Hands-on session:

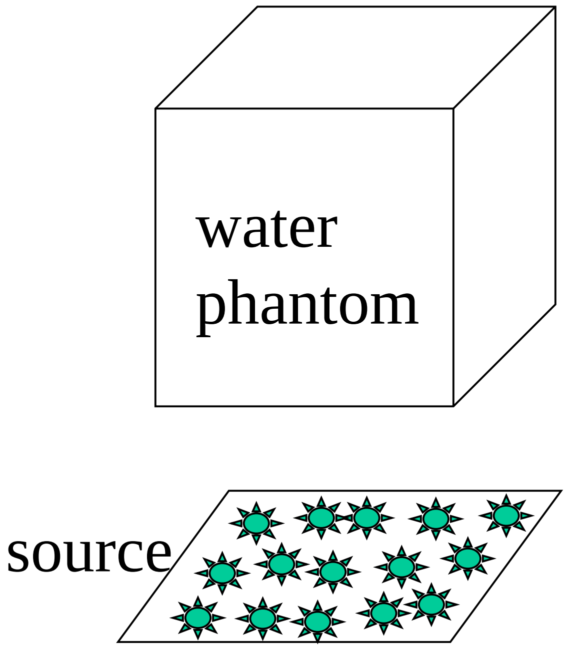
MCNP5 practical examples

Lecture 7

Special Topics:

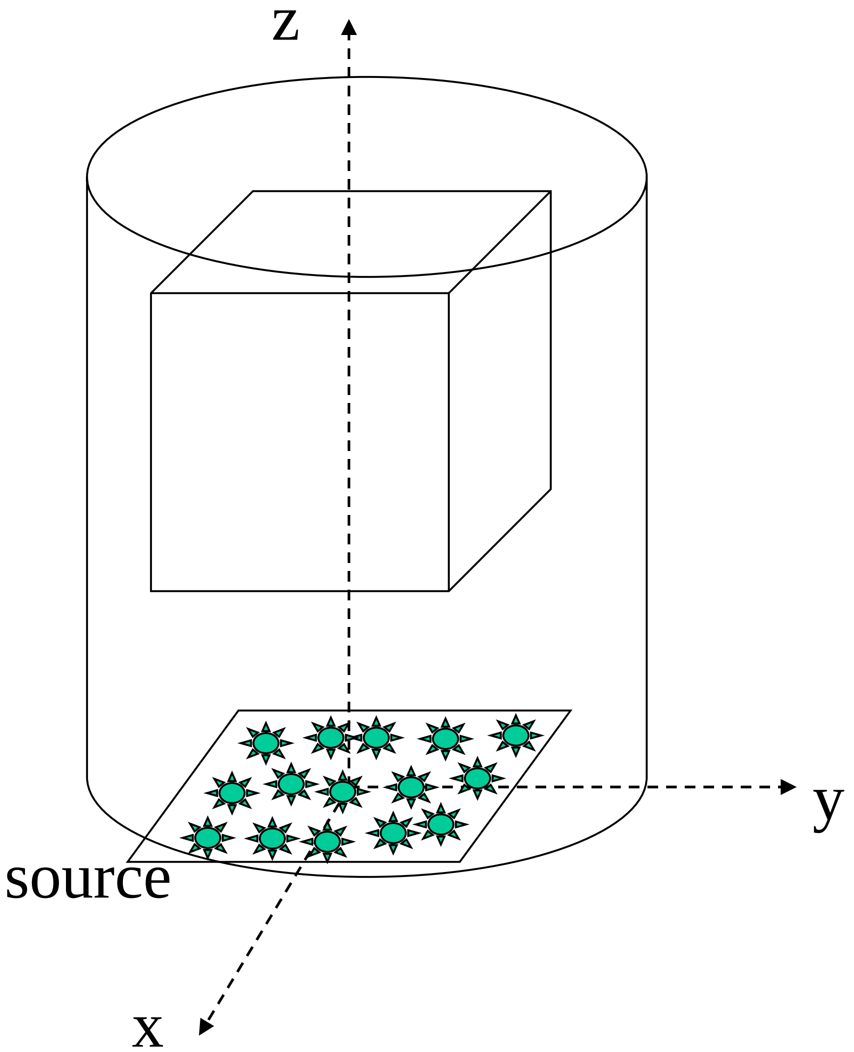
Device Modeling

Example 1: Problem statement



- Mono-energetic 10 MV planar photon source
- Cubic water phantom at 10 cm from the source, 10 cm each side
- Find exit spectrum
- Calculate depth dose with 1 cm steps

Example 1: Steps



- Setup coordinate system
- Identify all cells in your geometry (do not forget problem boundary)
- Specify surface cards
- Specify material cards
- Specify cell cards (do not forget to define outer space)
- Add source cards
- Add tally cards
- Add cut-off cards

Example 1: Input file using lattice

```
Water phantom
c Cell cards
c Water phantom
  1     1 -1.0  2 -1 4 -3 5 -6 fill=1 imp:p,e 1
c Lattice call for dose deposition
  10    1 -1.0  2 -1 4 -3 5 -10 lat=1 u=1 imp:p,e 1
c Air around
  100   2 -0.001293 (101 -102 -100) #1 imp:p,e 1
c Void cell
  999   0  -101:102:100 imp:p=0 imp:e=0

c Surface cards
c Water phantom
  1     px 5
  2     px -5
  3     py 5
  4     py -5
  5     pz 10
  6     pz 20
c Lattice cell
  10    pz 11
c Cylinder around the problem
  100    cz 9
  101    pz -0.1
  102    pz 25
```

Example 1: Input file – Data cards

```
c Data cards
mode p e
c Materials
  m1    1000. 2         8000. 1  $Water
  m2    7014.         -0.755636  $air (US S. Atm at sea level)
        8016.         -0.231475 18000.        -0.012889
c Source cards
sdef pos=0 0 0  x=d1 y=d2 z=0 erg=10 par=2  $
si1 -6 6
sp1 0 1
si2 -6 6
sp2 0 1
c Tallies
F1:p 6
e1 1 99i 10 $ Energy spectrum, step 0.1 MV
*F8:p (10<10[0:0 0:0 -9:0]) $Depth dose tally
cut:e j 0.1   $100 keV (default is 1 keV)
cut:p j 0.01  $10 keV (default is 1 keV)
PHYS:P 4j 1 $turns off Doppler broadening
nps 1000000
```

Example 1: Planar mono-directional source

c Source cards

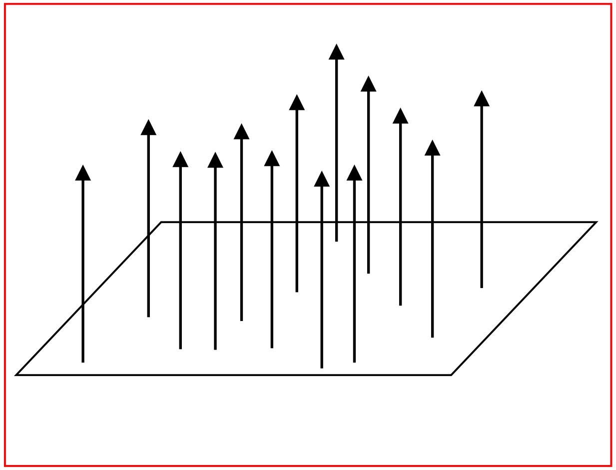
sdef pos=0 0 0 x=d1 y=d2 z=0 vec=0 0 1 dir=1 erg=10 par=2

si1 -6 6

sp1 0 1

si2 -6 6

sp2 0 1



Plane dimensions in x and y directions are defined as distributions

Checking geometry with Vised

Vised – graphical interface for MCNP used for:

- Visualization of input file geometry (cells and surfaces) in 2D and 3D
- Verification of source through particle tracking
- Plotting tallies
- Can be used for input file creation, particularly in case of complex geometries. However:
  - No source or tally definition capabilities
  - No cut cards definition capabilities
  - Define surfaces, cells, and materials

Running MCNP

- To run open MCNP command window, change directory to the location of your input file and type:

  mcnp5 i=iFile <o=oFile r=rFile>

- After run is finished – get two files
  - Output file (outp) – text file with tallies, etc.
  - Run file (runtpe) – binary file; can be used to restart simulation, add more histories, re-generate output, plot tallies in Vised

Other run options

- Interrupt: Ctrl+C
  - Choice of s (status), m (mcplot), q (quit), k (kill)
- Restart after ‘q’ or any other termination if run has not finished

  mcnp5 c r=rFile <o=oFile >
- Add number of histories with CONTINUE command (create input file, NPS new#)

  mcnp5 c i=iCont r=rFile <o=oFile >
- Regenerate lost output with CONTINUE (create input file, NPS –1)
- iCont file consists of just 2 lines + blank line:

```
CONTINUE
NPS 10000
```

```
CONTINUE
NPS -1
```

Statistical checks

- MCNP performs 10 statistical checks on each tally
  - Mean behavior
  - Relative error R (value, decrease, decrease rate)
  - Variance of variance VOV (value, decrease, decrease rate)
  - Figure of merit FOM (value, behavior)
  - Probability density functional PDF slope
- For each check: ‘desired’, ‘observed’, ‘passed?’
- Simple guidelines
  - R<0.1
  - run simulation until all checks pass

Example 2: Input file using transformations

```
Water phantom
c Cell cards
c Water phantom cells
 1     1 -1.0  2 -1 4 -3 5 -10 imp:p,e 1
 2     like 1 but trcl=1
 3     like 1 but trcl=2
 4     like 1 but trcl=3
c Air around
 100   2 -0.001293 (101 -102 -100) #1#2#3#4 imp:p,e 1
c Void cell
 999   0  -101:102:100 imp:p,e=0

c Surface cards
c Water phantom
 1     px 5
 2     px -5
 3     py 5
 4     py -5
 5     pz 10
 10    pz 11
c Cylinder around the problem
 100    cz 9
 101    pz -0.1
 102    pz 25
```

Example 2: Input file – Data cards

```
c Data cards
mode p e
c Materials
 m1    1000. 2        8000. 1  $Water
 m2    7014.         -0.755636  $air (US S. Atm at sea level)
       8016.         -0.231475 18000.        -0.012889
c Transformations
tr1 0 0 1
tr2 0 0 2
tr3 0 0 3
c Source cards
sdef pos=0 0 0  x=d1 y=d2 z=0 erg=10 par=2  $
si1 -6 6
sp1 0 1
si2 -6 6
sp2 0 1
c Tallies
F1:p 6
e1 1 99i 10 $ Energy spectrum, step 0.1 MV
*F8:p 1 2 3 4 $Depth dose tally
….
```

Example 3: Macrobodies

Provide a simplified way of defining surfaces. Example:

BOX: Arbitrarily oriented orthogonal box (all corners are 90°).
BOX *Vx Vy Vz A1x A1y A1z A2x A2y A2z A3x A3y A3z*
where *Vx Vy Vz* = *x*,*y*,*z* coordinates of corner
A1x A1y A1z = vector of first side
A2x A2y A2z = vector of second side
A2x A3y A3z = vector of third side

Example:
BOX –1 –1 –1 2 0 0 0 2 0 0 0 2
a cube centered at the origin, 2 cm on a side, sides parallel to the major axes.

Example 3: Input file using macrobodies

```
Water phantom
c Cell cards
c Water phantom
  1     1 -1.0  -7 fill=1 imp:p,e 1 $
c Lattice call for dose deposition
  10    1 -1.0  -10 lat=1 u=1 imp:p,e 1
c Air around
  100   2 -0.001293 -103 #1 imp:p,e 1
c Void cell
  999   0  103 imp:p=0 imp:e=0
```

```
c Surface cards
c Water phantom
 7     box -5 -5 10  10 0 0  0 10 0  0 0 10
c Lattice cell
 10    box -5 -5 10  10 0 0  0 10 0  0 0 1
c Cylinder around the problem
 103    rcc 0 0 -0.1  0 0 25  9
```