MCNP Basics

Basic Geometry
Cell Cards
Surface Cards
Data Cards

MCNP Basic Input

(MCNP5 manual, Volume II, Chapter 3)

Input File

- Title line
- Cell Cards
- Surface Cards
- Data Cards

Execution Line

MCNP INP File

TITLE line … **(required !)**

Cell Cards

.....

.....

blank line separator

Surface Cards

.....

.....

blank line separator

Data Cards

.....

.....

blank line separator (optional)

..... **(these lines would be ignored - useful for notes or saving options)**

.....

Input Characteristics

- Mnemonics (card names) begin within first 5 columns
- Input lines 80 columns
- Free field format
- Alphabetic characters are not case sensitive: UC, lc, MIXeD
- Continuation: 5 blanks or &
- Comment CARDS begin with "c "
- In-line comments begin with $
- Use spaces - don't use tabs (tabs are OK with MCNP5-1.51)
- For most numbers, these are the same:

  1 1. 1.0 1e0 1e+00 1.0e+0

- To read a section of input from another file (for MCNPX) :

  READ FILE=*filename*

- Units

  cm, g, MeV, atoms/barn-cm, shakes (1 sh = 10^{-8} sec)

Simple Input Example

```
Godiva critical - using ksrc & surfaces        ⇐ Title
c  CELL CARDS                                  ⇐ Comment
10   100     -18.74      -1                    ⇐ Cells
20    0                   1
                                               ⇐ Blank
c   SURFACE CARDS
1  so    8.741                                 ⇐ Surfaces
                                               ⇐ Blank
c  DATA CARDS
kcode    1000    1.0    10    50
ksrc   0.0   0.0   0.0
imp:n   1    0
m100    92235   -94.73                         ⇐ Materials
        92238   -5.27
```

Indent 5 or more spaces
for continuation

CELL CARDS

MCNP Cells

- **Cells are the basic geometry unit**
  - **volume of space bounded by surfaces**
  - **Cartesian coordinate system**
  - **Volumes calculated for many simple cells, not for complicated ones**

- **Cells are used for:**
  - **constructing the model**
  - **specifying the materials**
  - **variance reduction methods**
  - **performing tallies**

- **All of space must be defined**
  - **Every xyz point will lie either on a surface or within a uniquely defined cell.**
  - At least one cell will describe the problem exterior (outside world)

- **Repeated structure and lattice ability**
  - Cells may contain embedded geometry - lattice or repeated structure

Cell Card Format Examples

Cell #	Mat #	Den	Surfaces	Cell Data
10	300	9.65e-2	1 -2 3 -4 5 -6	

Positive Density ⇒ atoms/barn-cm

Cell #	Mat #	Den	Surfaces	Cell Data
10	300	-1.0	1 -2 3 -4 5 -6	imp:n=1.0

Negative Density ⇒ g/cm^3

Cell #	Mat #	Den	Surfaces	Cell Data
20	0		-7:8: -9	

Voids ⇒ Material # = 0, omit Density

SURFACE CARDS

MCNP Surfaces

- **Surfaces are used to define space**
  - **sign defines surface “sense” (+ or -)**
  - **combined with Boolean operators**
    - **intersection** space
    - **union** :
    - **complement** #

- **First, second, fourth order equations (26):**
  - plane
  - sphere
  - cylinder
  - cone
  - ellipsoid, hyperboloid, paraboloid
  - torus (elliptical or circular)

- **Macrobodies**
  - Primitive bodies - box, finite cylinder, sphere, …
  - MCNP internally translates to collections of surfaces

- **Can also specify surface by giving a few points (see manual)**

- **Special boundary types**
  - reflecting (mirror)
  - white (isotropic)
  - Periodic

- **Most surface areas calculated**

Surface Card Format

Surface #	Name	Data
10	px	5.0

plane normal to x-axis

equation: $x - D = 0$ data = D

50	so	11.1

sphere at origin

equation: $x^2 + y^2 + z^2 - R^2 = 0$ data = R

30	rcc	-6.0	0.0	0.0	12.0	0.0	0.0	4.0

right circular cylinder

12.0–cm high can about x-axis,
center of base at x = -6.0,
radius 4.0

MCNP Surface Cards

Table 3.1: MCNP Surface Cards

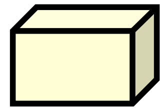
Mnemonic	Type	Description	Equation	Card Entries
P	Plane	General	$Ax + By + Cz - D = 0$	ABCD
PX		Normal to X-axis	$x - D = 0$	D
PY		Normal to Y-axis	$y - D = 0$	D
PZ		Normal to Z-axis	$z - D = 0$	D
SO	Sphere	Centered at Origin	$x^2 + y^2 + z^2 - R^2 = 0$	R
S		General	$(x-\bar{x})^2 + (y-\bar{y})^2 + (z-\bar{z})^2 - R^2 = 0$	$\bar{x}\ \bar{y}\ \bar{z}\ R$
SX		Centered on X-axis	$(x-\bar{x})^2 + y^2 + z^2 - R^2 = 0$	$\bar{x}\ R$
SY		Centered on Y-axis	$x^2 + (y-\bar{y})^2 + z^2 - R^2 = 0$	$\bar{y}\ R$
SZ		Centered on Z-axis	$y^2 + y^2 + (z-\bar{z})^2 - R^2 = 0$	$\bar{z}\ R$
C/X	Cylinder	Parallel to X-axis	$(y-\bar{y})^2 + (z-\bar{z})^2 - R^2 = 0$	$\bar{y}\ \bar{z}\ R$
C/Y		Parallel to Y-axis	$(x-\bar{x})^2 + (z-\bar{z})^2 - R^2 = 0$	$\bar{x}\ \bar{z}\ R$
C/Z		Parallel to Z-axis	$(x-\bar{x})^2 + (y-\bar{y})^2 - R^2 = 0$	$\bar{x}\ \bar{y}\ R$
CX		On X-axis	$y^2 + z^2 - R^2 = 0$	R
CY		On Y-axis	$x^2 + z^2 - R^2 = 0$	R
CZ		On Z-axis	$x^2 + y^2 - R^2 = 0$	R

MCNP Surface Cards

K/X	Cone	Parallel to X-axis	$\sqrt{(y-\bar{y})^2+(z-\bar{z})^2}-t(x-\bar{x}) = 0$	$\bar{x}\ \bar{y}\ \bar{z}\ t^2\ \pm 1$
K/Y		Parallel to Y-axis	$\sqrt{(x-\bar{x})^2+(z-\bar{z})^2}-t(y-\bar{y}) = 0$	$\bar{x}\ \bar{y}\ \bar{z}\ t^2\ \pm 1$
K/Z		Parallel to Z-axis	$\sqrt{(x-\bar{x})^2+(y-\bar{y})^2}-t(z-\bar{z}) = 0$	$\bar{x}\ \bar{y}\ \bar{z}\ t^2\ \pm 1$
KX		On X-axis	$\sqrt{y^2+z^2}-t(x-\bar{x}) = 0$	$\bar{x}\ t^2\ \pm 1$
KY		On Y-axis	$\sqrt{x^2+z^2}-t(y-\bar{y}) = 0$	$\bar{y}\ t^2\ \pm 1$
KZ		On Z-axis	$\sqrt{x^2+y^2}-t(z-\bar{z}) = 0$	$\bar{z}\ t^2\ \pm 1$ ± 1 used only for 1 sheet cone
SQ	Ellipsoid Hyperboloid Paraboloid	Axis parallel to X-, Y-, or Z-axis	$A(x-\bar{x})^2+B(y-\bar{y})^2+C(z-\bar{z})^2$ $+2D(x-\bar{x})+2E(y-\bar{y})$ $+2F(z-\bar{z})+G = 0$	A B C D E F G $\bar{x}$ $\bar{y}$ $\bar{z}$
GQ	Cylinder Cone Ellipsoid Hyperboloid Paraboloid	Axes not parallel to X-, Y-, or Z-axis	$Ax^2+By^2+Cz^2+Dxy+Eyz$ $+Fzx+Gx+Hy+Jz+K = 0$	A B C D E F G H J K
TX	Elliptical or circular torus. Axis is parallel to X-,Y-, or Z-axis		$(x-\bar{x})^2/B^2+(\sqrt{(y-\bar{y})^2+(z-\bar{z})^2}-A)^2/C^2-1 = 0$	$\bar{x}\ \bar{y}\ \bar{z}$ A B C
TY			$(y-\bar{y})^2/B^2+(\sqrt{(x-\bar{x})^2+(z-\bar{z})^2}-A)^2/C^2-1 = 0$	$\bar{x}\ \bar{y}\ \bar{z}$ A B C
TZ			$(z-\bar{z})^2/B^2+(\sqrt{(x-\bar{x})^2+(y-\bar{y})^2}-A)^2/C^2-1 = 0$	$\bar{x}\ \bar{y}\ \bar{z}$ A B C
XYZP		Surfaces defined by points		See pages 3–15 and 3–17

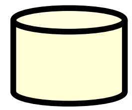
MCNP Macrobodies

- **Rectangular Parallelepiped**



  RPP xmin xmax ymin ymax zmin zmax

- **Right Circular Cylinder**



  RCC Vx Vy Vz Hx Hy Hz R

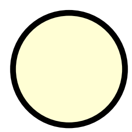
  Vx Vy Vz = center of base

  Hx Hy Hz = axis of cylinder, magnitude = height

  R = radius

- **Sphere**

  SPH Vx Vy Vz R



- **Others**

  ARB, BOX, ELL, HEX, REC, RHP, TRC, WED

Surface Sense

$F(X,Y,Z) = S$

where

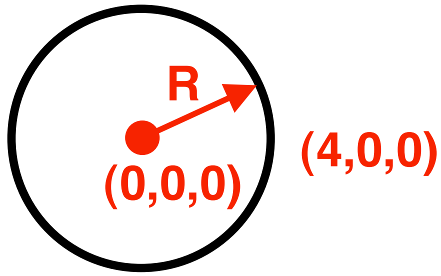
$F = 0$	is a surface equation
X,Y,Z	arbitrary 3-D coordinate
S	result of xyz point in equation

$S > 0$	positive sense, "outside"
$S = 0$	zero, point "on" surface
$S < 0$	negative sense, "inside"

For macrobodies,

- **inside the body is defined to have negative sense,**
- **outside the body to have positive sense**

Example



SO Surface Equation - sphere at origin

$$x^2 + y^2 + z^2 - R^2 = S \qquad R = 3.0$$

- Substitute (0,0,0), find S

  $0^2 + 0^2 + 0^2 - 3^2 = \text{neg}$

  Point (0,0,0) gives negative S.

  Inside of sphere has negative sense

- Substitute (4,0,0), find S

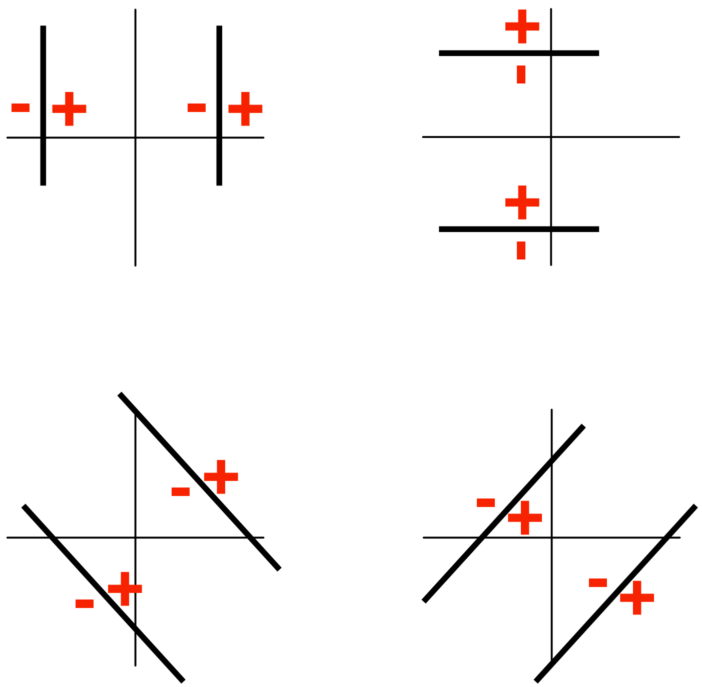
  $4^2 + 0^2 + 0^2 - 3^2 = \text{pos}$

  Point (4,0,0) gives positive S.

  Outside of sphere has positive sense

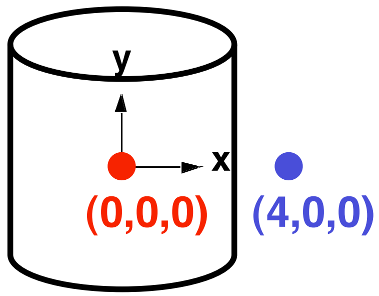
Surface Sense

- **Planes**



Note: The sense depends on the normalization of the surface equation. Multiplying both sides of the equation by -1 changes the sense. By convention, surface equations are defined & normalized so that the leading coefficient is positive.

- **Cylinders**



Inside of cylinder has negative sense

Outside of cylinder has positive sense

DATA CARDS

Material

Importance

Sources

Physics

Data Cards

card type	example
Source	**sdef**
Materials	**m**
Tallies	**f**
Problem Cutoffs	**nps**
Variance Reduction	**imp:n**
Energy and Thermal Treatment	**mode**

Peripheral Cards
ANY card other than cells and surfaces

Material Cards (Mn)

Mn ZAID1 fraction1 ZAID2 fraction2 .....

n = material number
ZAID = element or nuclide identifier: ZZZAAA
ZZZ = atomic number
AAA = atomic mass

Examples:

^{235}U $\Rightarrow$ 92235 ^{16}O $\Rightarrow$ 8016 Cu $\Rightarrow$ 29000

fraction: positive = atom fraction of ZAID
negative = mass fraction of ZAID

- **MCNP normalizes the fractions for a material to sum up to 1.0**
- **Density (g/cc or atoms/barn-cm) comes from the cell cards**

Cell & Material Cards

- **Cell & material cards should be consistent**
  - The overall material density (g/cc or atoms/barn-cm) comes from the cell card where a material is used
  - Fractions or number densities on a material card are normalized to sum up to 1.0
- **Examples**

```
10    100     -1.0     1 -2 . . .          $ cell:   mat 100, 1 g/cc
. . .
m100   1001    2        8016        1      $ mat:    H2O, using atom fractions
```

```
10    100     0.100     1 -2 . . .         $ cell:   mat 100, .1 at/barn-cm
. . .
m100   1001    2        8016        1      $ mat:    H2O
```

```
10    100     0.100     1 -2 . . .         $ cell:   mat 100, .1 at/barn-cm
. . .
m100   1001 .06667    8016 .03333          $ mat card:    H2O
```

Note: I usually use number densities on the material cards,
& then add them up to get the total to use on the cell cards

IMP:N Card

- **Each cell must have an "importance"**
  - **Used for variance reduction**
- **Importance of "0" terminates particle**
  - **Outside world cell usually 0**
- **Can be in data card block**

```
imp:n   1   2   4   0
```

or after surfaces on cell cards

```
20  0            -7:8:-9      imp:n=1
30  100  -1.0    1 2 3        imp:n=2
```

Source Cards

- **For criticality calculations, can use KSRC card to define initial neutron starting points**

  KSRC x1 y1 z1 x2 y2 z2 x3 y3 z3 .....

  - Can define any number of points, reused as needed
  - Points are used ONLY for initial source guess, ignored on subsequent cycles

- **For fixed-source or criticality calculations, can use SDEF card to define starting parameters for histories**
  - Very general sources can be described
  - For criticality calculations, only used for initial source guess, ignored on subsequent cycles

- **Cannot use both SDEF and KSRC in same calculation**

Problem Cutoffs

- **Number of histories to be run (for fixed-source problems):**

  NPS N

  – Terminate the Monte Carlo calculation after **N** histories have been run
  – In a continue-run, NPS is the total number of particles - including runs before the continue run (cumulative)
  – Negative entry will print output file at time of last history run

- **Number of cycles for KCODE (criticality problems):**

  KCODE npc kguess ndiscard ncycles

  – Run **ncycles** (total), throw away first **ndiscard** cycles, **npc** neutrons/cycle
  – In continue run, **ncycle** is total - including from previous runs

- **Computer time**

  CTME X

  – **X** = Maximum amount of computer time (minutes) for MC calculation
  – In a continue-run, CTME is the time relative to start of continue-run calculation; (i.e. not cumulative)

Energy and Thermal Treatment

- **Problem type:**

  MODE <*pl*$_1$> <*pl*$_2$> … <*pl*$_n$>

  – List of all particles to be transported in space-delimited format
  – If a particle is designated, the anti-particle will also be transported

- **Particle physics options:**

  PHYS:<*pl*> (*list of input parameters*)

  – Controls physics options; format varies based on particle type
  – Includes control of charged-particle straggling, upper energy limit, light ion recoil, implicit vs analog capture, bremsstrahlung production, secondary particle production, delayed gamma production, photonuclear particle production, fission multiplicity, etc.

- **Physics models (MCNPX):**

  LCA, LCB, LCC, LEA, LEB

  – Use to set physics parameters for the Bertini, ISABEL, CEM03, INCL4 and FLUKA options
  – All of the input values on the five cards have defaults that will be taken in the absence of the cards

MCNP Execution

MCNP Execution

(MCNP manual, Chapter 1)

mcnp5 i=inp01 o=outp01 ... [options]

Default File Name	Description
inp	**Input file**
outp	**ascii output file**
runtpe	**binary restart file**
mctal	**ascii tally results**
meshtal	**mesh tallies (mcnp5)**

Options	Operation
i	**Process input file**
p	**Plot geometry**
x	**Process xsec's**
r	**Particle transport**
z	**Plot tally results**
	Plot cross sections

default: ixr

Examples:

```
mcnp5    i=gdv
mcnp5    inp=test1   outp=test1o   run=test1r   ip
mcnp5    name=test1
mcnp5    i=test1   ixz
```

Running MCNP

- **Geometry plotting:**

  mcnp5 i=inp ip <-- process input & plot geometry

- **Run a problem: mcnp5 i=inp**
  - Creates files:

outp	output file
runtpe	restart file
mctal	tally file
srctp	source (for restart)
comout	(if plotting)

  - last letter changed, if file already exists

- **Run a problem: mcnp5 n=inp**
  - Creates files:

inpo	output file
inpr	restart file
inps	source
inpc	(if plotting)

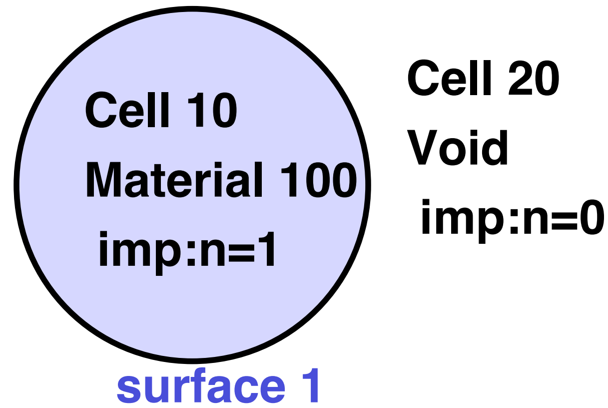
  - **aborts** if any of these already exist

Problem g1

Godiva critical -- using KSRC & surfaces

- Bare, high-enriched uranium sphere
- Sphere radius = 8.741 cm
- Material density = 18.74 g/cm3
- Nuclide Weight-fraction ZAID

Nuclide	Weight-fraction	ZAID
U235	94.73	92235
U238	5.27	92238



(1) Create & edit file "g1"

(2) Add title, cell cards, surface cards, data cards

surface card (sphere at origin): **surfnum so radius**

also use these data cards:

```
kcode  1000   1.0   10   50
ksrc   0.0   0.0   0.0
```

(3) Plot the geometry: **mcnp5 i=g1 ip**

(4) Run the problem: **mcnp5 i=g1**

(5) Rerun the problem: **mcnp5 i=g1**

Comments - g1

- **KSRC 0.0 0.0 0.0**
  - isotropic point source at (0.0, 0.0, 0.0)
  - used only for the source guess for initial cycle, ignored after that

- **KCODE 1000 1.0 10 50**
  - start 1000 particles
  - initial guess for Keff = 1.0
  - run 50 cycles, throw out the first 10

- **imp:n 1 0**
  - First cell (10) has importance 1, second cell (20) has importance 0
  - Could put this information on cell cards instead:

```
c   CELL CARDS
10    100    -18.7   -1       imp:n=1
20    0                1       imp:n=0
```

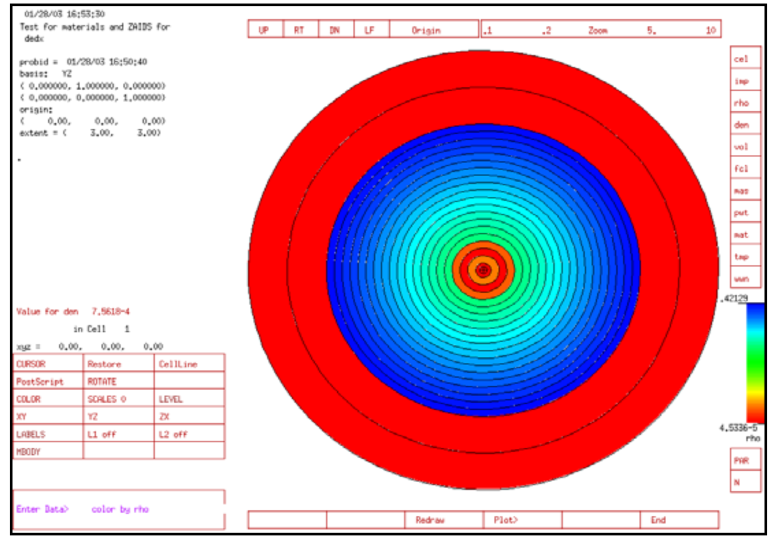
- **cleanup:**

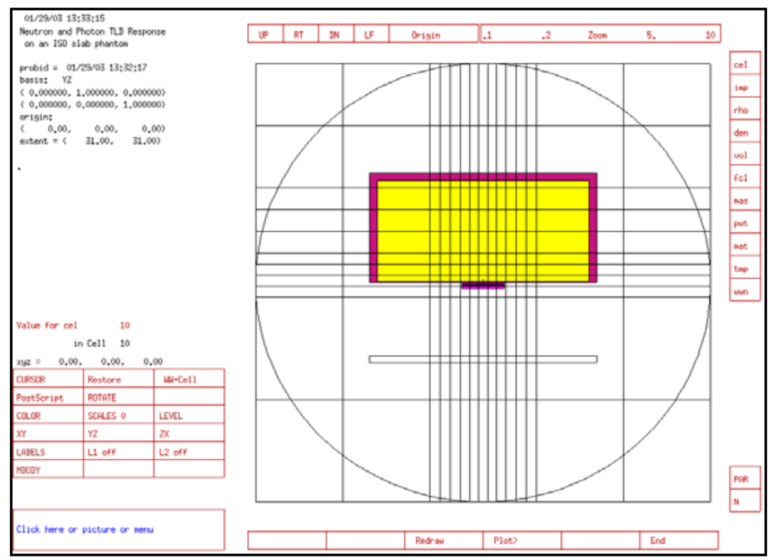
  Cygwin: `rm out* src* run* com*`

  DOS: `del out* src* run* com*`

Geometry Plotting

- **Interactive 2-dimensional slices**
- **Errors displayed as dashed (red) lines**
- **Many problem variables can be shown:**
  - cell & surface numbers
  - macrobody facets
  - importances imp:n
  - lattice variables u, lat, fill, level
  - material properties rho, den, …..
  - variance reduction parameters
  - weight windows mesh





Geometry Plot Commands

(MCNP manual, Appendix B)

ORIGIN X Y Z		Position the center of the
or	15.0 0.0 5.0	plot window at (X,Y,Z).
EXTENT EH		Scale the plot with extent EH
ex	25.0	Smaller EH, closer view
PX VX	px 3.0	Set the view plane to x=VX
PY VY	py 5.0	y=VY
PZ VZ	pz 0.01	z=VZ
LABEL S C DES		surface labels of size S cell labels of size C
la	0 1	
la	0 1 mat	DES is variable to display
la	0 2 den	(CEL, MAT, IMP:n, RHO, ...)

SDEF Source Examples

[Note: slides 34-37 give examples/recipes, see manual or "Sources" lecture for details]

- **Point source, isotropic in direction**

```
SDEF   x=1.0   y=3.2   z=0.0
```

- **Line source, isotropic in direction**

```
SDEF   x=d1    y=3.2   z=0.0   $ sample x from distribution 1
SI1    -10.0   10.0            $ source info, distrib 1
SP1    0.0     1.0             $ source probabilities, distr 1
```

- **Volume source in a box, isotropic in direction**

```
SDEF   x=d1    y=d2    z=d3    $ x,y,z from distributions
SI1    -1.0    1.0             $ extent for x
SP1    0.0     1.0             $ uniform probabilities for x
SI2    -0.0    3.2             $ extent for y
SP2    0.0     1.0             $ uniform probabilities for y
SI3    21.0    27.0            $ extent for z
SP3    0.0     1.0             $ uniform probabilities for z
```

SDEF Examples

- **Volume source in a box, isotropic in direction, specified CELL**

```
SDEF   x=d1   y=d2   z=d3       cel=13
SI1    -1.0    1.0
.....
```

$\Rightarrow$ **Sample x from distribution 1,**

$\Rightarrow$ **then y from distribution 2,**

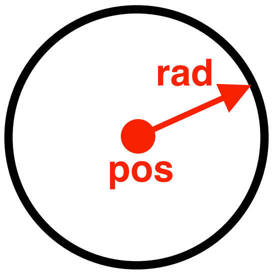
$\Rightarrow$ **then z from distribution 3,**

$\Rightarrow$ **then: accept x,y,z if that point is inside cell 13, otherwise reject the point & try again**

- **Could use this approach for arbitrary shapes:**
  - Sample in a box containing a spherical cell, then accept only if inside the cell
  - **Efficiency** of source sampling = (volume of cell) / (volume of box)

SDEF - Uniform Source in Sphere & Cylinder

Uniform source throughout volume of a sphere



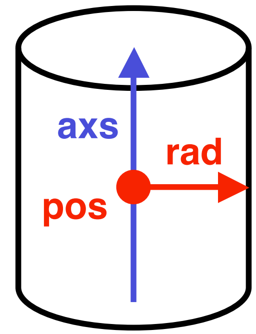
SDEF pos= 1.0 2.0 3.0 rad=d1
si1 0.0 3.5 $ inner & outer radii
sp1 -21 2 $ sample density ~ R^2

Why sample point density ~ R^2 ?

$$dV/dr = d(4/3\,\pi\, R^3)/dr = 4\pi R^2$$

probability of point
in dV at radius R ~ R^2

Uniform source throughout volume of a cylinder



SDEF pos= 1. 2. 3. axs=0. 0. 1. rad=d1 ext=d2
si1 0.0 3.5 $ inner & outer radii
sp1 -21 1 $ sample density ~ R
si2 -5.0 5.0 $ axial, along axs vector
sp2 0 1 $ uniform axial

Why sample point density ~ R ?

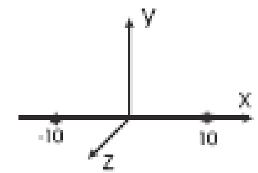
$$dV/dr = d(\pi R^2 h)/dr = 2\pi Rh$$

probability of point
in dV at radius R ~ R

SDEF Examples

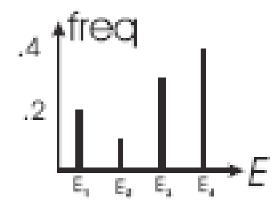
- **Two point isotropic 1-MeV photon sources on x-axis**

```
SDEF   ERG=1.00  PAR=2  POS=d5  $ E, particle type, location
SI5  L  -10 0 0   10 0 0        $ (x,y,z) for the 2 pt sources
SP5      .75   .25            $ relative strength of each source
```



- **Point isotropic source with 4 discrete energy photons**

```
SDEF   POS 0 0 0    ERG=d1   PAR=2
SI1  L   .3  .5  1.  2.5       $ the 4 discrete energies (MeV)
SP1      .2  .1  .3   .4       $ frequency of each energy
```

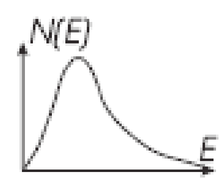


- **Point isotropic source with 4 histogram energy bins**

```
SDEF  POS 0 0 0  PAR=2 ERG=d1   $ position, particle type, E
SI1  H   .1  .3  .5  1.  2.5    $ histogram boundaries
SP1 D  0  .2  .4  .3  .2        $ probabilities for each bin
```

- **Point isotropic source with Maxwellian energy spectrum**

```
SDEF POS 0 0 0  PAR=2 ERG=d1  $ position, particle type, E
SP1 -2 0.5                    $ Maxwellian with temp a=0.5 MeV
```



* Examples and figures from: J.K. Shultis & R.E. Faw, "An MCNP Primer", www.mne.ksu.edu/~jks/MCNPprmr.pdf (2005)

Problem g2

Godiva critical -- using SDEF

Same as Problem g1, but use SDEF to sample the starting source guess uniformly in the volume of the sphere

(1) Copy file "g1" to "g2": **cp g1 g2**

(2) Edit file "g2"

Delete KSRC card

Add SDEF + SIn + SPn cards for uniform volume source in sphere

(3) Plot the geometry: **mcnp5 i=g2 ip**

(4) Run the problem: **mcnp5 i=g2**

(5) Compare the initial & final Keff to Problem g1

(6) Examine files created: ls

(5) Cleanup: rm out* com* run* src* g2?

Comments - g2

- **Keff - initial & final**

  g1 - point source - K starts high, decreases to converged K

  g2 - volume source - K starts low, increases to converged K

  Initial K depends on your guess for the source

  Converged K should be the same, regardless of initial guess (within statistics)

- **Files created**
  - **initial run, mcnp5 i=g2: outp, runtpe, srctp**

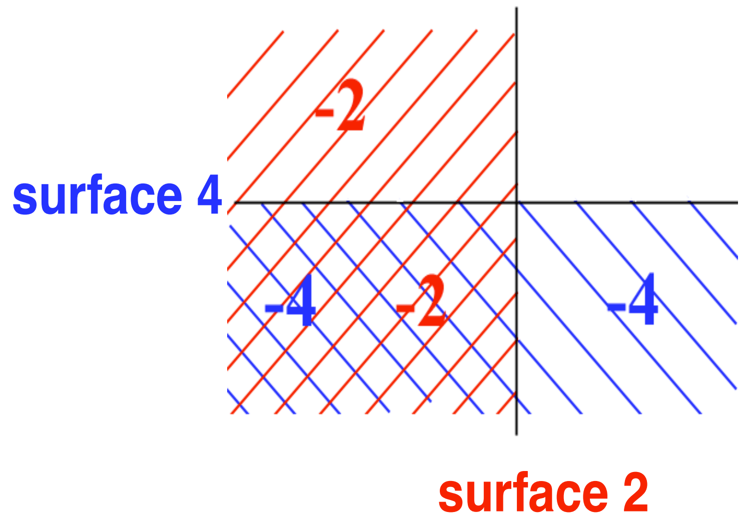
- Cleanup:

  Cygwin: `rm -f out* runtp* srct* comou*`

  DOS: `del out* runtp* srct* comou*`

MORE GEOMETRY

Boolean Intersection



INTERSECTION operator -
***blank* between surfaces**

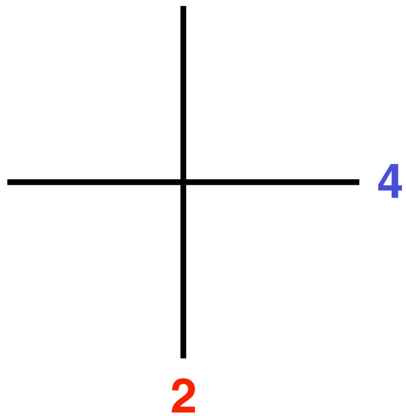
-4 -2 means

negative sense wrt 4 *AND* negative sense wrt 2

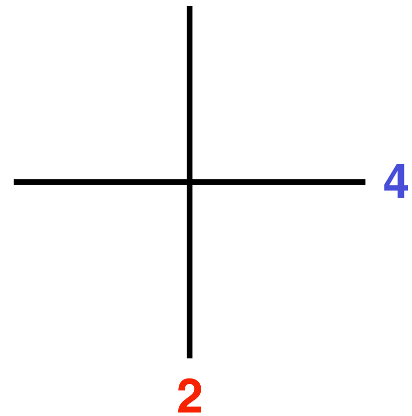
Only space where *BOTH* criteria are true
Only the space colored *BOTH* red *AND* blue

Intersection

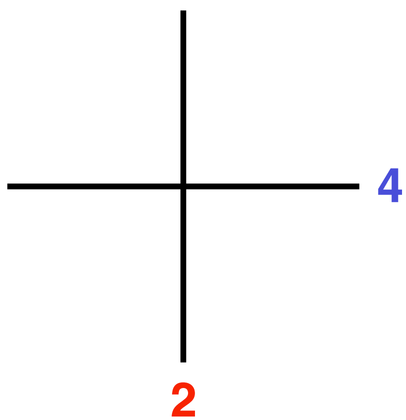
-4 -2



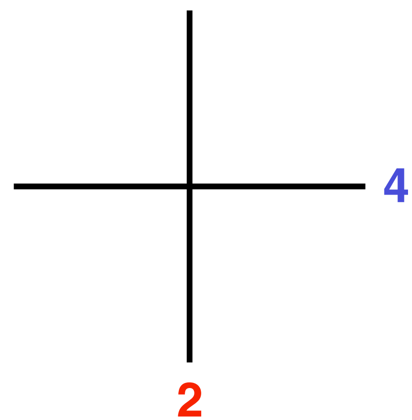
4 -2



-4 2

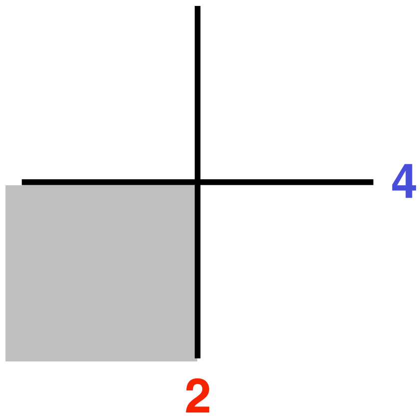


4 2

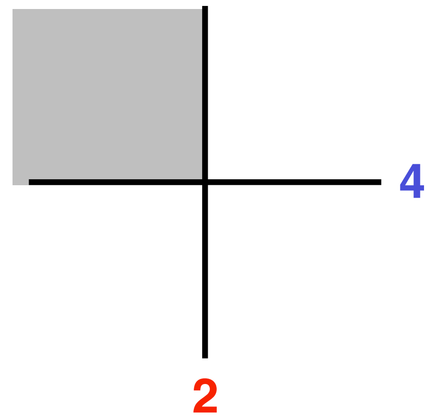


Intersection

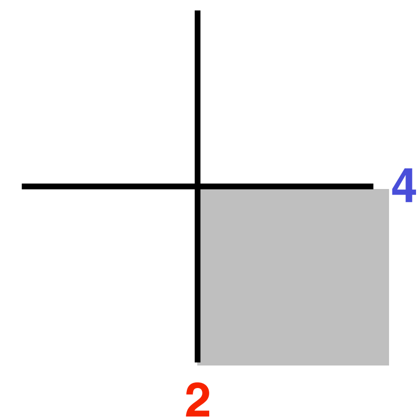
-4 -2



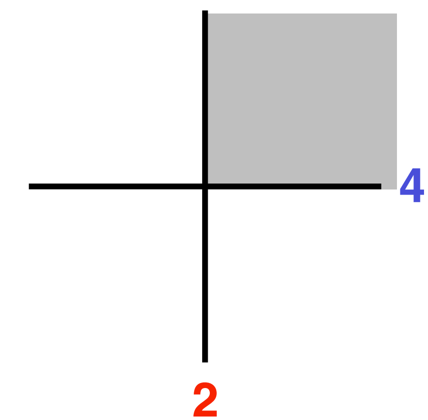
4 -2



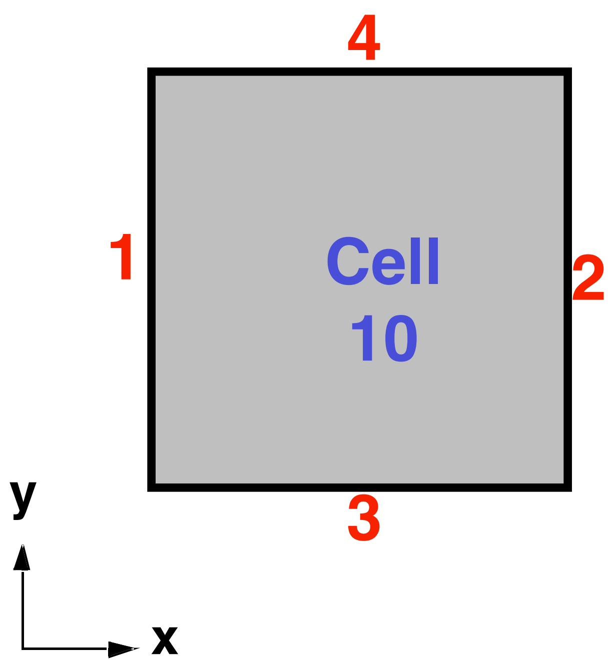
-4 2



4 2



Intersection



Surfaces:

1	px	-5.0
2	px	5.0
3	py	-5.0
4	py	5.0

Intersection logic for Cell 10 definition:

+1 -2 +3 -4

All sense criteria must be true for points in Cell 10

Union

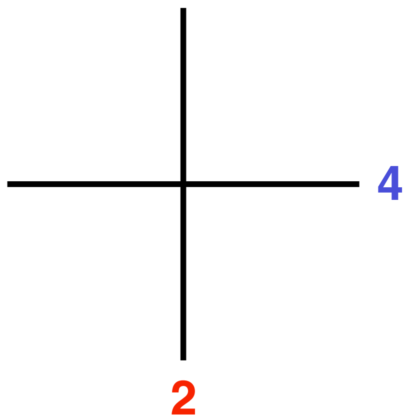
UNION operator
"**:**" between surfaces

+2 **:** +4 means
positive sense wrt 2
OR positive sense wrt 4
OR BOTH

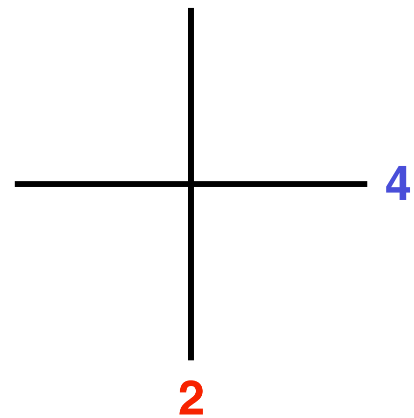
ONE sense criteria must be met for a point to be above 4 *OR* right of 2 *OR* BOTH

Union

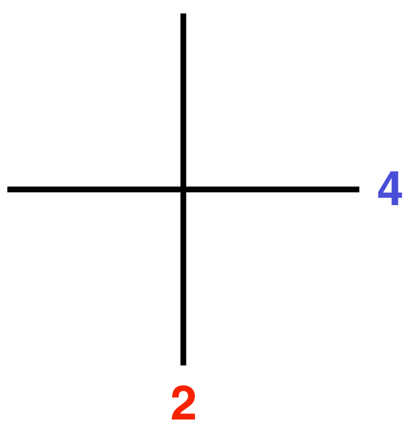
-4 : -2



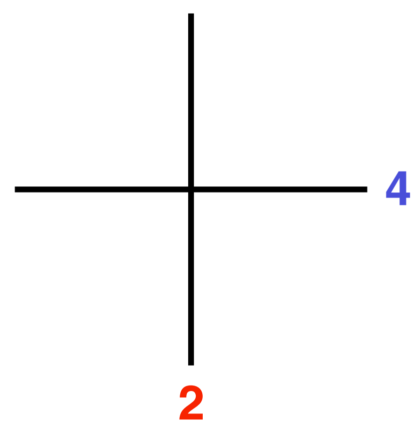
4 : -2



-4 : 2

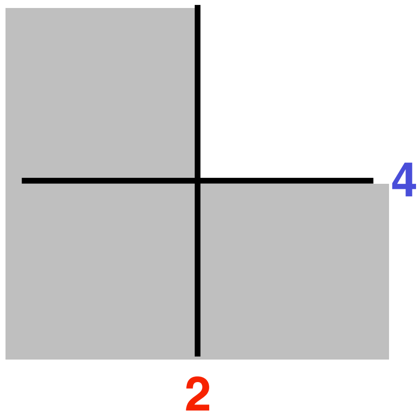


4 : 2

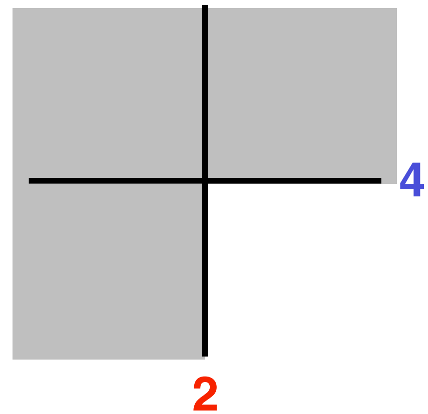


Union

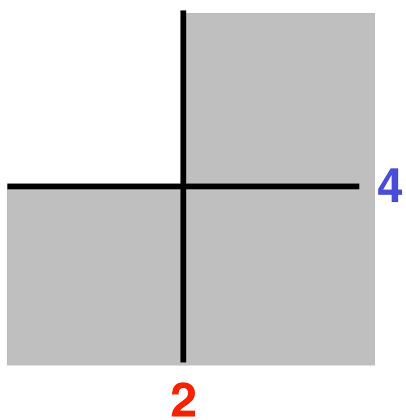
-4 : -2



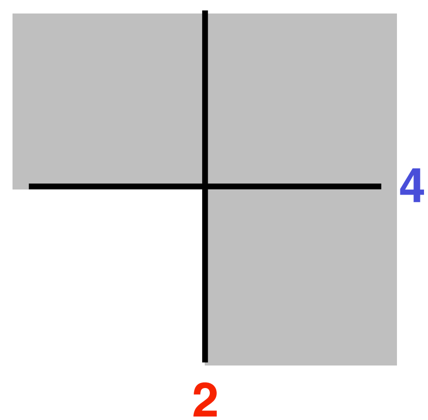
4 : -2



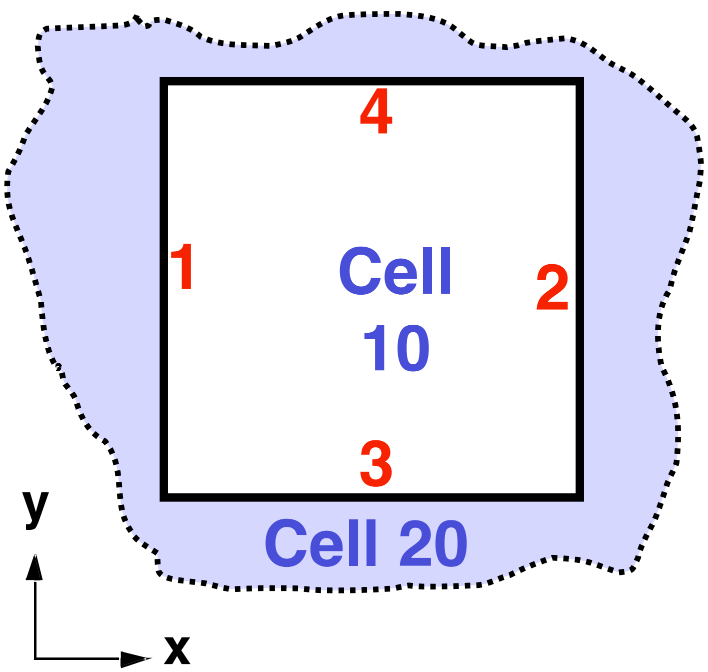
-4 : 2



4 : 2



Union



Surfaces:

1	px	-5.0
2	px	5.0
3	py	-5.0
4	py	5.0

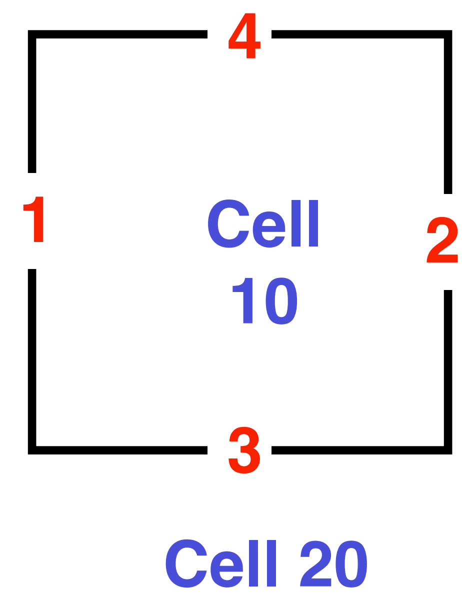
Union logic for Cell 20 definition:

-1 : 2 : -3 : 4

Only one (or more) sense criteria need be true for points in Cell 20

Complement Operator

COMPLEMENT operator
"#" before cell number



Cell 10 is +1 -2 +3 -4
Cell 20 is -1 : +2 : -3 : +4

Every + is -, every " " is ":"

Cell 20 is the *opposite* (complement) of Cell 10

Cell 20 definition using complement operator:

20 0 #10

Note:

The MCNP manual discourages the use of the complement operator, claiming it can lead to very inefficient tracking. That is nonsense -- use it whenever it is convenient for setting up input.

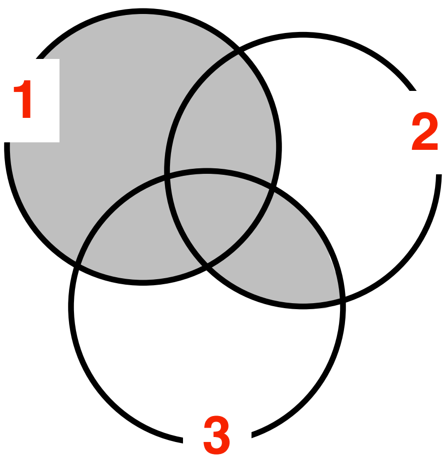
Order of Operations

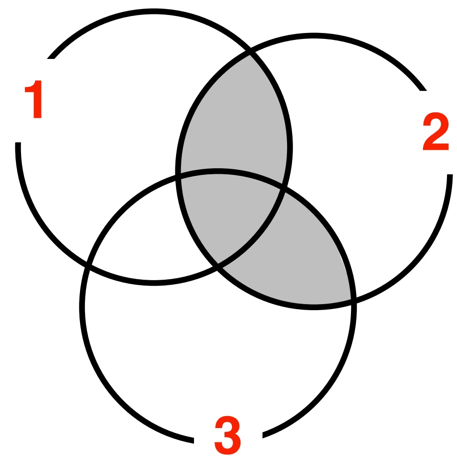
- Intersections are done before unions

  -1 : -3 -2 is equivalent to -1 : (-3 -2)

- Example

  -1 : -3 -2 is <u>not</u> the same as (-1 : -3) -2





Plutonium Nitrate Solution

In a Cylindrical tank

--

See Case Study #1

Sample input file: puc1

Plutonium Nitrate Solution in a Tank

Cell 10:

Radius = 12. 49 cm

Height = 39.24 cm

Density = 9.9270e-2 atoms/b-cm

Cell 30:

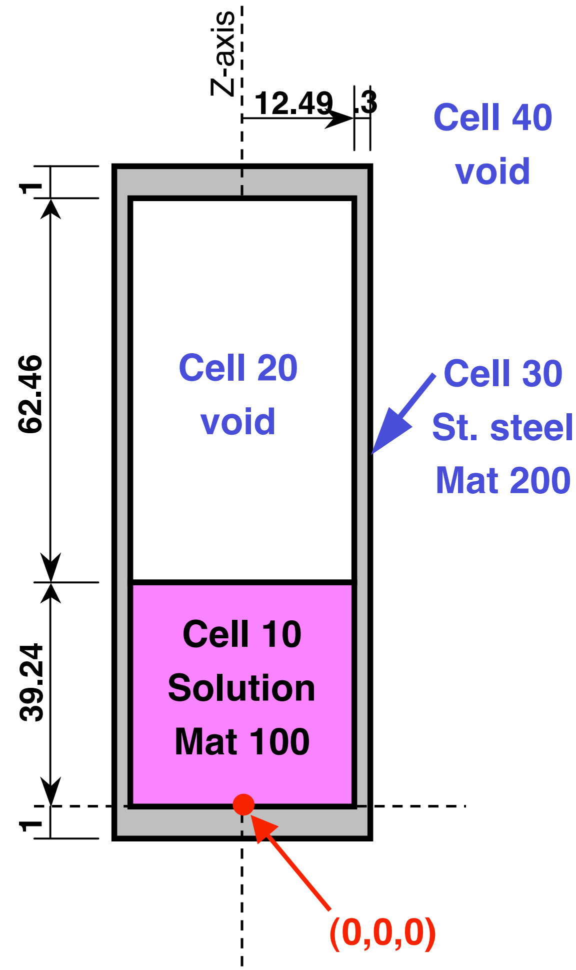
Tank thickness = 0.3 cm

Bottom thickness = 1.0 cm

Top thickness = 1.0 cm

Inside height = 101.7 cm

Density = 8.6360e-2 atoms/b-cm



Composition of Materials 100 & 200

Material 100		Material 200	

To save typing, just use these:

1001	6.0070e-2		
8016	3.6540e-2	26056	1.0
7014	2.3611e-3		
94239	2.7682e-4		

Use this card: mt100 lwtr to activate S(α,β) scattering law

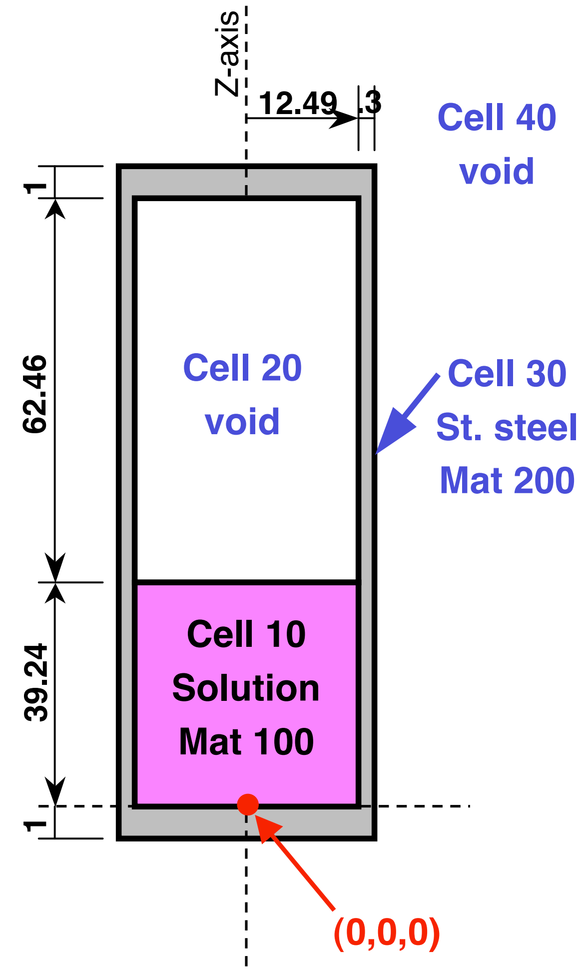
Problem puc1

Construct a single tank

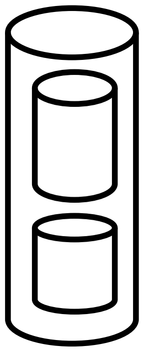
- Cell 10 – material 100
- Cell 20 – void
- Cell 30 – material 200
- Cell 40 – void

- Use ksrc, center of cell 10
- Use 1000 neutrons/cycle
- Discard 25 cycles, run 100 total
- Don't forget imp:n

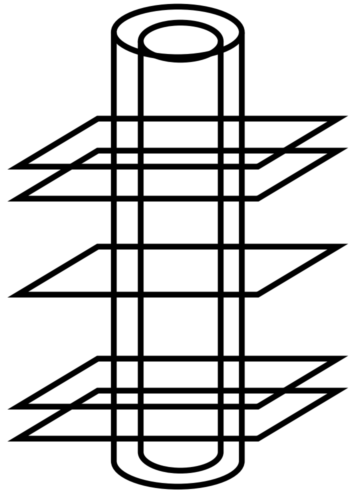
- Edit file "puc1"
- Plot
- Compute keff



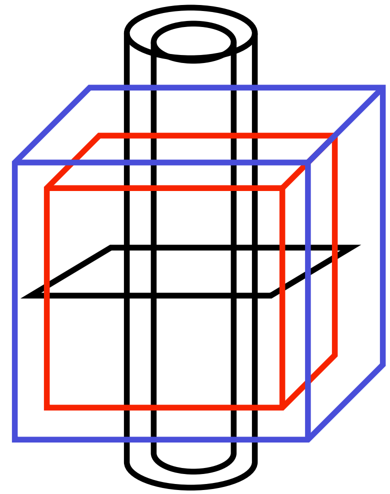
Possible geometry setups



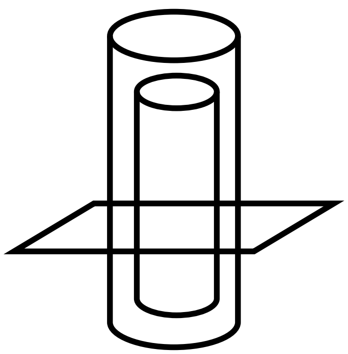
3 RCC bodies



2 infinite z-cylinders
+ 5 planes



2 infinite z-cylinders
+ 2 RPP bodies
+ 1 plane



2 RCC bodies
+ plane

Do it this way

(you'll see why later ...)