

LA-UR-

*Approved for public release;
distribution is unlimited.*

Title:

Author(s):

Submitted to:



Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

Medical Physics SDEF Sources

By Tim Goorley, X-5

LA-UR-05-7964

Abstract

While it is important to accurately represent the appropriate geometry for Medical Physics simulations, it is just as important to accurately represent the radiation source. The following slides give several examples of photon and neutron sources encountered in Medical Physics applications. These examples show how to construct the SDEF card in MCNP to simulate various radiation sources.

SDEF Sources

- Co-60 Photon Source (Exercises 1-3)
- Epithermal Neutron Beam (Exercises 4-5)

Co-60 Photon Source

- Photon Energies: 1.173 MeV, 1.332 MeV
- Both energies equally probable
- Isotropic

- Exercise 1: Point Source at origin

- Exercise 2: Source Sphere (equally prob)

Solutions

Simple input deck for Co-60 point or sphere source

```
100  1  -1.0  -10  imp:p=1
200  0           10  imp:p=0
```

```
10 so 5.0 $ Sphere at origin, 5 cm radius
```

```
c sdef erg=d1 cel=100 par=2 $ What would this line do? [Point Source @ origin]
c sdef erg=d1 cel=100 par=2 rad=2.0 $ What would this line do? [Thin Shell Src]
sdef erg=d1 cell=100 par=2 rad=d2 $ This is a homogeneous sphere source
si1 L 1.173 1.332 $ Discrete Co-60 Energies, in MeV
sp1 D 1.0 1.0 $ Equiprobable
si2 H 0 2.0 $ Radial Bin Distribution from 0.0 cm to 2.0 cm
sp2 -21 2 $ Power law sampling to 2nd power, for spherical sources
mode p $ Photon Source
nps 50
m1 1001 2 8016 1 $ Water, note molecular formula is atom fraction
print
```

Co-60 Seed Source

- Exercise 3:
 - 2 hemispheres rad = 1.0 cm
 - 1 cylinder rad = 1.0 cm, length = 1.0 cm
 - Hint: Use Cell Acceptance



Solutions

- Exercise 3

SDEF ERG=D1 RAD=D2 CEL = 100

- What would the following lines do?

SDEF ERG=D1 CEL=100

SDEF ERG=D1 RAD=2.0

Exercise 3 Input Deck

Simple input deck for Co-60 Seed source

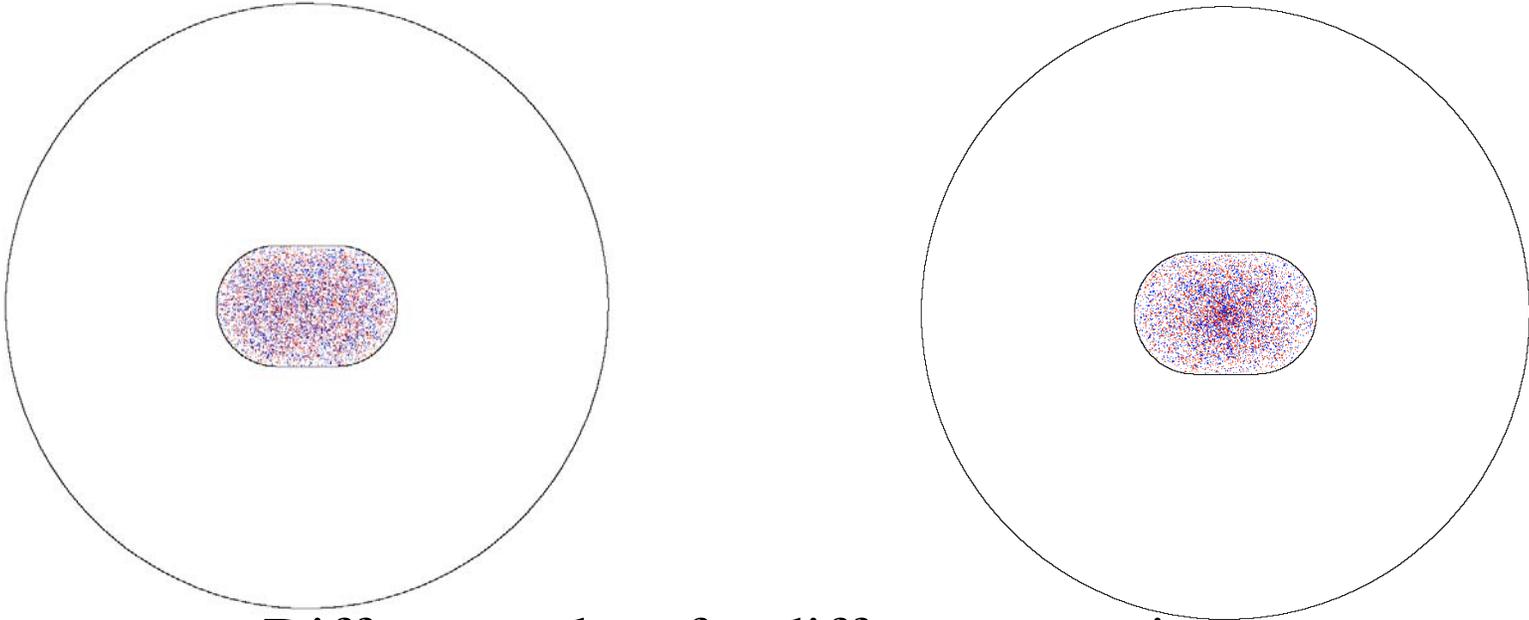
```
100  1  -1.0   -10:-20:-30   imp:p=1
200  0           10 20 30 -40   imp:p=1
300  0           40           imp:p=0
```

```
10 s   -0.5 0.0 0.0      1.0
20 s    0.5 0.0 0.0      1.0
30 rcc -0.5 0.0 0.0     1.0 0.0 0.0   1.0
40 so 5.0
```

```
c sdef erg=d1 cel=100 par=2           $ What would this line do?
c sdef erg=d1 cel=100 par=2 rad=2.0   $ What would this line do?
sdef erg=d1 cell=100 par=2 rad=d2
si1 L 1.173  1.332
sp1 D  1.0    1.0
si2 H  0      2.0
sp2 -21      2
mode p
nps 50
m1 1001 2 8016 1
print
```

Exercise 3 Plotting

- These Vised Source plotting pictures show the difference between SP2 -21 2.0 (left – correct) and SP2 - 21 1.0 (right – not homogeneous)
- Do you see a difference?



Different colors for different energies

Neutron Beam

- Monoenergetic Epithermal N's – 5.0 KeV
- Beam 5.0 cm radius
- Travels from $-x$ to $+x$ [monodirectional]
- Starts at $x = -5.0$
- Pass through a 1 cm rad ball of water at origin

- Exercise 4: Monodirectional beam

Neutron Beam – Ex 4 soln

- Exercise 4

SDEF POS= -5.0 0.0 0.0

VEC=1 0 0 \$ What if no vec card?

AXS=1 0 0 \$ What if no axs card?

DIR=1.0 \$ What if no dir card?

RAD=D3

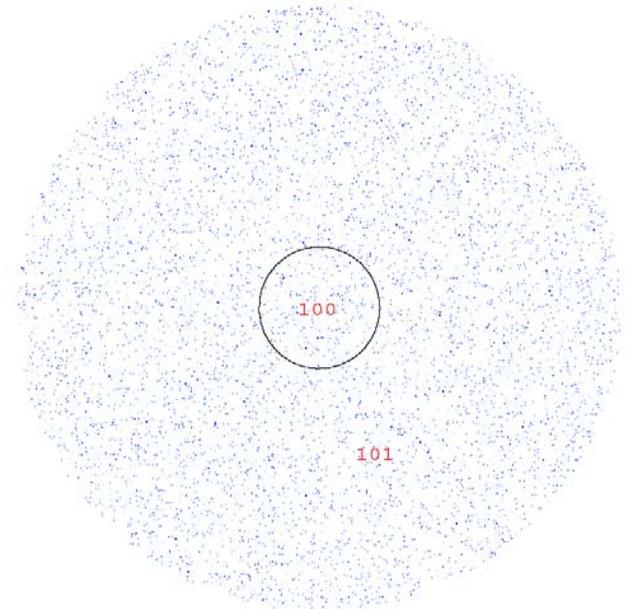
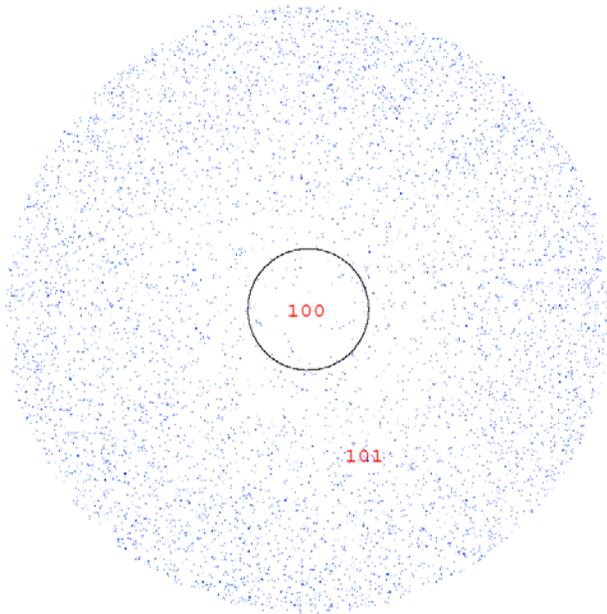
ERG=0.005 PAR=1

SI3 H 0.0 5.0

SP3 -21 1

Exercise 4 Plotting

- These Vised Source plotting pictures show the difference between SP2 -21 2.0 (left – not correct) and SP2 - 21 1.0 (right – correct)
- Do you see a difference?



Exercise 4 Input Deck

This is a simple monodir neutron beam problem

C Little geometry is needed

```
100 1 1.0 -10 imp:n=1
101 0 10 -20 imp:n=1 $ What if imp:n=0?
102 0 20 imp:n=0
```

```
10 so 1.0
20 so 20.0
```

mode n p

```
m1 1001 2 8016 1
```

```
sdef pos -5.0 0.0 0.0
```

```
    axs 1 0 0          $ What happens if no axs?
```

C If no axs, source becomes a spherical source

```
    vec 1 0 0          $ What happens if no vec?
```

C If no vec, no reference direction for particle direction

```
    dir 1.0            $ What happens if no dir? [isotropic source]
```

```
    erg=0.005    rad=d4    par 1
```

```
    ext=0.0          $ A disk source is a degenerate cylinder source
```

```
si4 H 0.0 5.0
```

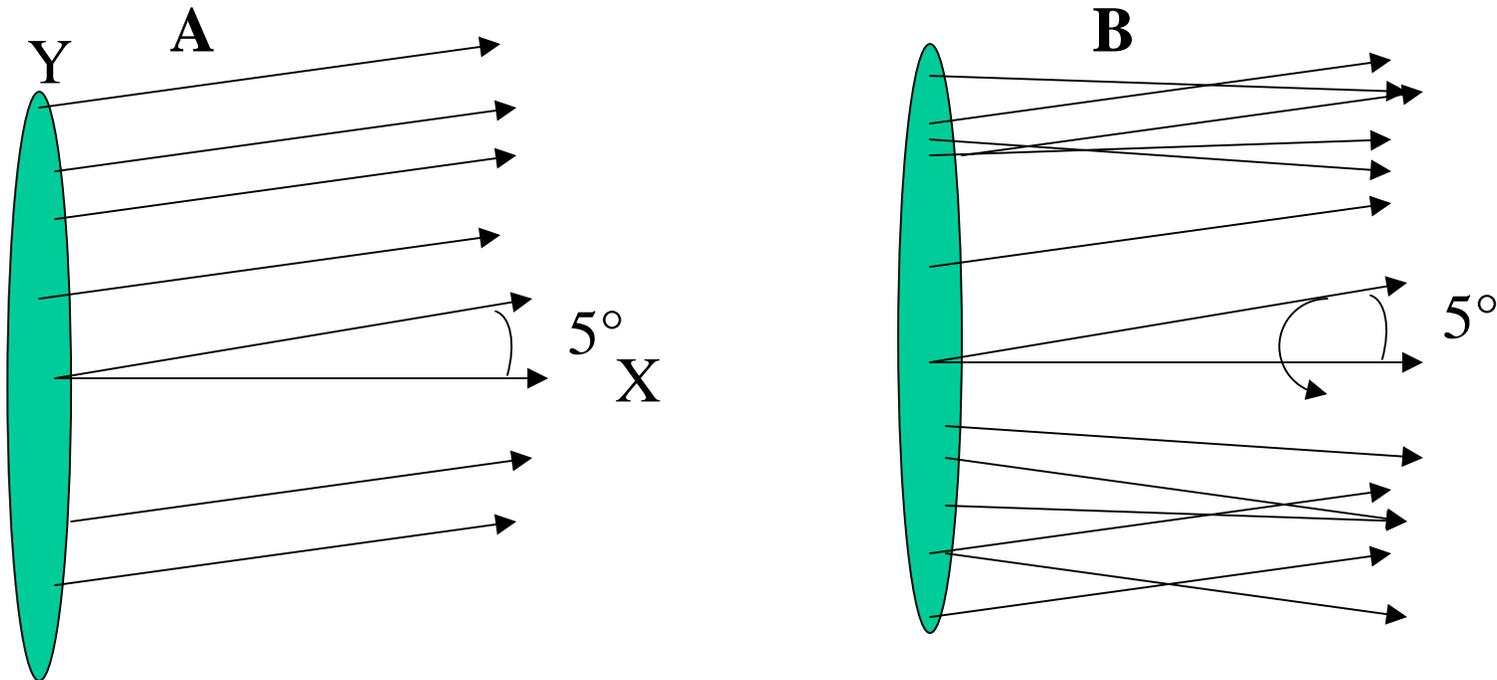
```
sp4 -21 1          $ Power Law, power=1 for disk sources
```

```
print
```

```
nps 50
```

Exercise 5

- Add beam divergence of 5°
- Think about difference between:



- Both are possible in MCNP (Do Both!)

Neutron Beam – Ex 5 soln A

Exercise 5

```
SDEF POS= -5.0 0.0 0.0  
      VEC=100 8.74 0.0  
      AXS=1 0 0  
      DIR=1  
      PAR=1  
      RAD=D3  
      ERG=0.005
```

Exercise 5

```
SDEF POS= -5.0 0.0 0.0  
      VEC=100 8.74 0.0  
      AXS=100 8.74 0.0  
      DIR=1  
      PAR=1  
      RAD=D3  
      ERG=0.005
```

The difference between these two is the cross section of the beam. The one on the right has a circular cross section, the one on the left has an elliptical cross section

Beam Cross Section

AXS & VEC different

AXS & VEC same

```
09/26/05 11:59:11
This is a simple monodir neutron
beam problem

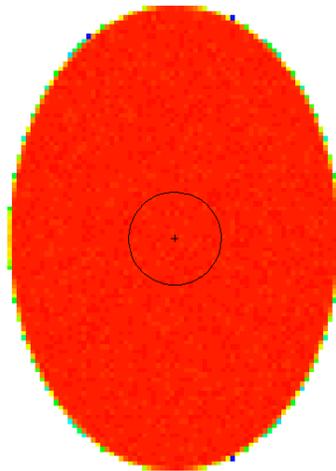
probid = 09/26/05 11:58:29
basis: YZ
( 0.000000, 1.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( 0.00, 0.00, 0.00)
extent = ( 6.00, 6.00)
```

```
Value for mesh tally 4
.0182364 .0447172
xyz = 0.00, 0.00, 0.00
```

CURSOR	Restore	CellLine
PostScript	ROTATE	
COLOR	SCALES 0	LEVEL
XY	YZ	ZX
LABELS	L1 off	L2 off
HBODY	FMESH 4	

[Click here or picture or menu](#)

UP RT DN LF Origin .1 .2 Zoom 5. 10



Redraw Plot> End

```
09/26/05 11:54:11
This is a simple monodir neutron
beam problem
```

```
probid = 09/26/05 11:53:33
basis: YZ
( 0.000000, 1.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( 0.00, 0.00, 0.00)
extent = ( 6.00, 6.00)
```

cel
inp
rho
den
vol
fcl
nas
put
mat
tup
sum

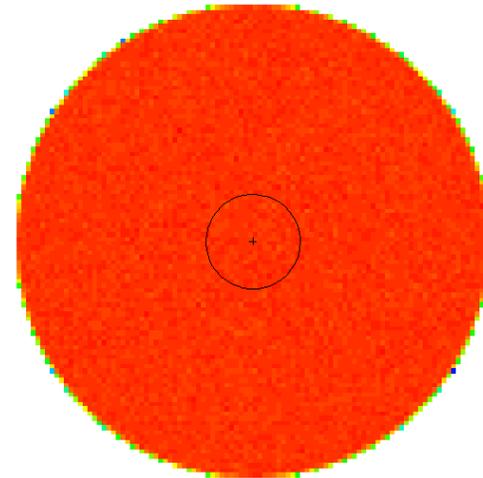
```
Value for mesh tally 4
.0207530 .0121539 .0616588
xyz = 0.00, 0.00, 0.00
```

CURSOR	Restore	CellLine
PostScript	ROTATE	
COLOR	SCALES 0	LEVEL
XY	YZ	ZX
LABELS	L1 off	L2 off
HBODY	FMESH 4	

PAR
N

[Click here or picture or menu](#)

UP RT DN LF Origin .1 .2 Zoom 5. 10



Redraw Plot> End

cel
inp
rho
den
vol
fcl
nas
put
mat
tup
sum

```
Value for mesh tally 4
.0161744 .0037395
8.6456-4 1.9988-4 4.6213-5
```

PAR
N

Which did you intend?

Neutron Beam – Ex 5 soln B

Exercise 5

SDEF POS= -5.0 0.0 0.0

VEC=1 0 0

AXS=1 0 0

DIR=0.9962 \$ = $\cos(5 \text{ deg} * \pi / 180)$

PAR=1

RAD=D3

ERG=0.005