
OpenNTP Documentation

Release 1.2

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CONTENTS:

Neutron Transport Package with Graphical User Interface

Neutron Transport Package **OpenNTP** (Open Neutron Transport Package from the Radiations and Nuclear Systems Group), is an open-source code written in FORTRAN90 for a pedagogical purpose to solve the steady-state multigroup neutron transport equation using either:

- Collision Probability Method (CP) in One-Dimensional for Slab, Cylindrical or Spherical geometry.
- Discrete Ordinate Method (S_N) in One or Two-Dimensional for Cartesian Geometry.
- Method of Characteristics (MOC) in One-Dimensional for Slab Geometry.

The code, including the graphical user interface is developed and maintained by [Mohamed LAHDOUR](#) (PhD student) and Prof. [Tarek EL BARDOUNI](#) from [University Abdelmalek Essaadi Tetouan Morocco](#) .

OpenNTP's main features are:

- free & open source software with a pedagogical purpose.
- solve the steady-state multigroup neutron transport equation in one, or two spatial dimensions.
- solve the steady-state multigroup neutron transport equation in a multiplicative medium with isotropic and anisotropic scattering source.
- simple framework to add and test new algorithms.
- provided with a graphical user interface written in Python programming language which has been developed to simplify the use of **OpenNTP**.
- computed results: k_{eff} and fluxes.

Recommended publication for citing

Lahdour, M., Bardouni, T. E., Chakir, E., Benaalilou, K., Mohammed, M., Bougueniz, H., and Yaakoubi, H. E., “[Ntp-ersn: A new package for solving the multigroup neutron transport equation in a slab geometry.](#),” *Applied Radiation and Isotopes*, 73:84 – **145** (2019a).

Lahdour, M., Bardouni, T. E., Mohammed, M., Ouahdani, S. E. “[The discrete ordinate method for angular flux calculations in slab geometry.](#),” *Heliyon*, e02211 **5** (2019).

QUICK INSTALL GUIDE

This quick install guide outlines the basic steps needed to install OpenNTP on your computer.

1.1 Installing on Linux

1. If you are using Ubuntu 18.10 or newer, open a terminal in a GNU/Linux box then install gfortran with the following command:

```
sudo apt-get update
sudo apt-get install gfortran
```

2. You need to install numpy (F2PY) and matplotlib library to run the package OpenNTP:

```
sudo apt install python-pip
sudo apt-get install python-numpy
pip install numpy matplotlib
```

3. You need to install PyQt5 on Ubuntu with python to run the GUI:

```
pip install --user pyqt5
sudo apt-get install python-pyqt5
sudo apt-get install pyqt5-dev-tools
sudo apt-get install qttools5-dev-tools
```

4. Install the OpenNTP package

```
git clone https://github.com/mohamedlahdour/OpenNTP.git
```

5. Import the *OpenNTP* and run the package in the following way:

```
cd OpenNTP
$ python main.py
```


THEORY AND METHODOGY

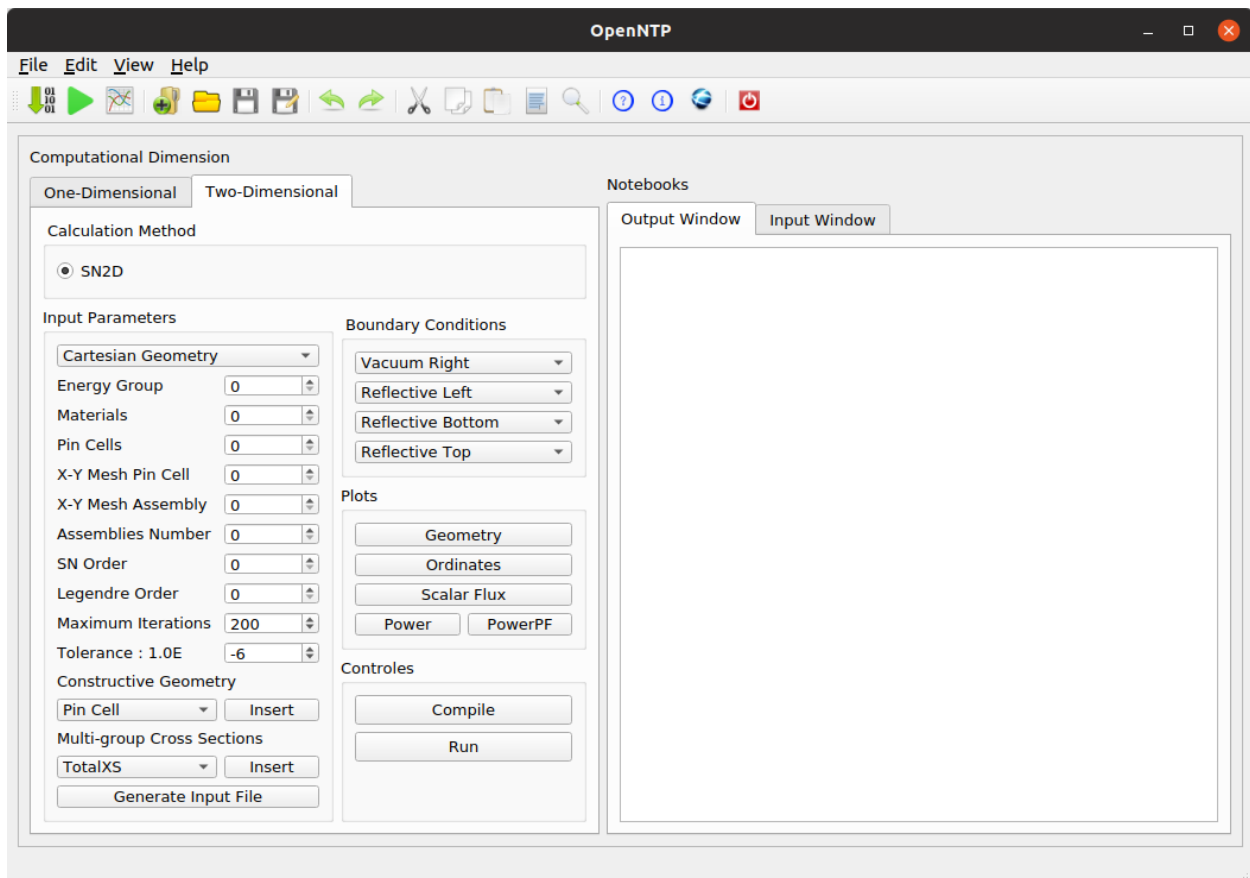
USER'S GUIDE

3.1 1. Graphical User Interface

A graphical user interface written in Python programming language has been developed to simplify the use of package OpenNTP. After starting the software by typing the following command line in a terminal:

```
cd OpenNTP
$ python main.py
```

A main window (GUI) of the package OpenNTP on an Ubuntu Linux machine will be displayed as in Figure below.



3.2 2. Examples & test suite

3.2.1 2.2. Two-dimensional benchmark

2.2.1. Creating JSON Input File

The input data file must be in JSON format. The first method is to write it directly in **Text editor** as is shown in the figure below, which illustrates an example input file of a C5G7 benchmark on deterministic transport calculations without spatial homogenization taken from [Lewis, E. E., et al.,2001].

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↪44780E-02],
  [0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,9.17420E-04,3.16774E-01,2.
↪38760E-01],
  [0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,4.97930E-02,1.
↪0991E+00]]],
    "XSChi":
[5.87910E-01,4.11760E-01,3.39060E-04,1.17610E-07,0.00000E+00,0.00000E+00,0.
↪00000E+00]
    },
    {
      "id": 6,
      "nom": "Guide Tube",
      "XSTotal":
[1.26032E-01,2.93160E-01,2.84240E-01,2.80960E-01,3.34440E-01,5.65640E-01,1.
↪17215E+00],
      "XSNuFission":

```

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```

[0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.
↪00000E+00],
  "XSfission":
[0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.
↪00000E+00],
  "XSscatter Matrix":
[[[6.61659E-02,5.90700E-02,2.83340E-04,1.46220E-06,2.06420E-08,0.00000E-00,0.
↪00000E-00],
  [0.00000E-00,2.40377E-01,5.24350E-02,2.49900E-04,1.92390E-05,2.98750E-06,4.
↪21400E-07],
  [0.00000E-00,0.00000E-00,1.83297E-01,9.23970E-02,6.94460E-03,1.08030E-03,2.
↪05670E-04],
  [0.00000E-00,0.00000E-00,0.00000E-00,7.88511E-02,1.70140E-01,2.58810E-02,4.
↪92970E-03],
  [0.00000E-00,0.00000E-00,0.00000E-00,3.73330E-05,9.97372E-02,2.06790E-01,2.
↪44780E-02],
  [0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,9.17260E-04,3.16765E-01,2.
↪38770E-01],
  [0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,4.97920E-02,1.
↪09912E+00]]],
  "XSchi":
[0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.
↪00000E+00]
    },
    {
      "id": 7,
      "nom": "Moderator",
      "XSTotal":
[1.59206E-01,4.12970E-01,5.90310E-01,5.84350E-01,7.18000E-01,1.25445E+00,2.
↪65038E+00],
      "XSNuFission":
[0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.
↪00000E+00],
      "XSfission":
[0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.
↪00000E+00],
      "XSscatter Matrix":
[[[4.44777E-02,1.13400E-01,7.23470E-04,3.74990E-06,5.31840E-08,0.00000E-00,0.
↪00000E-00],
  [0.00000E-00,2.82334E-01,1.29940E-01,6.23400E-04,4.80020E-05,7.44860E-06,1.
↪04550E-06],
  [0.00000E-00,0.00000E-00,3.45256E-01,2.24570E-01,1.69990E-02,2.64430E-03,5.
↪03440E-04],
  [0.00000E-00,0.00000E-00,0.00000E-00,9.10284E-02,4.15510E-01,6.37320E-02,1.
↪21390E-02],
  [0.00000E-00,0.00000E-00,0.00000E-00,7.14370E-05,1.39138E-01,5.11820E-01,6.
↪12290E-02],
  [0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,2.21570E-03,6.99913E-01,5.
↪37320E-01],
  [0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,0.00000E-00,1.32440E-01,2.
↪48070E+00]]],
      "XSchi":
[0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.00000E+00,0.
↪00000E+00]
    }
  ]
}

```

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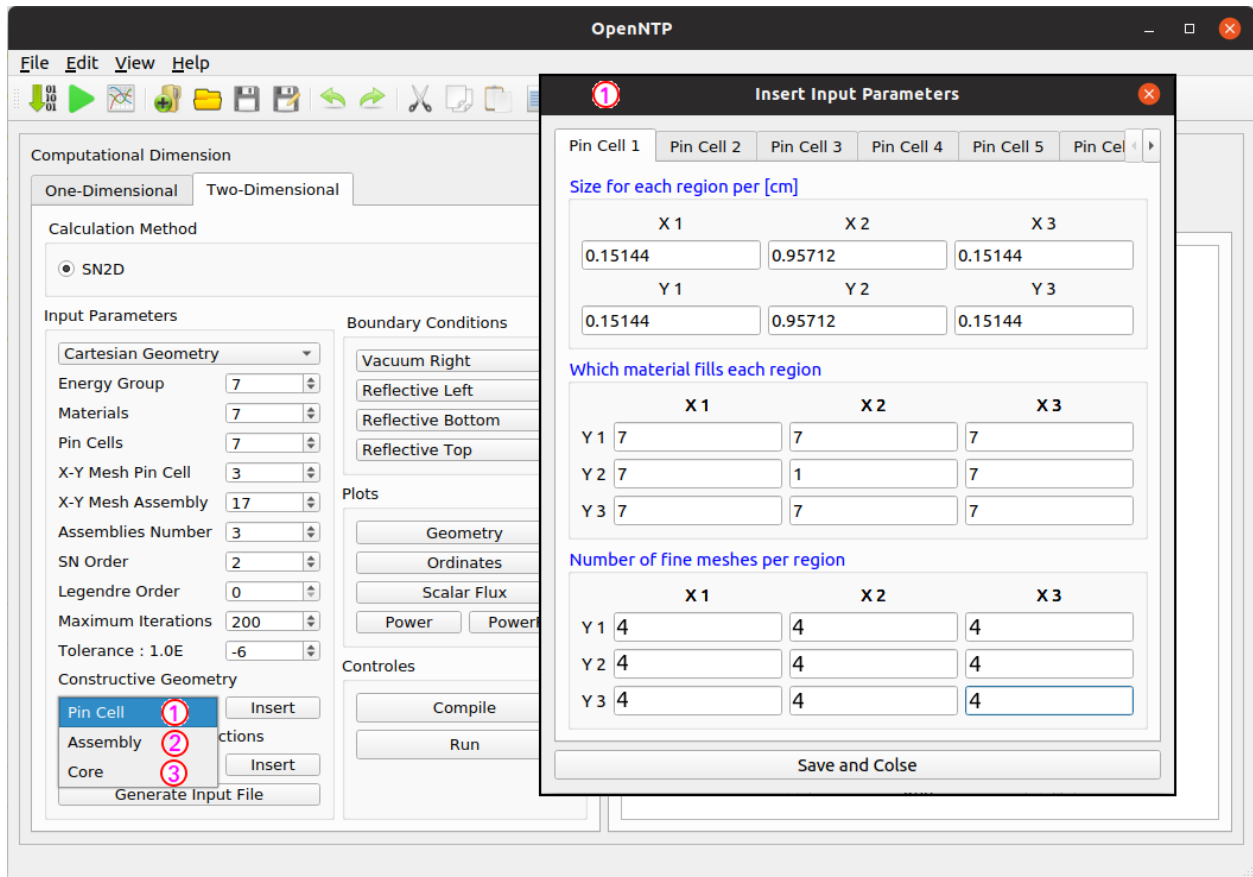
(continued from previous page)

}

2.2.2. Generating JSON Input File

To facilitate the creation of a new OpenNTP input file, a set of dialog boxes have been developed (Below) which allows users to create the OpenNTP input file in a simpler, faster and interactive. Users can fill up all information about the OpenNTP input file (including: number of group energy, materials, Pin cells, assemblies, type of geometry, multi-group cross sections ...) and once they have specified input files in JSON format will be automatically created in the window **Text editor** by clicking on button **Generate Input file**.

- Definition of Pin Cells by introducing in each coarse meshes size along the x and y-axis, then the material index and the number of fine mesh.



- inserting the pin cells index into each assembly.

2 Insert Input Parameters

Assembly 1 Assembly 2 Assembly 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	6	1	1	6	1	1	6	1	1	1	1	1
4	1	1	1	6	1	1	1	1	1	1	1	1	1	6	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	6	1	1	6	1	1	6	1	1	6	1	1	6	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	6	1	1	6	1	1	5	1	1	6	1	1	6	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	6	1	1	6	1	1	6	1	1	6	1	1	6	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	6	1	1	1	1	1	1	1	1	1	6	1	1	1
15	1	1	1	1	1	6	1	1	6	1	1	6	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Save and Colse

- Definition of the general structure of the reactor core by inserting the assembly indices in their locations.

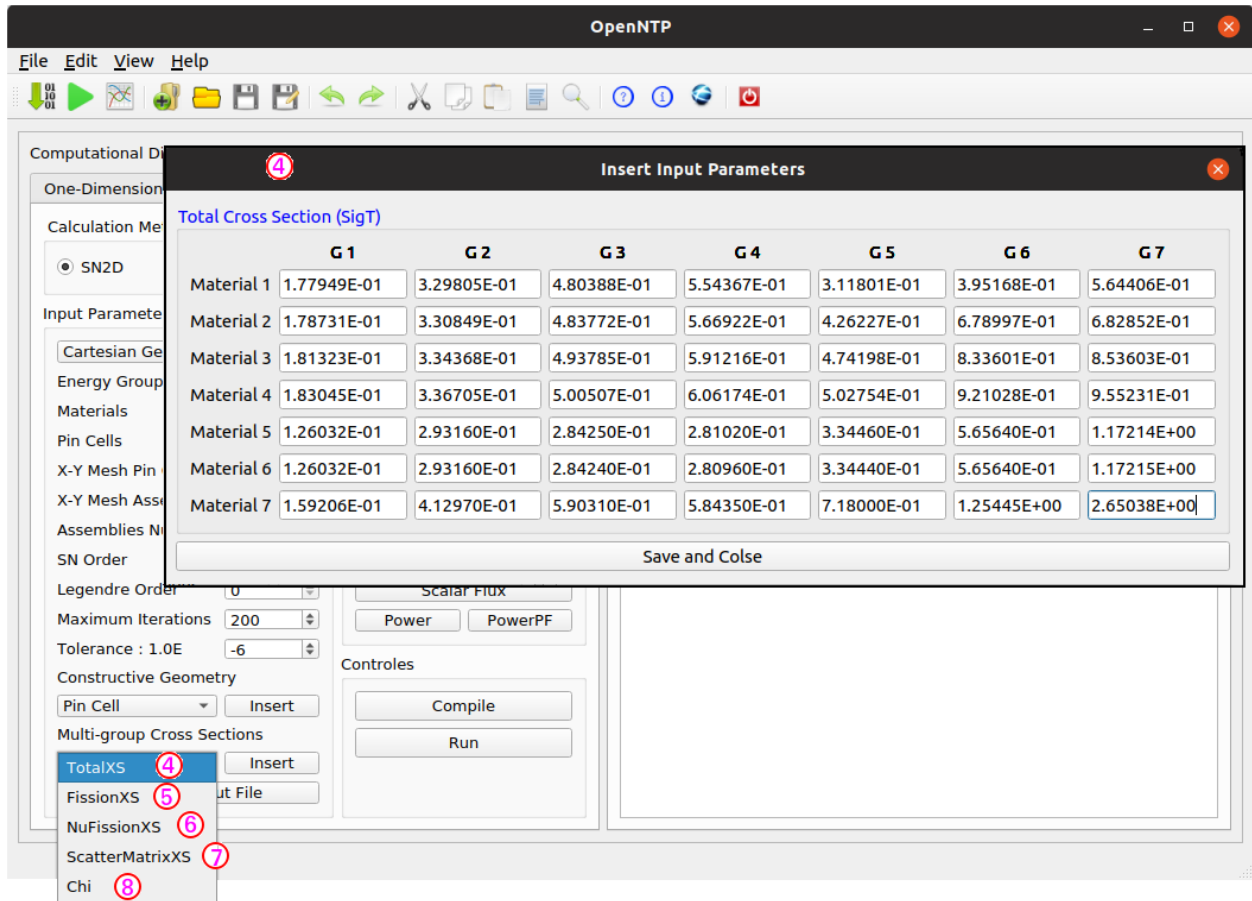
3 Insert Input Parameters

Core geometry:

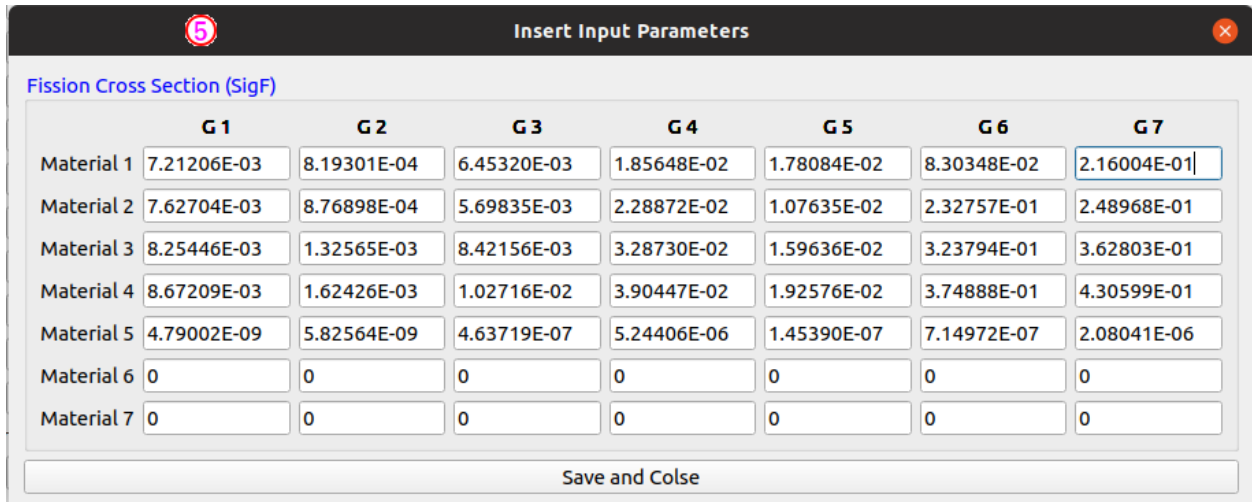
	1	2	3
1	3	3	3
2	2	1	3
3	1	2	3

Save and Colse

- Insertion of total multi-group macroscopic cross section data.



- Insertion of fission multi-group macroscopic cross section data



- Insertion of nu-fission multi-group macroscopic cross section data.

6 Insert Input Parameters

NuFission Cross Section (NuSigF)

	G 1	G 2	G 3	G 4	G 5	G 6	G 7
Material 1	2.00599E-02	2.02730E-03	1.57059E-02	4.51830E-02	4.33421E-02	2.02090E-01	5.25711E-01
Material 2	2.17530E-02	2.53510E-03	1.62679E-02	6.54741E-02	3.07241E-02	6.66651E-01	7.13990E-01
Material 3	2.38140E-02	3.85869E-03	2.41340E-02	9.43662E-02	4.57699E-02	9.28181E-01	1.04320E+00
Material 4	2.51860E-02	4.73951E-03	2.94781E-02	1.12250E-01	5.53030E-02	1.07500E+00	1.23930E+00
Material 5	1.32340E-08	1.43450E-08	1.12860E-06	1.27630E-05	3.53850E-07	1.74010E-06	5.06330E-06
Material 6	0	0	0	0	0	0	0
Material 7	0	0	0	0	0	0	0

Save and Colse

- Insertion of scatternig matrix multi-group macroscopic cross section data

7 Insert Input Parameters

Scatter Matrix Cross Section (SigS)

Material 1	Material 2	Material 3	Material 4	Material 5	Material 6	Material 7
G 1	1.27537E-01	4.23780E-02	9.43740E-06	5.51630E-09	0	0
G 2	0	3.24456E-01	1.63140E-03	3.14270E-09	0	0
G 3	0	0	4.50940E-01	2.67920E-03	0	0
G 4	0	0	0	4.52565E-01	5.56640E-03	0
G 5	0	0	0	1.25250E-04	2.71401E-01	1.02550E-02
G 6	0	0	0	0	1.29680E-03	2.65802E-01
G 7	0	0	0	0	0	8.54580E-03

Save and Colse

- Insertion of fission spectrum data.

8 Insert Input Parameters

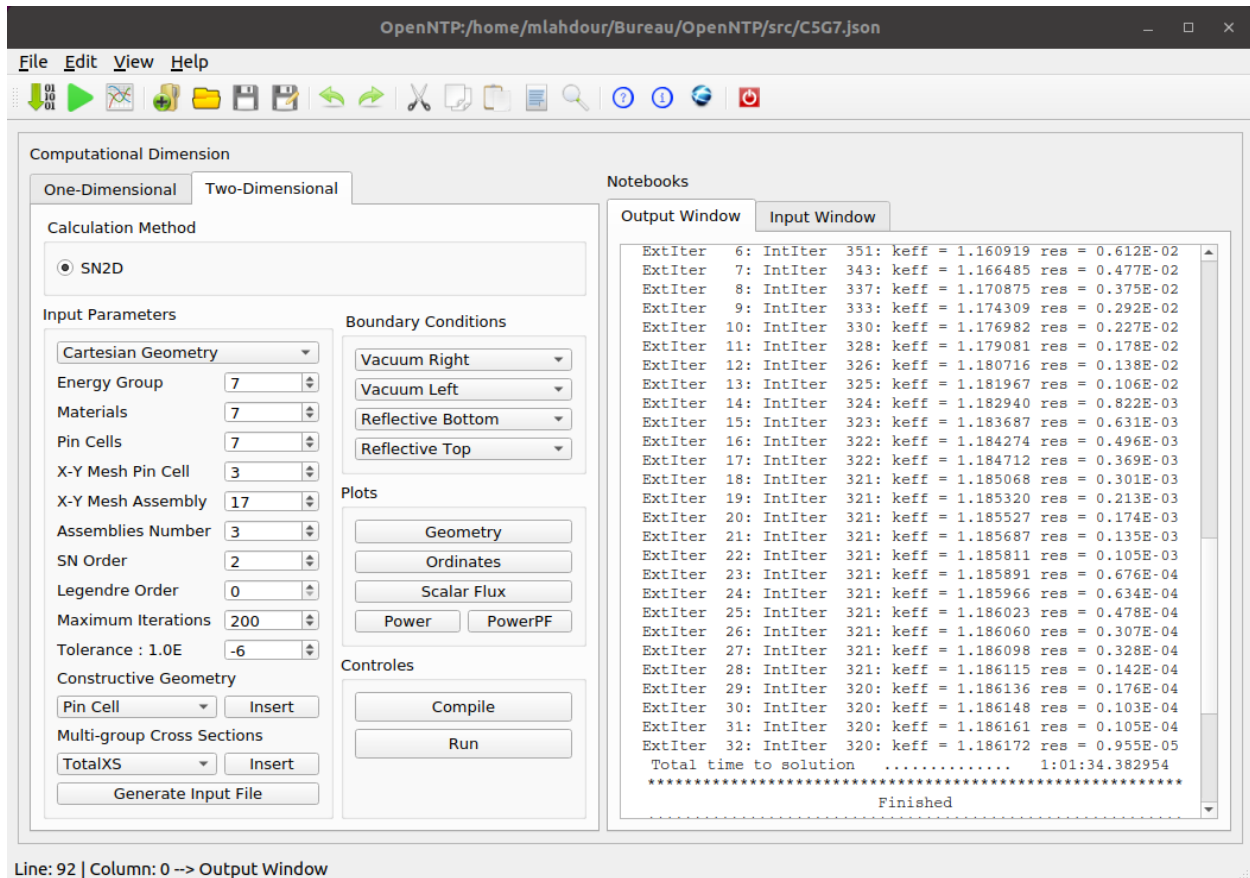
Density Function for Neutrons (Chi)

	G 1	G 2	G 3	G 4	G 5	G 6	G 7
Material 1	5.87910E-01	4.11760E-01	3.39060E-04	1.17610E-07	0	0	0
Material 2	5.87910E-01	4.11760E-01	3.39060E-04	1.17610E-07	0	0	0
Material 3	5.87910E-01	4.11760E-01	3.39060E-04	1.17610E-07	0	0	0
Material 4	5.87910E-01	4.11760E-01	3.39060E-04	1.17610E-07	0	0	0
Material 5	5.87910E-01	4.11760E-01	3.39060E-04	1.17610E-07	0	0	0
Material 6	0	0	0	0	0	0	0
Material 7	0	0	0	0	0	0	0

Save and Colse

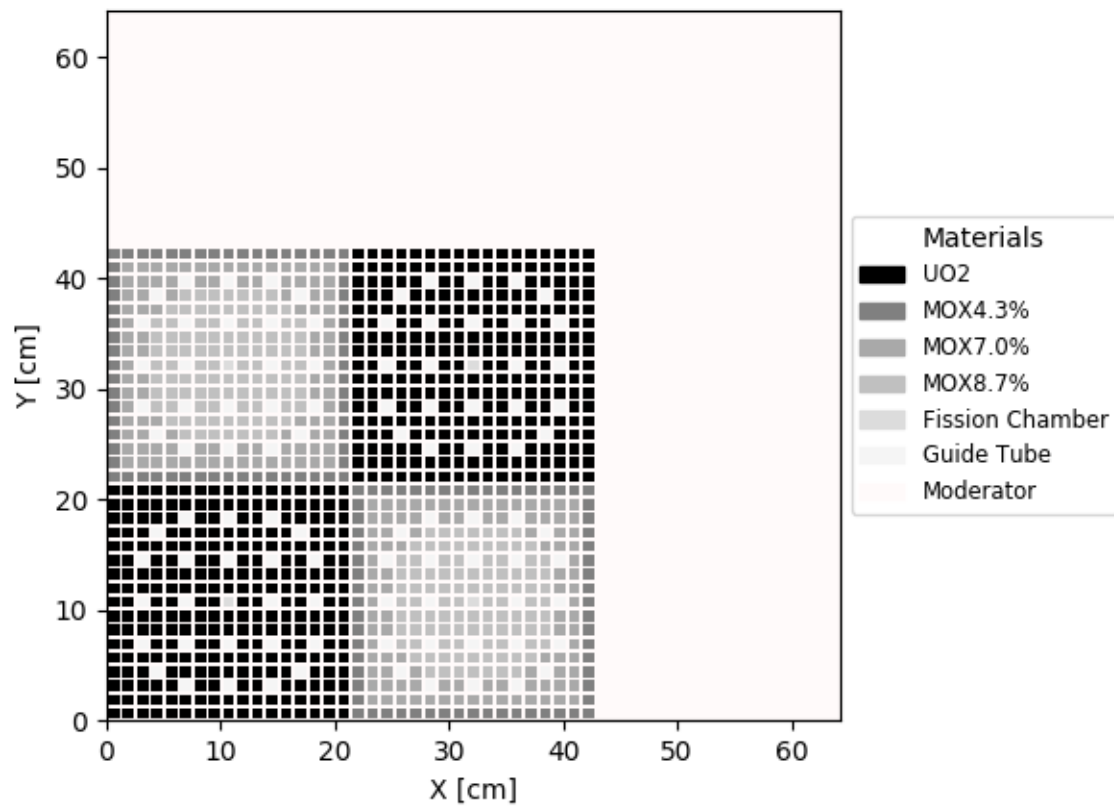
2.2.3. Running OpenNTP under a GUI

The **Run** button is used to running the multi-group scheme, and the figure below shows the values of the multiplication factor as a function of the iteration numbers.



2.2.4. Geometry Visualizations

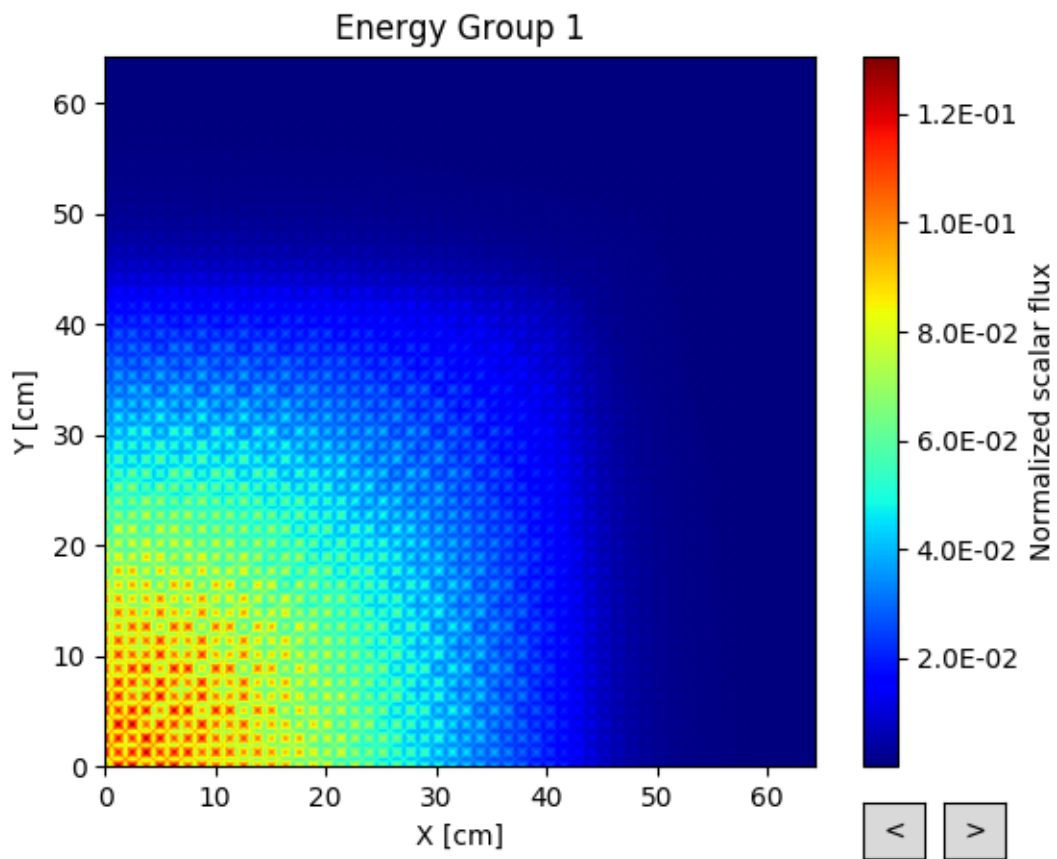
The **geometry** button allowing to plot in two dimensions the geometry to study. The plotting mode of the geometry is based on the presence of an input file. A depiction of the geometry for the example input file given in sub section [Creating JSON Input File](#) is illustrated in Figure below



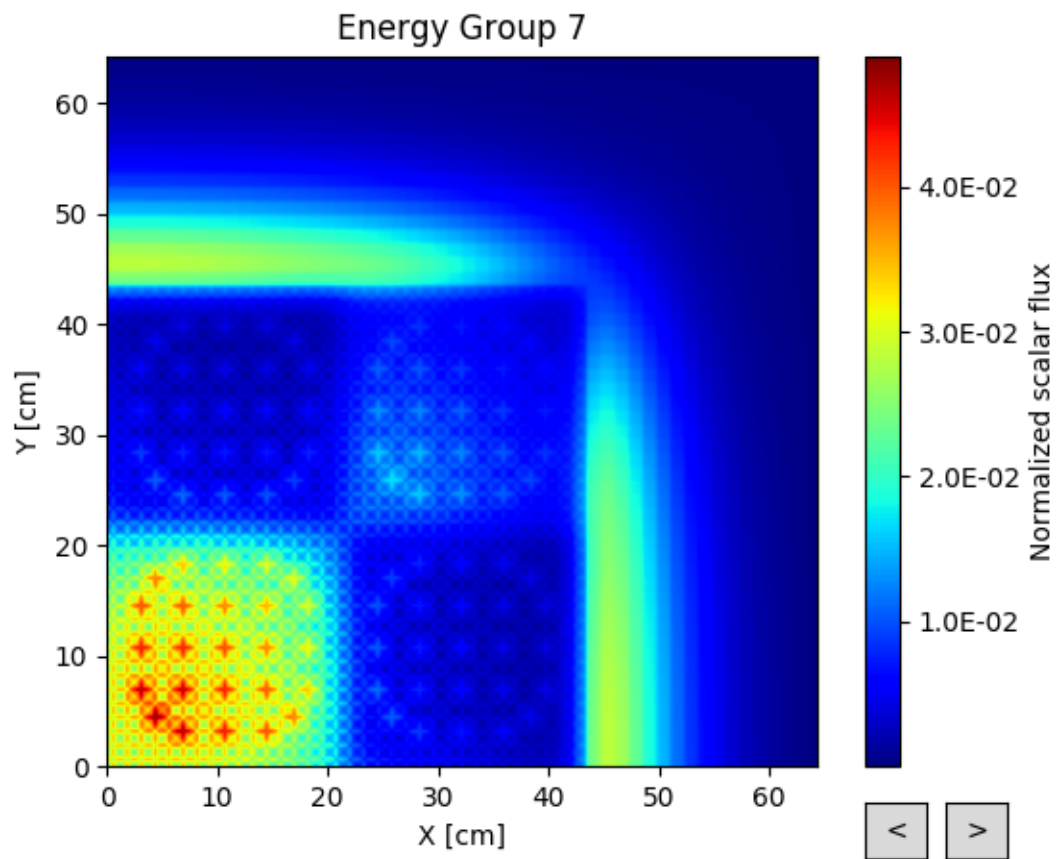
2.2.5. Flux Visualizations

The **Plot** button refers to a set of routines programming in fortran and python to plot the scalar flux in space of one or two-dimensional and in each energy group. The figure bellow shows the flux for the example input file given in sub section [Creating JSON Input File](#) after clicking on the **Plot** button.

- The 2D C5G7 benchmark solved with [OpenNTP](#)
- Thermal flux

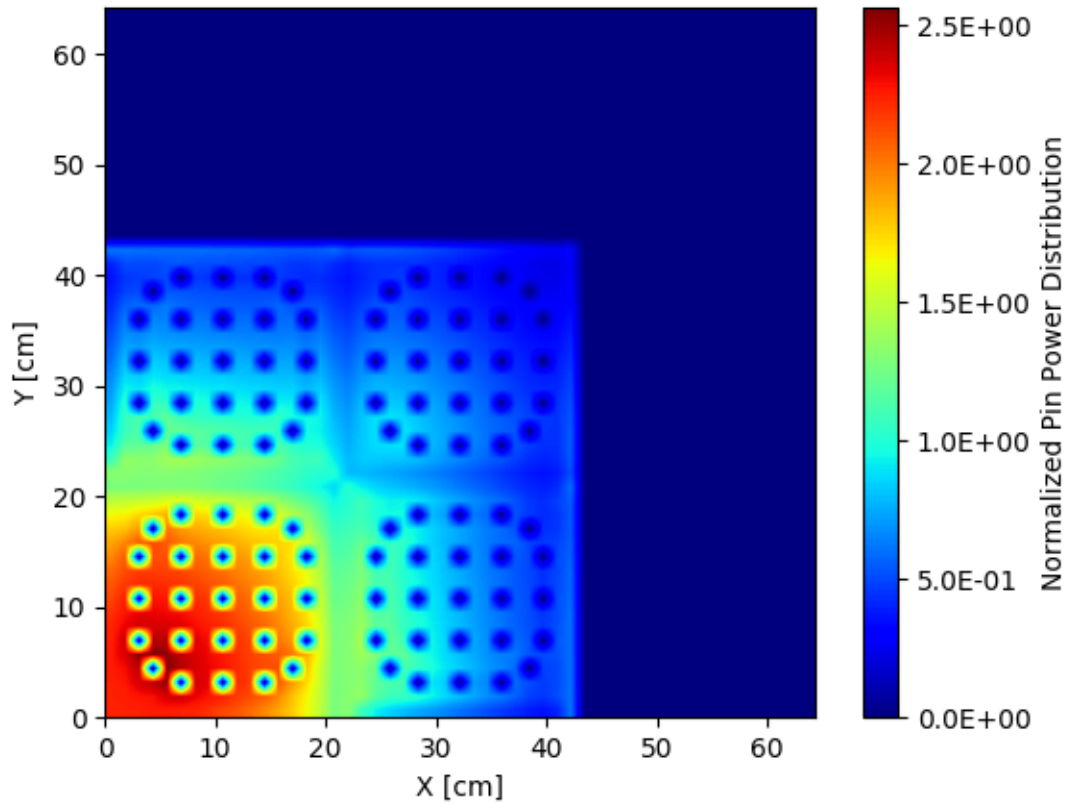


- Fast flux



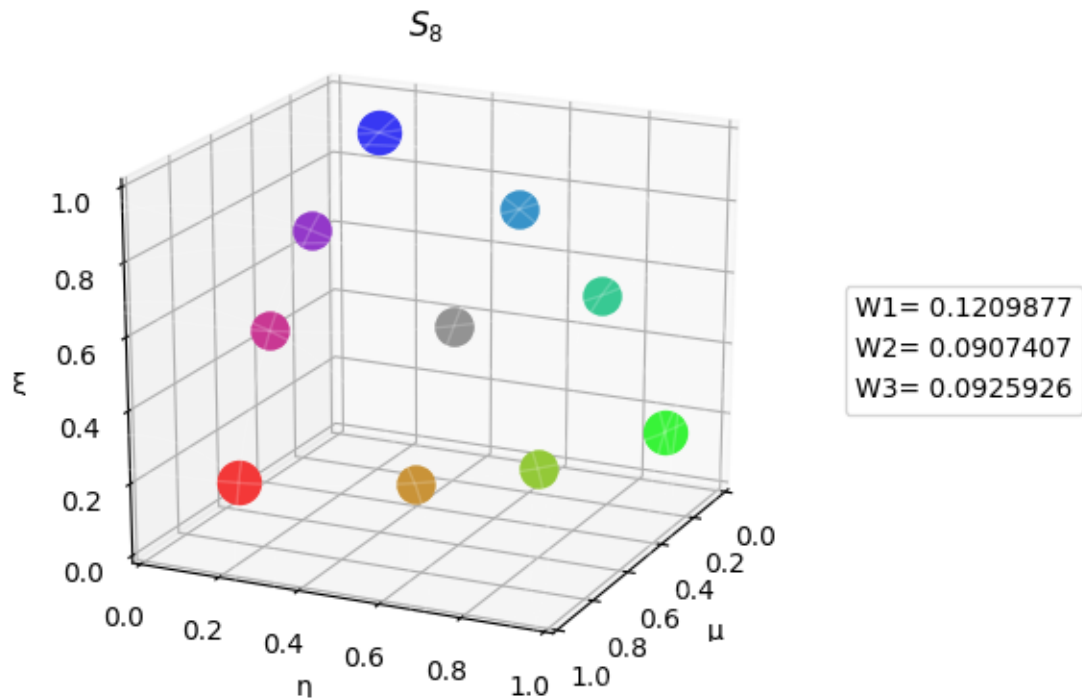
2.2.6. Pin Power Visualizations

Next we will visualize the pin power results obtained from the [OpenNTP](#) calculations.



2.2.7. Level symmetric gaussian quadrature sets visualizations

The level-symmetric quadrature set is used in the Discrete Ordinates (S_N) method (Lewis and Miller, 1984). The subscript N refers to the number of directions along each axis with half being positive and half negative. The figure below give the weights and angles used for each set in the 1st octant which will be displayed automatically by clicking on the **Ordinate** button



2.2.8. Simple Output

The following is the corresponding output to the above case. A brief outline of the output file contents is version and run time information, print of input values of the name list variables, print of relevant parameters after setup, calculation run time parameters method, scalar flux solution and output parameters solution to transport equation.

```

ERSN, UNIVERSITY ABDELMALEK ESSAADI FACULTY OF SCIENCES - TETOUAN, MO-
ROCCO CODE DEVELOPED BY MOHAMED LAHDOUR, PHD STUDENT OpenRSN: SN DIS-
CRETE ORDINATES METHOD DIMENSION: TWO DIMENSIONS (2D) GEOMETRY: CARTE-
SIAN VERSION NUMBER: 1.2 VERSION DATE: 20 August 2019 RAN ON: 2020-02-11 12:06:14.53
(H:M:S) *****

```

INPUT PARAMETER - VALUES FROM INPUT

```

ENERGY GROUPS NUMBER: 7 PIN CELLS NUMBER: 7 ASSEMBLIES NUMBER: 3 X REGIONS
NUMBER PIN CELL: 3 Y REGIONS NUMBER PIN CELL: 3 MATERIALS NUMBER: 7 SIZE OF
EACH X REGION PIN CELL 1 : 0.15144 0.95712 0.15144 SIZE OF EACH Y REGION PIN CELL 1
: 0.15144 0.95712 0.15144 SIZE OF EACH X REGION PIN CELL 2 : 0.15144 0.95712 0.15144 SIZE
OF EACH Y REGION PIN CELL 2 : 0.15144 0.95712 0.15144 SIZE OF EACH X REGION PIN CELL
3 : 0.15144 0.95712 0.15144 SIZE OF EACH Y REGION PIN CELL 3 : 0.15144 0.95712 0.15144 SIZE
OF EACH X REGION PIN CELL 4 : 0.15144 0.95712 0.15144 SIZE OF EACH Y REGION PIN CELL
4 : 0.15144 0.95712 0.15144 SIZE OF EACH X REGION PIN CELL 5 : 0.15144 0.95712 0.15144 SIZE

```

OF EACH Y REGION PIN CELL 5 : 0.15144 0.95712 0.15144 SIZE OF EACH X REGION PIN CELL
 6 : 0.15144 0.95712 0.15144 SIZE OF EACH Y REGION PIN CELL 6 : 0.15144 0.95712 0.15144
 SIZE OF EACH X REGION PIN CELL 7 : 0.15144 0.95712 0.15144 SIZE OF EACH Y REGION PIN
 CELL 7 : 0.15144 0.95712 0.15144 NUMBER OF DIRECTIONS ALONG EACH AXIS: 2 ORDER
 LEGENDRE POLYNOMIAL: 0 TOTAL NUMBER OF X FINE MESHES: 612 TOTAL NUMBER OF
 Y FINE MESHES: 612 CONVERGENCE CRITERION of KEFF AND FLUX: 1.0E-05

CALCULATION RUN-TIME PARAMETERS SN

LEVEL SYMMETRIC GAUSSIAN QUADRATURE SETS:

N. ORDER MU ETA PSI WEIGHTS I

1 5.77350E-01 5.77350E-01 5.77350E-01 1.00000E+00 I

PSEUDO CROSS SECTIONS DATA:

MATERIAL : 1

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING FISSION SPECTRUM I

1 1.77949E-01 5.04120E-02 2.00599E-02 1.27537E-01 5.87910E-01 I
 2 3.29805E-01 5.34898E-03 2.02730E-03 3.24456E-01 4.11760E-01 I
 3 4.80388E-01 2.94480E-02 1.57059E-02 4.50940E-01 3.39060E-04 I
 4 5.54367E-01 1.01802E-01 4.51830E-02 4.52565E-01 1.17610E-07 I
 5 3.11801E-01 4.04000E-02 4.33421E-02 2.71401E-01 0.00000E+00 I
 6 3.95168E-01 1.29366E-01 2.02090E-01 2.65802E-01 0.00000E+00 I
 7 5.64406E-01 2.91326E-01 5.25711E-01 2.73080E-01 0.00000E+00 I

MATERIAL : 2

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING FISSION SPECTRUM I

1 1.78731E-01 4.98550E-02 2.17530E-02 1.28876E-01 5.87910E-01 I
 2 3.30849E-01 5.39699E-03 2.53510E-03 3.25452E-01 4.11760E-01 I
 3 4.83772E-01 3.05840E-02 1.62679E-02 4.53188E-01 3.39060E-04 I
 4 5.66922E-01 1.09749E-01 6.54741E-02 4.57173E-01 1.17610E-07 I
 5 4.26227E-01 1.49413E-01 3.07241E-02 2.76814E-01 0.00000E+00 I
 6 6.78997E-01 4.26035E-01 6.66651E-01 2.52962E-01 0.00000E+00 I
 7 6.82852E-01 4.17845E-01 7.13990E-01 2.65007E-01 0.00000E+00 I

MATERIAL : 3

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING FISSION SPECTRUM I

```
1 1.81323E-01 5.08660E-02 2.38140E-02 1.30457E-01 5.87910E-01 |
2 3.34368E-01 5.93999E-03 3.85869E-03 3.28428E-01 4.11760E-01 |
3 4.93785E-01 3.54140E-02 2.41340E-02 4.58371E-01 3.39060E-04 |
4 5.91216E-01 1.27507E-01 9.43662E-02 4.63709E-01 1.17610E-07 |
5 4.74198E-01 1.91885E-01 4.57699E-02 2.82313E-01 0.00000E+00 |
6 8.33601E-01 5.83850E-01 9.28181E-01 2.49751E-01 0.00000E+00 |
7 8.53603E-01 5.94074E-01 1.04320E+00 2.59529E-01 0.00000E+00 |
```

MATERIAL : 4

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING FISSION SPECTRUM |

```
1 1.83045E-01 5.15410E-02 2.51860E-02 1.31504E-01 5.87910E-01 |
2 3.36705E-01 6.30200E-03 4.73951E-03 3.30403E-01 4.11760E-01 |
3 5.00507E-01 3.87150E-02 2.94781E-02 4.61792E-01 3.39060E-04 |
4 6.06174E-01 1.38153E-01 1.12250E-01 4.68021E-01 1.17610E-07 |
5 5.02754E-01 2.16983E-01 5.53030E-02 2.85771E-01 0.00000E+00 |
6 9.21028E-01 6.73414E-01 1.07500E+00 2.47614E-01 0.00000E+00 |
7 9.55231E-01 6.99138E-01 1.23930E+00 2.56093E-01 0.00000E+00 |
```

MATERIAL : 5

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING FISSION SPECTRUM |

```
1 1.26032E-01 5.98661E-02 1.32340E-08 6.61659E-02 5.87910E-01 |
2 2.93160E-01 5.27830E-02 1.43450E-08 2.40377E-01 4.11760E-01 |
3 2.84250E-01 1.00825E-01 1.12860E-06 1.83425E-01 3.39060E-04 |
4 2.81020E-01 2.01943E-01 1.27630E-05 7.90769E-02 1.17610E-07 |
5 3.34460E-01 2.34703E-01 3.53850E-07 9.97570E-02 0.00000E+00 |
6 5.65640E-01 2.48866E-01 1.74010E-06 3.16774E-01 0.00000E+00 |
7 1.17214E+00 7.30400E-02 5.06330E-06 1.09910E+00 0.00000E+00 |
```

MATERIAL : 6

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING FISSION SPECTRUM |

```
1 1.26032E-01 5.98661E-02 0.00000E+00 6.61659E-02 0.00000E+00 |
2 2.93160E-01 5.27830E-02 0.00000E+00 2.40377E-01 0.00000E+00 |
3 2.84240E-01 1.00943E-01 0.00000E+00 1.83297E-01 0.00000E+00 |
4 2.80960E-01 2.02109E-01 0.00000E+00 7.88511E-02 0.00000E+00 |
5 3.34440E-01 2.34703E-01 0.00000E+00 9.97372E-02 0.00000E+00 |
6 5.65640E-01 2.48875E-01 0.00000E+00 3.16765E-01 0.00000E+00 |
7 1.17215E+00 7.30300E-02 0.00000E+00 1.09912E+00 0.00000E+00 |
```

MATERIAL : 7

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING FISSION SPECTRUM I

```
1 1.59206E-01 1.14728E-01 0.00000E+00 4.44777E-02 0.00000E+00 I
2 4.12970E-01 1.30636E-01 0.00000E+00 2.82334E-01 0.00000E+00 I
3 5.90310E-01 2.45054E-01 0.00000E+00 3.45256E-01 0.00000E+00 I
4 5.84350E-01 4.93322E-01 0.00000E+00 9.10284E-02 0.00000E+00 I
5 7.18000E-01 5.78862E-01 0.00000E+00 1.39138E-01 0.00000E+00 I
6 1.25445E+00 5.54537E-01 0.00000E+00 6.99913E-01 0.00000E+00 I
7 2.65038E+00 1.69680E-01 0.00000E+00 2.48070E+00 0.00000E+00 I
```

REACTION RATE SOLUTION IN THE REACTOR CORE

REACTION RATE SOLUTION PER MATERIAL PER ENERGY GROUP:

MATERIAL : 1

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING I

```
1 1.30869E+03 3.70793E+02 1.47524E+02 9.38205E+02 I
2 4.88053E+03 7.91567E+01 3.00107E+01 4.80131E+03 I
3 3.18487E+03 1.95230E+02 1.04130E+02 2.98954E+03 I
4 1.32818E+03 2.43979E+02 1.08280E+02 1.08418E+03 I
5 5.13629E+02 6.65466E+01 7.13920E+01 4.47223E+02 I
6 7.70361E+02 2.52211E+02 3.93982E+02 5.18108E+02 I
7 1.85397E+03 9.56954E+02 1.72680E+03 8.97001E+02 I
```

MATERIAL : 2

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING I

```
1 1.31446E+03 3.66692E+02 1.59980E+02 9.48083E+02 I
2 4.89598E+03 7.98691E+01 3.75146E+01 4.81607E+03 I
3 3.20736E+03 2.02779E+02 1.07855E+02 3.00443E+03 I
4 1.35830E+03 2.62919E+02 1.56866E+02 1.09523E+03 I
5 7.02247E+02 2.46232E+02 5.06234E+01 4.56150E+02 I
6 1.32360E+03 8.30597E+02 1.29955E+03 4.93183E+02 I
7 2.24275E+03 1.37246E+03 2.34500E+03 8.70488E+02 I
```

MATERIAL : 3

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING I

```
1 1.33355E+03 3.74134E+02 1.75149E+02 9.59723E+02 |
2 4.94805E+03 8.79076E+01 5.71207E+01 4.86007E+03 |
3 3.27374E+03 2.34810E+02 1.59967E+02 3.03875E+03 |
4 1.41653E+03 3.05488E+02 2.26145E+02 1.11090E+03 |
5 7.81296E+02 3.16117E+02 7.53991E+01 4.65224E+02 |
6 1.62517E+03 1.13815E+03 1.80962E+03 4.86919E+02 |
7 2.80380E+03 1.95142E+03 3.42662E+03 8.52483E+02 |
```

MATERIAL : 4

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING |

```
1 1.34622E+03 3.79100E+02 1.85250E+02 9.67429E+02 |
2 4.98276E+03 9.32725E+01 7.01326E+01 4.88938E+03 |
3 3.31838E+03 2.56614E+02 1.95430E+02 3.06150E+03 |
4 1.45244E+03 3.30990E+02 2.68915E+02 1.12121E+03 |
5 8.28414E+02 3.57491E+02 9.11159E+01 4.70944E+02 |
6 1.79565E+03 1.31272E+03 2.09536E+03 4.82751E+02 |
7 3.13774E+03 2.29624E+03 4.07069E+03 8.41188E+02 |
```

MATERIAL : 5

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING |

```
1 9.27122E+02 4.40380E+02 9.73436E-05 4.86758E+02 |
2 4.33802E+03 7.81240E+02 2.12344E-04 3.55824E+03 |
3 1.88469E+03 6.68329E+02 7.48347E-03 1.21584E+03 |
4 6.73295E+02 4.83979E+02 3.05898E-02 1.89484E+02 |
5 5.50895E+02 3.86703E+02 5.82906E-04 1.64342E+02 |
6 1.10260E+03 4.85195E+02 3.39253E-03 6.17513E+02 |
7 3.85029E+03 2.39926E+02 1.66303E-02 3.61030E+03 |
```

MATERIAL : 6

GROUP TOTAL ABSORPTION NU*FISSION SCATTERING |

```
1 9.27122E+02 4.40380E+02 0.00000E+00 4.86758E+02 |
2 4.33802E+03 7.81240E+02 0.00000E+00 3.55824E+03 |
3 1.88462E+03 6.69110E+02 0.00000E+00 1.21499E+03 |
4 6.73151E+02 4.84378E+02 0.00000E+00 1.88941E+02 |
5 5.50862E+02 3.86703E+02 0.00000E+00 1.64309E+02 |
6 1.10260E+03 4.85213E+02 0.00000E+00 6.17495E+02 |
7 3.85032E+03 2.39894E+02 0.00000E+00 3.61036E+03 |
```


3.2. 2. Examples & test suite 31

18 6.78256E-01 6.72792E-01 6.65083E-01 6.65029E-01 6.63211E-01 6.59321E-01 6.59790E-01
6.54129E-01 6.43411E-01 6.40799E-01 6.33665E-01 6.20937E-01 6.12927E-01 6.04593E-01
5.98972E-01 6.12303E-01 6.58214E-01 4.82881E-01 5.10823E-01 5.16038E-01 5.13372E-01
5.03451E-01 4.87432E-01 4.70370E-01 4.48408E-01 4.22499E-01 3.98942E-01 3.72735E-01
3.44345E-01 3.17103E-01 2.90212E-01 2.68197E-01 2.59514E-01 2.83622E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
19 4.42095E-01 5.64925E-01 5.50849E-01 5.50124E-01 5.81366E-01 5.90499E-01 5.74105E-01
5.64924E-01 5.65123E-01 5.54044E-01 5.49973E-01 5.54877E-01 5.37227E-01 5.00155E-01
4.97996E-01 5.25564E-01 4.65625E-01 3.61835E-01 3.98533E-01 4.12624E-01 4.14858E-01
4.21092E-01 4.15837E-01 3.93617E-01 3.73060E-01 3.57111E-01 3.33010E-01 3.10966E-01
2.93248E-01 2.67175E-01 2.37880E-01 2.21301E-01 2.19802E-01 2.59514E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
20 3.97735E-01 5.03244E-01 5.18577E-01 5.28211E-01 5.57281E-01 0.00000E+00 5.00537E-01
4.92318E-01 0.00000E+00 4.82776E-01 4.78883E-01 0.00000E+00 5.13024E-01 4.79143E-01
4.69150E-01 4.74565E-01 4.31746E-01 3.40666E-01 3.82733E-01 4.13183E-01 4.25684E-01
4.34305E-01 0.00000E+00 3.89202E-01 3.68904E-01 0.00000E+00 3.29469E-01 3.07334E-01
0.00000E+00 2.74801E-01 2.45894E-01 2.26177E-01 2.21301E-01 2.68197E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
21 4.22562E-01 5.35614E-01 5.60081E-01 0.00000E+00 5.84619E-01 5.91118E-01 5.75718E-01
5.67319E-01 5.59793E-01 5.55429E-01 5.50640E-01 5.53784E-01 5.36631E-01 0.00000E+00
5.05856E-01 5.04244E-01 4.57285E-01 3.60414E-01 4.05420E-01 4.45386E-01 0.00000E+00
4.63262E-01 4.29976E-01 4.07907E-01 3.87035E-01 3.67569E-01 3.44728E-01 3.22133E-01
3.03120E-01 2.92272E-01 0.00000E+00 2.45894E-01 2.37880E-01 2.90212E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
22 4.63920E-01 6.29796E-01 6.53126E-01 6.45478E-01 6.92874E-01 6.45082E-01 6.25082E-01
6.14840E-01 6.11954E-01 6.02100E-01 5.96532E-01 6.03046E-01 6.35297E-01 5.81817E-01
5.87369E-01 5.88112E-01 4.98037E-01 3.92904E-01 4.55714E-01 5.00189E-01 5.08961E-01
4.92167E-01 4.66935E-01 4.41825E-01 4.18501E-01 3.98538E-01 3.72767E-01 3.48220E-01
3.28475E-01 3.10700E-01 2.92272E-01 2.74801E-01 2.67175E-01 3.17103E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
23 5.10323E-01 7.02171E-01 0.00000E+00 7.28069E-01 7.07726E-01 0.00000E+00 6.81985E-01
6.70982E-01 0.00000E+00 6.56968E-01 6.49850E-01 0.00000E+00 6.48036E-01 6.53859E-01
0.00000E+00 6.51837E-01 5.43828E-01 4.28139E-01 5.03370E-01 0.00000E+00 5.29323E-01
5.20009E-01 0.00000E+00 4.80083E-01 4.54620E-01 0.00000E+00 4.05323E-01 3.77628E-01
0.00000E+00 3.28475E-01 3.03120E-01 0.00000E+00 2.93248E-01 3.44345E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
24 5.66277E-01 7.50521E-01 7.16744E-01 7.80039E-01 7.57154E-01 7.46676E-01 7.38445E-01
7.28547E-01 7.20023E-01 7.12014E-01 7.03399E-01 6.95716E-01 6.90718E-01 6.98033E-01
6.38703E-01 6.92909E-01 5.97606E-01 4.68687E-01 5.37111E-01 5.64674E-01 5.65170E-01
5.54482E-01 5.38560E-01 5.13723E-01 4.87827E-01 4.63331E-01 4.33831E-01 4.04029E-01
3.77628E-01 3.48220E-01 3.22133E-01 3.07334E-01 3.10966E-01 3.72735E-01 0.00000E+00

0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
25 6.15008E-01 8.21678E-01 7.88942E-01 8.54404E-01 8.27957E-01 8.21777E-01 8.09267E-01
7.98832E-01 7.94813E-01 7.80633E-01 7.69000E-01 7.63520E-01 7.53075E-01 7.60362E-01
6.98300E-01 7.53026E-01 6.44131E-01 5.05292E-01 5.79060E-01 6.10275E-01 6.08860E-01
5.95752E-01 5.79827E-01 5.52746E-01 5.24225E-01 4.99123E-01 4.65820E-01 4.33831E-01
4.05323E-01 3.72767E-01 3.44728E-01 3.29469E-01 3.33010E-01 3.98942E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
26 6.60403E-01 8.95538E-01 0.00000E+00 9.21780E-01 8.94858E-01 0.00000E+00 8.74382E-01
8.63169E-01 1.86347E-05 8.43340E-01 8.29145E-01 0.00000E+00 8.11335E-01 8.16324E-01
0.00000E+00 8.14799E-01 6.86689E-01 5.38428E-01 6.26178E-01 0.00000E+00 6.53095E-01
6.38647E-01 0.00000E+00 5.92392E-01 5.61408E-01 1.48064E-05 4.99123E-01 4.63331E-01
0.00000E+00 3.98538E-01 3.67569E-01 0.00000E+00 3.57111E-01 4.22499E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
27 7.21457E-01 9.52174E-01 9.11029E-01 9.91423E-01 9.60415E-01 9.47133E-01 9.37153E-01
9.24928E-01 9.13748E-01 9.01737E-01 8.87858E-01 8.75256E-01 8.66333E-01 8.74127E-01
7.96960E-01 8.60078E-01 7.41340E-01 5.79204E-01 6.59801E-01 6.93314E-01 6.91612E-01
6.75854E-01 6.55361E-01 6.24702E-01 5.91549E-01 5.61408E-01 5.24225E-01 4.87827E-01
4.54620E-01 4.18501E-01 3.87035E-01 3.68904E-01 3.73060E-01 4.48408E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
28 7.73942E-01 1.03959E+00 9.96736E-01 1.07891E+00 1.04652E+00 1.03776E+00 1.01960E+00
1.00143E+00 9.93290E-01 9.75802E-01 9.62454E-01 9.54770E-01 9.40022E-01 9.44358E-01
8.64469E-01 9.29668E-01 7.87107E-01 6.13978E-01 7.03814E-01 7.38391E-01 7.35007E-01
7.17896E-01 6.96042E-01 6.60512E-01 6.24702E-01 5.92392E-01 5.52746E-01 5.13723E-01
4.80083E-01 4.41825E-01 4.07907E-01 3.89202E-01 3.93617E-01 4.70370E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
29 8.17305E-01 1.13362E+00 0.00000E+00 1.17755E+00 1.14435E+00 0.00000E+00 1.09431E+00
1.07202E+00 0.00000E+00 1.04404E+00 1.02974E+00 0.00000E+00 1.02266E+00 1.02401E+00
0.00000E+00 1.00374E+00 8.21783E-01 6.42043E-01 7.51694E-01 0.00000E+00 7.81797E-01
7.63445E-01 0.00000E+00 6.96042E-01 6.55361E-01 0.00000E+00 5.79827E-01 5.38560E-01
0.00000E+00 4.66935E-01 4.29976E-01 0.00000E+00 4.15837E-01 4.87433E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
30 8.73289E-01 1.17546E+00 1.23568E+00 1.23097E+00 1.31823E+00 1.20741E+00 1.17031E+00
1.14783E+00 1.13162E+00 1.11494E+00 1.10020E+00 1.10197E+00 1.16871E+00 1.06478E+00
1.05642E+00 1.02946E+00 8.63528E-01 6.72513E-01 7.69483E-01 8.39944E-01 8.49317E-01
8.14346E-01 7.63445E-01 7.17896E-01 6.75854E-01 6.38647E-01 5.95752E-01 5.54482E-01
5.20009E-01 4.92167E-01 4.63262E-01 4.34305E-01 4.21092E-01 5.03451E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
31 9.33156E-01 1.18551E+00 1.24214E+00 0.00000E+00 1.31178E+00 1.33835E+00 1.29591E+00
1.27217E+00 1.25676E+00 1.23493E+00 1.21340E+00 1.21571E+00 1.15698E+00 0.00000E+00

1.05003E+00 1.02120E+00 9.01548E-01 6.96448E-01 7.70790E-01 8.34426E-01 0.00000E+00
8.49317E-01 7.81797E-01 7.35007E-01 6.91612E-01 6.53095E-01 6.08860E-01 5.65170E-01
5.29323E-01 5.08961E-01 0.00000E+00 4.25685E-01 4.14858E-01 5.13372E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
32 1.01336E+00 1.28644E+00 1.31147E+00 1.33531E+00 1.41481E+00 0.00000E+00 1.28674E+00
1.26155E+00 0.00000E+00 1.22372E+00 1.20064E+00 0.00000E+00 1.24240E+00 1.13707E+00
1.09327E+00 1.07894E+00 9.39037E-01 7.17882E-01 7.84987E-01 8.24848E-01 8.34426E-01
8.39944E-01 0.00000E+00 7.38392E-01 6.93314E-01 0.00000E+00 6.10275E-01 5.64674E-01
0.00000E+00 5.00189E-01 4.45386E-01 4.13183E-01 4.12624E-01 5.16038E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
33 1.16831E+00 1.49017E+00 1.45900E+00 1.45770E+00 1.53221E+00 1.55493E+00 1.51119E+00
1.48132E+00 1.47371E+00 1.43348E+00 1.40799E+00 1.40163E+00 1.33776E+00 1.22701E+00
1.18856E+00 1.19897E+00 1.00352E+00 7.41562E-01 7.81522E-01 7.84987E-01 7.70790E-01
7.69483E-01 7.51694E-01 7.03814E-01 6.59801E-01 6.26178E-01 5.79061E-01 5.37111E-01
5.03370E-01 4.55714E-01 4.05420E-01 3.82734E-01 3.98533E-01 5.10823E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
34 1.45707E+00 1.44579E+00 1.42992E+00 1.43240E+00 1.43024E+00 1.42142E+00 1.41961E+00
1.40044E+00 1.36766E+00 1.35028E+00 1.32152E+00 1.27571E+00 1.23710E+00 1.19244E+00
1.14186E+00 1.11068E+00 1.10943E+00 7.44394E-01 7.41562E-01 7.17882E-01 6.96448E-01
6.72513E-01 6.42043E-01 6.13978E-01 5.79204E-01 5.38428E-01 5.05292E-01 4.68687E-01
4.28139E-01 3.92904E-01 3.60414E-01 3.40666E-01 3.61835E-01 4.82881E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
35 1.19321E+00 1.19893E+00 1.19626E+00 1.20504E+00 1.20847E+00 1.20020E+00 1.19838E+00
1.18090E+00 1.15057E+00 1.13753E+00 1.11231E+00 1.07333E+00 1.03968E+00 9.94650E-01
9.42545E-01 8.93242E-01 8.19544E-01 1.10943E+00 1.00352E+00 9.39037E-01 9.01548E-01
8.63528E-01 8.21783E-01 7.87107E-01 7.41340E-01 6.86689E-01 6.44131E-01 5.97606E-01
5.43828E-01 4.98037E-01 4.57285E-01 4.31746E-01 4.65625E-01 6.58214E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
36 1.40094E+00 1.40568E+00 1.42457E+00 1.43850E+00 1.48996E+00 1.50872E+00 1.46779E+00
1.43888E+00 1.42865E+00 1.38604E+00 1.35812E+00 1.34323E+00 1.27645E+00 1.17912E+00
1.10874E+00 1.01940E+00 8.93242E-01 1.11068E+00 1.19897E+00 1.07894E+00 1.02120E+00
1.02946E+00 1.00374E+00 9.29668E-01 8.60078E-01 8.14799E-01 7.53025E-01 6.92909E-01
6.51837E-01 5.88112E-01 5.04244E-01 4.74565E-01 5.25564E-01 6.12303E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
37 1.54211E+00 1.56562E+00 1.63480E+00 1.68345E+00 1.74349E+00 0.00000E+00 1.64078E+00
1.61039E+00 0.00000E+00 1.55049E+00 1.51480E+00 0.00000E+00 1.48511E+00 1.37050E+00
1.25942E+00 1.10874E+00 9.42545E-01 1.14186E+00 1.18856E+00 1.09327E+00 1.05003E+00
1.05642E+00 0.00000E+00 8.64469E-01 7.96960E-01 0.00000E+00 6.98300E-01 6.38703E-01
0.00000E+00 5.87369E-01 5.05856E-01 4.69150E-01 4.97996E-01 5.98972E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00

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0.00000E+00 0.00000E+00
38 1.66307E+00 1.69077E+00 1.79536E+00 0.00000E+00 1.88862E+00 1.79196E+00 1.74803E+00
1.71535E+00 1.68918E+00 1.64923E+00 1.61148E+00 1.58599E+00 1.60061E+00 0.00000E+00
1.37050E+00 1.17912E+00 9.94650E-01 1.19244E+00 1.22701E+00 1.13707E+00 0.00000E+00
1.06478E+00 1.02401E+00 9.44358E-01 8.74127E-01 8.16324E-01 7.60362E-01 6.98033E-01
6.53859E-01 5.81817E-01 0.00000E+00 4.79143E-01 5.00155E-01 6.04593E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
39 1.76023E+00 1.84410E+00 1.96232E+00 1.99282E+00 1.95282E+00 1.89013E+00 1.83951E+00
1.80271E+00 1.77762E+00 1.73149E+00 1.69297E+00 1.66787E+00 1.64829E+00 1.60061E+00
1.48511E+00 1.27645E+00 1.03968E+00 1.23710E+00 1.33776E+00 1.24240E+00 1.15698E+00
1.16871E+00 1.02266E+00 9.40022E-01 8.66333E-01 8.11335E-01 7.53075E-01 6.90718E-01
6.48036E-01 6.35297E-01 5.36631E-01 5.13024E-01 5.37227E-01 6.12927E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
40 1.83472E+00 1.95391E+00 0.00000E+00 1.98666E+00 1.97995E+00 0.00000E+00 1.91831E+00
1.88018E+00 0.00000E+00 1.80573E+00 1.76175E+00 0.00000E+00 1.66787E+00 1.58599E+00
0.00000E+00 1.34323E+00 1.07333E+00 1.27571E+00 1.40163E+00 0.00000E+00 1.21571E+00
1.10197E+00 0.00000E+00 9.54770E-01 8.75256E-01 0.00000E+00 7.63520E-01 6.95716E-01
0.00000E+00 6.03046E-01 5.53784E-01 0.00000E+00 5.54877E-01 6.20937E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
41 1.91199E+00 1.98958E+00 2.02886E+00 2.02574E+00 2.01661E+00 2.00447E+00 1.96524E+00
1.93013E+00 1.90134E+00 1.85149E+00 1.80314E+00 1.76175E+00 1.69297E+00 1.61148E+00
1.51481E+00 1.35812E+00 1.11231E+00 1.32152E+00 1.40799E+00 1.20064E+00 1.21340E+00
1.10020E+00 1.02974E+00 9.62454E-01 8.87858E-01 8.29145E-01 7.69000E-01 7.03399E-01
6.49850E-01 5.96532E-01 5.50640E-01 4.78883E-01 5.49973E-01 6.33665E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
42 1.96618E+00 2.04147E+00 2.08611E+00 2.08059E+00 2.06768E+00 2.05817E+00 2.01975E+00
1.98299E+00 1.95631E+00 1.90076E+00 1.85149E+00 1.80573E+00 1.73149E+00 1.64923E+00
1.55049E+00 1.38604E+00 1.13753E+00 1.35028E+00 1.43348E+00 1.22372E+00 1.23493E+00
1.11494E+00 1.04404E+00 9.75802E-01 9.01737E-01 8.43340E-01 7.80633E-01 7.12014E-01
6.56968E-01 6.02100E-01 5.55429E-01 4.82776E-01 5.54044E-01 6.40799E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
43 2.00176E+00 2.11176E+00 0.00000E+00 2.13812E+00 2.12582E+00 0.00000E+00 2.07731E+00
2.04038E+00 5.58203E-05 1.95631E+00 1.90134E+00 0.00000E+00 1.77762E+00 1.68918E+00
0.00000E+00 1.42865E+00 1.15057E+00 1.36766E+00 1.47371E+00 0.00000E+00 1.25676E+00
1.13162E+00 0.00000E+00 9.93290E-01 9.13748E-01 1.86347E-05 7.94813E-01 7.20023E-01
0.00000E+00 6.11954E-01 5.59793E-01 0.00000E+00 5.65124E-01 6.43410E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
44 2.05717E+00 2.13386E+00 2.17931E+00 2.17438E+00 2.16101E+00 2.14905E+00 2.10936E+00
2.07020E+00 2.04038E+00 1.98299E+00 1.93013E+00 1.88018E+00 1.80271E+00 1.71535E+00
1.61039E+00 1.43888E+00 1.18090E+00 1.40044E+00 1.48132E+00 1.26155E+00 1.27217E+00
1.14783E+00 1.07202E+00 1.00143E+00 9.24928E-01 8.63169E-01 7.98831E-01 7.28547E-01

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6.70982E-01 6.14840E-01 5.67319E-01 4.92318E-01 5.64924E-01 6.54129E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
45 2.09279E+00 2.18040E+00 2.22477E+00 2.21975E+00 2.20841E+00 2.19553E+00 2.14982E+00
2.10936E+00 2.07731E+00 2.01975E+00 1.96524E+00 1.91831E+00 1.83951E+00 1.74803E+00
1.64078E+00 1.46779E+00 1.19838E+00 1.41961E+00 1.51119E+00 1.28674E+00 1.29591E+00
1.17031E+00 1.09431E+00 1.01960E+00 9.37153E-01 8.74382E-01 8.09267E-01 7.38445E-01
6.81985E-01 6.25081E-01 5.75718E-01 5.00537E-01 5.74105E-01 6.59790E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
46 2.10376E+00 2.24210E+00 0.00000E+00 2.27978E+00 2.27106E+00 0.00000E+00 2.19553E+00
2.14905E+00 0.00000E+00 2.05817E+00 2.00447E+00 0.00000E+00 1.89013E+00 1.79196E+00
0.00000E+00 1.50872E+00 1.20020E+00 1.42142E+00 1.55493E+00 0.00000E+00 1.33835E+00
1.20741E+00 0.00000E+00 1.03776E+00 9.47133E-01 0.00000E+00 8.21777E-01 7.46676E-01
0.00000E+00 6.45082E-01 5.91118E-01 0.00000E+00 5.90499E-01 6.59321E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
47 2.11986E+00 2.21874E+00 2.36297E+00 2.40110E+00 2.35162E+00 2.27106E+00 2.20841E+00
2.16101E+00 2.12582E+00 2.06768E+00 2.01661E+00 1.97995E+00 1.95282E+00 1.88862E+00
1.74349E+00 1.48996E+00 1.20847E+00 1.43024E+00 1.53221E+00 1.41481E+00 1.31178E+00
1.31823E+00 1.14435E+00 1.04652E+00 9.60415E-01 8.94858E-01 8.27957E-01 7.57154E-01
7.07725E-01 6.92874E-01 5.84619E-01 5.57281E-01 5.81366E-01 6.63211E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
48 2.11684E+00 2.15110E+00 2.28292E+00 0.00000E+00 2.40110E+00 2.27978E+00 2.21975E+00
2.17438E+00 2.13812E+00 2.08059E+00 2.02574E+00 1.98666E+00 1.99282E+00 0.00000E+00
1.68345E+00 1.43850E+00 1.20504E+00 1.43240E+00 1.45770E+00 1.33531E+00 0.00000E+00
1.23097E+00 1.17755E+00 1.07891E+00 9.91423E-01 9.21779E-01 8.54403E-01 7.80039E-01
7.28069E-01 6.45478E-01 0.00000E+00 5.28211E-01 5.50124E-01 6.65029E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
49 2.10355E+00 2.13335E+00 2.22025E+00 2.28292E+00 2.36297E+00 0.00000E+00 2.22477E+00
2.17931E+00 0.00000E+00 2.08611E+00 2.02886E+00 0.00000E+00 1.96232E+00 1.79536E+00
1.63480E+00 1.42457E+00 1.19626E+00 1.42992E+00 1.45900E+00 1.31147E+00 1.24214E+00
1.23568E+00 0.00000E+00 9.96736E-01 9.11029E-01 0.00000E+00 7.88942E-01 7.16743E-01
0.00000E+00 6.53126E-01 5.60081E-01 5.18577E-01 5.50849E-01 6.65083E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
50 2.10385E+00 2.10830E+00 2.13335E+00 2.15110E+00 2.21874E+00 2.24210E+00 2.18040E+00
2.13386E+00 2.11176E+00 2.04147E+00 1.98958E+00 1.95391E+00 1.84410E+00 1.69077E+00
1.56562E+00 1.40568E+00 1.19893E+00 1.44579E+00 1.49017E+00 1.28644E+00 1.18551E+00
1.17546E+00 1.13362E+00 1.03959E+00 9.52174E-01 8.95538E-01 8.21677E-01 7.50520E-01
7.02170E-01 6.29796E-01 5.35615E-01 5.03244E-01 5.64925E-01 6.72792E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00
51 2.09492E+00 2.10385E+00 2.10355E+00 2.11684E+00 2.11986E+00 2.10376E+00 2.09279E+00


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2.05717E+00 2.00176E+00 1.96618E+00 1.91199E+00 1.83472E+00 1.76023E+00 1.66307E+00
1.54211E+00 1.40094E+00 1.19321E+00 1.45707E+00 1.16831E+00 1.01336E+00 9.33156E-01
8.73289E-01 8.17305E-01 7.73941E-01 7.21457E-01 6.60403E-01 6.15008E-01 5.66277E-01
5.10323E-01 4.63920E-01 4.22562E-01 3.97735E-01 4.42095E-01 6.78256E-01 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
0.00000E+00 0.00000E+00

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NORMALIZED SCALAR FLUX SOLUTION IN EACH PIN CELL

FLUXES PER PIN CELL PER ENERGY GROUP:

PINCELLGROUP1

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
38 39 40 41 42 43 44 45 46 47 48 49 50 51

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1 1.06064E-05 1.11139E-05 1.08359E-05 1.05875E-05 1.11061E-05 1.08378E-05 1.05775E-05
1.05298E-05 1.07909E-05 1.05044E-05 1.00094E-05 1.04011E-05 1.03046E-05 9.65948E-06
9.90360E-06 9.77081E-06 9.00704E-06 9.07268E-06 8.94949E-06 8.46573E-06 9.01100E-06
8.95119E-06 8.70069E-06 8.86569E-06 8.72028E-06 8.87507E-06 9.07571E-06 8.54504E-06
8.96606E-06 8.94333E-06 8.20726E-06 8.68833E-06 8.60915E-06 7.92200E-06 8.29500E-06
8.24752E-06 7.57457E-06 8.11329E-06 8.05384E-06 7.61560E-06 7.65461E-06 7.18312E-06
7.30115E-06 7.03244E-06 6.19688E-06 6.39445E-06 6.10254E-06 5.28859E-06 5.65707E-06
5.42998E-06 4.33893E-06
2 1.53106E-05 1.38411E-05 1.49977E-05 1.49314E-05 1.42022E-05 1.44692E-05 1.42480E-05
1.40825E-05 1.43730E-05 1.37561E-05 1.39763E-05 1.39465E-05 1.30458E-05 1.38302E-05
1.34673E-05 1.23621E-05 1.27008E-05 1.22483E-05 1.12882E-05 1.14833E-05 1.15030E-05
1.12313E-05 1.11013E-05 1.07960E-05 1.10338E-05 1.09579E-05 1.02968E-05 1.09530E-05
1.08543E-05 1.00360E-05 1.08222E-05 1.08468E-05 9.88048E-06 1.05417E-05 1.02525E-05
9.56918E-06 9.78460E-06 9.61012E-06 9.13539E-06 8.93975E-06 8.64180E-06 8.61482E-06
8.60167E-06 7.83262E-06 8.26451E-06 7.88804E-06 6.63924E-06 6.94277E-06 6.44868E-06
5.42784E-06 5.42998E-06
3 1.96459E-05 2.01599E-05 1.93859E-05 1.97781E-05 1.99479E-05 1.88713E-05 2.00545E-05
1.99240E-05 1.83877E-05 1.94046E-05 1.91109E-05 1.75777E-05 1.82996E-05 1.82099E-05
1.68613E-05 1.73268E-05 1.68308E-05 1.55670E-05 1.58644E-05 1.50983E-05 1.44378E-05
1.46950E-05 1.40787E-05 1.44775E-05 1.43191E-05 1.33176E-05 1.37773E-05 1.36322E-05
1.25589E-05 1.31170E-05 1.30862E-05 1.20536E-05 1.24695E-05 1.23459E-05 1.14069E-05
1.20945E-05 1.19838E-05 1.13395E-05 1.13563E-05 1.06802E-05 1.08383E-05 1.04575E-05
9.26820E-06 9.55662E-06 9.13770E-06 7.99519E-06 8.52814E-06 8.20561E-06 6.68195E-06
6.44875E-06 5.65710E-06
4 2.68466E-05 2.73326E-05 2.71249E-05 2.56946E-05 2.61862E-05 2.69039E-05 2.59902E-05
2.55578E-05 2.66996E-05 2.57180E-05 2.44936E-05 2.59121E-05 2.48320E-05 2.30289E-05
2.39240E-05 2.31625E-05 2.18665E-05 2.17610E-05 2.11647E-05 1.99916E-05 1.86876E-05
1.80760E-05 1.84153E-05 1.82534E-05 1.69950E-05 1.79261E-05 1.76367E-05 1.59408E-05
1.71764E-05 1.68260E-05 1.51955E-05 1.57197E-05 1.52890E-05 1.42057E-05 1.44611E-05
1.42506E-05 1.34814E-05 1.31051E-05 1.26496E-05 1.25875E-05 1.25424E-05 1.14469E-05
1.20439E-05 1.15269E-05 9.78115E-06 1.02146E-05 9.54220E-06 8.12468E-06 8.20563E-06
6.94283E-06 5.28855E-06
5 3.74080E-05 3.64943E-05 3.67881E-05 3.61453E-05 3.54709E-05 3.66336E-05 3.51899E-05
3.50451E-05 3.58651E-05 3.39116E-05 3.39146E-05 3.44069E-05 3.21409E-05 3.22486E-05
3.17777E-05 2.99471E-05 3.07395E-05 2.99174E-05 2.81733E-05 2.75513E-05 2.55807E-05

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2.50306E-05 2.44304E-05 2.25136E-05 2.33994E-05 2.28196E-05 2.08046E-05 2.19145E-05
2.14505E-05 1.95362E-05 2.02094E-05 1.95670E-05 1.78117E-05 1.86383E-05 1.81452E-05
1.70393E-05 1.69040E-05 1.57611E-05 1.59612E-05 1.52791E-05 1.34829E-05 1.37903E-05
1.31974E-05 1.16032E-05 1.23419E-05 1.18982E-05 9.79371E-06 9.54230E-06 8.52821E-06
6.63921E-06 6.10248E-06
6 5.08104E-05 5.03208E-05 4.86062E-05 5.07483E-05 5.05730E-05 4.63710E-05 4.97108E-05
4.94459E-05 4.53007E-05 4.83959E-05 4.76719E-05 4.35037E-05 4.53751E-05 4.42655E-05
4.11637E-05 4.15914E-05 4.11256E-05 3.94582E-05 3.78351E-05 3.57569E-05 3.55494E-05
3.40173E-05 2.98052E-05 3.12902E-05 3.07006E-05 2.74700E-05 2.97118E-05 2.89660E-05
2.58283E-05 2.66057E-05 2.55847E-05 2.36280E-05 2.37785E-05 2.31806E-05 2.19018E-05
2.08906E-05 1.97294E-05 1.97027E-05 1.91148E-05 1.69856E-05 1.76315E-05 1.67154E-05
1.41950E-05 1.48191E-05 1.38156E-05 1.17787E-05 1.18982E-05 1.02147E-05 7.99515E-06
7.88800E-06 6.39445E-06
7 6.83137E-05 6.76650E-05 6.94092E-05 6.80246E-05 6.64524E-05 6.86302E-05 6.52260E-05
6.43951E-05 6.67978E-05 6.37987E-05 6.23572E-05 6.33448E-05 6.00055E-05 5.90692E-05
5.92781E-05 5.65997E-05 5.50988E-05 5.37534E-05 5.09221E-05 5.09348E-05 4.89132E-05
4.42953E-05 4.40955E-05 4.08038E-05 3.67942E-05 3.84993E-05 3.78438E-05 3.43715E-05
3.52826E-05 3.41093E-05 3.07118E-05 3.21632E-05 3.12748E-05 2.89183E-05 2.82230E-05
2.60911E-05 2.63416E-05 2.50401E-05 2.16660E-05 2.23496E-05 2.08179E-05 1.77441E-05
1.83592E-05 1.73260E-05 1.43760E-05 1.38155E-05 1.23420E-05 9.78109E-06 9.13763E-06
8.26443E-06 6.19683E-06
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PINCELLGROUP4

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PINCELLGROUP6

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9.65195E-04 7.16275E-04 5.27050E-04 3.84558E-04 2.77382E-04 1.95975E-04 1.32466E-04
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OUTPUT PARAMETER - SOLUTION TO TRANSPORT EQUATION

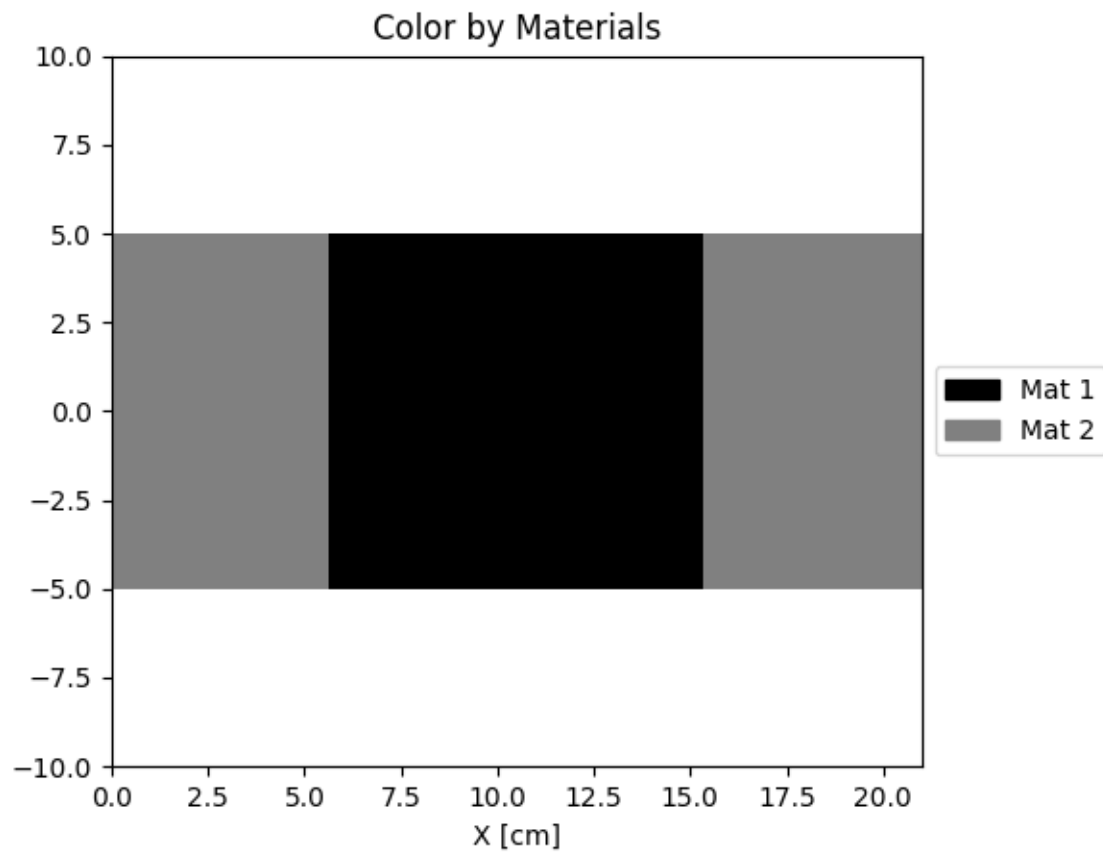
K-EFF = 1.186172 TOTAL OUTER ITERATIONS = 320 TOTAL INNER ITERATIONS = 33 TOTAL
EXECUTION TIME = 1:03:49.63 (H:M:S)

3.2.2 2.3. Slab

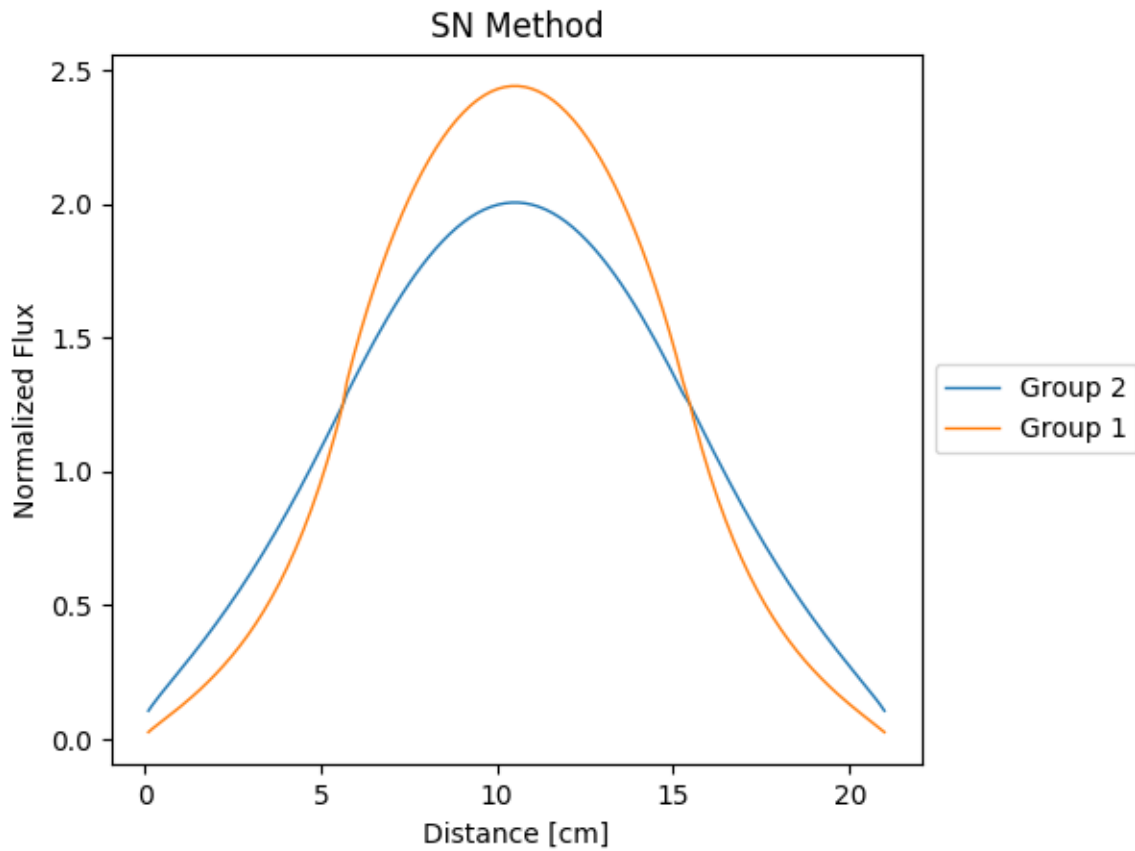
Setting up input file for slab geometry in two energy groups with isotropic scattering source.

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      "Total number of regions": 3,
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      "Number of fine meshes": [50, 50, 50],
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        "XSNuFission": [0, 0],
        "XSScatter Matrix": [[0.83975, 0.04749],
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        "XSChi": [0, 0]
      }
    ]
  }
}
```

Geometry in a one-dimensional slab



Flux in a one-dimensional slab



3.2.3 2.4. Cylinder or Pin Cell

An example for cylindrical infinite cell equivalent to the **TRIGA MARK-II** research reactor pin cell is presented here by using 7 energy groups

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{
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      "Criterion of Keff convergence": 1.0e-8
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    "materials": [
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        "id": 1,
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(continued from previous page)

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    "nom": "material 1",
    "XSTotal": [0.297551431, 0.288909664, 0.290306468, 0.286637159, 0.
↪295583239, 0.326837471, 0.155639234],
    "XSNuFission": [0, 0, 0, 0, 0, 0, 0, 0],
    "XSScatter Matrix": [[0.269680893, 0.021221626, 0, 0, 0, 0, 0, 0],
↪0],
                                [0, 0.013507066, 0.273815991, 0.001186857, 0, 0,
↪0],
                                [0, 0, 0.014034288, 0.270365363, 0.002092507, 0,
↪0],
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                                [0, 0, 0, 0, 0.001078437, 0.32539832, 0],
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↪14376993]]],
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  },
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↪013653221, 0.001011529, 0.00163296],
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↪000008685, 0.162129535, 0.352055605, 0],
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    "XSScatter Matrix": [[0, 0, 0, 0, 0, 0, 0, 0],
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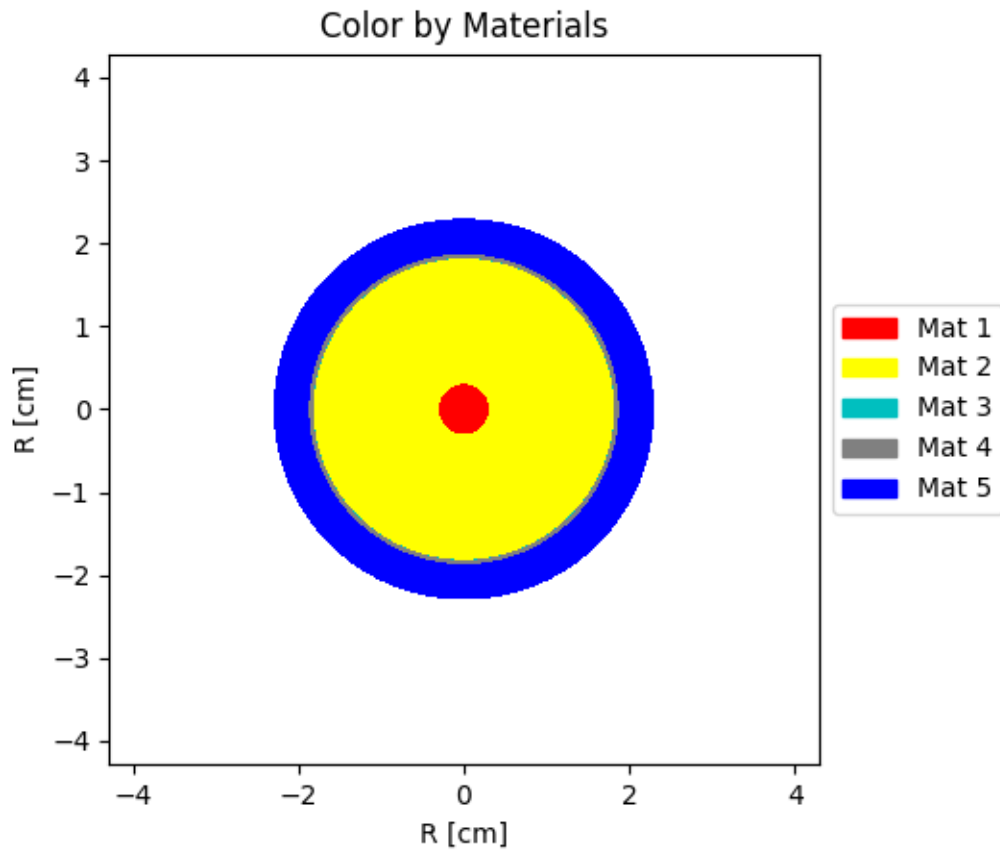
(continued from previous page)

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    "XSTotal": [1.153239138, 1.012997908, 0.947913799, 0.908546838, 0.
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↪003927282, 0, 0, 0],
                                [0.000005432, 0.055959691, 0.806723946, 0.
↪0],
                                [0, 0, 0.061596098, 0.790102323, 0.005981459, 0,
↪0],
                                [0, 0, 0, 0.003658891, 0.950937049, 0, 0],
                                [0, 0, 0, 0, 0.005035727, 0.459136241, 0],
                                [0, 0, 0, 0, 0.000075732, 0.014066679, 0.
↪185277698]]],
    "XSChi": [0, 0, 0, 0, 0, 0, 0]
  },
  {
    "id": 5,
    "nom": "material 5",
    "XSTotal": [3.102999797, 1.73516897, 0.980823407, 0.642418097, 0.
↪567747919, 0.419879925, 0.201975672],
    "XSNuFission": [0, 0, 0, 0, 0, 0, 0],
    "XSScatter Matrix": [[2.631785406, 0.437581882, 0.00907283, 0, 0, 0,
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↪0],
                                [0.141504305, 0.538385484, 0.292249692, 0.
↪002089256, 0, 0, 0],
                                [0.036338638, 0.123430676, 0.814518036, -0.
↪336757332, 0.001951418, 0, 0],
                                [0.003425563, 0.009933065, 0.061937554, 0.
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↪00000889, 0.203705679, 0.216356046, 0],
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↪0.089154896]]],
    "XSChi": [0, 0, 0, 0, 0, 0, 0]
  }
]
}
}

```

Geometry in a two-dimensional TRIGA Reactor



The infinite cell in OpenMC [OpenMC](#) is represented by hexagonal cell with reflective boundaries. The infinite multiplication factor values obtained in [OpenNTP](#) and [OpenMC](#) are shown in Table below.

Table 1: Calculate infinite multiplication factor k_{inf} .

Surface	k_{inf}
OpenNTP	1.403180
OoenMC	1.417226

3.2.4 2.5. Sphere

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**CHAPTER
FIVE**

HELP

if you're have trouble please email mlahdour@uae.ac.ma or mohamedlahdour@gmail.com

PUBLICATIONS

6.1 Overviews

- Lahdour, M., Bardouni, T. E., Chakir, E., Benaalilou, K., Mohammed, M., Bougueniz, H., and Yaakoubi, H. E., “Ntp-ersn: A new package for solving the multigroup neutron transport equation in a slab geometry.,” *Applied Radiation and Isotopes*, 73:84 – **145** (2019a).
- Lahdour, M., Bardouni, T. E., Mohammed, M., and Ouahdani, S. E.”The discrete ordinate method for angular flux calculations in slab geometry.,” *Heliyon*, 5(8):e02211. (2019b).

DEVELOPMENT TEAM

- Mohamed LAHDOUR
- Tarek EL BARDOUNI

INDICES AND TABLES

- `genindex`
- `modindex`
- `search`