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Author(s):	Currie, Karissa Lyn Rising, Michael Evan
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MCNP6 Source Primer

Release 1.0

Karissa Currie and Michael E. Rising

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CHAPTER

ONE

WHAT IS THIS DOCUMENT?

1.1 *Introduction*

This document contains examples of MCNP general source usage to support the MCNP6 User's Manual. The examples range from basic to advanced sources with different applications. There are also examples of how MCNP can fail and warnings for the users to look for at the output to ensure proper results are being created.

The overall aim of this document is to provide solid examples of how to define sources with MCNP as well as how to verify the sources are setup properly. The reasoning for needing such complex sources is not discussed in the present work. Also, this document is not meant to be exhaustive of every MCNP source option and combinations of source options possible. However, it is intended to frequently update this document with new source examples provided by users. Please feel free to contact the MCNP6 development team to learn about how to submit a new or updated source example. Please include "General Sources Primer" in the subject line to route the request to the appropriate developers.

1.2 *Sources in MCNP*

For information on defining sources in MCNP, see the source section (3.3.4 pg. 3-122) in the MCNP6 User's Manual.

The SDEF card is the generalized user-defined source definition. SDEF can define particle types (neutrons, photons, electrons, etc.), position on surfaces and in volumes, direction (beam, isotropic, etc.), and time distributions for each source particle. SDEF can also have dependent functions (ERG=FDIR=D1) and sources in repeated structures. In general, the source variables can be described as a single/discrete value, independent distribution, or a dependent distribution of another source variable.

There are many more source options within MCNP, and depending on the user's applications, these may be very useful. Source biasing can alter the sampling of probability distribution functions (PDFs), while adjusting particle weight, in order to sample important particles more often while sampling less important particles less frequently. Surface source write and read couples one problem with a complex source description (SSW) to problems with further calculations (SSR). The SSW calculation will take the particles from the source that cross user-defined surfaces and write them to a file. The SSR reads the specified surface(s) needed from the SSW file and continues the calculations with proper tallies. Examples of many of these kinds of sources are included in this document to help user's get started defining complex sources.

1.3 *Tallies in MCNP*

To verify sources in MCNP, the present document uses standard tallies, seen in the tallies section (3.3.5 pg. 3-176) in the MCNP6 User's Manual.

Standard tallies can verify energy, time, cell/surfaces, and direction (1D) by showing their distributions in the tally/cross section plotter. Mesh Tallies can show geometry and direction (3D) using the geometry plotter. Included in this current document are all of the MCNP6-specific plotting commands so that all of the plots can be reproduced.

Although not discussed in this version of this document, verification of source accuracy can also be shown using the MCTAL/MESHTAL or PTRAC features in MCNP. It is generally very easy to generate a MCTAL/MESHTAL file with MCNP and read and fetch the data using MCNPtools. Alternatively, PTRAC can be used to write all source events and MCNPtools can read the data and fetch the state of each source particle as it is created in MCNP6. These alternative source verification techniques will be explored in future versions of this document.

1.4 *Example Source*

This examples serve to show how the remainder of this document is organized. First, a short description of the source example is given. Second, the full MCNP input file is listed. Third, the tally plots are shown, each with a short description. Last, the MCNP plotting commands are given to reproduce the displayed plots.

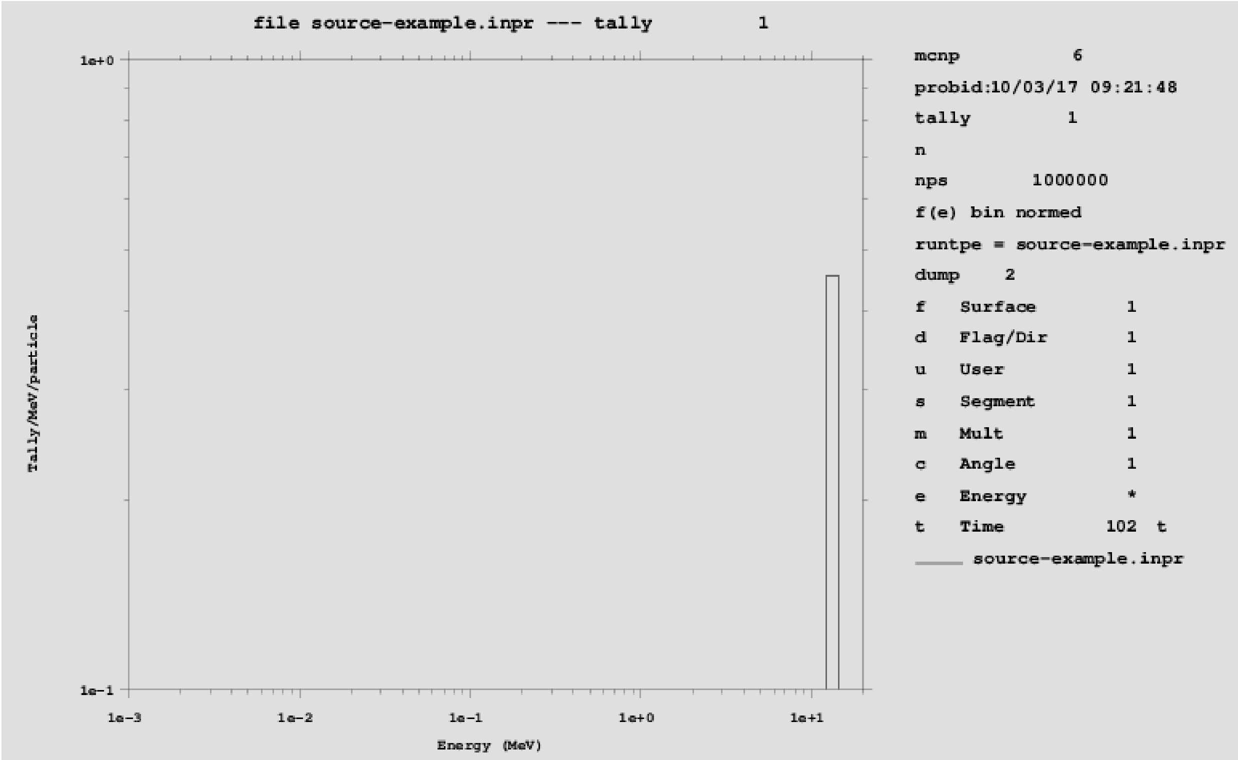
1.4.1 SDEF Defaults

The SDEF card is inserted with only default values.

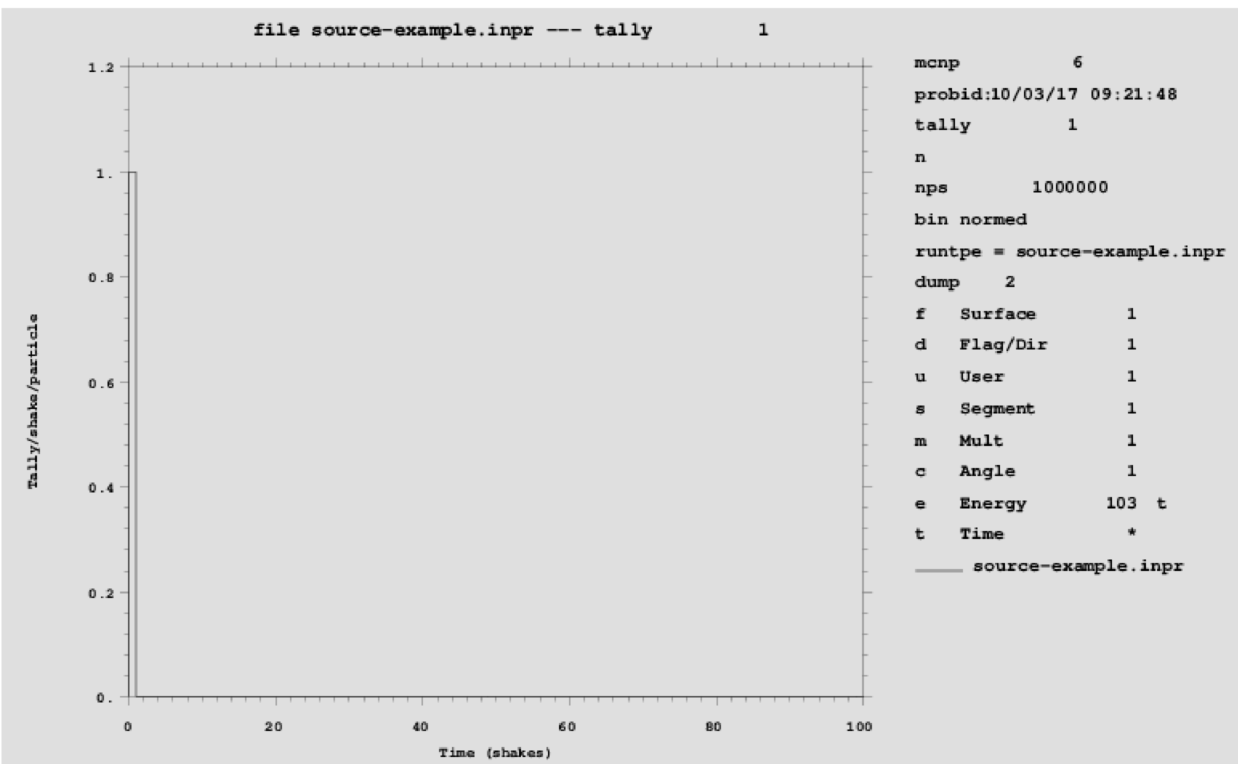
Listing 1.1: MCNP6 Input File

```
The default SDEF source in a vacuum
100    0    -1    IMP:N=1  $  inside sphere
999    0     1    IMP:N=0  $  outside world

1  SO  1

MODE N
NPS 1E6
c
SDEF
c
c
F1:N  1                $ ERG and TME tallies
E1  1E-6 100ilog 20
T1  0 99i 100
c
FMESH4:N  GEOM=XYZ    $ Geometry source tally
          ORIGIN=-1 -1 -1
          IMESH=1  IINTS=51
          JMESH=1  JINTS=51
          KMESH=1  KINTS=51
          TYPE=SOURCE
c
FMESH14:N GEOM=XYZ    $ Geometry flux tally
          ORIGIN=-1 -1 -1
          IMESH=1  IINTS=51
          JMESH=1  JINTS=51
          KMESH=1  KINTS=51
```

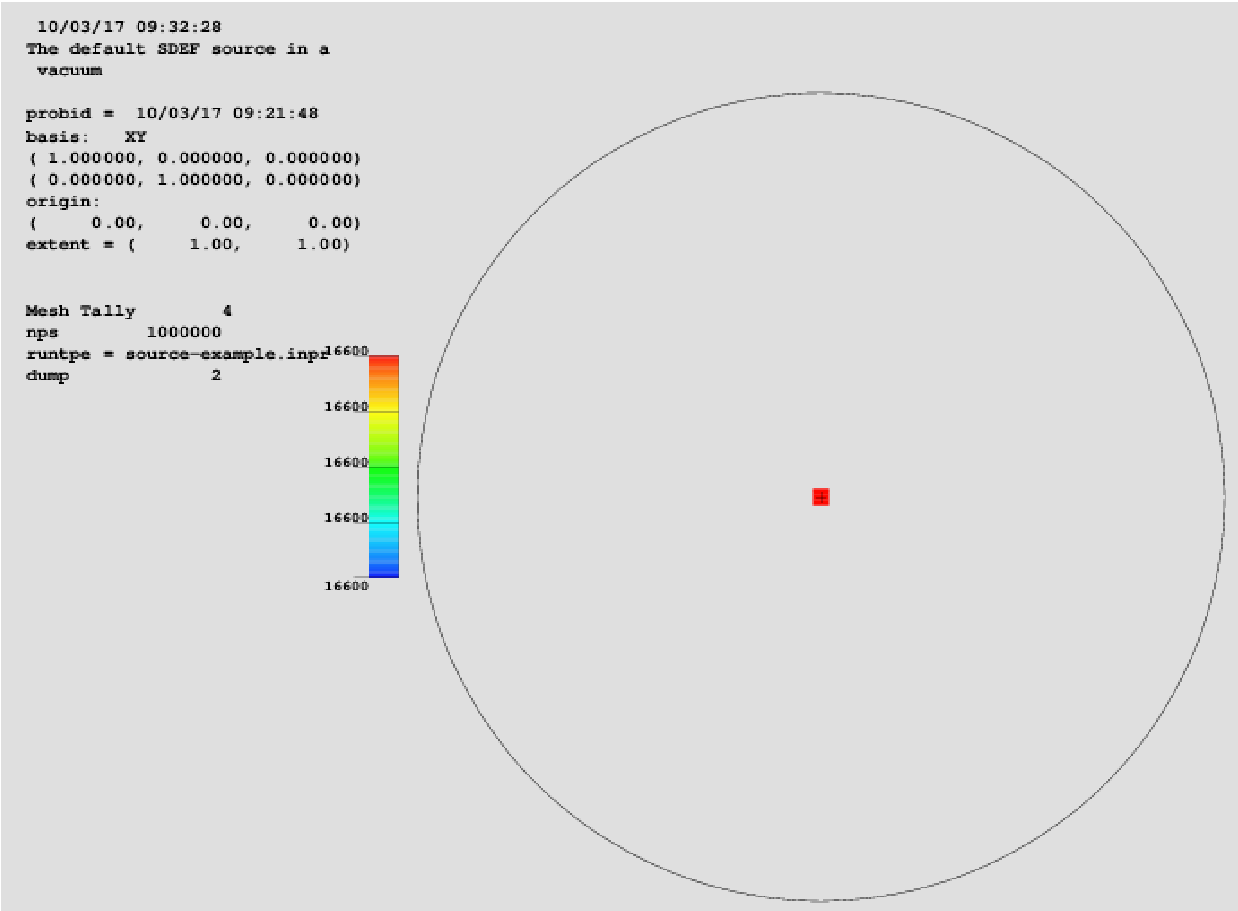
The energy distribution can be seen below where the default 14 MeV energy is the only bin with a value.



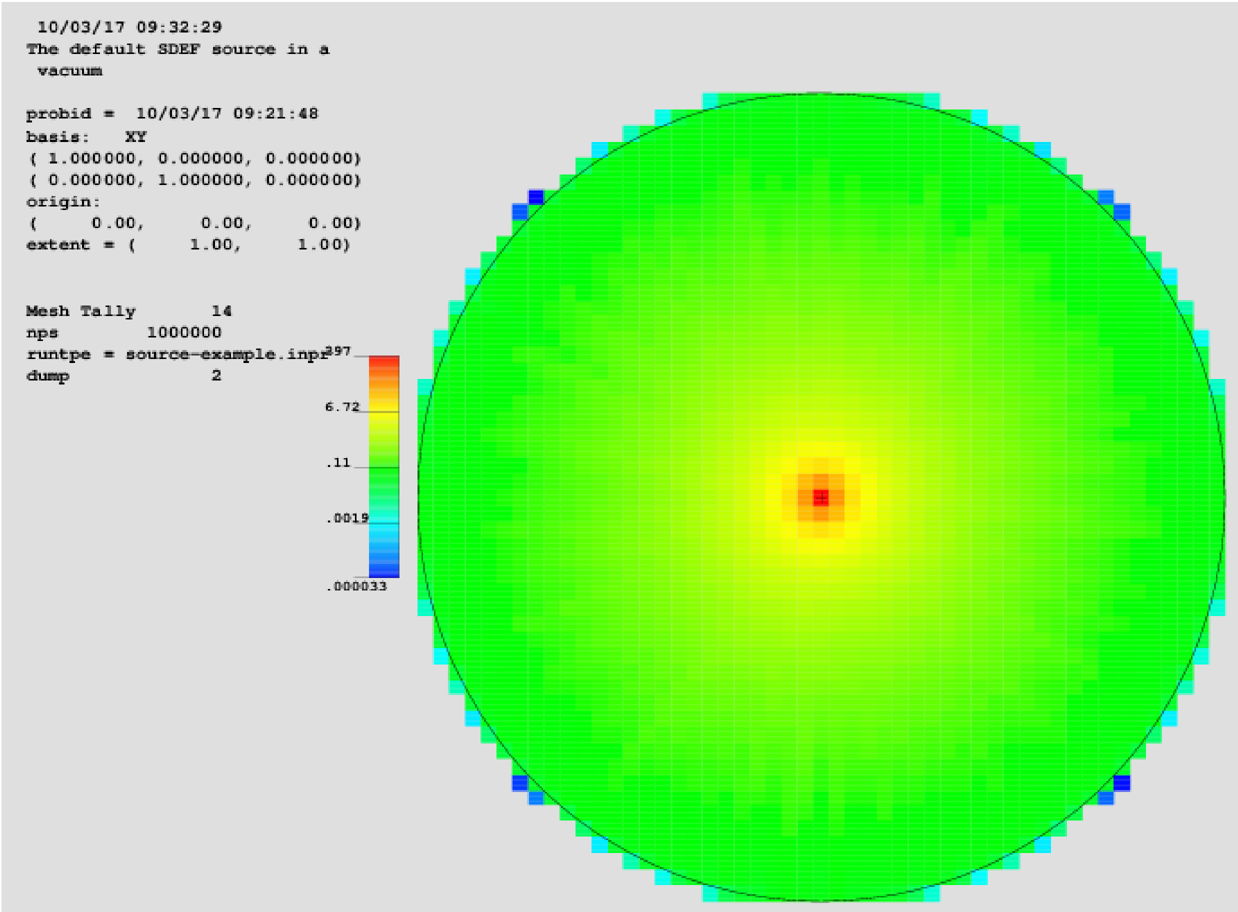
The time distribution can be seen below where the default 0 shake bin is the only bin with a value.



The position of the source can be seen below in the mesh plot where the origin location (x=0, y=0, z=0) is the only bin with a value.



The position of the flux can be seen below in the mesh plot where the flux is distributed isotropically by default.



Listing 1.2: MCNP6 Plotting Commands

```
tal 1 loglog free e xlims 1e-3 20
tal 1 linlin free t xlims 0 100
fmesh 4
basis 1 0 0 0 1 0
end
fmesh 14
file
end
end
```

1.5 Helpful Links

1.5.1 Documents

MCNP6 General Source Primer [PDF of this webpage]

MCNP6 User's Manual

An MCNP Primer by Shultis & Faw

1.5.2 Websites

MCNP Website

Python Sphinx Documentation

CHAPTER

TWO

BASIC SOURCES

Basic sources with single variables and independent probability distributions.

2.1 *Basic Distributions and Built-in Functions*

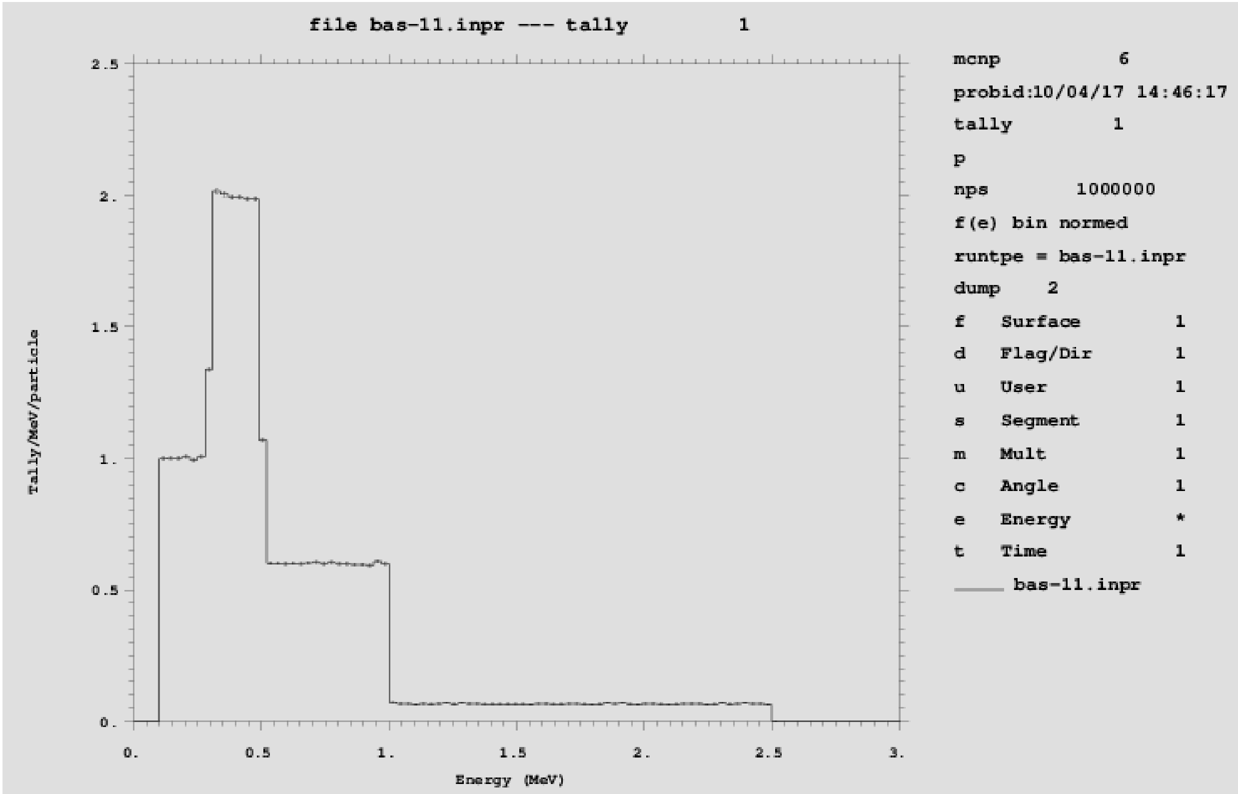
2.1.1 Histograms Bins with Probabilities

Example where energy bin boundaries are assigned with probabilities within each tabulated histogram bin. Within each bin, the energy is sampled uniformly. This example is from "An MCNP Primer" by Shultis and Faw, page 11 (see *Helpful Links*).

Listing 2.1: MCNP6 Input File

```
Tabulated energy spectrum - histograms
c
10  0      -1  IMP:P=1
99  0      +1  IMP:P=0

1  SO   1.0

MODE P
NPS 1e6
c
c ===> tabulated histogram PDF
c ===>   supply UPPER boundaries of bins
c ===>   lower bound of first bin assumed 0.0
c ===>   supply probability for each bin
c ===>   probabilities need not be normalized
c
SDEF  POS 0 0 0   PAR=2   ERG=D1
SI1  H  .1   .3     .5    1.     2.5
SP1  D  .0   .2     .4    .3    .1
c
c ===> Tally leakage, 1000 equal delta-E bins
c
F1:P  1
E1   .01  999i  30.
c
```

Below is the histogram plot for the simulated energy spectrum.



Listing 2.2: MCNP6 Plotting Commands

```
tal 1 linlin xlims 0 3
file
end
end
```

2.1.2 Piecewise Linear

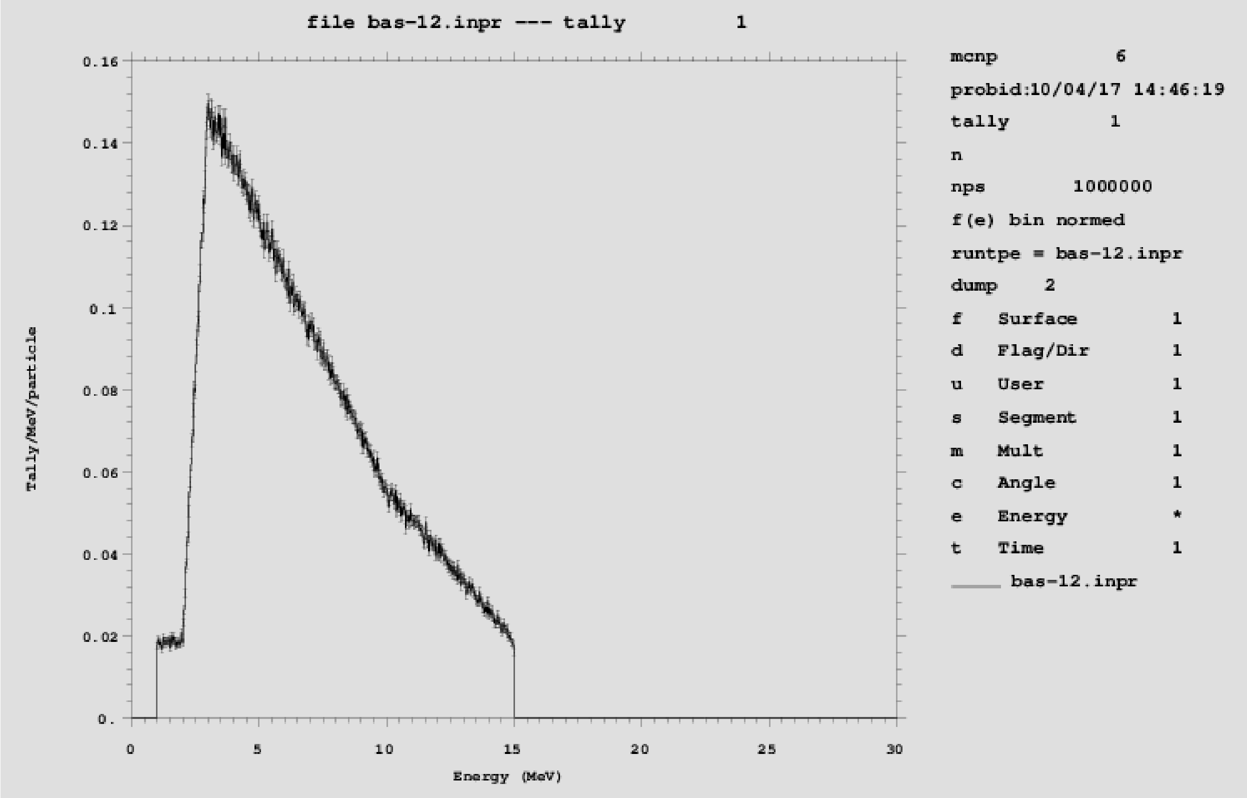
Example of a piecewise linear energy distribution where probabilities are user-defined at points and linearly interpolated between these points.

Listing 2.3: MCNP6 Input File

```
Tabulated energy spectrum - piecewise linear
c
10  0      -1  IMP:N=1
99  0      +1  IMP:N=0

1  SO   1.0

MODE N
NPS 1e6
c
c ===> Tabulated, piecewise linear PDF
c ===> Supply E points & pdf(E)
c ===> Linear interp between points
c
SDEF  X=0 Y=0 Z=0  ERG=D1
```

```
c
SI1   A     1.0   2.0   3.0    10.0    15.0
SP1          1.    1.    8.      3.      1.
c
c ===> Tally leakage, 1000 equal delta-E bins
c
F1:N  1
E1   .01  999i   30.
```

Below is the plot of the piecewise linear simulated energy spectrum tally.



Listing 2.4: MCNP6 Plotting Commands

```
tal 1 linlin
file
end
end
```

2.1.3 Discrete Probabilities

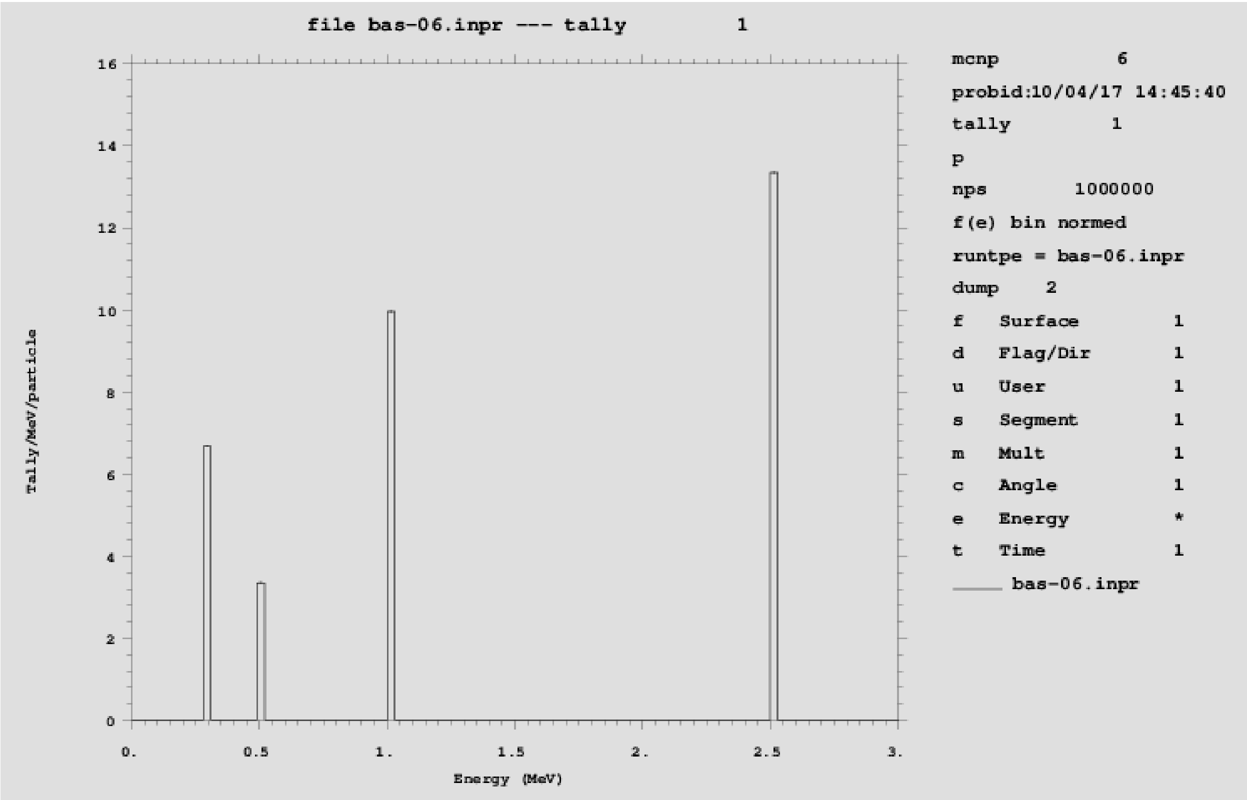
An example of a point isotropic source with discrete energy photons from "An MCNP Primer" by Shultis and Faw, page 11 (see *Helpful Links*).

Listing 2.5: MCNP6 Input File

```
Point Isotropic Source with Discrete Energy Photons
10   0      -1   IMP:P=1          $ Inside sphere
```

```
99  0      +1  IMP:P=0          $ Outside world

1  SO   1.0

MODE P
NPS  1e6
c
SDEF  POS=0 0 0  ERG=D1 PAR=2
c
SI1  L    0.3   0.5    1.0    2.5             $ The 4 discrete energies(MeV)
SP1       0.2   0.1    0.3    0.4             $ Frequency of each energy
c
F1:P  1
E1   0.01 999i  30.0
c
print
```

The four discrete photons energies can be seen below. The 2.5 MeV photon has the highest frequency of 40% and 0.5 MeV has the lowest frequency of 10%. The frequencies for 0.3 MeV and 1.0 MeV are 20% and 30%, respectively.



Listing 2.6: MCNP6 Plotting Commands

```
tal 1 linlin xlims 0 3
file
end
end
```

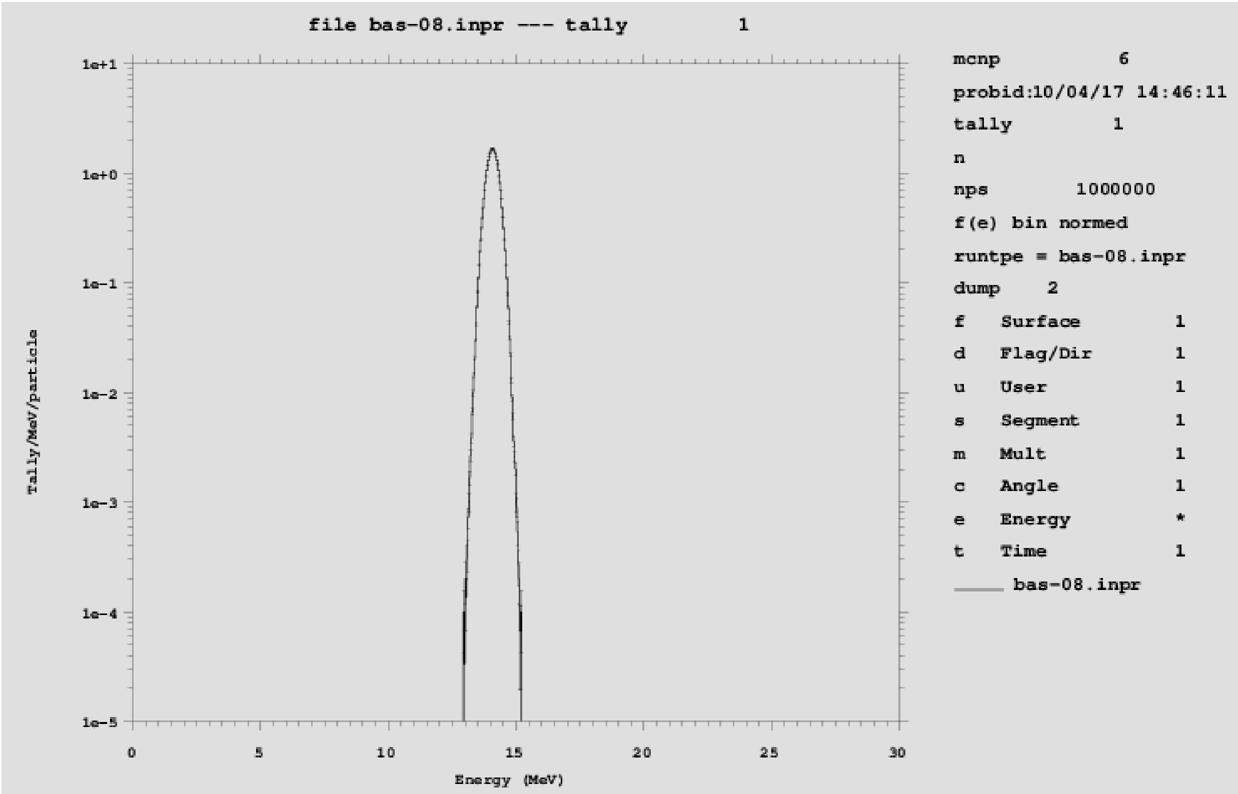
2.1.4 Gaussian Fusion Spectrum

Example of the MCNP built-in Gaussian spectrum for fusion neutrons.

Listing 2.7: MCNP6 Input File

```
Gaussian spectrum, fusion neutrons point source
c
10  0      -1  IMP:N=1
99  0      +1  IMP:N=0

 1  SO   1.0

MODE N
NPS  1e6
c
c ===> Use built-in Gaussian PDF for DT fusion, 10 KeV
c ===> No SI1 card needed
c
SDEF  X=0 Y=0 Z=0  ERG=D1
SP1  -4
c
c ===> Tally leakage, 1000 equal delta-E bins
c
F1:N  1
E1   .01  999i   30.
```

Below is the Gaussian energy spectrum plotted using the standard tally plotter.



Listing 2.8: MCNP6 Plotting Commands

```
tal 1
file
end
end
```

2.1.5 Watt Fission Spectrum

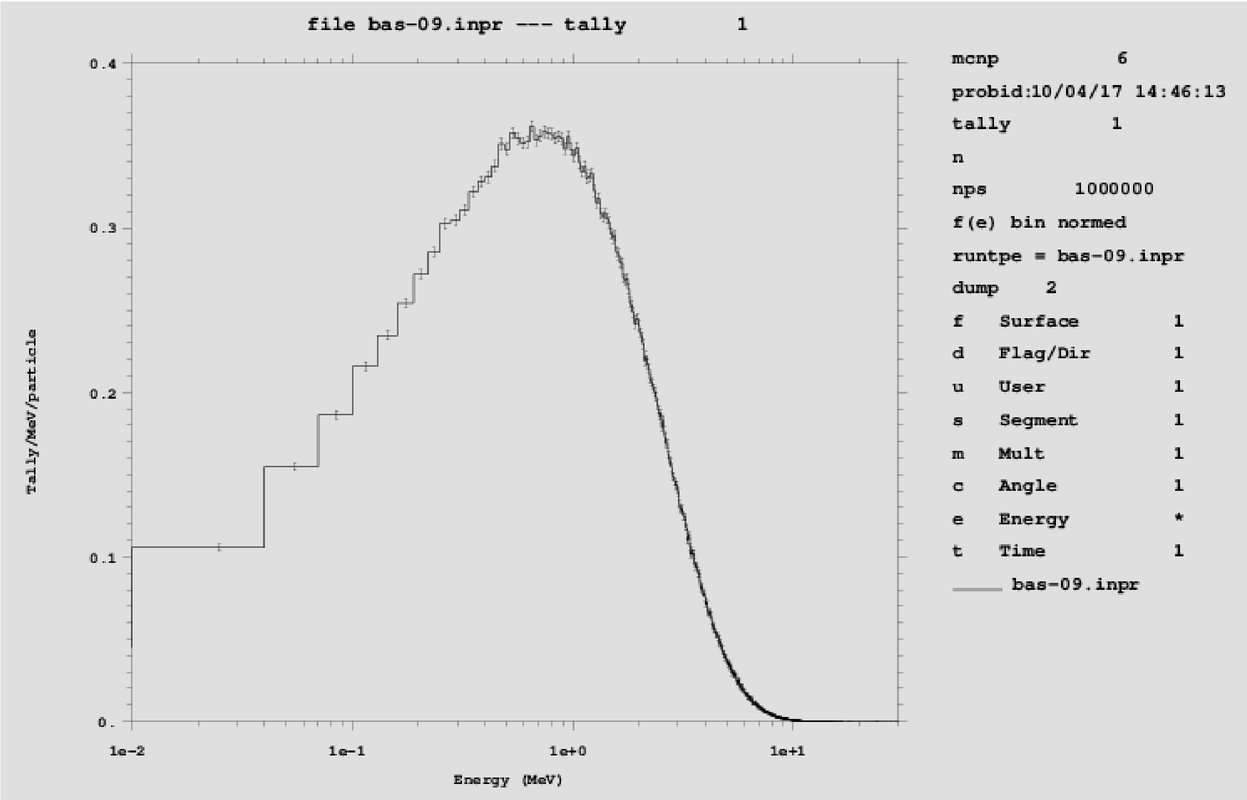
Example of Watt fisson neutrons from a point source.

Listing 2.9: MCNP6 Input File

```
Fission neutron point source
c
10  0      -1  IMP:N=1     $ Inside sphere
99  0      +1  IMP:N=0     $ Outside world

1  SO   1.0

MODE N
NPS 1e6
c
c ===> Use built-in fisson spectrum
c ===> Watt spectrum for u235 thermal fission
c
SDEF  X=0 Y=0 Z=0  ERG=D1
SP1  -3
c
```

```
c ===> Tally leakage, 1000 equal delta-E bins
c
F1:N   1
E1    .01   999i    30.
```

Below is the fission neutron energy spectrum.



Listing 2.10: MCNP6 Plotting Commands

```
tal 1 loglin xlims 1.e-2 3.e+1
file
end
end
```

2.1.6 Mixture of Fission and Fusion Spectra

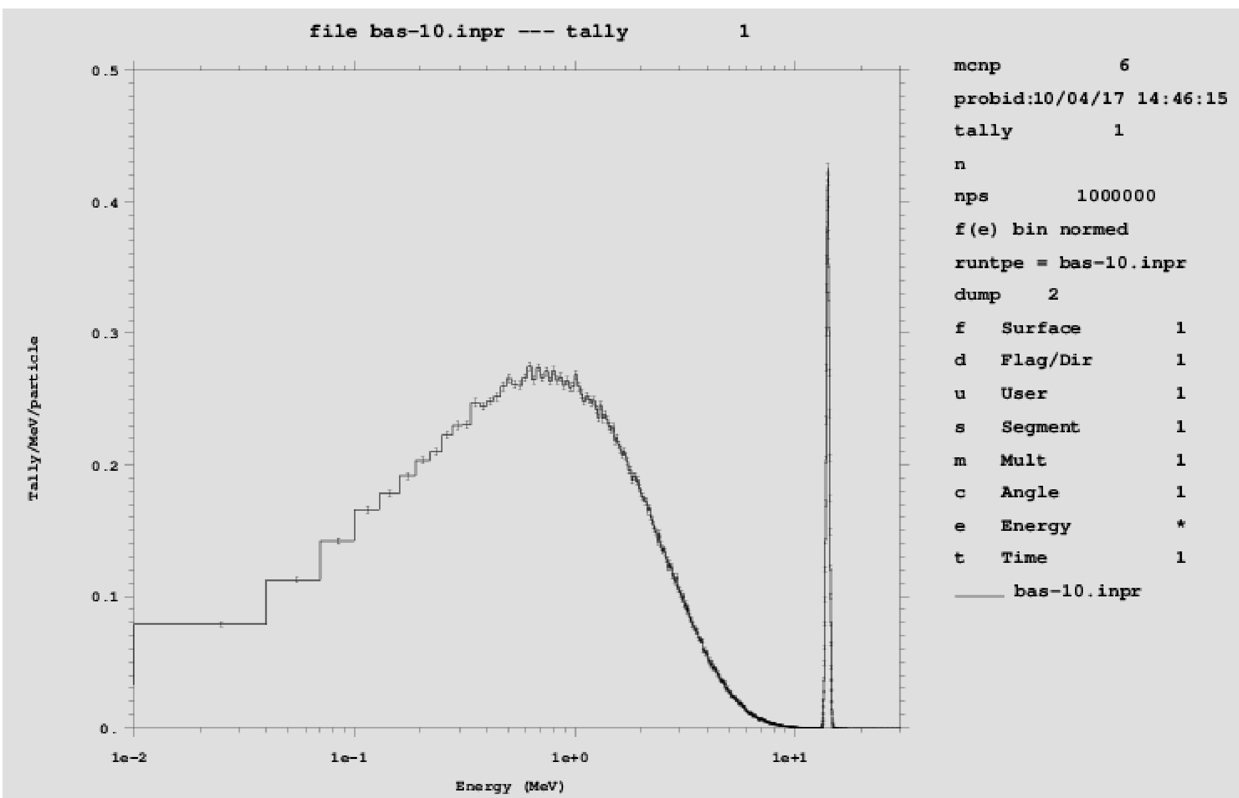
Example of two independent distributions, Watt fission and Gaussian fusion spectra, weighted and combined to create a single energy distribution.

Listing 2.11: MCNP6 Input File

```
Fusion neutrons + fission neutrons point source
c
10  0      -1  IMP:N=1      $ Inside sphere
99  0      +1  IMP:N=0      $ Outside sphere

1  SO   1.0
```

```
MODE N
NPS 1e6
c
c ===> Combine fission (75%) & fusion (25%)
c
SDEF  X=0 Y=0 Z=0  ERG=D1
c
c  ===> Select the PDF, 3 or 4
SI1 s  3   4
SP1  .75  .25
c
c  ===> Sample E from the selected PDF
SP3  -3         $ Fission
SP4  -4         $ Fusion
c
c ===> Tally leakage, 1000 equal delta-E bins
c
F1:N  1
E1   .01  999i   30.
```

The plot below shows the energy spectrum of the source with a combined 75% fission and 25% fusion.



Listing 2.12: MCNP6 Plotting Commands

```
tal 1 loglin xlims 1.e-2 3.e+1
file
end
end
```

2.2 *Positional Sources*

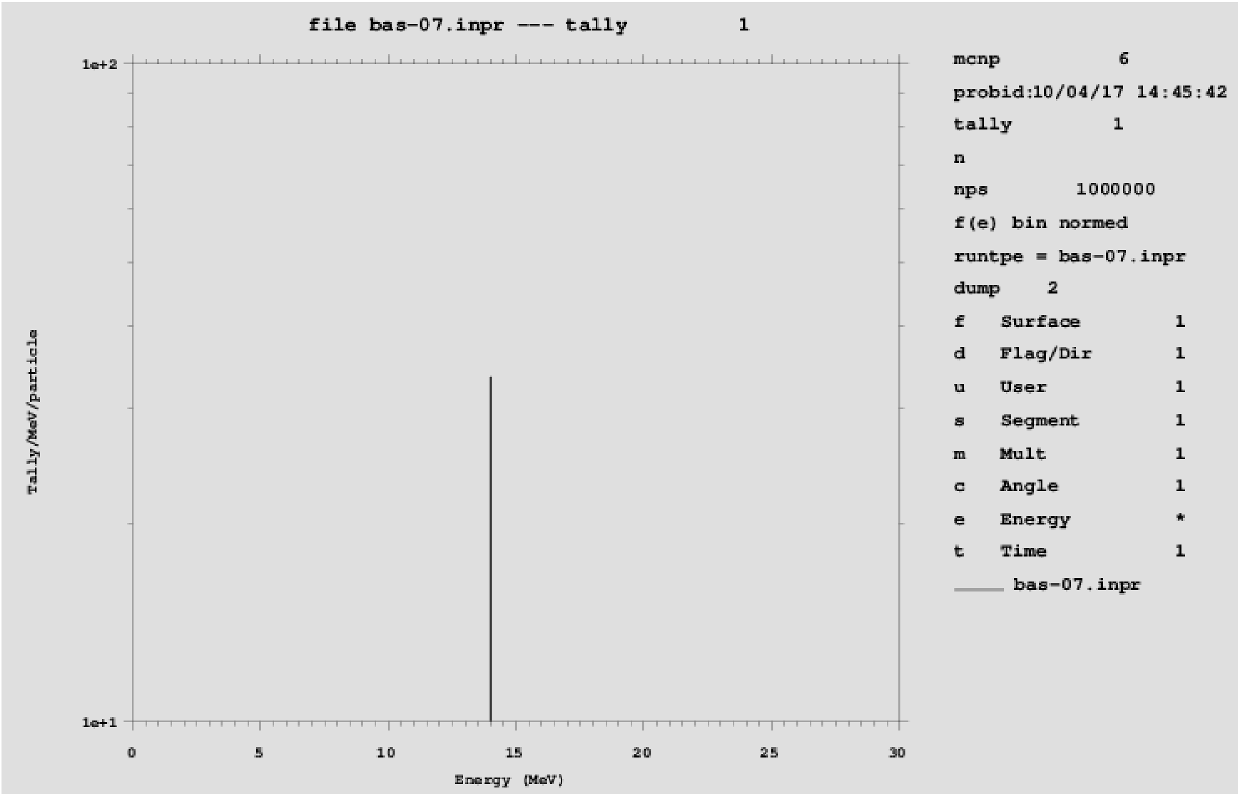
2.2.1 Isotropic Point Source

Example of a 14 MeV neutron isotropic point source (default position, energy, direction).

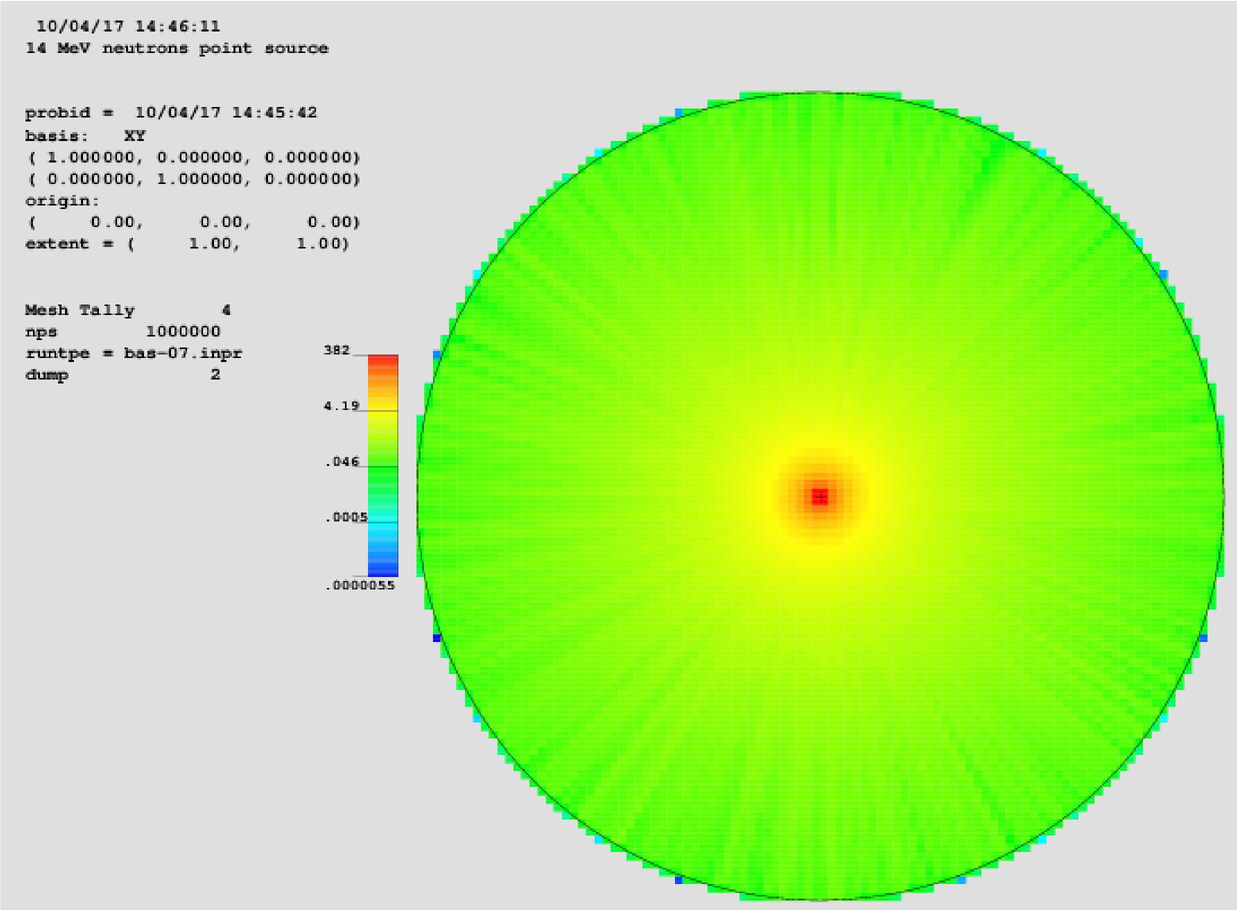
Listing 2.13: MCNP6 Input File

```
14 MeV neutrons point source
c
10  0      -1  IMP:N=1
99  0      +1  IMP:N=0

1  SO   1.0

MODE N
NPS  1e6
c
c ===> Single source energy
c
SDEF  X=0 Y=0 Z=0  ERG=14.0
c
c ===> Tally leakage, 1000 equal delta-E bins
c
F1:N  1
E1   .01  999i   30.
c
FMESH4:N  GEOM= xyz    ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0   IINTS= 100
          JMESH= 1.0   JINTS= 100
          KMESH= 1.0   KINTS= 100
c
print
```

Below is a plot of the single energy of the point source.



Below is the mesh plot of the flux from the point source.



Listing 2.14: MCNP6 Plotting Commands

```
tal 1
fmesh 4
file
end
end
```

2.2.2 Line Source along Coordinate Axis

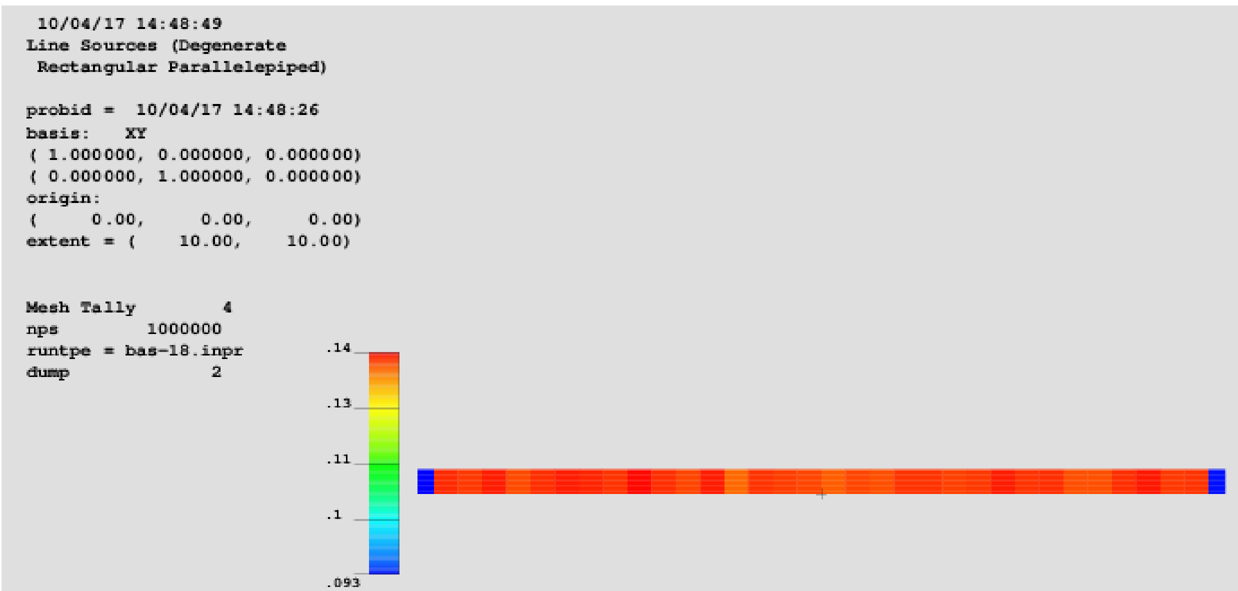
Line source example from "An MCNP Primer" by Shultis and Faw, page 12 (see *Helpful Links*).

Listing 2.15: MCNP6 Input File

```
Line Sources (Degenerate Rectangular Parallelepiped)
c
10  0      -1  IMP:P=1                 $ Inside parallelpiped
99  0      +1  IMP:P=0                 $ Outside parallelpiped

1  RPP   -20 20   -20 20  -20 20

MODE P
NPS 1e6
c
c --- Line monoenergetic photon source lying along the x-axis
```

```
c     this uses a degenerate Cartisian volumetric source.
c
SDEF  POS=0 0 0  X=d1 Y=0 Z=0  ERG=1.25 PAR=2
SI1  -10  10                          $ Xmin to xmax for line source
SP1  -21   0                          $ Uniform sampling on line here x^0
c
c
FMESH4:P  GEOM= xyz    ORIGIN= -30.0 -30.0 -30.0
          IMESH= 30.0   IINTS= 100
          JMESH= 30.0   JINTS= 100
          KMESH= 30.0   KINTS= 100
          TYPE=SOURCE
```

Degenerate rectangular parallelepiped line source lying along the x-axis from -10 to 10.



Listing 2.16: MCNP6 Plotting Commands

```
fmesh 4
ex 10
file
end
end
```

2.2.3 Line Source along User-defined Axis

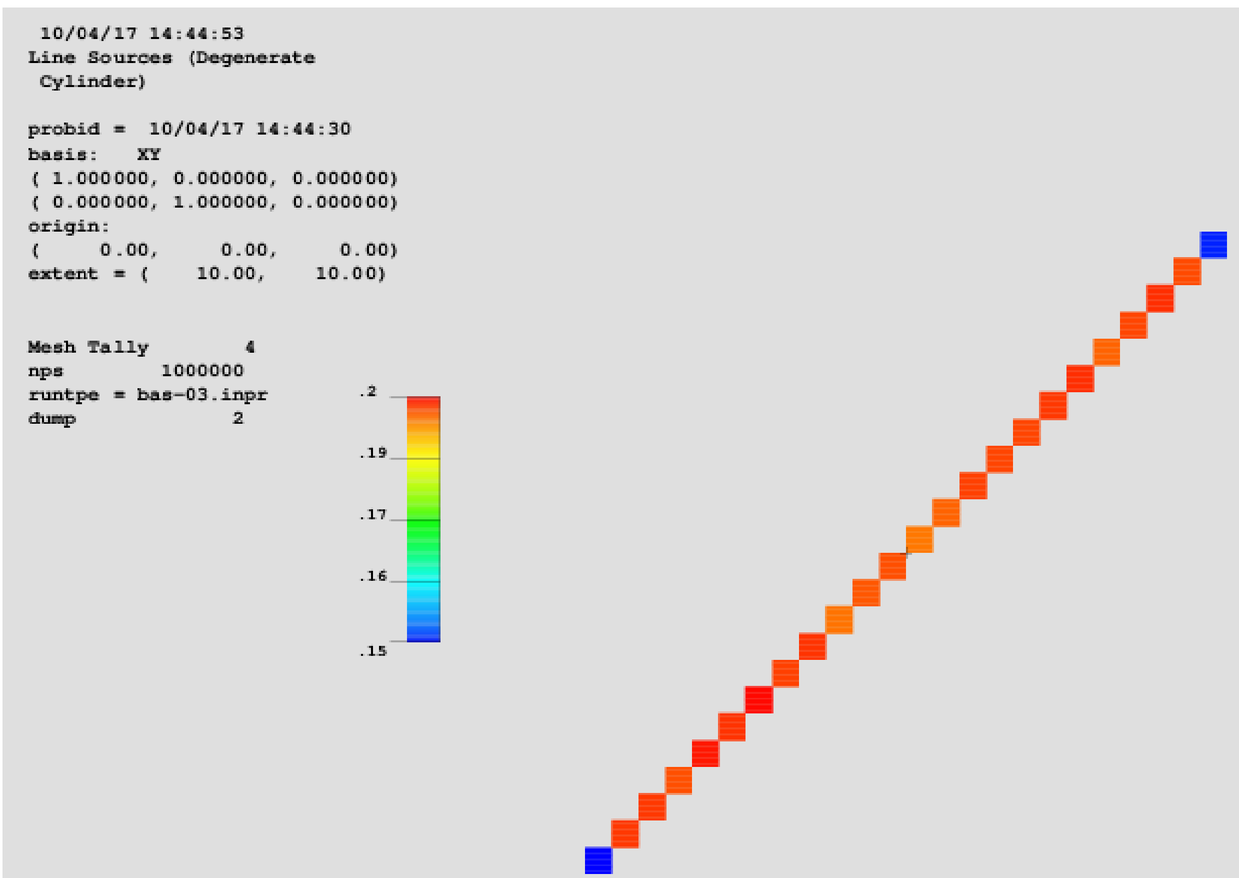
Line source example from "An MCNP Primer" by Shultis and Faw, page 13 (see *Helpful Links*).

Listing 2.17: MCNP6 Input File

```
Line Sources (Degenerate Cylinder)
c
10  0      -1  IMP:P=1                $ Inside parallelpiped
99  0      +1  IMP:P=0                $ Outside parallelpiped
```

```
1  RPP   -20 20   -20 20  -20 20

MODE P
NPS 1e6
c
c --- Line monoenergetic photon source lying along the AXS direction
c     this uses a degenerate cylindrical volumetric source.
c
SDEF  POS=0 0 0  AXS=1 1 0  EXT=D1  RAD=0  ERG=1.25 PAR=2
SI1  -10  10                          $ axial sampling range: -X to X
SP1  -21   0                          $ weighting for axial sampling: here constant
c
c
FMESH4:P  GEOM= xyz    ORIGIN= -30.0 -30.0 -30.0
          IMESH= 30.0   IINTS= 100
          JMESH= 30.0   JINTS= 100
          KMESH= 30.0   KINTS= 100
          TYPE=SOURCE
```

Degenerate cylindrical line source lying along a user-defined axis, 20 cm long.



Listing 2.18: MCNP6 Plotting Commands

```
fmesh 4
ex 10
file
```

```
end
end
```

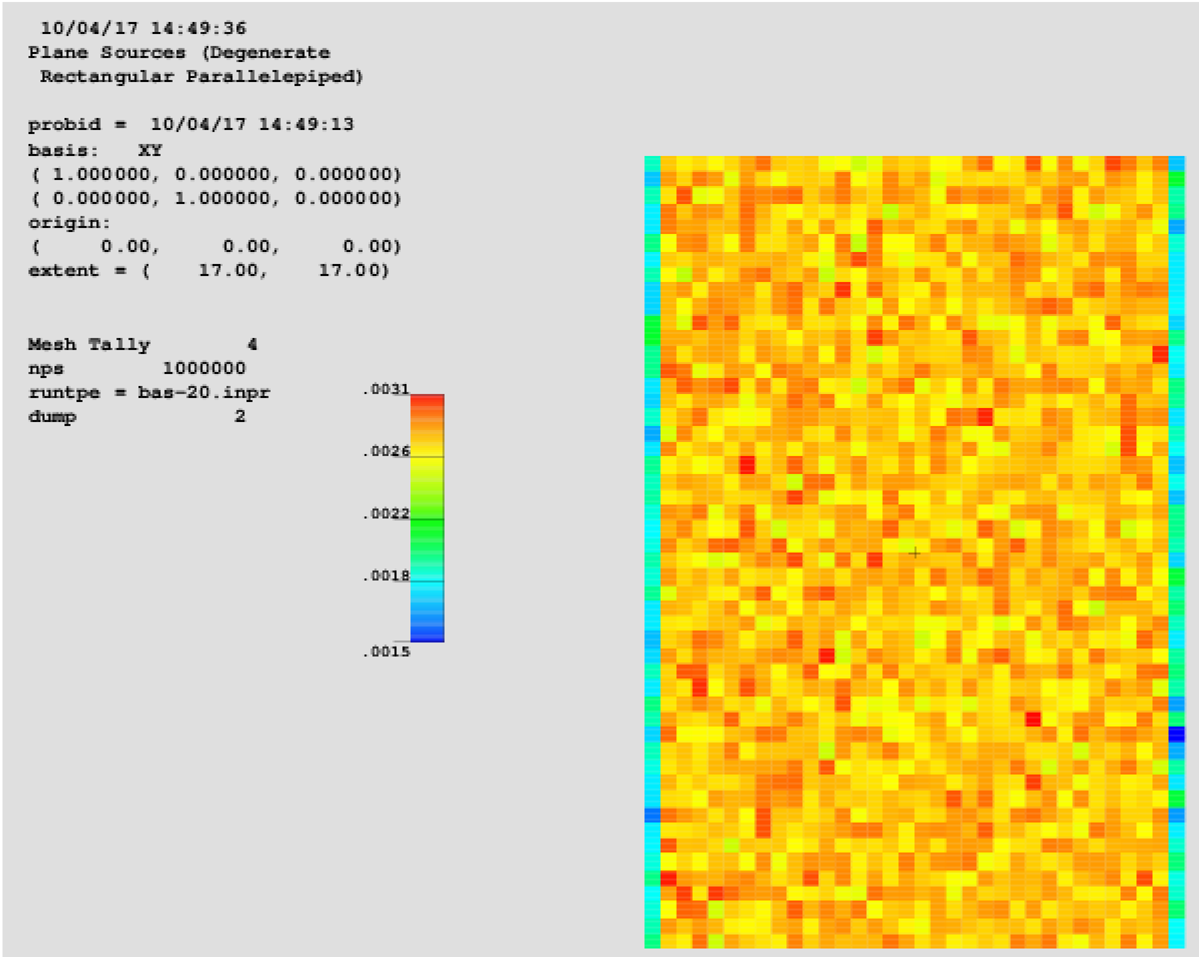
2.2.4 Plane Source

Degenerate cartisian volumetric source example from “An MCNP Primer” by Shultis and Faw, page 13 (see *Helpful Links*).

Listing 2.19: MCNP6 Input File

```
Plane Sources (Degenerate Rectangular Parallelepiped)
c
10  0      -1  IMP:P=1                 $ Inside parallelpiped
99  0      +1  IMP:P=0                 $ Outside parallelpiped

1  RPP   -20 20   -20 20  -20 20

MODE P
NPS 1e6
c
c --- Rectangular plane source centered on the orgin and perpendicular
c     to th y-axis. this uses a degenerate Cartesian volumetric source.
c
SDEF  POS=0 0 0  X=D1 Y=D2 Z=0  ERG=1.25 PAR=2
SI1  -10  10                   $ Xmin to xmax for line source
SP1    0   1                   $ Weighting for x sampling: here constant
SI2  -15  15                   $ Sampling range ymin to ymax
SP2    0   1                   $ Weighting for y sampling: here constant
c
FMESH4:P  GEOM= xyz    ORIGIN= -30.0 -30.0 -30.0
          IMESH= 30.0   IINTS= 100
          JMESH= 30.0   JINTS= 100
          KMESH= 30.0   KINTS= 100
          TYPE=SOURCE
```

Below is the mesh plot of the degenerate rectangular parallelepiped plane lying along XY plane.



Listing 2.20: MCNP6 Plotting Commands

```
fmesh 4
ex 17
file
end
end
```

2.2.5 Disk Source

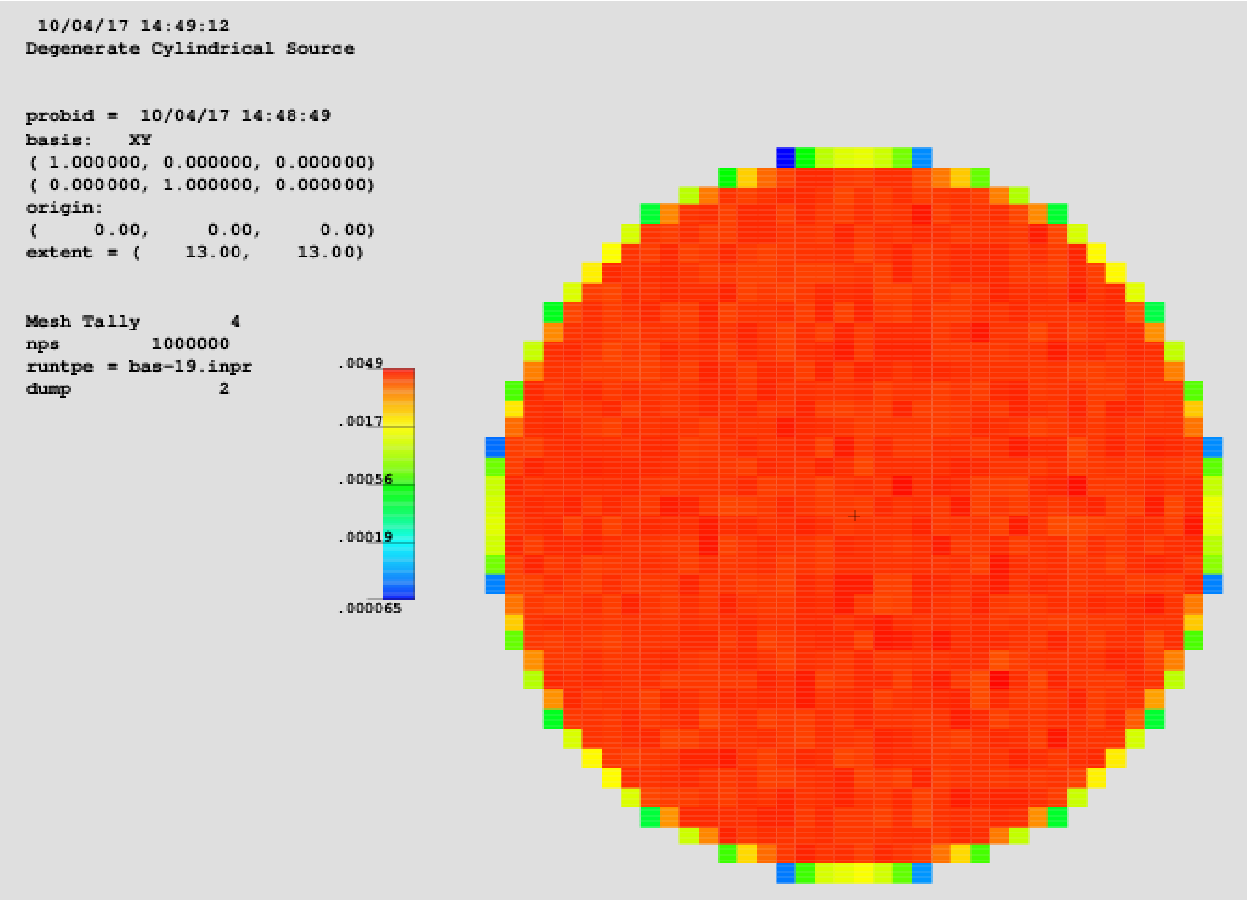
Degenerate cylindrical source example from "An MCNP Primer" by Shultis and Faw, page 13 (see *Helpful Links*).

Listing 2.21: MCNP6 Input File

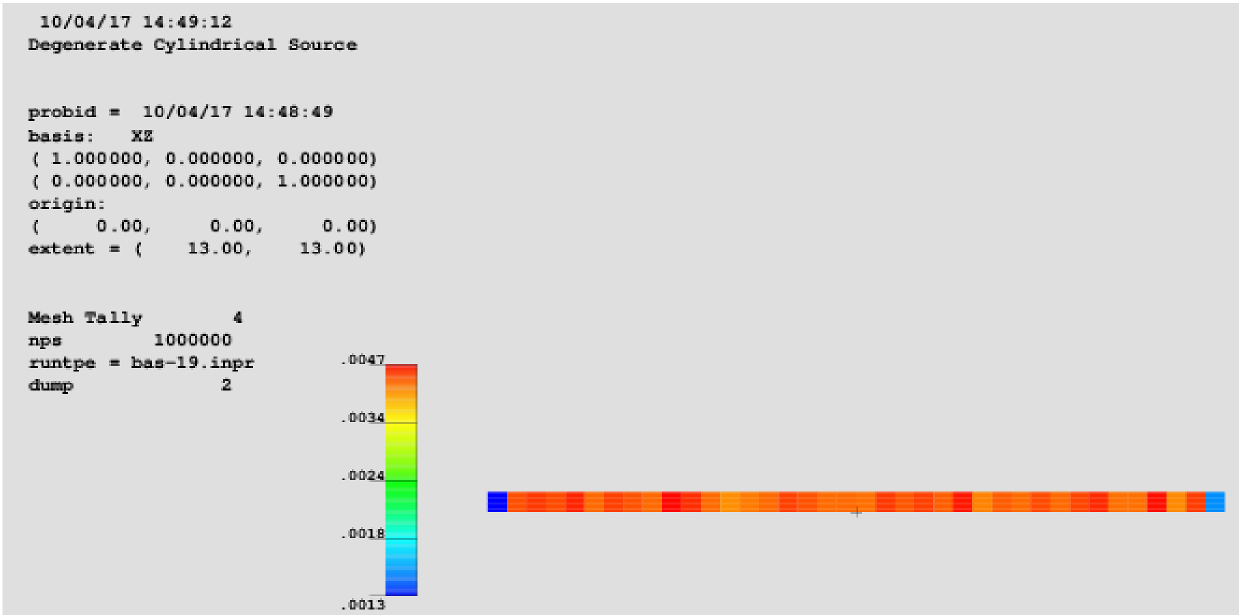
```
Degenerate Cylindrical Source
c
10   0       -1   IMP:P=1
99   0       +1   IMP:P=0

1   SO    30

MODE P
NPS   1e6
```

```
c
SDEF  PAR=2  POS=0 0 0  AXS=0 0 1 EXT=0  ERG=1.25 RAD=D1
c
si1    0   11             $ Radial sampling range: 0 to Rmax
sp1    -21  1             $ Radial sampling weighting: r^1 for disk source
c
c fmesh tally surrounding the source
c
FMESH4:P  GEOM= xyz    ORIGIN= -30.0 -30.0 -30.0
          IMESH= 30.0   IINTS= 100
          JMESH= 30.0   JINTS= 100
          KMESH= 30.0   KINTS= 100
          TYPE=SOURCE
c
print
```

Below is the mesh plot of the degenerate cylindrical disk seen on the XY plane.



Below is the mesh plot of the degenerate cylindrical disk seen on the XZ plane.



Listing 2.22: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 1 0  ex 13
basis 1 0 0  0 0 1  ex 13
file
end
end
```

2.2.6 Radial Shell Source Distribution

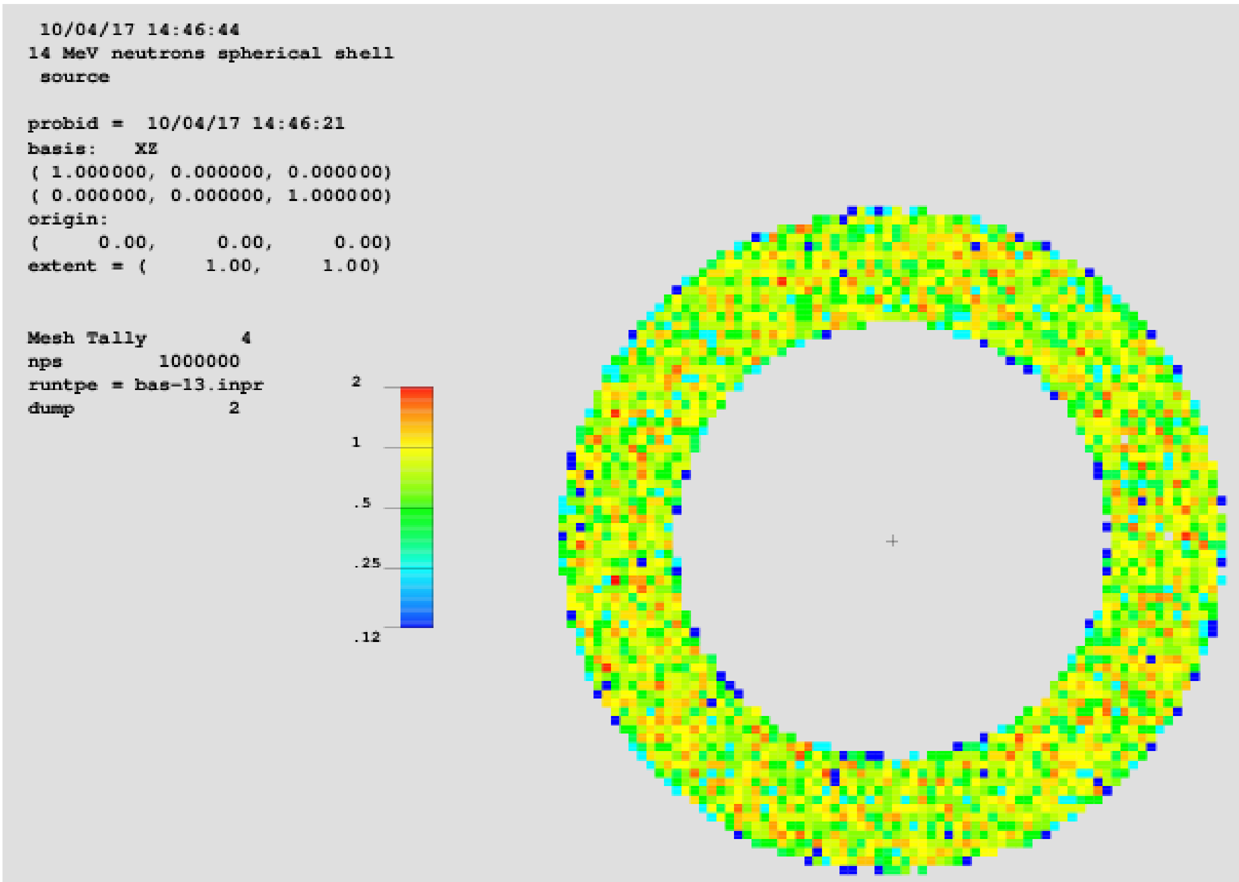
Example of the starting source position within a spherical shell.

Listing 2.23: MCNP6 Input File

```
14 MeV neutrons spherical shell source
c
10  0      -1  imp:n=1
99  0      +1  imp:n=0

1  SO   2.0

MODE N
NPS  1e6
c
c ===> Single source energy
c
SDEF  POS=0 0 0  ERG=14.0  RAD=d1
SI1 H 0.5 0.75
SP1 -21 2
c
c ===> fmesh tally surrounding the source
c
FMESH4:N  GEOM= xyz    ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0   IINTS= 100
```

```
          JMESH= 1.0    JINTS= 100
          KMESH= 1.0    KINTS= 100
          TYPE=SOURCE
c
print
```

Below is the mesh plot of the source locations within a spherical shell.



Listing 2.24: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 0 1
basis 0 1 0  1 0 0
file
end
end
```

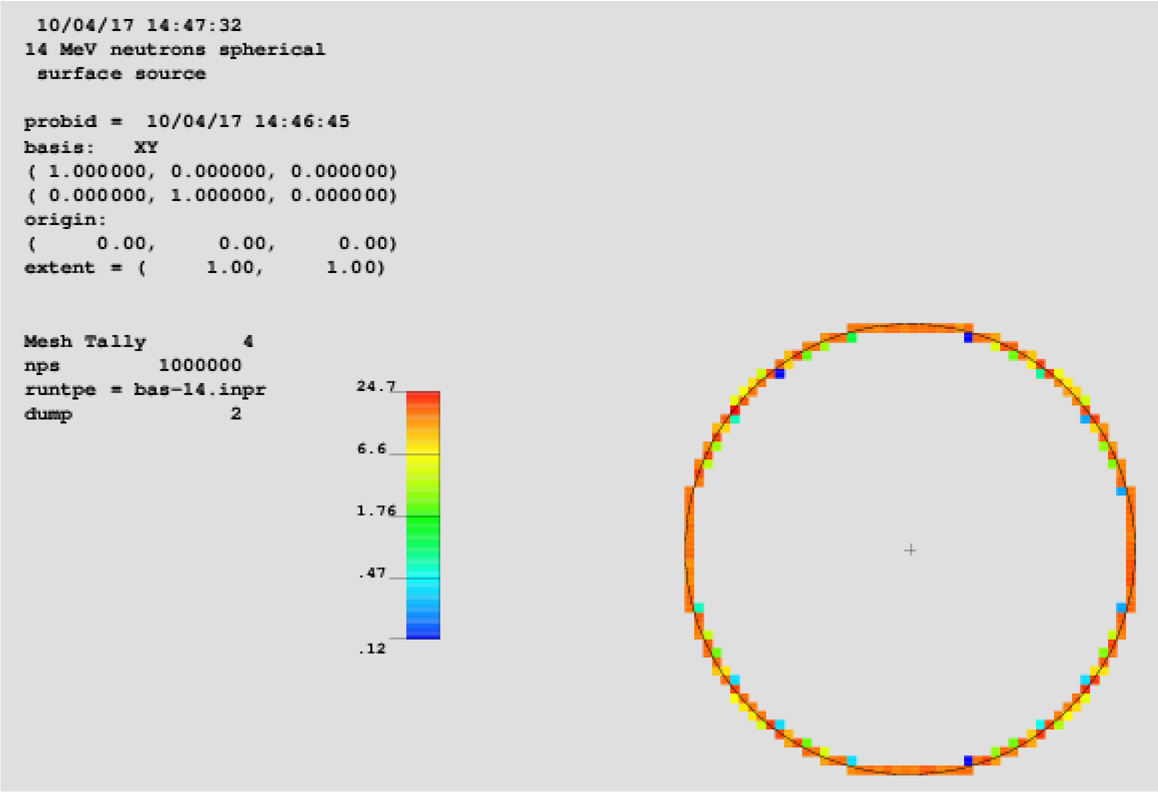
2.2.7 Surface Source

Example of source position defined on a spherical surface.

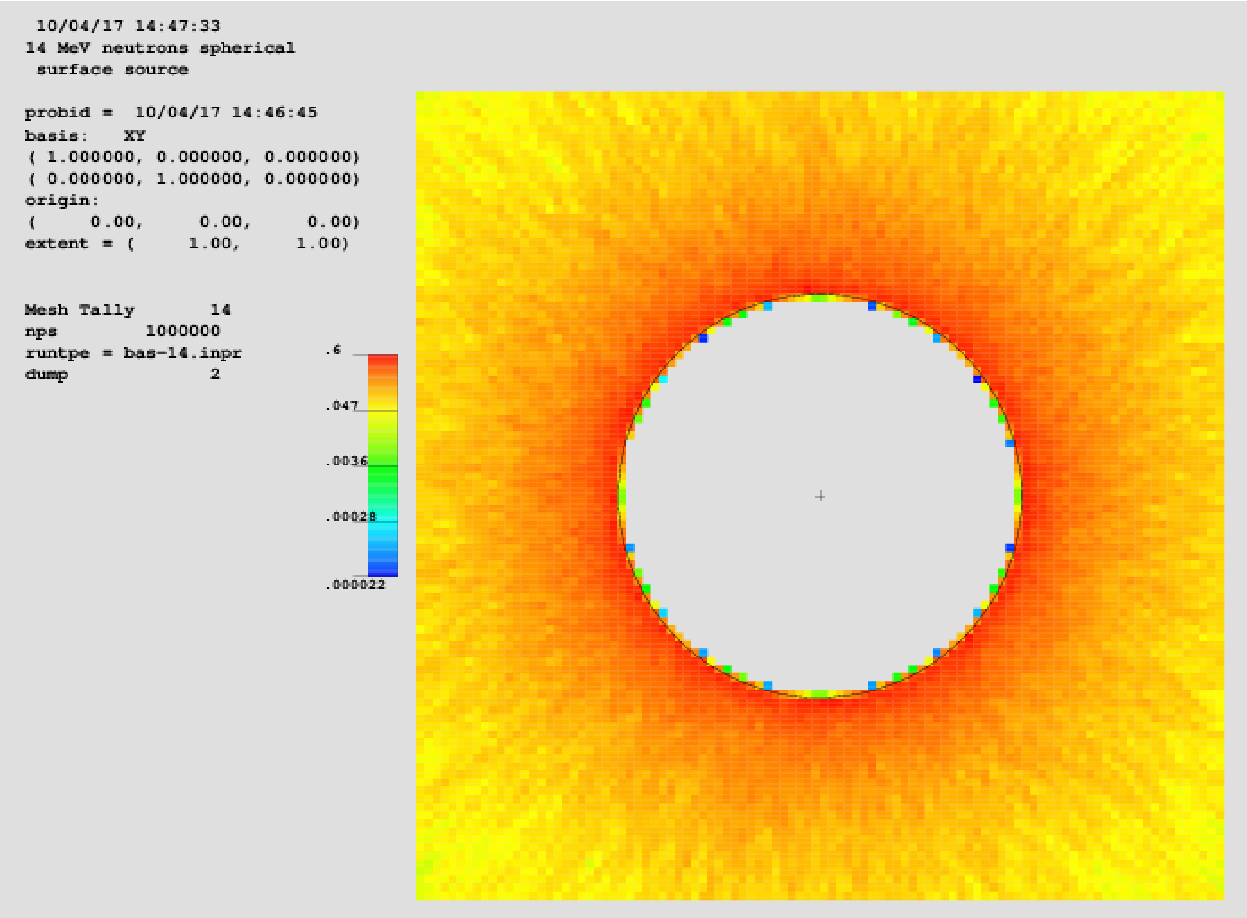
Listing 2.25: MCNP6 Input File

```
14 MeV neutrons spherical surface source
c
10  0      -1  IMP:N=1
20  0   +1 -2  IMP:N=1
99  0      +2  IMP:N=0

1  SO   0.5
2  SO   2.0

MODE N
NPS  1e6
c
c ===> Single source energy
c
SDEF  POS=0 0 0  ERG=14.0  RAD=D1  SUR=1
SI1 H 0.0 0.75
SP1 -21 1
c
c ===> fmesh tally surrounding the source
c
FMESH4:N  GEOM= xyz    ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0   IINTS= 100
          JMESH= 1.0   JINTS= 100
          KMESH= 1.0   KINTS= 100
          TYPE=SOURCE
c
FMESH14:N GEOM= xyz    ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0   IINTS= 100
          JMESH= 1.0   JINTS= 100
          KMESH= 1.0   KINTS= 100
c
print
```

Below is the mesh plot of the surface source locations on the spherical surface.



Note that the default directional distribution of surface source particles is a cosine distribution. Below is the mesh plot of the flux of particles due to the surface source distribution.



Listing 2.26: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0 0 1 0
end
fmesh 14
file
end
end
```

2.2.8 Uniform Cylindrical Source

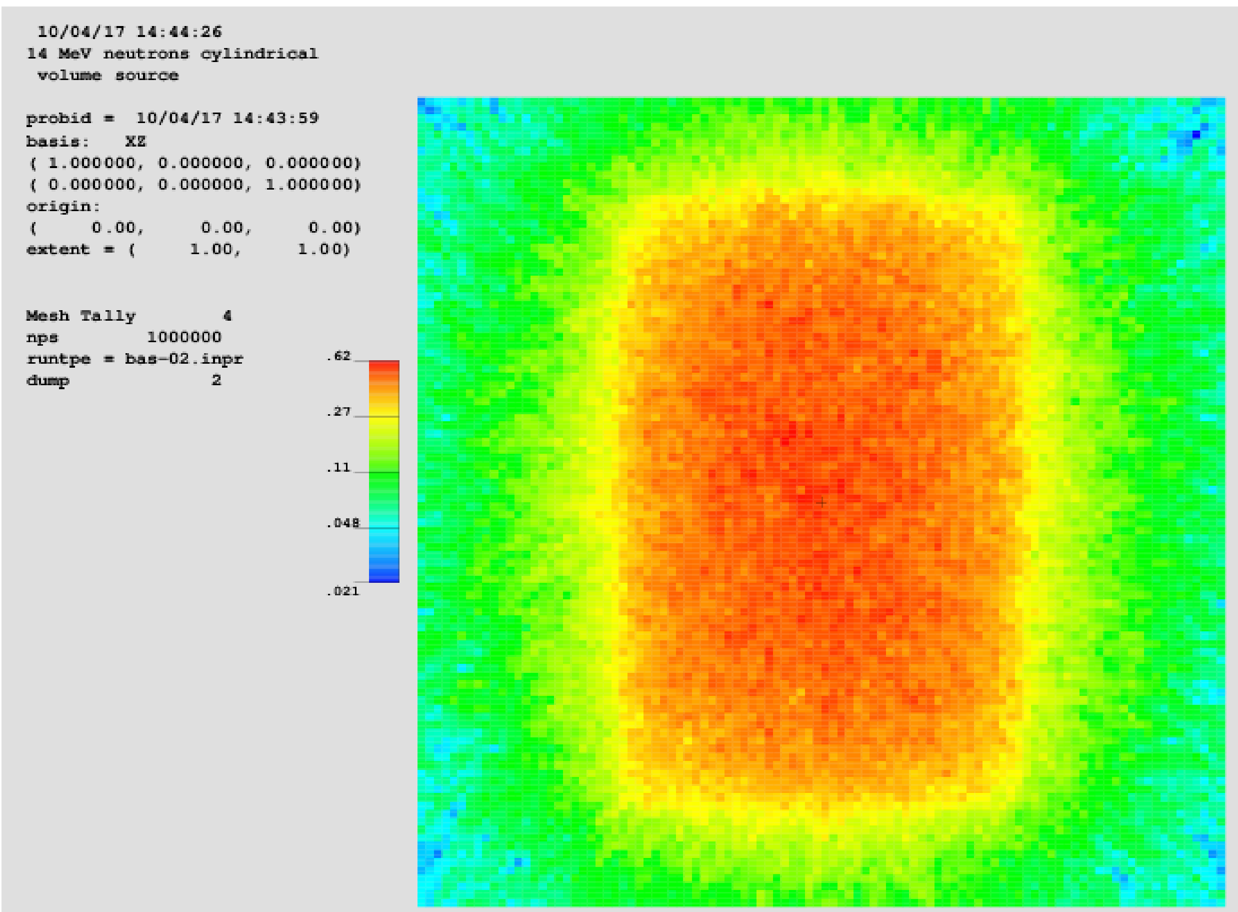
Cylindrical source using the built-in power law distribution with bin boundaries defined for radius and extent.

Listing 2.27: MCNP6 Input File

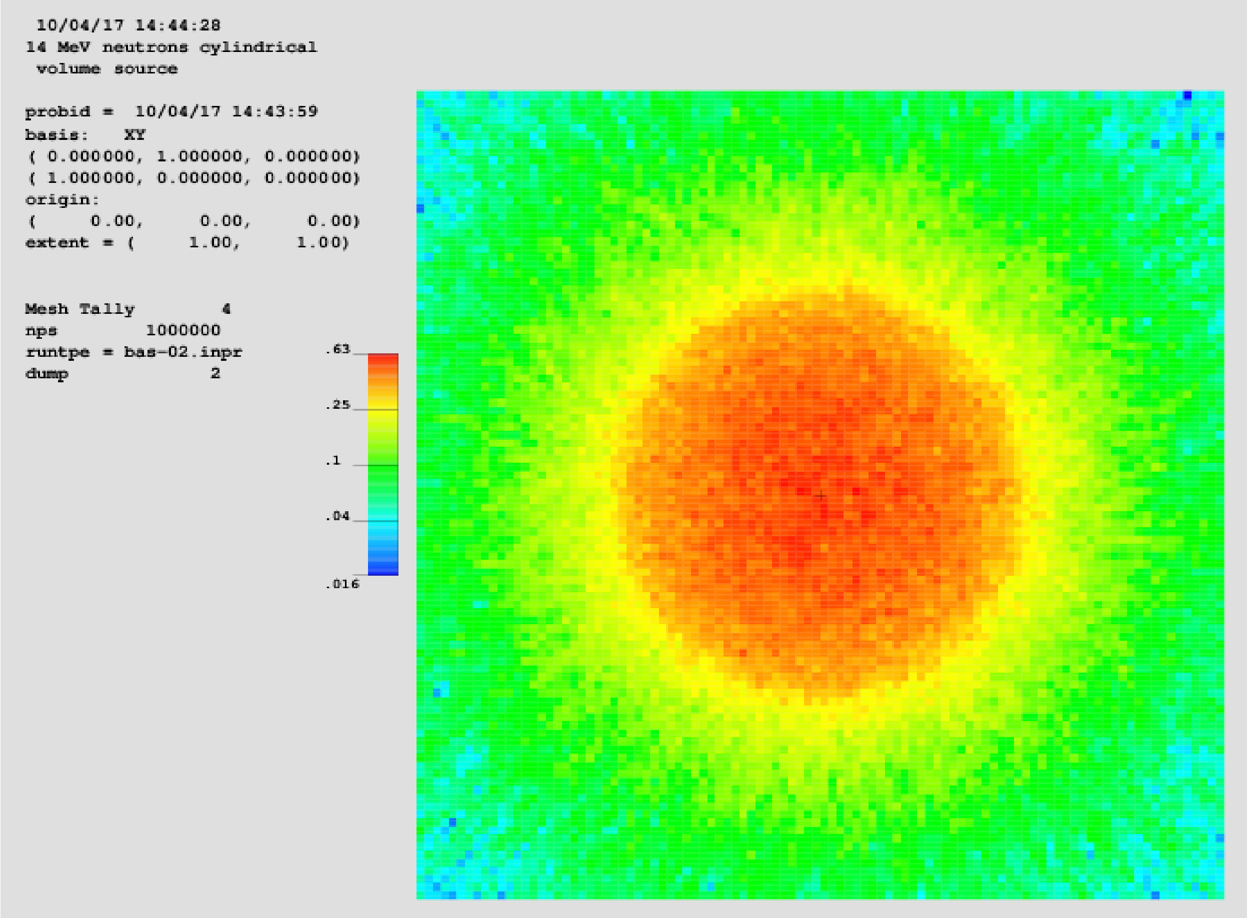
```
14 MeV neutrons cylindrical volume source
c
10   0       -1   IMP:N=1 $ Inside sphere
99   0       +1   IMP:N=0 $ Outside world

1   SO    2.0

MODE N
NPS   1e6
```

```
c
SDEF  POS=0 0 0  ERG=14.0  RAD=D1  AXS= 0 0 1  EXT=D2
SI1 H 0.0 0.5                  $ Histogram bin boundaries
SP1   -21   1
c
SI2 -0.75 0.75
SP2   -21    0
c
c ===> fmesh tally surrounding the source
c
FMESH4:N  GEOM= xyz    ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0   IINTS= 100
          JMESH= 1.0   JINTS= 100
          KMESH= 1.0   KINTS= 100
 print
```

Below is the flux mesh plot on the side of the cylindrical source on the XZ plane.



Below is the flux mesh plot on top of the cylindrical source on the XY plane.



Listing 2.28: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 0 1
basis 0 1 0  1 0 0
file
end
end
```

2.3 *Directional Sources*

2.3.1 Monodirectional Source

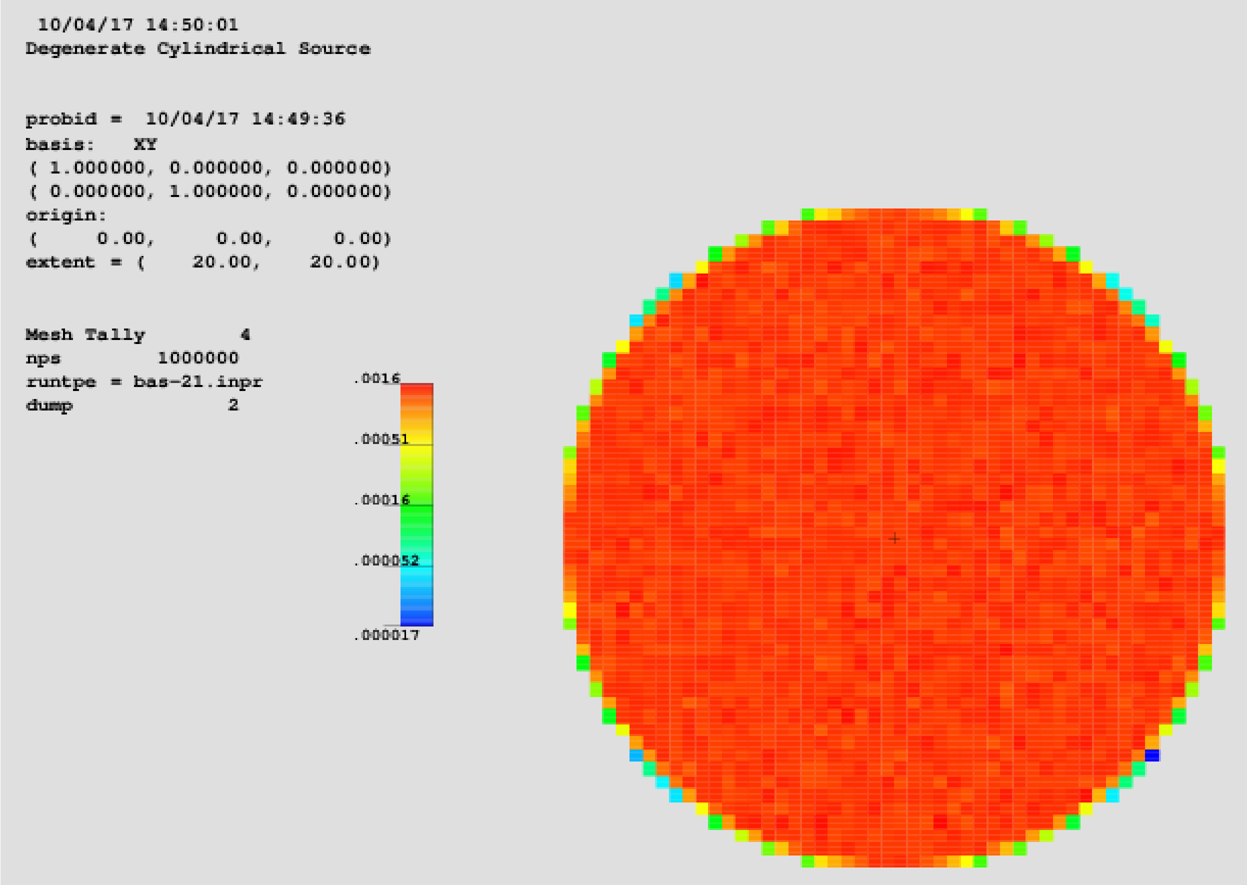
Monodirectional disk source example from "An MCNP Primer" by Shultis and Faw, page 13 (see *Helpful Links*).

Listing 2.29: MCNP6 Input File

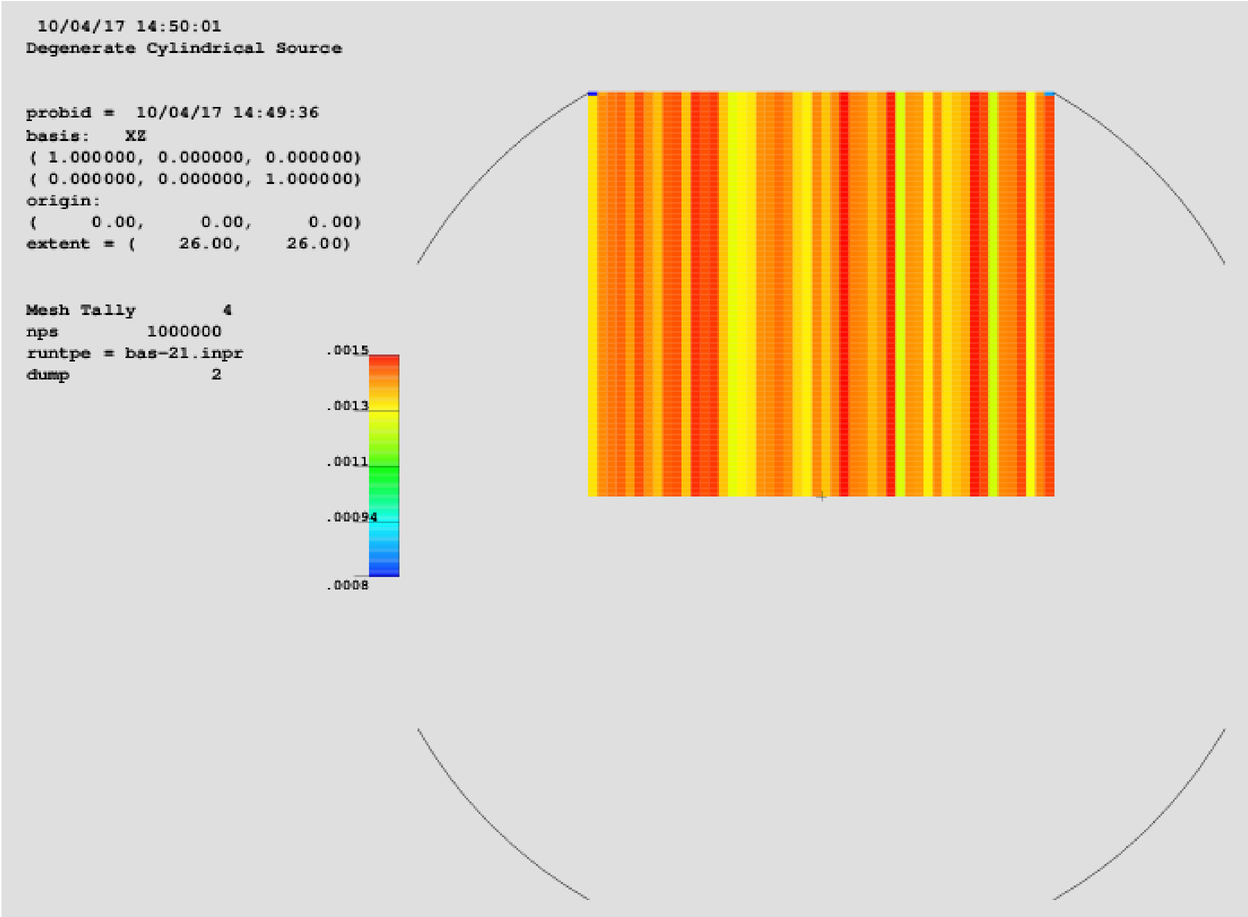
```
Degenerate Cylindrical Source
c
10  0      -1   IMP:N=1
99  0      +1   IMP:N=0

1  SO   30
```

```
MODE N
NPS  1e6
c
SDEF  PAR=1  POS=0 0 0  AXS=0 0 1 EXT=0  ERG=1.2 RAD=D1 VEC=0 0 1  DIR=1
c
SI1    0   15               $ Radial sampling range: 0 to Rmax (=15cm)
SP1    -21  1               $ Radial sampling weighting: r^1 for disk source
c
c fmesh tally surrounding the source
c
FMESH4:N  GEOM= xyz    ORIGIN= -30.0 -30.0 -30.0
          IMESH= 30.0   IINTS= 100
          JMESH= 30.0   JINTS= 100
          KMESH= 30.0   KINTS= 100
c
print
```

Below is the mesh plot of the flux of degenerate cylindrical disk seen on the XY plane.



The 1.2-Mev neutrons are uniformly emitted in the +z-direction as seen below in the flux mesh plot. Note that the default direction of the neutrons is isotropic if no DIR distribution is specified.



Listing 2.30: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 1 0  ex 20
basis 1 0 0  0 0 1  ex 26
file
end
end
```

2.3.2 Cone Beam

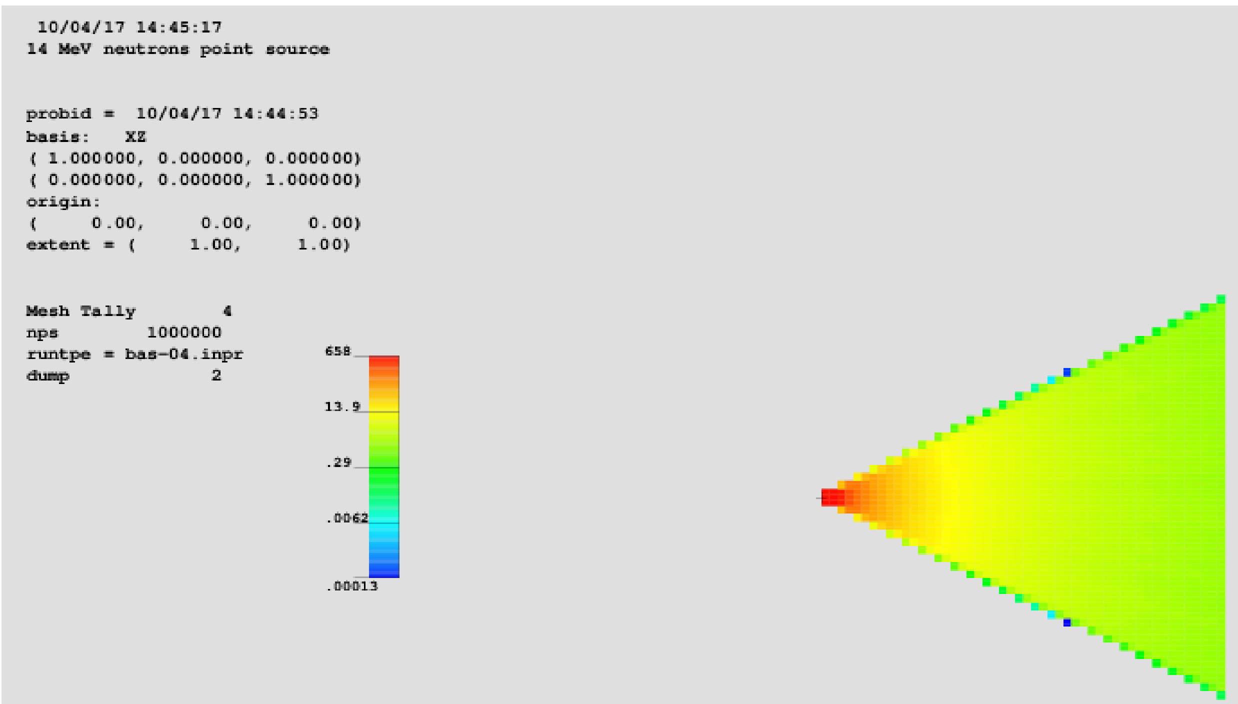
Example of uniformly distributed cone source with azimuthal symmetry.

Listing 2.31: MCNP6 Input File

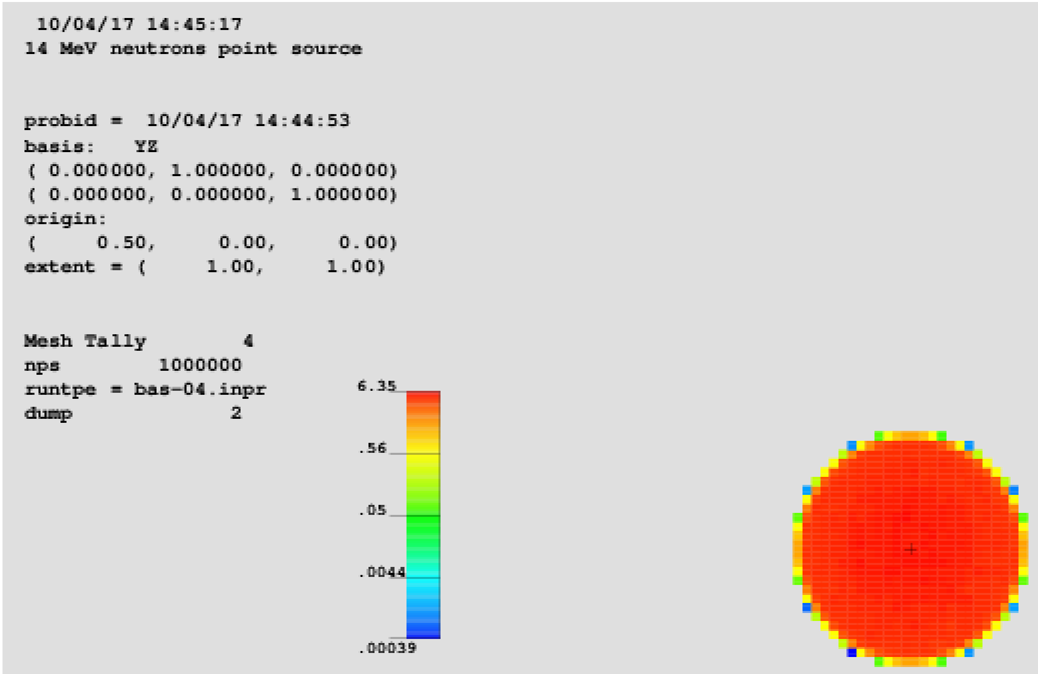
```
14 MeV neutrons point source
c
10  0      -1  IMP:N=1    $ Inside shpere
99  0      +1  IMP:N=0    $ Outside world

1  SO   2.0

MODE N
NPS  1e6
c
```

```
c ===> Single source energy
c
SDEF  X=0 Y=0 Z=0  ERG=14.0  VEC= 1 0 0  DIR=D1
SI1   -1    0.90   1
SP1  0  0.0      1
c
c ===> fmesh tally surrounding the source
c
FMESH4:N  GEOM= xyz    ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0   IINTS= 100
          JMESH= 1.0   JINTS= 100
          KMESH= 1.0   KINTS= 100
c
print
```

Below is a mesh plot of the flux showing a cone source with half angle of 25.8 degrees along the positive x-axis.



Flux mesh plot slicing through the x=0.5 cm plane seen on the YZ plane.



Listing 2.32: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 0 1
basis 1 0 0  0 0 1  px 0.5
file
end
end
```

2.3.3 Hollow Cone Source

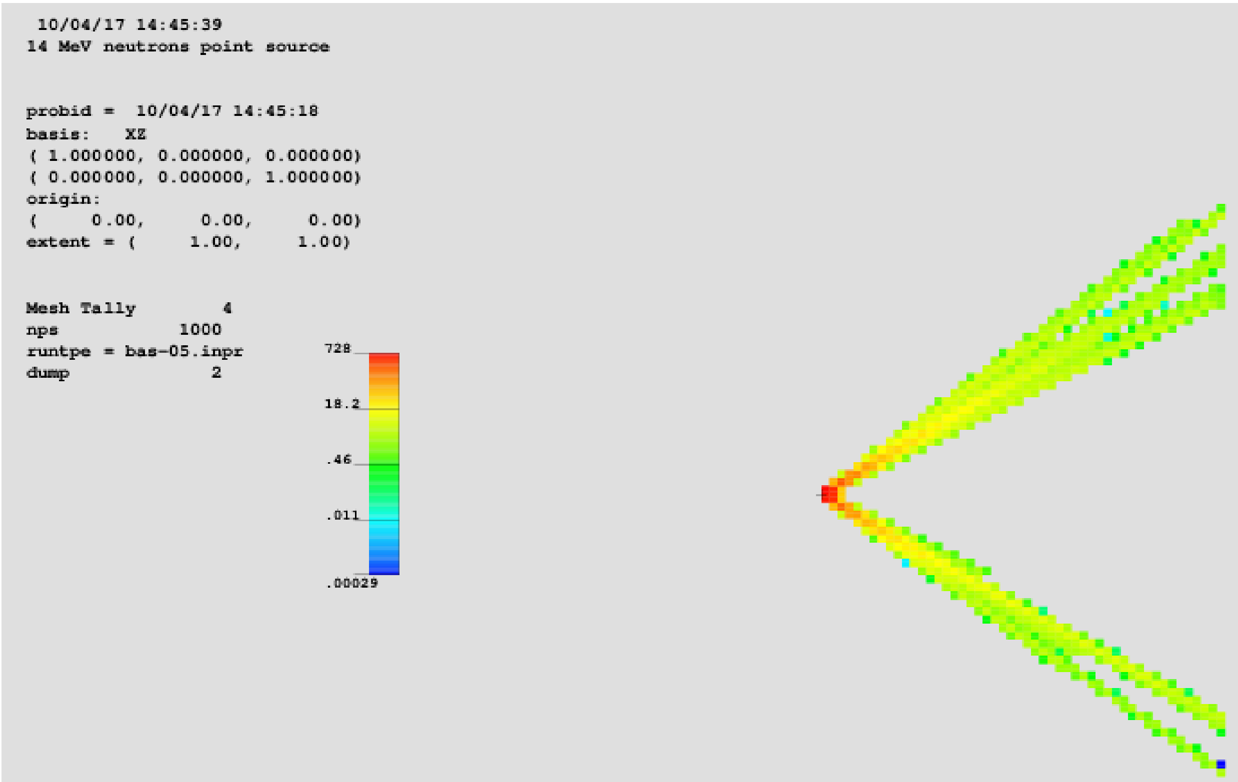
Example of uniformly sampled hollow cone source with azimuthal symmetry.

Listing 2.33: MCNP6 Input File

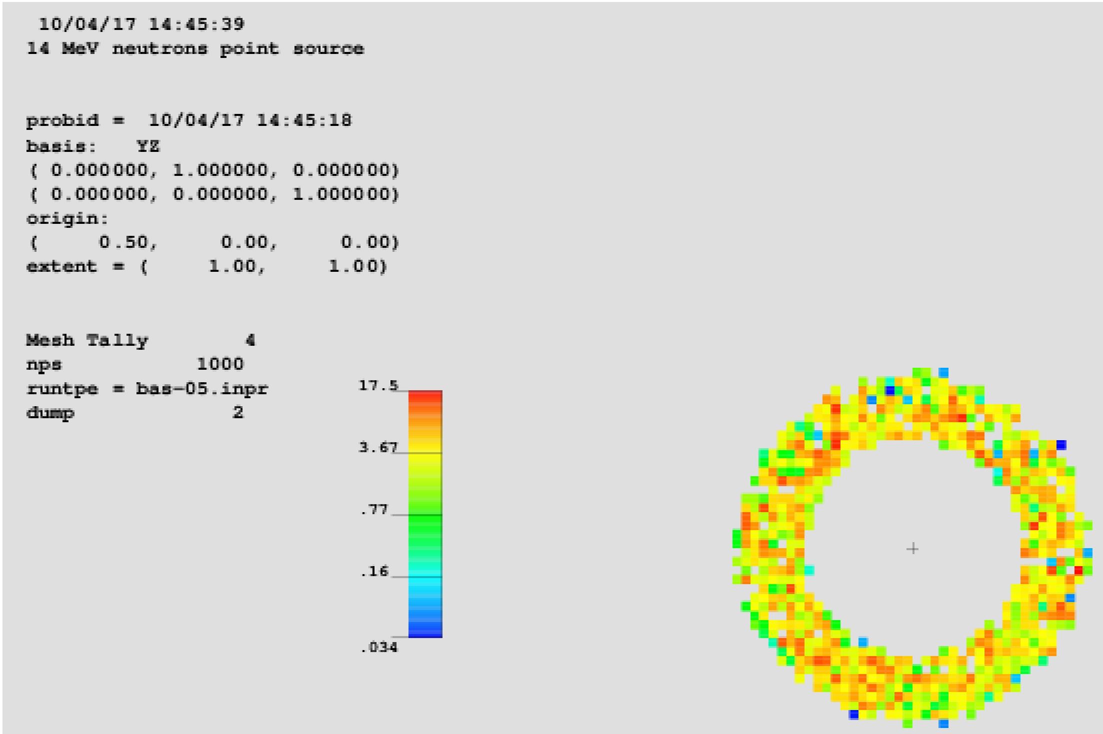
```
14 MeV neutrons point source
c
10  0      -1  IMP:N=1    $ Inside sphere
99  0      +1  IMP:N=0    $ Outside world

1  SO   2.0

MODE N
NPS  1e3
c
SDEF  X=0 Y=0 Z=0  ERG=14.0  VEC= 1 0 0  DIR=D1
SI1   -1    0.80   0.90   1                    $ Variable information
SP1    0     0.0    1.0   0                    $ Variable probability
c
FMESH4:N  GEOM= xyz   ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0  IINTS= 100
          JMESH= 1.0  JINTS= 100
          KMESH= 1.0  KINTS= 100
```

```
print
```

Below is a mesh plot of the flux showing a hollow cone source in the XY plane seen between $0.9 < \mu < 0.8$ only, with no source for $\mu < 0.8$ and $\mu > 0.9$.



From the bottom of the source cone shape seen from the YZ plane, a circular ring can be seen in the sliced source cone.



Listing 2.34: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 0 1
basis 1 0 0  0 0 1  px 0.5
file
end
end
```

2.4 *Multiple Independent Distributions*

2.4.1 Space, Energy and Time Distributions

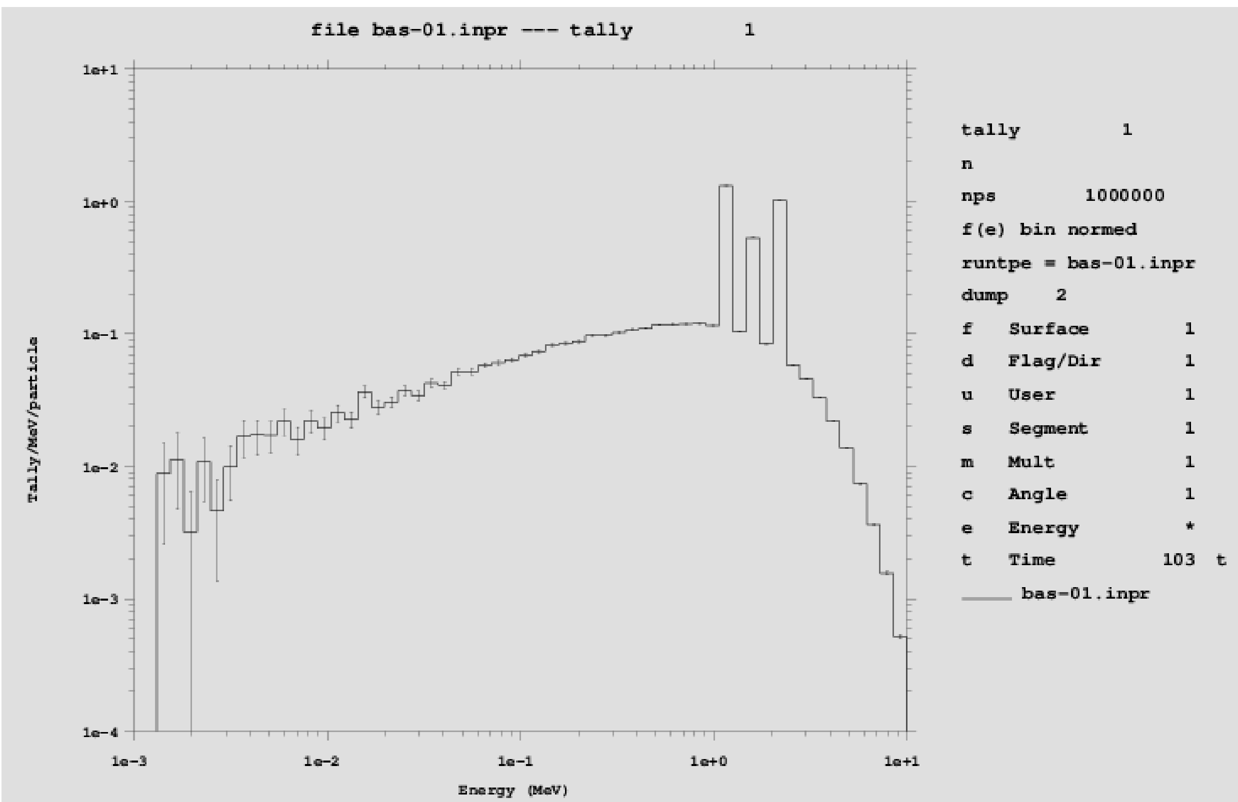
Example of a uniformly sampled spherical distribution with independent energy and time distributions.

Listing 2.35: MCNP6 Input File

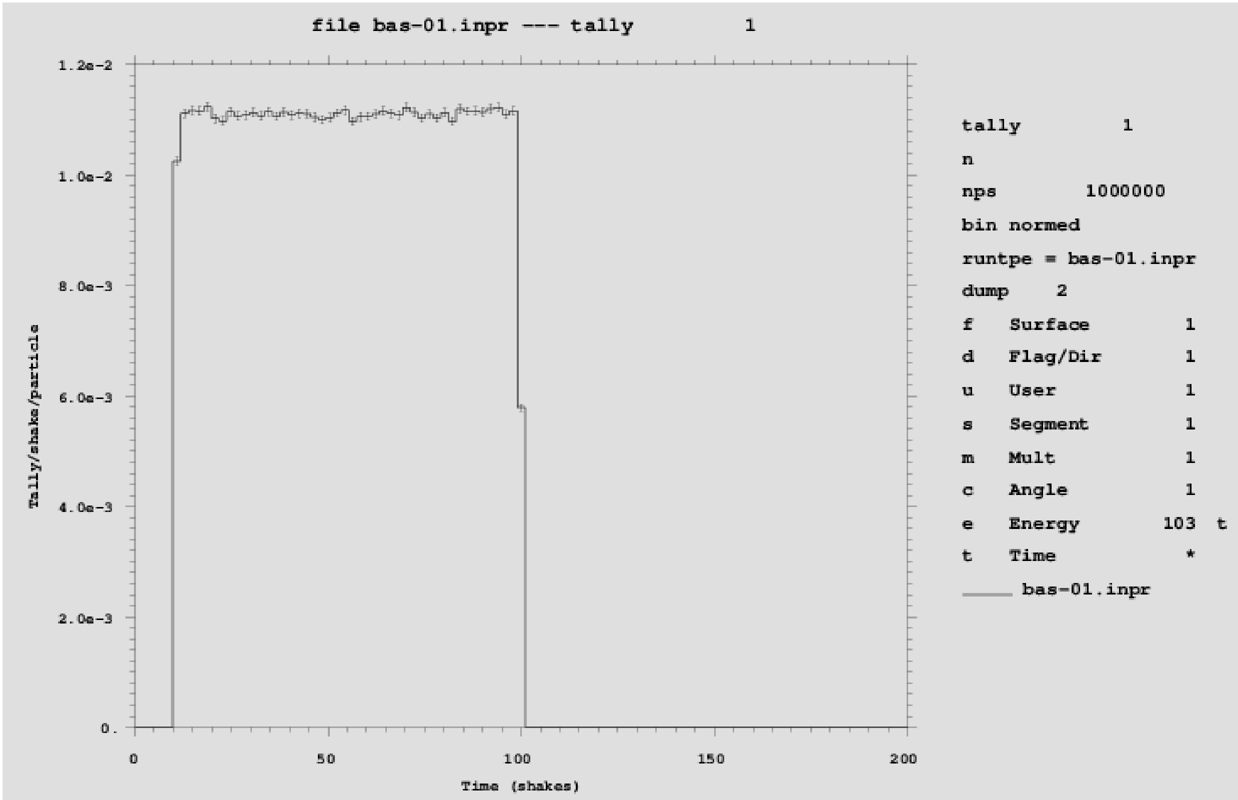
```
Basic Source in a Sphere
100    0    -1    IMP:N=1  $  inside sphere
999    0     1    IMP:N=0  $  outside world

1  SO  1

MODE N
NPS 1E6
PRDMP 2J -1
c
SDEF POS=0 0 0 RAD=D1 ERG=D2 TME=D3
c
```

```
SI1   0 1            $ RAD distribution
SP1 -21 2
c
SI2  S 21  22        $ ERG distribution
SP2     1   2
SP21 -3              $ Watt spectrum
SI22 L  1.1 1.5 2.2  $ Discrete lines
SP22     2   1   3
c
SI3  H  10  100       $ Pulse
SP3    0   1
c
F1:N  1               $ ERG and TME tallies
E1  1E-6 100ilog 10
T1  0 100i 200
c
FMESH4:N  GEOM=XYZ    $ Geometry tally
          ORIGIN=-1 -1 -1
          IMESH=1  IINTS=50
          JMESH=1  JINTS=50
          KMESH=1  KINTS=50
          TYPE=SOURCE
          OUT=NONE
```

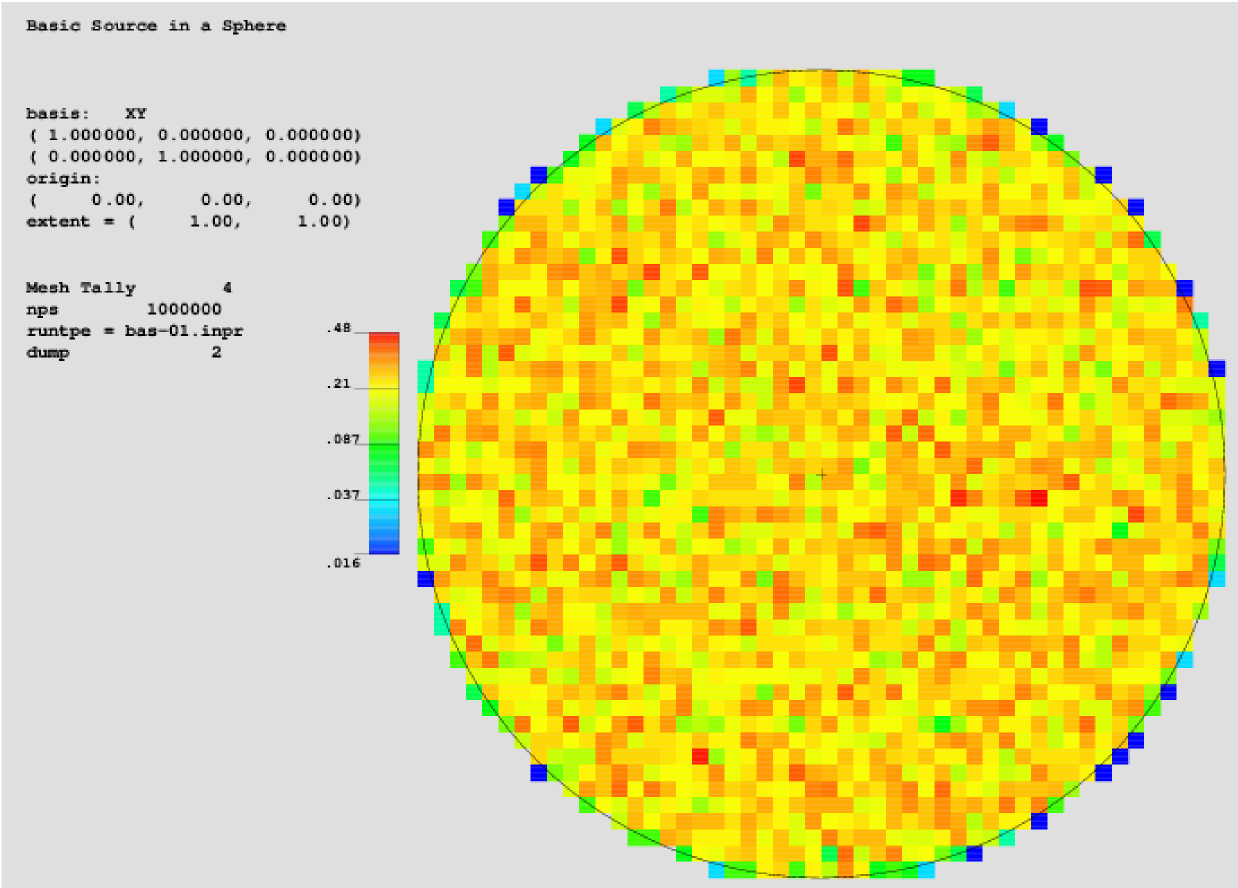
The energy distribution can be seen below where a continuous Watt spectrum defined by distribution 21 and the three discrete lines are defined in distribution 22. The selection of these two independent energy distributions is defined in distribution 2.



The time distribution can be seen below where the uniform PDF is defined in distribution 3.



The position distribution can be seen below with a uniform PDF in the spherical volume is defined in distribution 1.



Listing 2.36: MCNP6 Plotting Commands

```
tal 1 loglog free e xlims 1e-3 10
tal 1 linlin free t xlims 0 200
fmesh 4
file
end
end
```

2.4.2 Multiple Spatial Variable Distributions

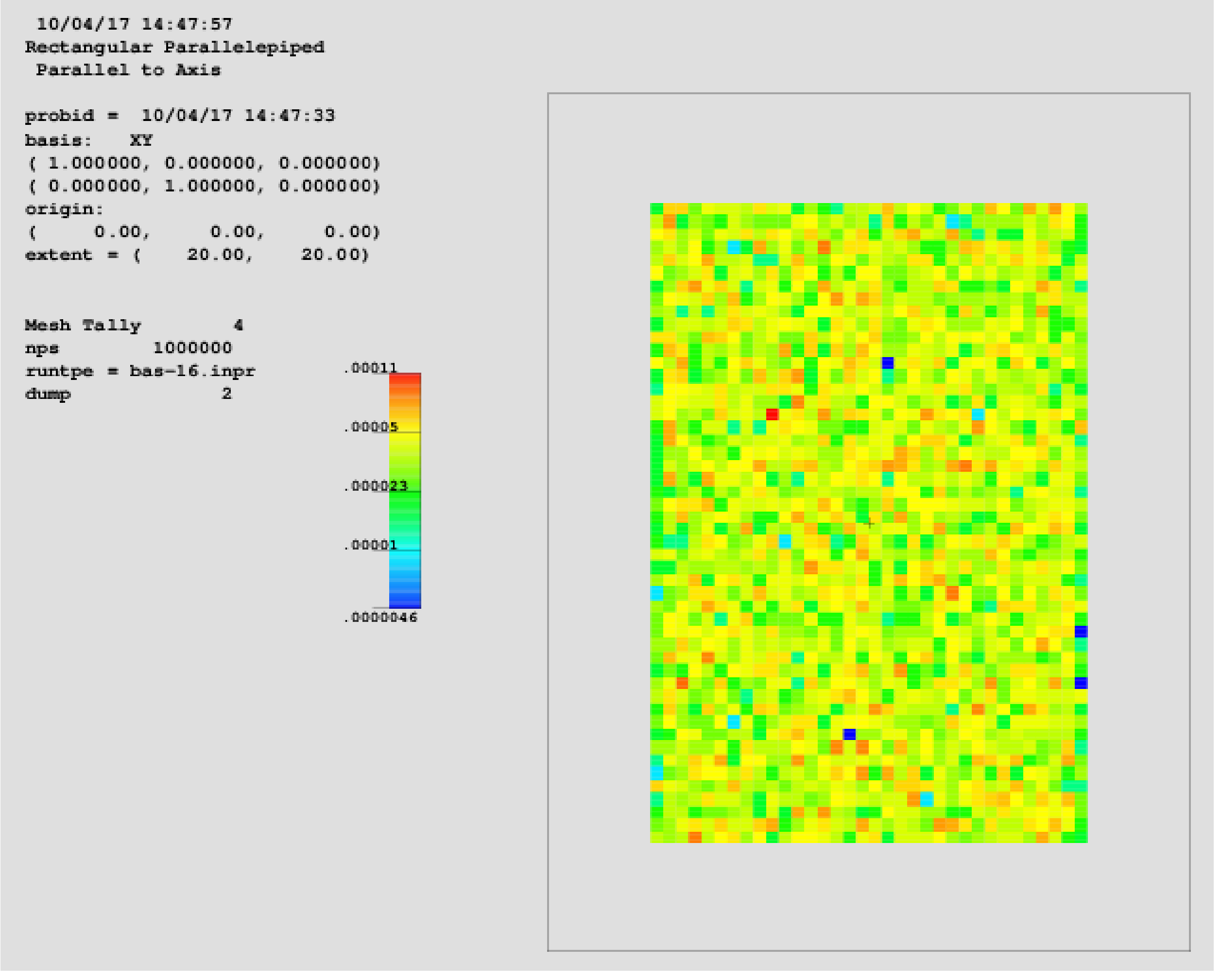
Example of a uniformly distributed monoenergetic source inside a rectangular parallelpiped taken from "An MCNP Primer" by Shultis and Faw, page 12 (see *Helpful Links*).

Listing 2.37: MCNP6 Input File

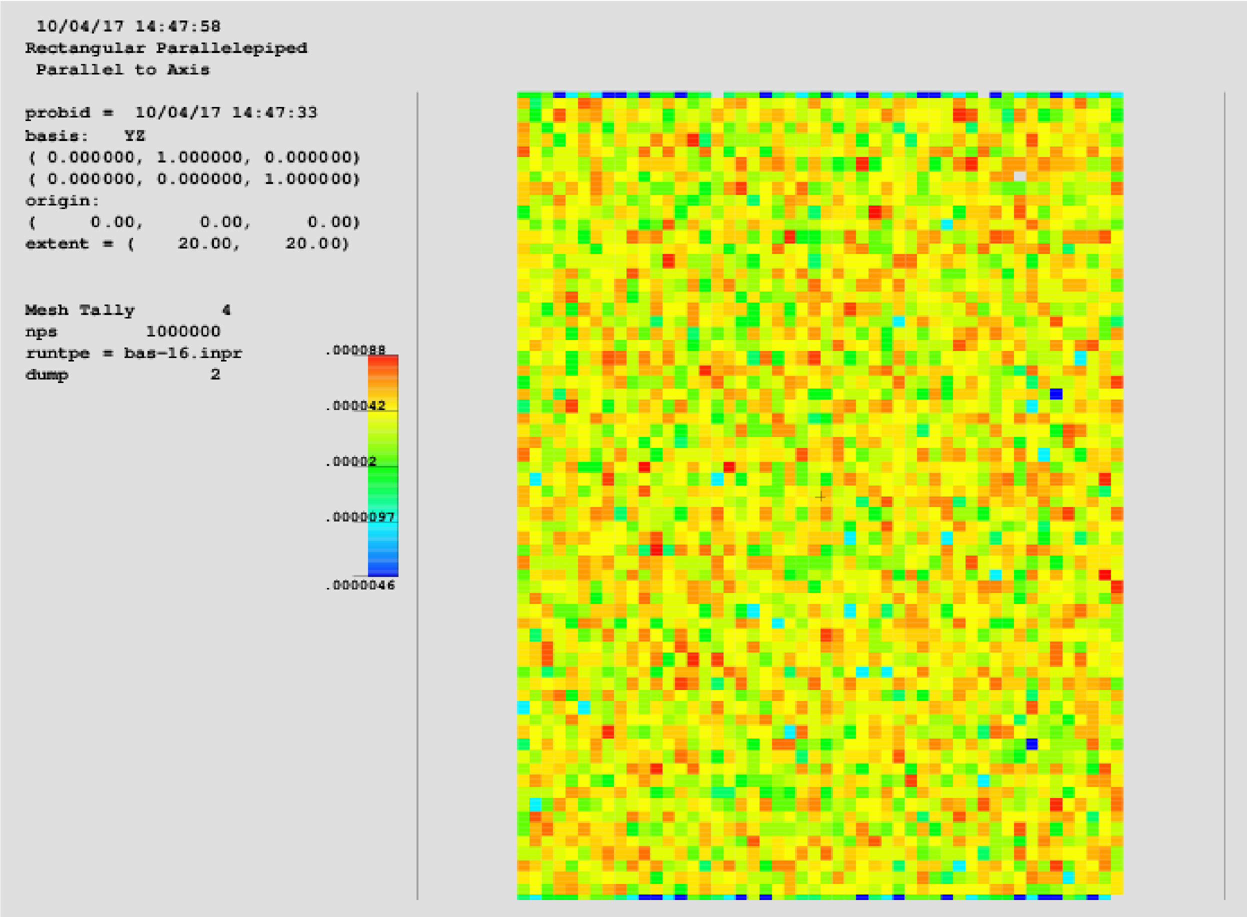
```
Rectangular Parallelepiped Parallel to Axis
c
10  0      -1  IMP:P=1                 $ Inside parallelpiped
99  0      +1  IMP:P=0                 $ Outside parallelpiped

1  RPP   -15 15   -20 20   -30 30

MODE P
NPS 1e6
```

```
c
SDEF   X=D1 Y=D2 Z=D3  ERG=1.25 PAR=2
SI1   -10  10                         $ X-range limits for source volume
SP1    0    1                         $ Umiform probability over x-range
SI2   -15  15                         $ Y-range limits for source volume
SP2    0    1                         $ Uniform probability over y-range
SI3   -20  20                         $ Z-range limits for source volume
SP3    0    1                         $ Uniform probability over z-range
c
FMESH4:P  GEOM= xyz    ORIGIN= -30.0 -30.0 -30.0
          IMESH= 30.0   IINTS= 100
          JMESH= 30.0   JINTS= 100
          KMESH= 30.0   KINTS= 100
          TYPE=SOURCE
```

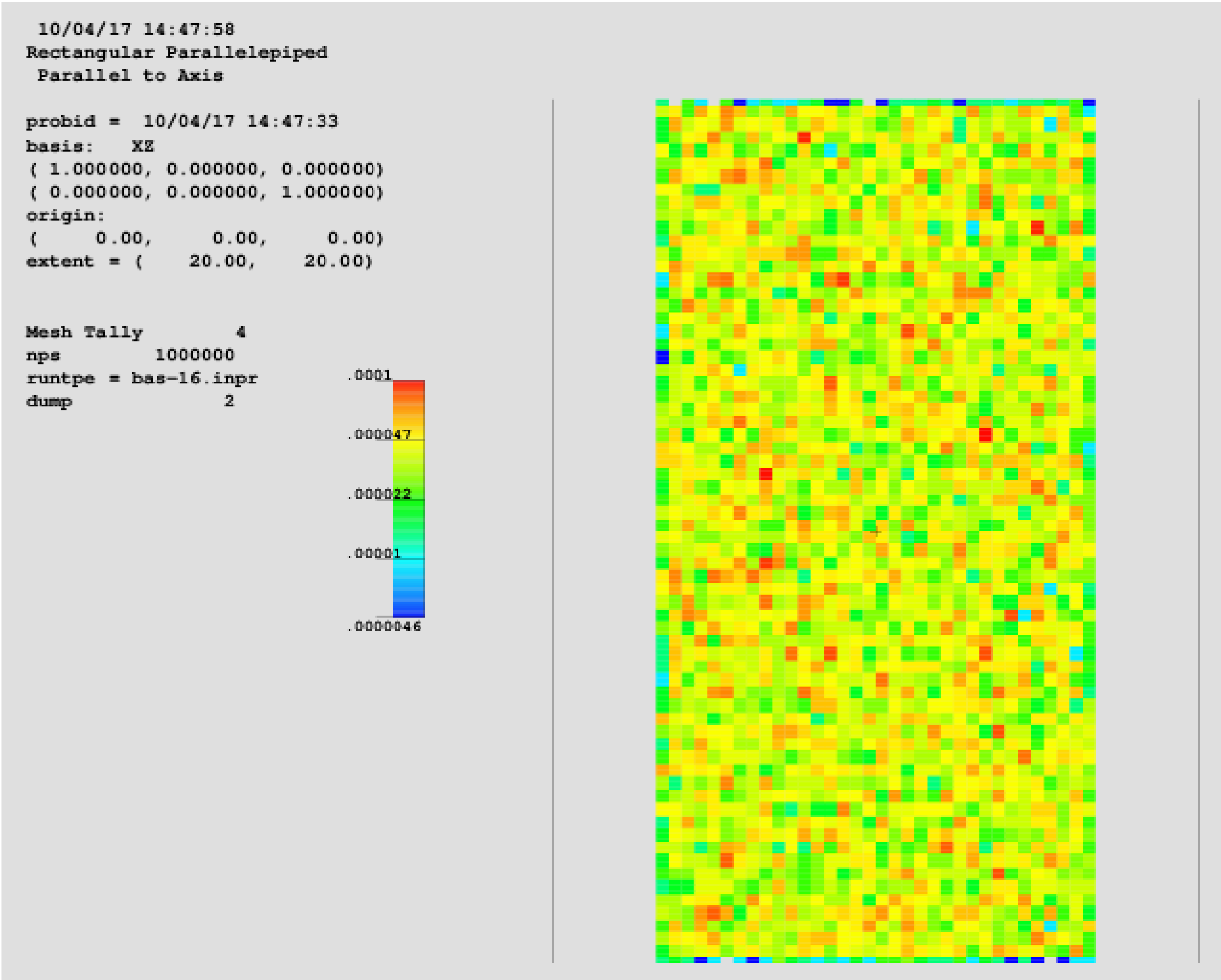
Below is the source seen on the XY plane.



Below is the source seen on the YZ plane.



Below is the source seen on the XZ plane.



Listing 2.38: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 1 0 ex 20
basis 0 1 0  0 0 1 ex 20
basis 1 0 0  0 0 1 ex 20
file
end
end
```

2.4.3 Single Cell Rejection

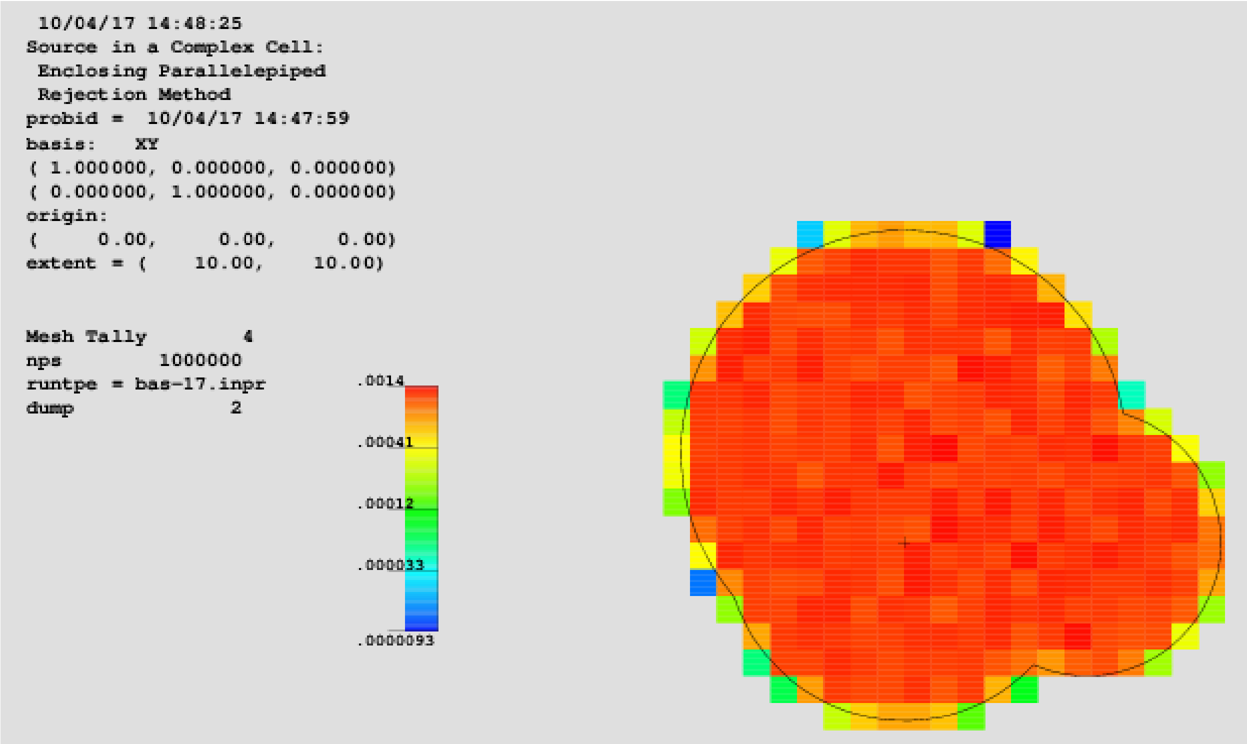
Example of the cell rejection method, where sampling is uniform within a parallelepliped and rejected if not within the desired cell. This example is taken from "An MCNP Primer" by Shultis and Faw, page 12 (*Helpful Links*).

Listing 2.39: MCNP6 Input File

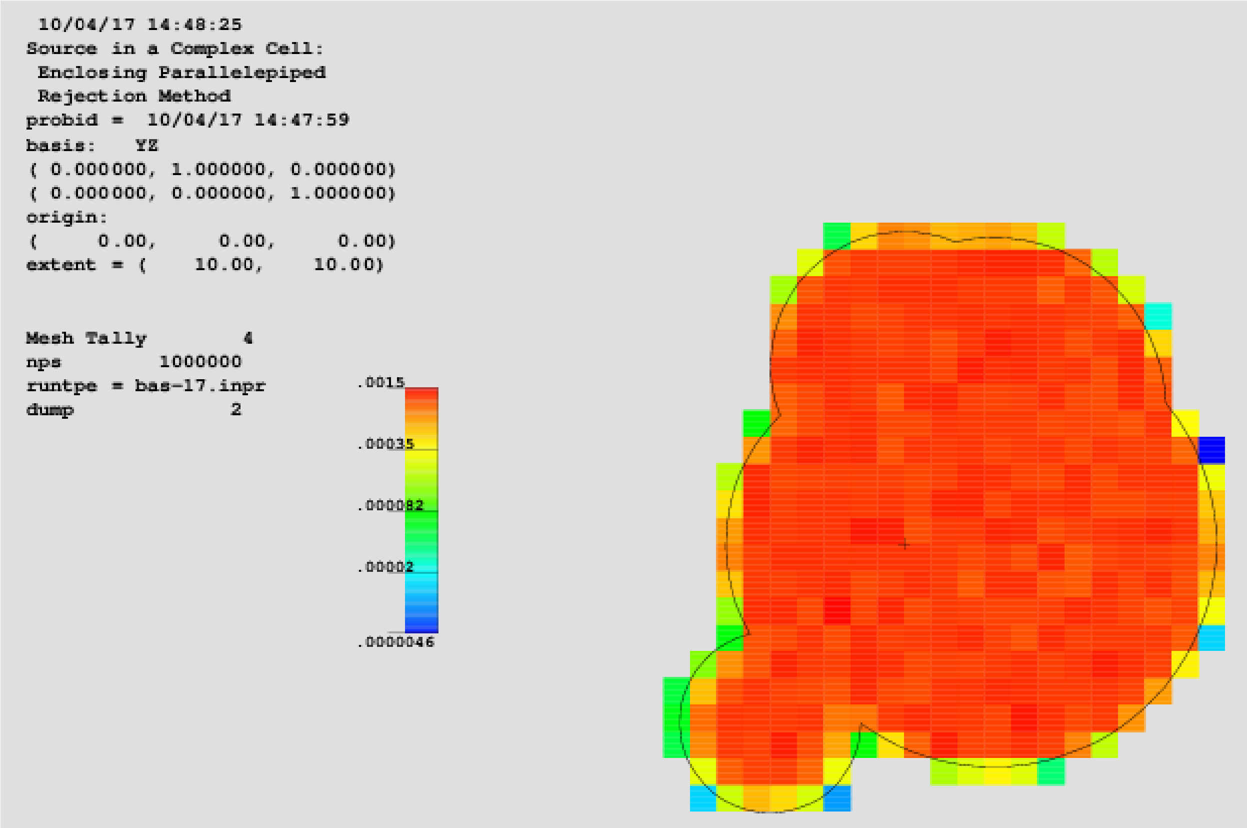
```
Source in a Complex Cell: Enclosing Parallelepiped Rejection Method
c
8   0      -1:-2:-3:-4:-5:-6   IMP:P=1             $ Inside complex cell
99  0      #8                  IMP:P=0             $ Outside complex cell
```

```
1 SO 4
2 SX 4.1 3
3 SZ 4 3
4 SY 2 5
5 S  1 2 3 4
6 S -2 -3 -4 2.85

MODE P
NPS 1e6
c
c Cell 8 is a complex source in which monoenergetic isotropic volumetric
c source exists. A rectangular parallelepiped envelops this cell (MCNP does
c NOT Check this!). Points, randomly picke din the rectangular parallelepiped
c are accepted as source points only if they are inside cell 8.
c
SDEF  X=D1 Y=D2 Z=D3  ERG=1.25 PAR=2 CEL=8
c
c NOTE: source parallelepipied is larger than cell 8, and hence source
c       positions sampled outside cell 8 are rejected
c
SI1  -12  12                            $ X-range limits for source volume
SP1   0    1                            $ Umiform probability over x-range
SI2  -11  11                            $ Y-range limits for source volume
SP2   0    1                            $ Uniform probability over y-range
SI3  -13  13                            $ Z-range limits for source volume
SP3   0    1                            $ Uniform probability over z-range
c
FMESH4:P  GEOM= xyz    ORIGIN= -30.0 -30.0 -30.0
          IMESH= 30.0   IINTS= 100
          JMESH= 30.0   JINTS= 100
          KMESH= 30.0   KINTS= 100
          TYPE=SOURCE
```

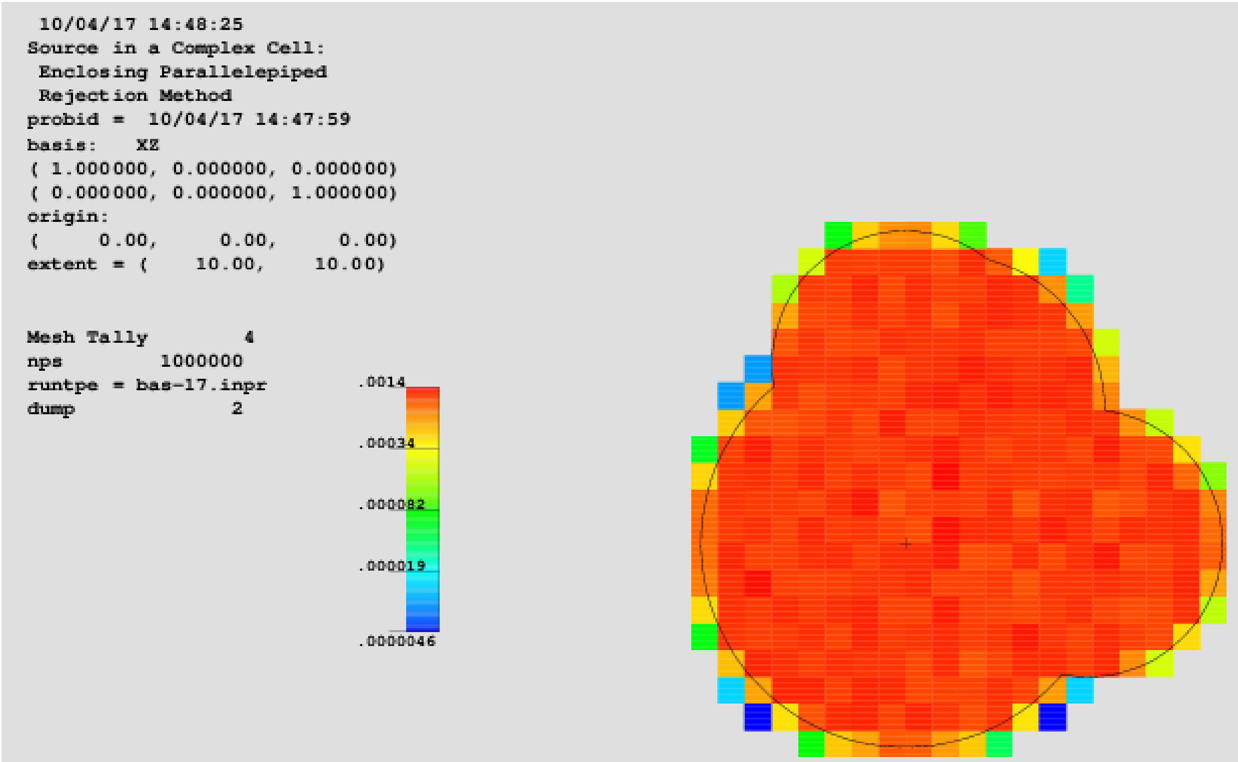
Due to rejection method the source is only seen in cell 8 as in the mesh plot below on the XY plane.



Mesh plot now viewed from the YZ plane.



Mesh plot now viewed from the XZ plane.



Listing 2.40: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 1 0  ex 10
basis 0 1 0  0 0 1  ex 10
basis 1 0 0  0 0 1  ex 10
file
end
end
```

2.4.4 Multiple Cell Rejection

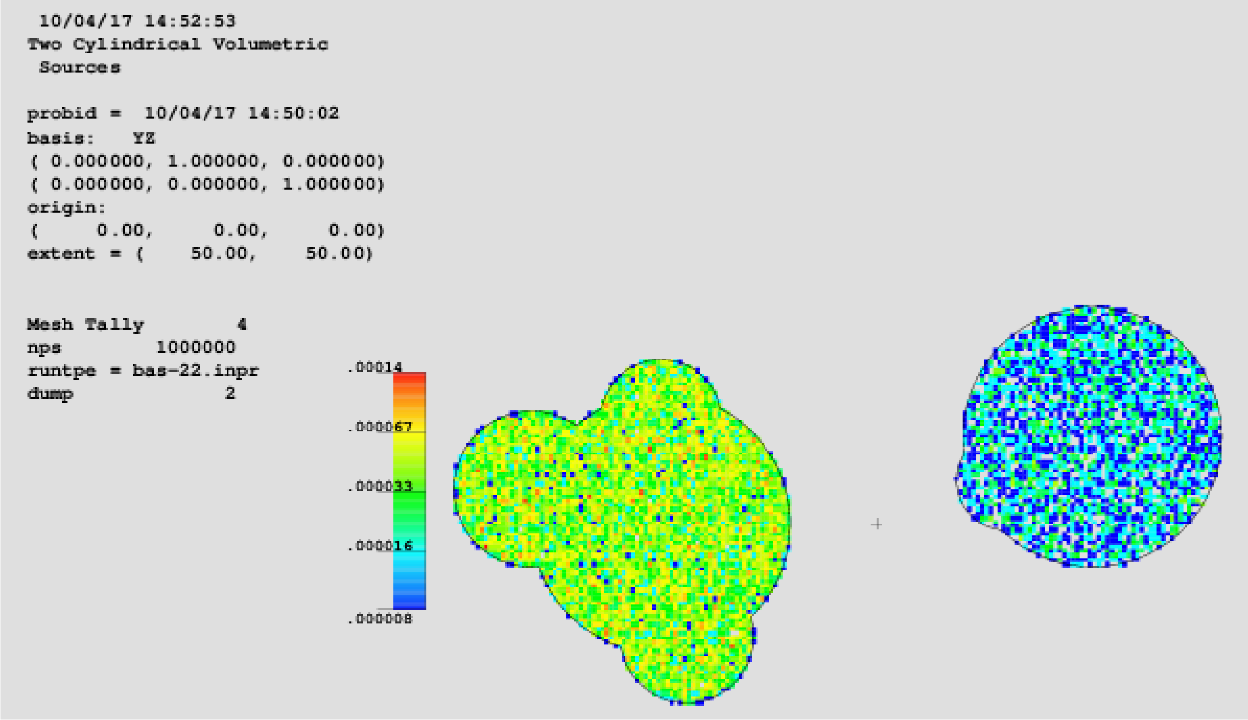
Example of uniformly sampling in a cylindrical volume and rejecting the sample if not in one of the two cells specified. This allows the source strength to vary by cell location (strength). This example was taken from "An MCNP Primer" by Shultis and Faw, page 14 (see *Helpful Links*).

Listing 2.41: MCNP6 Input File

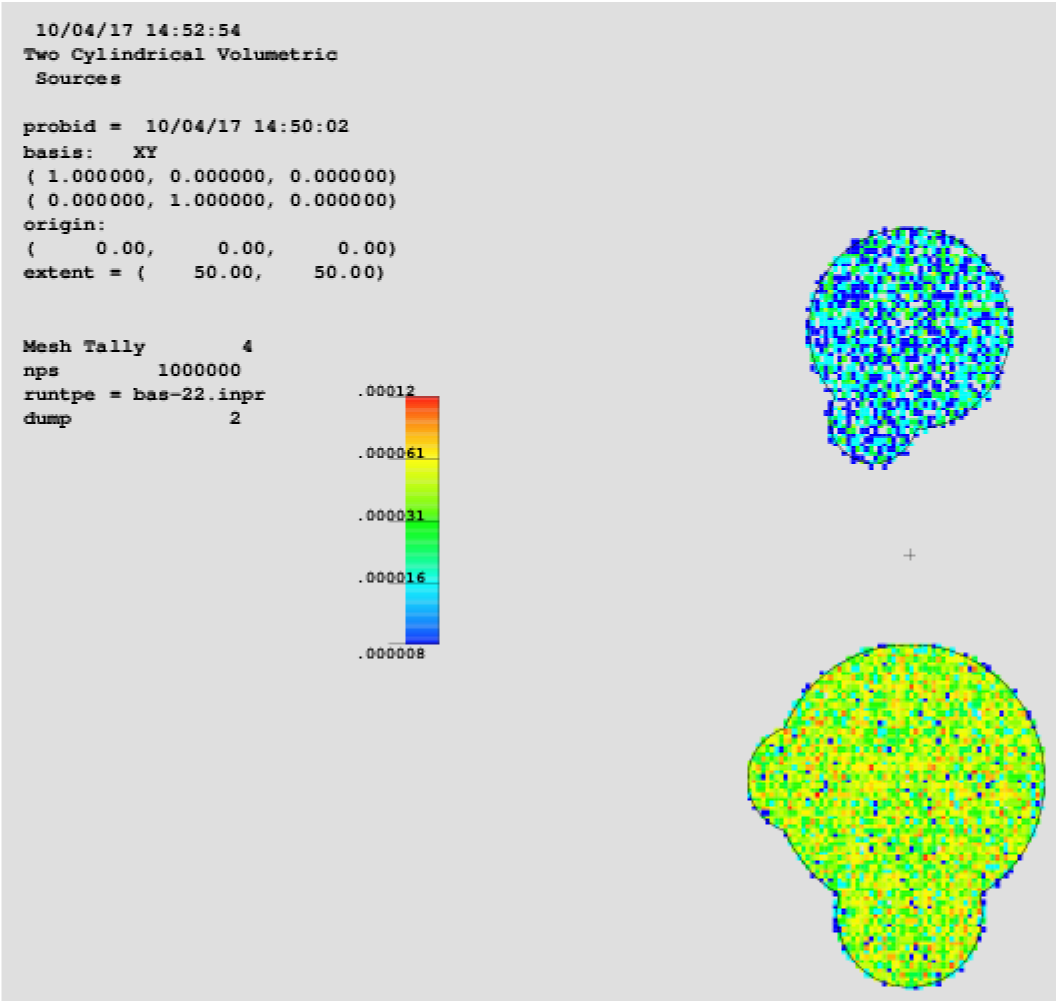
```
Two Cylindrical Volumetric Sources
8       0     -10:-20:-30:-40:-50        IMP:N=1
9       0     -60:-70:-80                IMP:N=1
999     0      #8 #9                     IMP:N=0

10 SY  -25    15
20 S     0   -25  12  7
30 S   -12   -25   0  6
40 S    -2   -22 -13  8
50 S     0   -40   4  9
60 S     0    25  10 15
70 S    -4    15   5  7
```

```
80 S      6   25  20  8

MODE N
NPS 1E6
c
c --- 2 volumetric sources uniformly distributed in cells 8 & 9 both sources
c emit-1.25 Mev photons. Surrounded both source cells by large sampling
c cylinder defined by the POS RAD and EXT parameters. The rejection
c technique is used to pick source points points with cells 8 & 9  with the
c specified frequency.
c
SDEF ERG=1.25 CEL d1 AXS=0 0 1 POS 0 0 0 RAD d2 EXT d5
c
SI1  L    8     9           $ Source cells: src 1=cell 8, src 2=cell9
SP1     0.8   0.2           $ 80% from src 1; 20% from src2=cell 9
c
SI2       0    50           $ Radius of cyl. containing cells 8 & 9
c
SI5      -30   30           $ Axial range of cyl. containing src cells
c
FMESH4:N  GEOM= xyz    ORIGIN= -50.0 -50.0 -50.0
          IMESH= 50.0   IINTS= 200
          JMESH= 50.0   JINTS= 200
          KMESH= 50.0   KINTS= 200
          TYPE=SOURCE
```

Below is cell 9 and 8 sources on the XZ plane.



Below is cell 9 and 8 sources on the XY plane.



Listing 2.42: MCNP6 Plotting Commands

```
fmesh 4
bas 0 1 0 0 0 1
bas 1 0 0 0 1 0
file
end
end
```

CHAPTER

THREE

INTERMEDIATE SOURCES

Sources with dependant variables, embedded distributions and cookie cutter cells.

3.1 *Dependent Variables*

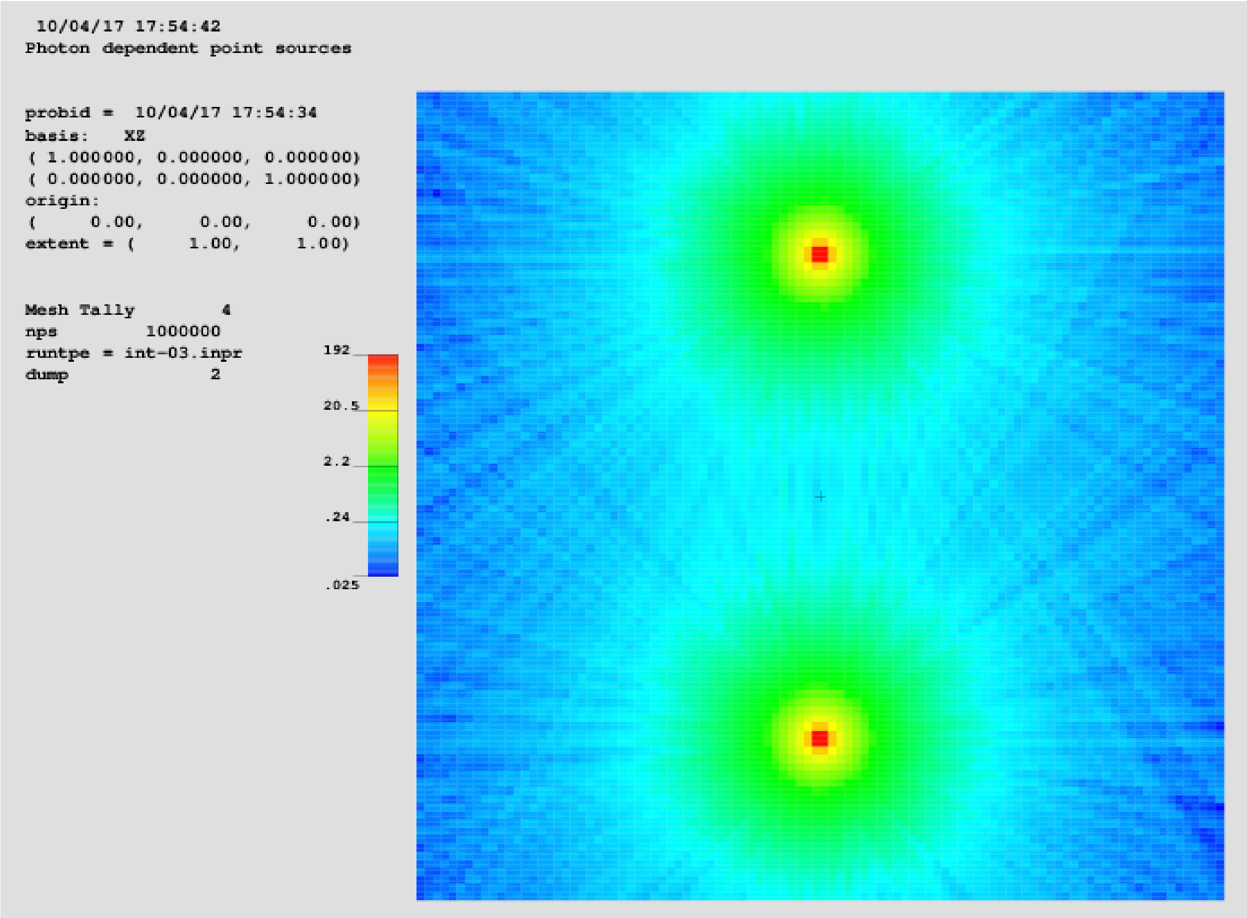
3.1.1 Energy Dependent on Position

This example shows how the energy depends on the sampled position.

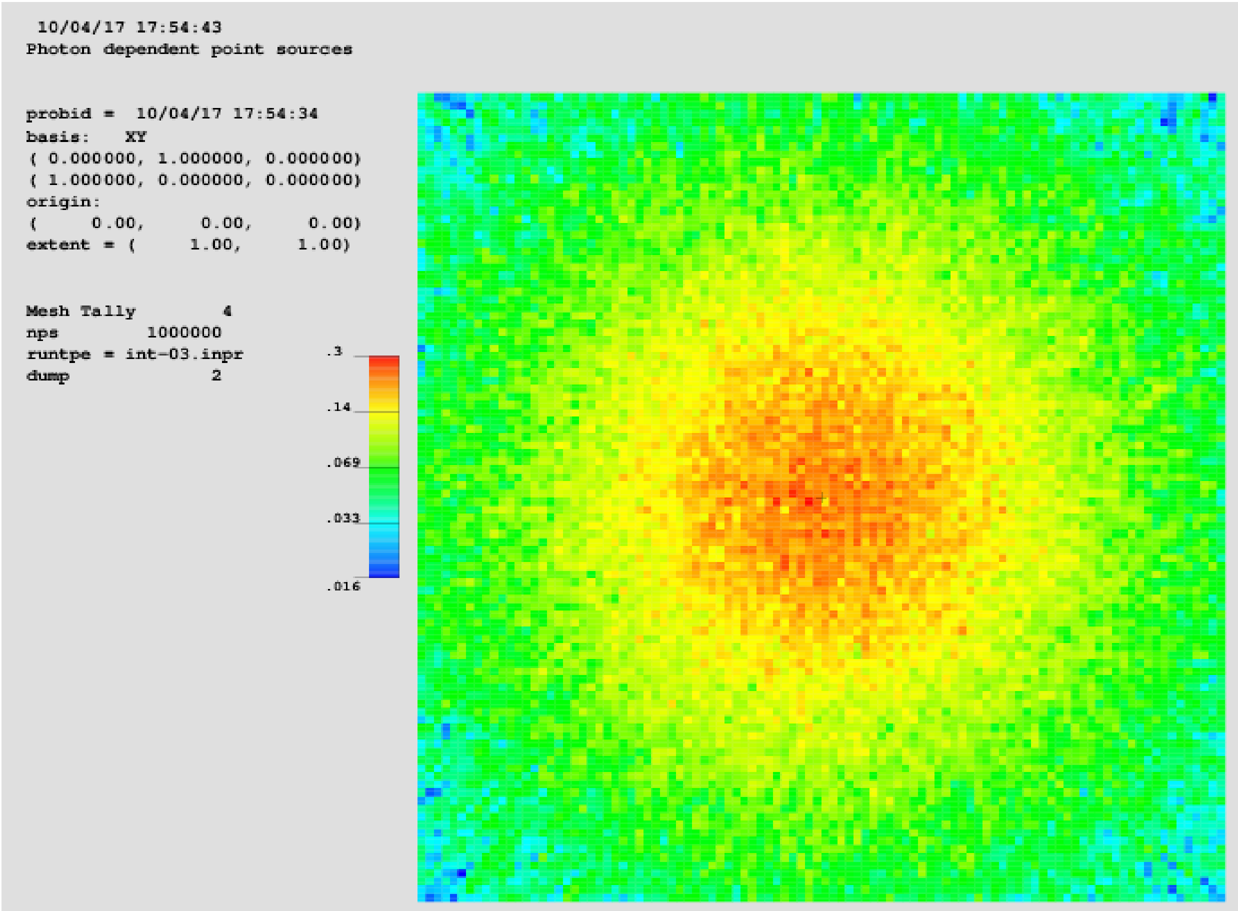
Listing 3.1: MCNP6 Input File

```
Photon dependent point sources
c
10  0      -1  IMP:P=1     $ Inside sphere
99  0      +1  IMP:P=0     $ Outside world

1  SO   2.0

MODE P
NPS  1e6
c
SDEF  POS=D10  ERG=FPOS=D20
c
SI10  L  0 0 -0.6   0 0 +0.6      $ Discrete values
SP10       1           1          $ Probabilities for values
DS20  L  0.14       1.88          $ Discrete values
c
FMESH4:P  GEOM= xyz    ORIGIN= -1.0 -1.0 -1.0
          IMESH= 1.0   IINTS= 100
          JMESH= 1.0   JINTS= 100
          KMESH= 1.0   KINTS= 100
          OUT=NONE
print
```

Below is an S-38 1.88 MeV gamma-ray point source and a Tc-99m 0.14 MeV gamma-ray point source shown on the XZ plane.



One of the point sources alone on the XY plane is seen below. Note that the output file contains the first 50 source particles in print table 110, where the energy and position sampling can be verified.



Listing 3.2: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 0 1
basis 0 1 0  1 0 0
file
end
end
```

3.1.2 Position Dependent on Energy

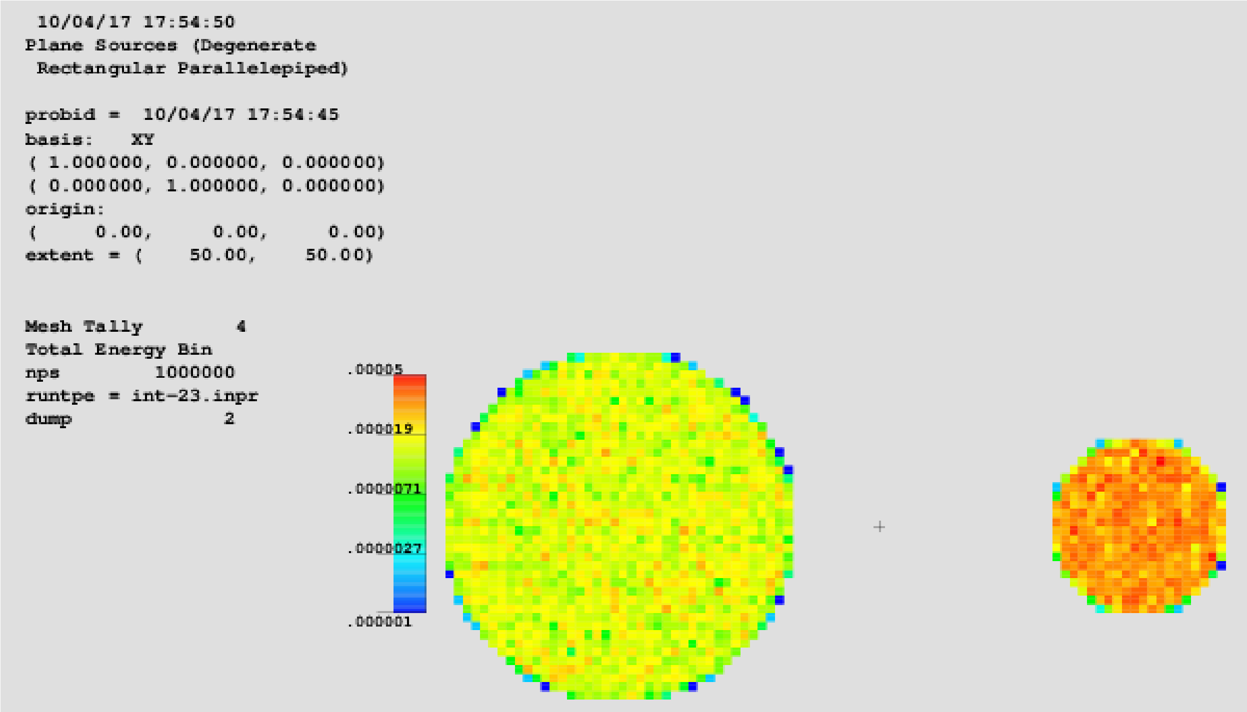
Example of two cylindrical sources containing different sources. In this example, the position, radius and extent are all functions of the selected photon energy, taken from "An MCNP Primer" by Shultis and Faw, page 14 (see *Helpful Links*).

Listing 3.3: MCNP6 Input File

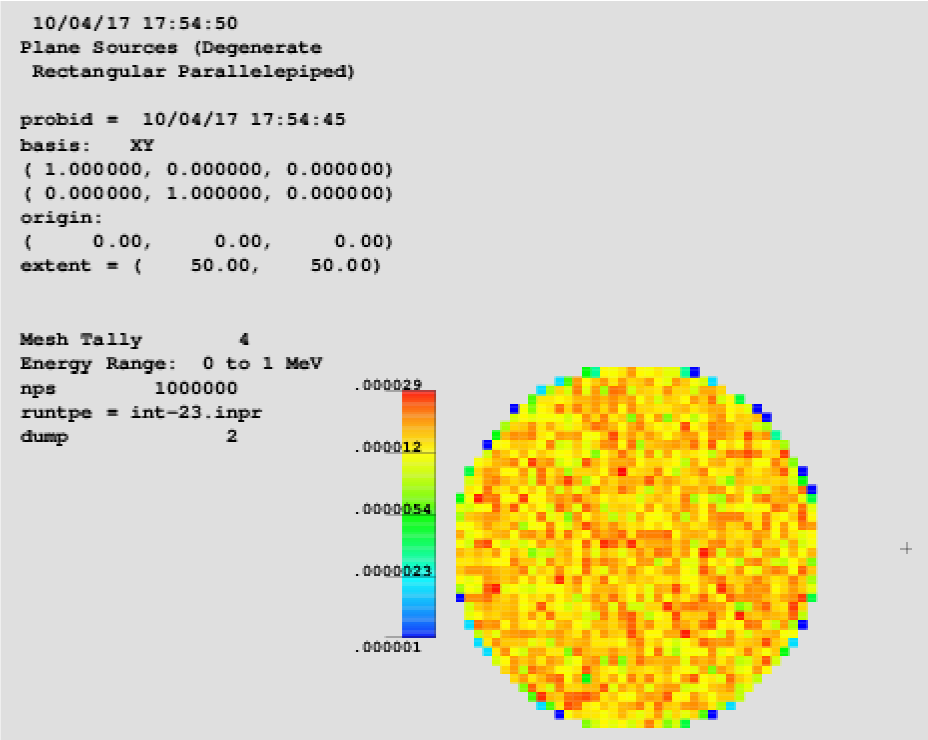
```
Plane Sources (Degenerate Rectangular Parallelepiped)
c
10  0      -1  IMP:P=1                  $ Inside parallelpiped
99  0      +1  IMP:P=0                  $ Outside parallelpiped

1  RPP   -60 60   -60 60  -60 60

MODE P
```

```
NPS 1e6
c
c --- Two spatially different cylindrical monoenergetic sources. The size
c and position of each cyl. source depends on the source energy (FERG).
c
SDEF  ERG=D1  POS=FERG D8  AXS=0 0 1  RAD=FERG D2  EXT=FERG D5
c
c -- Set source energies: 0.667 MeV for region 1 and 1.25 MeV for region 2
c
SI1  L  0.667   1.25         $ Fix energies
SP1       0.4    0.6         $ 20% from src 1(Cs-137); 80% from src 2 (Cs-60)
c
DS8  S      9  10            $ Get position for chosen source
SI9  L    -30  0  0          $ Center for sampling of src1
SP9         1                $ Prob. distn for src 2 center
SI10 L     30  0  0          $ Center for sampling of src2
SP10        1                $ Prob. distn for src 2 center
C -- Set radius and axial limits for each source
DS2  S      3  4             $ Sampling distn from each src axis
SI3         0 20             $ Radial sampling limits for src1
SP3       -21  1             $ Radial sampling weight for src1 r^1
SI4         0 10             $ Radial sampling limits for src2
SP4       -21  1             $ Radial sampling weight for src2 r^1
DS5  S      6  7             $ Axial sampling distns for each src
SI6       -10 10             $ Axial sampling limits for src1
SP6       -21  0             $ Axial sampling weight for src1 r^0
SI7       -30 30             $ Axial sampling limits for src2
SP7       -21  0             $ Axial sampling weight for src2 r^0
c
FMESH4:P  GEOM= xyz    ORIGIN= -50.0 -50.0 -50.0
          IMESH= 50.0   IINTS= 100
          JMESH= 50.0   JINTS= 100
          KMESH= 50.0   KINTS= 100
          EMESH= 1 2
          TYPE=SOURCE
          OUT=NONE
```

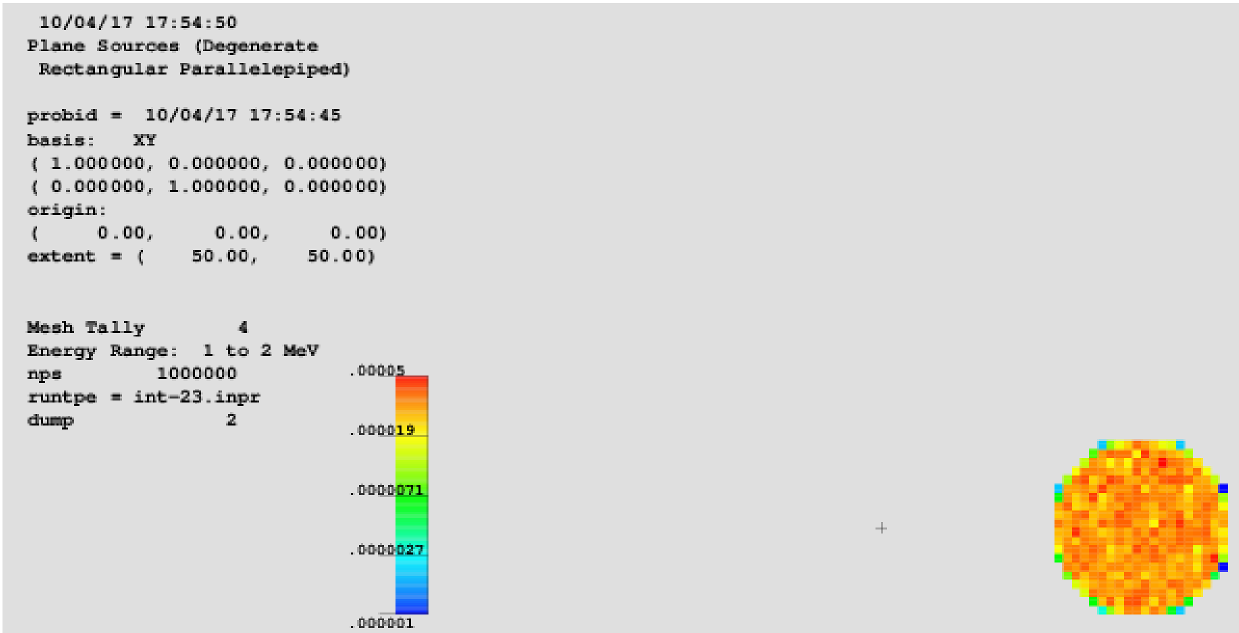
Below are the two monoenergetic sources.



Below is the 0.667 MeV Cs-137 source on the left.



Below is the 1.25 MeV Co-60 source on the right.



Listing 3.4: MCNP6 Plotting Commands

```
fmesh 4
bas 1 0 0 0 1 0
ebin 1
ebin 2
file
end
end
```

3.1.3 Position and Energy Dependent on Cell

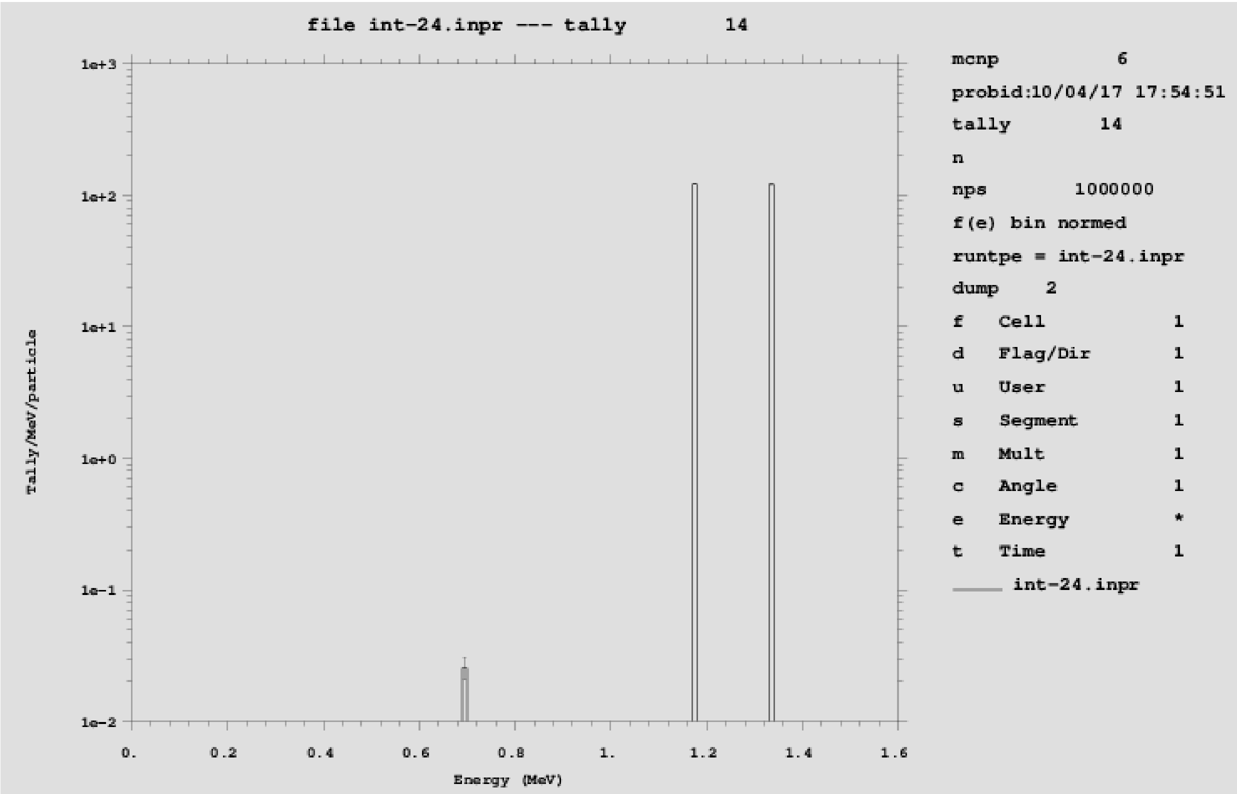
Example of the cell rejection method where the position, radius and extent position sampling as well as the energy is dependent on the sampled cell. This is an easy approach for two arbitrary volumetric sources with different energy photons. This example was taken from “An MCNP Primer” by Shultis and Faw, page 14 (see *Helpful Links*).

Listing 3.5: MCNP6 Input File

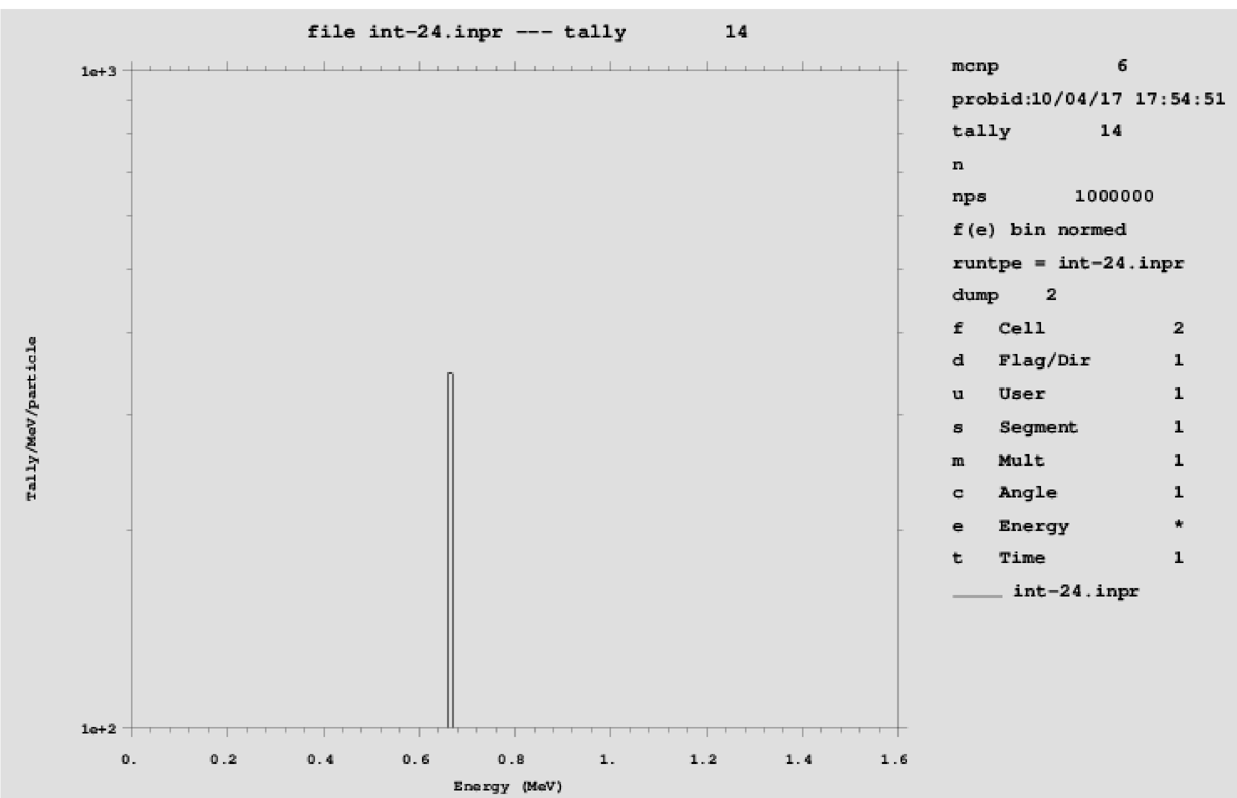
```
Two Arbitrary Volumetric Sources with different Energy Photons
8       0     -10:-30:-20:-40            IMP:N=1
9       0     -50:-60:-70:-80:-90:-100           IMP:N=1
999     0      #8  #9                    IMP:N=0

10   S   -32     0   -3   7
20   S   -34    -5    0   5
30   S   -25     3   -5   5
40   S   -32     0    4   6
50   SX   30     6
60   S    30     0    3    6
70   S    30     0   -3    6
80   S    34     0   -4    6
90   S    31     0   -8    4
100  S    31     0    8    4
```

```
MODE N
NPS 1E6
c
c --- 2 volumetric monoenergetic sources in comples-shaped cells 8 & 9
c Spatial sampling uses the rejection technique by placing a finite cylinder
c over each source cell. A random point inside a cylinder is accepted as a
c source point only if it is inside the source photon energies are functions
c of the source cells (FCEL).
c
SDEF   CEL=D1 AXS=0 0 1 POS=FCEL D2 RAD=FCEL D5 EXT=FCEL D8 ERG=FCEL D20
c
SI1  L    8     9       $ Choose which cell source refion to use for source
SP1     0.4   0.6       $ 40% from src 1; 60% from src2
c -- Set POS for each source
DS2  S    3    4        $ Based on the cell chosen, set distributions for POS
SI3  L   -30 0 0        $ Center for spatially sampling of src1
SP3       1             $ Prob. distn for src1 center
SI4  L    30 0 0        $ Center for spatially sampling of src2
SP4       1             $ Prob. distn for src2 center
c -- Set RAD for each source (must completely include cells 8 & 9
DS5  S    6    7        $ Distns for sampling axially for each src
SI6       0   20        $ Radial sampling limits for src1
SP6     -21    1        $ Radial sampling weight for src1
SI7       0   10        $ Radial sampling limits for src2
SP7     -21    1        $ Radial sampling weight for src2
c -- Set EXT for each source (must completely include cells 8 & 9)
DS8  S    9   10        $ Distns for sampling axially for each src
SI9     -10   10        $ Axial Sampling limits for src1
SP9     -21    0        $ Axial sampling weight for src1
SI10    -30   30        $ Axial sampling limits for src2
SP10    -21    0        $ Axial sampling weight for src2
c -- Set energies of photons for each source
DS20 S   21   22
SI21 L   0.6938 1.1732  1.3325  $ Co-60 spectra for src1
SP21 D   1.6312E-4 1       1    $ Frequencies of gammas
SI22 L   0.667                  $ Cs-137 spectrum for src2
SP22 D   1
c
F14:N  8 9 T
SD14   1 1 1
E14   0.5 99i 1.5
c
FMESH4:N  GEOM= xyz    ORIGIN= -75.0 -75.0 -75.0
          IMESH= 75.0   IINTS= 100
          JMESH= 75.0   JINTS= 100
          KMESH= 75.0   KINTS= 100
          TYPE=SOURCE
          OUT=NONE
```

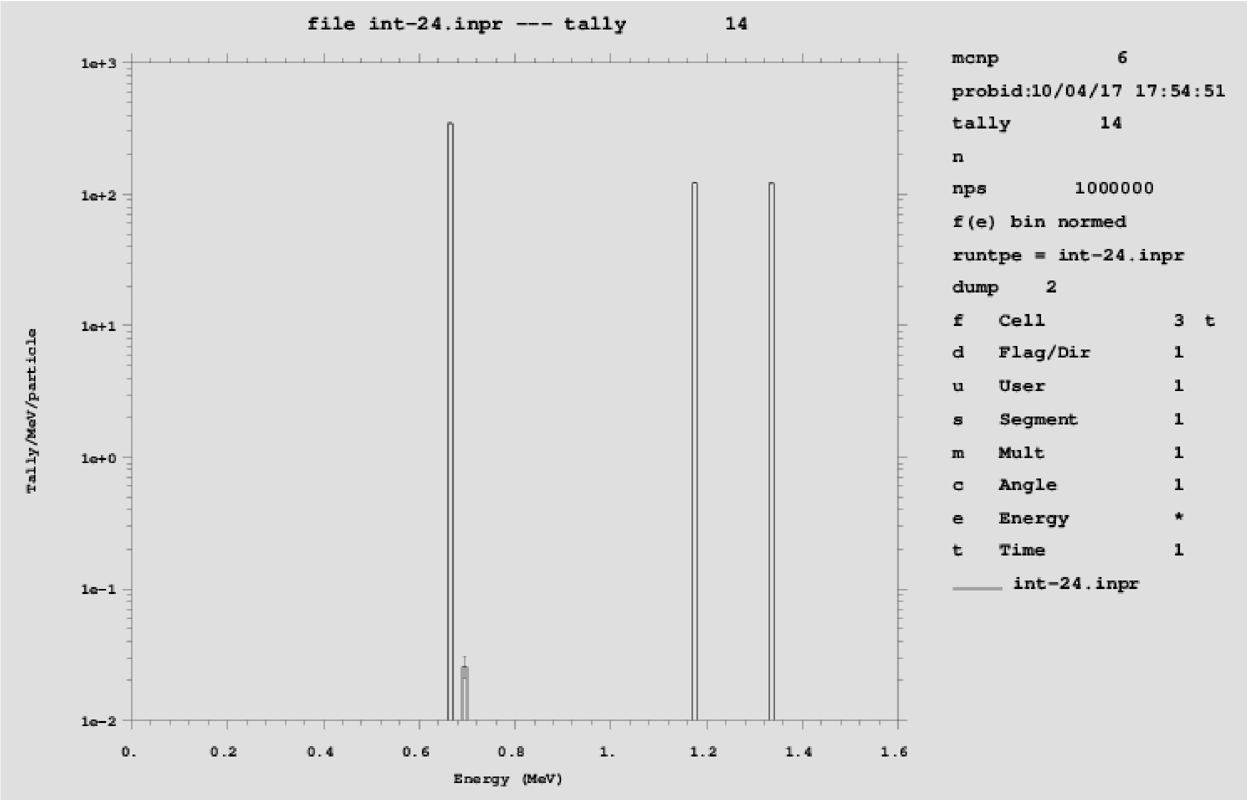
Below is the energy distribution in cell 8.



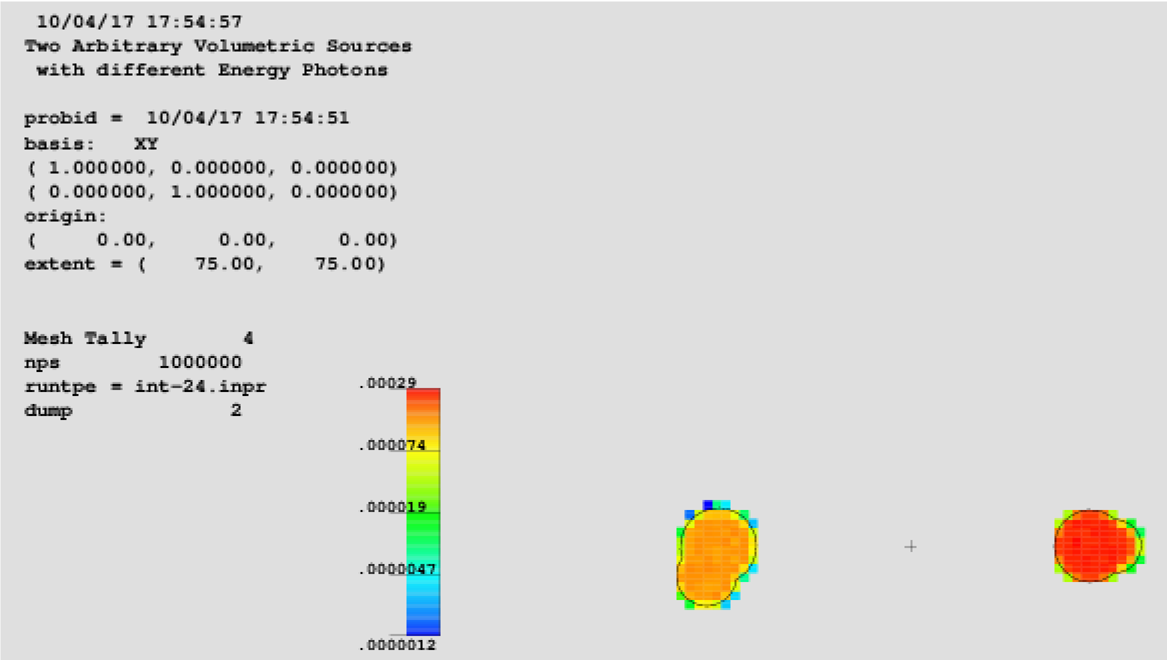
Below is the energy distribution in cell 9.



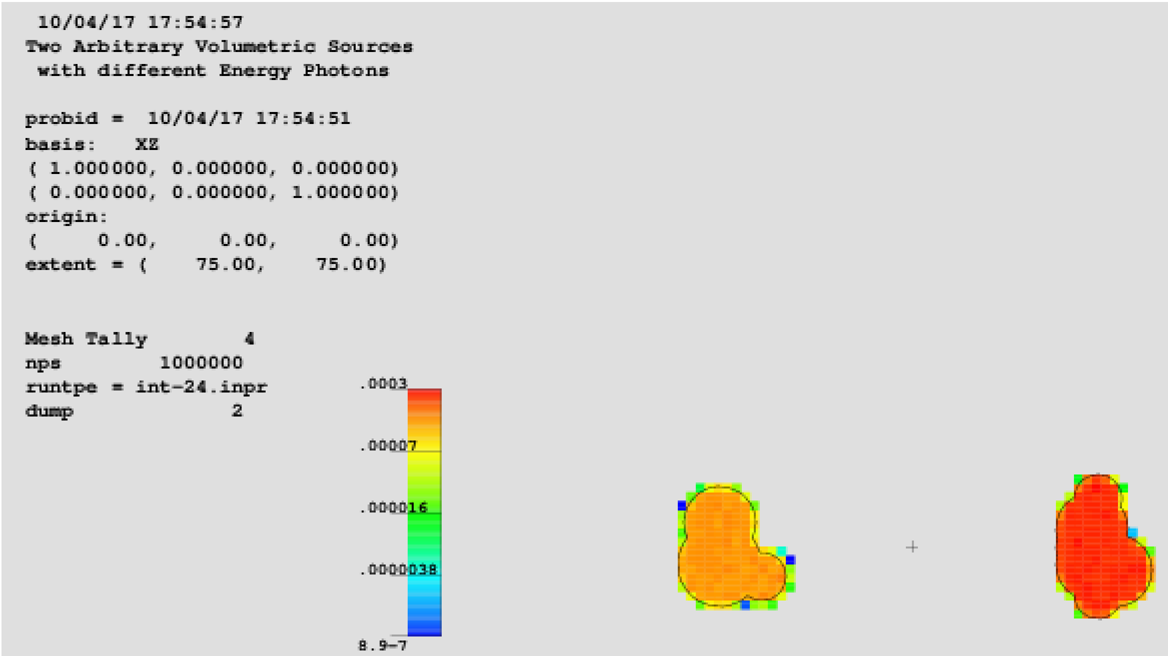
Below is the total energy distribution in cells 8 and 9.



Below is cell 8 and 9 sources on the XY plane.



Below is cell 8 and 9 sources on the XZ plane.



Listing 3.6: MCNP6 Plotting Commands

```
tal 14 fixed f 1
fixed f 2
fixed f 3
fmesh 4
bas 1 0 0 0 1 0
bas 1 0 0 0 0 1
file
end
end
```

3.1.4 Cell Dependent on Position

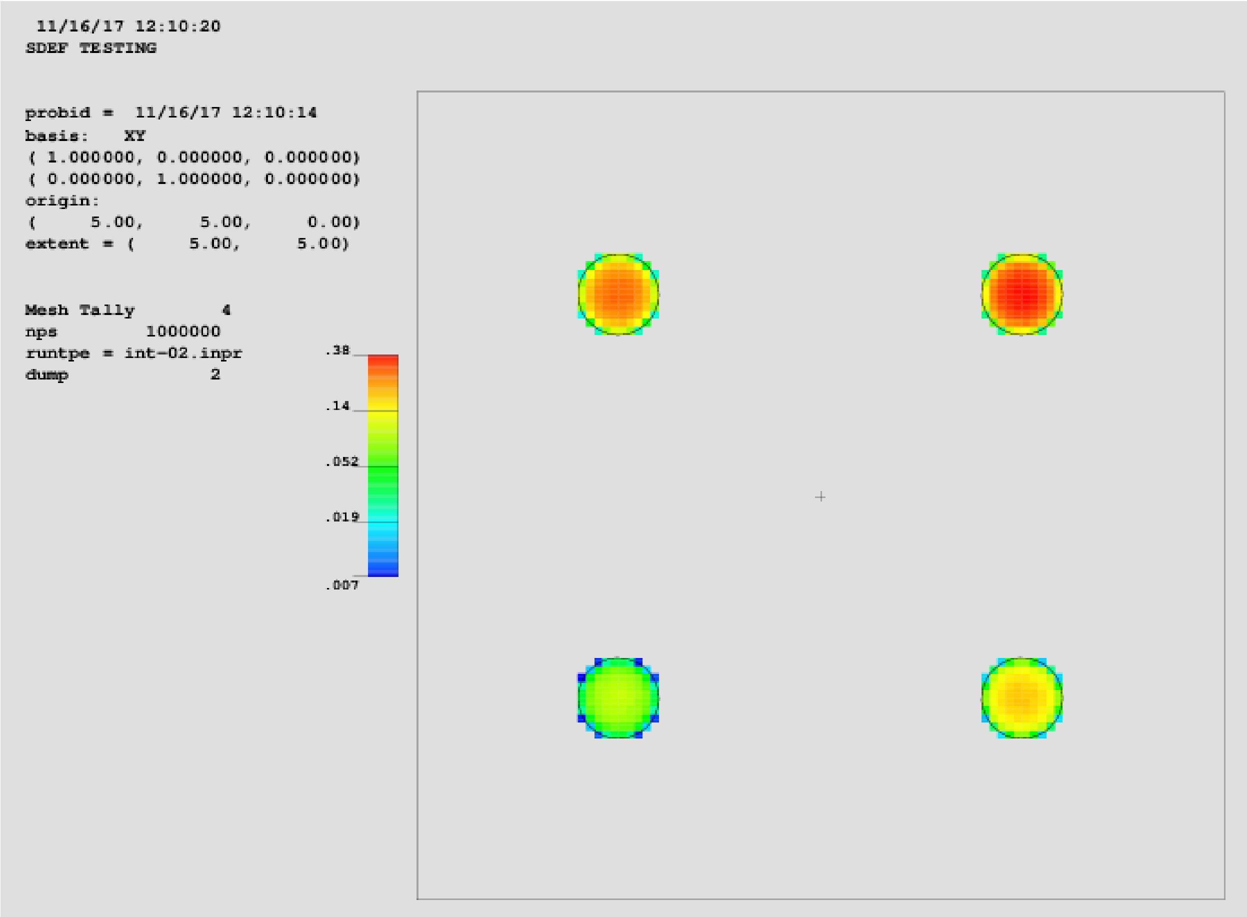
This example shows how the cell depends on the sampled position. According to the manual, this should likely not work, but appears to give the expected source distribution.

Listing 3.7: MCNP6 Input File

```
SDEF TESTING
10      1  1E-6  -1           IMP:N=1  $  inside sphere 1
20      1  1E-6  -2           IMP:N=1  $  inside sphere 2
30      1  1E-6  -3           IMP:N=1  $  inside sphere 3
40      1  1E-6  -4           IMP:N=1  $  inside sphere 4
50      2  1E-6  -5 1 2 3 4   IMP:N=1  $  inside box
99      0         5           IMP:N=0  $  outside

1  S   2.5 2.5 0 0.5
2  S   7.5 2.5 0 0.5
3  S   2.5 7.5 0 0.5
4  S   7.5 7.5 0 0.5
5  RPP 0 10 0 10 -1 1

MODE N
```

```
NPS 1e6
PRINT
c
M1    92235 1
M2    8016  1
      1001  2
c
FMESH4:N  GEOM=XYZ  ORIGIN=0 0 -1
          IMESH=10  IINTS=100
          JMESH=10  JINTS=100
          KMESH=1   KINTS=1
          TYPE=SOURCE
c
SDEF  POS=D1  CEL=FPOS=D2  RAD=D7
c
SI1 L 2.5 2.5 0      $ POS distribution
      7.5 2.5 0
      2.5 7.5 0
      7.5 7.5 0
SP1   1 2 3 4
c
DS2 S 3 4 5 6
c
SI3 L 10
SP3    1
c
SI4 L 20
SP4    1
c
SI5 L 30
SP5    1
c
SI6 L 40
SP6    1
c
SI7  0 0.5
SP7 -21 2
```

Below is the XY mesh plot of the four spherical sources.



Listing 3.8: MCNP6 Plotting Commands

```
fmesh 4
file
end
end
```

3.1.5 Spherical Radius Dependent on Position

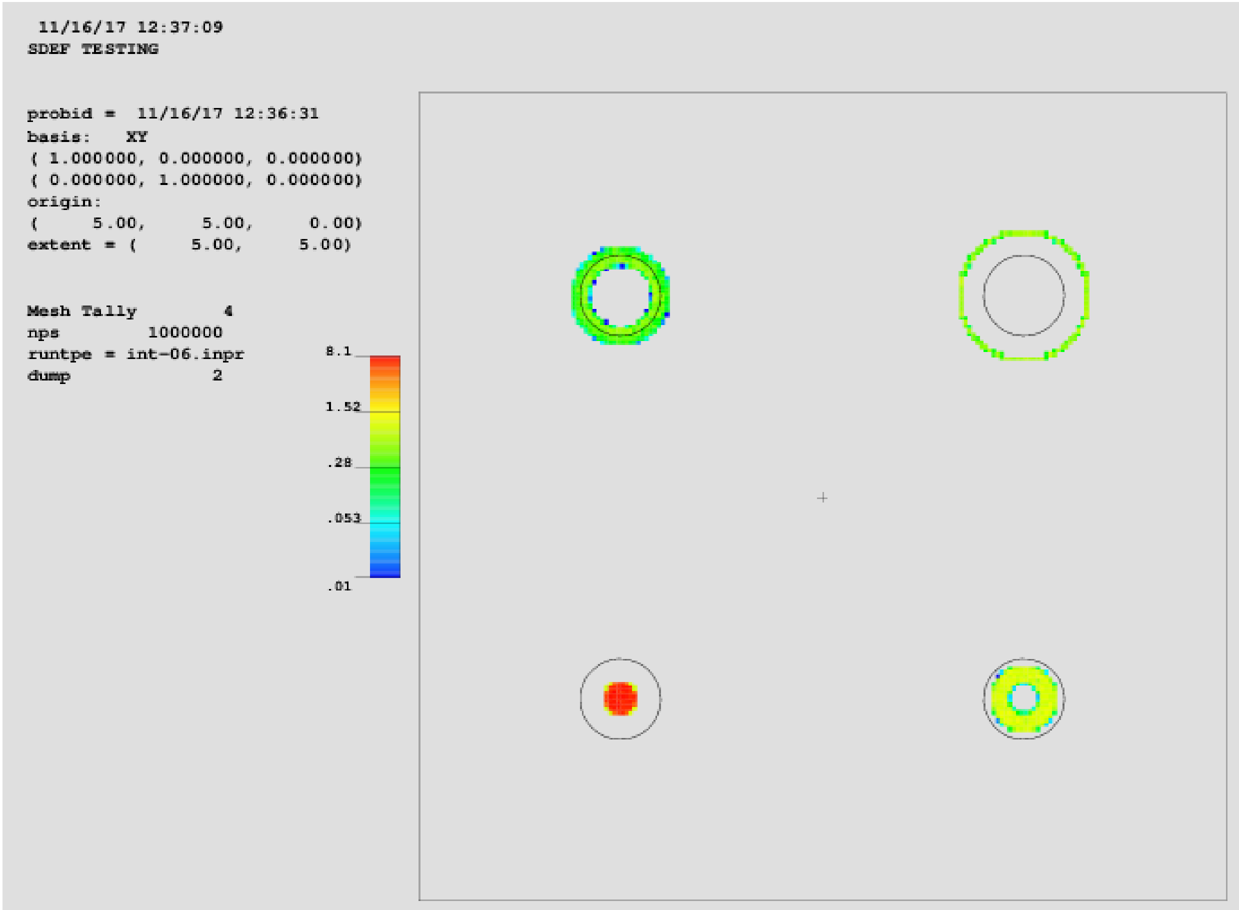
This example shows how the radius of the spherical volume source depends on the sampled position (RAD=FPOS). According to the manual, this should likely not work, but appears to give the expected source distribution in the radial dimension.

Listing 3.9: MCNP6 Input File

```
SDEF TESTING
10      1  1E-6  -1           IMP:N=1  $  inside sphere 1
20      1  1E-6  -2           IMP:N=1  $  inside sphere 2
30      1  1E-6  -3           IMP:N=1  $  inside sphere 3
40      1  1E-6  -4           IMP:N=1  $  inside sphere 4
50      2  1E-6  -5 1 2 3 4   IMP:N=1  $  inside box
99      0         5           IMP:N=0  $  outside

1  S   2.5 2.5 0 0.5
2  S   7.5 2.5 0 0.5
```

```
3  S   2.5 7.5 0 0.5
4  S   7.5 7.5 0 0.5
5  RPP 0 10 0 10 -1 1

MODE N
NPS 1e6
PRINT
c
M1    92235 1
M2    8016  1
      1001  2
c
FMESH4:N  GEOM=XYZ  ORIGIN=0 0 -1
          IMESH=10  IINTS=200
          JMESH=10  JINTS=200
          KMESH=1   KINTS=50
          TYPE=SOURCE
c
SDEF  POS=D1  RAD=FPOS=D2
c
SI1 L 2.5 2.5 0      $ POS distribution
      7.5 2.5 0
      2.5 7.5 0
      7.5 7.5 0
SP1   1 1 1 1
c
DS2 S 3 4 5 6
c
SI3  0 0.2
SP3 -21 2
c
SI4  0.2 0.4
SP4 -21 2
c
SI5  0.4 0.6
SP5 0   1
c
SI6 L 0.8
SP6    1
```

Below is the XY mesh plot of the four spherical sources to show the radial sampling is correct for each of the sampled positions.



Listing 3.10: MCNP6 Plotting Commands

```
fmesh 4
file
end
end
```

3.1.6 Cylindrical Extent Dependent on Position

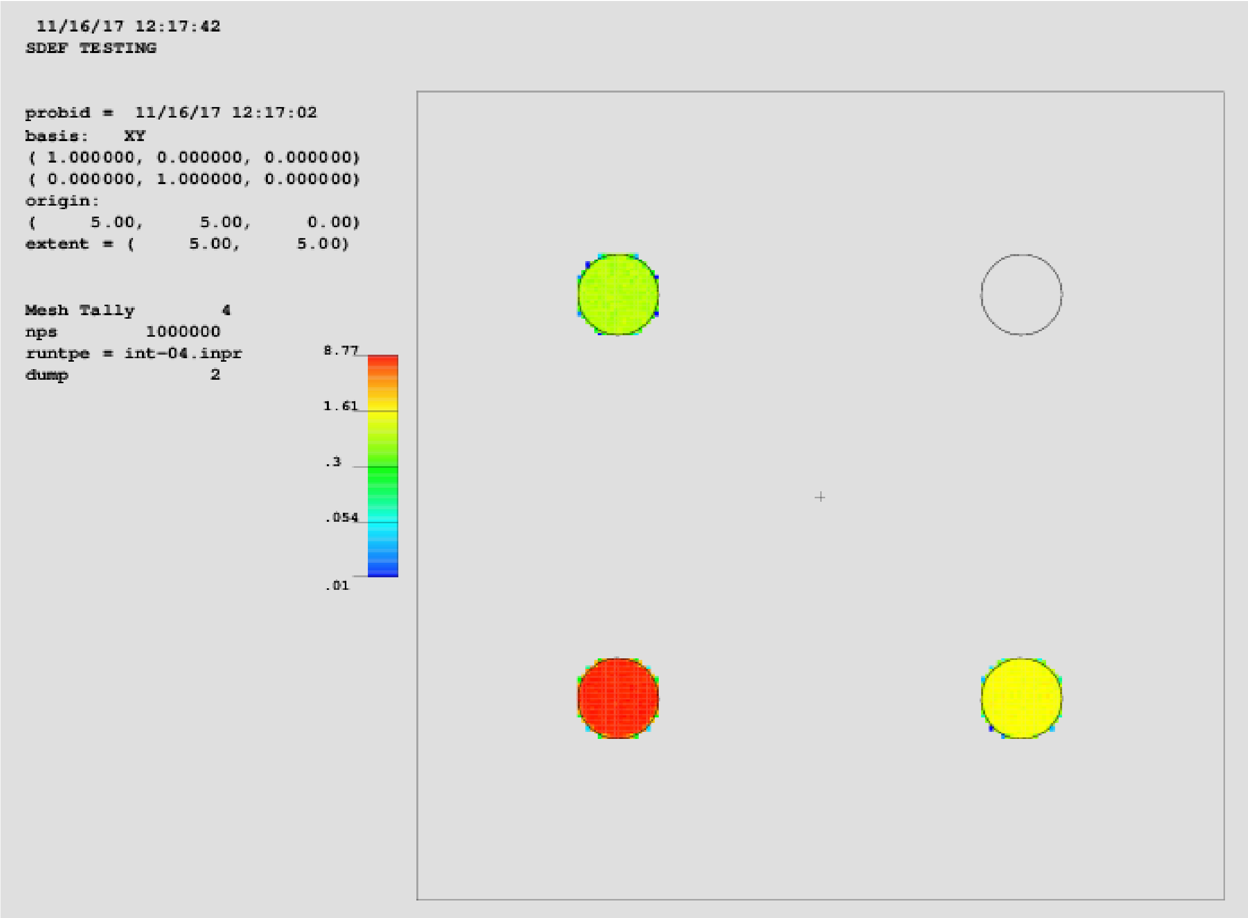
This example shows how the extent of the cylindrical volume source depends on the sampled position (EXT=FPOS). According to the manual, this should likely not work, but appears to give the expected source distribution in both radial and extent dimensions.

Listing 3.11: MCNP6 Input File

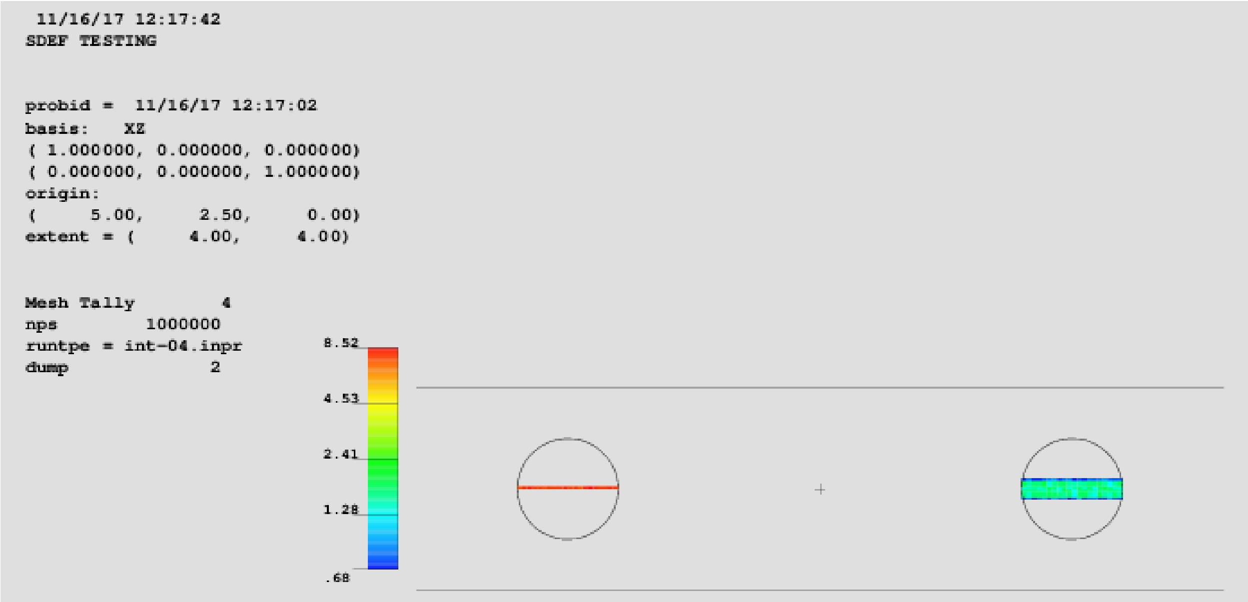
```
SDEF TESTING
10      1  1E-6  -1            IMP:N=1  $  inside sphere 1
20      1  1E-6  -2            IMP:N=1  $  inside sphere 2
30      1  1E-6  -3            IMP:N=1  $  inside sphere 3
40      1  1E-6  -4            IMP:N=1  $  inside sphere 4
50      2  1E-6  -5 1 2 3 4    IMP:N=1  $  inside box
99      0         5            IMP:N=0  $  outside

1   S    2.5 2.5 0 0.5
2   S    7.5 2.5 0 0.5
```

```
3  S   2.5 7.5 0 0.5
4  S   7.5 7.5 0 0.5
5  RPP 0 10 0 10 -1 1

MODE N
NPS 1e6
PRINT
c
M1    92235 1
M2    8016  1
      1001  2
c
FMESH4:N  GEOM=XYZ  ORIGIN=0 0 -1
          IMESH=10  IINTS=200
          JMESH=10  JINTS=200
          KMESH=1   KINTS=50
          TYPE=SOURCE
c
SDEF  POS=D1  EXT=FPOS=D2  AXS=0 0 1  RAD=D8
c
SI1 L 2.5 2.5 -0.1      $ POS distribution
      7.5 2.5 -0.1
      2.5 7.5 -0.1
      7.5 7.5 -0.1
SP1   1 1 1 1
c
DS2 S 3 4 5 6
c
SI3 L 0.1
SP3    1
c
SI4  0 0.2
SP4 0 1
c
SI5  0 0.4
SP5 0 1
c
SI6  0.2 0.6
SP6 0   1
c
SI8  0 0.5
SP8 -21 1
```

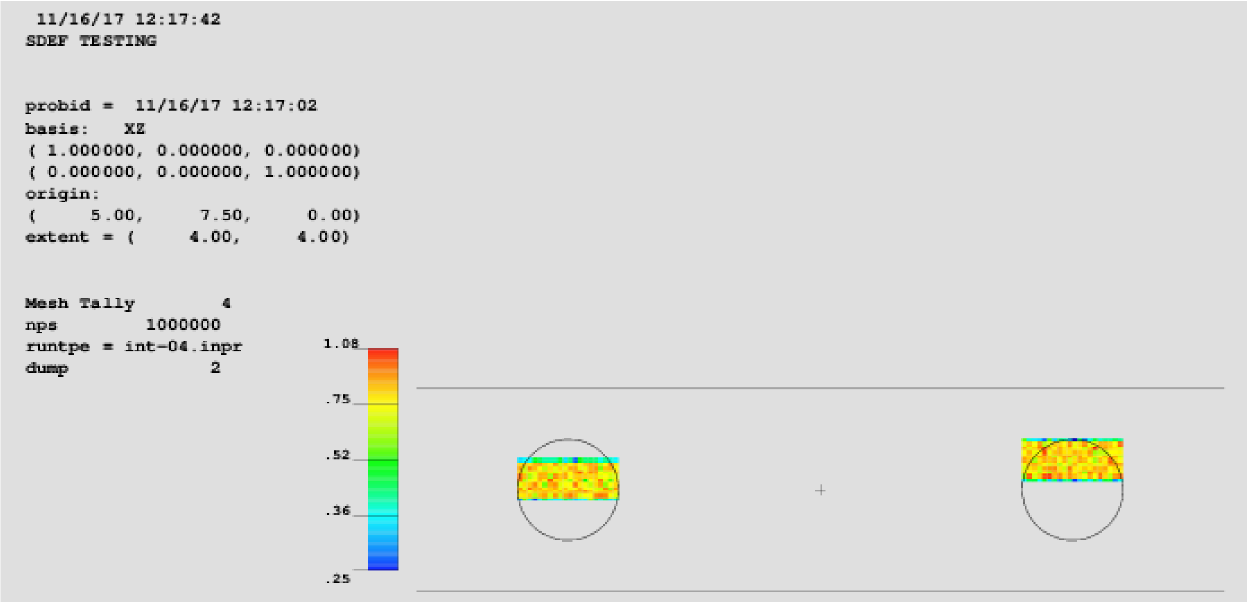
Below is the XY mesh plot of the four cylindrical sources to show the radial sampling is correct for each of the sampled positions.



Both plots below show the XZ mesh plot of the four cylinders. Slicing through the Y=2.5 plane:



And slicing through the Y=7.5 plane:



Listing 3.12: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0 0 1 0
basis 1 0 0 0 0 1 origin 5 2.5 0 extent 4
basis 1 0 0 0 0 1 origin 5 7.5 0 extent 4
file
end
end
```

3.1.7 Cylindrical Radius Dependent on Position

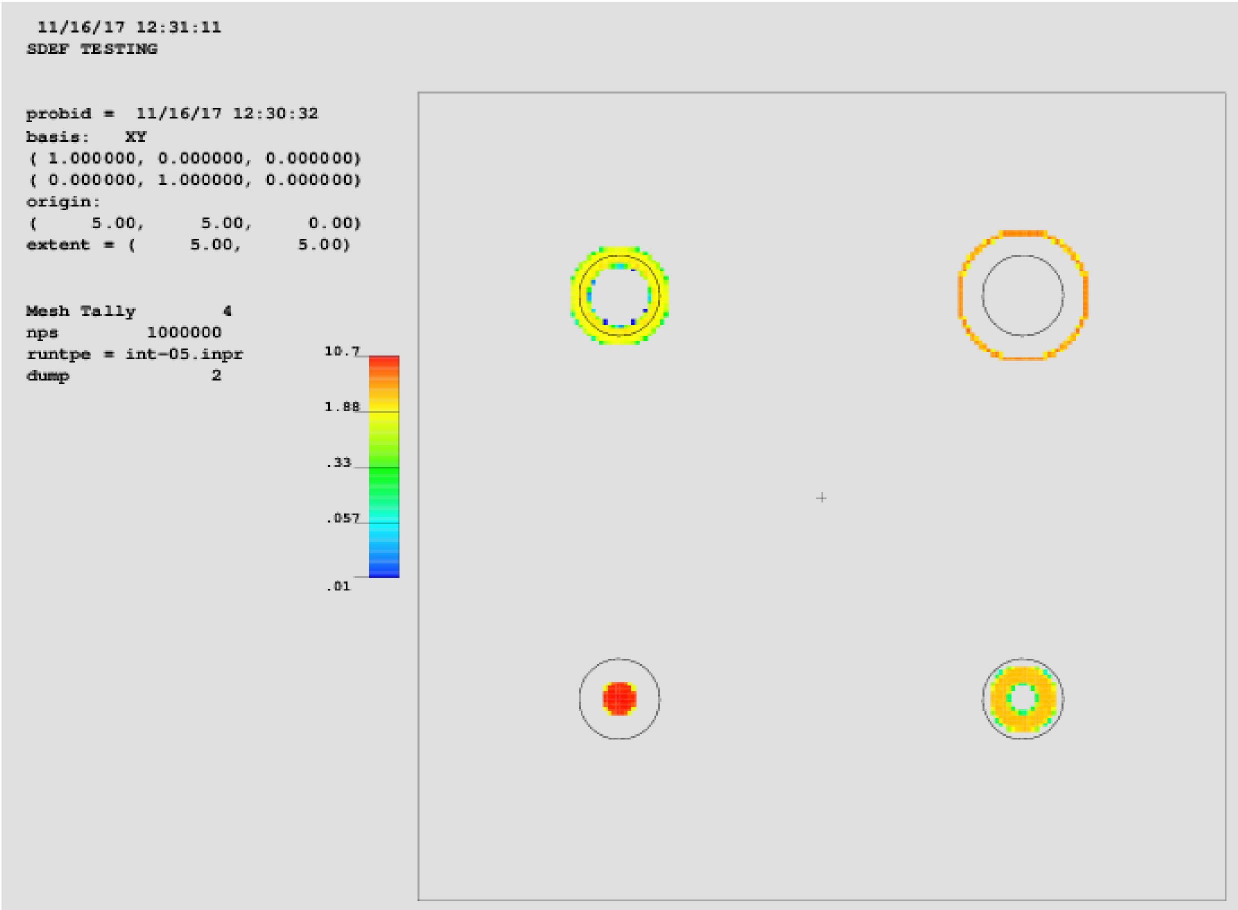
This example shows how the radius of the cylindrical volume source depends on the sampled position (RAD=FPOS). According to the manual, this should likely not work, but appears to give the expected source distribution in both radial and extent dimensions.

Listing 3.13: MCNP6 Input File

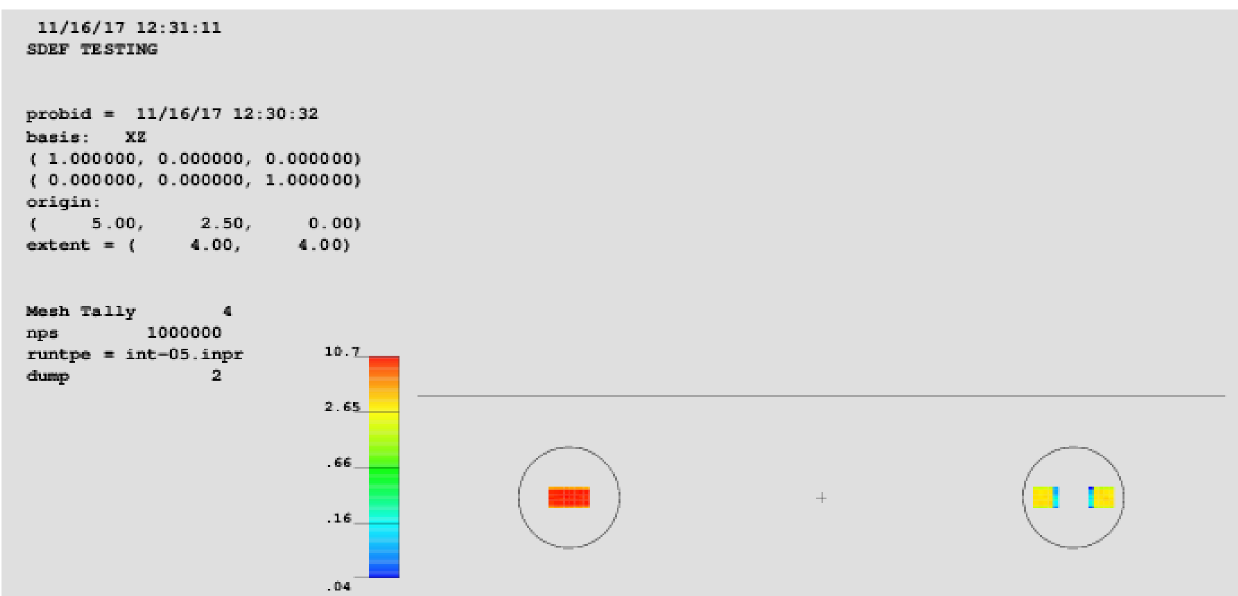
```
SDEF TESTING
10      1  1E-6  -1           IMP:N=1  $  inside sphere 1
20      1  1E-6  -2           IMP:N=1  $  inside sphere 2
30      1  1E-6  -3           IMP:N=1  $  inside sphere 3
40      1  1E-6  -4           IMP:N=1  $  inside sphere 4
50      2  1E-6  -5 1 2 3 4   IMP:N=1  $  inside box
99      0         5           IMP:N=0  $  outside

1   S   2.5 2.5 0 0.5
2   S   7.5 2.5 0 0.5
3   S   2.5 7.5 0 0.5
4   S   7.5 7.5 0 0.5
5  RPP  0 10 0 10 -1 1

MODE N
NPS 1e6
PRINT
```

```
c
M1    92235 1
M2    8016  1
      1001  2
c
FMESH4:N  GEOM=XYZ  ORIGIN=0 0 -1
          IMESH=10  IINTS=200
          JMESH=10  JINTS=200
          KMESH=1   KINTS=50
          TYPE=SOURCE
c
SDEF  POS=D1  RAD=FPOS=D2  AXS=0 0 1  EXT=D7
c
SI1 L 2.5 2.5 0.0      $ POS distribution
      7.5 2.5 0.0
      2.5 7.5 0.0
      7.5 7.5 0.0
SP1   1 1 1 1
c
DS2 S 3 4 5 6
c
SI3  0 0.2
SP3 -21 1
c
SI4  0.2 0.4
SP4 -21 1
c
SI5  0.4 0.6
SP5 0   1
c
SI6 L 0.8
SP6    1
c
SI7 -0.1 0.1
SP7 0 1
```

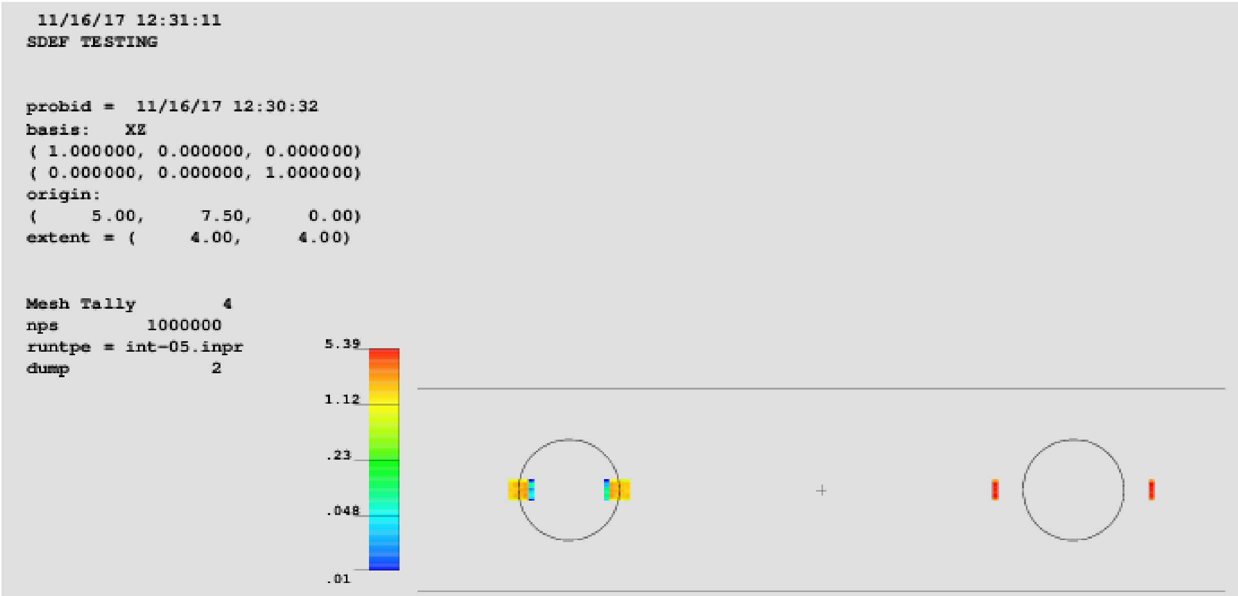
Below is the XY mesh plot of the four cylindrical sources to show the radial sampling is correct for each of the sampled positions.



Both plots below show the XZ mesh plot of the four cylinders. Slicing through the Y=2.5 plane:



And slicing through the Y=7.5 plane:



Listing 3.14: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0 0 1 0
basis 1 0 0 0 0 1 origin 5 2.5 0 extent 4
basis 1 0 0 0 0 1 origin 5 7.5 0 extent 4
file
end
end
```

3.2 *Embedded Functions*

3.2.1 Embedded Time Distributions

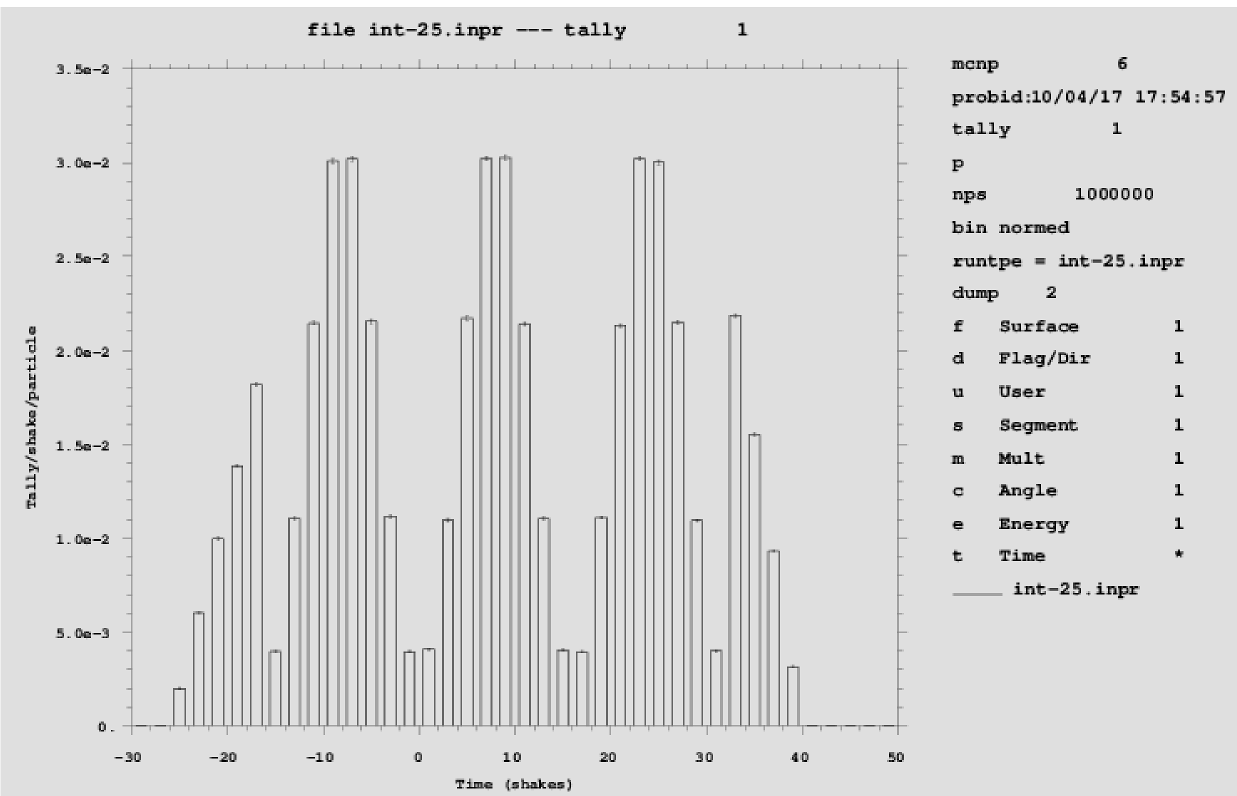
This example includes an embedded time distribution corresponding to a pulsed source that varies in overall pulse strength as a function of time. Taken from the MCNP6 User's Manual, page 3-153 (see *Helpful Links*).

Listing 3.15: MCNP6 Input File

```
Embedded Time Distributions
8    0    -10   IMP:P=1
99   0     10   IMP:P=0

10 SO 1

MODE P
NPS 1E6
c
SDEF   ERG D21   CEL=D11 TME=D41
c --- Set cell
SI11   L     8
SP11         1
c --- Set energy
SP21        -3
```

```
c
c --- Set Time distributions where 52 is embedded in 51 and 31 is embedded
c in 32 which is embedded in 33
c
SI41   S    52<51   (D31<32<D33)  61
SP41        .1      .8     .1
SI51   A    -26    -16
SP51          0      1
SI52   H      0  1  2
SP52          0  1  0
SI61   A     32     40
SP61          1      0
SI31          0  1  2
SP31          0  1  0
c --- Gaussian centered at t=8 with FWHM=8
SI32          0     16
SP32        -41  8  8
SI33        -16     32
SP33          0      1
c
F1:P  10
T1  -30 39i 50
c
```

Below is a plot of the overall time distribution of the source that has multiple levels of embedded distributions.



Listing 3.16: MCNP6 Plotting Commands

```
tal 1 linlin free t bar
file
end
end
```

3.3 *Cookie Cutter Cell*

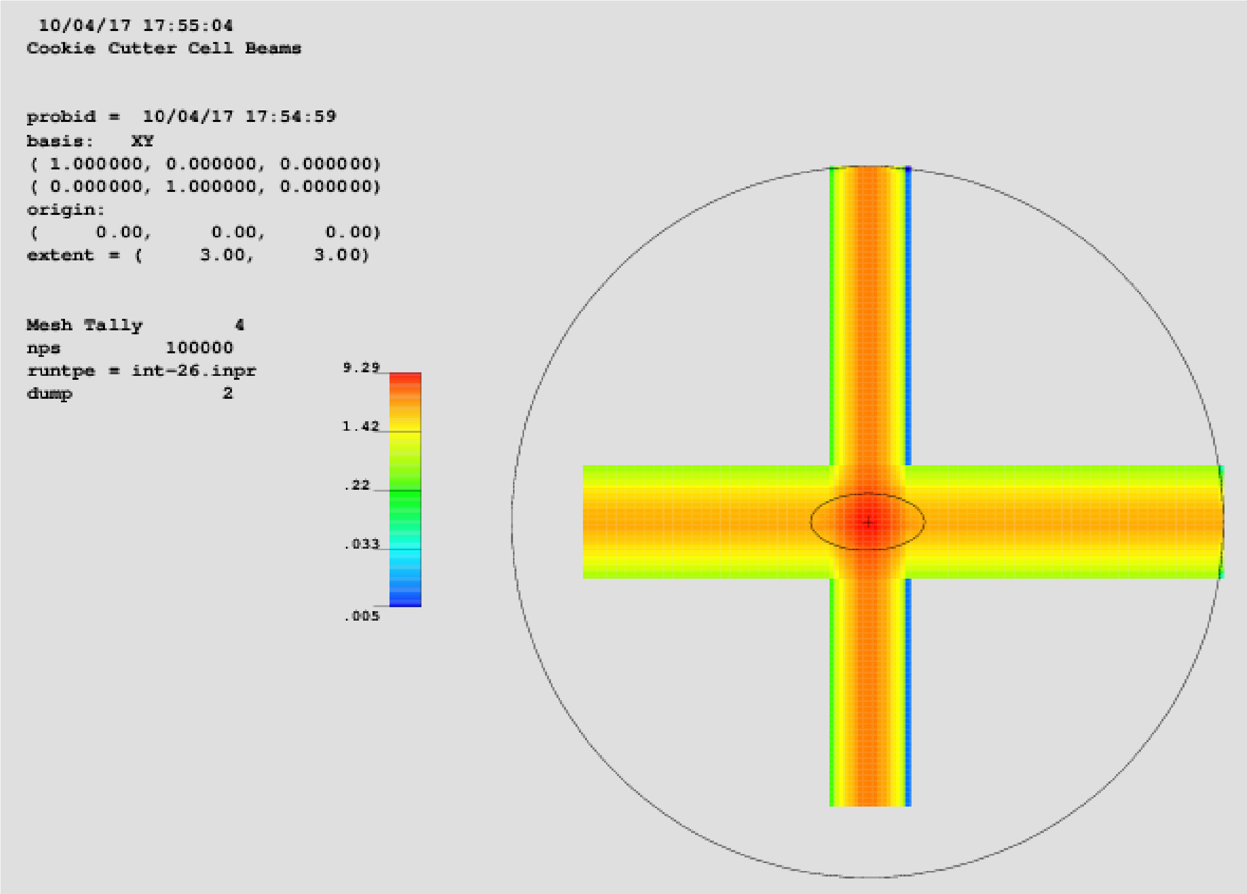
3.3.1 Intersecting Directional Beams

In this example, three monodirectional intersecting beams are modeled by sampling the X and Y positions with a truncated Gaussian distribution and then translating the source beam into three separate locations. To truncate the Gaussian distribution, the cookie cutter cell (ellipsoid in this case) is used on the CCC card. This example was taken from the MCNP6 User's Manual, page 3-151 (see *Helpful Links*).

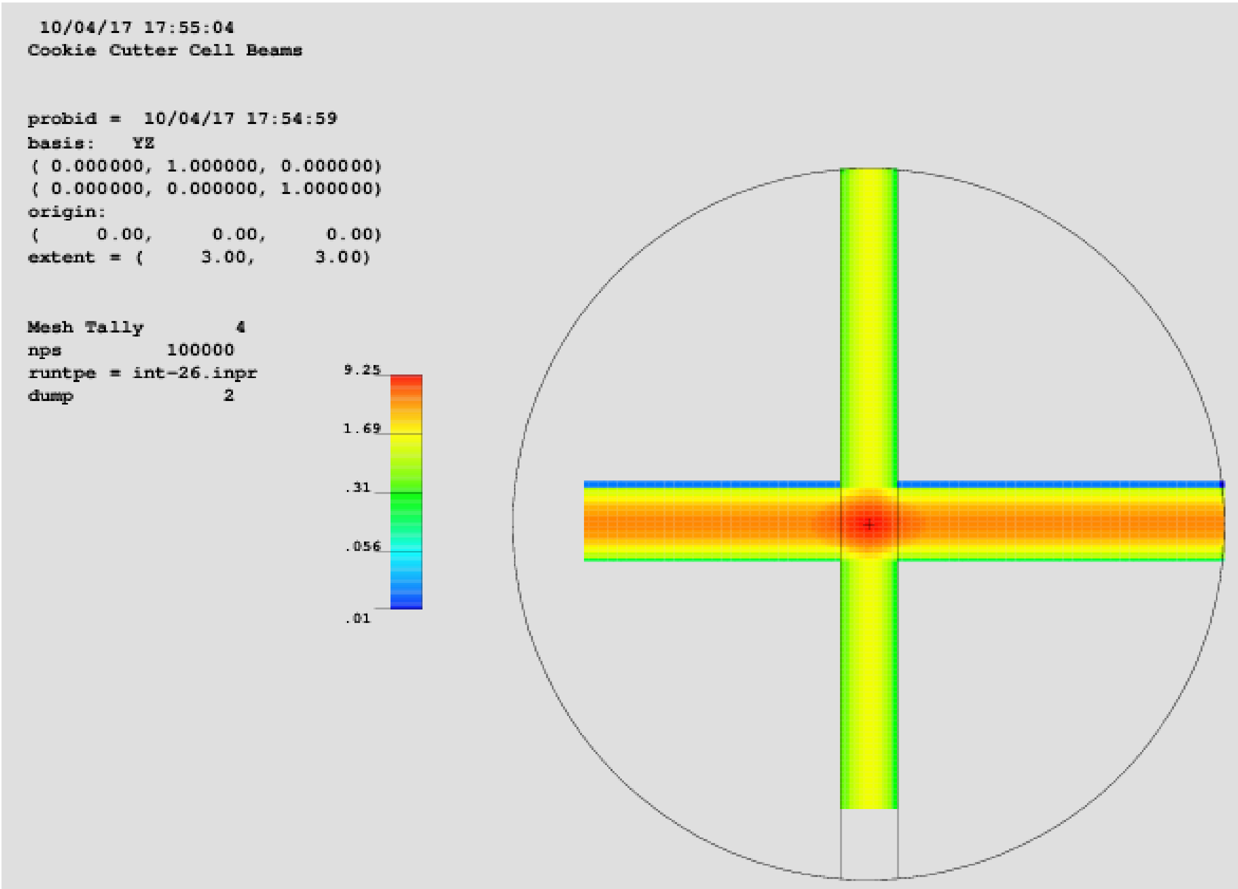
Listing 3.17: MCNP6 Input File

```
Cookie Cutter Cell Beams
888   0     -10  +9                IMP:N=1
999   0     -9   -10               IMP:N=1   $ Cookie cutter cell
1000  0     #999 #888              IMP:N=0   $ outside world

10  SO  2.5
9   SQ  25 100 0  0 0 0  -4 0 0 0 $ cookie cutter surface

NPS 1E5
c
SDEF     DIR=1 VEC=0 0 1  X=D1 Y=D2 Z=0 CCC=999 TR=D3
SP1     -41 0.470964    0
SP2     -41 0.235482   0
SI3  L   11  22  33
SP3       1  2  3
SB3       1  2  3
TR11      0  0 -2      1 0 0       0 1 0         0 0 1
TR22     -2  0  0      0 1 0       0 0 1         1 0 0
TR33      0 -2  0      0.707107 0  0.707107 0.707107 0 -0.707107  0 1 0
c
FMESH4:N  GEOM= xyz    ORIGIN= -2.5 -2.5 -2.5
          IMESH= 2.5   IINTS= 150
          JMESH= 2.5   JINTS= 150
          KMESH= 2.5   KINTS= 150
          OUT=NONE
```

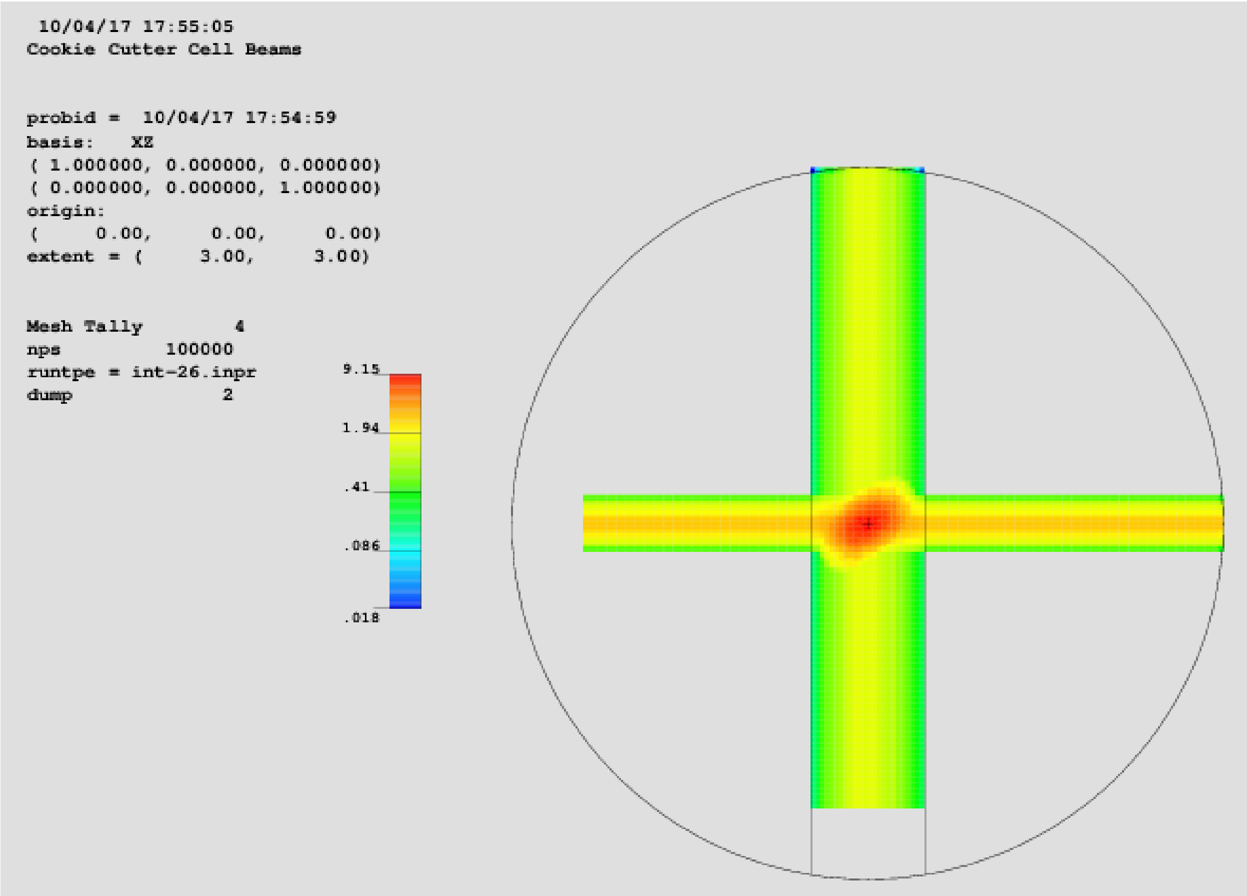
The flux from the source beams are seen intersecting on the different planes with visual of the cookie cutter cell at the origin. Below is the XY plane.



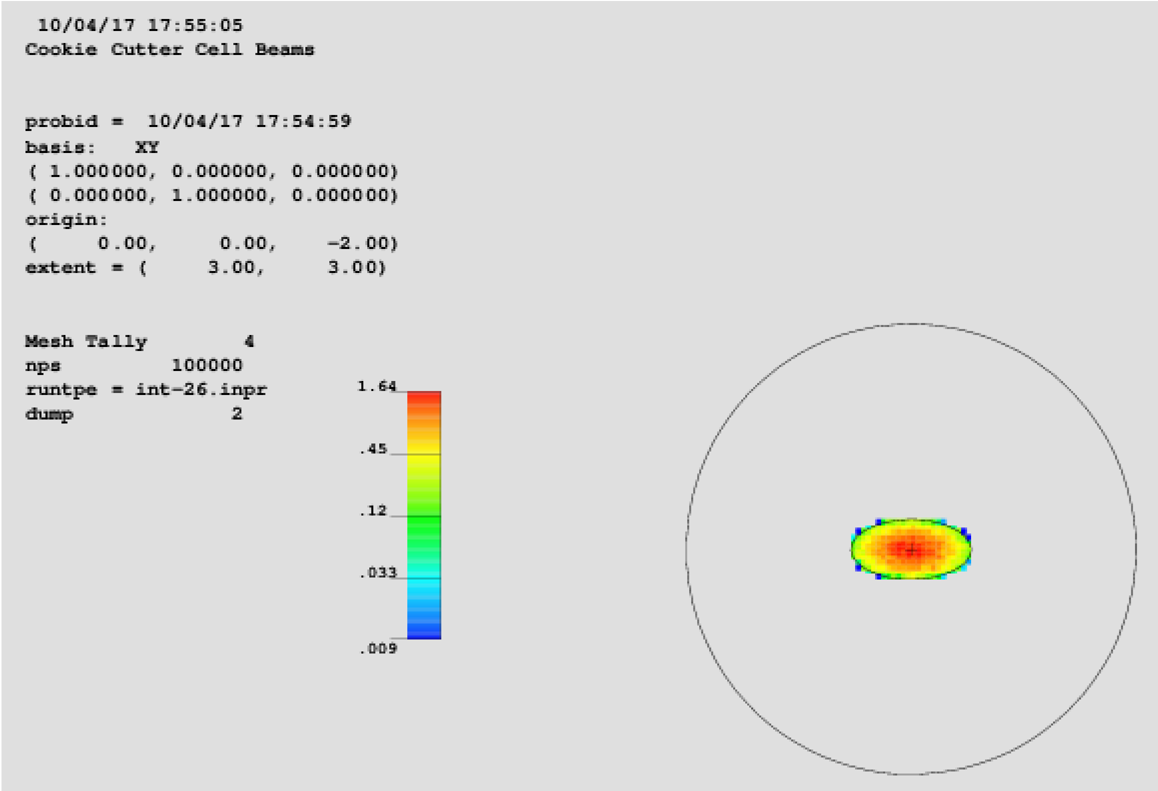
Below is the YZ plane.



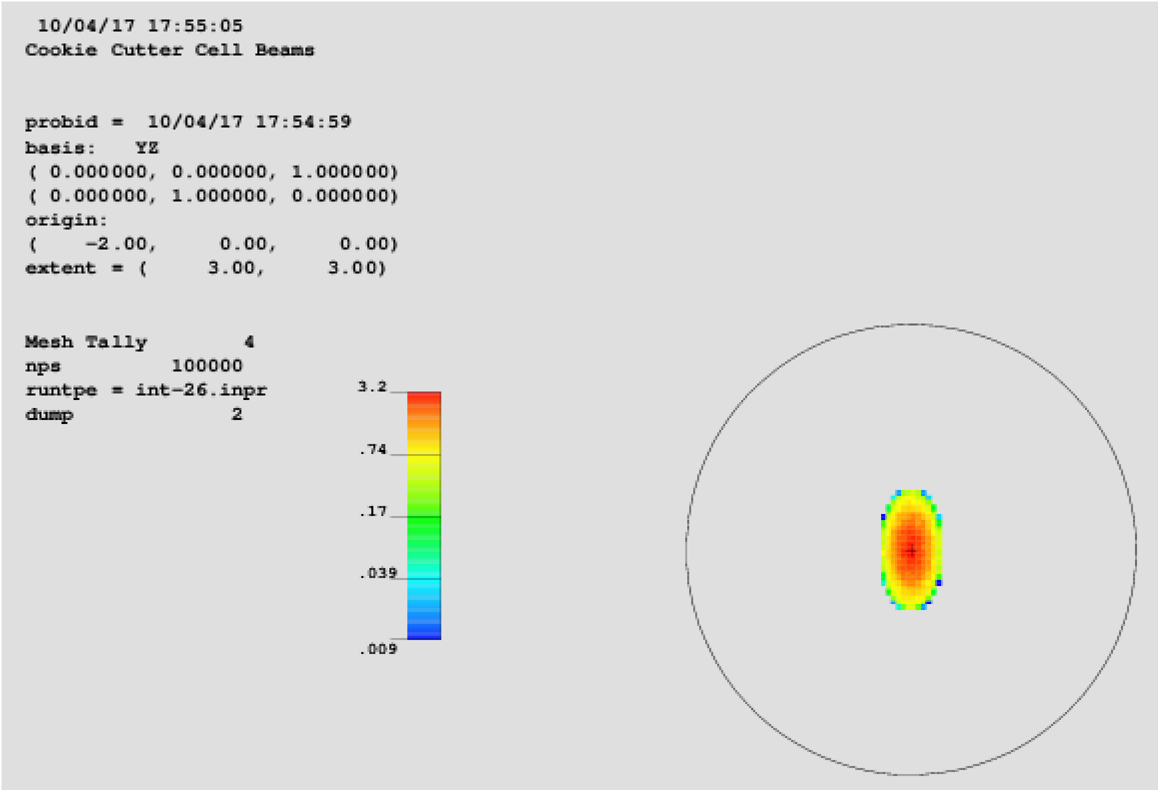
Below is the XZ plane.



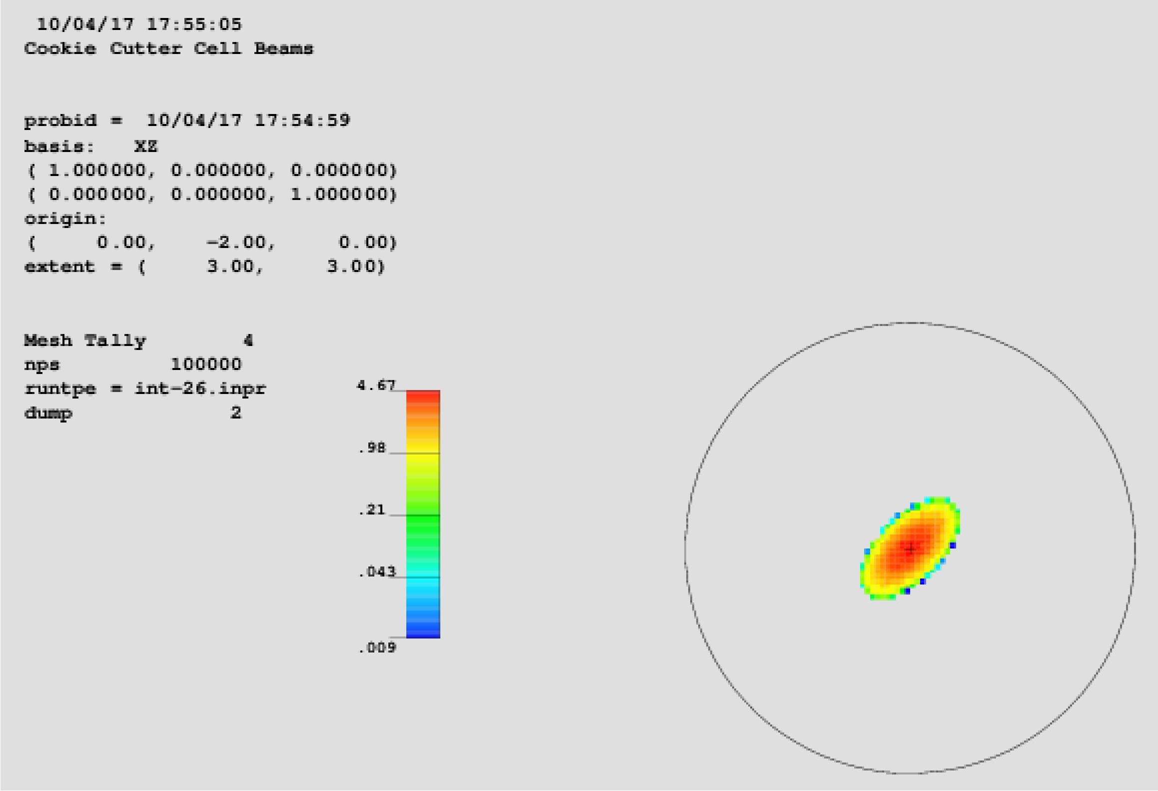
The following show the source locations and shape on the same mesh plots. Below is the XY plane.



Below is the YZ plane.



Below is the XZ plane.



Listing 3.18: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0  0 1 0 ex 3
basis 0 1 0  0 0 1 ex 3
basis 1 0 0  0 0 1 ex 3
basis 1 0 0  0 1 0 ex 3 or 0 0 -2
basis 0 0 1  0 1 0 ex 3 or -2 0 0
basis 1 0 0  0 0 1 ex 3 or 0 -2 0
file
end
end
```

CHAPTER FOUR

ADVANCED SOURCES

4.1 *Surface Source Write/Read*

4.1.1 Single Particle Coupling

Example of a Cs-137 photon source incased in a Tungsten shell creating a beam that strikes a Lead target.

Full calculation

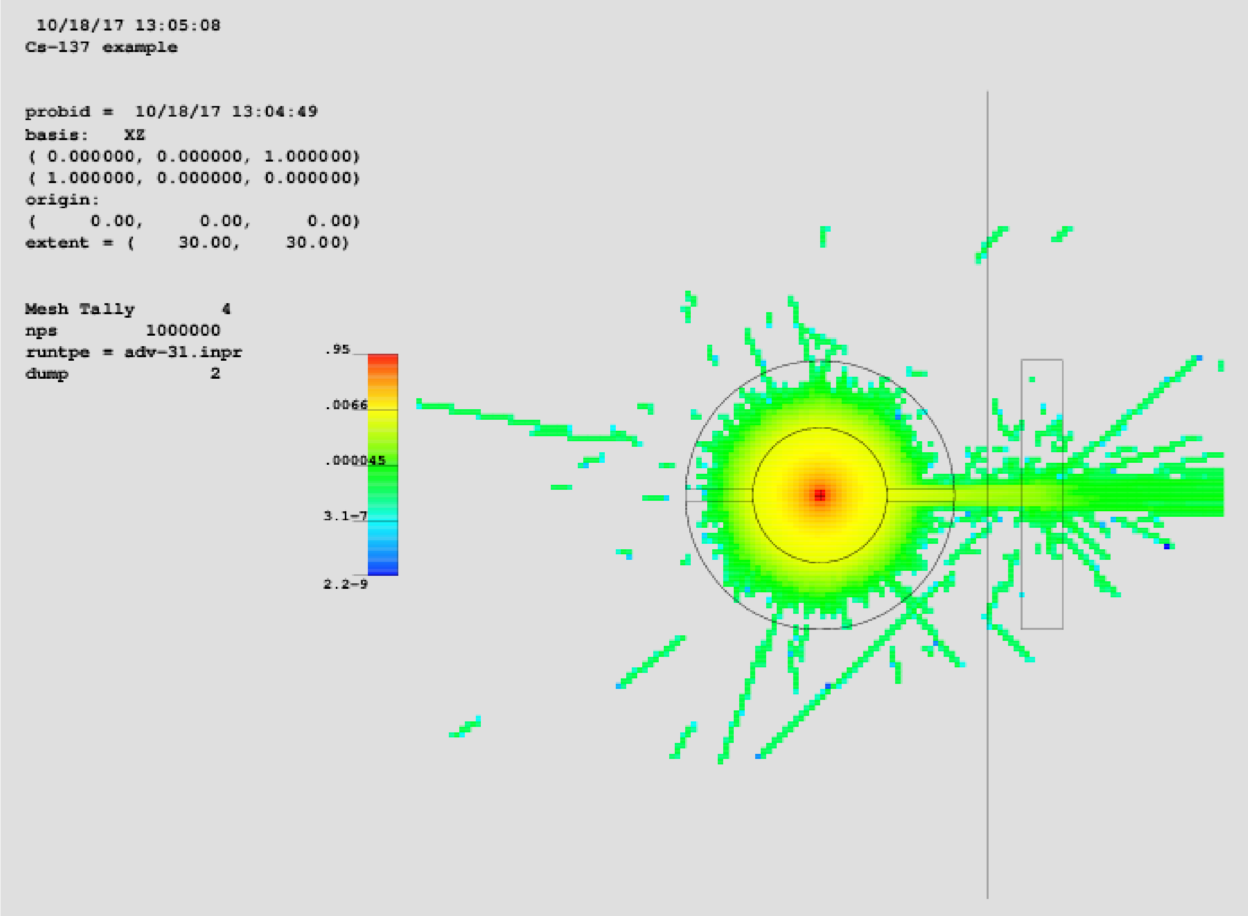
This portion of the example includes the full calculation without the surface write/read cards.

Listing 4.1: MCNP6 Input File

```
Cs-137 example
c
c  Cell Cards
c
 10   0            -1           IMP:P=1
 20   0            +1 -2 +3 -4  IMP:P=1
 30   100  -19.25  +1 -2 -3 -4  IMP:P=1
 40   100  -19.25  +1 -2    +4  IMP:P=1
 50   200  -7.874        -6     IMP:P=1
 60   0            -5 +2    -9  IMP:P=1
 70   0            +5    +6 -9  IMP:P=1
 99   0                     +9  IMP:P=0

c
c  Surface Cards
c
 1  SO    5
 2  SO    10
 3  PZ    0
 4  CZ    0.5
 5  PZ    12.5
 6  RPP  -10 10  -10 10  15 18
 9  SO    50

c
c  Data Cards
c
MODE P
NPS  1e6
c
```

```
SDEF PAR=P ERG=0.662
c
c Materials
c
M100 74184 1.0
M200 26056 1.0
c
FMESH4:P    GEOM=XYZ  ORIGIN=-20 -20 -30
            IMESH=20  IINTS=100
            JMESH=20  JINTS=100
            KMESH=30  KINTS=150
            OUT=NONE
```

Below is the plot of the photon flux from the source throughout the geometry including reflecting off the exterior Lead target.



Listing 4.2: MCNP6 Plotting Commands

```
fmesh 4
file
end
end
```

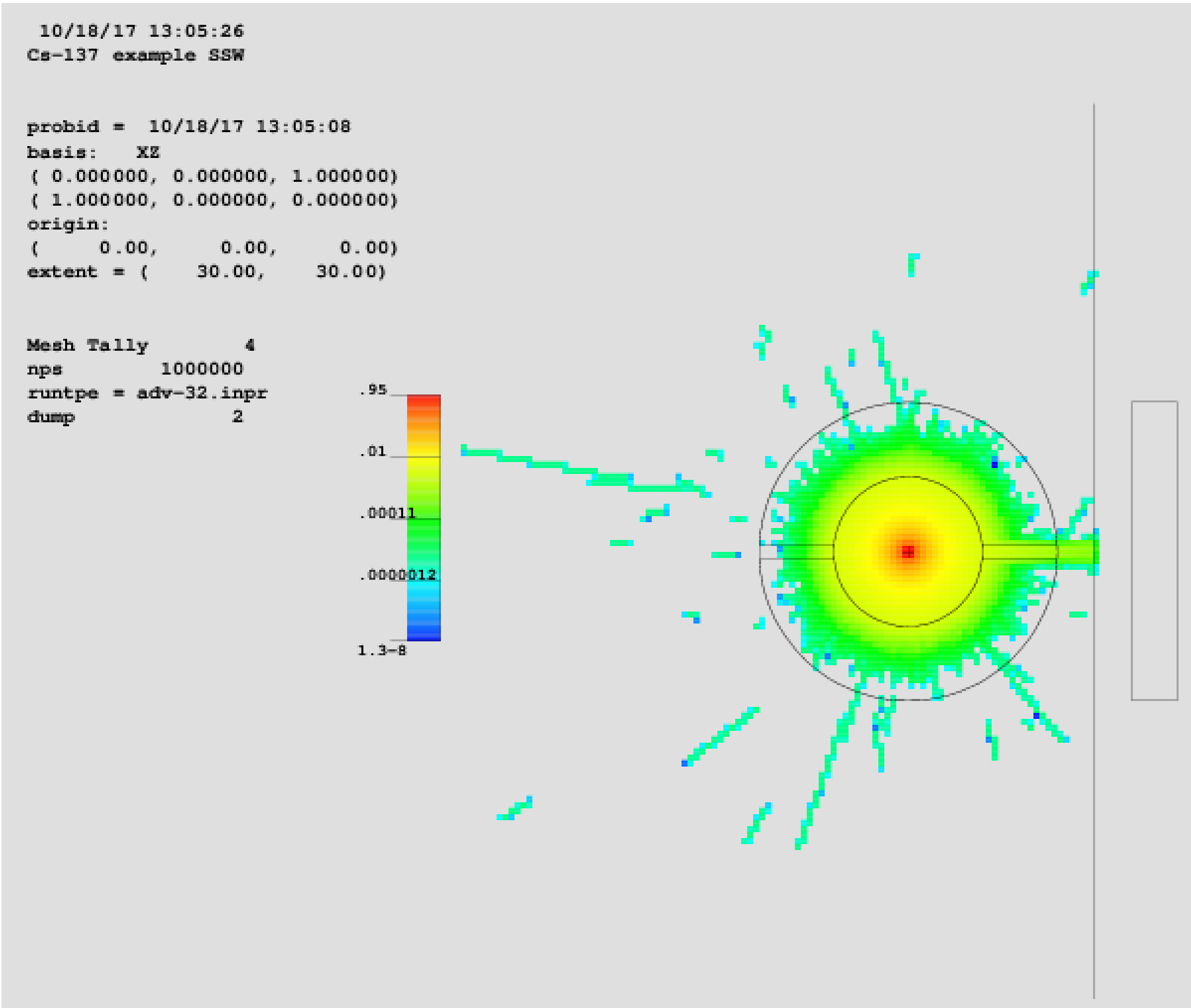
Surface Source Write

Example using the surface source write (SSW) option for Cs-137 exiting Tungsten shell.

Listing 4.3: MCNP6 Input File

```
Cs-137 example SSW
c
c  Cell Cards
c
 10   0             -1           IMP:P=1
 20   0             +1 -2 +3 -4  IMP:P=1
 30   100  -19.25  +1 -2 -3 -4  IMP:P=1
 40   100  -19.25  +1 -2    +4  IMP:P=1
 50   0                   -6     IMP:P=0
 60   0             -5 +2    -9  IMP:P=1
 70   0             +5    +6 -9  IMP:P=0
 99   0                      +9  IMP:P=0

c
c  Surface Cards
c
 1  SO    5
 2  SO    10
 3  PZ    0
 4  CZ    0.5
 5  PZ    12.5
 6  RPP  -10 10  -10 10  15 18
 9  SO    50

c
c  Data Cards
c
MODE P
NPS  1e6
SSW 5
c
SDEF PAR=P ERG=0.662
c
c Materials
c
M100 74184 1.0
M200 26056 1.0
c
FMESH4:P   GEOM=XYZ  ORIGIN=-20 -20 -30
           IMESH=20  IINTS=100
           JMESH=20  JINTS=100
           KMESH=30  KINTS=150
           OUT=NONE
```

Below, a plot shows the Cs-137 inside sphere case creating a beam. The SSW cuts off the beam when it intersects surface 5 so the source at this point can be used in further problems and applications using the surface source read (SSR) option.



Listing 4.4: MCNP6 Plotting Commands

```
fmesh 4
file
end
end
```

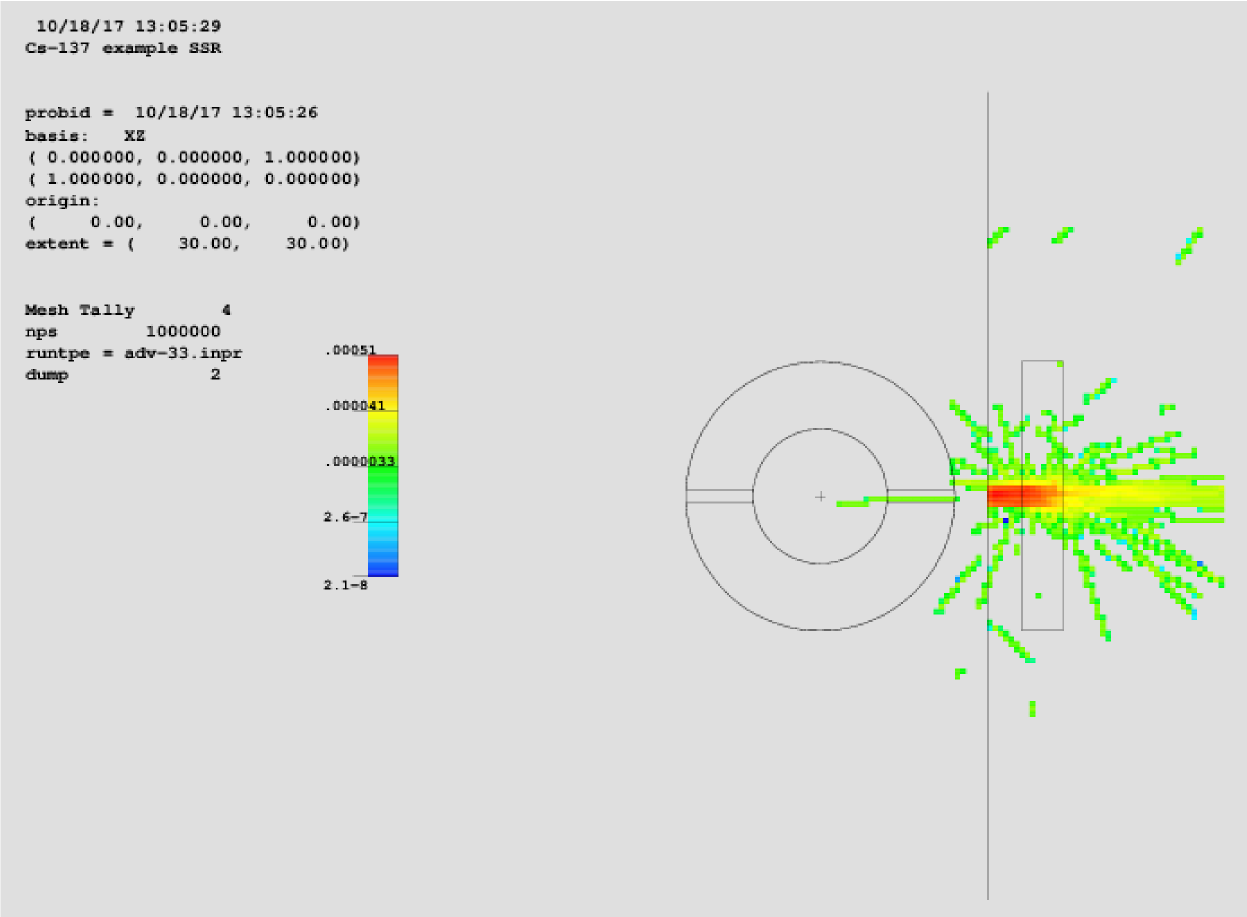
Surface Source Read

Continuation of the SSW for the Cs-137 beam where the surface source read (SSR) continues the calculation and has the beam hitting the Lead target. Note that seperating the two calculations can save computing time and make the code more efficient especially if you are planning to use the source created in your SSW calculations for multiple SSR applications.

Listing 4.5: MCNP6 Input File

```
Cs-137 example SSR
c
c  Cell Cards
c
 10   0            -1           IMP:P=1
 20   0            +1 -2 +3 -4  IMP:P=1
 30   100  -19.25  +1 -2 -3 -4  IMP:P=1
 40   100  -19.25  +1 -2    +4  IMP:P=1
 50   200  -7.874        -6     IMP:P=1
 60   0            -5 +2    -9  IMP:P=1
 70   0            +5    +6 -9  IMP:P=1
 99   0                     +9  IMP:P=0

c
c  Surface Cards
c
 1  SO    5
 2  SO    10
 3  PZ    0
 4  CZ    0.5
 5  PZ    12.5
 6  RPP  -10 10  -10 10  15 18
 9  SO    50

c
c  Data Cards
c
MODE P
NPS  1e6
SSR
c
c Materials
c
M100 74184 1.0
M200 26056 1.0
c
FMESH4:P   GEOM=XYZ  ORIGIN=-20 -20 -30
           IMESH=20  IINTS=100
           JMESH=20  JINTS=100
           KMESH=30  KINTS=150
           OUT=NONE
```

The plot below shows the continuation of the source at surface 5 and calculates the outcome of the source hitting the Lead target.



Listing 4.6: MCNP6 Plotting Commands

```
fmesh 4
file
end
end
```

4.1.2 Multiple Particle Coupling

Surface Source Write

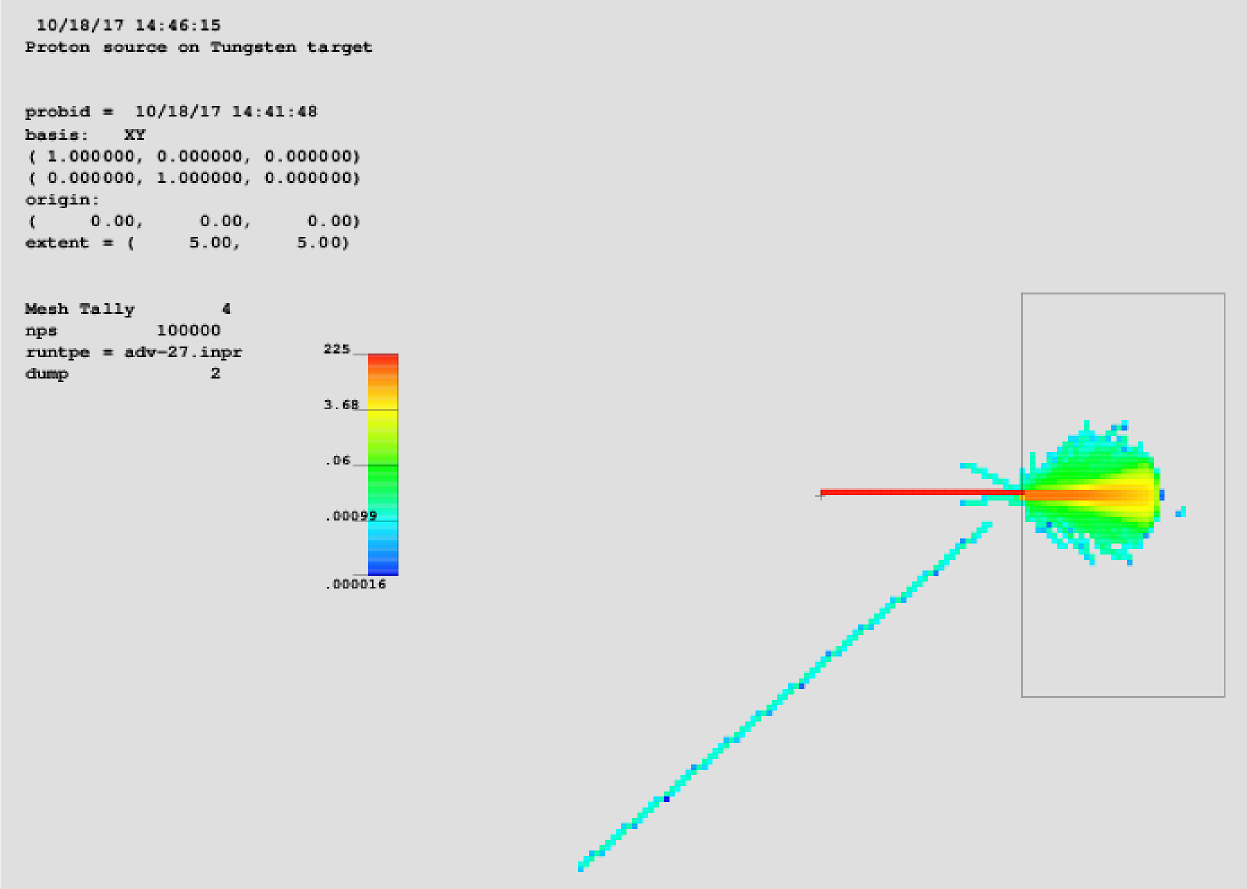
Example of a surface source write input file with a proton beam incident on a Tungsten target. Ultimately, the neutron spallation source from this proton beam is desired to model various configurations.

Listing 4.7: MCNP6 Input File

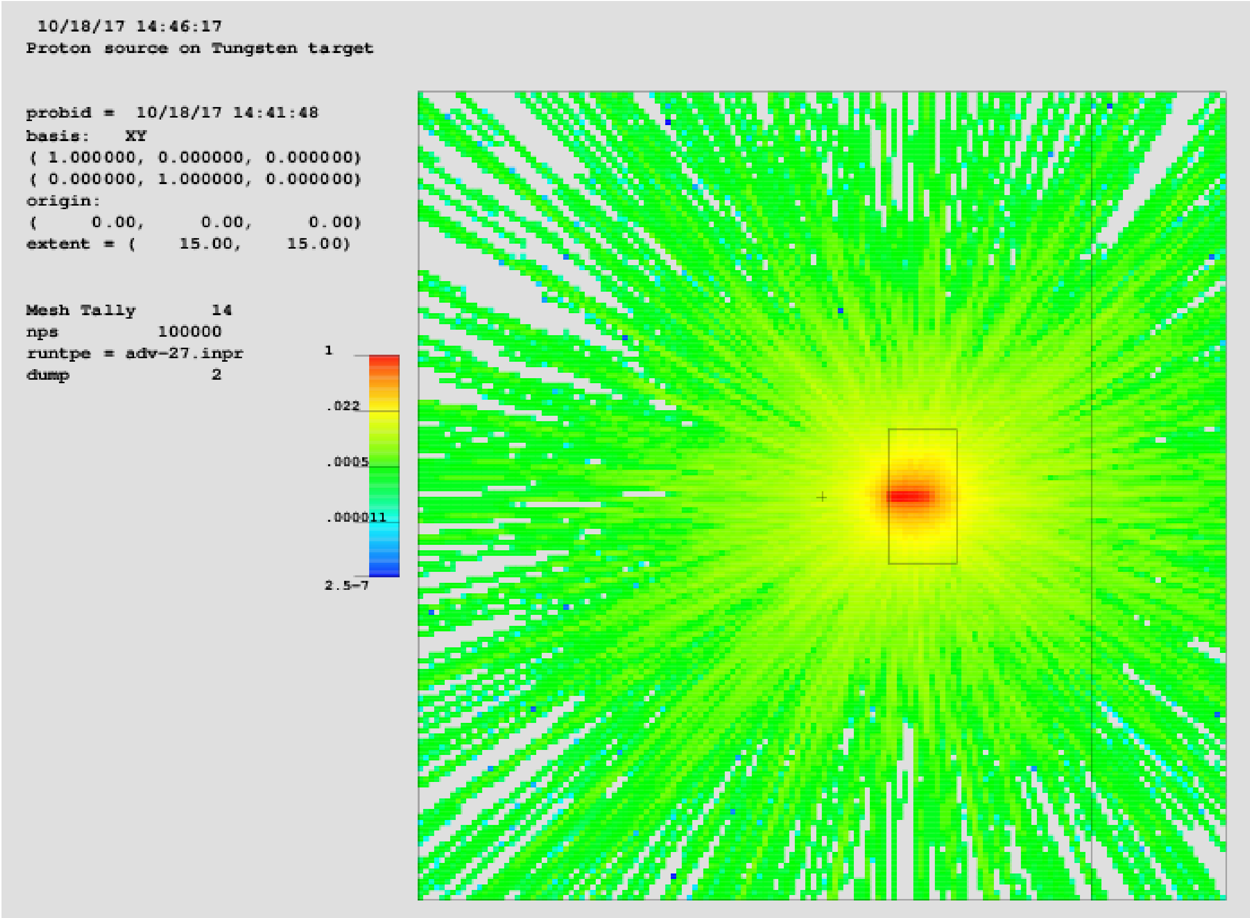
```
Proton source on Tungsten target
c
c  Cell Cards
c
 10   0              +1     -9      IMP:H,N=1
 20   0              -1  +2 -9      IMP:H,N=1
 30   100   -19.25      -2          IMP:H,N=1
 99   0                 +9          IMP:H,N=0
```

```
c
c  Surface Cards
c
 1  PX    10
 2  RPP  2.5  5  -2.5 2.5  -2.5 2.5
 9  RPP  -15 15   -15  15   -15  15

c
c  Data Cards
c
MODE H N
NPS  1e5
SSW 1 PTY=N
c
PHYS:H 150
SDEF PAR=H ERG=150 VEC=1 0 0 DIR=1
c
c Materials
c
M100 74184 1.0
c
FMESH4:H   GEOM=XYZ  ORIGIN=-5 -5 -5
           IMESH= 5  IINTS=150
           JMESH= 5  JINTS=150
           KMESH= 5  KINTS=150
           OUT=NONE
c
FMESH14:N  GEOM=XYZ  ORIGIN=-15 -15 -15
           IMESH=15  IINTS=150
           JMESH=15  JINTS=150
           KMESH=15  KINTS=150
           OUT=NONE
```

A flux mesh plot of the proton beam as it interacts with the Tungsten on the XY plane.



The flux mesh plot of the spallation neutrons created from the proton beam source on the XY plane.



Listing 4.8: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0 0 1 0
fmesh 14
file
end
end
```

Surface Source Read

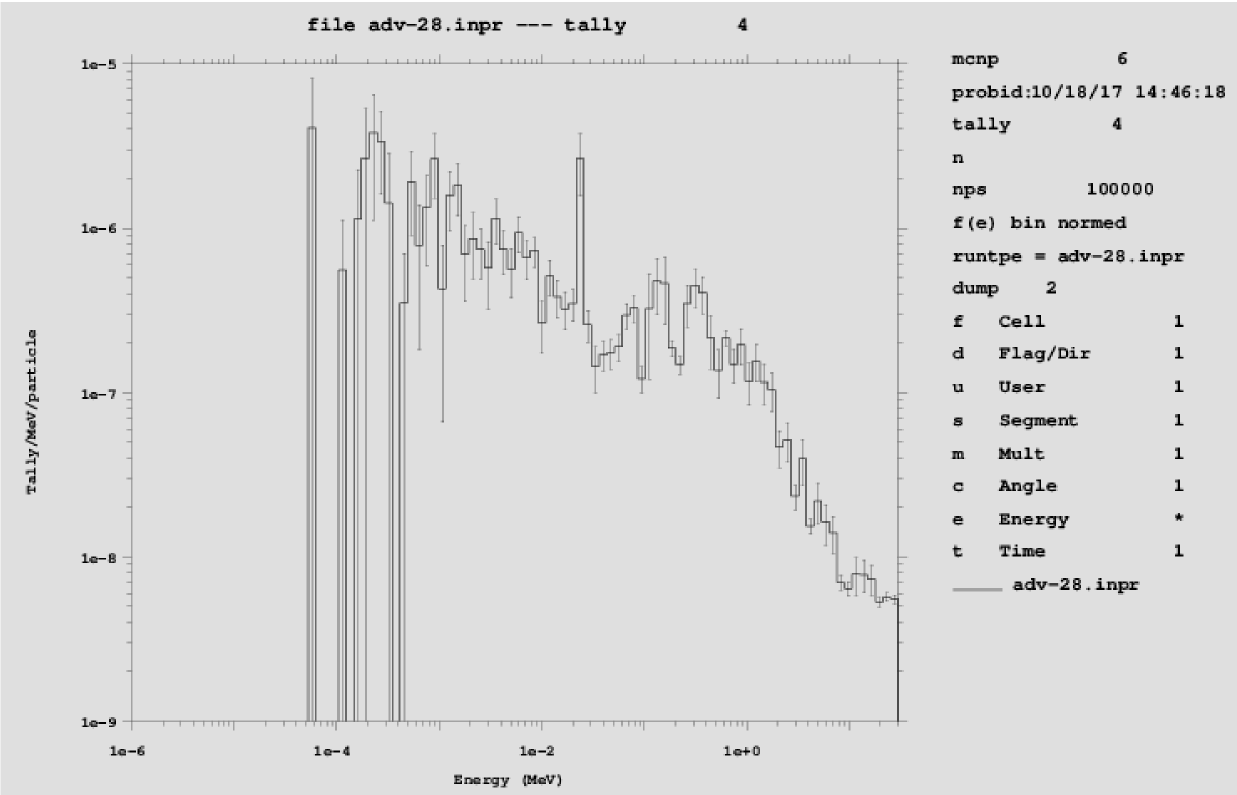
Surface source read file that tests neutrons produced from the high-energy proton source incident on the Tungsten spallation target.

Listing 4.9: MCNP6 Input File

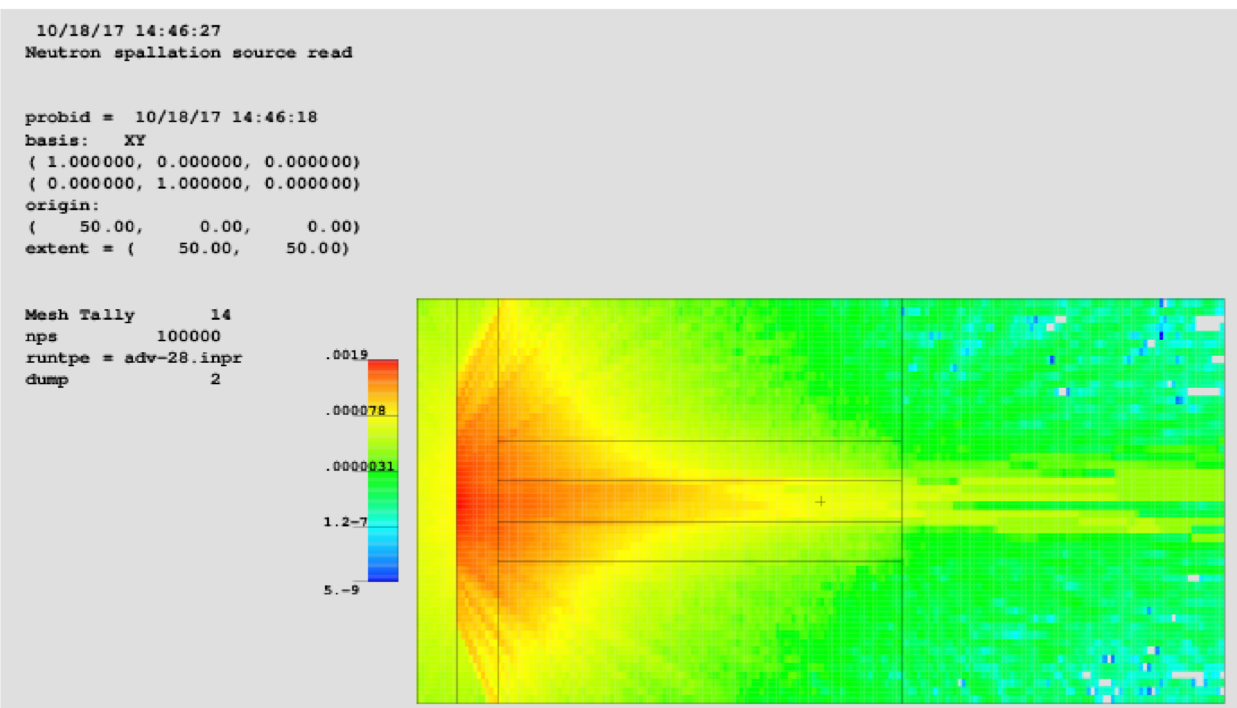
```
Neutron spallation source read
c
c  Cell Cards
c
 10   0           -11             -9  IMP:N=1
 20   0           +11 -2          -9  IMP:N=1
 30   100  -1.0       +2     +4 -5 -9  IMP:N=1
 40   200  -7.874     +2 +3 -4 -5     IMP:N=1
 50   0               +2 -3     -5     IMP:N=1
```

```
 60   0                        +5 -9  IMP:N=1
 99   0                           +9  IMP:N=0

c
c  Surface Cards
c
 11 PX    5
 2  PX   10
 3  CX  2.5
 4  CX  7.5
 5  PX   60
 9  RPP   0 100   -25  25   -25  25

c
c  Data Cards
c
MODE N
NPS  5e6
SSR NEW 11 TR=1
TR1 -5 0 0
c
c Materials
c
M100  1001 2 8016 1 5010 2
MT100 lwtr
M200  26056 1.0
c
F4:N 60
E4 1E-6 99ilog 30
c
FMESH14:N  GEOM=XYZ  ORIGIN= 0 -25 -25
           IMESH=100  IINTS=200
           JMESH=25  JINTS=50
           KMESH=25  KINTS=50
           OUT=NONE
c
PRINT
```

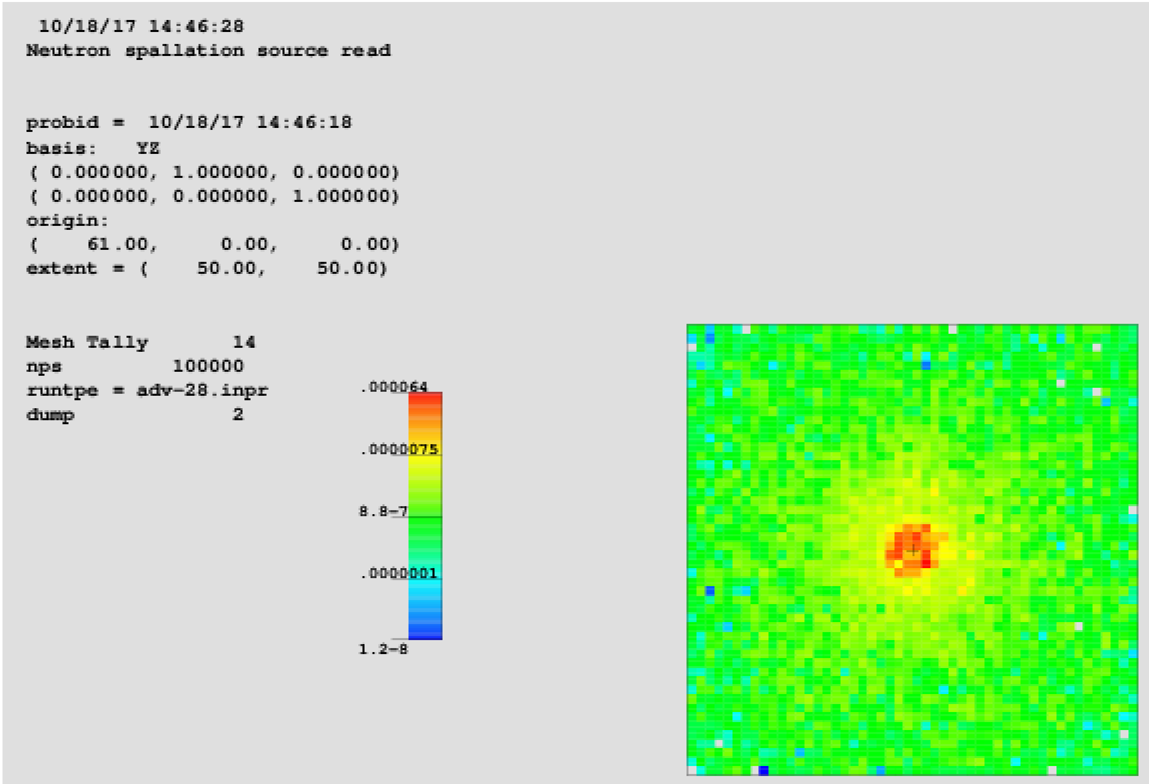
The following plot shows the energy spectrum of neutrons reaching the void cell beyond the borated water surrounded collimator.



The mesh plot of the flux of neutrons as they travel down the collimator.



The mesh plot at the end of the collimator showing the peak of neutrons traveling through the collimator.



Listing 4.10: MCNP6 Plotting Commands

```
tal 4 loglog xlims 1.e-6 3.e+1
fmesh 14
basis 1 0 0 0 1 0
basis 0 1 0 0 0 1 origin 61 0 0
file
end
end
```

4.1.3 Criticality Fission Source Coupling

Surface Source Write

This example is a neutron-only criticality calculation, where the fission source points are saved in the SSW cell location.

Listing 4.11: MCNP6 Input File

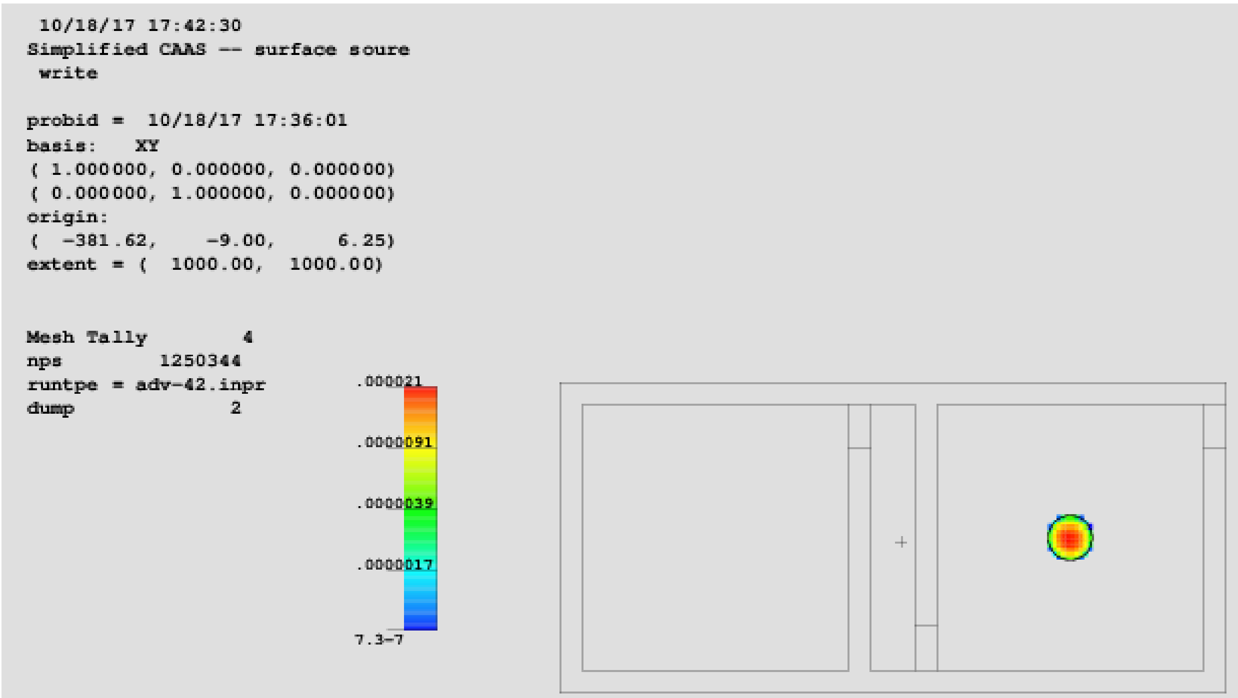
```
Simplified CAAS -- surface soure write
c ### cells
c
c >>>>> accident tank
c
100      1   9.9270e-2     -10  -12                  imp:n=1
101      3   4.8333e-5     -10  +12                  imp:n=1
102      2   8.6360e-2     +10  -11                  imp:n=1
c
c >>>>> facility rooms: nw. -> ne., sw. -> se.
```

```
c
200     3  4.8333e-5     -20                        imp:n=1
210     3  4.8333e-5     -21 +11                    imp:n=1
220     3  4.8333e-5     -22                        imp:n=1
c
c >>>>> doorways
c
260     3  4.8333e-5     -30                        imp:n=1
261     3  4.8333e-5     -31                        imp:n=1
262     3  4.8333e-5     -32                        imp:n=1
c
c >>>>> facility and rest of world
c
900     4  0.0764        -99 +20 +21 +22
                             +30 +31 +32            imp:n=1
999     0                +99                        imp:n=0

c ### surfaces
c
c >>>>> critical experiment tank
10    rcc    0  0  1     0  0  100     50
11    rcc    0  0  0     0  0  101    50.5
12    pz     13.6
c
c >>>>> rpp's for the empty space in the rooms
20    rpp   -1100  -500    -300   300    0  300
21    rpp    -300   300    -300   300    0  300
22    rpp    -450  -350    -300   300    0  300
c
c >>>>> doorways
30    rpp    -350  -300    -300  -200    0  250
31    rpp     300   350     200   300    0  250
32    rpp    -500  -450     200   300    0  250
c
c >>>>> building structure
99    rpp   -1150   350    -350   350  -50  310

mode   n
kcode  10000   1.0   25   125
ksrc   0 0 7
c
ssw   cel = 100
c
fmesh4:n   geom=xyz origin=-1150 -350 -50
           imesh=350  iints=150
           jmesh=350  jints=70
           kmesh=310  kints=36
           type=source
c
fmesh14:n  geom=xyz origin=-1150 -350 -50
           imesh=350  iints=150
           jmesh=350  jints=70
           kmesh=310  kints=36
c
c ### materials
c plutonium nitrate solution
m1     1001  6.0070e-2
       8016  3.6540e-2
```

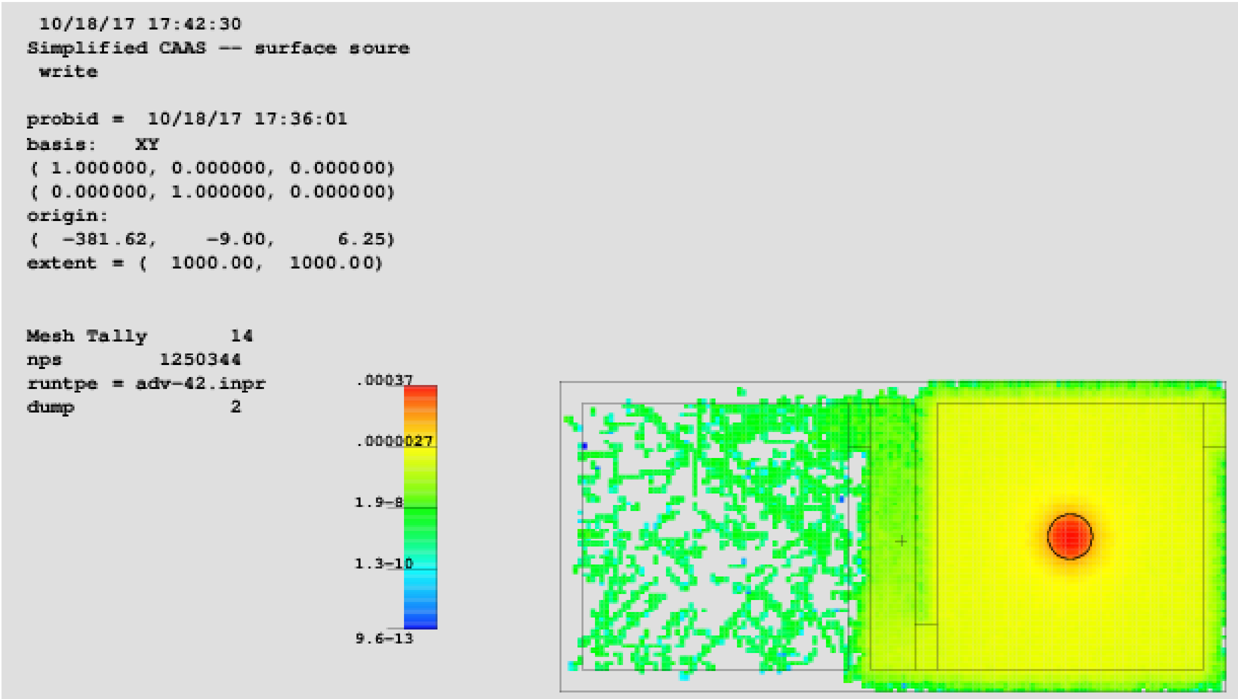
```
       7014  2.3699e-3
      94239  2.7682e-4
      94240  1.2214e-5
      94241  8.3390e-7
      94242  4.5800e-8
mt1    lwtr
c stainless steel
m2    24050  7.1866e-4     $ Cr-50  4.345%
      24052  1.3859e-2     $ Cr-52 83.789%
      24053  1.5715e-3     $ Cr-53  9.501%
      24054  3.9117e-4     $ Cr-54  2.365%
      26054  3.7005e-3     $ Fe-54  5.845%
      26056  5.8090e-2     $ Fe-56 91.754%
      26057  1.3415e-3     $ Fe-57  2.119%
      26058  1.7853e-4     $ Fe-58  0.282%
      28058  4.4318e-3     $ Ni-58 68.0769%
      28060  1.7071e-3     $ Ni-60 26.2231%
      28061  7.4207e-5     $ Ni-61  1.1399%
      28062  2.3661e-4     $ Ni-62  3.6345%
      28064  6.0256e-5     $ Ni-64  0.9256%
c dry air (typical of American Southwest)
m3     1001  1.7404E-10
       1002  1.3065E-14
       2003  8.3540E-16
       2004  4.5549E-10
       6000  1.11008E-08
       7014  3.8981E-05
       7015  1.3515E-07
       8016  9.1205E-06
       8017  3.4348E-09
      18036  3.0439E-10
      18038  5.3915E-11
      18040  8.0974E-08
      36078  1.7811E-14
      36080  1.1164E-13
      36082  5.6154E-13
      36083  5.49985E-13
      36084  2.69359E-12
      36086  7.98498E-13
      54124  2.30549E-13
mt3    lwtr
c los alamos concrete
m4     1001  0.00842
       8016  0.04423
      13027  0.00252
      14028  0.014690958
      14029  0.000718176
      14030  0.000460866
      11023  0.00105
      20040  2.84037E-03
      20042  1.89571E-05
      20043  3.95550E-06
      20044  6.11198E-05
      20046  1.17200E-07
      20048  5.47910E-06
      26054  0.000041788
      26056  0.000632003
      26057  0.000014347
```

```
      26058  0.000001862
      19039  6.43481E-04
      19040  8.07300E-08
      19041  4.64384E-05
mt4     lwtr
```

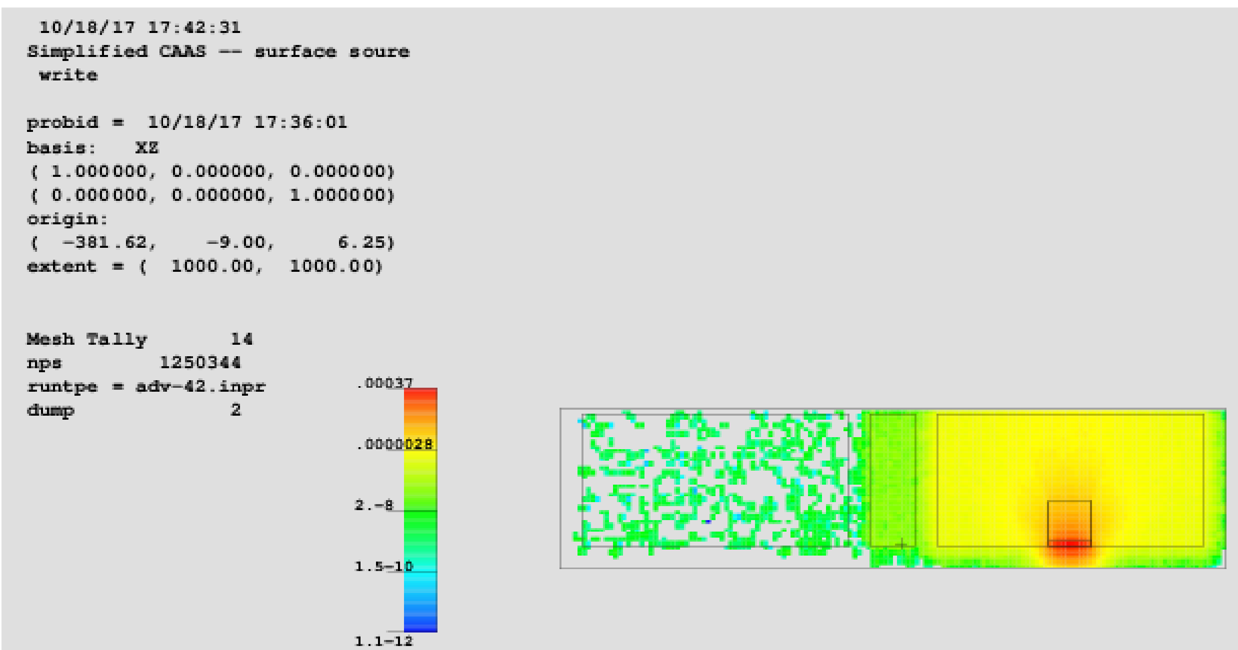
The following mesh plot contains the fission source locations over all of the active cycles.



Below is the flux mesh plot on the XY plane.



And the flux mesh plot now shown on the XZ plane.



Listing 4.12: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0 0 1 0 origin -381.62 -9 6.25 ex 1000
fmesh 14 basis 1 0 0 0 1 0 origin -381.62 -9 6.25 ex 1000
basis 1 0 0 0 0 1 origin -381.62 -9 6.25 ex 1000
file
end
end
```

Surface Source Read

This surface source read example continues the neutron-only criticality fission source. This SSR calculation is a fixed-source neutron-photon problem where the fission reactions are treated as capture reactions and photons are produced from the fission source locations.

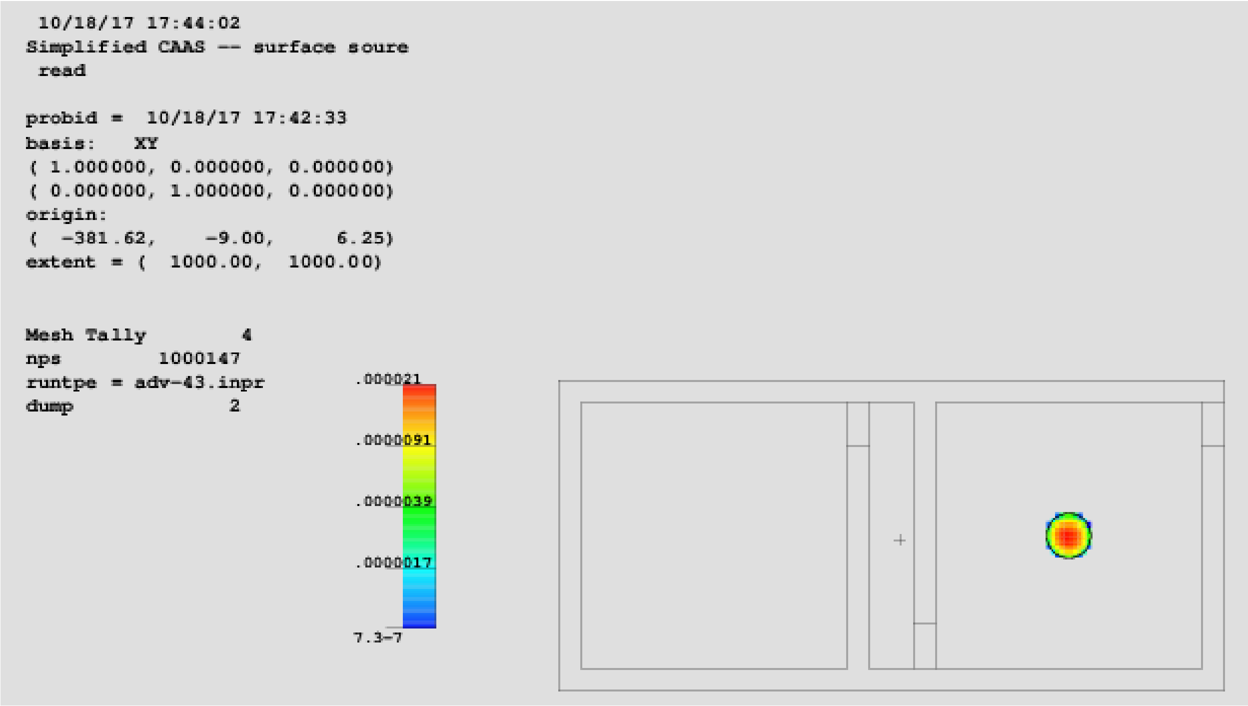
Listing 4.13: MCNP6 Input File

```
Simplified CAAS -- surface soure read
c ### cells
c
c >>>>> accident tank
c
100     1  9.9270e-2     -10 -12                 imp:n=1
101     3  4.8333e-5     -10 +12                 imp:n=1
102     2  8.6360e-2     +10 -11                 imp:n=1
c
c >>>>> facility rooms: nw. -> ne., sw. -> se.
c
200     3  4.8333e-5     -20                     imp:n=1
210     3  4.8333e-5     -21 +11                 imp:n=1
220     3  4.8333e-5     -22                     imp:n=1
c
c >>>>> doorways
c
260     3  4.8333e-5     -30                     imp:n=1
261     3  4.8333e-5     -31                     imp:n=1
262     3  4.8333e-5     -32                     imp:n=1
c
c >>>>> facility and rest of world
c
900     4  0.0764        -99 +20 +21 +22
                             +30 +31 +32         imp:n=1
999     0                +99                     imp:n=0

c ### surfaces
c
c >>>>> critical experiment tank
10    rcc    0  0  1     0  0  100     50
11    rcc    0  0  0     0  0  101    50.5
12    pz     13.6
c
c >>>>> rpp's for the empty space in the rooms
20    rpp   -1100  -500    -300   300    0  300
21    rpp    -300   300    -300   300    0  300
22    rpp    -450  -350    -300   300    0  300
c
c >>>>> doorways
30    rpp    -350  -300    -300  -200    0  250
31    rpp     300   350     200   300    0  250
32    rpp    -500  -450     200   300    0  250
c
c >>>>> building structure
99    rpp   -1150   350    -350   350  -50  310

nps    1E6
mode   n p
nonu   0 10r
```

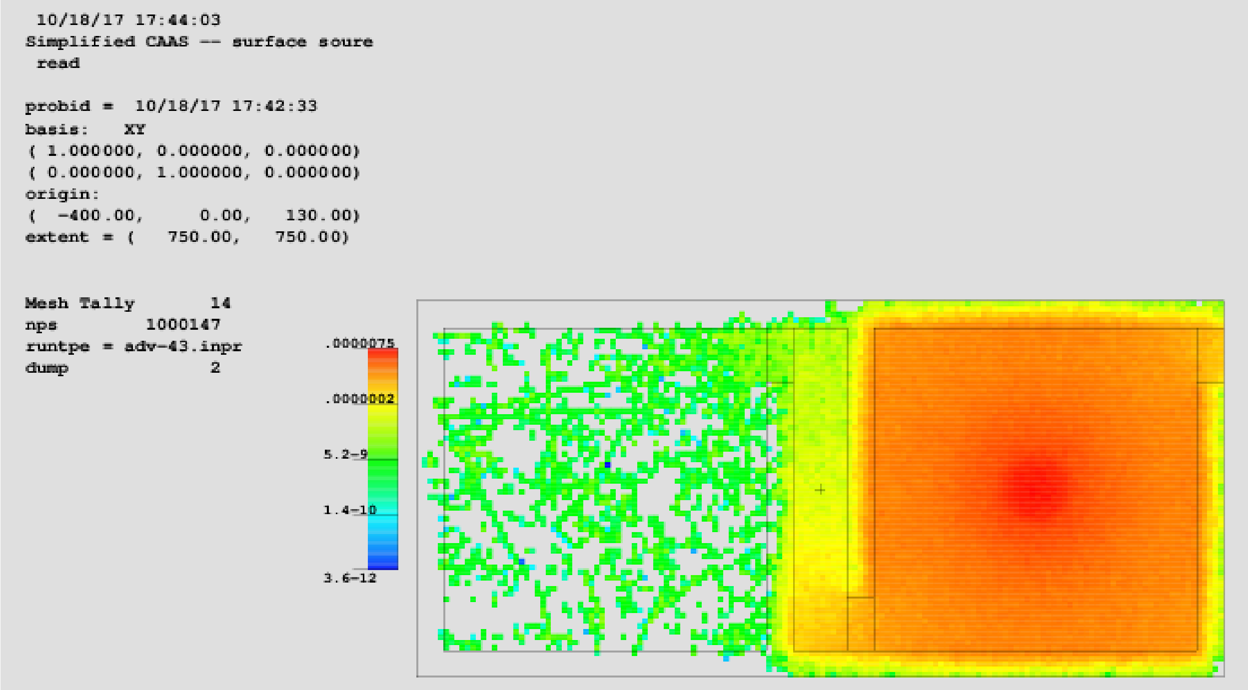
```
c
ssr   cel = 100   psc = 0.5
c
fmesh4:n   geom=xyz origin=-1150 -350 -50
           imesh=350  iints=150
           jmesh=350  jints=70
           kmesh=310  kints=36
           type=source
           out=none
c
fmesh14:n  geom=xyz origin=-1150 -350 -50
           imesh=350  iints=150
           jmesh=350  jints=70
           kmesh=310  kints=36
           out=none
c
fmesh24:p  geom=xyz origin=-1150 -350 -50
           imesh=350  iints=150
           jmesh=350  jints=70
           kmesh=310  kints=36
           out=none
c
print
c ### materials
c plutonium nitrate solution
m1      1001  6.0070e-2
        8016  3.6540e-2
        7014  2.3699e-3
       94239  2.7682e-4
       94240  1.2214e-5
       94241  8.3390e-7
       94242  4.5800e-8
mt1     lwtr
c stainless steel
m2     24050  7.1866e-4     $ Cr-50  4.345%
       24052  1.3859e-2     $ Cr-52 83.789%
       24053  1.5715e-3     $ Cr-53  9.501%
       24054  3.9117e-4     $ Cr-54  2.365%
       26054  3.7005e-3     $ Fe-54  5.845%
       26056  5.8090e-2     $ Fe-56 91.754%
       26057  1.3415e-3     $ Fe-57  2.119%
       26058  1.7853e-4     $ Fe-58  0.282%
       28058  4.4318e-3     $ Ni-58 68.0769%
       28060  1.7071e-3     $ Ni-60 26.2231%
       28061  7.4207e-5     $ Ni-61  1.1399%
       28062  2.3661e-4     $ Ni-62  3.6345%
       28064  6.0256e-5     $ Ni-64  0.9256%
c dry air (typical of American Southwest)
m3      1001  1.7404E-10
        1002  1.3065E-14
        2003  8.3540E-16
        2004  4.5549E-10
        6000  1.11008E-08
        7014  3.8981E-05
        7015  1.3515E-07
        8016  9.1205E-06
        8017  3.4348E-09
       18036  3.0439E-10
```

```
      18038  5.3915E-11
      18040  8.0974E-08
      36078  1.7811E-14
      36080  1.1164E-13
      36082  5.6154E-13
      36083  5.49985E-13
      36084  2.69359E-12
      36086  7.98498E-13
      54124  2.30549E-13
mt3    lwtr
c los alamos concrete
m4     1001  0.00842
       8016  0.04423
      13027  0.00252
      14028  0.014690958
      14029  0.000718176
      14030  0.000460866
      11023  0.00105
      20040  2.84037E-03
      20042  1.89571E-05
      20043  3.95550E-06
      20044  6.11198E-05
      20046  1.17200E-07
      20048  5.47910E-06
      26054  0.000041788
      26056  0.000632003
      26057  0.000014347
      26058  0.000001862
      19039  6.43481E-04
      19040  8.07300E-08
      19041  4.64384E-05
mt4    lwtr
```

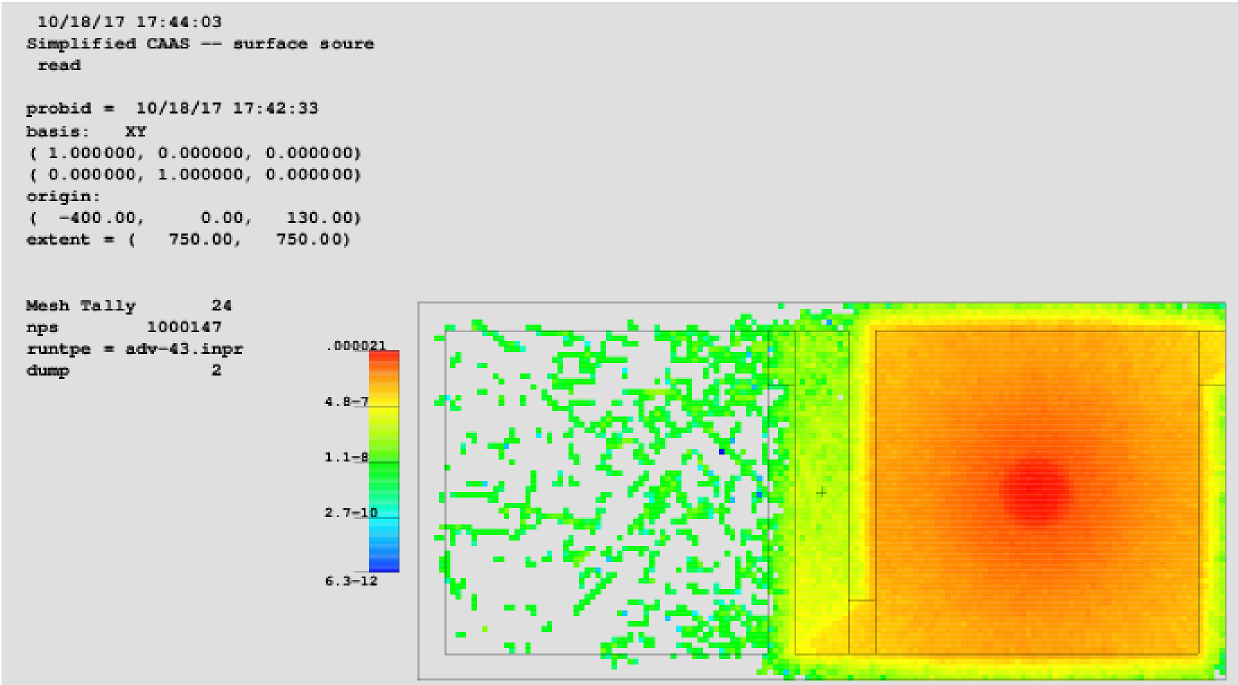
Below is a plot of the neutron source from the SSR file on the XY plane.



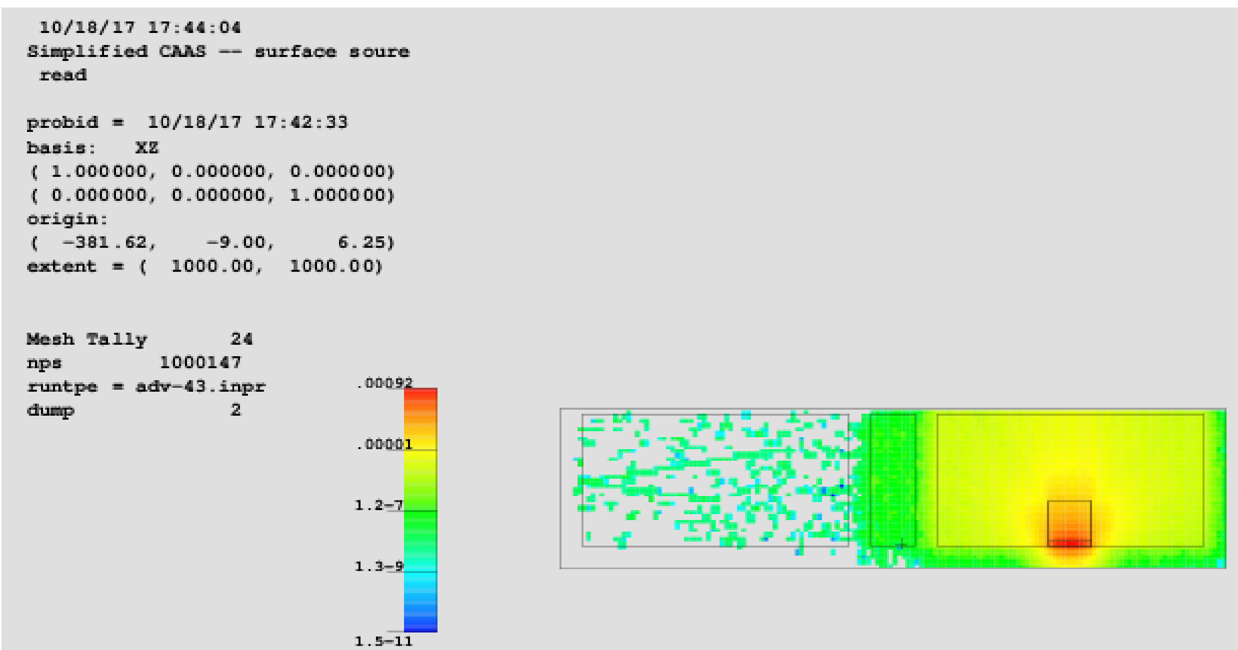
The neutron flux is now shown on the XY plane.



The photon flux is now shown on the XY plane.



The photon flux is now shown on the XZ plane.



Listing 4.14: MCNP6 Plotting Commands

```
fmesh  4
basis 1 0 0 0 1 0 origin -381.62 -9 6.25 ex 1000
fmesh 14
fmesh 24
basis 1 0 0 0 0 1 origin -381.62 -9 6.25 ex 1000
file
end
```

```
end
```

4.2 *Repeated Structure Lattices*

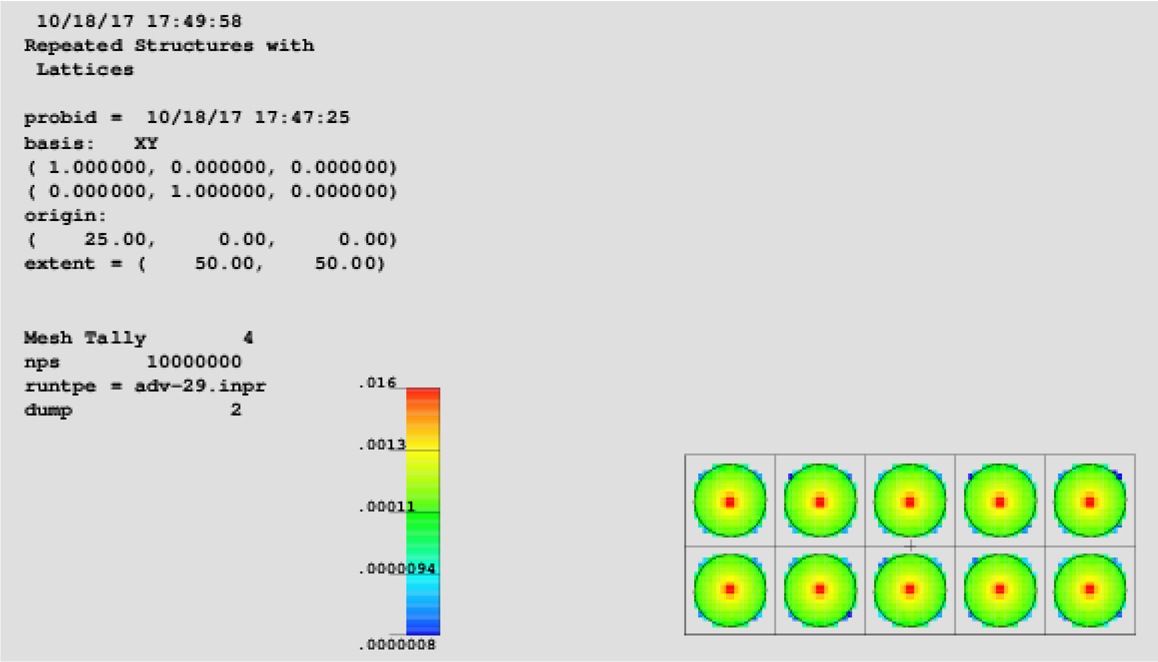
4.2.1 Repeated Structures with Lattice

Repeated structure lattice with uniform (in radius, not volume) spherical source in each sphere.

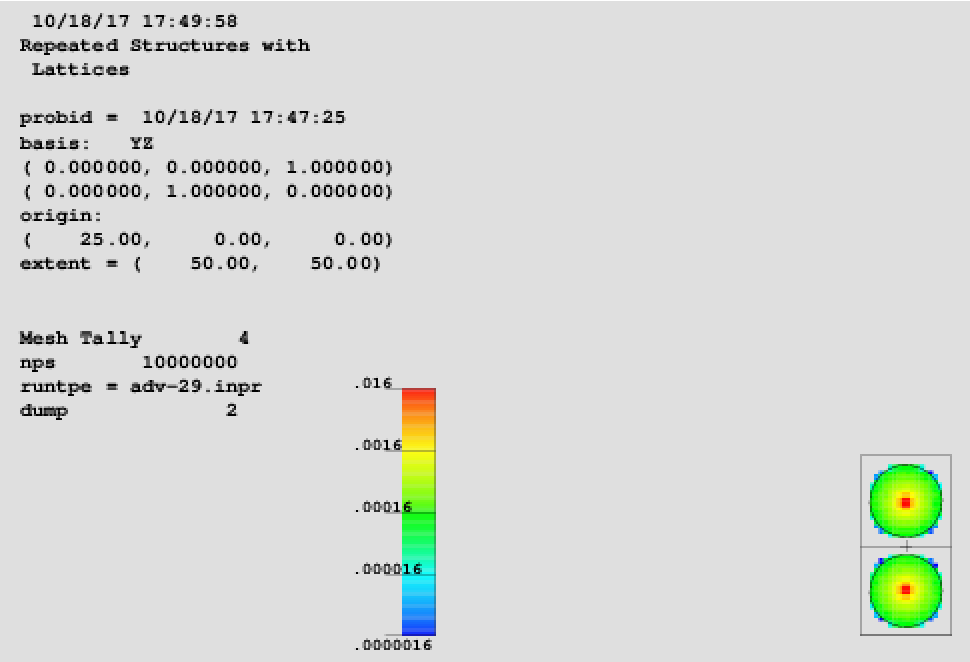
Listing 4.15: MCNP6 Input File

```
Repeated Structures with Lattices
1    0    -20                              FILL=1                IMP:N=1
2    0    -30                      U=1     FILL=2     LAT=1      IMP:N=1
3    0    -11                      U=-2                          IMP:N=1
4    0     11                      U=2                           IMP:N=1
5    0     20                                                    IMP:N=0

20  RPP   0  50 -10  10  -5  5
30  RPP   0  10   0  10   0  0
11  S     5   5   0   4

NPS 1e6
SDEF   RAD=D1  POS=D2
SI1     0  4
SP1     0  1
SI2 L  5 5 0   15 5 0    25 5 0    35 5 0    45 5 0
       5 -5 0  15 -5 0   25 -5 0   35 -5 0   45 -5 0
SP2    1   1   1   1   1   1   1   1    1   1
c
FMESH4:N  GEOM= xyz    ORIGIN= -50.0 -50.0 -50.0
          IMESH= 50.0   IINTS= 200
          JMESH= 50.0   JINTS= 200
          KMESH= 50.0   KINTS= 200
          TYPE=SOURCE
          OUT=NONE
```

Point sources seen inside of spheres of repeated structure on XY plane.



View from YZ plane.



Listing 4.16: MCNP6 Plotting Commands

```
fmesh 4
basis 1 0 0 0 1 0 origin 25 0 0
basis 0 0 1 0 1 0 origin 25 0 0
file
end
end
```

4.2.2 Displacement and Rotational Transformations

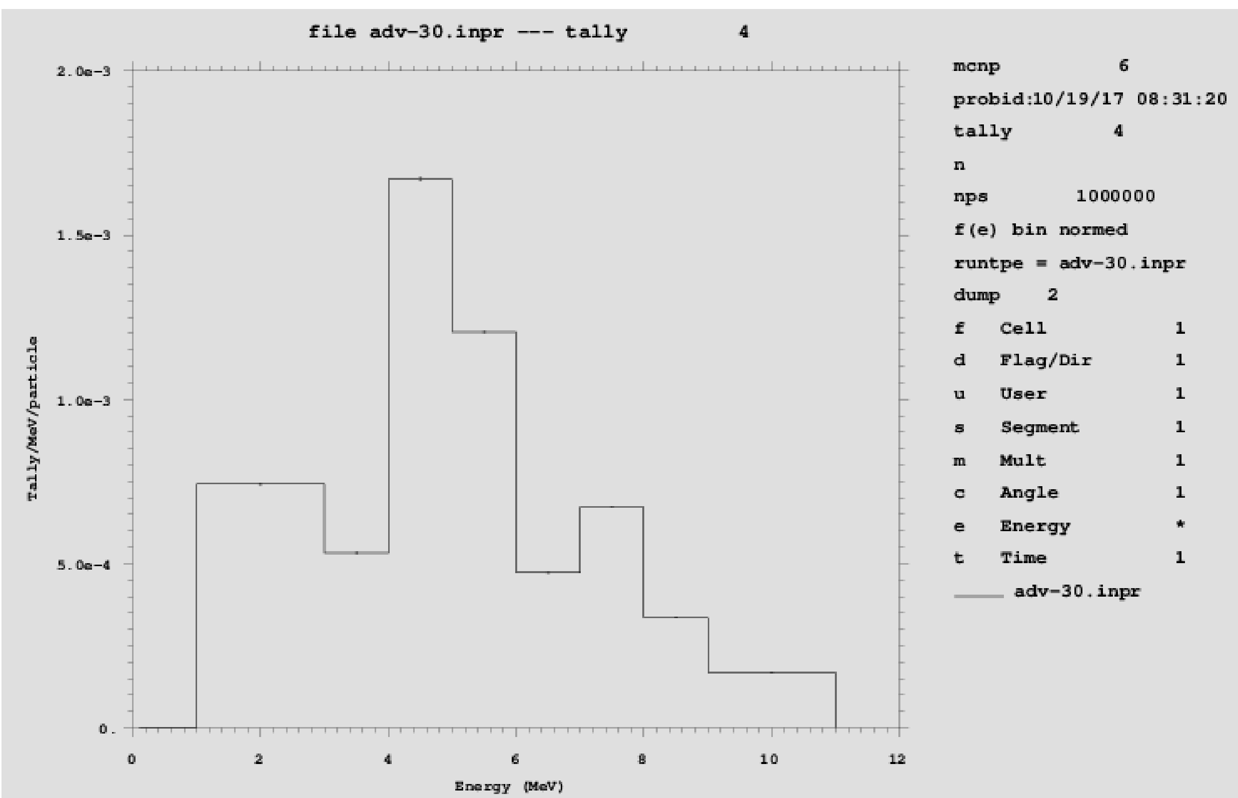
This example contains several LIKE n BUT repeated structures. The sampling of the cells indicated on the cel keyword shows how to obtain uniform sampling in each of the cylindrical pins within the geometry in a shorthand way. This example also contains source energy biasing (SB card) and a VOID card. Taken from the MCNP6 User's Manual, page 5-22 (see *Helpful Links*).

Listing 4.17: MCNP6 Input File

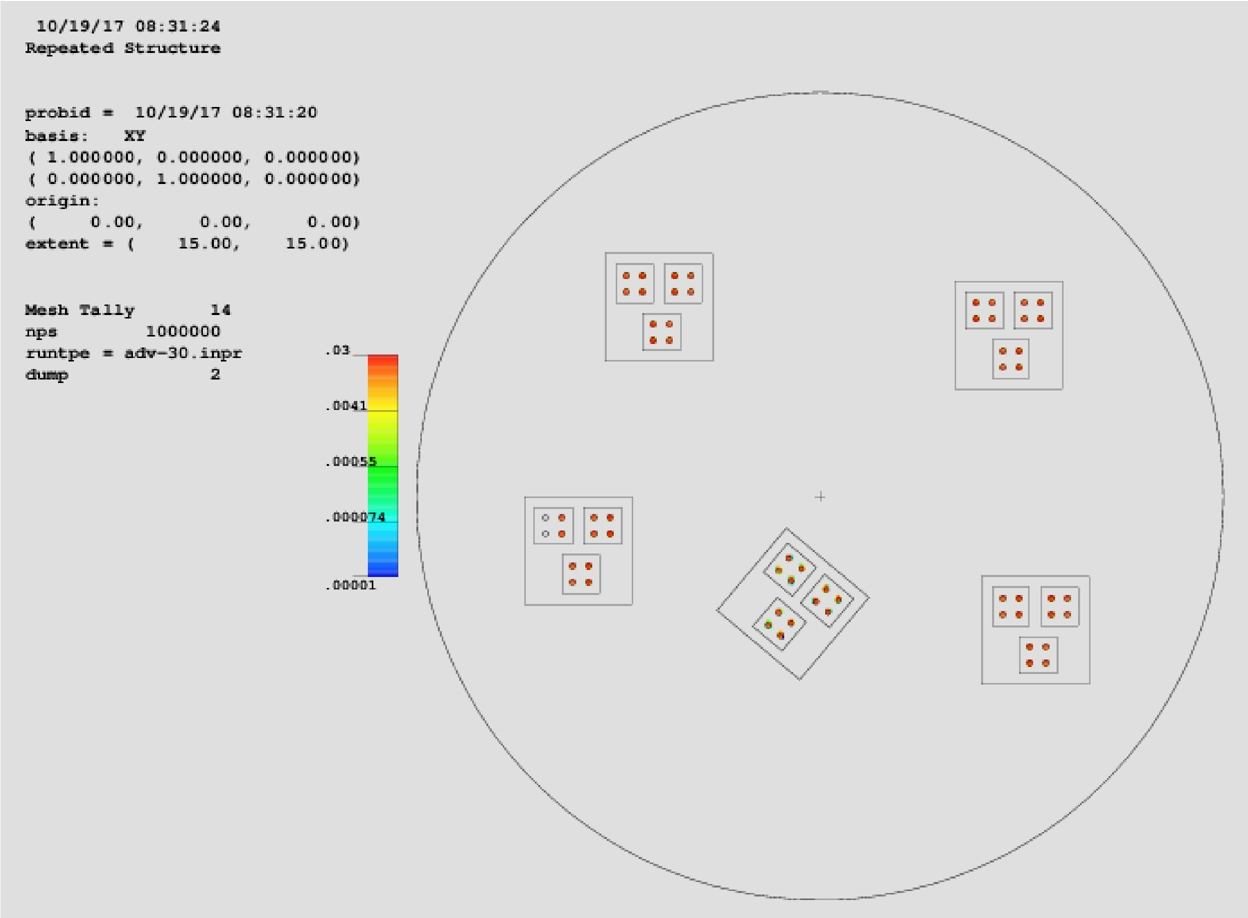
```
Repeated Structure
1   1 -0.5   -7  #2 #3 #4 #5 #6 IMP:N=1
2   0          1 -2 -3 4 5 -6    IMP:N=2 TRCL=2 FILL=1
3   LIKE 2 BUT TRCL=3
4   LIKE 2 BUT TRCL=4
5   LIKE 2 BUT TRCL=5            IMP:N=1
6   LIKE 2 BUT TRCL=6
7   0          7                 IMP:N=0
8   0          8 -9 -10 11 IMP:N=1 TRCL=(-.9 .9 0) FILL=2 U=1
9   LIKE 8 BUT TRCL=(.9 .9 0)
10  LIKE 8 BUT TRCL=(.1 -.9 0)
11  2 -18     #8 #9 #10 IMP:N=1 u=1
12  2 -18    -12 IMP:N=1 TRCL=(-.3 .3 0) U=2
13  LIKE 12 BUT TRCL=( .3  .3 0)
14  LIKE 12 BUT TRCL=( .3 -.3 0)
15  LIKE 12 BUT TRCL=(-.3 -.3 0)
16  1 -0.5  #12 #13 #14 #15 U=2 IMP:N=1

1  PX   -2
2  PY    2
3  PX    2
4  PY   -2
5  PZ   -2
6  PZ    2
7  SO   15
8  PX   -0.7
9  PY    0.7
10 PX    0.7
11 PY   -0.7
12 CZ    0.1

VOID
SDEF  ERG=D1 CEL=D2:D3:0 RAD=D5 EXT=D6 AXS=0 0 1 POS=D7
SI1     1   3     4     5     6     7     8    9     11
SP1     0  0.22  0.08  0.25  0.18  0.07  0.1  0.05  0.05
SB1     0  0.05  0.05  0.1   0.1   0.2   0.2  0.1   0.2
SI2  L  2 3 4 5 6
SP2     1 1 1 1 1
```

```
SI3  L  8  9 10
SP3     1  1  1
SI5    0 0.1
SP5   -21  1
SI6    -2  2
SP6     0  1
SI7 L  0.3 0.3 0  0.3 -0.3 0  -0.3 0.3 0  -0.3 -0.3 0
SP7    1          1            1           1
M1     6000   1
M2     92235  1
TR2    -6  7  1.2
TR3     7  6  1.1
TR4     8 -5  1.4
TR5*   -1 -4  1    40 130 90  50 40 90  90 90 0
TR6    -9 -2  1.3
F4:N    (2 3 4 5 6)
E4      1 3 4 5 6 7 8 9 11
FQ      F E
CUT:N   1E20  0.1
NPS     1000000
FMESH14:N  GEOM= xyz     ORIGIN= -10.0 -10.0 -10.0
           IMESH= 10.0   IINTS= 400
           JMESH= 10.0   JINTS= 400
           KMESH= 10.0   KINTS= 1
           TYPE=SOURCE
           OUT=NONE
PRINT
```

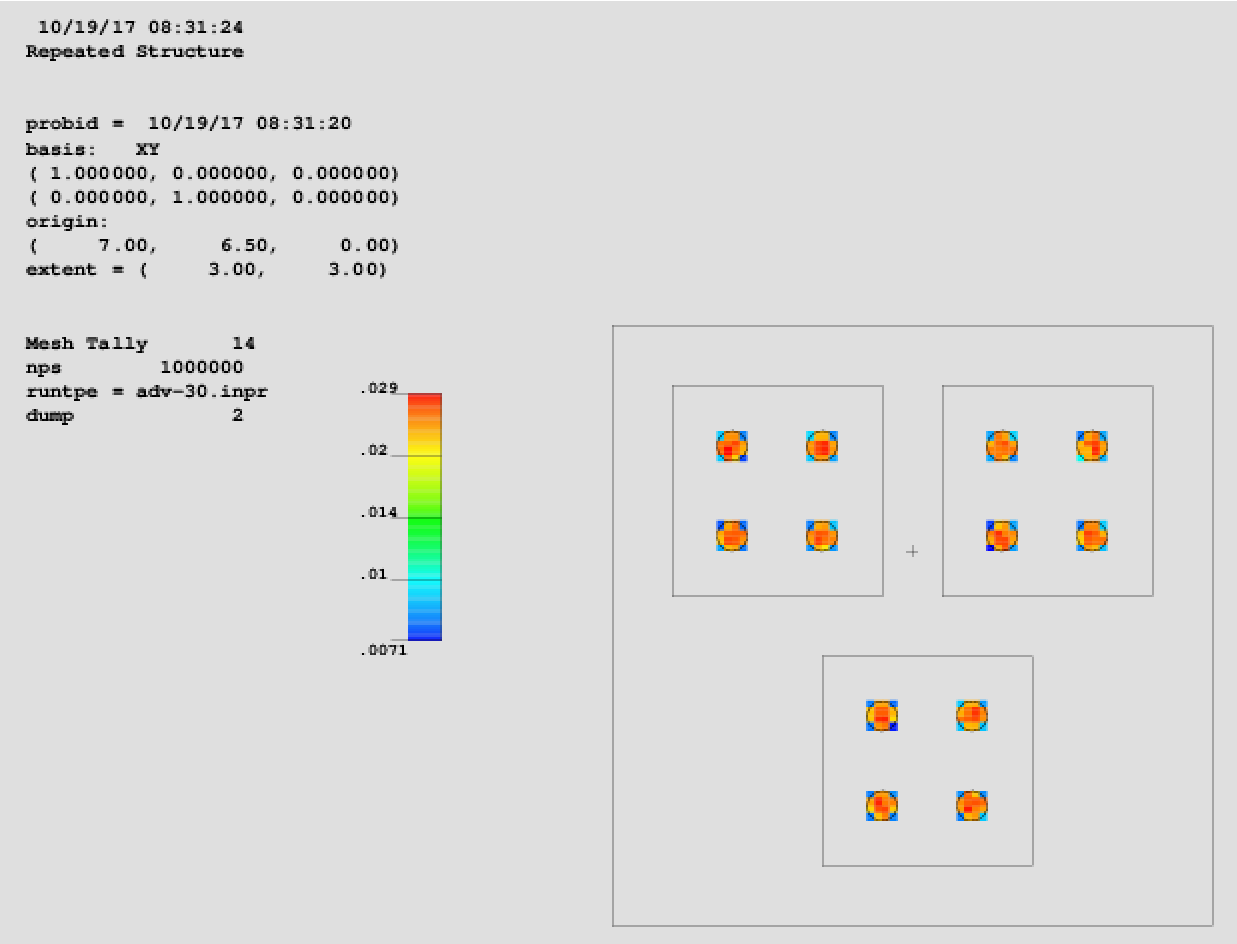
Energy distribution of the cells can be seen below.



The source mesh plot in the XY plane of the five level 0 cells 2-6 each with three level 1 cells 8-10 each containing four level 2 cells 12-15.



Closer view of the source mesh plot in the XY plane of cell 3.



Listing 4.18: MCNP6 Plotting Commands

```
tal 4 linlin
fmesh 14
basis 1 0 0  0 1 0 ex 15 la 0
basis 1 0 0 0 1 0 origin 7 6.5 0 ex 3
file
end
end
```

4.2.3 Lattices with Dependence on Sampled Cell

This example, modified from the example in the MCNP6 User's Manual, page 5-33 (see *Helpful Links*), consists of several source variables dependent on the selected cell. The selected cell is sampled from 4 separate distributions, all with lattice descriptions and some specific elements given.

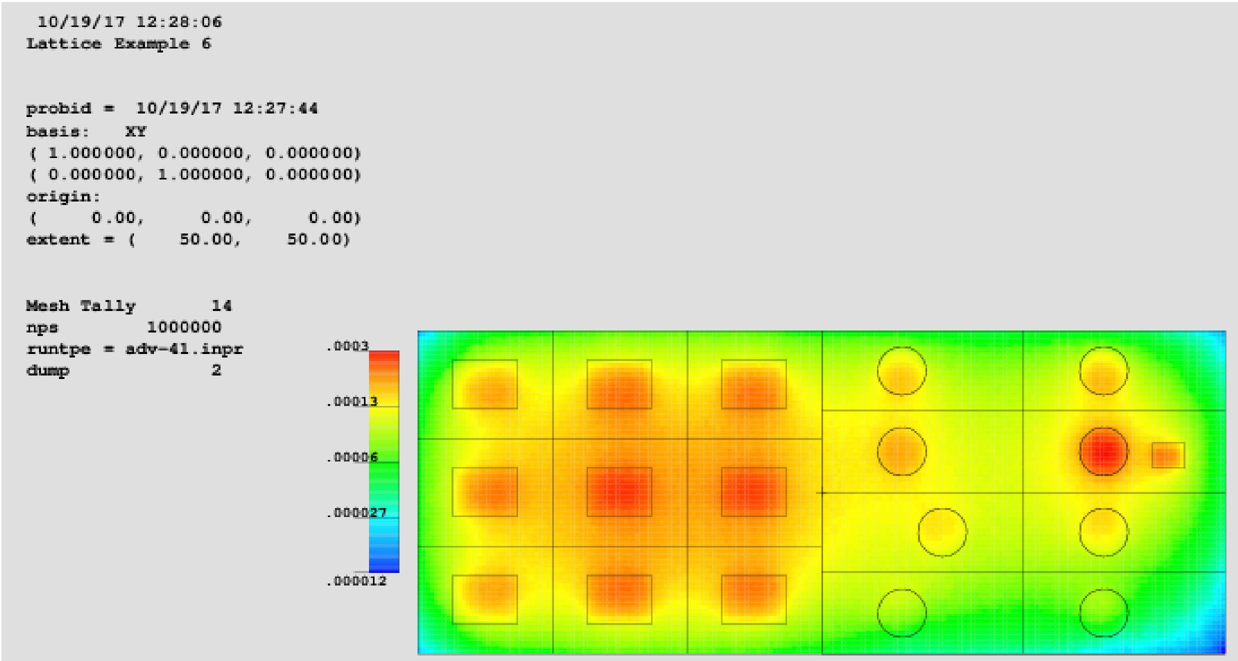
Listing 4.19: MCNP6 Input File

```
Lattice Example 6
1  0         1:-3:-4:5:6:-7    imp:n=0
2  0        -2  3   4 -5 -6  7 imp:n=1 fill=1 (-25 0 0)
3  0        -1  2   4 -5 -6  7 imp:n=1 fill=2 (0 -20 0)
4  0       -11 12 -14 13       imp:n=1 lat=1 u=1 fill=-1:1 -1:1 0:0 3 8r
5  3  -1.0 -15  2 -18 17       imp:n=1 lat=1 u=2
```

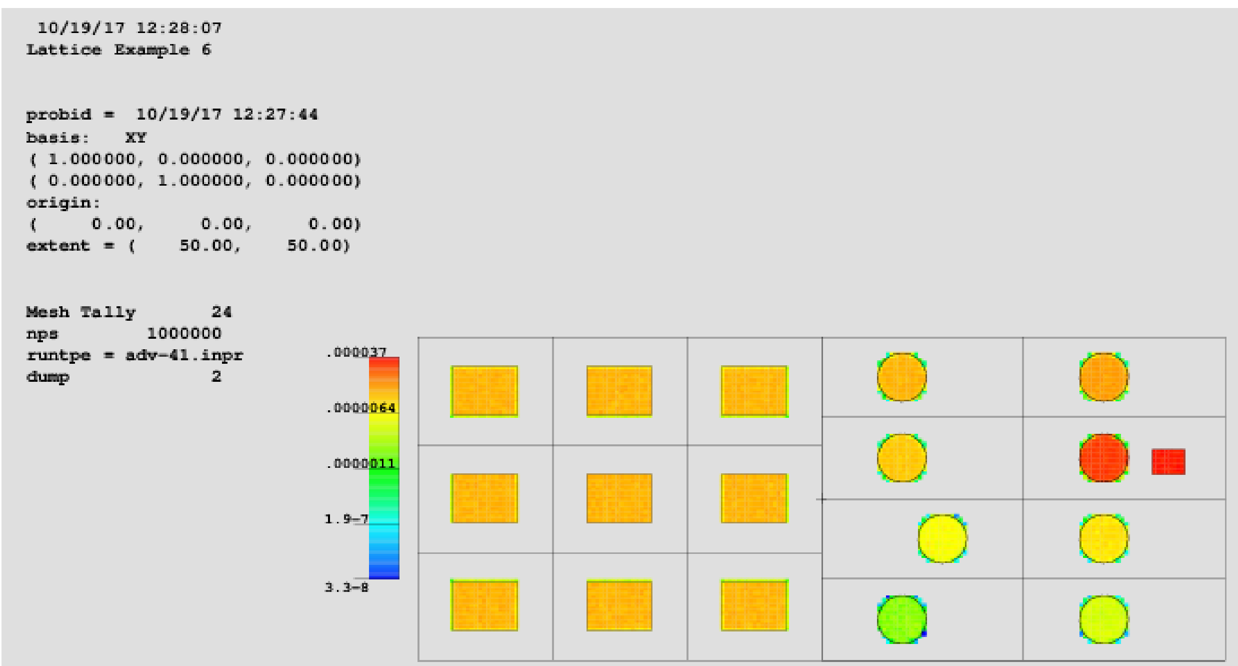
```
            fill=0:1 0:3 0:0  4 4 4(5 0 0) 4 4 5 4 4
6  1  -0.9  21:-22:-23:24      imp:n=1 u=3
7  1  -0.9  19                 imp:n=1 u=4
8  2  -18   -21 22 23 -24      imp:n=1 u=3
9  1  -0.9  20(31:-32:-33:34)  imp:n=1 u=5
11 2  -18   -19                imp:n=1 u=4
13 2  -18   -20                imp:n=1 u=5
15 2  -18   -31 32 33 -34      imp:n=1 u=5

1 px   50
2 px    0
3 px  -50
4 py  -20
5 py   20
6 pz   60
7 pz  -60
11 px   8.334
12 px  -8.334
13 py  -6.67
14 py   6.67
15 px  25
17 py   0
18 py  10
19 c/z 10 5 3
20 c/z 10 5 3
21 px   4
22 px  -4
23 py  -3
24 py   3
31 px  20
32 px  16
33 py   3
34 py   6

m1    6000 0.4   8016 0.2   11023 0.2   29000 0.2
m2   92238 0.98 92235 0.02
m3    1001 1
sdef  erg fcel d1 x fcel d11 y fcel d13 z fcel d15 cel d6
      rad fcel d17 ext fcel d19 pos fcel d21 axs fcel d23
ds1     s  d2 d3 d4 d5
sp2        -2 1.2
sp3        -2 1.3
sp4        -2 1.4
sp5        -2 1.42
si6     s  d7 d8 d9 d10
sp6        0.65 0.2 0.1 0.05
si7     l  2:4:8
sp7        1
si8     l  3:5(0 0 0):11 3:5(1 0 0):11 3:5(0 1 0):11 3:5(1 1 0):11
           3:5(0 2 0):11 3:5(0 3 0):11 3:5(1 3 0):11
sp8        1 2 3 4 5 6 7
si9     l  3:5(1 2 0):13
sp9        1
si10    l  3:5(1 2 0):15
sp10       1
ds11    s  d12 0 0 d25
si12       -4 4
sp12        0 1
```

```
ds13    s  d14 0 0 d26
si14       -3 3
sp14        0 1
ds15    s  d16 0 0 d16
si16      -60 60
sp16        0 1
ds17    s  0 d18 d18 0
si18       0 3
sp18     -21 1
ds19    s  0 d20 d20 0
si20     -60 60
sp20       0 1
ds21    s  0 d22 d22 0
si22    l  10 5 0
sp22       1
ds23    s  0 d24 d24 0
si24    l  0 0 1
sp24       1
si25       16 20
sp25       0 1
si26       3 6
sp26       0 1
f2:n   1
e2     0.1 1 20
f6:n   2 4 6 8 3 5 7 9 11 13 15
sd6    1 1 1 1 1 1 1 1 1 1 1
print
nps 1E6
c tallies
FMESH14:N  GEOM= xyz    ORIGIN= -50.0 -20.0 -60.0
           IMESH= 50.0   IINTS= 200
           JMESH= 20.0   JINTS=  80
           KMESH= 60.0   KINTS=   1
           OUT=NONE
FMESH24:N  GEOM= xyz    ORIGIN= -50.0 -20.0 -60.0
           IMESH= 50.0   IINTS= 200
           JMESH= 20.0   JINTS=  80
           KMESH= 60.0   KINTS=   1
           TYPE=SOURCE
           OUT=NONE
FMESH34:N  GEOM= xyz    ORIGIN= -50.0 -20.0 -60.0
           IMESH= 50.0   IINTS= 200
           JMESH= 20.0   JINTS=   1
           KMESH= 60.0   KINTS= 200
           TYPE=SOURCE
           OUT=NONE
```

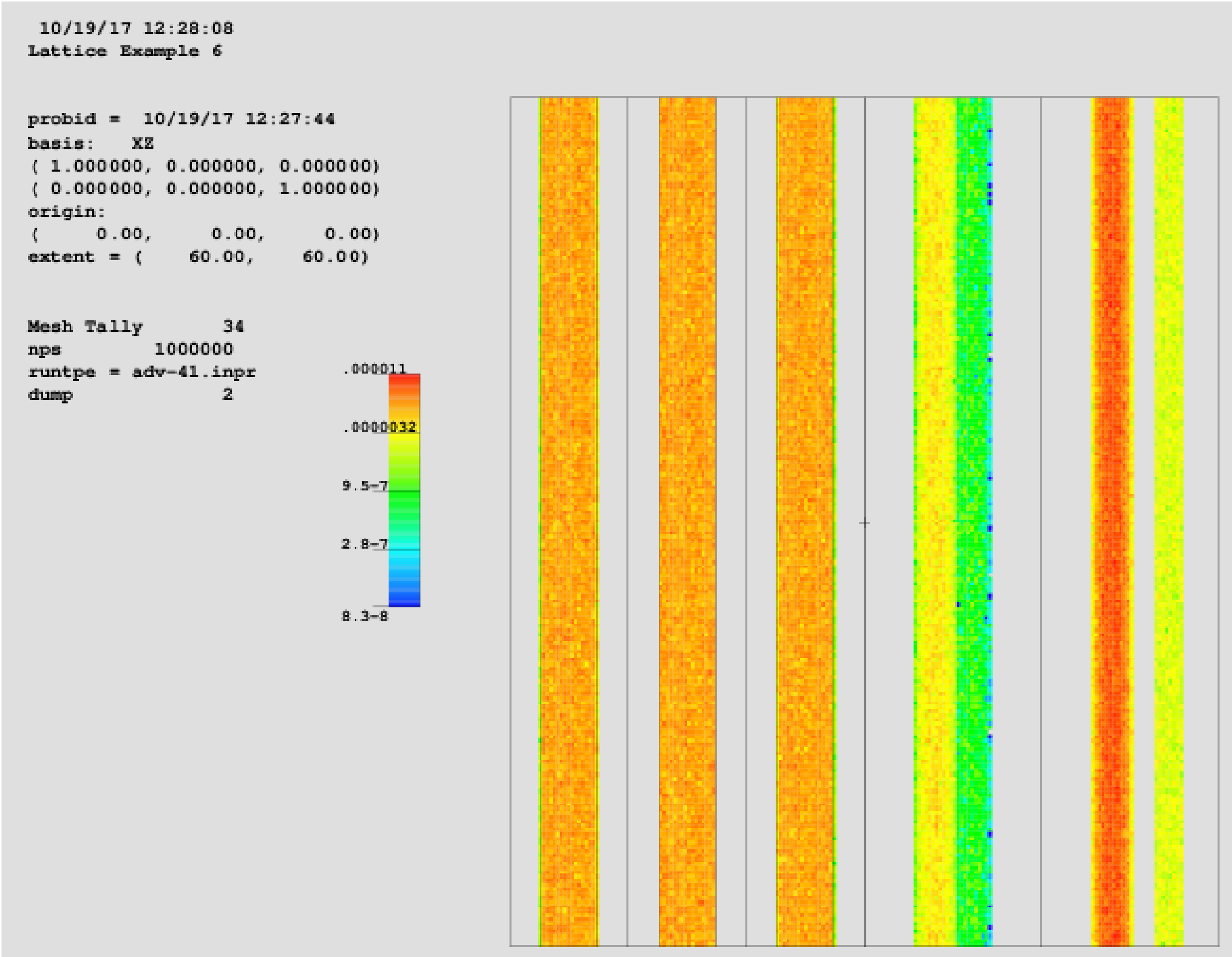
Below is a plot of the flux in the XY plane.



Below is a plot of the source in the XY plane.



Below is a plot of the source in the XZ plane.



Listing 4.20: MCNP6 Plotting Commands

```
fmesh 14
basis 1 0 0 0 1 0
fmesh 24
fmesh 34 basis 1 0 0 0 0 1
file
end
end
```

CHAPTER

FIVE

KNOWN SOURCE ERRORS

Dependent source variable combinations that do not work together.

5.1 *Fatal Error Given*

5.1.1 Axis as a Function of Position

The axis (AXS) variable cannot be a function of position (POS).

Listing 5.1: MCNP6 Input File

```
SDEF TESTING
10      1  1E-6  -1          IMP:N=1  $  inside sphere 1
20      1  1E-6  -2          IMP:N=1  $  inside sphere 2
30      1  1E-6  -3          IMP:N=1  $  inside sphere 3
40      1  1E-6  -4          IMP:N=1  $  inside sphere 4
50      2  1E-6  -5 1 2 3 4  IMP:N=1  $  inside box
99      0         5          IMP:N=0  $  outside

1  S   2.5 2.5 0 0.5
2  S   7.5 2.5 0 0.5
3  S   2.5 7.5 0 0.5
4  S   7.5 7.5 0 0.5
5  RPP 0 10 0 10 -1 1

MODE N
NPS 1e6
PRINT
c
M1     92235 1
M2     8016  1
       1001  2
c
FMESH4:N  GEOM=XYZ  ORIGIN=0 0 -1
          IMESH=10  IINTS=200
          JMESH=10  JINTS=200
          KMESH=1   KINTS=1
          TYPE=SOURCE
c
SDEF  POS=D1  AXS=FPOS=D2  EXT=D7  RAD=D8
c
SI1 L 2.5 2.5 -0.1      $ POS distribution
      7.5 2.5 -0.1
```

```
      2.5 7.5 -0.1
      7.5 7.5 -0.1
SP1   1 1 1 1
c
DS2 S 3 4 5 6
c
SI3 L 0 0 1
SP3 1
c
SI4 L 0 1 0
SP4 1
c
SI5 L 1 0 0
SP5 1
c
SI6 L 1 1 1
SP6 1
c
SI7  0 0.2
SP7 0 1
c
SI8  0 0.5
SP8 -21 1
```

Below is the fatal error MCNP will give with the AXS=FPOS dependent variable in the input file.

```
         Code Name & Version = MCNP6, 1.0
         Copyright LANS/LANL/DOE - see output file

    _/      _/        _/_/_/       _/      _/       _/_/_/         _/_/_/
   _/_/  _/_/      _/            _/_/    _/       _/    _/     _/
  _/  _/  _/      _/            _/  _/  _/       _/_/_/       _/_/_/
 _/      _/      _/            _/    _/_/       _/           _/    _/
_/      _/        _/_/_/      _/      _/       _/             _/_/

 warning.  Physics models disabled.

 comment.  total nubar used if fissionable isotopes are present.
 fatal error.  impossible source variable dependencies.
 warning.    1 materials had unnormalized fractions. print table 40.
comment. using random number generator  1, initial seed = 19073486328125
imcn   is done

xact   is done

mcnp     ver=6    , ld=05/28/13  08/01/17 08:27:36
         Code Name & Version = MCNP6, 1.0
         Copyright LANS/LANL/DOE - see output file
```

5.1.2 Surface as a Function of Position

The surface (SUR) variable cannot be a function of position (POS).

Listing 5.2: MCNP6 Input File

```
SDEF TESTING
10     1  1E-6  -1          IMP:N=1  $  inside sphere 1
20     1  1E-6  -2          IMP:N=1  $  inside sphere 2
30     1  1E-6  -3          IMP:N=1  $  inside sphere 3
40     1  1E-6  -4          IMP:N=1  $  inside sphere 4
50     2  1E-6  -5 1 2 3 4  IMP:N=1  $  inside box
99     0         5          IMP:N=0  $  outside

1  S   2.5 2.5 0 0.5
2  S   7.5 2.5 0 0.5
3  S   2.5 7.5 0 0.5
4  S   7.5 7.5 0 0.5
5  RPP 0 10 0 10 -1 1

MODE N
NPS 1e6
PRINT
c
M1    92235 1
M2    8016  1
      1001  2
c
FMESH4:N  GEOM=XYZ  ORIGIN=0 0 -1
          IMESH=10  IINTS=100
          JMESH=10  JINTS=100
          KMESH=1   KINTS=1
          TYPE=SOURCE
c
SDEF  POS=D1  SUR=FPOS=D2  RAD=D7
c
SI1 L 2.5 2.5 0      $ POS distribution
      7.5 2.5 0
      2.5 7.5 0
      7.5 7.5 0
SP1   1 3 5 10
c
DS2 S 3 4 5 6
c
SI3 L 1
SP3    1
c
SI4 L 2
SP4    1
c
SI5 L 3
SP5    1
c
SI6 L 4
SP6    1
c
SI7 L 0.5
SP7    1
```

Below is the fatal error MCNP will give with the SUR=FPOS dependent variable in the input file.

```
         Code Name & Version = MCNP6, 1.0
         Copyright LANS/LANL/DOE - see output file

    _/      _/        _/_/_/       _/      _/       _/_/_/         _/_/_/
   _/_/   _/_/     _/             _/_/    _/       _/    _/     _/
  _/  _/  _/      _/             _/  _/  _/       _/_/_/       _/_/_/
 _/      _/      _/             _/    _/_/       _/           _/    _/
_/      _/        _/_/_/       _/      _/       _/             _/_/

 warning.  Physics models disabled.

 comment.  total nubar used if fissionable isotopes are present.
 fatal error.  impossible source variable dependencies.
 warning.    1 materials had unnormalized fractions. print table 40.
comment. using random number generator  1, initial seed = 19073486328125
imcn   is done

xact   is done

mcnp     ver=6    , ld=05/28/13  08/01/17 08:27:36
         Code Name & Version = MCNP6, 1.0
         Copyright LANS/LANL/DOE - see output file
```

5.2 *No Fatal Error Given*