3000,end=999)kcode,ncycle
 3000 format(a5,i5)
c
        do 200 ncy=1,ncycle
           read(13,3010,end=998)(xkeff(k),k=1,3),dummy1,dummy2
 200   continue
 3010 format(1p5e12.5)
c
 998   continue
c
 999   continue
c
c Processing xdata and frac and cellv to get triangle xsections c
c     call parameters (imat,llw,lup,it,itn,calln)
c
c     imat: material number to fetch from cell volume array
c     llw : starting line number cell volume to be found the array
c     lup : final line number to find cell volume
c     it  : order of tally in mcx file no. iu
c     itn : problem number of tally(only used in if statements)
c     calln: variable to count no of calls from main
c
        indf=1
         call tri(4,1,152,6,64,1)
```

```
         call tri(1,1,152,7,74,2)
         call tri(2,1,152,8,84,3)
         call tri(0,153,511,9,94,4)
         call tri(5,155,158,10,104,5)
         call tri(5,514,521,11,114,6)
         call tri(4,292,510,15,164,7)
         call tri(1,292,510,16,174,8)
         call tri(2,292,510,17,184,9)
         call tri(7,2,0,19,204,10)
        do ilk=1,2 write(20,555)((((trr(ilk,i,j,k,l),l=1,5),k=1,3),j=1,12),i=1,24)
 555  format(1p5e13.5)
        end do
c
        stop
        end
        subroutine tri(imat,llw,lup,it,itn,ncall)
c
        integer ind1,lupf1,indf,nff
        real cellv,xdata,trr common/datv/cellv(3659),ind1(3659,5),lupf1(2),indf
        common/datc/nff(35)
        common/datx/xdata(2,35,3,5,14,62)
        common/rslt/trr(2,24,12,3,5)
c
        write(11,1001)imat,llw,lup,it,itn,jale
 1001 format(5x,'tri ',6i8)
c
        ic=0
        idmat=1
        iflagd=0
        iflags=0
        nseg=12
        nm=3
c
c --- check for dummy elements that have 14 segments, ignore 1st & last -c
        if(itn.ge.94.and.itn.le.114)iflagd=1
c
c --- check for fuel materials to assign no. of multipliers
c
        if(itn.eq.64.or.itn.eq.164)then
            nm=5
            lupf1(indf)=lup
            indf=indf+1
        endif
c
c --- check for aluminum tallies to separate al200, al300, and al600
c
        if(itn.eq.84.or.itn.eq.184)idmat=3
c
c --- check for tally 94 to separate 2 cells
c
        if(itn.eq.94)idmat=2
c
c --- check for imat=7 to separate the cells of tally 204
c
        if(imat.eq.7)idmat=llw
c
                llup=lup
                lllw=llw
c
c  do loop to separate cells in same tally
c
        do 500 jj=1,idmat
        if(imat.eq.7)then
            lup=lupf1(jj)
```

```
            llw=lup-12
            if(jj.eq.2)ic=4
        else
            if(idmat.eq.3)then
                if(jj.eq.1)then
                    imat=2
                endif
                if(jj.eq.2)then
                    imat=3
                    ic=30
                endif
                if(jj.eq.3)then
                    imat=6
                    ic=60
                endif
            endif
c
c   if tally94 then take llw of both cells from call parameters
c
            if(itn.eq.94)then
                if(jj.eq.1)then
                    lup=lllw+1
                endif
                if(jj.eq.2)then
                    ic=1
                    llw=llup
                    lup=llup+2
                endif
            endif
        endif
c -----------------------------------------------------------------------
c       CALCULATION OF TRIANGLE REACTION RATE TOTALS
c -----------------------------------------------------------------------
        ind=0
        do 410 ii=llw,lup
                imt=indl(ii,5)
        if(imat.eq.imt)then
            if(ind.eq.0)then
                ic=ic+1
                ni1=indl(ii,4)
                ni2=indl(ii+1,4)
                ni3=indl(ii+2,4)
                nct=indl(ii,3)
        do 400 ie=1,3
            do 400 im=1,nm
                do 400 is=1,nseg
c ignore 1st segment ----------------------
                          iss=is
                          isg=is+iflagd
c fmm = total cellv / segment volume
                          fmm=12.
                          if(iflags.eq.1)then
                              iss=iss+5
                              fmm=6.4357647
                              if(isg.eq.1)fmm=14.768897
                          endif
                          if(iflags.eq.2)then
                              fmm=5.5642353
                              if(isg.eq.6)fmm=9.8615507
                          endif
c fuel multiplier adjustment
                          imn=im
                          if(imat.eq.4.and.im.le.3)imn=im+2
                          if(imat.eq.4.and.im.gt.3)imn=im-3
```

```
                 cv1=cellv(ii)/fmm
                 cv2=cellv(ii+1)/fmm
                 cv3=cellv(ii+2)/fmm
                     if(nct.eq.0)then
c
          trr(1,ni1,iss,ie,im)=trr(1,ni1,iss,ie,im)
       x                                +xdata(1,it,ie,imn,isg,ic)*cv1
          trr(2,ni1,iss,ie,im)=trr(2,ni1,iss,ie,im)+
       x    (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv1)**2
c
                         ind=0
                     elseif(nct.eq.1)then
c
          trr(1,ni1,iss,ie,im)=trr(1,ni1,iss,ie,im)
       x                                +xdata(1,it,ie,imn,isg,ic)*cv1
          trr(1,ni2,iss,ie,im)=trr(1,ni2,iss,ie,im)
       x                                +xdata(1,it,ie,imn,isg,ic)*cv2
          trr(2,ni1,iss,ie,im)=trr(2,ni1,iss,ie,im)+
       x    (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv1)**2
          trr(2,ni2,iss,ie,im)=trr(2,ni2,iss,ie,im)+
       x    (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv2)**2
c
                         ind=1
                     elseif(nct.eq.2)then
c
          trr(1,ni1,iss,ie,im)=trr(1,ni1,iss,ie,im)
       x                                +xdata(1,it,ie,imn,isg,ic)*cv1
          trr(1,ni2,iss,ie,im)=trr(1,ni2,iss,ie,im)
       x                                +xdata(1,it,ie,imn,isg,ic)*cv2
          trr(1,ni3,iss,ie,im)=trr(1,ni3,iss,ie,im)
       x                                +xdata(1,it,ie,imn,isg,ic)*cv3
          trr(2,ni1,iss,ie,im)=trr(2,ni1,iss,ie,im)+
       x    (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv1)**2
          trr(2,ni2,iss,ie,im)=trr(2,ni2,iss,ie,im)+
       x    (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv2)**2
          trr(2,ni3,iss,ie,im)=trr(2,ni3,iss,ie,im)+
       x    (xdata(1,it,ie,imn,isg,ic)*xdata(2,it,ie,imn,isg,ic)*cv3)**2
c
                         ind=2
                     endif
                     imark=ii+nct
 400  continue
             else
                 ind=ind-1
             endif
         endif
         if(imark.eq.lup.and.jj.eq.2)goto 600
 410  continue
 500  continue
 600  continue
         return
         end
```

Program : prohx1n.f

```
        program prohx1n
c This program processes mctal file of input file outhx2
        character*8 kod,ver
        character*19 probid
        character*79 title
        character*4 ntal,vals
        character*5 tally,kcode
        character*2 f,d,u,s,m,c,e,t
```

```
        character*3 tfc
        character*75 fcomment
c
        integer tallyn(56),pbname,ptype,nff(90)
        dimension xkeff(3),ebin(3),jtf(8)
c
        dimension celln(10000),fldat(2,3,12,5000),rrdat(2,3,5,12,5000)
        dimension trf(2,40,20,12,3),trr(2,40,20,12,3,5)
        dimension nj(9),k1(9),k2(9),jj(9,32),i1(9,32),i2(9,32),nseq(9,32) dimension
        itri(40,20)
        dimension cvol(5,2166),no(5,2166),nom(5)
        dimension cvol2(5,2166),no2(5,2166),nom2(5)
        dimension voltr(40,20,12,3)
        dimension flx(40,20,12,3),totxs(40,20,12,3),absxs(40,20,12,3)
        dimension elsct(40,20,12,3),diffc(40,20,12,3),fisnu(40,20,12,3)
        dimension fisxs(40,20,12,3)
c
        real*8 stflx,sttxs,staxs,stels,stfxs,stfnu
        dimension stflx(40,20,12,3),sttxs(40,20,12,3),staxs(40,20,12,3)
        dimension stels(40,20,12,3),stfxs(40,20,12,3),stfnu(40,20,12,3)
c
        open(unit=11,file='hxln.ou',form='formatted',status='unknown')
        open(unit=12,file='inpt',form='formatted',status='old')
        open(unit=13,file='mcxoh',form='formatted',status='old')
        open(unit=14,file='tlista1',form='formatted',status='unknown')
        open(unit=15,file='tri600.1',form='formatted',status='old')
        open(unit=16,file='vale',form='formatted',status='old')
        open(unit=17,file='vale2',form='formatted',status='old')
        open(unit=18,file='tlista3',form='formatted',status='old')
        open(unit=20,file='debug.o',form='formatted',status='unknown')
c
c   Sequential reading  from mctal file, first fluxes then reaction rates
c After data has been read subroutines process the data and add it to the
c triangle totals of fluxes or reaction rates.
        write(11,10)
10    format(///5x,'PROHX1.F - AN MCNP TALLY PROCESSING PROGRAM',//)
c
c Reading the general info about tallies (not to be processed)
c
        read(13,501)kod,ver,probid,knod,nps,rnr
 501   format(2a8,a19,i5,i11,i15)
        write(11,5011)kod,ver,probid,knod,nps,rnr
 5011  format('Tally file:'/,'mcxoh',2x,2a8,a19,i5,i11,i15)
c
        read(13,502)title
 502   format(1x,a79)
        write(11,502)title
c
c        nt=56
        read(13,503)ntal,nt
 503   format(a5,i5)
c
        read(13,600)(tallyn(i),i=1,nt)
 600   format(16i5)
c
c ***** Start tally loop
c
        nfkeep1=1
        nfkeep2=0
        nfkeep3=1
        nfkeep4=0
        do 100 n=1,nt
           read(13,504)tally,pbname,ptype
 504       format(a5,2i5)
```

```
       read(13,505)fcomment
 505        format(5x,a75)
       read(13,506)f,nff(n)
 506        format(a2,i8)
            nf=nff(n)
            if(n.le.17)then
                nfkeep1=nfkeep2+1
                nfkeep2=nfkeep2+nf
            endif
            if(n.gt.17)then
                nfkeep3=nfkeep4+1
                nfkeep4=nfkeep4+nf
            endif
            if(n.le.17)read(13,507) (celln(i),i=nfkeep1,nfkeep2)
            if(n.gt.17)read(13,507) (celln(i),i=nfkeep3,nfkeep4)
 507        format(11i7)
            read(13,506)d,idumm
            read(13,506)u,idumm
            read(13,506)s,ns
                if(ns.eq.0)ns=1
            read(13,506)m,nm
                if(nm.eq.0)nm=1
            read(13,506)c,nc
                if(nc.eq.0)nc=1
            read(13,506)e,ne
            read(13,509)(ebin(i),i=1,ne-1)
 509        format(1p6e13.5)
            read(13,506)t,idumm
            read(13,510)vals
 510        format(a4)
c
c Read list of tally/error data pairs
c
            if(n.le.17)then
                read(13,511)((((fldat(it,ie,is,ic),it=1,2),
       x ie=1,3),is=1,ns),ic=nfkeep1,nfkeep2)
 511        format(4(1pe13.5,0pf7.4))
            endif
            if(n.gt.17)then
                read(13,511)(((((rrdat(it,ie,im,is,ic),it=1,2),
       x ie=1,3),im=1,nm),is=1,ns),ic=nfkeep3,nfkeep4)
            endif
c
c Read tally fluctuation data
c
            read(13,512)tfc,nfc,(jtf(i),i=1,8)
 512        format(a3,i5,8i8)
            do 150 j=1,nfc

       read(13,513)nps,xtally,xerr,fom
 513           format(i11,1p3e13.5)
 150        continue
c
c ***** End of tally loop
 100  continue
c
c Read kcode data
c

       read(13,3000,end=999)kcode,ncycle
 3000 format(a5,i5)

        do 200 ncy=1,ncycle
           read(13,3010,end=999)(xkeff(k),k=1,3),dummy1,dummy2
```

```
 200   continue
 3010  format(1p5e12.5)
 999   continue
c
c Multiplier sequence change for detector uranium coatings c
        do 778 ic=1,2166
            if((ic.ge. 213.and.ic.le. 248).or.
       x
       (ic.ge.2107.and.ic.le.2112).or.
       x
       (ic.ge.2125.and.ic.le.2130).or.
       x
       (ic.ge.2143.and.ic.le.2148))then
        do 777 it=1,2
            do 777 ie=1,3
                do 777 is=1,12
                    xx1=rrdat(it,ie,1,is,ic)
                    xx2=rrdat(it,ie,2,is,ic)
                    rrdat(it,ie,1,is,ic)=rrdat(it,ie,3,is,ic)
                    rrdat(it,ie,2,is,ic)=rrdat(it,ie,4,is,ic)
                    rrdat(it,ie,3,is,ic)=rrdat(it,ie,5,is,ic)
                    rrdat(it,ie,4,is,ic)=xx1
                    rrdat(it,ie,5,is,ic)=xx2
 777   continue
            endif
 778   continue
c
c Read segment volume data from vale
c
        do 413 ill=1,2166
        read(16,'(2i6,5(1pe13.5,i3))')ic,noc,cvol(1,ill),no(1,ill),
       x cvol(2,ill),no(2,ill),cvol(3,ill),no(3,ill),cvol(4,ill),
       x no(4,ill),cvol(5,ill),no(5,ill)
 413   continue
c same for trr from vale2
        do 531 ill=1,2166
        read(17,'(2i6,5(1pe13.5,i3))')ic,noc,cvol2(1,ill),no2(1,ill),
       x cvol2(2,ill),no2(2,ill),cvol2(3,ill),no2(3,ill),cvol2(4,ill), x
       no2(4,ill),cvol2(5,ill),no2(5,ill)
 531   continue
c
c Read cell number to triangle number conversion data from inpt
c
        read(12,301) (nj(n),n=1,9)
        read(12,301) (k1(ik),ik=1,9)
        read(12,301) (k2(ik),ik=1,9)
 301   format(9i3)
        do 101 ii=1,9
            read(12,302) (jj(ii,ij),ij=1,nj(ii))
 101   continue
        do 102 ii=1,9
            read(12,302) (i1(ii,iin),iin=1,nj(ii))
            read(12,302) (i2(ii,iin),iin=1,nj(ii))
 302   format(23i3)
 102   continue
        do 103 isq=1,9
            read(12,303) (nseq(isq,iin),iin=1,nj(isq))
 303   format(14i5)
 103   continue
        do 110 ng=1,9
            do 110 nn=1,nj(ng)
                do 110 ie=1,2
                    do 110 i=i1(ng,nn),i2(ng,nn)
                    do 110 k=k1(ng),k2(ng),-1
```

```
                    j=jj(ng,nn)
                    ic=nseq(ng,nn)+i-i1(ng,nn)
                    is=k1(ng)+1-k
         nom(1)=no(1,ic)
         nom(2)=no(1,ic)+no(2,ic)
         nom(3)=no(1,ic)+no(2,ic)+no(3,ic)
         nom(4)=no(1,ic)+no(2,ic)+no(3,ic)+no(4,ic)
         nom(5)=no(1,ic)+no(2,ic)+no(3,ic)+no(4,ic)+no(5,ic)
         if(is.le.nom(1))cvlm=cvol(1,ic)
         if(is.gt.nom(1).and.is.le.nom(2))cvlm=cvol(2,ic)
         if(is.gt.nom(2).and.is.le.nom(3))cvlm=cvol(3,ic)
         if(is.gt.nom(3).and.is.le.nom(4))cvlm=cvol(4,ic)
         if(is.gt.nom(4).and.is.le.nom(5))cvlm=cvol(5,ic)
      trf(1,i,j,k,ie)=trf(1,i,j,k,ie)+fldat(1,ie,is,ic)*cvlm
      voltr(i,j,k,ie)=voltr(i,j,k,ie)+cvlm
      trf(2,i,j,k,ie)=trf(2,i,j,k,ie)+(fldat(1,ie,is,ic)*cvlm*
     x                                          fldat(2,ie,is,ic))**2
 110  continue
c
c    the same thing for trr data from vale2 and inpt
c
      read(12,301) (nj(n),n=1,9)
      read(12,301) (k1(ik),ik=1,9)
      read(12,301) (k2(ik),ik=1,9)
      do 191 ii=1,9
         read(12,302) (jj(ii,ij),ij=1,nj(ii))
 191  continue
      do 192 ii=1,9
         read(12,302) (i1(ii,iin),iin=1,nj(ii))
         read(12,302) (i2(ii,iin),iin=1,nj(ii))
 192  continue
      do 193 isq=1,9
read(12,303) (nseq(isq,iin),iin=1,nj(isq))
 193  continue
      do 111 ng=1,9
         do 111 nn=1,nj(ng)
            do 111 ie=1,2
               do 111 i=i1(ng,nn),i2(ng,nn)
               do 111 k=k1(ng),k2(ng),-1
                    j=jj(ng,nn)
                    ic=nseq(ng,nn)+i-i1(ng,nn)
                    is=k1(ng)+1-k
         nom2(1)=no2(1,ic)
         nom2(2)=no2(1,ic)+no2(2,ic)
         nom2(3)=no2(1,ic)+no2(2,ic)+no2(3,ic)
         nom2(4)=no2(1,ic)+no2(2,ic)+no2(3,ic)+no2(4,ic)
         nom2(5)=no2(1,ic)+no2(2,ic)+no2(3,ic)+no2(4,ic)+no2(5,ic)
         if(is.le.nom2(1))cvlm=cvol2(1,ic)
         if(is.gt.nom2(1).and.is.le.nom2(2))cvlm=cvol2(2,ic)
         if(is.gt.nom2(2).and.is.le.nom2(3))cvlm=cvol2(3,ic)
         if(is.gt.nom2(3).and.is.le.nom2(4))cvlm=cvol2(4,ic)
         if(is.gt.nom2(4).and.is.le.nom2(5))cvlm=cvol2(5,ic)
                    do 111 im=1,5
      trr(1,i,j,k,ie,im)=trr(1,i,j,k,ie,im)+rrdat(1,ie,im,is,ic)*cvlm
      trr(2,i,j,k,ie,im)=trr(2,i,j,k,ie,im)+(rrdat(1,ie,im,is,ic)*
     x                                          cvlm* rrdat(2,ie,im,is,ic))**2
 111  continue
c
c      Read the rest of the conversion data for flux from tlista1
c
      do 312 loop=1,846
      read(14,'(i6,i6,4i3,i6)',end=313)isqn,ncl,i,j,ktop,kbot,idm2 ic=isqn
         nom(1)=no(1,ic)
         nom(2)=no(1,ic)+no(2,ic)
```

```
            nom(3)=no(1,ic)+no(2,ic)+no(3,ic)
            nom(4)=no(1,ic)+no(2,ic)+no(3,ic)+no(4,ic)
            nom(5)=no(1,ic)+no(2,ic)+no(3,ic)+no(4,ic)+no(5,ic)
        do 312 ie=1,2
        do 312 k=ktop,kbot,-1
            is=ktop+1-k
            if(is.le.nom(1))cvlm=cvol(1,ic)
            if(is.gt.nom(1).and.is.le.nom(2))cvlm=cvol(2,ic)
            if(is.gt.nom(2).and.is.le.nom(3))cvlm=cvol(3,ic)
            if(is.gt.nom(3).and.is.le.nom(4))cvlm=cvol(4,ic)
            if(is.gt.nom(4).and.is.le.nom(5))cvlm=cvol(5,ic)
        trf(1,i,j,k,ie)=trf(1,i,j,k,ie)+fldat(1,ie,is,ic)*cvlm
        voltr(i,j,k,ie)=voltr(i,j,k,ie)+cvlm
        trf(2,i,j,k,ie)=trf(2,i,j,k,ie)+(fldat(1,ie,is,ic)*cvlm*
       x                                      fldat(2,ie,is,ic))**2
 312  continue
c
c       end tlista1
c
 313  continue
c
c       Continue for trr data from tlista3
c
        do 412 loop=1,846
        read(18,'(i6,i6,4i3,i6)',end=433)isqn,ncl,i,j,ktop,kbot,idm2 ic=isqn
            nom2(1)=no2(1,ic)
            nom2(2)=no2(1,ic)+no2(2,ic)
            nom2(3)=no2(1,ic)+no2(2,ic)+no2(3,ic)
            nom2(4)=no2(1,ic)+no2(2,ic)+no2(3,ic)+no2(4,ic)
            nom2(5)=no2(1,ic)+no2(2,ic)+no2(3,ic)+no2(4,ic)+no2(5,ic)
        do 412 ie=1,2
        do 412 k=ktop,kbot,-1
            is=ktop+1-k
            if(is.le.nom2(1))cvlm=cvol2(1,ic)
            if(is.gt.nom2(1).and.is.le.nom2(2))cvlm=cvol2(2,ic)
            if(is.gt.nom2(2).and.is.le.nom2(3))cvlm=cvol2(3,ic)
            if(is.gt.nom2(3).and.is.le.nom2(4))cvlm=cvol2(4,ic)
            if(is.gt.nom2(4).and.is.le.nom2(5))cvlm=cvol2(5,ic)
                           do 412 im=1,5
        trr(1,i,j,k,ie,im)=trr(1,i,j,k,ie,im)+rrdat(1,ie,im,is,ic)*cvlm
        trr(2,i,j,k,ie,im)=trr(2,i,j,k,ie,im)+(rrdat(1,ie,im,is,ic)*
       x                                      cvlm*rrdat(2,ie,im,is,ic))**2
 412  continue
c
c       end tlista1
c
 433  continue
c
        do 882 j=1,20
            read(15,881,end=882)(itri(i,j),i=1,40)
 881        format(40i4)
 882  continue
c
c   Final processing to get volume averaged flux and cross sections
c   also diffusion coefficient
c
        do 911 j=1,20
            do 911 i=1,40
                if(itri(i,j).ne.0)then
                    do 912 k=1,12
                        do 912 ie=1,3
c  if the flux is not zero, process cross sections
        if(trf(1,i,j,k,ie) .ne. 0.0)then
```

```
           flx(i,j,k,ie)=trf(1,i,j,k,ie)/voltr(i,j,k,ie)
           totxs(i,j,k,ie)=trr(1,i,j,k,ie,2)/trf(1,i,j,k,ie)
           absxs(i,j,k,ie)=trr(1,i,j,k,ie,1)/trf(1,i,j,k,ie)
           elsct(i,j,k,ie)=trr(1,i,j,k,ie,3)/trf(1,i,j,k,ie)
           diffc(i,j,k,ie)=1/(3*totxs(i,j,k,ie))
       fisnu(i,j,k,ie)=trr(1,i,j,k,ie,4)/trf(1,i,j,k,ie)
       fisxs(i,j,k,ie)=trr(1,i,j,k,ie,5)/trf(1,i,j,k,ie)
c
           stflx(i,j,k,ie)=(sqrt(trf(2,i,j,k,ie)))/trf(1,i,j,k,ie)
           sttxs(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,2)/
       x trr(1,i,j,k,ie,2)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
           staxs(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,1)/
       x trr(1,i,j,k,ie,1)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
            if(fisnu(i,j,k,ie).ne.0.0)then
           stfnu(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,4)/
       x trr(1,i,j,k,ie,4)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
           stfxs(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,5)/
       x trr(1,i,j,k,ie,5)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
            endif
        endif
 912  continue
                 endif
 911  continue
c
c   Write the results to the file hx1.out
c
        write(11,466)
466  format(/,'Note: gp#1 = fast gp and, gp#2 = thermal gp.',/)
        write(11,461)
461  format('   I    J    K   ',9x,'FLUX    stdev',2x,'DIFF.COEFF. ',
       x 'TOT.XSECTION stdev ABS.XSECTION stdev',1x,
       x 'NU*FISS.XSEC stdev',2x,'FISS.XSECT  stdev')
        do 894 j=1,20
            do 894 i=1,40
                 if(itri(i,j).ne.0)then
                     do 896 k=1,12
                         kplus=k+4
        write(11,462)i,j,kplus
        write(11,463)flx(i,j,k,2),stflx(i,j,k,2),diffc(i,j,k,2),
       x totxs(i,j,k,2),sttxs(i,j,k,2),absxs(i,j,k,2),staxs(i,j,k,2), x
       fisnu(i,j,k,2),stfnu(i,j,k,2),fisxs(i,j,k,2),stfxs(i,j,k,2)
        write(11,464)flx(i,j,k,1),stflx(i,j,k,1),diffc(i,j,k,1),
       x totxs(i,j,k,1),sttxs(i,j,k,1),absxs(i,j,k,1),staxs(i,j,k,1), x
       fisnu(i,j,k,1),stfnu(i,j,k,1),fisxs(i,j,k,1),stfxs(i,j,k,1)
 896                 continue
                endif
 894  continue
c
 462  format(3i4,'  gp#')
 463  format(14x,' 1 ',1pe13.5,0pf6.3,1pe13.5,4(1pe13.5,0pf6.3))
 464  format(14x,' 2 ',1pe13.5,0pf6.3,1pe13.5,4(1pe13.5,0pf6.3)) c
        stop
        end
```

Program : prohx2n.f

```
        program prohx2n
c This program processes mctal file of input file outhx2
        character*8 kod,ver
        character*19 probid
        character*79 title
        character*4 ntal,vals
        character*5 tally,kcode
```

```
         character*2 f,d,u,s,m,c,e,t
         character*3 tfc
         character*75 fcomment
c
         integer tallyn(56),pbname,ptype,nff(90)
         dimension xkeff(3),ebin(3),jtf(8)
c
         dimension celln(10000),fldat(2,3,12,5000),rrdat(2,3,5,12,5000)
         dimension trf(2,60,30,4,3),trr(2,60,30,4,3,3)
         dimension itri(40,20),itribig(60,30)
         dimension cvol(5,2166),no(2),nom(2)
         dimension voltr(60,30,4,3)
         dimension flx(60,30,4,3),totxs(60,30,4,3),absxs(60,30,4,3)
         dimension elsct(60,30,4,3),diffc(60,30,4,3)
c
         real*8 stflx,sttxs,staxs,stels
         dimension stflx(40,20,12,3),sttxs(40,20,12,3),staxs(40,20,12,3)
         dimension stels(40,20,12,3)
c
         open(unit=11,file='hx2n.ou',form='formatted',status='unknown')
         open(unit=13,file='mc10t',form='formatted',status='old')
         open(unit=14,file='tccl.c2',form='formatted',status='unknown')
         open(unit=15,file='tri600.2',form='formatted',status='old')
         open(unit=16,file='vvva.c2',form='formatted',status='old')
c
c   Sequential reading  from mctal file, first fluxes then reaction rates
c After data has been read subroutines process the data and add it to the
c triangle totals of fluxes or reaction rates.
         write(11,10)
10   format(///5x,'PROHX2.F - AN MCNP TALLY PROCESSING PROGRAM',//)
c
c Reading the general info about tallies (not to be processed)
c
         read(13,501)kod,ver,probid,knod,nps,rnr
 501  format(2a8,a19,i5,i11,i15)
         write(11,5011)kod,ver,probid,knod,nps,rnr
 5011 format('Tally file:'/,'mc10t',2x,2a8,a19,i5,i11,i15)
c
         read(13,502)title
 502  format(1x,a79)
         write(11,502)title
c
c         nt=56
         read(13,503)ntal,nt
 503  format(a5,i5)
c
         read(13,600)(tallyn(i),i=1,nt)
 600  format(16i5)
c
c ***** Start tally loop
c
         nfkeep1=1
         nfkeep2=0
         nfkeep3=1
         nfkeep4=0
         do 100 n=1,nt
            read(13,504)tally,pbname,ptype
 504        format(a5,2i5)
            read(13,505)fcomment
 505        format(5x,a75)
            read(13,506)f,nff(n)
 506        format(a2,i8)
            nf=nff(n)
            if(n.le.18)then
```

```
                nfkeep1=nfkeep2+1
                nfkeep2=nfkeep2+nf
            endif
            if(n.gt.18)then
                nfkeep3=nfkeep4+1
                nfkeep4=nfkeep4+nf
            endif
            if(n.le.18)read(13,507) (celln(i),i=nfkeep1,nfkeep2)
            if(n.gt.18)read(13,507) (celln(i),i=nfkeep3,nfkeep4)
 507        format(11i7)
            read(13,506)d,idumm
            read(13,506)u,idumm
            read(13,506)s,ns
                if(ns.eq.0)ns=1
            read(13,506)m,nm
                if(nm.eq.0)nm=1
            read(13,506)c,nc
                if(nc.eq.0)nc=1
            read(13,506)e,ne
            read(13,509)(ebin(i),i=1,ne-1)
 509        format(1p6e13.5)
            read(13,506)t,idumm
            read(13,510)vals
 510        format(a4)
c
c Read list of tally/error data pairs
c
            if(n.le.18)then
                read(13,511)((((fldat(it,ie,is,ic),it=1,2),
       x ie=1,3),is=1,ns),ic=nfkeep1,nfkeep2)
 511        format(4(1pe13.5,0pf7.4))
            endif
            if(n.gt.18)then
                read(13,511)(((((rrdat(it,ie,im,is,ic),it=1,2),
x ie=1,3),im=1,nm),is=1,ns),ic=nfkeep3,nfkeep4)
            endif
c
c Read tally fluctuation data
c
           read(13,512)tfc,nfc,(jtf(i),i=1,8)
 512       format(a3,i5,8i8)
           do 150 j=1,nfc
              read(13,513)nps,xtally,xerr,fom
 513          format(i11,1p3e13.5)
 150       continue
c
c ***** End of tally loop
 100  continue
c
c Read kcode data
c
        read(13,3000,end=999)kcode,ncycle
 3000 format(a5,i5)

        do 200 ncy=1,ncycle
           read(13,3010,end=999)(xkeff(k),k=1,3),dummy1,dummy2
 200  continue
 3010 format(1p5e12.5)
 999  continue
c
c Read segment volume data from vvva.c2
c
        do 413 ic=1,1210 if((ic.le.36).or.(ic.gt.78.and.ic.le.300).or.
       x         (ic.gt.540.and.ic.le.570).or.
```

```
       x         (ic.gt.642.and.ic.le.846).or.
       x         (ic.gt.846.and.ic.le.1102))then
read(16,*,end=417)ic,cvol(1,ic),cvol(2,ic)
             endif
             if((ic.gt.36.and.ic.le.78).or.
       x         (ic.gt.300.and.ic.le.462).or.
       x         (ic.gt.570.and.ic.le.642).or.
       x         (ic.gt.462.and.ic.le.540).or.(ic.gt.1102))then
                read(16,*,end=417)ic,cvol(1,ic)
             endif
 413  continue
 417  continue
c
c       Read the rest of the conversion data for flux from tccl.c
c
        do 312 loop=1,1210
             if((loop.le.36).or.(loop.gt.78.and.loop.le.300).or.
       x         (loop.gt.540.and.loop.le.570).or.
       x         (loop.gt.642.and.loop.le.846))then
                 no(1)=1
                 no(2)=1
                 ktop=4
                 kbot=3
             endif
             if(loop.gt.36.and.loop.le.78)then
                 no(1)=1
                 ktop=4
                 kbot=4
             endif
             if((loop.gt.300.and.loop.le.462).or.
       x        (loop.gt.570.and.loop.le.642))then
                 no(1)=1
                 ktop=3
                 kbot=3
             endif
             if((loop.gt.462.and.loop.le.540).or.(loop.gt.1102))then
                 no(1)=4
                 ktop=4
                 kbot=1
             endif
             if(loop.gt.846.and.loop.le.1102)then
                 no(1)=1
                 no(2)=2
                 ktop=3
                 kbot=1
             endif
            nom(1)=no(1)
            nom(2)=no(1)+no(2)
        read(14,'(i6,i6,2i3)',end=313)isqn,ncl,i,j
        ic=isqn
        do 312 ie=1,2
        do 312 k=ktop,kbot,-1
            is=ktop+1-k
            if(is.le.nom(1))cvlm=cvol(1,ic)
            if(is.gt.nom(1).and.is.le.nom(2))cvlm=cvol(2,ic)
        trf(1,i,j,k,ie)=trf(1,i,j,k,ie)+fldat(1,ie,is,ic)*cvlm
        voltr(i,j,k,ie)=voltr(i,j,k,ie)+cvlm
        trf(2,i,j,k,ie)=trf(2,i,j,k,ie)+(fldat(1,ie,is,ic)*cvlm*
       x                                    fldat(2,ie,is,ic))**2
        if(ic.eq.918)then
            trf(1,19,8,k,ie)=trf(1,19,8,k,ie)+fldat(1,ie,is,ic)*cvlm
            voltr(19,8,k,ie)=voltr(19,8,k,ie)+cvlm
            trf(2,19,8,k,ie)=trf(2,19,8,k,ie)+(fldat(1,ie,is,ic)*cvlm* x
                                        fldat(2,ie,is,ic))**2
```

```
        endif
                            do 312 im=1,3
        trr(1,i,j,k,ie,im)=trr(1,i,j,k,ie,im)+
       x                                 rrdat(1,ie,im,is,ic)*cvlm
        trr(2,i,j,k,ie,im)=trr(2,i,j,k,ie,im)+(rrdat(1,ie,im,is,ic)* x
                                   cvlm* rrdat(2,ie,im,is,ic))**2
        if(ic.eq.918)then
            trr(1,19,8,k,ie,im)=trr(1,19,8,k,ie,im)+
       x                                        rrdat(1,ie,im,is,ic)*cvlm
        trr(2,19,8,k,ie,im)=trr(2,19,8,k,ie,im)+(rrdat(1,ie,im,is,ic)* x
                                       cvlm* rrdat(2,ie,im,is,ic))**2
        endif
 312  continue
c
c       end tccl.c
c
 313  continue
c
c
c   read triangle mesh from tri600.2
c
        do 882 j=1,20
            read(15,881,end=882)(itri(i,j),i=1,40)
 881        format(40i2)
 882  continue
        do 885 j=21,30
            read(15,886,end=885)(itribig(i,j),i=41,60
            )
 886        format(20i2)
 885  continue
c
c   Final processing to get volume averaged flux and cross sections
c   also diffusion coefficient
c
        do 911 j=1,20
            do 911 i=1,40
                 if(itri(i,j).ne.0)then
                     do 912 k=1,4
                         do 912 ie=1,3
c  if the flux is zero set xsections to zero automatically
       if(trf(1,i,j,k,ie) .ne. 0.0)then
           flx(i,j,k,ie)=trf(1,i,j,k,ie)/voltr(i,j,k,ie)
           totxs(i,j,k,ie)=trr(1,i,j,k,ie,2)/trf(1,i,j,k,ie)
           absxs(i,j,k,ie)=trr(1,i,j,k,ie,1)/trf(1,i,j,k,ie)
           elsct(i,j,k,ie)=trr(1,i,j,k,ie,3)/trf(1,i,j,k,ie)
        if(totxs(i,j,k,ie).ne. 0.)diffc(i,j,k,ie)=1/(3*totxs(i,j,k,ie))
c
           stflx(i,j,k,ie)=(sqrt(trf(2,i,j,k,ie)))/trf(1,i,j,k,ie)
           sttxs(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,2)/
       x trr(1,i,j,k,ie,2)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
           staxs(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,1)/
       x trr(1,i,j,k,ie,1)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
        endif
 912  continue
                 endif
 911  continue
c
c   Write the results to the file hx2.ou
c
        write(11,466)
466  format(/,'Note: gp#1 = fast gp and, gp#2 = thermal gp.',/)
        write(11,461)
461  format('   I   J   K  ',9x,'FLUX    stdev',2x,'DIFF.COEFF. ',
       x 'TOT.XSECTION stdev ABS.XSECTION stdev')
```

```
        do 894 j=1,20
            do 894 i=1,40
                 if(itri(i,j).ne.0)then
                     do 896 k=1,4
        write(11,462)i,j,k
        write(11,463)flx(i,j,k,2),stflx(i,j,k,2),diffc(i,j,k,2),
       x totxs(i,j,k,2),sttxs(i,j,k,2),absxs(i,j,k,2),staxs(i,j,k,2)
        write(11,464)flx(i,j,k,1),stflx(i,j,k,1),diffc(i,j,k,1),
       x totxs(i,j,k,1),sttxs(i,j,k,1),absxs(i,j,k,1),staxs(i,j,k,1)
 896                 continue
                 endif
 894  continue
c
c   graphite reflector
c
        do 941 j=21,30
            do 941 i=41,60
                 if(itribig(i,j).ne.0)then
                     do 942 k=1,4
                         do 942 ie=1,3
c  if the flux is zero set xsections to zero automatically if(trf(1,i,j,k,ie)
        .ne. 0.0)then
           flx(i,j,k,ie)=trf(1,i,j,k,ie)/voltr(i,j,k,ie)
           totxs(i,j,k,ie)=trr(1,i,j,k,ie,2)/trf(1,i,j,k,ie)
           absxs(i,j,k,ie)=trr(1,i,j,k,ie,1)/trf(1,i,j,k,ie)
           elsct(i,j,k,ie)=trr(1,i,j,k,ie,3)/trf(1,i,j,k,ie)
        if(totxs(i,j,k,ie).ne. 0.)diffc(i,j,k,ie)=1/(3*totxs(i,j,k,ie))
c
           stflx(i,j,k,ie)=(sqrt(trf(2,i,j,k,ie)))/trf(1,i,j,k,ie)
           sttxs(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,2)/
       x trr(1,i,j,k,ie,2)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
           staxs(i,j,k,ie)=sqrt(trr(2,i,j,k,ie,1)/
       x trr(1,i,j,k,ie,1)**2+trf(2,i,j,k,ie)/trf(1,i,j,k,ie)**2)
        endif
 942  continue
                 endif
 941  continue
c
c   Write the results to the file hx2.ou
c
        do 994 j=21,30
            do 994 i=41,60
                 if(itribig(i,j).ne.0)then
                     do 996 k=1,4
                         imin=i-40
                         jmin=j-20
        write(11,465)imin,jmin,k
        write(11,463)flx(i,j,k,2),stflx(i,j,k,2),diffc(i,j,k,2),
       x totxs(i,j,k,2),sttxs(i,j,k,2),absxs(i,j,k,2),staxs(i,j,k,2)
        write(11,464)flx(i,j,k,1),stflx(i,j,k,1),diffc(i,j,k,1),
       x totxs(i,j,k,1),sttxs(i,j,k,1),absxs(i,j,k,1),staxs(i,j,k,1)
 996                 continue
                 endif
 994  continue
c
 462  format(3i4,'  gp#')
 463  format(14x,' 1 ',1pe13.5,0pf6.3,1pe13.5,2(1pe13.5,0pf6.3))
 464  format(14x,' 2 ',1pe13.5,0pf6.3,1pe13.5,2(1pe13.5,0pf6.3))
 465  format(3(i3,'B'),'  gp#')
c
        stop
        end
```

Program : sibel.f

```
        character*6 titl
        character*1 adum
        integer cnum,vnum
        dimension cnum(3,1000),flx(3,2,12,1000),abx(3,2,12,1000),
       +             tox(3,2,12,1000),elx(3,2,12,1000),fnu(3,2,12,1000),
       +             fis(3,2,12,1000),vnum(200),vol(200),indt(3,1000)
        dimension tabx(12,2),ttox(12,2),telx(12,2),tfnu(12,2),
       +             tfis(12,2),tflx(12,2)
c        3 : nf 1=8, 2=9, 3=10 , ifile
c        2 : ie
c       12 : is
c      100 : cell number
        open(unit=8,file='mcn2.inp',form='formatted',status='old')
        open(unit=9,file='mcn5.inp',form='formatted',status='old')
        open(unit=10,file='mcn4.inp',form='formatted',status='old')
        open(unit=11,file='vol.out',form='formatted',status='old')
        open(unit=12,file='rslts',form='formatted',status='unknown')
c
        do 88 nf=1,3
            ifile=nf+7
            icn=0
 10     read(ifile,'(a6,i6,/)',end=88)titl,num1
        if(titl.eq."1tally")then
            if(num1.eq.124.or.num1.eq.334.or.num1.eq.214)itype=1
            if(num1.eq.134.or.num1.eq.344.or.num1.eq.224)itype=1
            if(num1.eq.144.or.num1.eq.354.or.num1.eq.234)itype=1
            if(num1.eq.164.or.num1.eq.364.or.num1.eq.244)itype=2
            if(num1.eq.174.or.num1.eq.374.or.num1.eq.254)itype=3
            if(num1.eq.184.or.num1.eq.384.or.num1.eq.264)itype=3
            if(num1.eq.194)itype=1
            if(num1.eq.204)itype=3
        elseif(titl.eq." cell ")then
            icn=icn+1
            cnum(nf,icn)=num1
            indt(nf,icn)=itype
            if(itype.eq.1)then
                read(ifile,'(a)')adum
                do is=1,12
                    read(ifile,*)idum,flx(nf,1,is,icn),rdum,flx(nf,2,is,icn)
c                   write(12,'(3h #0,2i7,1p2e13.5)')cnum(nf,icn),
c       +                                 icn,flx(nf,1,is,icn),flx(nf,2,is,icn)
                enddo
                read(ifile,'(a)')adum
            endif
            if(itype.eq.2)then
                read(ifile,'(a,/)')adum
                do is=1,12
                   read(ifile,*)idum,fnu(nf,1,is,icn),rdum,fis(nf,1,is,icn),
       +                        rdum,abx(nf,1,is,icn),rdum,tox(nf,1,is,icn),
       +                        rdum,elx(nf,1,is,icn),rdum
                enddo
                read(ifile,'(a,////)')adum
                do is=1,12
                   read(ifile,*)idum,fnu(nf,2,is,icn),rdum,fis(nf,2,is,icn),
       +                        rdum,abx(nf,2,is,icn),rdum,tox(nf,2,is,icn),
       +                        rdum,elx(nf,2,is,icn),rdum
                enddo
                read(ifile,'(a,////////////////)')adum
            endif
            if(itype.eq.3)then
                read(ifile,'(a,/)')adum
                do is=1,12
                   read(ifile,*)idum,abx(nf,1,is,icn),rdum,tox(nf,1,is,icn),
```

```
       +                          rdum,elx(nf,1,is,icn),rdum
                 enddo
                 read(ifile,'(a,////)')adum
                 do is=1,12
                    read(ifile,*)idum,abx(nf,2,is,icn),rdum,tox(nf,2,is,icn),
       +                           rdum,elx(nf,2,is,icn),rdum
                 enddo
                    read(ifile,'(a,/////////////////)',end=88)adum
             endif
c             write(12,*)nf,icn,cnum(nf,icn)
         endif
         goto 10
 88      continue
         do i=1,193
             read(11,*)idum,vnum(i),vl
             vol(i)=vl/12.
c             write(12,*)idum,vnum(i),vol(i)
         end do
         do 90 i=1,193
             tvol=tvol+vol(i)
             if(i.le.37)then
                 nconv=vnum(i)-71000
                 nf=1
             elseif(i.gt.37.and.i.le.113)then
                 nconv=vnum(i)-11000
                 nf=2
             elseif(i.gt.113)then
                 nconv=vnum(i)-81000
                 nf=3
             endif
             do 90 j=1,1000
                 if(nf.eq.1)ncmp=cnum(nf,j)-81000
                 if(nf.eq.2)ncmp=cnum(nf,j)-42000
                 if(nf.eq.3)ncmp=cnum(nf,j)-82000
                 if(ncmp.eq.nconv)then
                    write(12,*)i,vnum(i),cnum(nf,j),nconv,ncmp,nf do is=1,12
                          do ie=1,2
                          if(indt(nf,j).eq.1)then
                             tflx(is,ie)=tflx(is,ie)+flx(nf,ie,is,j)*vol(i)
                          endif
                          if(indt(nf,j).eq.2)then
                             tfnu(is,ie)=tfnu(is,ie)+fnu(nf,ie,is,j)*vol(i)
                             tfis(is,ie)=tfis(is,ie)+fis(nf,ie,is,j)*vol(i)
                             tabx(is,ie)=tabx(is,ie)+abx(nf,ie,is,j)*vol(i)
                             ttox(is,ie)=ttox(is,ie)+tox(nf,ie,is,j)*vol(i)
                             telx(is,ie)=telx(is,ie)+elx(nf,ie,is,j)*vol(i)
                          endif
                          if(indt(nf,j).eq.3)then
                             tabx(is,ie)=tabx(is,ie)+abx(nf,ie,is,j)*vol(i)
                             ttox(is,ie)=ttox(is,ie)+tox(nf,ie,is,j)*vol(i)
                             telx(is,ie)=telx(is,ie)+elx(nf,ie,is,j)*vol(i)
                          endif
                          enddo
                     enddo
                 endif
 90     continue
        write(12,19)
19   format('  K  gp#',5x,'FLUX',4x,'TOT.XSECTION',2x,
       x          'ABS.XSECTION',1x,'NU*FISS.XSEC',2x,'FISS.XSECT')
        nn=0
        do 91 is=12,1,-1
            nn=nn+1
            do 91 ie=2,1,-1
                 if(ie.eq.2)iee=1
```

```
                 if(ie.eq.1)iee=2
                 flux=tflx(is,ie)/tvol siga=tabx(is,ie)/tflx(is,ie)
                 sigt=ttox(is,ie)/tflx(is,ie)
                 sige=telx(is,ie)/tflx(is,ie) sigf=tfis(is,ie)/tflx(is,ie)
                 sfnu=tfnu(is,ie)/tflx(is,ie)
                 write(12,20)nn,iee,flux,sigt,siga,sfnu,sigf
 20        format(2i3,1p5e13.5)
c                 write(12,*)nn,iee,flux,sigt,siga,sfnu,sigf
 91        continue
           write(12,'(13h total vol = ,1p5e13.5)')tvol*12
           stop

          end
```

File : rslts

```
  K  gp#     FLUX     TOT.XSECTION ABS.XSECTION NU*FISS.XSEC  FISS.XSECT
  1  1  3.64298E-04  5.54066E-01  2.29585E-03  9.05881E-03  3.68822E-03
  1  2  7.13615E-05  1.87641E+00  3.36208E-02  2.85794E-01  1.17288E-01
  2  1  4.47630E-04  5.62481E-01  2.28250E-03  9.16390E-03  3.73346E-03
  2  2  6.83401E-05  1.81449E+00  3.16205E-02  2.66815E-01  1.09498E-01
  3  1  5.13602E-04  5.64775E-01  2.23828E-03  9.00610E-03  3.66894E-03
  3  2  7.25782E-05  1.78767E+00  3.14100E-02  2.65587E-01  1.08994E-01
  4  1  5.45928E-04  5.70975E-01  2.32829E-03  9.42292E-03  3.84006E-03
  4  2  7.66283E-05  1.79394E+00  3.16111E-02  2.68949E-01  1.10374E-01
  5  1  5.36221E-04  5.69695E-01  2.25072E-03  9.20519E-03  3.75128E-03
  5  2  7.25827E-05  1.78241E+00  3.18629E-02  2.75376E-01  1.13012E-01
  6  1  5.04040E-04  5.77033E-01  2.26380E-03  9.28217E-03  3.78327E-03
  6  2  5.97613E-05  1.74026E+00  3.17982E-02  2.80191E-01  1.14988E-01
  7  1  4.49893E-04  5.78575E-01  2.32567E-03  9.42908E-03  3.84369E-03
  7  2  4.91919E-05  1.72769E+00  3.18037E-02  2.85593E-01  1.17205E-01
  8  1  3.92346E-04  5.80923E-01  2.39860E-03  9.52839E-03  3.88470E-03
  8  2  4.20241E-05  1.71519E+00  3.19280E-02  2.87597E-01  1.18027E-01
  9  1  3.41173E-04  5.78941E-01  2.47606E-03  9.80863E-03  3.99929E-03
  9  2  3.55777E-05  1.69937E+00  3.17879E-02  2.87257E-01  1.17888E-01
 10  1  2.81711E-04  5.79020E-01  2.47141E-03  9.63444E-03  3.92791E-03
 10  2  2.96850E-05  1.70773E+00  3.20984E-02  2.93157E-01  1.20309E-01
 11  1  2.32209E-04  5.79536E-01  2.43172E-03  9.80162E-03  3.99709E-03
 11  2  2.47867E-05  1.74561E+00  3.35301E-02  3.06559E-01  1.25809E-01
 12  1  1.69892E-04  5.75283E-01  2.38011E-03  9.59636E-03  3.91062E-03
 12  2  2.40555E-05  1.77757E+00  3.56112E-02  3.31846E-01  1.36187E-01
total vol =   2.97691E+03
```

APPENDIX C

SAMPLE CROSS SECTION RESULTS

The statisticals errors are given as fractions of the mean values (not percent).

Note: gp#1 = fast gp and, gp#2 = thermal gp.

```
 I  J  K    #    FLUX                  DIFF.COEFF.  TOT.XSECTION        ABS.XSECTION        NU*FISS.XSEC
 1  1  1    1  gp#
                1 3.38054E-04   0.004  6.47461E-01  5.14831E-01  0.006  1.77148E-03  0.023  6.86954E-03  0.018
                2 7.89351E-05   0.007  2.04577E-01  1.62938E+00  0.012  2.91081E-02  0.012  2.16739E-01  0.017
 2  1  1    2  gp#
                1 3.23577E-04   0.003  5.84091E-01  5.70688E-01  0.006  2.08680E-03  0.027  7.97850E-03  0.020
                2 6.73537E-05   0.007  1.74331E-01  1.91207E+00  0.012  3.38143E-02  0.012  2.60419E-01  0.017
 3  1  1    3  gp#
                1 4.16894E-04   0.003  5.95811E-01  5.59462E-01  0.005  2.19321E-03  0.016  8.56051E-03  0.013
                2 6.40614E-05   0.007  1.87418E-01  1.77856E+00  0.011  3.21240E-02  0.011  2.74704E-01  0.015
 4  1  1    4  gp#
                1 3.72052E-04   0.003  6.13087E-01  5.43697E-01  0.006  2.08060E-03  0.019  8.17046E-03  0.015
                2 7.72946E-05   0.007  1.74265E-01  1.91279E+00  0.012  3.35979E-02  0.011  2.83051E-01  0.014
 5  1  1    5  gp#
                1 3.79682E-04   0.003  5.95163E-01  5.60071E-01  0.006  2.15876E-03  0.019  8.58054E-03  0.014
                2 7.46005E-05   0.007  1.77411E-01  1.87888E+00  0.012  3.30801E-02  0.011  2.78113E-01  0.014
 1  2  1    6  gp#
                1 3.64298E-04   0.003  6.01613E-01  5.54066E-01  0.005  2.29584E-03  0.019  9.05882E-03  0.014
                2 7.13615E-05   0.007  1.77645E-01  1.87640E+00  0.012  3.36208E-02  0.011  2.85795E-01  0.014
 2  2  1    7  gp#
                1 3.83154E-04   0.004  7.10580E-01  4.69100E-01  0.006  1.51488E-03  0.016  5.34825E-03  0.014
                2 7.69991E-05   0.010  2.70937E-01  1.23030E+00  0.014  2.31018E-02  0.013  1.45343E-01  0.017
 3  2  1    8  gp#
                1 3.44853E-04   0.007  8.36864E-01  3.98312E-01  0.010  6.04059E-04  0.017  7.19519E-04  0.035
                2 8.85555E-05   0.012  3.77713E-01  8.82504E-01  0.019  1.55418E-02  0.016  1.31446E-02  0.039
 4  2  1    9  gp#
                1 3.93086E-04   0.005  6.68311E-01  4.98770E-01  0.008  1.46222E-03  0.020  5.19318E-03  0.019
                2 7.98228E-05   0.011  2.61006E-01  1.27711E+00  0.016  2.44535E-02  0.015  1.43749E-01  0.022
 5  2  1   10 gp#
                1 4.11785E-04   0.004  6.50910E-01  5.12103E-01  0.007  1.50474E-03  0.021  5.12921E-03  0.019
                2 8.02617E-05   0.010  2.77602E-01  1.20076E+00  0.015  2.19677E-02  0.014  1.38628E-01  0.020
 6  2  1   11 gp#
                1 3.95111E-04   0.004  6.86559E-01  4.85513E-01  0.006  1.54065E-03  0.017  5.62050E-03  0.014
                2 7.58043E-05   0.010  2.74662E-01  1.21361E+00  0.014  2.31875E-02  0.013  1.64200E-01  0.017
 7  2  1   12 gp#
                1 3.56950E-04   0.004  6.36081E-01  5.24043E-01  0.006  1.78533E-03  0.025  6.65870E-03  0.018
                2 8.22461E-05   0.007  2.07068E-01  1.60977E+00  0.012  2.92780E-02  0.012  2.24602E-01  0.017
 2  3  1   13 gp#
                1 3.56063E-04   0.003  6.13793E-01  5.43072E-01  0.006  1.91506E-03  0.016  7.81668E-03  0.013
                2 7.24516E-05   0.007  1.75604E-01  1.89821E+00  0.012  3.33570E-02  0.011  2.82391E-01  0.014
 3  3  1   14 gp#
                1 4.06859E-04   0.003  6.00848E-01  5.54771E-01  0.005  2.09334E-03  0.016  8.50146E-03  0.012
                2 6.30080E-05   0.006  1.86829E-01  1.78416E+00  0.011  3.36514E-02  0.011  2.96881E-01  0.015
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4   3   1  15   gp#
                 1  3.94125E-04   0.005  6.75756E-01   4.93275E-01   0.008  1.37575E-03   0.020  4.76325E-03   0.019
                 2  7.93925E-05   0.011  2.64315E-01   1.26112E+00   0.016  2.33115E-02   0.015  1.29636E-01   0.023
5   3   1  16   gp#
                 1  3.49148E-04   0.006  8.25931E-01   4.03585E-01   0.010  5.75133E-04   0.015  6.86477E-04   0.032
                 2  8.56548E-05   0.012  3.72167E-01   8.95656E-01   0.020  1.56852E-02   0.016  1.29194E-02   0.038
6   3   1  17   gp#
                 1  4.74456E-04   0.003  5.99901E-01   5.55647E-01   0.006  2.05068E-03   0.017  8.06770E-03   0.013
                 2  7.69861E-05   0.008  1.93982E-01   1.71837E+00   0.013  3.13166E-02   0.012  2.56146E-01   0.016
7   3   1  18   gp#
                 1  4.38447E-04   0.003  5.98380E-01   5.57059E-01   0.005  2.14714E-03   0.018  8.58033E-03   0.012
                 2  6.67504E-05   0.007  1.86802E-01   1.78442E+00   0.011  3.34234E-02   0.011  2.92854E-01   0.014
8   3   1  19   gp#
                 1  3.41655E-04   0.003  5.83675E-01   5.71094E-01   0.006  1.95038E-03   0.021  7.87598E-03   0.017
                 2  7.12548E-05   0.007  1.75647E-01   1.89775E+00   0.011  3.37999E-02   0.012  2.61019E-01   0.016
4   4   1  20   gp#
                 1  3.16320E-04   0.003  5.82923E-01   5.71831E-01   0.006  1.99297E-03   0.023  7.70844E-03   0.017
                 2  6.58284E-05   0.007  1.72969E-01   1.92713E+00   0.012  3.41124E-02   0.012  2.64348E-01   0.017
5   4   1  21   gp#
                 1  3.39966E-04   0.004  6.51938E-01   5.11296E-01   0.006  1.90404E-03   0.029  7.04084E-03   0.020
                2   7.94716E-05   0.007  2.03480E-01   1.63816E+00   0.012  2.97974E-02   0.012  2.26942E-01   0.017
  6    4  1  22  gp#
                1   3.87267E-04   0.004  7.11758E-01   4.68324E-01   0.006  1.51048E-03   0.018  5.32675E-03   0.013
                2   7.65609E-05   0.010  2.69331E-01   1.23764E+00   0.014  2.35198E-02   0.013  1.50135E-01   0.017
  7    4  1  23  gp#
                1   3.80352E-04   0.003  5.99517E-01   5.56003E-01   0.005  2.26056E-03   0.017  9.18210E-03   0.013
                2   7.16546E-05   0.007  1.79222E-01   1.85989E+00   0.011  3.37579E-02   0.011  2.89314E-01   0.014
  8    4  1  24  gp#
                1   3.85929E-04   0.003  6.09690E-01   5.46726E-01   0.005  2.02534E-03   0.018  8.01844E-03   0.013
                2   7.36476E-05   0.007  1.76561E-01   1.88793E+00   0.011  3.38017E-02   0.011  2.89071E-01   0.014
  1    1  2  25  gp#
                1   4.19569E-04   0.003  6.46341E-01   5.15724E-01   0.006  1.70618E-03   0.021  6.68183E-03   0.016
                2   6.90502E-05   0.008  2.10729E-01   1.58181E+00   0.012  2.73875E-02   0.013  2.05876E-01   0.019
  2    1  2  26  gp#
                1   4.01605E-04   0.003  5.74784E-01   5.79928E-01   0.005  2.06125E-03   0.021  7.80132E-03   0.016
                2   6.17037E-05   0.007  1.79710E-01   1.85484E+00   0.012  3.19870E-02   0.013  2.48193E-01   0.018
  3    1  2  27  gp#
                1   5.21895E-04   0.002  5.92475E-01   5.62611E-01   0.004  2.15534E-03   0.016  8.49426E-03   0.012
                2   5.84766E-05   0.007  1.97555E-01   1.68729E+00   0.011  2.99972E-02   0.012  2.57072E-01   0.015
  4    1  2  28  gp#
                1   4.70133E-04   0.003  6.06876E-01   5.49261E-01   0.005  2.05273E-03   0.017  8.05053E-03   0.013
                2   7.11523E-05   0.007  1.80794E-01   1.84372E+00   0.012  3.16578E-02   0.012  2.67082E-01   0.015
  5    1  2  29  gp#
                1   4.70503E-04   0.003  5.90971E-01   5.64044E-01   0.005  2.20083E-03   0.017  8.76439E-03   0.012
                2   7.05229E-05   0.008  1.83113E-01   1.82037E+00   0.013  3.09309E-02   0.012  2.55175E-01   0.015
  1    2  2  30  gp#
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                1  4.47633E-04  0.003  5.92616E-01  5.62478E-01  0.005  2.28249E-03  0.016  9.16387E-03  0.013
                2  6.83403E-05  0.007  1.83707E-01  1.81449E+00  0.012  3.16204E-02  0.012  2.66814E-01  0.015
2    2  2  31  gp#
                1  4.72751E-04  0.004  7.10773E-01  4.68973E-01  0.005  1.47699E-03  0.015  5.21909E-03  0.012
                2  6.51313E-05  0.010  2.75863E-01  1.20833E+00  0.015  2.18072E-02  0.014  1.40213E-01  0.018
3    2  2  32  gp#
                1  4.36116E-04  0.006  8.36750E-01  3.98367E-01  0.009  5.67936E-04  0.015  7.08248E-04  0.029
                2  7.33852E-05  0.013  4.11278E-01  8.10482E-01  0.021  1.38937E-02  0.017  1.32691E-02  0.040
4    2  2  33  gp#
                1  4.89798E-04  0.004  6.76059E-01  4.93054E-01  0.007  1.51560E-03  0.021  5.16633E-03  0.018
                2  6.75232E-05  0.011  2.71030E-01  1.22988E+00  0.017  2.27954E-02  0.016  1.38877E-01  0.024
5    2  2  34  gp#
                1  3.63485E-04  0.003  4.71177E-01  7.07448E-01  0.006  1.94239E-03  0.016  6.86615E-03  0.015
                2  7.06649E-05  0.010  2.91462E-01  1.14366E+00  0.016  2.06389E-02  0.015  1.29130E-01  0.022
6    2  2  35  gp#
                1  3.37509E-04  0.003  4.72320E-01  7.05737E-01  0.005  2.29867E-03  0.017  8.29008E-03  0.012
                2  6.68248E-05  0.010  2.78855E-01  1.19537E+00  0.015  2.22782E-02  0.014  1.53660E-01  0.019
7    2  2  36  gp#
                1  4.03739E-04  0.003  5.88362E-01  5.66545E-01  0.005  1.96974E-03  0.023  7.42000E-03  0.016
                2  7.42401E-05  0.007  2.08689E-01  1.59727E+00  0.012  2.74406E-02  0.013  2.05790E-01  0.018
2    3  2  37  gp#
                1  4.51003E-04  0.003  6.05647E-01  5.50376E-01  0.005  2.03145E-03  0.015  7.99235E-03  0.012
                2  6.74914E-05  0.007  1.81816E-01  1.83335E+00  0.012  3.18871E-02  0.012  2.71780E-01  0.015
3    3  2  38  gp#
                1  5.11312E-04  0.002  5.93125E-01  5.61995E-01  0.004  2.15638E-03  0.014  8.77238E-03  0.011
                2  5.64826E-05  0.007  1.95748E-01  1.70287E+00  0.012  3.10048E-02  0.012  2.69352E-01  0.016
4    3  2  39  gp#
                1  4.92083E-04  0.004  6.73757E-01  4.94738E-01  0.007  1.39796E-03  0.020  4.82230E-03  0.018
                2  6.67077E-05  0.011  2.80828E-01  1.18696E+00  0.018  2.14269E-02  0.016  1.23509E-01  0.025
5    3  2  40  gp#
                1  4.42364E-04  0.006  8.22954E-01  4.05045E-01  0.009  5.73075E-04  0.014  7.76931E-04  0.030
                2  7.34106E-05  0.012  4.16299E-01  8.00707E-01  0.021  1.36663E-02  0.017  1.52468E-02  0.038
6    3  2  41  gp#
                1  5.85680E-04  0.003  5.98343E-01  5.57094E-01  0.005  2.09843E-03  0.016  8.25967E-03  0.013
                2  6.75187E-05  0.008  2.04361E-01  1.63110E+00  0.014  2.97570E-02  0.013  2.48066E-01  0.018
7    3  2  42  gp#
                1  5.43284E-04  0.002  5.93521E-01  5.61620E-01  0.004  2.19845E-03  0.014  8.92272E-03  0.011
                2  6.08897E-05  0.007  1.95783E-01  1.70257E+00  0.012  3.12514E-02  0.012  2.73428E-01  0.016
8    3  2  43  gp#
                1  4.21609E-04  0.003  5.78502E-01  5.76200E-01  0.005  2.07927E-03  0.021  7.92464E-03  0.016
                2  6.31126E-05  0.007  1.79874E-01  1.85315E+00  0.012  3.16054E-02  0.012  2.42246E-01  0.018
4    4  2  44  gp#
                1  3.98991E-04  0.003  5.76164E-01  5.78539E-01  0.005  2.02912E-03  0.022  7.87366E-03  0.014
                2  6.12565E-05  0.008  1.78854E-01  1.86371E+00  0.012  3.15692E-02  0.013  2.40872E-01  0.018
5    4  2  45  gp#
                1  4.25245E-04  0.003  6.42612E-01  5.18716E-01  0.005  1.80267E-03  0.020  6.85788E-03  0.015
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             2   7.22601E-05   0.007   2.10438E-01   1.58400E+00   0.012   2.74943E-02   0.012   2.08271E-01   0.018
6    4  2   46   gp#
             1   4.87944E-04   0.004   7.08061E-01   4.70769E-01   0.005   1.49817E-03   0.016   5.38139E-03   0.013
             2   6.80562E-05   0.010   2.80148E-01   1.18985E+00   0.014   2.17350E-02   0.013   1.42824E-01   0.017
7    4  2   47   gp#
             1   4.74919E-04   0.003   5.92583E-01   5.62509E-01   0.005   2.26041E-03   0.016   9.09741E-03   0.012
             2   7.04634E-05   0.007   1.84420E-01   1.80747E+00   0.012   3.17900E-02   0.011   2.68055E-01   0.015
8    4  2   48   gp#
             1   4.79409E-04   0.003   6.07021E-01   5.49130E-01   0.005   1.98694E-03   0.015   8.00336E-03   0.012
             2   6.83802E-05   0.007   1.81229E-01   1.83930E+00   0.012   3.22765E-02   0.012   2.76381E-01   0.015
1    1  3   49   gp#
             1   4.73367E-04   0.003   6.44812E-01   5.16946E-01   0.005   1.78488E-03   0.020   6.91646E-03   0.016
             2   7.59968E-05   0.007   2.08756E-01   1.59676E+00   0.012   2.78513E-02   0.012   2.15127E-01   0.018
2    1  3   50   gp#
             1   4.54045E-04   0.003   5.74003E-01   5.80717E-01   0.005   2.08947E-03   0.020   7.86827E-03   0.015
             2   6.88585E-05   0.007   1.80432E-01   1.84742E+00   0.012   3.21634E-02   0.012   2.52964E-01   0.017
3    1  3   51   gp#
             1   5.91747E-04   0.002   5.90074E-01   5.64900E-01   0.004   2.11292E-03   0.013   8.54216E-03   0.010
             2   6.56401E-05   0.007   1.96950E-01   1.69248E+00   0.011   3.02523E-02   0.011   2.60571E-01   0.015
4    1  3   52   gp#
             1   5.32964E-04   0.003   6.03683E-01   5.52166E-01   0.005   2.01789E-03   0.015   8.01398E-03   0.011
             2   7.77066E-05   0.007   1.81704E-01   1.83449E+00   0.011   3.20423E-02   0.011   2.75581E-01   0.014
5    1  3   53   gp#
             1   5.32918E-04   0.003   5.85564E-01   5.69252E-01   0.005   2.20789E-03   0.015   8.76451E-03   0.011
             2   7.56166E-05   0.007   1.84175E-01   1.80988E+00   0.012   3.11280E-02   0.011   2.61553E-01   0.015
1    2  3   54   gp#
             1   5.13604E-04   0.003   5.90207E-01   5.64774E-01   0.005   2.23828E-03   0.014   9.00607E-03   0.011
             2   7.25781E-05   0.007   1.86462E-01   1.78767E+00   0.012   3.14100E-02   0.011   2.65587E-01   0.015
2    2  3   55   gp#
             1   5.33248E-04   0.004   7.02633E-01   4.74406E-01   0.005   1.47674E-03   0.014   5.34885E-03   0.012
             2   6.69638E-05   0.010   2.75385E-01   1.21042E+00   0.014   2.20425E-02   0.013   1.50578E-01   0.017
3    2  3   56   gp#
             1   4.84662E-04   0.005   8.34216E-01   3.99577E-01   0.008   5.71641E-04   0.014   7.74637E-04   0.030
             2   7.03176E-05   0.013   4.15710E-01   8.01841E-01   0.021   1.34751E-02   0.018   1.60592E-02   0.040
4    2  3   57   gp#
             1   5.43857E-04   0.004   6.72743E-01   4.95484E-01   0.006   1.54570E-03   0.020   5.43212E-03   0.017
             2   6.65390E-05   0.011   2.70741E-01   1.23119E+00   0.017   2.27062E-02   0.016   1.43973E-01   0.024
5    2  3   58   gp#
             1   4.10529E-04   0.003   4.80243E-01   6.94093E-01   0.005   1.92677E-03   0.014   6.83554E-03   0.014
             2   6.92565E-05   0.011   2.83584E-01   1.17543E+00   0.016   2.04139E-02   0.015   1.27362E-01   0.021
6    2  3   59   gp#
             1   3.79252E-04   0.003   4.78517E-01   6.96597E-01   0.004   2.27089E-03   0.015   8.09959E-03   0.011
             2   6.88266E-05   0.010   2.72875E-01   1.22156E+00   0.015   2.25431E-02   0.014   1.60889E-01   0.018
7    2  3   60   gp#
             1   4.54812E-04   0.003   5.90003E-01   5.64969E-01   0.005   2.02630E-03   0.018   7.54790E-03   0.014
             2   7.51596E-05   0.007   2.08083E-01   1.60193E+00   0.012   2.79440E-02   0.012   2.16020E-01   0.018
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2    3 3  61  gp#
              1   5.20534E-04   0.003   5.99322E-01   5.56184E-01   0.005   2.01336E-03   0.014   8.20757E-03   0.011
              2   7.22690E-05   0.007   1.80962E-01   1.84201E+00   0.012   3.22905E-02   0.011   2.77005E-01   0.015
3    3 3  62  gp#
              1   5.79898E-04   0.002   5.87330E-01   5.67540E-01   0.004   2.16299E-03   0.014   8.70850E-03   0.011
              2   6.29814E-05   0.007   1.96652E-01   1.69504E+00   0.011   3.14543E-02   0.012   2.77690E-01   0.015
4    3 3  63  gp#
              1   5.49057E-04   0.004   6.76567E-01   4.92683E-01   0.006   1.39109E-03   0.018   4.86783E-03   0.017
              2   6.49970E-05   0.011   2.74049E-01   1.21633E+00   0.017   2.17459E-02   0.016   1.31713E-01   0.024
5    3 3  64  gp#
              1   4.96638E-04   0.005   8.23828E-01   4.04615E-01   0.008   5.75362E-04   0.013   7.45305E-04   0.024
              2   6.86052E-05   0.013   4.17969E-01   7.97506E-01   0.022   1.35528E-02   0.018   1.75698E-02   0.037
6    3 3  65  gp#
              1   6.59182E-04   0.003   5.97174E-01   5.58185E-01   0.005   1.98846E-03   0.014   7.87345E-03   0.011
              2   7.07984E-05   0.008   2.07094E-01   1.60957E+00   0.013   2.96532E-02   0.013   2.52394E-01   0.017
7    3 3  66  gp#
              1   6.17544E-04   0.002   5.92381E-01   5.62701E-01   0.004   2.17458E-03   0.013   8.80951E-03   0.010
              2   6.66480E-05   0.006   1.97048E-01   1.69164E+00   0.011   3.15548E-02   0.011   2.80701E-01   0.015
8    3 3  67  gp#
              1   4.75389E-04   0.003   5.75525E-01   5.79181E-01   0.005   2.08345E-03   0.017   7.89823E-03   0.014
              2   6.64069E-05   0.007   1.79594E-01   1.85603E+00   0.012   3.19414E-02   0.012   2.50800E-01   0.017
4    4 3  68  gp#
              1   4.48698E-04   0.003   5.71653E-01   5.83104E-01   0.005   2.06977E-03   0.021   7.99168E-03   0.014
              2   6.44836E-05   0.007   1.80580E-01   1.84590E+00   0.012   3.22228E-02   0.012   2.54794E-01   0.017
5    4 3  69  gp#
              1   4.77559E-04   0.003   6.43203E-01   5.18240E-01   0.005   1.75477E-03   0.017   6.88598E-03   0.014
              2   7.44909E-05   0.007   2.06495E-01   1.61425E+00   0.012   2.80510E-02   0.012   2.14294E-01   0.018
6    4 3  70  gp#
              1   5.48651E-04   0.004   7.01276E-01   4.75324E-01   0.005   1.48412E-03   0.014   5.38195E-03   0.011
              2   6.76717E-05   0.010   2.66920E-01   1.24881E+00   0.014   2.27204E-02   0.013   1.55215E-01   0.017
7    4 3  71  gp#
              1   5.28801E-04   0.003   5.91501E-01   5.63538E-01   0.004   2.22447E-03   0.014   8.98950E-03   0.012
              2   7.52648E-05   0.007   1.84619E-01   1.80552E+00   0.012   3.14472E-02   0.011   2.64488E-01   0.015
8    4 3  72  gp#
              1   5.36622E-04   0.003   6.02096E-01   5.53622E-01   0.005   1.99443E-03   0.015   7.99869E-03   0.011
              2   7.58199E-05   0.007   1.81570E-01   1.83583E+00   0.011   3.26155E-02   0.011   2.82219E-01   0.014
1    1 4  73  gp#
              1   4.95598E-04   0.003   6.42329E-01   5.18945E-01   0.005   1.85630E-03   0.020   7.09655E-03   0.014
              2   7.65826E-05   0.007   2.07396E-01   1.60723E+00   0.012   2.82045E-02   0.012   2.19122E-01   0.018
2    1 4  74  gp#
              1   4.74741E-04   0.003   5.73237E-01   5.81493E-01   0.005   2.02994E-03   0.018   7.73223E-03   0.014
              2   6.53160E-05   0.007   1.80689E-01   1.84479E+00   0.012   3.19563E-02   0.012   2.52757E-01   0.017
3    1 4  75  gp#
              1   6.17552E-04   0.002   5.89924E-01   5.65045E-01   0.004   2.11434E-03   0.013   8.57695E-03   0.010
              2   6.47233E-05   0.007   1.98247E-01   1.68140E+00   0.011   3.00745E-02   0.011   2.61156E-01   0.015
4    1 4  76  gp#
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              1   5.54906E-04   0.003   5.98247E-01   5.57183E-01   0.005   2.06425E-03   0.014   8.26737E-03   0.012
              2   7.84826E-05   0.007   1.81789E-01   1.83362E+00   0.011   3.18838E-02   0.011   2.73346E-01   0.014
5     1  4   77  gp#
              1   5.59030E-04   0.003   5.86904E-01   5.67952E-01   0.004   2.17250E-03   0.013   8.93458E-03   0.011
              2   7.94193E-05   0.007   1.85848E-01   1.79358E+00   0.012   3.10979E-02   0.011   2.61533E-01   0.015
1     2  4   78  gp#
              1   5.45929E-04   0.003   5.83797E-01   5.70974E-01   0.004   2.32829E-03   0.013   9.42288E-03   0.011
              2   7.66281E-05   0.007   1.85810E-01   1.79395E+00   0.012   3.16112E-02   0.011   2.68950E-01   0.015
2     2  4   79  gp#
              1   5.72757E-04   0.004   7.02362E-01   4.74589E-01   0.005   1.51826E-03   0.013   5.51785E-03   0.012
              2   6.98331E-05   0.010   2.68789E-01   1.24013E+00   0.014   2.22170E-02   0.013   1.52798E-01   0.017
3     2  4   80  gp#
              1   5.19869E-04   0.005   8.42344E-01   3.95721E-01   0.008   5.73404E-04   0.015   7.62600E-04   0.030
              2   6.97931E-05   0.013   4.16213E-01   8.00872E-01   0.021   1.31802E-02   0.018   1.64232E-02   0.037
4     2  4   81  gp#
              1   5.77842E-04   0.004   6.70467E-01   4.97166E-01   0.006   1.46156E-03   0.018   5.33161E-03   0.016
              2   6.69180E-05   0.011   2.72353E-01   1.22390E+00   0.017   2.20621E-02   0.016   1.40259E-01   0.023
5     2  4   82  gp#
              1   4.29114E-04   0.003   4.81279E-01   6.92599E-01   0.005   1.96094E-03   0.016   7.06802E-03   0.014
              2   6.93887E-05   0.010   2.80565E-01   1.18808E+00   0.016   2.09085E-02   0.015   1.32314E-01   0.022
6     2  4   83  gp#
              1   3.94965E-04   0.003   4.82497E-01   6.90851E-01   0.004   2.25521E-03   0.013   8.22500E-03   0.011
              2   6.70061E-05   0.010   2.67053E-01   1.24819E+00   0.014   2.32702E-02   0.014   1.67802E-01   0.017
7     2  4   84  gp#
              1   4.76817E-04   0.003   5.89908E-01   5.65060E-01   0.005   2.00938E-03   0.018   7.66695E-03   0.014
              2   7.65261E-05   0.007   2.10494E-01   1.58358E+00   0.012   2.79893E-02   0.012   2.18251E-01   0.017
2     3  4   85  gp#
              1   5.50896E-04   0.003   5.99793E-01   5.55748E-01   0.005   2.08201E-03   0.015   8.32685E-03   0.011
              2   7.81140E-05   0.007   1.83700E-01   1.81455E+00   0.011   3.18159E-02   0.011   2.71281E-01   0.015
3     3  4   86  gp#
              1   6.19988E-04   0.002   5.88726E-01   5.66194E-01   0.004   2.26812E-03   0.014   9.04748E-03   0.011
              2   6.59067E-05   0.007   1.96051E-01   1.70024E+00   0.011   3.11853E-02   0.011   2.75036E-01   0.015
4     3  4   87  gp#
              1   5.83982E-04   0.004   6.72068E-01   4.95981E-01   0.006   1.42319E-03   0.018   4.90042E-03   0.016
              2   6.62982E-05   0.011   2.71000E-01   1.23001E+00   0.017   2.19295E-02   0.016   1.37196E-01   0.024
5     3  4   88  gp#
              1   5.24364E-04   0.005   8.31794E-01   4.00740E-01   0.008   5.58804E-04   0.015   7.58792E-04   0.029
              2   6.79756E-05   0.013   4.18048E-01   7.97356E-01   0.022   1.32555E-02   0.018   1.81832E-02   0.036
6     3  4   89  gp#
              1   6.91119E-04   0.003   6.00405E-01   5.55181E-01   0.005   2.01805E-03   0.014   8.05769E-03   0.011
              2   7.32082E-05   0.008   2.08548E-01   1.59835E+00   0.013   2.90439E-02   0.013   2.45217E-01   0.017
7     3  4   90  gp#
              1   6.43603E-04   0.002   5.89682E-01   5.65276E-01   0.004   2.19672E-03   0.012   8.93065E-03   0.010
              2   6.92345E-05   0.006   1.96834E-01   1.69347E+00   0.011   3.11883E-02   0.011   2.76726E-01   0.015
8     3  4   91  gp#
              1   4.97354E-04   0.003   5.72837E-01   5.81899E-01   0.005   2.03215E-03   0.017   7.88302E-03   0.014
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            2   7.04551E-05   0.007  1.80126E-01   1.85056E+00   0.011  3.22406E-02   0.012  2.56408E-01   0.017
4    4  4  92  gp#
            1   4.71376E-04   0.003  5.73011E-01   5.81722E-01   0.005  1.99379E-03   0.019  7.87221E-03   0.013
            2   6.89676E-05   0.007  1.79383E-01   1.85823E+00   0.012  3.22200E-02   0.012  2.56974E-01   0.017
5    4  4  93  gp#
            1   5.04019E-04   0.003  6.41605E-01   5.19531E-01   0.005  1.81800E-03   0.019  7.01114E-03   0.014
            2   7.76999E-05   0.007  2.07931E-01   1.60310E+00   0.012  2.83287E-02   0.012  2.22775E-01   0.017
6    4  4  94  gp#
            1   5.75760E-04   0.004  7.02507E-01   4.74491E-01   0.005  1.50640E-03   0.013  5.50414E-03   0.011
            2   6.99798E-05   0.010  2.68697E-01   1.24055E+00   0.014  2.24759E-02   0.013  1.55884E-01   0.017
7    4  4  95  gp#
            1   5.60485E-04   0.002  5.85519E-01   5.69295E-01   0.004  2.32458E-03   0.014  9.36588E-03   0.011
            2   7.76100E-05   0.007  1.86165E-01   1.79052E+00   0.012  3.13266E-02   0.011  2.67246E-01   0.014
8    4  4  96  gp#
            1   5.63416E-04   0.002  6.00678E-01   5.54928E-01   0.004  2.07351E-03   0.014  8.26250E-03   0.011
            2   7.92088E-05   0.007  1.82228E-01   1.82921E+00   0.011  3.21363E-02   0.011  2.77996E-01   0.014
1    1  5  97  gp#
            1   4.76265E-04   0.003  6.37383E-01   5.22972E-01   0.005  1.87540E-03   0.019  7.03342E-03   0.015
            2   6.90748E-05   0.008  2.13494E-01   1.56133E+00   0.013  2.72775E-02   0.013  2.09613E-01   0.019
2    1  5  98  gp#
            1   4.58053E-04   0.003  5.72760E-01   5.81977E-01   0.005  2.14147E-03   0.019  8.13621E-03   0.014
            2   6.24233E-05   0.007  1.81749E-01   1.83403E+00   0.012  3.19598E-02   0.013  2.54660E-01   0.018
3    1  5  99  gp#
            1   6.07005E-04   0.002  5.86949E-01   5.67909E-01   0.004  2.23622E-03   0.014  8.86392E-03   0.010
            2   6.51117E-05   0.007  1.97614E-01   1.68679E+00   0.011  3.01634E-02   0.011  2.62232E-01   0.015
4    1  5 100  gp#
            1   5.40990E-04   0.003  5.94806E-01   5.60407E-01   0.005  2.23282E-03   0.014  8.75311E-03   0.012
            2   7.24350E-05   0.007  1.85126E-01   1.80057E+00   0.012  3.18222E-02   0.011  2.74738E-01   0.015
5    1  5 101  gp#
            1   5.54859E-04   0.003  5.80873E-01   5.73849E-01   0.005  2.30445E-03   0.014  9.12244E-03   0.011
            2   7.32119E-05   0.007  1.86069E-01   1.79145E+00   0.012  3.11882E-02   0.011  2.64705E-01   0.015
1    2  5 102  gp#
            1   5.36222E-04   0.003  5.85110E-01   5.69693E-01   0.004  2.25071E-03   0.014  9.20518E-03   0.011
            2   7.25825E-05   0.007  1.87012E-01   1.78242E+00   0.012  3.18630E-02   0.011  2.75377E-01   0.015
2    2  5 103  gp#
            1   5.64009E-04   0.004  7.04802E-01   4.72946E-01   0.005  1.49758E-03   0.013  5.32561E-03   0.011
            2   6.66115E-05   0.010  2.65913E-01   1.25354E+00   0.014  2.25803E-02   0.013  1.58930E-01   0.017
3    2  5 104  gp#
            1   5.23348E-04   0.005  8.30058E-01   4.01578E-01   0.008  5.77668E-04   0.014  7.37085E-04   0.028
            2   6.64925E-05   0.013  4.26309E-01   7.81906E-01   0.022  1.30134E-02   0.018  1.79399E-02   0.038
4    2  5 105  gp#
            1   5.76518E-04   0.004  6.68261E-01   4.98807E-01   0.006  1.54339E-03   0.018  5.38096E-03   0.016
            2   6.51104E-05   0.011  2.69000E-01   1.23916E+00   0.018  2.22893E-02   0.016  1.42978E-01   0.024
5    2  5 106  gp#
            1   4.28040E-04   0.003  4.83814E-01   6.88970E-01   0.005  1.98039E-03   0.015  6.86039E-03   0.013
            2   6.86540E-05   0.010  2.77238E-01   1.20233E+00   0.016  2.10052E-02   0.015  1.36896E-01   0.021
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6    2 5 107  gp#
          1   3.92779E-04   0.003  4.81190E-01  6.92728E-01  0.004  2.37888E-03  0.014  8.46918E-03  0.011
          2   6.66099E-05   0.010  2.68651E-01  1.24077E+00  0.015  2.29622E-02  0.014  1.68675E-01  0.018
7    2 5 108  gp#
          1   4.62016E-04   0.003  5.91079E-01  5.63940E-01  0.005  2.04420E-03  0.018  7.75714E-03  0.014
          2   7.50677E-05   0.007  2.12257E-01  1.57042E+00  0.012  2.74845E-02  0.012  2.14053E-01  0.018
2    3 5 109  gp#
          1   5.37964E-04   0.003  6.00186E-01  5.55384E-01  0.005  2.04274E-03  0.014  8.27726E-03  0.011
        2  7.30111E-05      0.007  1.85848E-01  1.79358E+00  0.011  3.19724E-02  0.011  2.76849E-01  0.015
3    3 5 110  gp#
        1  6.26930E-04      0.002  5.91165E-01  5.63858E-01  0.004  2.19450E-03  0.013  8.97665E-03  0.010
        2  6.64310E-05      0.006  1.97327E-01  1.68924E+00  0.011  3.13654E-02  0.011  2.78564E-01  0.015
4    3 5 111  gp#
        1  5.96313E-04      0.004  6.72316E-01  4.95799E-01  0.006  1.43852E-03  0.019  5.06269E-03  0.017
        2  6.63514E-05      0.011  2.69379E-01  1.23741E+00  0.018  2.19815E-02  0.016  1.39552E-01  0.024
5    3 5 112  gp#
        1  5.37061E-04      0.005  8.31008E-01  4.01119E-01  0.008  5.56506E-04  0.014  7.27361E-04  0.026
        2  6.47568E-05      0.013  4.19256E-01  7.95059E-01  0.022  1.31188E-02  0.019  1.79912E-02  0.040
6    3 5 113  gp#
        1  6.98284E-04      0.003  5.93693E-01  5.61458E-01  0.005  1.97688E-03  0.013  8.01854E-03  0.011
        2  7.17648E-05      0.008  2.05328E-01  1.62342E+00  0.014  2.89302E-02  0.013  2.39865E-01  0.017
7    3 5 114  gp#
        1  6.45402E-04      0.002  5.90317E-01  5.64668E-01  0.004  2.20887E-03  0.013  8.77409E-03  0.010
        2  6.82774E-05      0.006  1.97984E-01  1.68364E+00  0.011  3.06897E-02  0.011  2.70588E-01  0.015
8    3 5 115  gp#
        1  4.79366E-04      0.003  5.70181E-01  5.84610E-01  0.005  2.04390E-03  0.019  7.84260E-03  0.013
        2  6.76390E-05      0.007  1.82899E-01  1.82250E+00  0.012  3.13732E-02  0.012  2.48123E-01  0.017
4    4 5 116  gp#
        1  4.71010E-04      0.003  5.66822E-01  5.88074E-01  0.005  2.12736E-03  0.018  8.29906E-03  0.014
        2  6.29627E-05      0.008  1.82739E-01  1.82409E+00  0.013  3.15892E-02  0.013  2.48576E-01  0.018
5    4 5 117  gp#
        1  4.88528E-04      0.003  6.40212E-01  5.20661E-01  0.005  1.76394E-03  0.018  6.93422E-03  0.016
        2  7.18816E-05      0.007  2.11001E-01  1.57977E+00  0.012  2.77896E-02  0.013  2.16201E-01  0.019
6    4 5 118  gp#
        1  5.75316E-04      0.004  7.03273E-01  4.73975E-01  0.005  1.50252E-03  0.014  5.43318E-03  0.012
        2  6.47278E-05      0.010  2.68437E-01  1.24176E+00  0.014  2.25986E-02  0.013  1.59912E-01  0.017
7    4 5 119  gp#
        1  5.42474E-04      0.002  5.85911E-01  5.68915E-01  0.004  2.32922E-03  0.014  9.39959E-03  0.011
        2  7.06102E-05      0.007  1.88136E-01  1.77177E+00  0.012  3.14767E-02  0.011  2.68942E-01  0.015
8    4 5 120  gp#
        1  5.58397E-04      0.003  5.97149E-01  5.58208E-01  0.005  2.08424E-03  0.015  8.28948E-03  0.012
        2  7.26398E-05      0.007  1.85081E-01  1.80101E+00  0.011  3.14506E-02  0.011  2.69526E-01  0.014
1    1 6 121  gp#
        1  4.48169E-04      0.003  6.34556E-01  5.25301E-01  0.005  1.88870E-03  0.022  6.98395E-03  0.015
        2  5.71853E-05      0.009  2.25064E-01  1.48106E+00  0.015  2.59849E-02  0.015  1.96500E-01  0.021
2    1 6 122  gp#
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            1  4.33800E-04    0.003  5.61428E-01  5.93725E-01  0.005  2.20252E-03  0.019  8.12691E-03  0.015
            2  5.17236E-05    0.008  1.90788E-01  1.74714E+00  0.014  3.08290E-02  0.014  2.44158E-01  0.020
  3    1  6 123  gp#
            1  5.80031E-04    0.002  5.83266E-01  5.71495E-01  0.004  2.20676E-03  0.014  8.58127E-03  0.010
            2  5.87843E-05    0.007  2.00166E-01  1.66529E+00  0.012  3.01430E-02  0.012  2.64622E-01  0.016
  4    1  6 124  gp#
            1  4.96691E-04    0.003  5.89713E-01  5.65246E-01  0.005  2.09582E-03  0.019  8.44968E-03  0.011
            2  5.99953E-05    0.008  1.93429E-01  1.72329E+00  0.013  3.04171E-02  0.013  2.62365E-01  0.017
  5    1  6 125  gp#
            1  5.06045E-04    0.003  5.77075E-01  5.77626E-01  0.005  2.28993E-03  0.014  9.22587E-03  0.011
            2  5.88156E-05    0.008  1.92042E-01  1.73573E+00  0.014  3.05515E-02  0.013  2.64327E-01  0.017
  1    2  6 126  gp#
            1  5.04039E-04    0.003  5.77666E-01  5.77035E-01  0.005  2.26380E-03  0.014  9.28223E-03  0.010
            2  5.97615E-05    0.008  1.91543E-01  1.74025E+00  0.013  3.17982E-02  0.012  2.80190E-01  0.016
  2    2  6 127  gp#
            1  5.36070E-04    0.004  7.03343E-01  4.73927E-01  0.005  1.50887E-03  0.014  5.38906E-03  0.011
            2  6.12865E-05    0.010  2.68998E-01  1.23917E+00  0.015  2.23688E-02  0.014  1.57219E-01  0.018
  3    2  6 128  gp#
            1  5.04999E-04    0.005  8.33841E-01  3.99757E-01  0.008  5.83178E-04  0.015  7.58082E-04  0.037
            2  6.30525E-05    0.014  4.27141E-01  7.80383E-01  0.022  1.29291E-02  0.019  1.80151E-02  0.039
  4    2  6 129  gp#
            1  5.63428E-04    0.004  6.66345E-01  5.00241E-01  0.006  1.52188E-03  0.018  5.30847E-03  0.015
            2  6.24657E-05    0.012  2.72535E-01  1.22308E+00  0.018  2.23338E-02  0.017  1.46585E-01  0.024
  5    2  6 130  gp#
            1  4.17829E-04    0.003  4.89194E-01  6.81393E-01  0.005  1.92698E-03  0.015  6.85024E-03  0.014
            2  6.67040E-05    0.010  2.81095E-01  1.18584E+00  0.016  2.10509E-02  0.015  1.40752E-01  0.022
  6    2  6 131  gp#
            1  3.66630E-04    0.003  4.77462E-01  6.98136E-01  0.005  2.39170E-03  0.014  8.72512E-03  0.012
            2  6.04513E-05    0.011  2.74536E-01  1.21417E+00  0.015  2.27116E-02  0.014  1.67602E-01  0.019
  7    2  6 132  gp#
            1  4.22765E-04    0.003  5.83877E-01  5.70897E-01  0.005  2.05934E-03  0.018  7.75161E-03  0.015
            2  6.00429E-05    0.008  2.24939E-01  1.48188E+00  0.014  2.65841E-02  0.014  2.06296E-01  0.020
  2    3  6 133  gp#
            1  5.04245E-04    0.003  5.90250E-01  5.64733E-01  0.005  2.07184E-03  0.014  8.40204E-03  0.011
            2  5.91012E-05    0.008  1.93291E-01  1.72451E+00  0.013  3.08411E-02  0.013  2.69627E-01  0.016
  3    3  6 134  gp#
            1  5.96216E-04    0.002  5.85303E-01  5.69505E-01  0.004  2.24464E-03  0.014  9.12674E-03  0.010
            2  6.16738E-05    0.007  1.97773E-01  1.68544E+00  0.012  3.13093E-02  0.012  2.80652E-01  0.015
  4    3  6 135  gp#
            1  5.75714E-04    0.004  6.80574E-01  4.89782E-01  0.006  1.49098E-03  0.019  5.14245E-03  0.017
            2  6.33660E-05    0.012  2.77360E-01  1.20181E+00  0.018  2.17016E-02  0.017  1.39206E-01  0.025
  5    3  6 136  gp#
            1  5.19091E-04    0.005  8.25860E-01  4.03620E-01  0.008  5.52463E-04  0.013  7.23206E-04  0.025
            2  6.33294E-05    0.014  4.14470E-01  8.04239E-01  0.023  1.31683E-02  0.019  1.92727E-02  0.038
  6    3  6 137  gp#
            1  6.77423E-04    0.003  5.95562E-01  5.59695E-01  0.005  2.02910E-03  0.014  8.00138E-03  0.011
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            2  7.06349E-05     0.008  2.09056E-01  1.59447E+00  0.013  2.92538E-02  0.013  2.48216E-01  0.017
7     3  6 138  gp#
            1  6.05993E-04     0.002  5.86344E-01  5.68495E-01  0.004  2.25724E-03  0.013  9.05963E-03  0.010
            2  6.31794E-05     0.007  1.97999E-01  1.68351E+00  0.011  3.11860E-02  0.012  2.79285E-01  0.015
8     3  6 139  gp#
            1  4.40391E-04     0.003  5.60953E-01  5.94227E-01  0.005  2.11371E-03  0.019  8.17157E-03  0.014
            2  5.39443E-05     0.008  1.88036E-01  1.77271E+00  0.013  3.09810E-02  0.014  2.45542E-01  0.019
4     4  6 140  gp#
            1  4.44988E-04     0.003  5.62243E-01  5.92863E-01  0.005  2.16605E-03  0.019  8.36334E-03  0.016
            2  5.45397E-05     0.008  1.90975E-01  1.74543E+00  0.014  3.03453E-02  0.014  2.40273E-01  0.019
5     4  6 141  gp#
            1  4.61371E-04     0.003  6.35766E-01  5.24302E-01  0.005  1.81740E-03  0.018  7.10023E-03  0.015
            2  5.95579E-05     0.008  2.24034E-01  1.48787E+00  0.014  2.66009E-02  0.015  2.06387E-01  0.021
6     4  6 142  gp#
            1  5.51509E-04     0.004  7.09121E-01  4.70066E-01  0.005  1.47964E-03  0.014  5.34523E-03  0.011
            2  6.09632E-05     0.010  2.74246E-01  1.21545E+00  0.015  2.19586E-02  0.014  1.53483E-01  0.018
7     4  6 143  gp#
            1  5.09739E-04     0.003  5.83724E-01  5.71046E-01  0.005  2.32848E-03  0.014  9.33501E-03  0.011
            2  5.93874E-05     0.008  1.90556E-01  1.74927E+00  0.013  3.13364E-02  0.012  2.73800E-01  0.016
8     4  6 144  gp#
            1  5.11964E-04     0.003  5.93648E-01  5.61500E-01  0.005  2.15987E-03  0.015  8.40354E-03  0.011
            2  6.09059E-05     0.008  1.92346E-01  1.73299E+00  0.013  3.07307E-02  0.012  2.65846E-01  0.016
1     1  7 145  gp#
            1  4.25083E-04     0.003  6.26780E-01  5.31819E-01  0.005  2.00756E-03  0.019  6.71576E-03  0.015
            2  5.18893E-05     0.009  2.36668E-01  1.40844E+00  0.015  3.23576E-02  0.019  1.89586E-01  0.023
2     1  7 146  gp#
            1  4.97286E-04     0.004  7.11362E-01  4.68585E-01  0.006  1.62799E-03  0.018  6.38946E-03  0.015
            2  5.60711E-05     0.011  2.55863E-01  1.30278E+00  0.016  2.32203E-02  0.017  1.87300E-01  0.023
3     1  7 147  gp#
            1  5.43445E-04     0.002  5.88018E-01  5.66876E-01  0.004  2.18775E-03  0.014  8.74003E-03  0.011
            2  5.48721E-05     0.007  1.99833E-01  1.66806E+00  0.012  3.03751E-02  0.013  2.68254E-01  0.017
4     1  7 148  gp#
            1  4.58051E-04     0.003  5.86484E-01  5.68359E-01  0.005  2.21142E-03  0.015  8.80393E-03  0.012
            2  4.97897E-05     0.009  1.95373E-01  1.70614E+00  0.015  3.04413E-02  0.014  2.65406E-01  0.018
5     1  7 149  gp#
            1  4.64525E-04     0.003  5.74081E-01  5.80638E-01  0.005  2.32923E-03  0.015  9.21316E-03  0.011
            2  4.92848E-05     0.009  1.91778E-01  1.73812E+00  0.015  3.10273E-02  0.014  2.73949E-01  0.018
1     2  7 150  gp#
            1  4.49894E-04     0.003  5.76130E-01  5.78573E-01  0.005  2.32567E-03  0.015  9.42907E-03  0.011
            2  4.91917E-05     0.009  1.92935E-01  1.72770E+00  0.014  3.18037E-02  0.014  2.85593E-01  0.018
2     2  7 151  gp#
            1  4.92374E-04     0.004  7.01192E-01  4.75381E-01  0.005  1.49101E-03  0.013  5.38590E-03  0.012
            2  5.59696E-05     0.011  2.77229E-01  1.20237E+00  0.016  2.20092E-02  0.015  1.50371E-01  0.020
3     2  7 152  gp#
            1  4.96102E-04     0.005  8.18713E-01  4.07143E-01  0.008  7.56529E-04  0.017  6.92473E-04  0.028
            2  6.17666E-05     0.014  4.20732E-01  7.92270E-01  0.022  1.81864E-02  0.023  1.58341E-02  0.041
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4    2 7 153  gp#
            1  5.79243E-04    0.004  6.99611E-01  4.76455E-01  0.006  1.55203E-03  0.018  4.96178E-03  0.016
            2  6.38134E-05    0.011  2.87576E-01  1.15911E+00  0.018  2.47131E-02  0.019  1.40783E-01  0.024
5    2 7 154  gp#
            1  4.16728E-04    0.003  4.96434E-01  6.71455E-01  0.006  2.17355E-03  0.016  6.64423E-03  0.016
            2  6.25389E-05    0.011  2.88879E-01  1.15389E+00  0.016  2.50837E-02  0.018  1.30316E-01  0.022
6    2 7 155  gp#
            1  3.45126E-04    0.003  4.81811E-01  6.91835E-01  0.005  2.35380E-03  0.014  8.58233E-03  0.012
            2  5.57632E-05    0.011  2.76762E-01  1.20440E+00  0.016  2.26161E-02  0.015  1.64021E-01  0.020
7    2 7 156  gp#
            1  4.11124E-04    0.003  5.81283E-01  5.73444E-01  0.006  2.30621E-03  0.020  7.72387E-03  0.016
            2  5.18184E-05    0.009  2.34930E-01  1.41886E+00  0.015  3.23869E-02  0.018  1.92306E-01  0.023
2    3 7 157  gp#
            1  4.47322E-04    0.003  5.86882E-01  5.67973E-01  0.005  2.21710E-03  0.016  8.74445E-03  0.012
            2  4.87427E-05    0.008  1.97054E-01  1.69159E+00  0.014  3.01436E-02  0.014  2.61550E-01  0.018
3    3 7 158  gp#
            1  5.56505E-04    0.002  5.85720E-01  5.69100E-01  0.004  2.35569E-03  0.016  9.25126E-03  0.012
            2  5.85012E-05    0.007  2.01979E-01  1.65033E+00  0.012  3.02292E-02  0.012  2.69753E-01  0.016
4    3 7 159  gp#
            1  5.95861E-04    0.004  7.06412E-01  4.71868E-01  0.006  1.45395E-03  0.018  4.58892E-03  0.017
            2  6.55956E-05    0.011  2.98714E-01  1.11589E+00  0.018  2.28247E-02  0.019  1.23619E-01  0.026
5    3 7 160  gp#
            1  5.10086E-04    0.005  8.19478E-01  4.06763E-01  0.008  7.40260E-04  0.015  7.10914E-04  0.026
            2  6.06459E-05    0.014  4.12402E-01  8.08273E-01  0.023  1.82010E-02  0.023  1.68016E-02  0.040
6    3 7 161  gp#
            1  6.86505E-04    0.003  6.22531E-01  5.35448E-01  0.005  2.09416E-03  0.015  7.59542E-03  0.012
            2  7.17551E-05    0.008  2.24148E-01  1.48711E+00  0.014  3.05339E-02  0.016  2.22762E-01  0.018
7    3 7 162  gp#
            1  5.56908E-04    0.002  5.85794E-01  5.69029E-01  0.004  2.31309E-03  0.017  9.23225E-03  0.010
            2  5.72650E-05    0.007  1.99968E-01  1.66693E+00  0.012  3.03546E-02  0.012  2.69143E-01  0.016
8    3 7 163  gp#
            1  5.06028E-04    0.004  7.10404E-01  4.69216E-01  0.006  1.70068E-03  0.020  6.38892E-03  0.014
            2  5.97675E-05    0.011  2.63406E-01  1.26547E+00  0.016  2.19548E-02  0.017  1.73009E-01  0.022
4    4 7 164  gp#
            1  5.05549E-04    0.004  7.05320E-01  4.72599E-01  0.006  1.69096E-03  0.020  6.55411E-03  0.016
            2  6.02087E-05    0.011  2.57137E-01  1.29633E+00  0.016  2.28102E-02  0.016  1.80882E-01  0.022
5    4 7 165  gp#
            1  4.49342E-04    0.003  6.25136E-01  5.33218E-01  0.006  2.02392E-03  0.020  6.75811E-03  0.015
            2  5.16188E-05    0.009  2.34012E-01  1.42443E+00  0.015  3.15649E-02  0.018  1.89835E-01  0.022
6    4 7 166  gp#
            1  5.12783E-04    0.004  7.04857E-01  4.72909E-01  0.005  1.49437E-03  0.015  5.33588E-03  0.013
            2  5.57681E-05    0.011  2.70356E-01  1.23294E+00  0.015  2.28692E-02  0.015  1.61595E-01  0.019
7    4 7 167  gp#
            1  4.66566E-04    0.003  5.77924E-01  5.76777E-01  0.005  2.34870E-03  0.015  9.59704E-03  0.012
            2  5.04680E-05    0.008  1.94801E-01  1.71115E+00  0.014  3.22158E-02  0.013  2.91838E-01  0.017
8    4 7 168  gp#
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          1  4.59980E-04    0.003  5.86888E-01  5.67968E-01  0.005  2.20225E-03  0.017  8.64182E-03  0.012
          2  5.13806E-05    0.008  1.96808E-01  1.69370E+00  0.014  3.06013E-02  0.013  2.66841E-01  0.017
1    1 8 169  gp#
          1  3.38243E-04    0.003  5.96527E-01  5.58790E-01  0.006  2.00977E-03  0.023  7.27262E-03  0.019
          2  3.87205E-05    0.010  2.19084E-01  1.52148E+00  0.017  3.04441E-02  0.017  2.03429E-01  0.025
2    1 8 170  gp#
          1  4.00895E-04    0.003  6.44515E-01  5.17185E-01  0.006  1.84189E-03  0.021  7.16485E-03  0.017
          2  4.64403E-05    0.010  2.32131E-01  1.43597E+00  0.016  2.56179E-02  0.016  2.06090E-01  0.023
3    1 8 171  gp#
          1  4.82878E-04    0.002  5.84328E-01  5.70456E-01  0.004  2.22899E-03  0.017  8.85328E-03  0.015
          2  5.11361E-05    0.007  2.00446E-01  1.66296E+00  0.012  3.00054E-02  0.013  2.63770E-01  0.017
4    1 8 172  gp#
          1  4.08746E-04    0.003  5.87001E-01  5.67858E-01  0.005  2.17222E-03  0.016  8.50490E-03  0.013
          2  4.34839E-05    0.009  2.00584E-01  1.66181E+00  0.015  2.95824E-02  0.015  2.56327E-01  0.019
5    1 8 173  gp#
          1  4.18569E-04    0.003  5.72477E-01  5.82265E-01  0.005  2.40204E-03  0.017  9.39877E-03  0.013
          2  4.51223E-05    0.009  1.91958E-01  1.73649E+00  0.015  3.14008E-02  0.015  2.79795E-01  0.019
1    2 8 174  gp#
          1  3.92346E-04    0.003  5.73799E-01  5.80923E-01  0.005  2.39860E-03  0.017  9.52839E-03  0.012
          2  4.20242E-05    0.009  1.94342E-01  1.71519E+00  0.015  3.19279E-02  0.015  2.87597E-01  0.019
2    2 8 175  gp#
          1  4.37866E-04    0.004  7.00244E-01  4.76025E-01  0.006  1.52935E-03  0.017  5.36089E-03  0.013
          2  4.93946E-05    0.012  2.80104E-01  1.19003E+00  0.017  2.15287E-02  0.016  1.48045E-01  0.021
3    2 8 176  gp#
          1  4.06674E-04    0.006  7.82812E-01  4.25815E-01  0.009  7.13442E-04  0.016  7.62279E-04  0.027
          2  5.03910E-05    0.015  3.94353E-01  8.45266E-01  0.025  1.65732E-02  0.021  1.72871E-02  0.045
4    2 8 177  gp#
          1  4.77928E-04    0.004  6.60660E-01  5.04546E-01  0.007  1.66684E-03  0.020  5.49894E-03  0.018
          2  5.28502E-05    0.012  2.72429E-01  1.22356E+00  0.019  2.35410E-02  0.018  1.40940E-01  0.025
5    2 8 178  gp#
          1  3.33725E-04    0.003  4.62037E-01  7.21443E-01  0.006  2.32244E-03  0.017  7.86400E-03  0.016
          2  5.18977E-05    0.012  2.71418E-01  1.22812E+00  0.018  2.42405E-02  0.017  1.41182E-01  0.024
6    2 8 179  gp#
          1  3.07525E-04    0.003  4.79038E-01  6.95839E-01  0.005  2.40067E-03  0.016  8.55634E-03  0.012
          2  5.08579E-05    0.012  2.79220E-01  1.19380E+00  0.017  2.21083E-02  0.016  1.62821E-01  0.020
7    2 8 180  gp#
          1  3.20827E-04    0.003  5.40961E-01  6.16188E-01  0.006  2.31253E-03  0.020  8.34051E-03  0.018
          2  3.94658E-05    0.009  2.19743E-01  1.51693E+00  0.016  3.08858E-02  0.017  2.07618E-01  0.024
2    3 8 181  gp#
          1  3.99636E-04    0.003  5.85845E-01  5.68979E-01  0.005  2.19665E-03  0.018  8.73359E-03  0.014
          2  4.25257E-05    0.009  1.96485E-01  1.69648E+00  0.015  3.09136E-02  0.015  2.72161E-01  0.019
3    3 8 182  gp#
          1  4.90231E-04    0.002  5.82766E-01  5.71985E-01  0.004  2.37047E-03  0.015  9.44614E-03  0.012
          2  4.99410E-05    0.007  1.99251E-01  1.67293E+00  0.013  3.10868E-02  0.013  2.76090E-01  0.017
4    3 8 183  gp#
          1  4.89688E-04    0.004  6.63748E-01  5.02199E-01  0.007  1.56390E-03  0.022  5.11128E-03  0.019
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              2  5.26709E-05     0.012  2.72275E-01  1.22425E+00  0.019  2.34419E-02  0.018  1.36649E-01  0.027
 5     3  8 184  gp#
              1  4.10818E-04     0.006  7.78839E-01  4.27987E-01  0.009  7.05101E-04  0.018  7.81784E-04  0.029
              2  5.04595E-05     0.015  3.94804E-01  8.44302E-01  0.025  1.64990E-02  0.022  2.02834E-02  0.044
 6     3  8 185  gp#
              1  5.68004E-04     0.003  5.88314E-01  5.66590E-01  0.005  2.15359E-03  0.016  8.28325E-03  0.014
              2  5.94907E-05     0.008  2.09262E-01  1.59290E+00  0.014  3.08399E-02  0.014  2.42061E-01  0.019
 7     3  8 186  gp#
              1  4.99624E-04     0.002  5.83328E-01  5.71434E-01  0.004  2.26760E-03  0.015  8.97430E-03  0.011
              2  5.14854E-05     0.007  2.00361E-01  1.66366E+00  0.013  3.07270E-02  0.013  2.74264E-01  0.017
 8     3  8 187  gp#
              1  4.11593E-04     0.003  6.42581E-01  5.18742E-01  0.006  1.91552E-03  0.020  7.39037E-03  0.016
              2  4.65700E-05     0.010  2.36702E-01  1.40824E+00  0.016  2.52969E-02  0.017  2.03833E-01  0.023
 4     4  8 188  gp#
              1  4.09845E-04     0.003  6.37747E-01  5.22673E-01  0.006  1.94236E-03  0.020  7.38439E-03  0.017
              2  4.49267E-05     0.010  2.30524E-01  1.44598E+00  0.016  2.61434E-02  0.017  2.13955E-01  0.023
 5     4  8 189  gp#
              1  3.54887E-04     0.003  5.94826E-01  5.60388E-01  0.006  2.16894E-03  0.019  7.71885E-03  0.017
              2  3.90012E-05     0.009  2.16621E-01  1.53879E+00  0.016  3.19092E-02  0.017  2.23056E-01  0.026
 6     4  8 190  gp#
              1  4.49476E-04     0.004  6.98261E-01  4.77377E-01  0.006  1.54546E-03  0.015  5.48733E-03  0.013
              2  5.01387E-05     0.012  2.75225E-01  1.21113E+00  0.016  2.18818E-02  0.016  1.51917E-01  0.020
 7     4  8 191  gp#
              1  4.07959E-04     0.003  5.77406E-01  5.77295E-01  0.005  2.46431E-03  0.015  9.95682E-03  0.012
              2  4.26945E-05     0.009  1.95702E-01  1.70327E+00  0.015  3.16448E-02  0.014  2.85133E-01  0.018
 8     4  8 192  gp#
              1  4.08020E-04     0.003  5.85295E-01  5.69513E-01  0.005  2.18501E-03  0.016  8.64781E-03  0.012
              2  4.41111E-05     0.009  1.97563E-01  1.68722E+00  0.015  3.03867E-02  0.015  2.66682E-01  0.019
 1     1  9 193  gp#
              1  3.11933E-04     0.004  6.07249E-01  5.48923E-01  0.006  2.07238E-03  0.021  7.47469E-03  0.019
              2  3.80086E-05     0.010  2.29131E-01  1.45477E+00  0.017  3.34519E-02  0.020  1.94156E-01  0.026
 2     1  9 194  gp#
              1  3.73972E-04     0.004  7.12510E-01  4.67830E-01  0.007  1.73077E-03  0.028  6.46955E-03  0.019
              2  4.29400E-05     0.013  2.60801E-01  1.27811E+00  0.019  2.23689E-02  0.019  1.77339E-01  0.026
 3     1  9 195  gp#
              1  4.21032E-04     0.003  5.84867E-01  5.69930E-01  0.005  2.09967E-03  0.015  8.56009E-03  0.012
              2  4.28025E-05     0.008  2.00125E-01  1.66563E+00  0.014  3.00247E-02  0.014  2.63284E-01  0.018
 4     1  9 196  gp#
              1  3.52891E-04     0.003  5.84643E-01  5.70148E-01  0.006  2.11034E-03  0.017  8.36596E-03  0.013
              2  3.84335E-05     0.010  1.99034E-01  1.67476E+00  0.017  3.01042E-02  0.016  2.62270E-01  0.021
 5     1  9 197  gp#
              1  3.62628E-04     0.003  5.68124E-01  5.86727E-01  0.006  2.27992E-03  0.016  9.20584E-03  0.012
              2  3.88741E-05     0.010  1.95054E-01  1.70893E+00  0.016  3.10752E-02  0.016  2.76353E-01  0.020
 1     2  9 198  gp#
              1  3.41173E-04     0.003  5.75764E-01  5.78941E-01  0.005  2.47606E-03  0.017  9.80863E-03  0.013
              2  3.55777E-05     0.010  1.96151E-01  1.69937E+00  0.016  3.17879E-02  0.016  2.87257E-01  0.020
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2    2 9 199  gp#
          1  3.78487E-04    0.004  7.05051E-01  4.72779E-01  0.006  1.51650E-03  0.017  5.43747E-03  0.014
          2  4.30872E-05    0.013  2.79751E-01  1.19154E+00  0.018  2.15844E-02  0.017  1.44356E-01  0.022
3    2 9 200  gp#
          1  3.73055E-04    0.006  7.93654E-01  4.19998E-01  0.009  7.68803E-04  0.017  7.27035E-04  0.032
          2  4.74435E-05    0.015  4.14150E-01  8.04861E-01  0.025  1.90050E-02  0.024  1.76005E-02  0.044
4    2 9 201  gp#
          1  4.41663E-04    0.004  6.75270E-01  4.93630E-01  0.007  1.57051E-03  0.020  5.16539E-03  0.019
          2  4.87127E-05    0.012  2.94397E-01  1.13226E+00  0.020  2.39414E-02  0.020  1.34453E-01  0.028
5    2 9 202  gp#
          1  3.14129E-04    0.004  4.80421E-01  6.93836E-01  0.006  2.39947E-03  0.021  7.14361E-03  0.016
          2  4.59221E-05    0.012  2.72042E-01  1.22530E+00  0.019  2.65162E-02  0.019  1.37990E-01  0.025
6    2 9 203  gp#
          1  2.71412E-04    0.003  4.80648E-01  6.93508E-01  0.005  2.30715E-03  0.015  8.54607E-03  0.013
          2  4.37395E-05    0.012  2.76892E-01  1.20384E+00  0.018  2.28501E-02  0.017  1.67320E-01  0.022
7    2 9 204  gp#
          1  2.99334E-04    0.004  5.58952E-01  5.96354E-01  0.006  2.23744E-03  0.020  7.61149E-03  0.017
          2  3.55676E-05    0.010  2.31163E-01  1.44198E+00  0.017  3.29116E-02  0.019  2.05729E-01  0.025
2    3 9 205  gp#
          1  3.41858E-04    0.003  5.85498E-01  5.69316E-01  0.006  2.21609E-03  0.018  8.68661E-03  0.014
          2  3.67282E-05    0.010  1.98221E-01  1.68162E+00  0.016  3.01016E-02  0.016  2.60708E-01  0.020
3    3 9 206  gp#
          1  4.21584E-04    0.003  5.86273E-01  5.68563E-01  0.005  2.33127E-03  0.017  9.16204E-03  0.012
          2  4.38609E-05    0.008  1.99500E-01  1.67084E+00  0.014  3.10804E-02  0.014  2.78619E-01  0.019
4    3 9 207  gp#
          1  4.50003E-04    0.005  6.92879E-01  4.81085E-01  0.007  1.49067E-03  0.020  4.75111E-03  0.019
          2  4.76075E-05    0.013  2.87408E-01  1.15979E+00  0.021  2.39036E-02  0.021  1.30807E-01  0.029
5    3 9 208  gp#
          1  3.79711E-04    0.006  7.94938B-01  4.19320E-01  0.009  7.72563E-04  0.018  7.47994E-04  0.040
          2  4.52543E-05    0.016  3.97906E-01  8.37720E-01  0.026  1.90436E-02  0.024  1.78056E-02  0.045
6    3 9 209  gp#
          1  5.25603E-04    0.003  6.07526E-01  5.48674E-01  0.005  2.11417E-03  0.015  7.92873E-03  0.014
          2  5.23088E-05    0.009  2.16618E-01  1.53880E+00  0.015  3.16992E-02  0.016  2.37261E-01  0.020
7    3 9 210  gp#
          1  4.30324E-04    0.003  5.85868E-01  5.68956E-01  0.005  2.23454E-03  0.016  8.96579E-03  0.012
          2  4.35665E-05    0.008  2.01952E-01  1.65056E+00  0.014  2.99889E-02  0.014  2.65303E-01  0.018
8    3 9 211  gp#
          1  3.90318E-04    0.004  7.04551E-01  4.73114E-01  0.006  1.63715E-03  0.020  6.38095E-03  0.016
          2  4.20227E-05    0.013  2.63443E-01  1.26530E+00  0.018  2.33152E-02  0.020  1.93593E-01  0.027
4    4 9 212  gp#
          1  3.83313E-04    0.004  7.11107E-01  4.68752E-01  0.007  1.70924E-03  0.022  6.54166E-03  0.017
          2  4.26415E-05    0.013  2.59188E-01  1.28607E+00  0.019  2.31972E-02  0.019  1.89395E-01  0.026
5    4 9 213  gp#
          1  3.21971E-04    0.004  6.05042E-01  5.50926E-01  0.006  2.17319E-03  0.022  7.21999E-03  0.019
          2  3.54089E-05    0.010  2.27335E-01  1.46626E+00  0.017  3.29233E-02  0.019  1.97323E-01  0.026
6    4 9 214  gp#
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           1  3.92109E-04     0.004  7.03118E-01  4.74079E-01  0.006  1.47437E-03  0.016  5.25380E-03  0.014
           2  4.30876E-05     0.013  2.77069E-01  1.20307E+00  0.018  2.18588E-02  0.017  1.48454E-01  0.022
 7    4  9 215  gp#
           1  3.45204E-04     0.003  5.75650E-01  5.79055E-01  0.005  2.30745E-03  0.017  9.42791E-03  0.013
           2  3.53408E-05     0.010  1.96584E-01  1.69563E+00  0.016  3.18175E-02  0.016  2.89322E-01  0.020
 8    4  9 216  gp#
           1  3.42295E-04     0.003  5.87437E-01  5.67437E-01  0.006  2.14136E-03  0.017  8.49901E-03  0.013
           2  3.62168E-05     0.010  1.99154E-01  1.67374E+00  0.016  3.03326E-02  0.016  2.68434E-01  0.020
 1    1  10 217  gp#
           1  2.58620E-04     0.004  6.00765E-01  5.54848E-01  0.007  2.13113E-03  0.023  7.38551E-03  0.019
           2  3.14183E-05     0.011  2.28472E-01  1.45897E+00  0.018  3.42261E-02  0.021  2.07800E-01  0.028
 2    1  10 218  gp#
           1  3.12610E-04     0.005  7.12753E-01  4.67670E-01  0.007  1.72964E-03  0.024  6.59712E-03  0.021
           2  3.70239E-05     0.014  2.63522E-01  1.26492E+00  0.021  2.23211E-02  0.021  1.77555E-01  0.029
 3    1  10 219  gp#
           1  3.55853E-04     0.003  5.88273E-01  5.66630E-01  0.005  2.24223E-03  0.019  8.81058E-03  0.014
           2  3.81110E-05     0.009  1.99804E-01  1.66830E+00  0.015  2.94586E-02  0.015  2.55889E-01  0.020
 4    1  10 220  gp#
           1  2.97642E-04     0.004  5.88274E-01  5.66629E-01  0.006  2.27093E-03  0.021  8.90778E-03  0.015
           2  3.36336E-05     0.011  1.96851E-01  1.69333E+00  0.019  2.90803E-02  0.018  2.45540E-01  0.023
 5    1  10 221  gp#
           1  3.02337E-04     0.003  5.71211E-01  5.83556E-01  0.006  2.33416E-03  0.019  9.21633E-03  0.016
           2  3.13507E-05     0.011  1.91202E-01  1.74336E+00  0.018  3.18353E-02  0.018  2.84278E-01  0.023
 1    2  10 222  gp#
           1  2.81711E-04     0.003  5.75685E-01  5.79020E-01  0.006  2.47142E-03  0.022  9.63443E-03  0.014
           2  2.96850E-05     0.010  1.95190E-01  1.70774E+00  0.017  3.20984E-02  0.017  2.93157E-01  0.022
 2    2  10 223  gp#
           1  3.17197E-04     0.005  6.95875E-01  4.79013E-01  0.007  1.52712E-03  0.017  5.42428E-03  0.015
           2  3.76443E-05     0.014  2.87134E-01  1.16090E+00  0.019  2.17066E-02  0.018  1.46790E-01  0.024
 3    2  10 224  gp#
           1  3.14256E-04     0.007  7.93731E-01  4.19958E-01  0.010  7.54145E-04  0.020  7.47425E-04  0.034
           2  4.20524E-05     0.017  4.18492E-01  7.96511E-01  0.026  1.89943E-02  0.026  1.60209E-02  0.049
 4    2  10 225  gp#
           1  3.79151E-04     0.005  6.82633E-01  4.88305E-01  0.008  1.59812E-03  0.021  5.13000E-03  0.021
           2  4.44710E-05     0.013  2.79035E-01  1.19459E+00  0.021  2.51988E-02  0.021  1.37938E-01  0.028
 5    2  10 226  gp#
           1  2.66669E-04     0.004  4.90527E-01  6.79541E-01  0.007  2.31453E-03  0.020  7.30992E-03  0.020
           2  4.18791E-05     0.013  2.71412E-01  1.22815E+00  0.021  2.63023E-02  0.021  1.33600E-01  0.027
 6    2  10 227  gp#
           1  2.30216E-04     0.003  4.86387E-01  6.85325E-01  0.006  2.45944E-03  0.019  8.76763E-03  0.016
           2  3.78646E-05     0.014  2.77757E-01  1.20009E+00  0.019  2.30820E-02  0.019  1.64272E-01  0.024
 7    2  10 228  gp#
           1  2.51261E-04     0.004  5.57482E-01  5.97927E-01  0.007  2.42261E-03  0.023  8.23877E-03  0.020
           2  2.87168E-05     0.011  2.32017E-01  1.43668E+00  0.019  3.29679E-02  0.021  2.08498E-01  0.029
 2    3  10 229  gp#
           1  2.89790E-04     0.003  5.85777E-01  5.69045E-01  0.006  2.29522E-03  0.018  8.88514E-03  0.014
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            2  3.03961E-05     0.011  1.98898E-01  1.67590E+00  0.018  2.99614E-02  0.017  2.57793E-01  0.022
3    3  10 230  gp#
            1  3.60693E-04     0.003  5.85917E-01  5.68908E-01  0.005  2.27284E-03  0.017  9.38560E-03  0.014
            2  3.69453E-05     0.009  1.98524E-01  1.67906E+00  0.015  3.08584E-02  0.015  2.75898E-01  0.020
4    3  10 231  gp#
            1  3.80464E-04     0.005  6.95856E-01  4.79026E-01  0.008  1.51517E-03  0.023  4.61297E-03  0.021
            2  4.30767E-05     0.013  2.84861E-01  1.17016E+00  0.021  2.47572E-02  0.022  1.31529E-01  0.030
5    3  10 232  gp#
            1  3.23573E-04     0.007  7.86065E-01  4.24053E-01  0.010  7.66611E-04  0.021  7.16751E-04  0.051
            2  3.95551E-05     0.017  4.01817E-01  8.29565E-01  0.028  1.96664E-02  0.027  1.58453E-02  0.048
6    3  10 233  gp#
            1  4.42143E-04     0.003  6.07474E-01  5.48720E-01  0.006  2.08405E-03  0.017  7.80891E-03  0.014
            2  4.37412E-05     0.010  2.17526E-01  1.53238E+00  0.017  3.07111E-02  0.018  2.30551E-01  0.022
7    3  10 234  gp#
            1  3.66265E-04     0.003  5.88327E-01  5.66579E-01  0.005  2.29920E-03  0.018  9.12079E-03  0.014
            2  3.70358E-05     0.009  1.99298E-01  1.67253E+00  0.015  3.05984E-02  0.016  2.71680E-01  0.021
8    3  10 235  gp#
            1  3.26086E-04     0.005  7.11123E-01  4.68742E-01  0.007  1.75383E-03  0.022  6.40184E-03  0.018
            2  3.42453E-05     0.014  2.60709E-01  1.27857E+00  0.021  2.29188E-02  0.022  1.86980E-01  0.029
4    4  10 236  gp#
            1  3.22615E-04     0.005  7.04172E-01  4.73370E-01  0.007  1.74004E-03  0.023  6.57892E-03  0.018
            2  3.73157E-05     0.014  2.64880E-01  1.25843E+00  0.020  2.22051E-02  0.021  1.76454E-01  0.028
5    4  10 237  gp#
            1  2.69881E-04     0.004  6.00050E-01  5.55509E-01  0.007  2.15703E-03  0.023  7.09396E-03  0.019
            2  3.19126E-05     0.011  2.23535E-01  1.49119E+00  0.018  3.37870E-02  0.020  2.04340E-01  0.028
6    4  10 238  gp#
            1  3.27686E-04     0.005  7.04283E-01  4.73295E-01  0.007  1.47157E-03  0.016  5.39482E-03  0.016
            2  3.72966E-05     0.013  2.73875E-01  1.21710E+00  0.019  2.24172E-02  0.018  1.52323E-01  0.023
7    4  10 239  gp#
            1  2.84671E-04     0.003  5.73960E-01  5.80760E-01  0.006  2.39475E-03  0.019  9.71596E-03  0.014
            2  3.19274E-05     0.010  1.93402E-01  1.72353E+00  0.017  3.17376E-02  0.017  2.85248E-01  0.021
8    4  10 240  gp#
            1  2.86073E-04     0.003  5.89476E-01  5.65474E-01  0.006  2.16801E-03  0.020  8.58701E-03  0.015
            2  3.05507E-05     0.011  1.98871E-01  1.67613E+00  0.017  3.02569E-02  0.017  2.63385E-01  0.022
1    1  11 241  gp#
            1  2.10013E-04     0.004  6.03930E-01  5.51940E-01  0.008  2.11126E-03  0.025  7.54377E-03  0.023
            2  2.47903E-05     0.012  2.23563E-01  1.49100E+00  0.022  3.47083E-02  0.024  2.12287E-01  0.032
2    1  11 242  gp#
            1  2.50080E-04     0.005  7.19896E-01  4.63030E-01  0.008  1.58466E-03  0.024  6.11239E-03  0.020
            2  2.74491E-05     0.016  2.66951E-01  1.24867E+00  0.024  2.23094E-02  0.024  1.75943E-01  0.033
3    1  11 243  gp#
            1  2.87147E-04     0.003  5.93803E-01  5.61354E-01  0.006  2.28127E-03  0.024  8.71450E-03  0.015
            2  2.92654E-05     0.010  1.99922E-01  1.66732E+00  0.017  2.94508E-02  0.017  2.55611E-01  0.022
4    1  11 244  gp#
            1  2.41021E-04     0.004  5.92457E-01  5.62629E-01  0.007  2.08445E-03  0.020  8.40040E-03  0.016
            2  2.58689E-05     0.013  1.98733E-01  1.67730E+00  0.021  2.93629E-02  0.020  2.49998E-01  0.027
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5    1  11 245  gp#
          1  2.47861E-04    0.004  5.75513E-01  5.79193E-01  0.007  2.30462E-03  0.021  9.29036E-03  0.016
          2  2.61078E-05    0.012  1.92479E-01  1.73179E+00  0.019  3.12800E-02  0.019  2.77937E-01  0.025
1    2  11 246  gp#
          1  2.32209E-04    0.004  5.75172E-01  5.79537E-01  0.007  2.43171E-03  0.024  9.80162E-03  0.016
          2  2.47867E-05    0.011  1.90956E-01  1.74560E+00  0.018  3.35301E-02  0.018  3.06559E-01  0.024
2    2  11 247  gp#
          1  2.59409E-04    0.005  7.06406E-01  4.71872E-01  0.008  1.48373E-03  0.021  5.39987E-03  0.017
          2  3.29699E-05    0.014  2.82659E-01  1.17928E+00  0.020  2.20659E-02  0.019  1.43506E-01  0.025
3    2  11 248  gp#
          1  2.54634E-04    0.008  7.84674E-01  4.24805E-01  0.011  8.18750E-04  0.022  7.15795E-04  0.037
          2  3.91364E-05    0.017  3.99689E-01  8.33982E-01  0.026  2.02642E-02  0.026  1.36265E-02  0.052
4    2  11 249  gp#
          1  3.05829E-04    0.005  6.81469E-01  4.89140E-01  0.009  1.53394E-03  0.022  4.96000E-03  0.020
          2  4.00415E-05    0.014  2.85131E-01  1.16905E+00  0.022  2.59624E-02  0.022  1.35959E-01  0.031
5    2  11 250  gp#
          1  2.16851E-04    0.004  4.99521E-01  6.67306E-01  0.007  2.19389E-03  0.023  6.85637E-03  0.021
          2  3.74712E-05    0.014  2.62468E-01  1.27000E+00  0.022  2.82128E-02  0.022  1.26719E-01  0.029
6    2  11 251  gp#
          1  1.84297E-04    0.004  4.95194E-01  6.73136E-01  0.006  2.38807E-03  0.019  8.76279E-03  0.016
          2  3.34563E-05    0.015  2.76709E-01  1.20464E+00  0.021  2.38285E-02  0.020  1.54916E-01  0.026
7    2  11 252  gp#
          1  1.97116E-04    0.004  5.67331E-01  5.87546E-01  0.008  2.50400E-03  0.031  8.43071E-03  0.024
          2  2.57432E-05    0.011  2.22234E-01  1.49992E+00  0.020  3.36497E-02  0.022  2.05334E-01  0.031
2    3  11 253  gp#
          1  2.34974E-04    0.004  5.84772E-01  5.70022E-01  0.007  2.04481E-03  0.019  8.52325E-03  0.017
          2  2.71274E-05    0.012  2.00386E-01  1.66346E+00  0.019  3.02020E-02  0.018  2.62548E-01  0.024
3    3  11 254  gp#
          1  2.92742E-04    0.003  5.88797E-01  5.66126E-01  0.006  2.21537E-03  0.022  8.87483E-03  0.015
          2  3.08850E-05    0.009  1.99340E-01  1.67218E+00  0.016  3.11904E-02  0.016  2.78914E-01  0.021
4    3  11 255  gp#
          1  3.06406E-04    0.006  6.90640E-01  4.82644E-01  0.009  1.45660E-03  0.022  4.70613E-03  0.024
          2  3.88493E-05    0.014  2.85237E-01  1.16862E+00  0.023  2.50161E-02  0.024  1.20168E-01  0.032
5    3  11 256  gp#
          1  2.56923E-04    0.008  7.89153E-01  4.22394E-01  0.011  7.77597E-04  0.021  7.48621E-04  0.039
          2  3.83988E-05    0.017  3.93535E-01  8.47023E-01  0.028  2.00270E-02  0.027  1.61564E-02  0.053
6    3  11 257  gp#
          1  3.61742E-04    0.004  6.11494E-01  5.45113E-01  0.006  2.11133E-03  0.019  7.74287E-03  0.017
          2  3.83397E-05    0.011  2.14207E-01  1.55613E+00  0.019  3.08020E-02  0.019  2.28569E-01  0.024
7    3  11 258  gp#
          1  2.93560E-04    0.003  5.89029E-01  5.65903E-01  0.006  2.24808E-03  0.018  9.08528E-03  0.015
          2  3.04703E-05    0.009  1.97409E-01  1.68854E+00  0.016  3.10990E-02  0.017  2.76277E-01  0.022
8    3  11 259  gp#
          1  2.67205E-04    0.005  7.04195E-01  4.73354E-01  0.008  1.71849E-03  0.026  6.57139E-03  0.020
          2  2.91453E-05    0.015  2.66852E-01  1.24913E+00  0.022  2.23133E-02  0.023  1.80498E-01  0.032
4    4  11 260  gp#
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          1  2.61082E-04    0.005  7.09714E-01  4.69672E-01  0.008  1.56293E-03  0.025  6.05377E-03   0.022
          2  3.11264E-05    0.015  2.59832E-01  1.28288E+00  0.022  2.30039E-02  0.022  1.83638E-01   0.030
 5    4  11 261   gp#
          1  2.13618E-04    0.004  6.08847E-01  5.47483E-01  0.008  2.13706E-03  0.027  7.13572E-03   0.021
          2  2.49943E-05    0.012  2.29148E-01  1.45466E+00  0.020  3.44837E-02  0.023  1.93860E-01   0.032
 6    4  11 262   gp#
          1  2.62769E-04    0.005  7.02672E-01  4.74380E-01  0.008  1.52577E-03  0.021  5.33742E-03   0.016
          2  3.22264E-05    0.015  2.83069E-01  1.17757E+00  0.022  2.11503E-02  0.020  1.32825E-01   0.026
 7    4  11 263   gp#
          1  2.29640E-04    0.004  5.74183E-01  5.80535E-01  0.007  2.38550E-03  0.020  9.72179E-03   0.016
          2  2.43129E-05    0.012  1.94208E-01  1.71637E+00  0.019  3.17312E-02  0.019  2.83786E-01   0.025
 8    4  11 264   gp#
          1  2.31506E-04    0.004  5.86157E-01  5.68675E-01  0.007  2.32232E-03  0.024  8.85053E-03   0.018
          2  2.54244E-05    0.013  1.98253E-01  1.68135E+00  0.022  2.94991E-02  0.020  2.53216E-01   0.026
 1    1  12 265   gp#
          1  1.52696E-04    0.005  6.08211E-01  5.48055E-01  0.009  2.14766E-03  0.030  7.47278E-03   0.028
          2  2.46944E-05    0.012  2.18189E-01  1.52773E+00  0.020  3.60190E-02  0.022  2.02622E-01   0.031
 2    1  12 266   gp#
          1  1.91719E-04    0.006  7.10915E-01  4.68879E-01  0.009  1.66884E-03  0.030  6.36640E-03   0.023
          2  3.03332E-05    0.015  2.64820E-01  1.25872E+00  0.022  2.31048E-02  0.023  1.82236E-01   0.031
 3    1  12 267   gp#
          1  2.16276E-04    0.004  5.91365E-01  5.63668E-01  0.006  2.15886E-03  0.024  8.60465E-03   0.017
          2  3.00087E-05    0.010  1.91170E-01  1.74365E+00  0.016  3.21720E-02  0.017  2.81495E-01   0.022
 4    1  12 268   gp#
          1  1.76509E-04    0.004  5.95132E-01  5.60100E-01  0.008  2.18712E-03  0.030  8.77064E-03   0.022
          2  2.54304E-05    0.012  1.89179E-01  1.76200E+00  0.020  3.13484E-02  0.019  2.68575E-01   0.025
 5    1  12 269   gp#
          1  1.83885E-04    0.005  5.76700E-01  5.78001E-01  0.008  2.12680E-03  0.023  9.05617E-03   0.019
          2  2.49332E-05    0.012  1.83272E-01  1.81880E+00  0.020  3.36797E-02  0.019  3.01035E-01   0.024
 1    2  12 270   gp#
          1  1.69891E-04    0.004  5.79424E-01  5.75284E-01  0.008  2.38011E-03  0.023  9.59638E-03   0.017
          2  2.40555E-05    0.011  1.87522E-01  1.77757E+00  0.018  3.56112E-02  0.018  3.31846E-01   0.023
 2    2  12 271   gp#
          1  1.93677E-04    0.006  7.08892E-01  4.70217E-01  0.009  1.51413E-03  0.023  5.33269E-03   0.019
          2  3.62292E-05    0.015  2.81183E-01  1.18547E+00  0.021  2.28493E-02  0.020  1.42657E-01   0.025
 3    2  12 272   gp#
          1  1.90194E-04    0.009  7.81857E-01  4.26335E-01  0.013  8.38216E-04  0.024  6.86268E-04   0.037
          2  4.47286E-05    0.017  3.75499E-01  8.87707E-01  0.027  2.21975E-02  0.026  1.36014E-02   0.051
 4    2  12 273   gp#
          1  2.29329E-04    0.006  6.78682E-01  4.91148E-01  0.010  1.60058E-03  0.028  5.03114E-03   0.026
          2  4.21019E-05    0.014  2.84480E-01  1.17173E+00  0.022  2.66838E-02  0.022  1.27256E-01   0.031
 5    2  12 274   gp#
          1  1.60428E-04    0.005  5.01415E-01  6.64786E-01  0.011  2.23596E-03  0.022  7.07478E-03   0.022
          2  3.96643E-05    0.014  2.41536E-01  1.38006E+00  0.027  3.12843E-02  0.022  1.33981E-01   0.028
 6    2  12 275   gp#
          1  1.37183E-04    0.004  5.00607E-01  6.65859E-01  0.008  2.22309E-03  0.022  8.60368E-03   0.019
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           2   3.59746E-05     0.015  2.59956E-01  1.28227E+00  0.024  2.61168E-02  0.022  1.54487E-01  0.026
 7    2   12 276  gp#
           1   1.46673E-04     0.005  5.69366E-01  5.85446E-01  0.009  2.32420E-03  0.030  7.98387E-03  0.025
           2   2.59720E-05     0.012  2.11092E-01  1.57909E+00  0.023  3.61357E-02  0.023  2.03633E-01  0.031
 2    3   12 277  gp#
           1   1.73985E-04     0.004  5.85913E-01  5.68913E-01  0.008  2.15947E-03  0.025  8.36799E-03  0.018
           2   2.41063E-05     0.012  1.90831E-01  1.74675E+00  0.020  3.17772E-02  0.019  2.74404E-01  0.025
 3    3   12 278  gp#
           1   2.14956E-04     0.004  5.91226E-01  5.63801E-01  0.006  2.23680E-03  0.022  8.60466E-03  0.016
           2   3.05383E-05     0.010  1.89384E-01  1.76010E+00  0.016  3.30766E-02  0.016  2.93305E-01  0.022
 4    3   12 279  gp#
           1   2.27313E-04     0.006  6.91629E-01  4.81954E-01  0.010  1.58034E-03  0.030  4.77893E-03  0.031
           2   4.13006E-05     0.014  2.78159E-01  1.19836E+00  0.022  2.61770E-02  0.023  1.21833E-01  0.032
 5    3   12 280  gp#
           1   1.86478E-04     0.009  7.73132E-01  4.31147E-01  0.013  8.21756E-04  0.022  7.45666E-04  0.042
           2   4.26124E-05     0.017  3.90140E-01  8.54394E-01  0.026  2.14140E-02  0.026  1.60003E-02  0.050
 6    3   12 281  gp#
           1   2.67431E-04     0.004  6.09961E-01  5.46483E-01  0.008  2.11665E-03  0.026  7.71964E-03  0.018
           2   3.94900E-05     0.010  2.04970E-01  1.62626E+00  0.017  3.47934E-02  0.018  2.61119E-01  0.022
 7    3   12 282  gp#
           1   2.18838E-04     0.004  5.92978E-01  5.62134E-01  0.006  2.25062E-03  0.026  9.01479E-03  0.017
           2   3.10889E-05     0.010  1.88735E-01  1.76615E+00  0.016  3.30757E-02  0.017  2.93868E-01  0.022
 8    3   12 283  gp#
           1   1.94627E-04     0.006  7.15075E-01  4.66151E-01  0.009  1.79137E-03  0.030  6.71506E-03  0.024
           2   2.96221E-05     0.016  2.58931E-01  1.28735E+00  0.023  2.35016E-02  0.023  1.86324E-01  0.031
 4    4   12 284  gp#
           1   1.88140E-04     0.006  7.06838E-01  4.71584E-01  0.009  1.76143E-03  0.033  6.62879E-03  0.025
           2   3.03258E-05     0.015  2.55578E-01  1.30423E+00  0.022  2.39660E-02  0.023  1.92168E-01  0.032
 5    4   12 285  gp#
           1   1.55535E-04     0.005  6.07260E-01  5.48913E-01  0.009  2.18649E-03  0.031  7.34456E-03  0.027
           2   2.59414E-05     0.012  2.21358E-01  1.50586E+00  0.020  3.71765E-02  0.023  2.04527E-01  0.031
 6    4   12 286  gp#
           1   1.88912E-04     0.006  7.09346E-01  4.69916E-01  0.009  1.48190E-03  0.022  5.33843E-03  0.020
           2   3.46479E-05     0.015  2.81243E-01  1.18522E+00  0.021  2.22631E-02  0.020  1.34085E-01  0.026
 7    4   12 287  gp#
           1   1.69746E-04     0.004  5.85017E-01  5.69784E-01  0.008  2.38471E-03  0.025  9.49299E-03  0.020
           2   2.34136E-05     0.013  1.84526E-01  1.80643E+00  0.021  3.40566E-02  0.020  3.05902E-01  0.025
 8    4   12 288  gp#
           1   1.75103E-04     0.004  5.92226E-01  5.62848E-01  0.008  2.16968E-03  0.026  8.34971E-03  0.020
           2   2.38501E-05     0.013  1.92970E-01  1.72739E+00  0.020  3.15979E-02  0.020  2.72150E-01  0.025

AVERAGE NU  :  NU(1) =   2.45326E+00,           NU(2) =   2.43670E+00
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APPENDIX D

ONE GROUP BALANCE CHECK RESULTS

The ratios of residual to total loss and total source are given in percent.

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 I   J  K  TOTAL LEAKAGE TOTAL ABSORP  TOTAL LOSS   TOTAL SOURCE   RESIDUAL     RESID/LOSS    RESID/SOURCE
17   9  5   2.09500E-05  1.08633E-05   3.18133E-05  1.94863E-05  1.23269E-05   3.87478E+01  6.32595E+01
18   9  5   2.04100E-05  1.12020E-05   3.16120E-05  2.01796E-05  1.14325E-05   3.61650E+01  5.66538E+01
19   9  5  -6.42744E-06  1.16479E-05   5.22051E-06  2.12275E-05  1.60070E-05   3.06617E+02  7.54068E+01
20   9  5  -3.57556E-06  1.35869E-05   1.00113E-05  2.49896E-05  1.49783E-05   1.49614E+02  5.99382E+01
21   9  5   2.27540E-05  1.31283E-05   3.58823E-05  2.40741E-05  1.18082E-05   3.29081E+01  4.90494E+01
17  10  5  -5.79491E-06  1.29490E-05   7.15408E-06  2.37628E-05  1.66088E-05   2.32158E+02  6.98938E+01
18  10  5  -4.01155E-06  7.78670E-06   3.77515E-06  1.32785E-05  9.50331E-06   2.51733E+02  7.15694E+01
19  10  5  -9.12188E-06  2.16344E-06  -6.95844E-06  1.41621E-06  8.37465E-06  -1.20352E+02  5.91344E+02
20  10  5  -4.62608E-06  8.06749E-06   3.44140E-06  1.35546E-05  1.01132E-05   2.93868E+02  7.46108E+01
21  10  5   1.32212E-05  7.81022E-06   2.10314E-05  1.32766E-05  7.75482E-06   3.68725E+01  5.84096E+01
22  10  5  -7.42257E-06  8.37898E-06   9.56404E-07  1.47099E-05  1.37535E-05   1.43804E+03  9.34982E+01
23  10  5  -9.59164E-06  1.15940E-05   2.00238E-06  2.09093E-05  1.89069E-05   9.44221E+02  9.04235E+01
18  11  5  -8.24828E-06  1.26277E-05   4.37944E-06  2.33096E-05  1.89301E-05   4.32250E+02  8.12119E+01
19  11  5  -7.19076E-06  1.20575E-05   4.86677E-06  2.22283E-05  1.73616E-05   3.56737E+02  7.81056E+01
20  11  5   6.60932E-06  7.38191E-06   1.39912E-05  1.22043E-05  1.78688E-06   1.27714E+01  1.46413E+01
21  11  5   2.45990E-05  2.09609E-06   2.66951E-05  1.35015E-06  2.53449E-05   9.49423E+01  1.87719E+03
22  11  5   2.42193E-05  1.30372E-05   3.72565E-05  2.36150E-05  1.36415E-05   3.66151E+01  5.77663E+01
23  11  5  -8.61004E-06  1.27270E-05   4.11694E-06  2.33770E-05  1.92601E-05   4.67824E+02  8.23889E+01
24  11  5  -1.08853E-05  1.18032E-05   9.17828E-07  2.13508E-05  2.04330E-05   2.22623E+03  9.57012E+01
20  12  5   1.97611E-05  1.10101E-05   3.07712E-05  1.98968E-05  1.08744E-05   3.53395E+01  5.46539E+01
21  12  5   2.07099E-05  1.13918E-05   3.21017E-05  2.04877E-05  1.16140E-05   3.61789E+01  5.66879E+01
22  12  5  -8.03719E-06  7.94306E-06  -9.41279E-08  1.35962E-05  1.36904E-05  -1.45444E+04  1.00692E+02
23  12  5  -4.61657E-06  1.32087E-05   8.59213E-06  2.42926E-05  1.57005E-05   1.82731E+02  6.46306E+01
24  12  5   2.36130E-05  1.32678E-05   3.68809E-05  2.44539E-05  1.24270E-05   3.36950E+01  5.08181E+01
17   9  6   2.44444E-05  9.58311E-06   3.40275E-05  1.70681E-05  1.69594E-05   4.98403E+01  9.93631E+01
18   9  6   2.36080E-05  1.03622E-05   3.39702E-05  1.85004E-05  1.54699E-05   4.55394E+01  8.36191E+01
19   9  6  -6.60220E-06  1.08546E-05   4.25236E-06  1.95216E-05  1.52693E-05   3.59078E+02  7.82172E+01
20   9  6  -2.72485E-06  1.25576E-05   9.83276E-06  2.28537E-05  1.30209E-05   1.32424E+02  5.69751E+01
21   9  6   2.65776E-05  1.22816E-05   3.88592E-05  2.21828E-05  1.66764E-05   4.29149E+01  7.51771E+01
17  10  6  -5.90344E-06  1.23370E-05   6.43356E-06  2.24003E-05  1.59667E-05   2.48178E+02  7.12791E+01
18  10  6  -6.49261E-06  6.87178E-06   3.79167E-07  1.16329E-05  1.12537E-05   2.96801E+03  9.67406E+01
19  10  6  -2.37293E-05  1.79280E-06  -2.19365E-05  1.28631E-06  2.32228E-05  -1.05864E+02  1.80538E+03
20  10  6  -1.51755E-05  7.16104E-06  -8.01443E-06  1.19420E-05  1.99565E-05  -2.49007E+02  1.67111E+02
21  10  6   5.04393E-06  6.92675E-06   1.19707E-05  1.16540E-05  3.16644E-07   2.64517E+00  2.71704E+00
22  10  6  -7.47699E-06  7.61885E-06   1.41853E-07  1.31038E-05  1.29619E-05   9.13758E+03  9.89175E+01
23  10  6  -8.67323E-06  1.03229E-05   1.64963E-06  1.83260E-05  1.66764E-05   1.01092E+03  9.09984E+01
18  11  6  -8.95884E-06  1.20642E-05   3.10539E-06  2.20103E-05  1.89050E-05   6.08780E+02  8.58912E+01
19  11  6  -9.89108E-06  1.09255E-05   1.03446E-06  1.97556E-05  1.87212E-05   1.80975E+03  9.47637E+01
20  11  6  -2.86092E-06  6.46613E-06   3.60522E-06  1.06424E-05  7.03719E-06   1.95195E+02  6.61240E+01
21  11  6   1.33206E-05  1.85618E-06   1.51768E-05  1.46716E-06  1.37097E-05   9.03329E+01  9.34436E+02
22  11  6   2.12792E-05  1.20845E-05   3.33637E-05  2.16485E-05  1.17152E-05   3.51135E+01  5.41154E+01
23  11  6  -9.98156E-06  1.19053E-05   1.92369E-06  2.15582E-05  1.96345E-05   1.02067E+03  9.10768E+01
24  11  6  -1.33766E-05  1.05066E-05  -2.87001E-06  1.86833E-05  2.15533E-05  -7.50983E+02  1.15361E+02
20  12  6   2.31005E-05  1.00783E-05   3.31789E-05  1.79478E-05  1.52310E-05   4.59058E+01  8.48629E+01
21  12  6   2.35470E-05  1.01177E-05   3.36647E-05  1.80175E-05  1.56472E-05   4.64796E+01  8.68446E+01
22  12  6  -9.84199E-06  7.26927E-06  -2.57272E-06  1.23813E-05  1.49540E-05  -5.81253E+02  1.20779E+02
23  12  6  -3.23655E-06  1.28250E-05   9.58847E-06  2.32752E-05  1.36867E-05   1.42741E+02  5.88039E+01
24  12  6   2.77566E-05  1.24779E-05   4.02345E-05  2.28011E-05  1.74334E-05   4.33295E+01  7.64585E+01
17   9  7   2.60302E-05  1.10048E-05   3.70350E-05  1.96793E-05  1.73557E-05   4.68631E+01  8.81930E+01
18   9  7   2.57992E-05  1.17673E-05   3.75664E-05  2.10515E-05  1.65149E-05   4.39620E+01  7.84502E+01
19   9  7  -7.86799E-06  1.23152E-05   4.44726E-06  2.22223E-05  1.77750E-05   3.99685E+02  7.99874E+01
20   9  7  -3.07869E-06  1.40929E-05   1.10142E-05  2.57593E-05  1.47451E-05   1.33874E+02  5.72418E+01
21   9  7   2.99518E-05  1.35498E-05   4.35016E-05  2.45186E-05  1.89830E-05   4.36375E+01  7.74228E+01
17  10  7  -7.00036E-06  1.32243E-05   6.22393E-06  2.39699E-05  1.77460E-05   2.85125E+02  7.40344E+01
18  10  7  -7.36828E-06  7.56406E-06   1.95785E-07  1.29726E-05  1.27769E-05   6.52597E+03  9.84908E+01
19  10  7  -2.50965E-05  1.84115E-06  -2.32553E-05  1.50900E-06  2.47643E-05  -1.06489E+02  1.64111E+03
20  10  7  -2.02804E-05  7.48752E-06  -1.27929E-05  1.25701E-05  2.53630E-05  -1.98258E+02  2.01773E+02
21  10  7   4.76907E-06  6.96884E-06   1.17379E-05  1.16602E-05  7.77308E-08   6.62220E-01  6.66635E-01
22  10  7  -7.80465E-06  8.20889E-06   4.04248E-07  1.41858E-05  1.37816E-05   3.40918E+03  9.71503E+01
23  10  7  -9.92454E-06  1.10832E-05   1.15862E-06  1.97253E-05  1.85666E-05   1.60247E+03  9.41262E+01
18  11  7  -9.56595E-06  1.33377E-05   3.77171E-06  2.43609E-05  2.05892E-05   5.45884E+02  8.45173E+01
19  11  7  -1.10068E-05  1.24710E-05   1.46423E-06  2.26040E-05  2.11398E-05   1.44374E+03  9.35222E+01
20  11  7  -5.05634E-07  6.78028E-06   6.27465E-06  1.12659E-05  4.99124E-06   7.95461E+01  4.43040E+01
21  11  7   1.27223E-05  1.86113E-06   1.45835E-05  1.58005E-06  1.30034E-05   8.91655E+01  8.22977E+02
22  11  7   1.94527E-05  1.28591E-05   3.23117E-05  2.31253E-05  9.18645E-06   2.84307E+01  3.97248E+01
23  11  7  -1.24551E-05  1.33408E-05   8.85691E-07  2.42177E-05  2.33320E-05   2.63433E+03  9.63428E+01
24  11  7  -1.41471E-05  1.14762E-05  -2.67093E-06  2.04681E-05  2.31390E-05  -8.66330E+02  1.13049E+02
20  12  7   2.67750E-05  1.12103E-05   3.79853E-05  2.00733E-05  1.79120E-05   4.71551E+01  8.92331E+01
21  12  7   2.61484E-05  1.08184E-05   3.69667E-05  1.93066E-05  1.76601E-05   4.77730E+01  9.14717E+01
22  12  7  -1.10486E-05  7.86604E-06  -3.18259E-06  1.34951E-05  1.66777E-05  -5.24029E+02  1.23583E+02
23  12  7  -3.90860E-06  1.36494E-05   9.74077E-06  2.47310E-05  1.49903E-05   1.53892E+02  6.06131E+01
24  12  7   3.07936E-05  1.40726E-05   4.48662E-05  2.57638E-05  1.91025E-05   4.25765E+01  7.41447E+01
17   9  8   2.66442E-05  1.14001E-05   3.80442E-05  2.03562E-05  1.76881E-05   4.64934E+01  8.68928E+01
18   9  8   2.66448E-05  1.13212E-05   3.79660E-05  2.02378E-05  1.77283E-05   4.66951E+01  8.76000E+01
19   9  8  -5.60382E-06  1.23475E-05   6.74371E-06  2.22633E-05  1.55196E-05   2.30134E+02  6.97093E+01
20   9  8  -2.59271E-06  1.43208E-05   1.17281E-05  2.61152E-05  1.43871E-05   1.22672E+02  5.50908E+01
21   9  8   3.06421E-05  1.42429E-05   4.48850E-05  2.58394E-05  1.90457E-05   4.24321E+01  7.37079E+01
17  10  8  -5.72001E-06  1.42476E-05   8.52760E-06  2.58272E-05  1.72996E-05   2.02866E+02  6.69821E+01
18  10  8  -7.66642E-06  8.08838E-06   4.21957E-07  1.38704E-05  1.34485E-05   3.18716E+03  9.69579E+01
19  10  8  -2.84972E-05  1.85003E-06  -2.66472E-05  1.54710E-06  2.81943E-05  -1.05806E+02  1.82239E+03
20  10  8  -2.42442E-05  7.42888E-06  -1.68153E-05  1.25024E-05  2.93178E-05  -1.74351E+02  2.34496E+02
21  10  8   6.94965E-06  7.29730E-06   1.42469E-05  1.22491E-05  1.99783E-06   1.40229E+01  1.63100E+01
22  10  8  -7.99573E-06  8.38803E-06   3.92297E-07  1.45339E-05  1.41416E-05   3.60482E+03  9.73008E+01
23  10  8  -9.30556E-06  1.14444E-05   2.13888E-06  2.04160E-05  1.82771E-05   8.54518E+02  8.95235E+01
18  11  8  -9.71859E-06  1.41975E-05   4.47895E-06  2.58520E-05  2.13731E-05   4.77189E+02  8.26747E+01
19  11  8  -9.93786E-06  1.31872E-05   3.24929E-06  2.38041E-05  2.05548E-05   6.32594E+02  8.63499E+01
20  11  8  -5.43385E-06  7.18465E-06   1.75080E-06  1.19919E-05  1.02411E-05   5.84938E+02  8.54001E+01
21  11  8   1.38520E-05  1.86351E-06   1.57155E-05  1.63858E-06  1.40769E-05   8.95735E+01  8.59091E+02
22  11  8   2.25806E-05  1.31591E-05   3.57397E-05  2.35882E-05  1.21515E-05   3.40001E+01  5.15154E+01
23  11  8  -1.21486E-05  1.37786E-05   1.62999E-06  2.49782E-05  2.33482E-05   1.43241E+03  9.34743E+01
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20 12  8   2.82614E-05  1.19469E-05   4.02083E-05  2.14951E-05  1.87132E-05   4.65406E+01  8.70578E+01
21 12  8   2.76984E-05  1.16609E-05   3.93593E-05  2.09031E-05  1.84562E-05   4.68915E+01  8.82938E+01
22 12  8  -1.28208E-05  8.20863E-06  -4.61217E-06  1.41182E-05  1.87303E-05  -4.06107E+02  1.32668E+02
23 12  8  -3.71709E-06  1.43853E-05   1.06682E-05  2.60649E-05  1.53968E-05   1.44324E+02  5.90708E+01
24 12  8   3.20848E-05  1.46471E-05   4.67319E-05  2.67515E-05  1.99805E-05   4.27555E+01  7.46892E+01
17  9  9   2.53011E-05  1.00849E-05   3.53860E-05  1.78799E-05  1.75061E-05   4.94719E+01  9.79095E+01
18  9  9   2.58040E-05  1.10184E-05   3.68224E-05  1.96798E-05  1.71426E-05   4.65547E+01  8.71073E+01
19  9  9  -8.50158E-06  1.25221E-05   4.02049E-06  2.25192E-05  1.84987E-05   4.60112E+02  8.21464E+01
20  9  9  -1.98645E-06  1.36102E-05   1.16238E-05  2.47067E-05  1.30829E-05   1.12553E+02  5.29529E+01
21  9  9   3.00989E-05  1.35784E-05   4.36773E-05  2.45113E-05  1.91660E-05   4.38809E+01  7.81924E+01
17 10  9  -4.40800E-06  1.37338E-05   9.32578E-06  2.49951E-05  1.56693E-05   1.68021E+02  6.26895E+01
18 10  9  -8.67401E-06  7.91776E-06  -7.56251E-07  1.36292E-05  1.43855E-05  -1.90221E+03  1.05549E+02
19 10  9  -3.19039E-05  1.81442E-06  -3.00895E-05  1.58315E-06  3.16726E-05  -1.05261E+02  2.00061E+03
20 10  9  -2.42600E-05  7.42659E-06  -1.68334E-05  1.24472E-05  2.92806E-05  -1.73943E+02  2.35239E+02
21 10  9   2.01653E-06  7.34438E-06   9.36090E-06  1.23704E-05  3.00946E-06   3.21492E+01  2.43280E+01
22 10  9  -8.89770E-06  8.43079E-06  -4.66914E-07  1.46037E-05  1.50706E-05  -3.22771E+03  1.03197E+02
23 10  9  -8.75748E-06  1.10628E-05   2.30533E-06  1.97088E-05  1.74034E-05   7.54923E+02  8.83030E+01
18 11  9  -1.00787E-05  1.35430E-05   3.46428E-06  2.47367E-05  2.12724E-05   6.14050E+02  8.59954E+01
19 11  9  -1.40301E-05  1.33476E-05  -6.82477E-07  2.42022E-05  2.48847E-05  -3.64624E+03  1.02820E+02
20 11  9  -3.34667E-06  7.34757E-06   4.00090E-06  1.23136E-05  8.31274E-06   2.07772E+02  6.75084E+01
21 11  9   1.26131E-05  1.78577E-06   1.43989E-05  1.56015E-06  1.28387E-05   8.91648E+01  8.22916E+02
22 11  9   1.82155E-05  1.28045E-05   3.10200E-05  2.28785E-05  8.14147E-06   2.62459E+01  3.55857E+01
23 11  9  -1.45835E-05  1.34109E-05  -1.17263E-06  2.42071E-05  2.53797E-05  -2.16434E+03  1.04844E+02
24 11  9  -1.30334E-05  1.15210E-05  -1.51235E-06  2.06012E-05  2.21135E-05  -1.46220E+03  1.07341E+02
20 12  9   2.62798E-05  1.10075E-05   3.72873E-05  1.96161E-05  1.76713E-05   4.73922E+01  9.00858E+01
21 12  9   2.54790E-05  1.06175E-05   3.60965E-05  1.89827E-05  1.71138E-05   4.74112E+01  9.01545E+01
22 12  9  -1.17250E-05  7.84928E-06  -3.87571E-06  1.35152E-05  1.73909E-05  -4.48715E+02  1.28677E+02
23 12  9  -2.28317E-06  1.33574E-05   1.10742E-05  2.41582E-05  1.30840E-05   1.18148E+02  5.41595E+01
24 12  9   3.01876E-05  1.33693E-05   4.35569E-05  2.42766E-05  1.92803E-05   4.42647E+01  7.94194E+01
17  9 10   2.15189E-05  8.22003E-06   2.97389E-05  1.44081E-05  1.53308E-05   5.15513E+01  1.06404E+02
18  9 10   2.20032E-05  9.16972E-06   3.11730E-05  1.62005E-05  1.49724E-05   4.80302E+01  9.24196E+01
19  9 10  -8.24839E-06  1.14647E-05   3.21636E-06  2.05919E-05  1.73756E-05   5.40224E+02  8.43805E+01
20  9 10   1.37552E-06  1.10365E-05   1.24120E-05  1.99947E-05  7.58274E-06   6.10921E+01  3.79237E+01
21  9 10   2.60188E-05  1.12391E-05   3.72579E-05  2.02732E-05  1.69846E-05   4.55867E+01  8.37786E+01
17 10 10  -2.92867E-06  1.18201E-05   8.89140E-06  2.14846E-05  1.25932E-05   1.41634E+02  5.86150E+01
18 10 10  -1.03184E-05  7.31180E-06  -3.00658E-06  1.25602E-05  1.55668E-05  -5.17758E+02  1.23937E+02
19 10 10  -3.25172E-05  1.73198E-06  -3.07852E-05  1.52308E-06  3.23083E-05  -1.04947E+02  2.12124E+03
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21 10 10  -5.85201E-07  7.22951E-06   6.64431E-06  1.22861E-05  5.64178E-06   8.49114E+01  4.59200E+01
22 10 10  -1.07706E-05  7.71212E-06  -3.05844E-06  1.33689E-05  1.64273E-05  -5.37114E+02  1.22877E+02
23 10 10  -5.59000E-06  8.88607E-06   3.29607E-06  1.57086E-05  1.24126E-05   3.76588E+02  7.90175E+01
18 11 10  -6.46345E-06  1.11341E-05   4.67062E-06  2.02298E-05  1.55592E-05   3.33129E+02  7.69122E+01
19 11 10  -1.28098E-05  1.25913E-05  -2.18551E-07  2.28156E-05  2.30342E-05  -1.05395E+04  1.00958E+02
20 11 10  -6.20587E-06  7.06128E-06   8.55416E-07  1.18153E-05  1.09599E-05   1.28123E+03  9.27601E+01
21 11 10   2.80865E-06  1.77459E-06   4.58323E-06  1.60052E-06  2.98272E-06   6.50789E+01  1.86360E+02
22 11 10   1.52782E-05  1.28461E-05   2.81243E-05  2.30189E-05  5.10541E-06   1.81530E+01  2.21792E+01
23 11 10  -1.35496E-05  1.28175E-05  -7.32111E-07  2.32015E-05  2.39336E-05  -3.26912E+03  1.03155E+02
24 11 10  -9.73118E-06  9.50501E-06  -2.26178E-07  1.68926E-05  1.71188E-05  -7.56872E+03  1.01339E+02
20 12 10   2.21699E-05  9.51364E-06   3.16835E-05  1.68743E-05  1.48093E-05   4.67412E+01  8.77625E+01
21 12 10   2.31688E-05  8.80277E-06   3.19715E-05  1.56125E-05  1.63591E-05   5.11676E+01  1.04782E+02
22 12 10  -1.55968E-05  7.19622E-06  -8.40061E-06  1.23400E-05  2.07407E-05  -2.46895E+02  1.68076E+02
23 12 10   1.28050E-06  1.16602E-05   1.29407E-05  2.10790E-05  8.13823E-06   6.28884E+01  3.86083E+01
24 12 10   2.62574E-05  1.13757E-05   3.76332E-05  2.05527E-05  1.70805E-05   4.53868E+01  8.31059E+01
17  9 11   1.90871E-05  7.73382E-06   2.68210E-05  1.27286E-05  1.40923E-05   5.25422E+01  1.10713E+02
18  9 11   1.97922E-05  7.71669E-06   2.75089E-05  1.37187E-05  1.37902E-05   5.01298E+01  1.00521E+02
19  9 11  -8.90223E-06  1.08329E-05   1.93065E-06  1.95252E-05  1.75946E-05   9.11329E+02  9.01120E+01
20  9 11   2.87152E-06  9.59607E-06   1.24676E-05  1.72966E-05  4.82902E-06   3.87326E+01  2.79189E+01
21  9 11   2.28087E-05  9.89685E-06   3.27055E-05  1.78323E-05  1.48732E-05   4.54763E+01  8.34064E+01
17 10 11  -1.13411E-06  1.01055E-05   8.97144E-06  1.83433E-05  9.37191E-06   1.04464E+02  5.10916E+01
18 10 11  -9.56722E-06  6.50099E-06  -3.06624E-06  1.10998E-05  1.41661E-05  -4.62002E+02  1.27624E+02
19 10 11  -3.44563E-05  2.04008E-06  -3.24162E-05  1.32535E-06  3.37416E-05  -1.04089E+02  2.54587E+03
20 10 11  -2.67593E-05  7.33534E-06  -1.94240E-05  1.18919E-05  3.13159E-05  -1.61223E+02  2.63337E+02
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22 10 11  -1.02465E-05  7.03473E-06  -3.21176E-06  1.21431E-05  1.53548E-05  -4.78081E+02  1.26449E+02
23 10 11  -5.31105E-06  8.01106E-06   2.70001E-06  1.31781E-05  1.04781E-05   3.88078E+02  7.95115E+01
18 11 11  -4.85946E-06  9.28794E-06   4.42848E-06  1.67080E-05  1.22795E-05   2.77286E+02  7.34949E+01
19 11 11  -1.28959E-05  1.16551E-05  -1.24082E-06  2.09893E-05  2.22301E-05  -1.79156E+03  1.05912E+02
20 11 11  -1.17102E-05  6.80690E-06  -4.90332E-06  1.08743E-05  1.57776E-05  -3.21775E+02  1.45091E+02
21 11 11   2.66142E-06  2.04745E-06   4.70887E-06  1.38554E-06  3.32333E-06   7.05760E+01  2.39859E+02
22 11 11   1.32990E-05  1.23148E-05   2.56138E-05  2.12594E-05  4.35439E-06   1.70002E+01  2.04822E+01
23 11 11  -1.26924E-05  1.14483E-05  -1.24412E-06  2.06129E-05  2.18571E-05  -1.75683E+03  1.06036E+02
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21 12 11   1.95974E-05  7.79876E-06   2.73962E-05  1.28726E-05  1.45236E-05   5.30133E+01  1.12826E+02
22 12 11  -1.34105E-05  6.85556E-06  -6.55496E-06  1.17817E-05  1.83366E-05  -2.79737E+02  1.55637E+02
23 12 11   1.86110E-06  1.05918E-05   1.24529E-05  1.92612E-05  6.80836E-06   5.46731E+01  3.53475E+01
24 12 11   2.25413E-05  9.83282E-06   3.23741E-05  1.77362E-05  1.46379E-05   4.52147E+01  8.25308E+01
17  9 12   1.67038E-05  6.09413E-06   2.27979E-05  1.03664E-05  1.24315E-05   5.45290E+01  1.19920E+02
18  9 12   1.62438E-05  7.02712E-06   2.32709E-05  1.24789E-05  1.07920E-05   4.63754E+01  8.64815E+01
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21  9 12   2.06611E-05  9.20748E-06   2.98686E-05  1.66065E-05  1.32620E-05   4.44014E+01  7.98605E+01
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22 10 12  -1.03722E-05  6.33373E-06  -4.03851E-06  1.09433E-05  1.49818E-05  -3.70974E+02  1.36904E+02
23 10 12  -6.19429E-06  6.41497E-06   2.20679E-07  1.09008E-05  1.06802E-05   4.83968E+03  9.79756E+01
18 11 12  -4.47586E-06  8.36550E-06   3.88963E-06  1.51073E-05  1.12177E-05   2.88399E+02  7.42533E+01
19 11 12  -1.20159E-05  1.02616E-05  -1.75436E-06  1.84718E-05  2.02262E-05  -1.15291E+03  1.09498E+02
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21 11 12   1.70324E-06  1.67318E-06   3.37642E-06  1.34852E-06  2.02790E-06   6.00607E+01  1.50380E+02
22 11 12   1.22930E-05  1.08868E-05   2.31799E-05  1.91601E-05  4.01976E-06   1.73416E+01  2.09798E+01
23 11 12  -1.32251E-05  1.03380E-05  -2.88705E-06  1.86577E-05  2.15448E-05  -7.46256E+02  1.15474E+02
24 11 12  -8.98163E-06  7.10272E-06  -1.87891E-06  1.25703E-05  1.44492E-05  -7.69021E+02  1.14947E+02
20 12 12   1.70529E-05  7.14974E-06   2.42027E-05  1.26750E-05  1.15277E-05   4.76297E+01  9.09480E+01
21 12 12   1.76428E-05  6.70191E-06   2.43447E-05  1.14716E-05  1.28731E-05   5.28785E+01  1.12218E+02
22 12 12  -1.27842E-05  5.92339E-06  -6.86084E-06  1.01123E-05  1.69731E-05  -2.47391E+02  1.67847E+02
23 12 12   2.52396E-06  9.00881E-06   1.15328E-05  1.62822E-05  4.74938E-06   4.11815E+01  2.91692E+01
24 12 12   2.00091E-05  8.49830E-06   2.85074E-05  1.53360E-05  1.31714E-05   4.62035E+01  8.58858E+01
17  9 13   1.48830E-05  5.89762E-06   2.07806E-05  9.73905E-06  1.10416E-05   5.31340E+01  1.13374E+02
18  9 13   1.54614E-05  5.71910E-06   2.11805E-05  1.00631E-05  1.11174E-05   5.24886E+01  1.10476E+02
19  9 13  -8.90966E-06  8.26315E-06  -6.46508E-07  1.49159E-05  1.55625E-05  -2.40716E+03  1.04334E+02
20  9 13   1.70182E-06  7.24215E-06   8.94397E-06  1.30696E-05  4.12563E-06   4.61276E+01  3.15666E+01
21  9 13   1.78815E-05  7.80483E-06   2.56863E-05  1.41217E-05  1.15646E-05   4.50226E+01  8.18928E+01
17 10 13  -2.02735E-06  7.53434E-06   5.50699E-06  1.36053E-05  8.09830E-06   1.47055E+02  5.95232E+01
18 10 13  -9.52700E-06  4.89582E-06  -4.63119E-06  8.30165E-06  1.29328E-05  -2.79255E+02  1.55786E+02
19 10 13  -2.64911E-05  1.64175E-06  -2.48493E-05  1.10943E-06  2.59587E-05  -1.04465E+02  2.33984E+03
20 10 13  -2.43663E-05  5.47849E-06  -1.88878E-05  8.85626E-06  2.77441E-05  -1.46889E+02  3.13271E+02
21 10 13  -3.67289E-06  5.48739E-06   1.81451E-06  8.60542E-06  6.79091E-06   3.74256E+02  7.89143E+01
22 10 13  -9.14615E-06  5.57489E-06  -3.57126E-06  9.66564E-06  1.32369E-05  -3.70651E+02  1.36948E+02
23 10 13  -3.82426E-06  5.77238E-06   1.94812E-06  9.62319E-06  7.67507E-06   3.93973E+02  7.97560E+01
18 11 13  -4.12396E-06  7.00381E-06   2.87985E-06  1.25809E-05  9.70106E-06   3.36860E+02  7.71094E+01
19 11 13  -1.17770E-05  8.93610E-06  -2.84085E-06  1.61292E-05  1.89700E-05  -6.67759E+02  1.17613E+02
20 11 13  -8.35216E-06  5.23660E-06  -3.11556E-06  8.38940E-06  1.15050E-05  -3.69275E+02  1.37137E+02
21 11 13   8.12682E-07  1.60163E-06   2.41431E-06  1.09293E-06  1.32138E-06   5.47313E+01  1.20903E+02
22 11 13   9.35787E-06  9.56223E-06   1.89201E-05  1.66258E-05  2.29434E-06   1.21265E+01  1.37999E+01
23 11 13  -1.12113E-05  8.58445E-06  -2.62685E-06  1.54607E-05  1.80876E-05  -6.88565E+02  1.16990E+02
24 11 13  -6.93623E-06  5.97273E-06  -9.63498E-07  1.06564E-05  1.16199E-05  -1.20601E+03  1.09042E+02
20 12 13   1.47451E-05  5.98097E-06   2.07261E-05  1.06139E-05  1.01122E-05   4.87895E+01  9.52724E+01
21 12 13   1.49745E-05  5.68113E-06   2.06557E-05  9.33833E-06  1.13173E-05   5.47905E+01  1.21192E+02
22 12 13  -1.15728E-05  4.98491E-06  -6.58790E-06  8.48084E-06  1.50687E-05  -2.28734E+02  1.77680E+02
23 12 13   1.53332E-06  7.44386E-06   8.97718E-06  1.35181E-05  4.54090E-06   5.05827E+01  3.35913E+01
24 12 13   1.78937E-05  7.00721E-06   2.49009E-05  1.26672E-05  1.22337E-05   4.91295E+01  9.65776E+01
17  9 14   1.34712E-05  5.08503E-06   1.85562E-05  8.46297E-06  1.00932E-05   5.43928E+01  1.19263E+02
18  9 14   1.36492E-05  4.90606E-06   1.85553E-05  8.66087E-06  9.89438E-06   5.33239E+01  1.14242E+02
19  9 14  -7.69829E-06  7.20118E-06  -4.97107E-07  1.29244E-05  1.34215E-05  -2.69993E+03  1.03846E+02
20  9 14   1.58802E-06  6.12437E-06   7.71240E-06  1.09410E-05  3.22862E-06   4.18627E+01  2.95093E+01
21  9 14   1.43050E-05  6.49729E-06   2.08023E-05  1.17323E-05  9.07001E-06   4.36010E+01  7.73080E+01
17 10 14  -1.34062E-06  6.32698E-06   4.98636E-06  1.14492E-05  6.46288E-06   1.29611E+02  5.64481E+01
18 10 14  -6.86878E-06  4.27086E-06  -2.59792E-06  7.26716E-06  9.86507E-06  -3.79730E+02  1.35749E+02
19 10 14  -2.31014E-05  1.40803E-06  -2.16934E-05  9.11206E-07  2.26046E-05  -1.04200E+02  2.48073E+03
20 10 14  -2.18343E-05  5.03743E-06  -1.67969E-05  8.10246E-06  2.48993E-05  -1.48238E+02  3.07306E+02
21 10 14  -1.60378E-06  4.81017E-06   3.20639E-06  7.56602E-06  4.35962E-06   1.35967E+02  5.76211E+01
22 10 14  -8.71215E-06  4.81599E-06  -3.89616E-06  8.26217E-06  1.21583E-05  -3.12059E+02  1.47157E+02
23 10 14  -3.41881E-06  4.85727E-06   1.43846E-06  8.08059E-06  6.64212E-06   4.61751E+02  8.21985E+01
18 11 14  -3.53823E-06  5.84169E-06   2.30346E-06  1.04406E-05  8.13713E-06   3.53257E+02  7.79375E+01
19 11 14  -8.99195E-06  7.52352E-06  -1.46843E-06  1.36174E-05  1.50858E-05  -1.02734E+03  1.10783E+02
20 11 14  -8.20579E-06  4.68388E-06  -3.52190E-06  7.44219E-06  1.09641E-05  -3.11311E+02  1.47324E+02
21 11 14   1.69572E-06  1.37773E-06   3.07345E-06  8.61147E-07  2.21230E-06   7.19811E+01  2.56902E+02
22 11 14   8.42112E-06  7.81154E-06   1.62327E-05  1.35761E-05  2.65660E-06   1.63658E+01  1.95683E+01
23 11 14  -9.79511E-06  7.46670E-06  -2.32841E-06  1.34410E-05  1.57694E-05  -6.77259E+02  1.17323E+02
24 11 14  -6.07487E-06  4.83566E-06  -1.23921E-06  8.51509E-06  9.75430E-06  -7.87139E+02  1.14553E+02
20 12 14   1.22419E-05  4.95779E-06   1.71997E-05  8.73194E-06  8.46774E-06   4.92320E+01  9.69744E+01
21 12 14   1.21230E-05  5.11750E-06   1.72405E-05  8.45974E-06  8.78075E-06   5.09310E+01  1.03795E+02
22 12 14  -1.02516E-05  4.37068E-06  -5.88093E-06  7.47030E-06  1.33512E-05  -2.27026E+02  1.78724E+02
23 12 14   1.54923E-06  6.56026E-06   8.10950E-06  1.19071E-05  3.79764E-06   4.68295E+01  3.18938E+01
24 12 14   1.48306E-05  5.84835E-06   2.06790E-05  1.05332E-05  1.01457E-05   4.90631E+01  9.63213E+01
17  9 15   9.49242E-06  4.11000E-06   1.36024E-05  6.86659E-06  6.73583E-06   4.95194E+01  9.80958E+01
18  9 15   9.03990E-06  3.61378E-06   1.26537E-05  6.37630E-06  6.27738E-06   4.96091E+01  9.84486E+01
19  9 15  -6.82484E-06  5.60677E-06  -1.21807E-06  1.00115E-05  1.12296E-05  -9.21919E+02  1.12167E+02
20  9 15   1.64738E-06  4.74124E-06   6.38862E-06  8.51620E-06  2.12759E-06   3.33027E+01  2.49828E+01
21  9 15   1.19210E-05  5.30473E-06   1.72258E-05  9.58646E-06  7.63932E-06   4.43482E+01  7.96886E+01
17 10 15  -3.00111E-07  5.44231E-06   5.14220E-06  9.90293E-06  4.76073E-06   9.25815E+01  4.80739E+01
18 10 15  -6.82133E-06  3.62537E-06  -3.19596E-06  6.14974E-06  9.34570E-06  -2.92423E+02  1.51969E+02
19 10 15  -1.97274E-05  1.29470E-06  -1.84327E-05  7.17610E-07  1.91503E-05  -1.03893E+02  2.66862E+03
20 10 15  -1.77808E-05  4.36130E-06  -1.34195E-05  6.98088E-06  2.04004E-05  -1.52020E+02  2.92233E+02
21 10 15  -1.38786E-06  4.08804E-06   2.70018E-06  6.25301E-06  3.55282E-06   1.31577E+02  5.68178E+01
22 10 15  -6.65632E-06  4.02287E-06  -2.63345E-06  6.81737E-06  9.45081E-06  -3.58876E+02  1.38628E+02
23 10 15  -2.43682E-06  4.20715E-06   1.77032E-06  6.96771E-06  5.19739E-06   2.93584E+02  7.45925E+01
18 11 15  -2.44881E-06  5.03927E-06   2.59046E-06  9.15116E-06  6.56070E-06   2.53264E+02  7.16925E+01
19 11 15  -8.10617E-06  6.20631E-06  -1.89986E-06  1.12445E-05  1.31443E-05  -6.91856E+02  1.16896E+02
20 11 15  -7.45653E-06  3.92233E-06  -3.53420E-06  6.12796E-06  9.66216E-06  -2.73390E+02  1.57673E+02
21 11 15   5.36742E-07  1.30179E-06   1.83853E-06  8.15055E-07  1.02348E-06   5.56681E+01  1.25571E+02
22 11 15   7.76074E-06  6.68344E-06   1.44442E-05  1.15974E-05  2.84682E-06   1.97091E+01  2.45471E+01
23 11 15  -8.44220E-06  6.14957E-06  -2.29263E-06  1.11171E-05  1.34097E-05  -5.84906E+02  1.20623E+02
24 11 15  -3.86211E-06  3.98472E-06   1.22614E-07  7.03670E-06  6.91409E-06   5.63889E+03  9.82575E+01
20 12 15   9.83779E-06  4.11404E-06   1.39518E-05  7.31745E-06  6.63438E-06   4.75521E+01  9.06652E+01
21 12 15   9.78463E-06  3.92867E-06   1.37133E-05  6.38798E-06  7.32532E-06   5.34176E+01  1.14673E+02
22 12 15  -7.95981E-06  3.41111E-06  -4.54870E-06  5.69928E-06  1.02480E-05  -2.25295E+02  1.79812E+02
23 12 15   1.17770E-06  5.06120E-06   6.23890E-06  9.15837E-06  2.91947E-06   4.67946E+01  3.18776E+01
24 12 15   1.19702E-05  4.76521E-06   1.67354E-05  8.51116E-06  8.22427E-06   4.91429E+01  9.66293E+01
17  9 16   7.28334E-06  3.73610E-06   1.10194E-05  6.16232E-06  4.85713E-06   4.40778E+01  7.88198E+01
18  9 16   7.59789E-06  3.78685E-06   1.13847E-05  6.76772E-06  4.61702E-06   4.05545E+01  6.82213E+01
19  9 16  -4.99492E-06  5.65740E-06   6.62488E-07  1.03378E-05  9.67536E-06   1.46046E+03  9.35916E+01
20  9 16   9.66348E-07  4.61710E-06   5.58345E-06  8.40210E-06  2.81865E-06   5.04821E+01  3.35469E+01
21  9 16   8.30468E-06  4.98985E-06   1.32945E-05  9.19736E-06  4.09717E-06   3.08184E+01  4.45472E+01
17 10 16  -1.07623E-06  5.20143E-06   4.12520E-06  9.64063E-06  5.51543E-06   1.33701E+02  5.72102E+01
18 10 16  -4.17346E-06  3.66297E-06  -5.10492E-07  6.21895E-06  6.72945E-06  -1.31823E+03  1.08209E+02
19 10 16  -1.16236E-05  1.45514E-06  -1.01685E-05  7.41015E-07  1.09095E-05  -1.07287E+02  1.47224E+03
20 10 16  -7.46552E-06  4.15957E-06  -3.30596E-06  6.53018E-06  9.83614E-06  -2.97528E+02  1.50626E+02
21 10 16   1.06110E-06  4.24316E-06   5.30426E-06  6.46775E-06  1.16349E-06   2.19351E+01  1.79891E+01
```

```
22 10 16  -5.75871E-06  4.00638E-06  -1.75233E-06  6.75721E-06  8.50954E-06  -4.85613E+02  1.25933E+02
23 10 16  -2.71754E-06  3.92732E-06   1.20978E-06  6.47830E-06  5.26852E-06   4.35494E+02  8.13257E+01
18 11 16  -1.72124E-06  4.44976E-06   2.72852E-06  8.09392E-06  5.36539E-06   1.96641E+02  6.62892E+01
19 11 16  -5.91484E-06  5.92040E-06   5.55773E-09  1.08377E-05  1.08321E-05   1.94901E+05  9.99487E+01
20 11 16  -1.73394E-06  3.94821E-06   2.21427E-06  6.13564E-06  3.92137E-06   1.77095E+02  6.39113E+01
21 11 16   6.32173E-06  1.40224E-06   7.72397E-06  8.23216E-07  6.90075E-06   8.93421E+01  8.38268E+02
22 11 16   8.12292E-06  7.01344E-06   1.51364E-05  1.24116E-05  2.72480E-06   1.80017E+01  2.19537E+01
23 11 16  -6.43806E-06  6.07438E-06  -3.63684E-07  1.11407E-05  1.15044E-05  -3.16329E+03  1.03264E+02
24 11 16  -4.07764E-06  3.84284E-06  -2.34803E-07  6.84582E-06  7.08062E-06  -3.01556E+03  1.03430E+02
20 12 16   7.42412E-06  3.95819E-06   1.13823E-05  7.09508E-06  4.28722E-06   3.76657E+01  6.04253E+01
21 12 16   7.40386E-06  3.94784E-06   1.13517E-05  6.46655E-06  4.88515E-06   4.30345E+01  7.55449E+01
22 12 16  -6.70992E-06  3.36894E-06  -3.34098E-06  5.67047E-06  9.01146E-06  -2.69725E+02  1.58919E+02
23 12 16   1.04669E-06  4.79825E-06   5.84494E-06  8.79883E-06  2.95389E-06   5.05375E+01  3.35714E+01
24 12 16   8.96014E-06  4.39318E-06   1.33533E-05  7.97567E-06  5.37765E-06   4.02720E+01  6.74256E+01


  Core total loss     =  2.46031E-03
  Core total source   =  4.04258E-03
  Core total residual =  1.58228E-03
  Residual/Loss (%)   =  6.43122E+01
  Residual/Source (%) =  3.91402E+01
```

APPENDIX E

THE TEST OF HOMOGENIZATION PROCEDURE

The files given in this Appendix are:

hesap : MCNP results for one fuel element test run in which

mult 1 = absorption reaction rate

mult 2 = total reaction rate

mult 3 = elastic scattering reaction rate

mult 4 = (n,γ) reaction rate

mult 5 = n * sigma fission reaction rate

mult 6 = fission reaction rate

hes.f : Cross section proccesing and neutron balance calculation program for the test.

Program: hes.f

```
c
c       this program calculates neutron balance for a separated individual
c       fuel element rhomboid.
c
        character*1 adum
        character*18 adum2
        integer celln
        real    keff
        dimension fl(100),rra(100),rrt(100),rre(100),rrg(100)
        dimension rrn(100),rrf(100)
        dimension scur(4),sflx(4)
        dimension are(2),vol(6),celln(100)
c
        open(unit=8,file='hesap',form='formatted',status='old')
        open(unit=9,file='hes.ou',form='formatted',status='unknown')
c
        keff=0.03292
c
c       reading hesap
c
        read(8,'(a)')adum
        do i=1,2
        read(8,*)celln(i),fl(i),rdum,rra(i),rdum,rrt(i),rdum,
     +             rre(i),rdum,rrg(i),rdum
        end do
        do i=3,17
        read(8,*)celln(i),fl(i),rdum,rra(i),rdum,rrt(i),rdum,
     +             rre(i),rdum,rrg(i),rdum,rrn(i),rdum,rrf(i),rdum
        end do
        do i=18,93
        read(8,*)celln(i),fl(i),rdum,rra(i),rdum,rrt(i),rdum,
     +             rre(i),rdum,rrg(i),rdum
        end do
        read(8,'(a)')adum
        do i=1,4
        read(8,*)idum,scur(i),rdum,sflx(i),rdum
        end do
        read(8,'(a)')adum
        do i=1,2
        read(8,'(a18,4x,1pe13.5))')adum2,are(i)
        end do
        read(8,'(a)')adum
        do i=1,6
        read(8,'(a18,1pe13.5))',end=99)adum2,vol(i)
        end do
 99     continue
        flx=0.
        absr=0.
        totr=0.
        fnur=0.
        fisr=0.
        tvol=0.
        do i=1,93
             if(i.ge.1.and.i.lt.3)vl=vol(1)
             if(i.ge.3.and.i.lt.18)vl=vol(2)
             if(i.eq.18.or.i.eq.33)vl=vol(3)
             if(i.ge.19.and.i.lt.33)vl=vol(4)
             if(i.ge.34.and.i.lt.64)vl=vol(5)
             if(i.ge.64)vl=vol(6)
             flx=flx+fl(i)*vl
             absr=absr+rra(i)*vl
             totr=totr+rrt(i)*vl
```

```
            fnur=fnur+rrn(i)*vl
            fisr=fisr+rrf(i)*vl
            tvol=tvol+vl
        end do
        avgflx=flx/tvol
        siga=(absr+fisr)/flx
        sigt=totr/flx
        signu=fnur/flx
        sigf=fisr/flx
        tleak=(scur(1)+scur(2)+scur(3)+scur(4))/tvol
        tloss=tleak+siga*avgflx
        tsource=(1./keff)*signu*avgflx
        resid=abs(tloss-tsource)
        write(9,101)flx,absr,totr,fnur,fisr,tvol
 101  format(2x,'flx    :',1pe13.5,/,2x,
     +             'absr   :',1pe13.5,/,2x,
     +             'totr   :',1pe13.5,/,2x,
     +             'fnur   :',1pe13.5,/,2x,
     +             'fisr   :',1pe13.5,/,2x,
     +             'tvol   :',1pe13.5,/)
c
        write(9,100)avgflx,siga,sigt,signu,sigf,tleak,tloss,tsource,
     +              resid,resid/tloss,resid/tsource
 100  format(2x,'avgflx :',1pe13.5,/,2x,
     +        'siga:',1pe13.5,/,2x,
     +        'sigt:',1pe13.5,/,2x,
     +        'signu:',1pe13.5,/,2x,
     +        'sigf :',1pe13.5,//,2x,
     +        'tleak:',1pe13.5,/,2x,
     +        'tloss:',1pe13.5,/,2x,
     +        'tsource:',1pe13.5,/,2x,
     +        'residual:',1pe13.5,//,2x,
     +        'resid/tloss:',1pe13.5,/,2x,
     +        'resid/tsource :',1pe13.5)
        stop
        end
```

File: hesap

cell	flux		mult 1		mult 2		mult 3		mult 4		mult 5		mult 6	
51600	7.02409E-03	0.0053	2.25882E-06	0.0217	1.32949E-03	0.0063	1.24032E-03	0.0066	8.15709E-07	0.0433				
51610	6.99179E-03	0.0053	2.36019E-06	0.0188	1.32671E-03	0.0062	1.23767E-03	0.0064	8.21551E-07	0.0314				
51401	1.00776E-02	0.0085	4.11712E-05	0.0445	1.94850E-03	0.0092	1.61824E-03	0.0092	3.94450E-05	0.0465	3.43509E-04	0.0334	1.37477E-04	0.0343
51402	1.26658E-02	0.0084	5.40254E-05	0.0367	2.48758E-03	0.0091	2.05671E-03	0.0090	5.19054E-05	0.0382	4.71008E-04	0.0375	1.88965E-04	0.0384
51403	1.50343E-02	0.0080	6.51373E-05	0.0377	2.94956E-03	0.0086	2.44183E-03	0.0085	6.26862E-05	0.0392	5.45208E-04	0.0342	2.18618E-04	0.0350
51404	1.66859E-02	0.0071	7.19693E-05	0.0321	3.28333E-03	0.0080	2.72242E-03	0.0081	6.93244E-05	0.0333	6.04098E-04	0.0285	2.42284E-04	0.0292
51405	1.79298E-02	0.0064	7.40129E-05	0.0333	3.51230E-03	0.0074	2.90759E-03	0.0071	7.10584E-05	0.0346	6.58462E-04	0.0341	2.64119E-04	0.0349
51406	1.91710E-02	0.0067	7.80557E-05	0.0324	3.73358E-03	0.0072	3.10287E-03	0.0071	7.49497E-05	0.0337	6.69491E-04	0.0272	2.68237E-04	0.0279
51407	1.97035E-02	0.0064	8.62829E-05	0.0353	3.86549E-03	0.0072	3.19891E-03	0.0071	8.30042E-05	0.0366	7.18251E-04	0.0296	2.88044E-04	0.0303
51408	1.99591E-02	0.0063	8.83276E-05	0.0352	3.92970E-03	0.0073	3.24826E-03	0.0071	8.51093E-05	0.0366	7.37506E-04	0.0294	2.95887E-04	0.0301
51409	1.97402E-02	0.0062	8.54950E-05	0.0346	3.88215E-03	0.0071	3.21964E-03	0.0070	8.22840E-05	0.0359	7.09731E-04	0.0294	2.84568E-04	0.0301
51410	1.92083E-02	0.0065	8.28024E-05	0.0316	3.76033E-03	0.0072	3.11971E-03	0.0071	7.98230E-05	0.0327	6.82505E-04	0.0286	2.73626E-04	0.0292
51411	1.82022E-02	0.0069	8.03788E-05	0.0334	3.57374E-03	0.0075	2.95581E-03	0.0074	7.73662E-05	0.0347	6.62602E-04	0.0314	2.65680E-04	0.0321
51412	1.69692E-02	0.0068	7.66859E-05	0.0520	3.32850E-03	0.0078	2.74869E-03	0.0074	7.39271E-05	0.0539	6.23662E-04	0.0351	2.50141E-04	0.0359
51413	1.48948E-02	0.0071	6.34061E-05	0.0368	2.91039E-03	0.0080	2.41567E-03	0.0080	6.09082E-05	0.0383	5.22288E-04	0.0318	2.09214E-04	0.0326
51414	1.28430E-02	0.0081	5.38938E-05	0.0419	2.51182E-03	0.0091	2.08316E-03	0.0090	5.17528E-05	0.0436	4.57037E-04	0.0401	1.83154E-04	0.0411
51415	1.01497E-02	0.0085	4.44919E-05	0.0487	1.97757E-03	0.0097	1.64174E-03	0.0097	4.27757E-05	0.0506	3.47980E-04	0.0393	1.39303E-04	0.0402
51101	7.94785E-03	0.0061	2.45836E-06	0.0252	4.34486E-03	0.0082	4.34182E-03	0.0082	7.36981E-07	0.0605				
51102	1.00459E-02	0.0059	3.26557E-06	0.0264	5.60839E-03	0.0078	5.60441E-03	0.0078	1.16602E-06	0.0603				
51103	1.21385E-02	0.0056	3.90188E-06	0.0275	6.77379E-03	0.0075	6.76897E-03	0.0075	1.38730E-06	0.0649				
51104	1.38672E-02	0.0053	4.53483E-06	0.0228	7.72140E-03	0.0072	7.71585E-03	0.0072	1.57194E-06	0.0504				
51105	1.52046E-02	0.0051	4.93985E-06	0.0224	8.47193E-03	0.0069	8.46595E-03	0.0069	1.73134E-06	0.0496				
51106	1.61858E-02	0.0049	5.31517E-06	0.0234	9.03815E-03	0.0067	9.03172E-03	0.0067	1.86565E-06	0.0532				
51107	1.68142E-02	0.0048	5.42966E-06	0.0203	9.33208E-03	0.0064	9.32539E-03	0.0064	1.81385E-06	0.0449				
51108	1.72929E-02	0.0047	5.58127E-06	0.0199	9.66740E-03	0.0065	9.66062E-03	0.0065	1.96611E-06	0.0447				
51109	1.72890E-02	0.0047	5.56322E-06	0.0201	9.65651E-03	0.0065	9.64971E-03	0.0065	1.90656E-06	0.0453				
51110	1.69807E-02	0.0048	5.36489E-06	0.0207	9.49986E-03	0.0065	9.49342E-03	0.0065	1.89495E-06	0.0448				
51111	1.63837E-02	0.0049	5.15480E-06	0.0212	9.13960E-03	0.0067	9.13324E-03	0.0067	1.79853E-06	0.0474				
51112	1.54544E-02	0.0050	4.97881E-06	0.0222	8.59548E-03	0.0068	8.58941E-03	0.0068	1.74729E-06	0.0498				
51113	1.39886E-02	0.0052	4.41220E-06	0.0223	7.76471E-03	0.0070	7.75926E-03	0.0070	1.53284E-06	0.0491				
51114	1.21733E-02	0.0055	4.00566E-06	0.0262	6.76505E-03	0.0075	6.76010E-03	0.0075	1.41169E-06	0.0620				
51115	1.01535E-02	0.0058	3.21997E-06	0.0261	5.57329E-03	0.0077	5.56931E-03	0.0077	1.04809E-06	0.0617				
51116	8.03536E-03	0.0062	2.48032E-06	0.0251	4.36380E-03	0.0082	4.36069E-03	0.0082	7.12804E-07	0.0652				
51201	8.80307E-03	0.0078	2.88327E-06	0.0253	1.68743E-03	0.0093	1.57296E-03	0.0096	9.84113E-07	0.0455				
51202	9.48465E-03	0.0079	3.21147E-06	0.0288	1.83607E-03	0.0090	1.71449E-03	0.0093	1.18405E-06	0.0546				
51203	1.10875E-02	0.0070	3.76870E-06	0.0339	2.13817E-03	0.0082	1.99681E-03	0.0085	1.47731E-06	0.0741				
51204	1.16565E-02	0.0071	3.97081E-06	0.0264	2.26809E-03	0.0082	2.12028E-03	0.0085	1.48674E-06	0.0480				
51205	1.33710E-02	0.0072	4.51864E-06	0.0235	2.57899E-03	0.0079	2.40764E-03	0.0081	1.61730E-06	0.0342				
51206	1.37552E-02	0.0070	4.61054E-06	0.0222	2.67091E-03	0.0078	2.49541E-03	0.0080	1.70303E-06	0.0332				
51207	1.48268E-02	0.0069	4.99503E-06	0.0240	2.86829E-03	0.0075	2.67867E-03	0.0077	1.86273E-06	0.0329				
51208	1.52010E-02	0.0067	5.06041E-06	0.0278	2.96161E-03	0.0078	2.76755E-03	0.0081	1.90284E-06	0.0364				
51209	1.61205E-02	0.0063	5.41652E-06	0.0209	3.11175E-03	0.0070	2.90760E-03	0.0073	2.07966E-06	0.0345				
51210	1.64405E-02	0.0064	5.47664E-06	0.0206	3.17497E-03	0.0070	2.96661E-03	0.0072	2.09336E-06	0.0338				
51211	1.70809E-02	0.0061	5.63600E-06	0.0192	3.30434E-03	0.0068	3.08784E-03	0.0070	2.10953E-06	0.0318				
51212	1.72847E-02	0.0066	5.95150E-06	0.0231	3.33453E-03	0.0071	3.11363E-03	0.0073	2.21659E-06	0.0372				
51213	1.75438E-02	0.0059	6.06393E-06	0.0221	3.38692E-03	0.0065	3.16277E-03	0.0067	2.32826E-06	0.0414				
51214	1.78723E-02	0.0062	6.01987E-06	0.0211	3.46557E-03	0.0069	3.23655E-03	0.0071	2.24508E-06	0.0306				
51215	1.79025E-02	0.0060	5.91052E-06	0.0185	3.47643E-03	0.0070	3.25059E-03	0.0073	2.28472E-06	0.0310				
51216	1.79310E-02	0.0061	6.05122E-06	0.0201	3.47185E-03	0.0068	3.24263E-03	0.0070	2.27418E-06	0.0326				
51217	1.77770E-02	0.0060	5.95778E-06	0.0206	3.44379E-03	0.0068	3.21855E-03	0.0070	2.17543E-06	0.0309				
51218	1.78085E-02	0.0062	5.90488E-06	0.0226	3.45516E-03	0.0070	3.23081E-03	0.0072	2.25564E-06	0.0392				
51219	1.72810E-02	0.0060	5.65633E-06	0.0244	3.36124E-03	0.0070	3.14332E-03	0.0072	2.26203E-06	0.0495				
51220	1.71158E-02	0.0060	5.62432E-06	0.0194	3.31622E-03	0.0067	3.10192E-03	0.0070	2.15678E-06	0.0328				
51221	1.64692E-02	0.0061	5.57877E-06	0.0257	3.19780E-03	0.0068	2.98720E-03	0.0070	2.02408E-06	0.0315				
51222	1.62713E-02	0.0062	5.36558E-06	0.0191	3.14783E-03	0.0068	2.94073E-03	0.0071	2.01836E-06	0.0318				
51223	1.55525E-02	0.0067	5.35865E-06	0.0228	2.99953E-03	0.0073	2.79899E-03	0.0075	2.01957E-06	0.0383				
51224	1.49841E-02	0.0064	5.00390E-06	0.0221	2.89375E-03	0.0071	2.70306E-03	0.0074	1.85047E-06	0.0332				
51225	1.36870E-02	0.0067	4.53677E-06	0.0245	2.65698E-03	0.0075	2.48318E-03	0.0078	1.66387E-06	0.0359				
51226	1.31380E-02	0.0066	4.58871E-06	0.0241	2.53183E-03	0.0075	2.36184E-03	0.0078	1.61263E-06	0.0362				
51227	1.17851E-02	0.0075	4.00785E-06	0.0236	2.28973E-03	0.0088	2.13771E-03	0.0091	1.43278E-06	0.0432				
51228	1.14073E-02	0.0077	3.81213E-06	0.0241	2.19948E-03	0.0086	2.05317E-03	0.0089	1.34453E-06	0.0405				
51229	9.64104E-03	0.0077	3.19404E-06	0.0246	1.85748E-03	0.0089	1.73215E-03	0.0092	1.09114E-06	0.0402				

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51230  8.98359E-03  0.0079  2.96857E-06  0.0227  1.71656E-03  0.0088  1.59880E-03  0.0091  1.01625E-06  0.0412
51301  8.22127E-03  0.0216  2.37498E-06  0.0640  1.60255E-03  0.0261  1.50677E-03  0.0270  9.34723E-07  0.0921
51302  3.96066E-03  0.0386  1.32721E-06  0.1287  7.86061E-04  0.0472  7.30642E-04  0.0490  4.20873E-07  0.1932
51303  9.99037E-03  0.0222  3.00416E-06  0.0743  1.92544E-03  0.0252  1.80336E-03  0.0259  9.72766E-07  0.0807
51304  5.05105E-03  0.0320  1.75047E-06  0.1162  9.60045E-04  0.0351  8.93606E-04  0.0361  6.32382E-07  0.1325
51305  1.10464E-02  0.0218  3.53849E-06  0.0648  2.09498E-03  0.0246  1.96055E-03  0.0252  1.26887E-06  0.0872
51306  6.54616E-03  0.0287  2.74006E-06  0.1092  1.25184E-03  0.0329  1.16637E-03  0.0339  9.24343E-07  0.1332
51307  1.09909E-02  0.0213  3.68784E-06  0.0690  2.12084E-03  0.0235  1.98801E-03  0.0241  1.39946E-06  0.1066
51308  7.41795E-03  0.0263  2.51051E-06  0.0996  1.44845E-03  0.0305  1.35636E-03  0.0315  9.11673E-07  0.1198
51309  1.12788E-02  0.0206  3.66101E-06  0.0621  2.17077E-03  0.0241  2.03289E-03  0.0248  1.53919E-06  0.0982
51310  8.57554E-03  0.0251  2.95531E-06  0.0805  1.67877E-03  0.0312  1.57126E-03  0.0322  1.20887E-06  0.1168
51311  1.14814E-02  0.0209  3.87326E-06  0.0726  2.19557E-03  0.0235  2.05430E-03  0.0241  1.47017E-06  0.0958
51312  9.59073E-03  0.0246  3.07008E-06  0.0971  1.84405E-03  0.0269  1.72872E-03  0.0275  1.31846E-06  0.1710
51313  1.15016E-02  0.0231  4.07682E-06  0.0938  2.20811E-03  0.0264  2.06381E-03  0.0271  1.52054E-06  0.1510
51314  9.94780E-03  0.0227  3.74469E-06  0.0783  1.91939E-03  0.0261  1.79175E-03  0.0268  1.62304E-06  0.1273
51315  1.09294E-02  0.0222  3.63230E-06  0.0720  2.06226E-03  0.0254  1.92526E-03  0.0261  1.45203E-06  0.1064
51316  1.06639E-02  0.0229  3.49498E-06  0.0869  2.05540E-03  0.0271  1.93048E-03  0.0280  1.62441E-06  0.1125
51317  1.04879E-02  0.0223  3.03488E-06  0.0734  2.02353E-03  0.0275  1.89927E-03  0.0284  1.17994E-06  0.0901
51318  1.11506E-02  0.0218  3.88900E-06  0.0897  2.15615E-03  0.0248  2.01779E-03  0.0254  1.71603E-06  0.1574
51319  9.76950E-03  0.0259  2.86357E-06  0.0728  1.91999E-03  0.0299  1.79838E-03  0.0303  1.13747E-06  0.1080
51320  1.10558E-02  0.0214  3.70768E-06  0.0733  2.14570E-03  0.0247  2.01509E-03  0.0254  1.60551E-06  0.1122
51321  8.85385E-03  0.0252  2.75640E-06  0.0941  1.70308E-03  0.0290  1.59795E-03  0.0297  1.11384E-06  0.1196
51322  1.13941E-02  0.0206  3.57255E-06  0.0774  2.21630E-03  0.0234  2.07440E-03  0.0239  1.21371E-06  0.0770
51323  7.61984E-03  0.0272  2.36184E-06  0.0873  1.44808E-03  0.0303  1.35820E-03  0.0311  8.74631E-07  0.1259
51324  1.11088E-02  0.0214  3.60866E-06  0.0618  2.14674E-03  0.0248  2.01427E-03  0.0256  1.44574E-06  0.0849
51325  6.24001E-03  0.0302  2.16592E-06  0.0810  1.21717E-03  0.0351  1.13598E-03  0.0361  6.61633E-07  0.0929
51326  1.05864E-02  0.0219  3.77664E-06  0.0729  2.02869E-03  0.0239  1.89538E-03  0.0246  1.54311E-06  0.1098
51327  5.21349E-03  0.0313  1.90061E-06  0.1163  1.00883E-03  0.0377  9.41739E-04  0.0391  5.39113E-07  0.1189
51328  9.60458E-03  0.0226  3.59889E-06  0.0953  1.81026E-03  0.0247  1.68475E-03  0.0252  1.40568E-06  0.1739
51329  4.13057E-03  0.0365  1.53007E-06  0.1082  7.83724E-04  0.0408  7.24601E-04  0.0422  4.21467E-07  0.1468
51330  8.40236E-03  0.0228  2.86134E-06  0.0753  1.61338E-03  0.0252  1.50764E-03  0.0259  8.47574E-07  0.0742


surf#  surface current      surface flux
51009  2.52707E-01  0.0041  6.93031E-03  0.0059
51070  2.53094E-01  0.0041  6.96816E-03  0.0060
51100  2.37790E-01  0.0042  6.13665E-03  0.0058
51130  2.37681E-01  0.0042  6.08135E-03  0.0056


surface            area:
51009,51070    6.61189E+01
51100,51130    6.62298E+01


volumes
**6**  2.73877E+01
**4**  3.76983E+00
**101,116  7.33689E+00
**1**  1.26456E+01
**2**  2.95498E+00
**3**  2.89576E-01
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