LA-UR-14-21281
Approved for public release; distribution is unlimited.

Title:	MCNP6 Class
Author(s):	Hughes, H. Grady III James, Michael R.
Intended for:	MCNP6 class at Alabama Agricultural and Mechanical University, March 3 - 7, 2014.
Issued:	2014-02-27

Pages 223-282 only:

Advanced Tallies

- **PTRAC**
- **FM, F8, FTn (CAP, PHL, TAG)**
- **F5, FY5, mesh, radiography**

Advanced Tallies

Additional Tally Capabilities

- Particle Tracks (PTRAC)
- Reaction Multipliers (FM)
- Pulse Height (F8)
- Special Treatments (FTn)
  - Neutron Capture (CAP)
  - Pulse-Height Light (PHL)
  - Tally Tagging (TAG)
- Next Event: Point (F5), Ring (FY5)
- Special Tallies
  - Mesh Tallies
  - Radiography

PTRAC – Particle Tracks

PTRAC enables writing particles to a file for post-processing

- **Useful for particle track plotting in MORITZ**
- **Useful for post-processing using various filters**

PTRAC differs from SSW / SSR:

- **Filters events**
- **Can be ascii**

PTRAC format:

PTRAC KEYWORD=*value(s)* …

Example:

PTRAC **FILE=*asc* WRITE=*all* EVENT=*sur* MAX=*50000***

PTRAC – Particle Tracks

PTRAC Options:

FILE = asc or bin	(default=bin)
MAX = maximum number of events	(default=10000)
WRITE = pos or all	pos=x,y,z (default)
	all=x,y,z,u,v,w,E,W,T
EVENT = src, bnk, col, sur, ter, cap	(default=all)
TYPE = p, p, p, …	particle types n, p, …
FILTER = values,parameter …	
= 2,ICL	(cell 2)
= .001,14.0,E	(.001 < E < 14.0)

History Filter Keywords:

NPS, CELL, SURFACE, TALLY, VALUE

… only write PTRAC events to particles in NPS range, passing through cells in CELL list, crossing surfaces in SURFACE list, contributing to tallies in TALLY list, etc.

Los Alamos
NATIONAL LABORATORY
EST. 1943

Exercise 1

copy c:\MCNP6\EXAMPLES\atal1

Check that the following line is present

PTRAC* FILE=*asc* WRITE=*all

Run the problem and examine output.

mcnp6 i=tal1

Exercise 1 - PTRAC output

See Appendix F in MCNP6 Manual

```
 -1
mcnp     6                        01/15/14 02/03/14 11:50:33
tal3 - PTRAC Example
   1.4000E+01  1.0000E+00  1.0000E+02  0.0000E+00  0.0000E+00  1.0000E+00  1.0000E+00  0.0000E+00  1.0000E+00  1.0000E+04
   0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  1.0000E+00  2.0000E+00  0.0000E+00  0.0000E+00
     2     7     9     8     9     8     9     8     9     8     9     0     4     0     0     0     0     0     0     0
    1    2    7    8    9   16   17   18   19   20   21   22   23   24   25   26   27   28    7    8   10   11   16   17   18   19   20   21   22   23
   24   25   26   27   28    7    8   12   13   16   17   18   19   20   21   22   23   24   25   26   27   28    7    8   10   11   16   17   18   19
   20   21   22   23   24   25   26   27   28    7    8   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28
          1        1000
       3000           1          40           2           3           0           0
  -0.20000E+01  0.00000E+00  0.00000E+00  0.10000E+01  0.00000E+00  0.00000E+00  0.20000E+01  0.10000E+01  0.00000E+00
       3000           2         2.2         179           2           2           2           0
  -0.11000E+01  0.00000E+00  0.00000E+00  0.10000E+01  0.00000E+00  0.00000E+00  0.20000E+01  0.10000E+01  0.30021E-02
       4000           3         1.2         179           2           1           1           0
  -0.10000E+01  0.00000E+00  0.00000E+00  0.10000E+01  0.00000E+00  0.00000E+00  0.20000E+01  0.10000E+01  0.33356E-02
       4000           3        3000          -1           2           1           1           1
  -0.31983E+00  0.00000E+00  0.00000E+00 -0.92576E-01  0.94706E+00 -0.30743E+00  0.37435E+00  0.10000E+01  0.56044E-02
       4000           3        3000          -1           2           1           1           2
  -0.34593E+00  0.26700E+00 -0.86672E-01 -0.48678E+00 -0.51751E+00  0.70372E+00  0.17852E+00  0.10000E+01  0.65448E-02
       5000           3        3000          -3           2           1           1           3
  -0.47352E+00  0.13135E+00  0.97781E-01 -0.48678E+00 -0.51751E+00  0.70372E+00  0.17852E+00  0.10000E+01  0.74191E-02
       2011           3          12           1           2           1           1           3
  -0.47352E+00  0.13135E+00  0.97781E-01 -0.48678E+00 -0.51751E+00  0.70372E+00  0.17852E+00  0.10000E+01  0.74191E-02
. . .
```

Header

Particle track information

Exercise 1 - PTRAC output

```
 -1
mcnp     6                       01/15/14 02/03/14 11:50:33
tal3 - PTRAC Example
```

Code Version, Run ID and Title

BUFFER=100 **FILE=ASC** **MAX=10000**

```
 1.4000E+01  1.0000E+00  1.0000E+02  0.0000E+00  0.0000E+00  1.0000E+00  1.0000E+00  0.0000E+00  1.0000E+00  1.0000E+04
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  1.0000E+00  2.0000E+00  0.0000E+00  0.0000E+00
```

WRITE=ALL

PTRAC settings echoed

Number of variables listed on given lines

```
  2    7    9    8    9    8    9    8    9    8    9    0    4    0    0    0    0    0    0    0
```

Types of variables listed on given lines

nps src bnk

```
 1   2   7   8   9  16  17  18  19  20  21  22  23  24  25  26  27  28   7   8  10  11  16  17  18  19  20  21  22  23
24  25  26  27  28   7   8  12  13  16  17  18  19  20  21  22  23  24  25  26  27  28   7   8  10  11  16  17  18  19
20  21  22  23  24  25  26  27  28   7   8  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28
```

sur col ter

Exercise 1 - PTRAC output

See Appendix F in MCNP6 Manual

1 Event node nsr particle cell material ncp

x y z u v w energy weight time

-0 ... 0000E+01 0.10000E+01 0.00000E+00

Event node surface angle particle cell material ncp

3000 2 2.2 179 2 2 2 0

sur Line (7 8 12 13 16 17 18 19)
(20 21 22 23 24 25 26 27 28)

-0.11000E+01 0.00000E+00 0.00000E+00 0.10000E+01 0.00000E+00 0.00000E+00 0.20000E+01 0.10000E+01 0.30021E-02

4000 3 1.2 179 2 1 1 0

-0 ... 01 0.10000E+01 0.33356E-02

Event node ZA MTP particle cell material ncp

4000 3 3000 -1 2 1 1 1

col Line (7 8 10 11 16 17 18 19)
(20 21 22 23 24 25 26 27 28)

-0.31983E+00 0.00000E+00 0.00000E+00 -0.92576E-01 0.94706E+00 -0.30743E+00 0.37435E+00 0.10000E+01 0.56044E-02

.
.
.

Event node nter branch particle cell material ncp

ter Line (7 8 14 15 16 17 18 19)
(20 12 22 23 24 25 26 27 28)

- ... +00 0.10000E+01 0.74191E-02

Event node ZA NTYN particle cell material ncp

5000 4 32000 3 3 1 1 3

bnk Line (7 8 10 11 16 17 18 19)
(20 21 22 23 24 25 26 27 28)

-0.47352E+00 0.13135E+00 0.97781E-01 -0.18214E+00 0.77149E-01 0.98024E+00 0.17852E+00 0.10000E+01 0.74191E-02

Los Alamos NATIONAL LABORATORY EST. 1943

Reaction Multipliers (FM)

Form: FMn (C_1 m_1 R_1) (C_2 m_2 R_2) . . . T

n = tally number

C_i = multiplicative constant (if -1 for n=4, use cell ρ_a)

m_i = material number identified on an Mm card

R_i = a combination of ENDF reaction numbers

What It Does:

$$C \cdot \int \Phi(E) R_m(E)\, dE$$

Common Neutron R Values

-1 = total cross section

-2 = absorption

-4 = heating (MeV/collision)

-6 = fission cross-section

-7 = fission ν

-8 = fission Q (MeV/fission)

FM Reaction Values

NEUTRONS

1	Total
-2	Absorption
-4	Heating
-5	gamma prod’n
-6	total fission
-7	fission v
-8	fission Q
16	(n,2n)
17	(n,3n)
18	(n,fx)

PHOTONS

-1	incoherent
-2	coherent
-3	photoelectric
-4	pair production
-5	total
-6	heating
1	PN total
2	PN non-elastic
3	PN elastic
4	PN heating
> 4	PN other rxns.
I00R	PN particle I from rxn. R

PROTONS

1	total
2	non-elastic
3	elastic
4	heating
>4	other rxns.
I00R	particle I from rxn. R

Examples of FM

```
F2:N   1 2                      $ 36 tally bins
FM2    (1.0) (2.0) (3.0)        $ Constant multipliers
E2     .5 1 2 4 10 T            $ Energy bins

F4:N   (1 2) 3 T                $ 6 tally bins
FM4    (-1 1 -6 -7)             $ Track-length estimate of keff
       (-1 2  1 -4)             $ Neutron Heating (MeV/cm3)
```

Pulse Height Tally

F8:<*pl*> $C_1 \ldots C_n$

- **Different from all other tallies**
  - Surface estimator of cell energy deposition
  - Can use variance reduction with F8
  - Energy is accumulated from all tracks of a particle's history
- **Mimics pulse-height detectors: energy bins contain pulses**
  - Energy <0: non-analog negative score balance
  - Energy ~ 0: particles pass through without energy loss
  - Energy > 0: pulse of W put into appropriate energy bin

Exercise 2: Pulse Height Tallies

copy c:\MCNP6\EXAMPLES\atal2

- Use energy bins 0 1.e-6 0.1 199i 2.0
- Do a pulse-height tally (F8) in H2O
- Run the problem.

mcnp6 i=tal2 n=tal2a.

- Examine output file summary table.
- Plot tally 8 results.

Exercise 2: Pulse Height Tallies

- Change radius from 10000 to 10 cm
- Run the problem.

  mcnp6 i=tal2 n=tal2b.

- Examine output file summary table and Plot tally 8.
- What is different and why?

- Repeat the last two steps with “mode p e” and F8:e instead of F8:p.

Exercise 2: Pulse Height Tallies

copy c:\MCNP6\EXAMPLES\atal2

- Use energy bins 0 1.e-6 0.1 199i 2.0
- Do a pulse-height tally (F8) in H2O
- Do an energy-deposition pulse-height tally (*F8)
- Do energy deposition (F6) and equivalent FM4 energy deposition
- Do +F6 energy deposition
- Plot the tallies

Exercise 3: Pulse Height Tallies

copy c:\MCNP6\EXAMPLES\atal3

- Use energy bins 0 1.e-6 .001 .01 .1 100ilog 101
- Do a pulse-height tally (F8) in H2O
- Do an energy-deposition pulse-height tally (*F8)
- Do energy deposition (F6) and equivalent FM4 energy deposition
- Do +F6 energy deposition
- Plot the tallies

Tally Treatments (FT)

Form: **FTn id_1 $p_{1,1}$ $p_{1,2}$ … id_2 $p_{2,1}$ $p_{2,2}$… …**

n = tally number

Id = Special tally treatments given below

$p_{i,j}$ = parameter j for the i^{th} tally treatment.

Special tally treatments:

- FRV Fixed arbitrary reference direction for tally 1 cosine binning.
- GEB Gaussian energy broadening.
- TMC Time convolution.
- INC Identify the number of collisions.
- ICD Identify the cell from which each detector score is made.
- SCX Identify the sampled index of a specified source distribution.
- SCD Identify which of the specified source distributions was used.
- ELC Electron current tally.
- PTT Put different multigroup particle types in different user bins.
- PHL Pulse-height light tally with anticoincidence (f8 only). (MCNP6)
- CAP Coincidence capture (f8 only). (MCNP6)
- RES Residual nuclei. (MCNP6)
- TAG Tally tagging. (MCNP6)
- LET Tally stopping powers instead of energy. (MCNP6)
- ROC Receiver-operator characterization (MCNP6)

FTn TAG : Tally Tagging

Tally tagging separates a tally into bins by how and where the scoring particle was produced:

1) a cell of interest where particles are produced;

2) a target nuclide from which the particle is emitted; and

3) a reaction or, in the case of spallation, a residual nuclide of interest.

not for F8 tallies!

FT*n* TAG *a*

a=1 : collided particles lose their tag; bremsstrahlung and annihilation photons included in the bin of collided particles;

a=2 : collided particles lose their tag; bremsstrahlung and annihilation photons given special tags for segregation;

a=3 : all collided particles retain their production tag.

FTn TAG : Tally Tagging

FUn card required:

FU*n bin*$_1$ *bin*$_2$ ... *bin*$_N$

***bin*$_J$ = CCCCCZZAAA.RRRRR**

CCCCC = *cell number or 00000*

ZZAAA = *target nuclide identifier*

RRRRR = *reaction identifier (e.g. 00102 for n,γ) or residual nuclide ZAID for model reactions*

FTn TAG : Tally Tagging

bin_J* = CCCCCZZAAA.RRRRR *special cases:

-0000000001 or -1 source particle tag for all cells
-CCCCC00001 source (i.e., uncollided) particle tag for cell CCCCC
0000000000 or 0 scattered particle tag
10000000000 or 1e10 everything else tag

<u>Photon tally special designations for ZZAAA.RRRRR:</u>

00000.00001	***bremsstrahlung from electrons***
ZZ000.00003	***fluorescence from nuclide ZZ***
00000.00003	***K x-rays from electrons***
00000.00004	***annihilation photons from e-***
ZZ000.00005	***Compton photons from nuclide ZZ***
ZZAAA.00006	***muonic x-rays from nuclide ZZAAA***

FTn TAG : Tally Tagging

binJ* = CCCCCZZAAA.RRRRR *special cases:

<u>Electron special designations for ZZAAA.RRRRR:</u>

ZZ000.00001 ***photoelectric from nuclide ZZ***

ZZ000.00003 ***Compton recoil from nuclide ZZ***

ZZ000.00004 ***pair production from nuclide ZZ***

ZZ000.00005 ***Auger electron from nuclide ZZ***

00000.00005 ***Auger electron from electrons***

00000.00006 ***knock-on electrons***

<u>Neutron/photon special designations for ZZAAA.RRRRR:</u>

ZZAAA.99999 ***delayed particles from fission or residuals of ZZAAA***

FTn TAG : Tally Tagging

Examples:

F5:P 0 0 0 1

FT5 TAG 3

FU5 -1.0 0000106012.00005 0000106012.00000 0000026056.00102 0000026056.00000 0000000000.00051 10000000000.00000

-1.0 ***Source photons***

0000106012.00005	***Compton from 12C cell 1***
0000106012.00000	***Remaining photons from 12C in cell 1***
0000126056.00102	***Capture gammas from 56Fe in cell 1***
0000026056.00000	***Remaining photons/gammas from 56Fe***
0000000000.00051	***Remaining 1st inelastic level [n,n'] gammas***
10000000000.00000	***Remaining gammas***

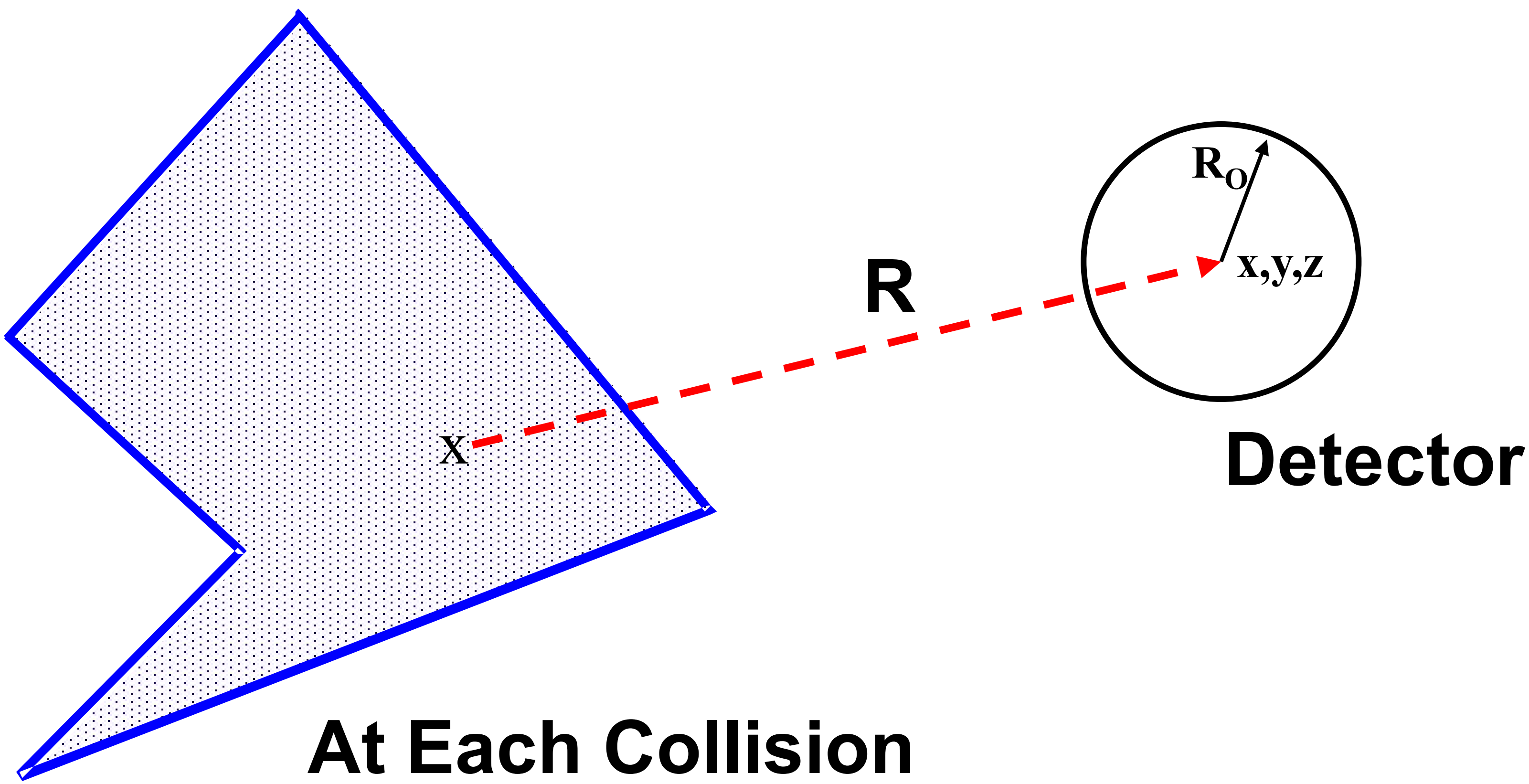
Physics muon example will use tagging

Exercise 7: Tally Tagging

copy c:\MCNP6\EXAMPLES\atal7

- **Add photon type 1 tally to back plane of water block.**
- **FT TAG option to tally 1.**
  - **Source**
  - **Bremstrahlung**
  - **Fluorescence from both**
  - **Compton from Oxygen**
  - **Annihilation photons**
  - **Everything else (1e10)**

Point Detectors



At Each Collision

$$\Phi = Wp(\mu)e^{-\lambda}/(2\pi R^2)$$

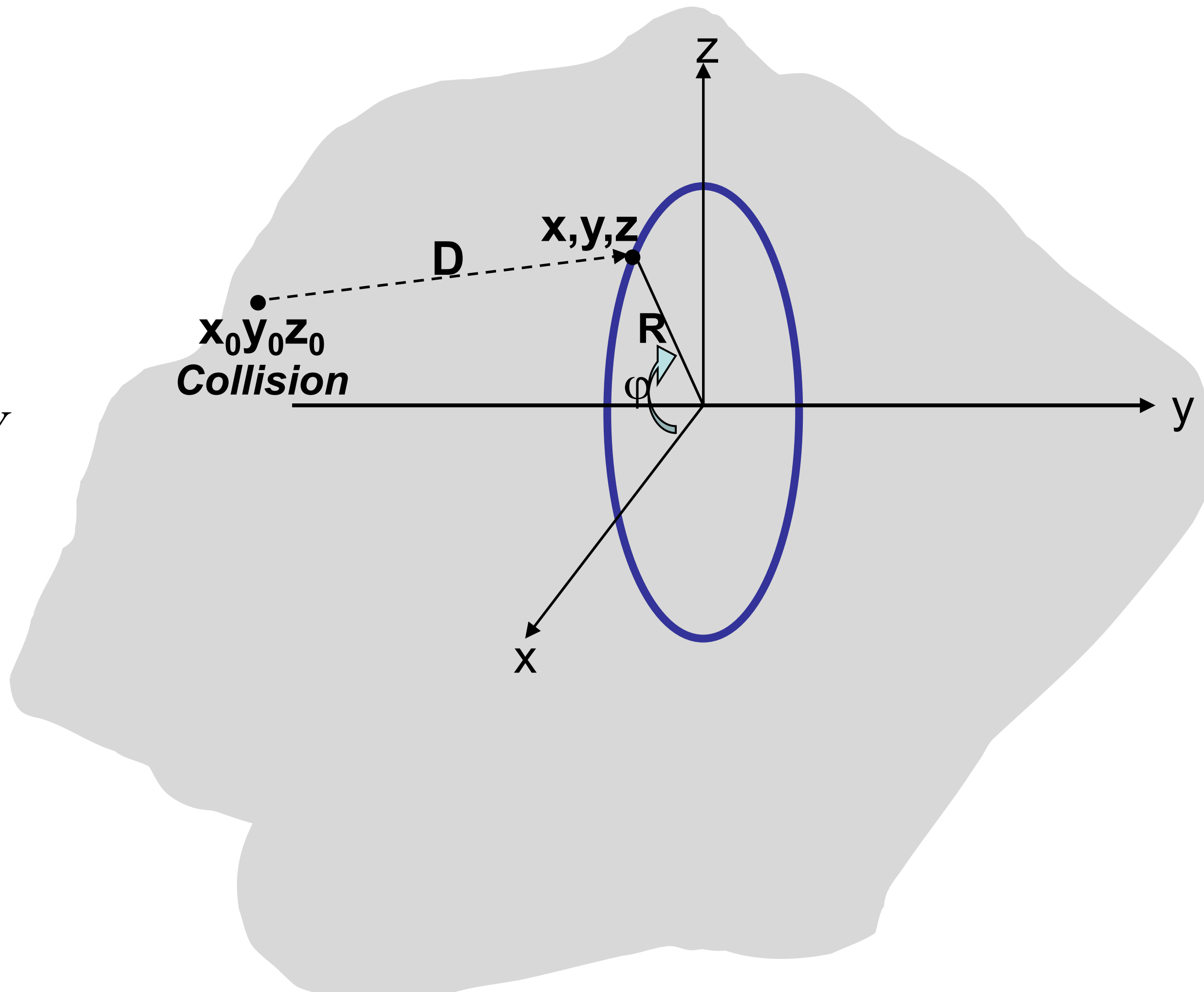
Ring Detector

Sample from:

$$\xi = \frac{C}{2\pi}\int_{-\pi}^{\varphi}\frac{d\varphi'}{R^2}$$

Adjust weight:

$$W' = \frac{D^2(\varphi)}{A}W$$



Detector Cards

Point Detectors

F5:<pl> X Y Z R_O

Ring Detectors

F5x:<pl> X R R_O

F5y:<pl> Y R R_O

F5z:<pl> Z R R_O

Radiography Tallies

FI5:<pl> X_1 Y_1 Z_1 R_O X_2 Y_2 Z_2 F_1 F_2 F_3

Exercise 8: Point Detectors

copy c:\MCNP6\EXAMPLES\atal3

- Add a point detector on axis at y=99.9

- Run the Problem, look at the output

```
1tally    5         nps =    100000
           tally type 5    particle flux at a point detector.          units   1/cm**2
           particle(s): photon

 detector located at x,y,z = 0.00000E+00 9.99000E+01 0.00000E+00
                2.27358E-05 0.0121

 detector located at x,y,z = 0.00000E+00 9.99000E+01 0.00000E+00
 uncollided photon flux
                0.00000E+00 0.0000

 detector score diagnostics                      cumulative        tally         cumulative
                                                 fraction of       per           fraction of
   times average score      transmissions        transmissions     history       total tally
        1.00000E-01           30490                0.33210       6.85395E-07       0.03015
        1.00000E+00           53640                0.91636       3.56283E-06       0.18685
        2.00000E+00             500                0.92181       1.37010E-07       0.19288
        5.00000E+00             181                0.92378       1.52987E-07       0.19961
        1.00000E+01            2116                0.94682       3.68268E-06       0.36158
        1.00000E+02            3498                0.98493       1.42777E-05       0.98957
        1.00000E+03               0                0.98493       0.00000E+00       0.98957
        1.00000E+38               0                0.98493       0.00000E+00       0.98957
  before dd roulette           1384                1.00000       2.37164E-07       1.00000

 average tally per history = 2.27358E-05       largest score = 1.21288E-03
 (largest score)/(average tally) = 5.33468E+01      nps of largest score =    57279
```

```
score contributions by cell
       cell     misses       hits    tally per history    weight per hit
    3    13      55294      91809       2.27358E-05          2.47642E-05
    4    14     100000          0       0.00000E+00          0.00000E+00
      total     155294      91809       2.27358E-05          2.47642E-05

score misses
  russian roulette on pd                     0
  psc=0.                                100564
  russian roulette in transmission       54730
  underflow in transmission                  0
  hit a zero-importance cell                 0
  energy cutoff                              0
```

```
1analysis of the results in the tally fluctuation chart bin (tfc) for tally   5 with nps =    100000    print table 160


 normed average tally per history  = 2.27358E-05          unnormed average tally per history  = 2.27358E-05
 estimated tally relative error    = 0.0121               estimated variance of the variance  = 0.0004
 relative error from zero tallies  = 0.0044               relative error from nonzero scores  = 0.0113

 number of nonzero history tallies =       34012          efficiency for the nonzero tallies  = 0.3401
 history number of largest  tally  =       46298          largest  unnormalized history tally = 1.29479E-03
 (largest  tally)/(average tally)  = 5.69493E+01          (largest  tally)/(avg nonzero tally)= 1.93696E+01

 (confidence interval shift)/mean  = 0.0001               shifted confidence interval center  = 2.27384E-05


 if the largest  history score sampled so far were to occur on the next history, the tfc bin quantities would change as follows:

      estimated quantities           value at nps           value at nps+1           value(nps+1)/value(nps)-1.

      mean                            2.27358E-05             2.27485E-05                     0.000559
      relative error                  1.21135E-02             1.21195E-02                     0.000496
      variance of the variance        4.39517E-04             4.42102E-04                     0.005882
      shifted center                  2.27384E-05             2.27384E-05                     0.000000
      figure of merit                 2.00086E+05             1.99888E+05                    -0.000992

 the estimated slope of the 200 largest  tallies starting at  7.70242E-04 appears to be decreasing at least exponentially.
 the large score tail of the empirical history score probability density function appears to have no unsampled regions.
```

```
===================================================================================================================================

          results of 10 statistical checks for the estimated answer for the tally fluctuation chart (tfc) bin of tally   5

tfc bin     --mean--      ---------relative error---------      ----variance of the variance----      --figure of merit--     -pdf-
behavior    behavior      value   decrease   decrease rate      value   decrease   decrease rate       value     behavior     slope

desired      random       <0.05      yes      1/sqrt(nps)       <0.10      yes        1/nps           constant    random      >3.00
observed     random        0.01      yes          yes            0.00      yes         yes            constant    random      10.00
passed?       yes           yes      yes          yes             yes      yes         yes              yes         yes         yes

===================================================================================================================================



this tally meets the statistical criteria used to form confidence intervals: check the tally fluctuation chart to verify.
the results in other bins associated with this tally may not meet these statistical criteria.

estimated asymmetric confidence interval(1,2,3 sigma): 2.2463E-05 to 2.3014E-05; 2.2187E-05 to 2.3289E-05; 2.1912E-05 to 2.3565E-05
estimated  symmetric confidence interval(1,2,3 sigma): 2.2460E-05 to 2.3011E-05; 2.2185E-05 to 2.3287E-05; 2.1910E-05 to 2.3562E-05

fom = (histories/minute)*(f(x) signal-to-noise ratio)**2 = (2.936E+06)*( 2.611E-01)**2 = (2.936E+06)*(6.815E-02) = 2.001E+05
```

Recommendations

- **Read output file carefully:**
  - **Understand all warning messages;**
  - **Ensure cross section tables are the ones you wanted;**
  - **Check source with 1st 50 histories;**
  - **Check summary to ensure problem is reasonable;**
  - **Check convergence.**
- **Use PRINT card;**
- **Use FC, FQ, TF;**
- **Cross compare with multiple estimators and summary table.**

Special Tallies

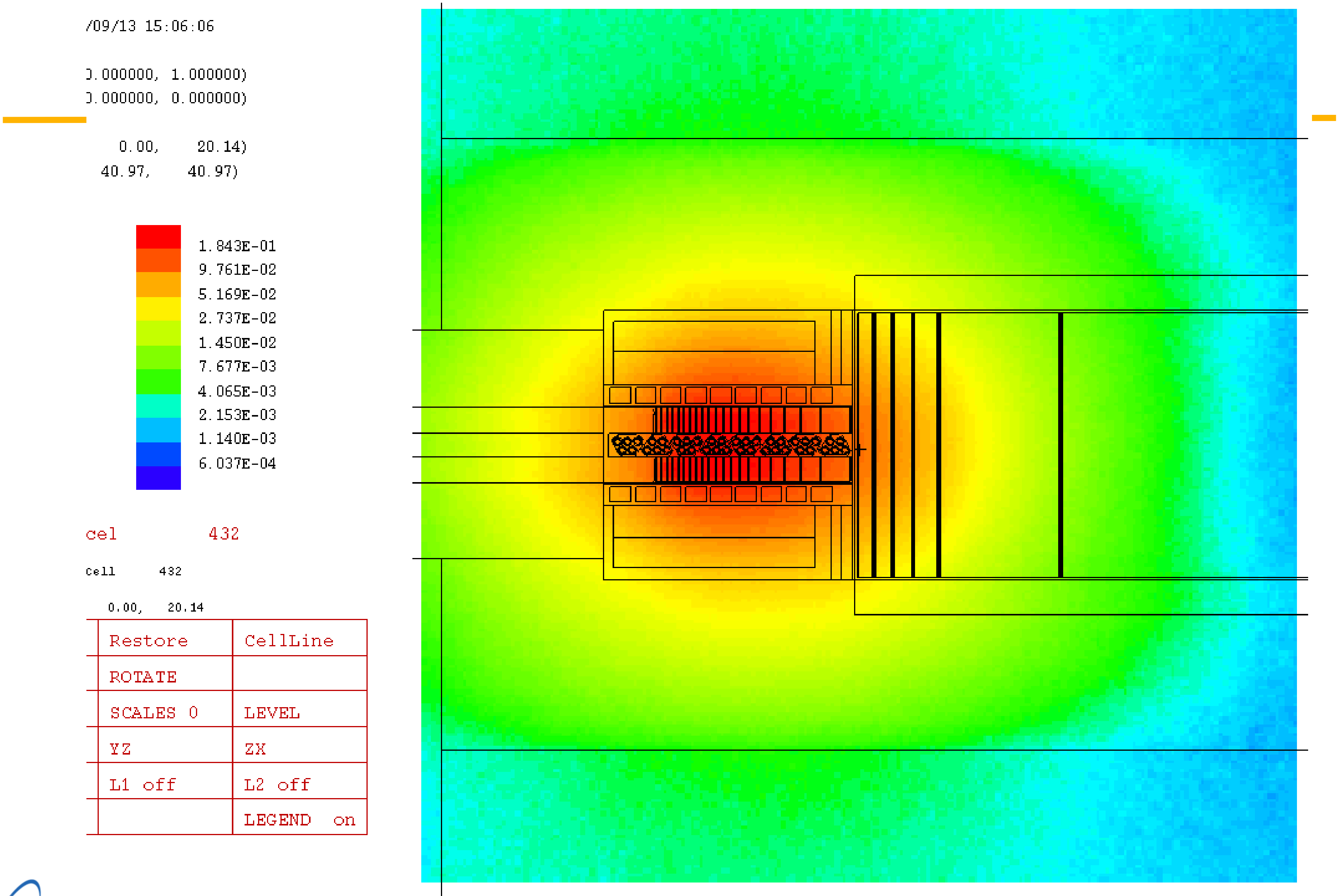
- Mesh Tallies

- Radiography

MCNP6 TMESH Tallies

There are 4 types of MCNP6 mesh tallies :

Type 1:	**Track Averaged Mesh Tally**
Type 2:	**Source Mesh Tally**
Type 3:	**Energy Deposition Mesh Tally**
Type 4:	**DXTRAN Mesh Tally**


/09/13 15:06:06
).000000, 1.000000)
).000000, 0.000000)
0.00, 20.14)
40.97, 40.97)
1.843E-01
9.761E-02
5.169E-02
2.737E-02
1.450E-02
7.677E-03
4.065E-03
2.153E-03
1.140E-03
6.037E-04
cel 432
cell 432
0.00, 20.14
Restore
CellLine
ROTATE
SCALES 0
LEVEL
YZ
ZX
L1 off
L2 off
LEGEND on

Track Averaged Mesh Tally (type 1)

FORM: (R,C,S)MESHn:<*pl*>   keyword = value

n = 1, 11, 21, 31,... **(note, number must not duplicate one used for an 'F1' tally)**

<*pl*> is a particle type. There is no default.

Example:

```
tmesh
   rmesh1:n   flux
     cora1  -15.0 99i 15.0
     corb1  -15.0 15.0
     corc1  -30.5 99i 30.5
endmd
```

Track-Averaged Mesh Tally

Keyword	Description
TRAKS	Tally the number of tracks through each mesh volume. No values accompany the keyword
FLUX	Tally the average fluence (particle weight times track length divided by volume) in units of number/cm^2. If the source is considered to be steady state in particles per second, then the value becomes flux in number/cm^2-s
TRANS	Translate or rotate the mesh according to a specified TR card. This keyword must be followed by a single reference to a TR card.

Additional keywords:

DOSE, POPUL, PEDEP, MFACT

Source Mesh Tally (type 2)

Form: **(R,C,S)MESH*n* <*pl*$_1$> <*pl*$_2$>...<*pl*$_n$> trans = #**

n = 2, 12, 22, 32, ...(note, number must not duplicate one used for an 'F2' tally)

<*pl*> = particle type(s) (Up to 10 allowed)

Example: Source Mesh tally

```
tmesh
    RMesh2 n h
     cora2  -15.0 99i 15.0
     corb2  -15.0 15.0
     corc2  -30.5 99i 30.5
endmd
```

MCNP6 Mesh Tally Plotting

- From MDATA files
  - Use gridconv and postprocessor (e.g Moritz, Tecplot, PAW, etc.)

OR,

- From MCTAL files make a contour plot
  - MCNP6 z
  - rmc = <mctal filename>
  - tal n free ik contour 5 95 10 %
  - this tells MCNP to plot tally "n", set the plot indices to your mesh tally coordinates (ik=xz), contour colors where blue=5<95=red, with 10 percent interpolates in between.

OR,

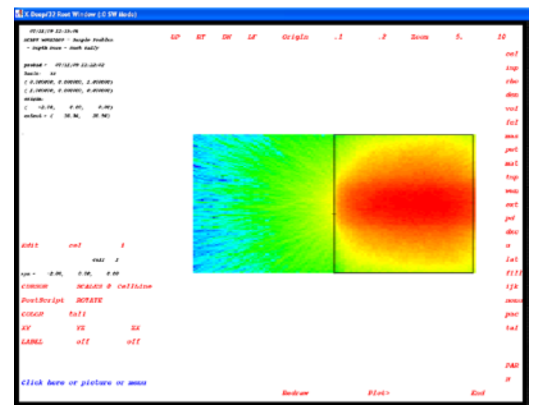
  -

Mesh Tally Plots

Superimposed on problem geometry!

- **From INP file during run:**
  - mplot freq 5000 PLOT ex 40 py 4 la 0 1 tal color on la 0 0
    (see manual for mplot command detail)

OR,



- **From runtpe:**
  - mcnp6 z run = <runtpe filename>
  - <mcplot> plot $brings up the geometry plotter
  - [buttons] tal, N, color

Mesh Tally Exercise

Copy C:\MCNP6\EXAMPLES\atal9

1. **Plot and understand the geometry.**

2. **Add a rectangular flux mesh tally for protons and neutrons within the water. Use one bin in the "y" direction.**

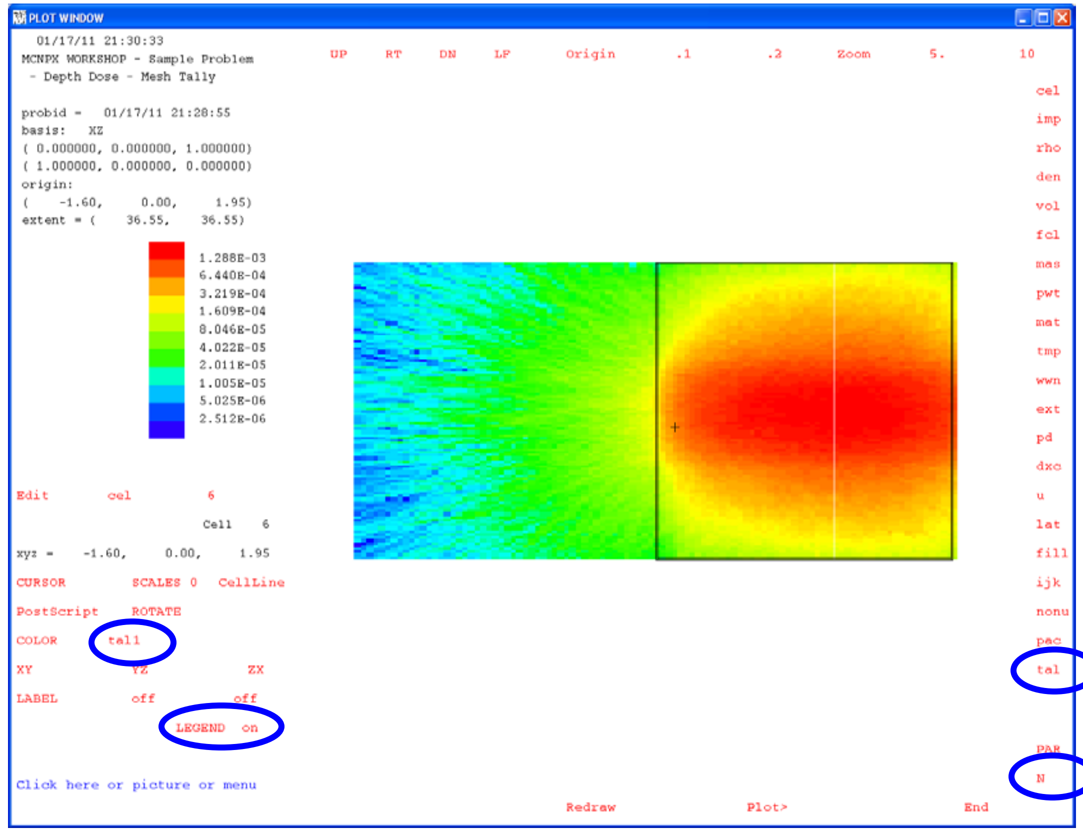
3. **Add a rectangular source mesh tally for protons and neutrons within the water.**

4. **Plot your results with the MCNP plotter.**

Plotting the Mesh Tally

MCNP6 Z
MCPLOT> runtpe talmhr
MCPLOT> plot
Click on tal
Click on color twice
Click on ZX
Turn surf labels off
Zoom in
Click on Legend

To plot other tallies:
Click on tal
Click on N to cycle through tallies
Click redraw



Energy Deposition Mesh Tally (type 3)

General Form:

(R,C,S)MESHn ***keyword***

n = 3, 13, 23, 33, ...

Example: ***Mesh tally of total energy deposited, all sources***

```
tmesh
        RMesh3 total
         cora3  -15.0 99i 15.0
         corb3  -15.0 15.0
         corc3  -30.5 99i 30.5
endmd
```

Some type 3 Mesh Tally keywords

Keyword	Description
TOTAL	If TOTAL appears on the input line, score energy deposited from any source. (DEFAULT)
DE/DX	If DE/DX appears on the input line, score ionization from charged particles.
RECOL	If RECOL appears on the input line, score energy transferred to recoil nuclei above tabular limits.

Additional keywords TLEST, DELCT, MFACT, NTERG, TRANS

(see the manual)

Mesh Plot Contour Command

FORM: CONTOUR [cmin cmax cstep] [commands]

All command entries are optional

cmin	minimum contour value
cmax	maximum contour value
cstep	number of contour steps
% or pct	interpret step values as percentages
log	step values logarithmic with cstep interpolates
All	contours normalized to min and max values of entire tally
noall	contours normalized to min and max values of contour slice (FIXED command)
line/noline	do/don't draw lines around contours
color	make color contour plot
nocolor	contour lines only

Mesh Plot Contour Command

FORM: Contour [cmin cmax cstep] [commands]

EXAMPLES

CONTOUR 5 95 10 & line color

There will be 10 contour lines at 5%, 15%,…95% of the maximum value.
Lines will be drawn around the oclored contours as in Figure 1.
Note: this is the default setting

CONTOUR 1e-4 1e-2 12 log

There will be 12 contour lines logarithmically spaced between 1e-4 and 1e-2

DXTRAN Mesh Tally (type 4)

General Form: **(R,C,S)MESHn:<*pl*> trans = #**

n = 4, 14, 24, 34, ... (note, number must not duplicate one used for an ‘F4’ tally)

<*pl*> **is a particle type. There is no default.**

***** **use * for DXTRAN; omit * for F5**

trans **must be followed by a single reference to a TR card that can be used to translate and/or rotate the entire mesh. Only one TR card is permitted with a mesh card.**

MCNP6 FMESH Tally

FMESH4:n GEOM=cyl ORIGIN= –100 0 0

IMESH=5 10	IINTS=5 2
JMESH= 100 200	JINTS 10 5
KMESH .5 1	KINTS=1 2
AXS= 1 0 0 VEC=0 1 0	OUT=ij

Out = cf, ij, jk, ik ; GEOM = rec, cyl, xyz, rzt

- *MCNP6 has many more options and GEOM = sph, rpt*
- *MCNP6 allows E, T, FM, etc.*

MCNP6 FMESH Tally

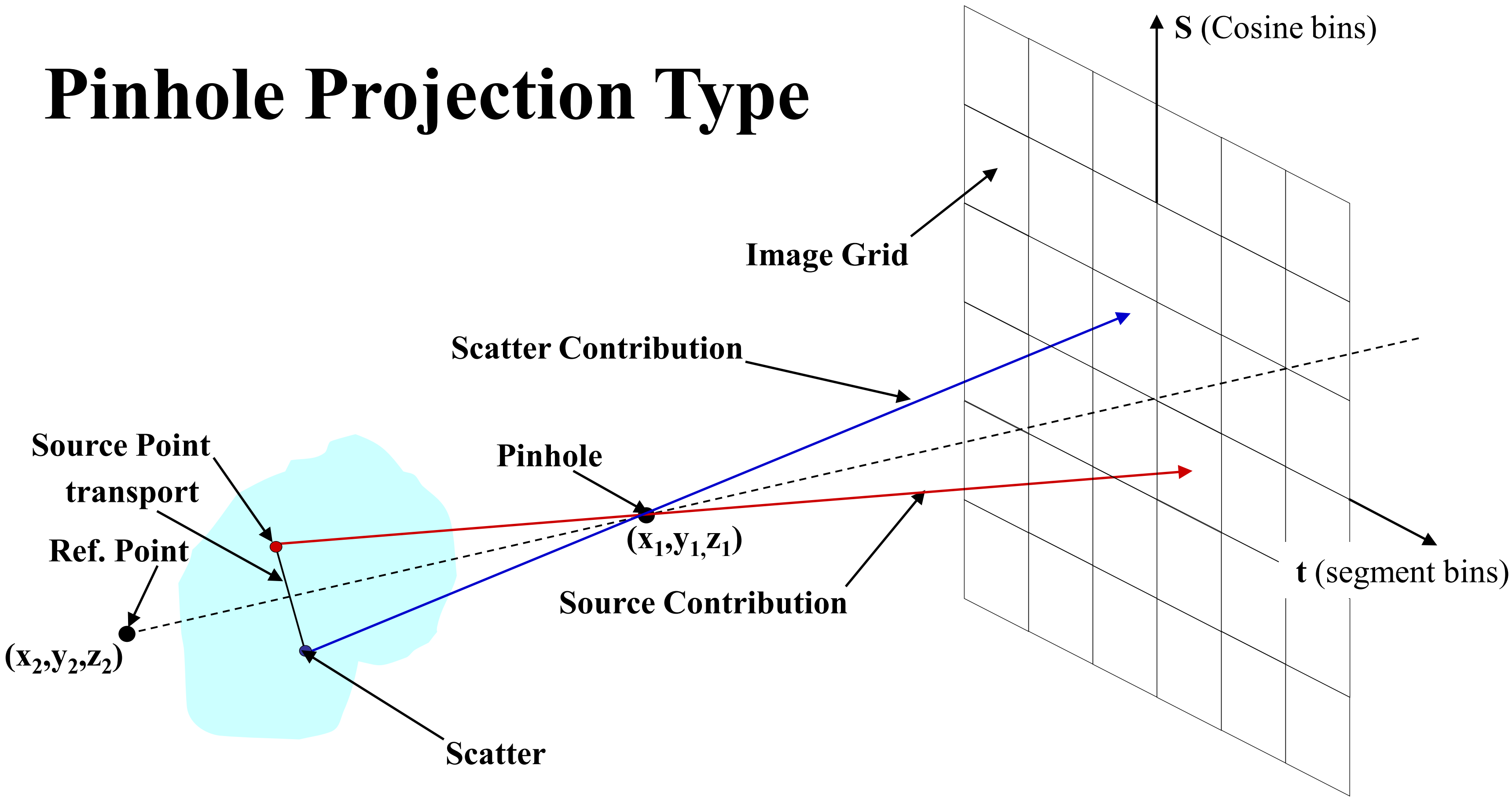
```
fmesh504:n geom=rec origin -400 -400 0
           imesh 400  iints 99
           jmesh 400  jints 99
           kmesh 400  kints  1

mplot    freq  5000   fmesh 504
```

In geometry plot: click fmesh

The Radiography Tally

Pinhole Projection Type



RADIOGRAPHY TALLY
(Pinhole Projection type)

General Form:

FIPn:<*pl*> X_1 Y_1 Z_1 R_0 X_2 Y_2 Z_2 F_1 F_2 F_3

FS*n* -20. 99i 20. ***$ establishes an image grid with***

C*n* -20. 99i 20. ***$ 100 Seg. x 100 Cos. bins***

n is the tally number and must end with a 5 since this is a detector-type tally.

<*pl*> is the particle type for the tally. ***Neutrons or photons only!***

(see next slide for explanation of Argument elements)

Pinhole Radiography Arguments

X_1, Y_1, Z_1 The coordinates of the pinhole.

R_0 Pinhole Radius.

Note, neither the pinhole nor the grid should be located within a highly scattering media.

X_2, Y_2, Z_2 The reference coordinates that establish the reference direction cosines for the normal to the detector grid. This direction is defined as being from X_2, Y_2, Z_2 to the pinhole at X_1, Y_1, Z_1 .

F_1 If F1>0, the radius of a cylindrical collimator, centered on and parallel to the reference direction, which establishes a radial field of view through the object.

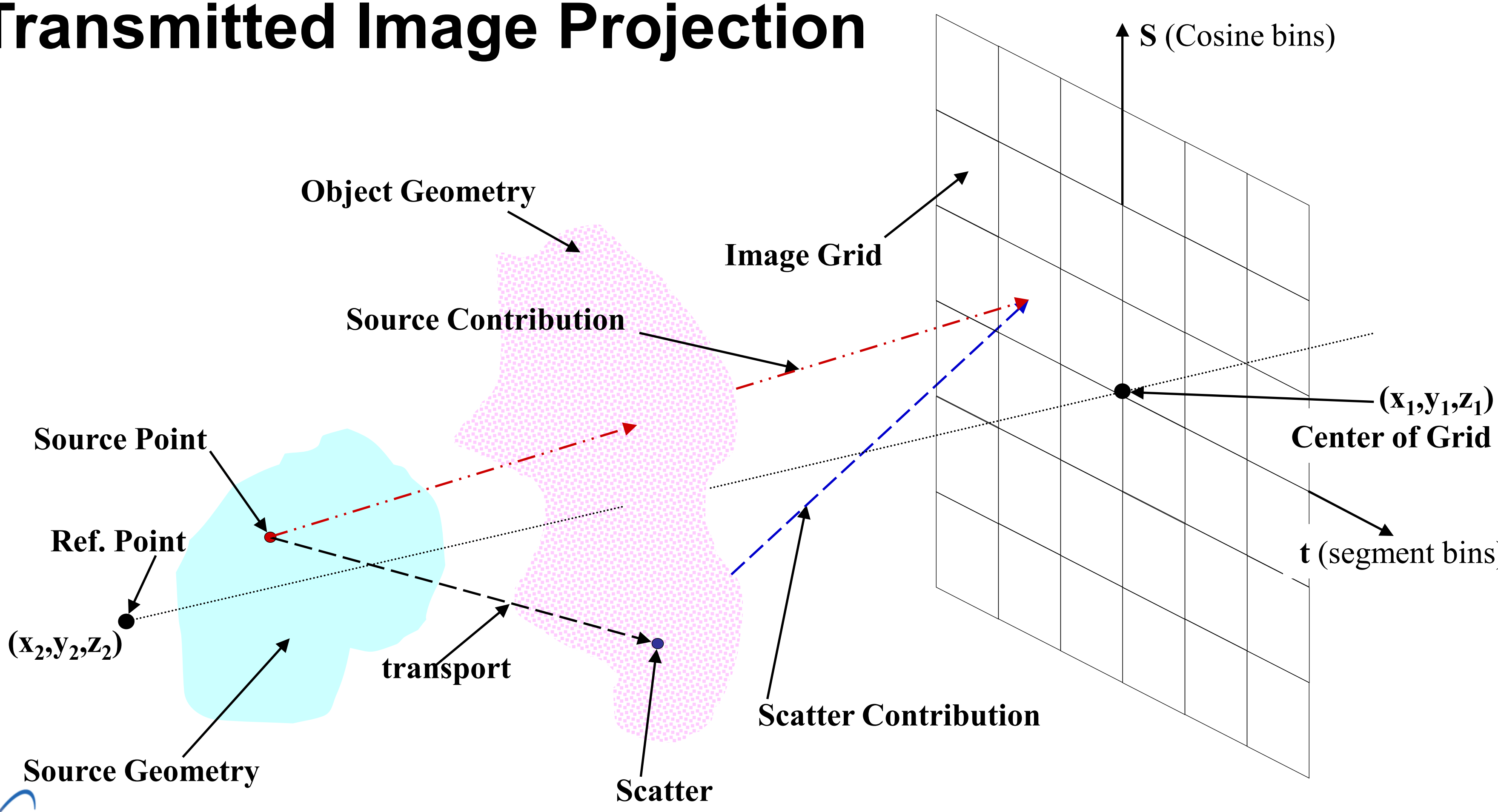
F_2 The radius of the pinhole perpendicular to the reference direction.

- F2=0 represents a perfect pinhole
- F2>0 the point through which the particle contribution will pass is picked randomly. This simulates a less-than-perfect pinhole.

F_3 The distance from the pinhole at X_1, Y_1, Z_1 to the detector grid along the direction established from X_2, Y_2, Z_2 to X_1, Y_1, Z_1 , and perpendicular to this reference vector.

Radiography Tally

Transmitted Image Projection



Radiography Tally

Transmitted Image Projection Type

General Form: FI(R/C)n:<pl> X_1 Y_1 Z_1 R_0 X_2 Y_2 Z_2 F_1 F_2 F_3

FI*R* is used to establish a grid on a *plane surface*
FI*C* is used to establish a grid on a *cylindrical surface*.

n	=	the tally number and must end with a 5 since this is a detector type tally.
<*pl*>	=	the particle type for the tally. (N or P only)
X_1 Y_1 Z_1	=	Center of rect. or cyl. grid defined with FSn and Cn
R_0	=	0.00
X_2 Y_2 Z_2	=	reference point defining rectangular grid outward normal or of cylindrical grid axis. May be thought of as the eye of the observer.
F_1	=	-1/0 Scattered contribution only/Source + scattered contributions
F_2	=	radial field of view. Cylinder along the axis.
F_3	=	0 /1 Contributions to grid bin centers/random positions

Transmitted Image Projection

NPSMG on the NPS card

NPS NPP NPSMG

NPP = number of histories requested

NPSMG = number of *direct source contributions* requested

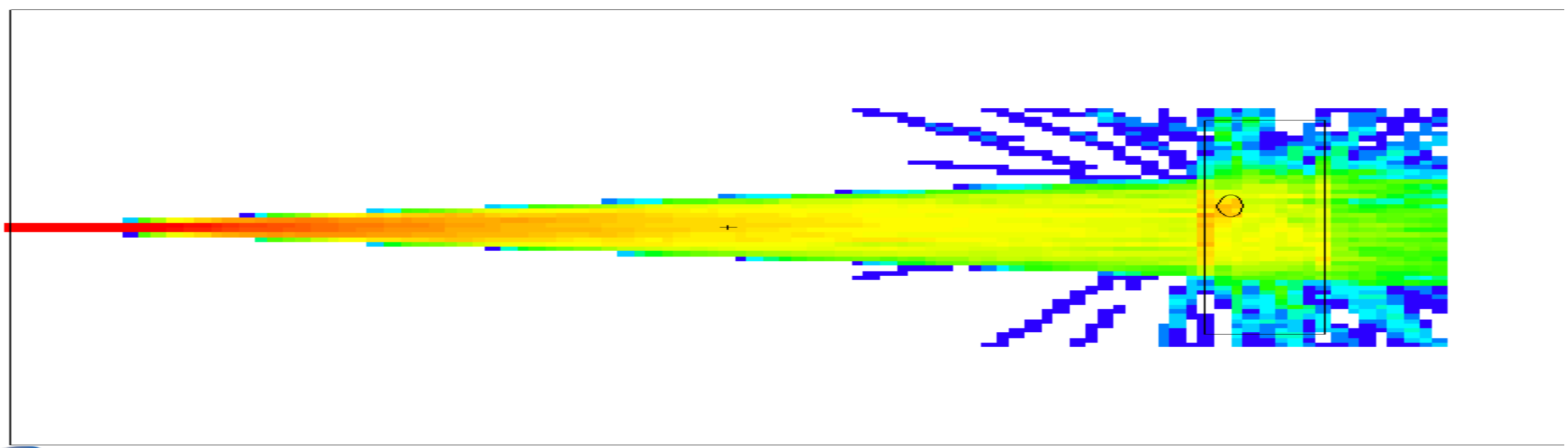
Example: NPS 100000 60000

Exercise Rad 10

Transmitted Image Projection: ^{235}U sphere in water

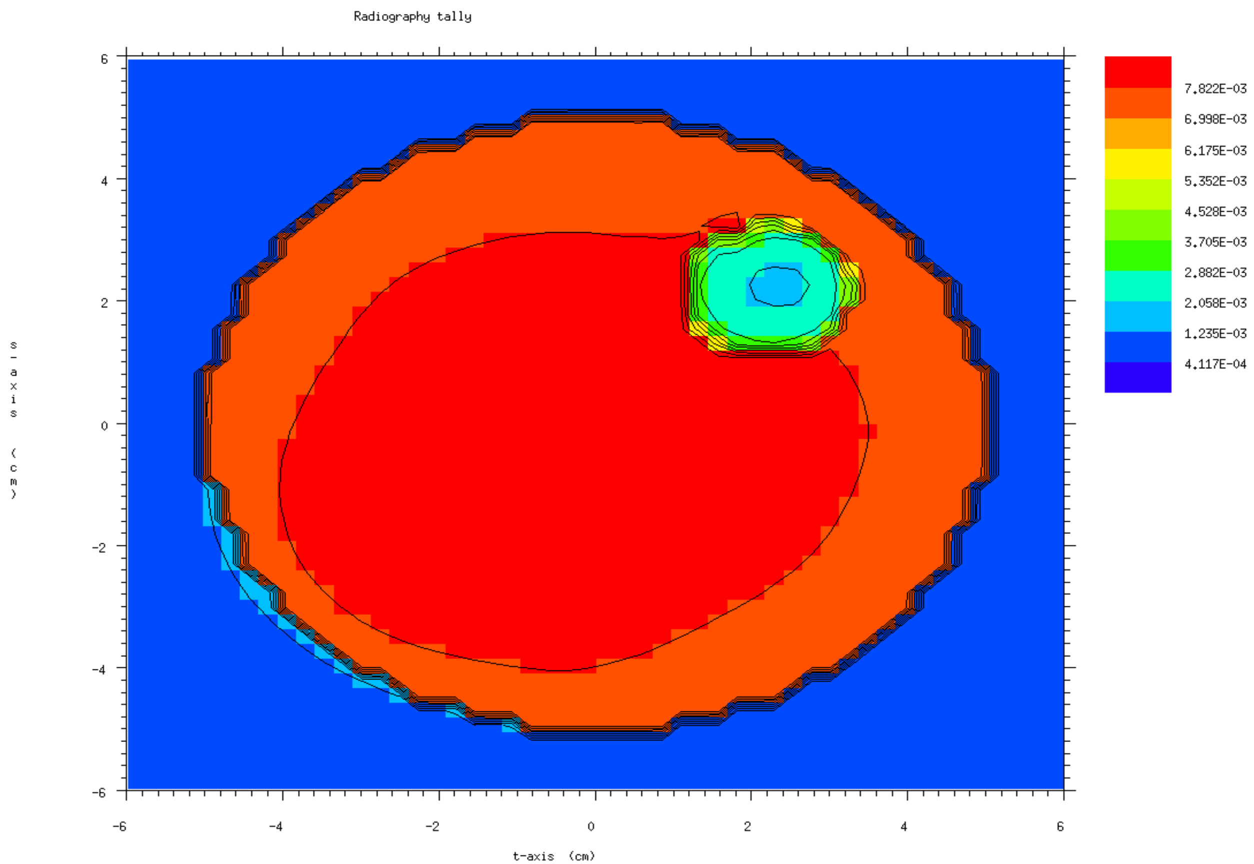
Copy %inputs%\tally\rad10

- 10-cm radius, 10-cm tall water tank
- 2-cm radius 235U off-center sphere
- 1-MeV photon source 100-cm away .999 < μ < 1.0 cone
- Radiography tally behind tank



Exercise Rad 10

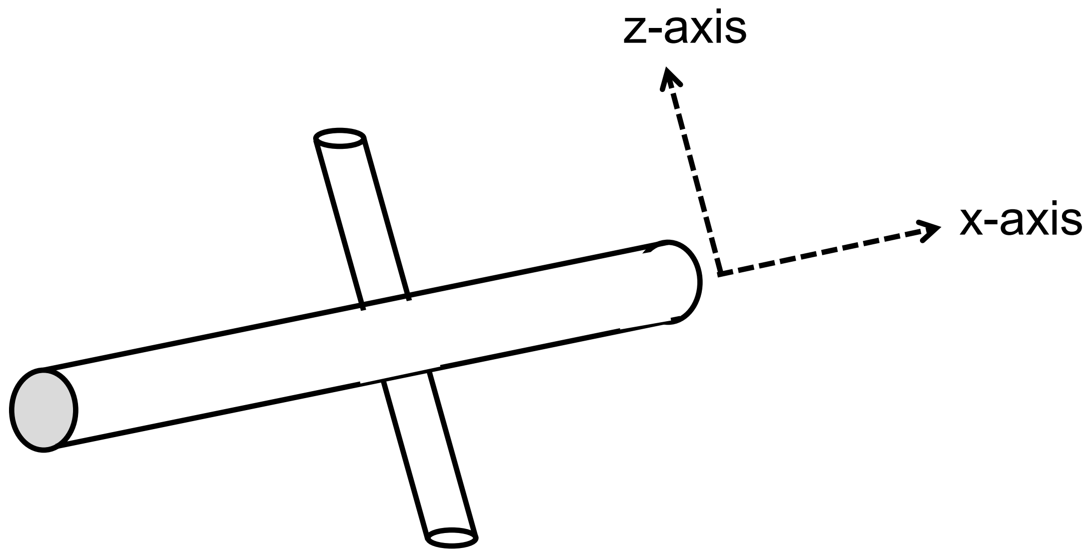
Transmitted Image Projection: ^{235}U sphere in water



Exercise Rad 11
Safeguards Radiography

Larger pipe contains 50% (atom) UO_2 and 50% H_2O. UO_2 is 10% (atom) enriched. Use a gram density of 10.0. Inner pipe radius is1.0 cm and overall length is 40 cm. Place origin at the center of this pipe. Pipe is made of ^{208}Pb with a thickness of 1.0 mm. Use a gram density of 11.4.

Enclose this geometry in a large sphere. This requires 5 cells and 4 surfaces.



Void pipe through center of larger pipe (R=0.5 cm). Length large enough to pass through larger pipe.

Exercise Rad 2
Safeguards Radiography

Copy %inputs%\tally\rad11

- Specify a spontaneous photon (sp) source spread uniformly throughout the HEU solution.
- Run MODE "p" only and turn on delayed gammas (PHYS:P 6th entry).
- Use a cylindrical TI tally around the larger pipe, with the image grid centered at the origin (use 0.001,0,0 due to a bug). Use a cylindrical radius of 10 cm for the image surface. Use 20 segments along the axis of the pipe and 18 angular segments around the outside surface of the pipe (i.e., every 20 degrees).
- Run 500,000 histories. You may encounter a "bad trouble" – think about this for awhile (hint: look at the volumes calculated for each cell).
- Modify the input to increase 235U component to 20% (atom). Generate contour plots of both cases that clearly show the effect of the higher enrichment.
- Can you see the void cross pipe? Why or why not?
- Note the TIC s-axis is always along the cylinder axis. What t-axis was chosen (i.e., what corresponds to q=0)? Does the cross pipe image help with this?

Exercise Rad 2
Safeguards Radiography