EEAE ΕΛΛΗΝΙΚΗ ΕΠΙΤΡΟΠΗ ΑΤΟΜΙΚΗΣ ΕΝΕΡΓΕΙΑΣ
GREEK ATOMIC ENERGY COMMISSION

Gamma Spectrometry Working Group
Monte Carlo Action

ICRM

MCNP
The perspective of a new user

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Content

- Introduction
- Input file
- Output file - Results
- Conclusions -Comments

Introduction

- Distributed through **RSICC** (**R**adiation **S**afety **I**nformation **C**omputational **C**enter) at Oak Ridge National Laboratory, USA;
- Code Contribution is not free
- Written in FORTRAN 90
- Computer Platforms:
  - ✓ UNIX
  - ✓ Windows/DOS

Introduction

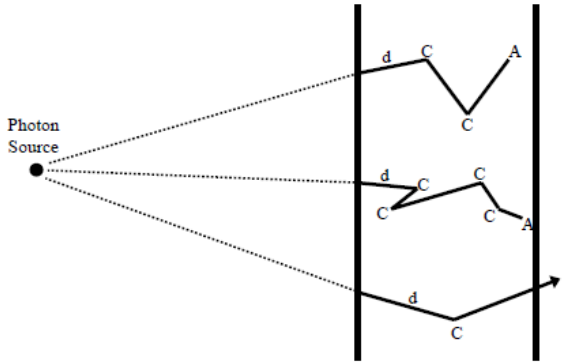
- General & powerful code
- Numerous **variance reduction techniques** may be invoked by the user
- Particle type: **neutron, photon, electron**
- Continuous-energy Cross Section Tables
- Complete control over **source term**
- **Flexible tallies**
- Criticality calculations are supported

“Particles” transported in MCNP

Neutrons → **n:** 10^{-11} to 20 MeV (150 MeV for several isotopes)

Photons → **p:** 1 keV to 100 GeV
(incoherent, coherent, photoelectric and pair production cross sections)

Electrons → **e:** 1 keV to 1 GeV



d = distance to collision
C = collision site
A = absorption

MCNP Basic Input

- Lengths in cm
- Energies in MeV
- Times in sec
- Temperatures in kT
- Atomic densities in units of atoms/barn-cm
- Mass densities in g/cm^3
- Cross section in barns
- Heat number in MeV/collision
- Atomic weight ratio based on a neutron mass of 1.00866497 amu

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Input file - Structure

```
C ICRM(GSWG- MONTE CARLO ACTION)
C DETECTOR A - FILTER SOURCE
C ********** BLOCK 1: CELLS **********
1 0       (12 -1 -15)
2 1 -5.323 (12 -2 -16) (1:15)
3 1 -5.323 (2:16) (12 -17 -3)
4 0       (-12:17:3) (13 -18 -4)
.....
C ********** BLOCK 2: SURFACES **********
1 CZ 0.5
2 CZ 2.9
3 CZ 3.0
4 CZ 3.9
....
C ********** BLOCK 3: DATA **********
MODE P E
imp:p 1 8r 0
imp:e 1 8r 0
SDEF CEL=6 ERG=0.200 PAR=2 POS=0 0 6.85 AXS=0 0 1 RAD=D2 EXT=D3
....
M3 1000 -0.067958 6000 -0.441715 8000 -0.490327 $ Cellulose
M4 82000 -1.0 $ Pb
```

Title Card

Cells Card

Surface Card

Data Card

Input file - Structure

```
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C DETECTOR A - FILTER SOURCE
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Title Card

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Surface Card

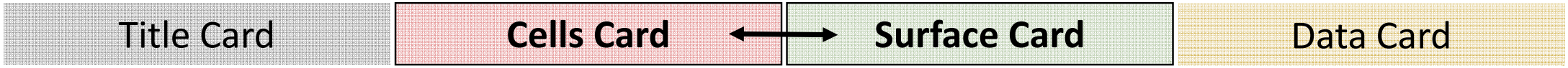
Data Card

Geometry definition

Input file – Geometry (1)

Surface Cards

- “Simplest” cards
- Specification by equation coefficients or points
- Standard Surfaces designated by mnemonics
- Planes, cylinders, and cones are infinite in extent



Input file – Geometry (2)

```
C ********** BLOCK 2: SURFACES **********
1 CZ 0.5
2 CZ 2.9
3 CZ 3.0
4 CZ 3.9
5 CZ 4.0
12 PZ 0.0
13 PZ -1.3
14 PZ -1.4
15 PZ 4.0
16 PZ 5.9
17 PZ 6.0
18 PZ 6.5
19 PZ 6.6
24 PZ 17.6
25 PZ -12.4
26 CZ 15
27 PZ 22.6
28 PZ -17.4
29 CZ  20
30 SO 50
```

Surface 1:
$x^2 + y^2 - R^2 = 0$, **cylinder** on z-axis, R=2.9

Surface 13:
$z - D = 0$, **plane** normal to z-axis, Z=-1.3

All dimensions are expressed in **cm**

Surface 30:
$x^2 + y^2 + z^2 - R^2 = 0$, **sphere** centered at origin, R=50

Title Card | **Cells Card** | **Surface Card** | Data Card

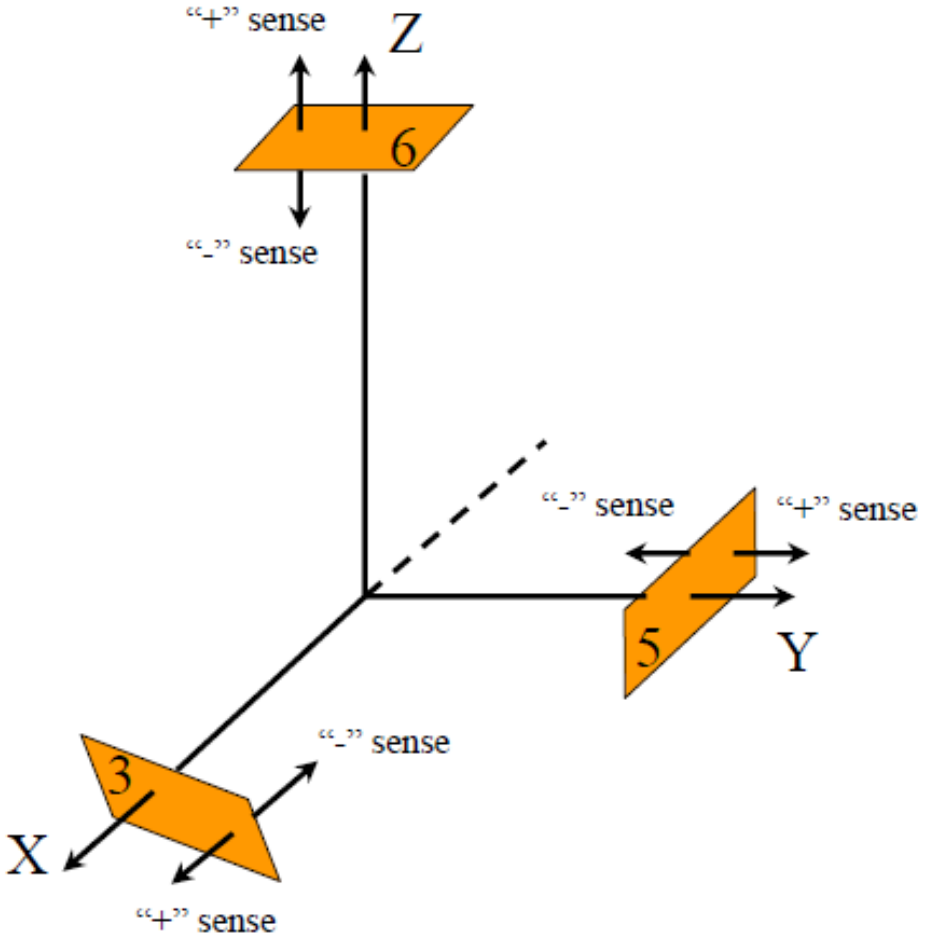
Table 3.1: MCNP Surface Cards

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
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	$\sqrt{(x-\bar{x})^2 + (y-\bar{y})^2} - t(z-\bar{z}) = 0$	$\bar{x}\ \bar{y}\ \bar{z}\ t^2 \pm 1$

Input file – Geometry (3)

Surface sense:

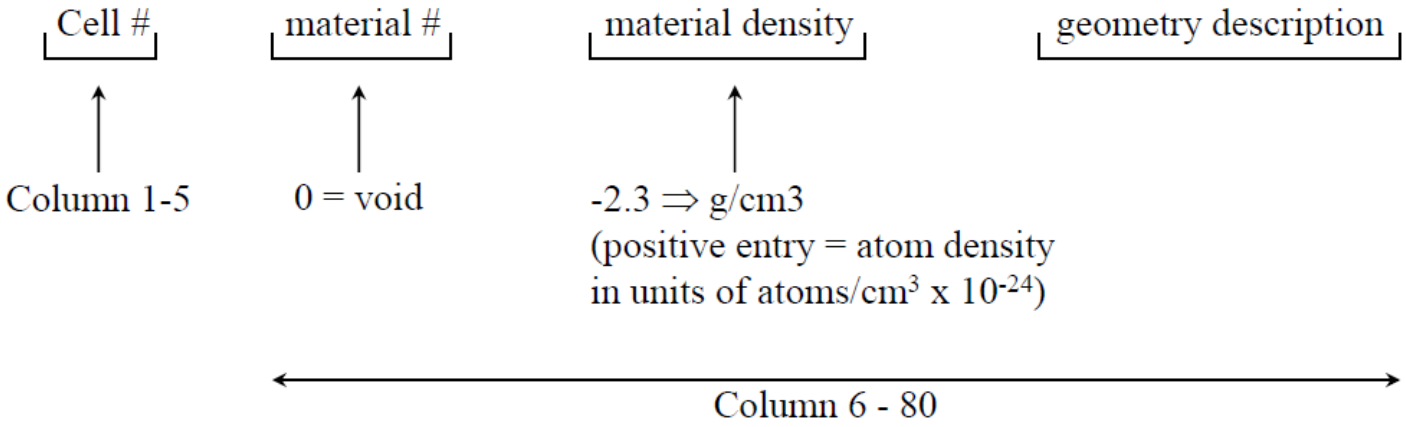
- **Above plane:** “+” or positive sense
- **Below plane:** “–” or negative sense
- **Inside cylinder or sphere:** “–”
- **Outside cylinder or sphere:** “+”



Input file – Geometry (4)

Cell Cards:

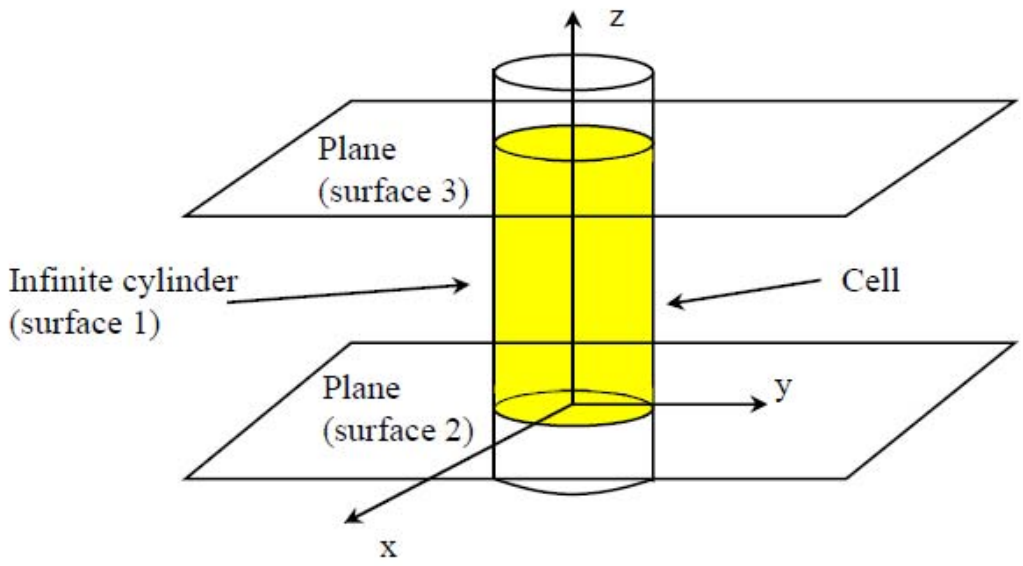
- Cells are the **basic geometry** unit
- **Cartesian** Coordinate System
- Each region must be uniquely defined (no “cookie cutter” cells allowed)
- At least one cell must describe the **problem exterior**



Title Card | **Cells Card** | Surface Card | Data Card

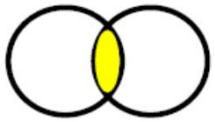
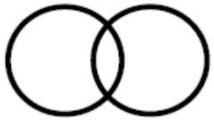
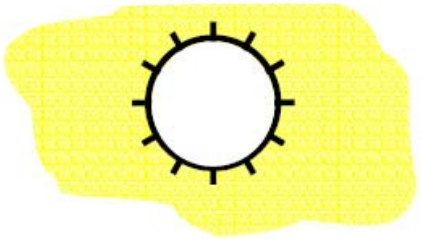
Input file – Geometry (4)

- Cells are built up using one or more surfaces.
- Cells are volumes in space bounded by simple surfaces:



Input file – Geometry (5)

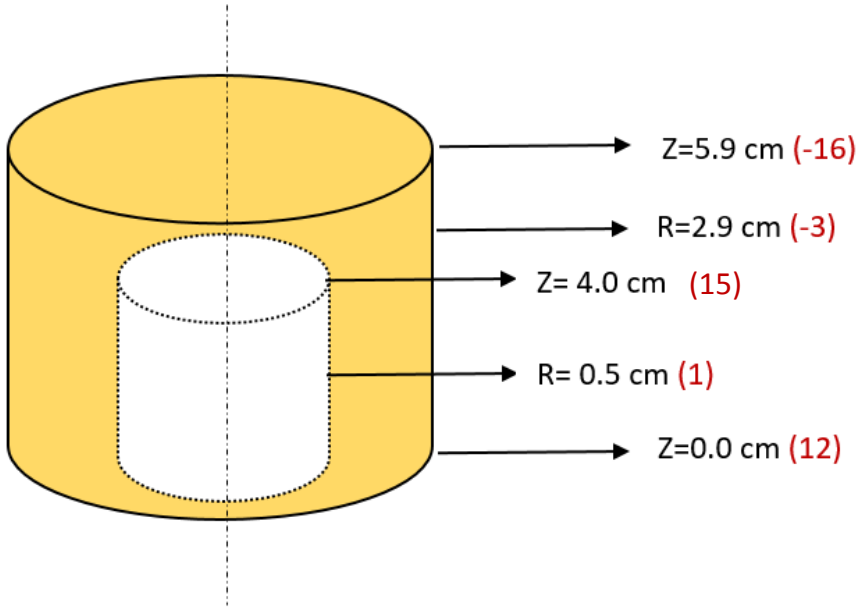
Surfaces are combined using 3 operators:

	Name	Operation	Designator	
AND	Intersection			Blank space between surface numbers
OR	Union		:	Between surface numbers
NOT	Complement		#	Points outside of cell or surface

Title Card	**Cells Card**	Surface Card	Data Card

Input file – Geometry (6)

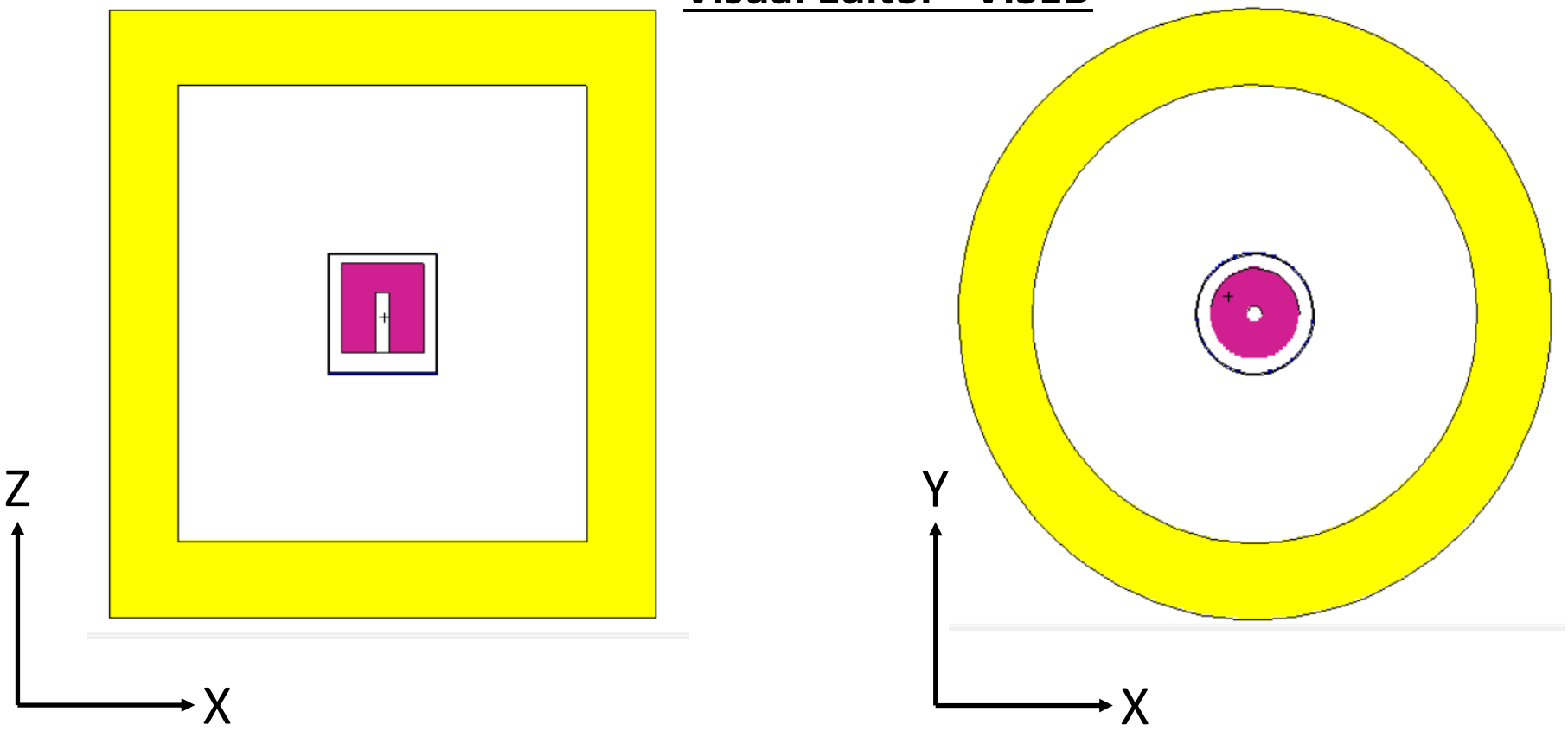
```
C ********** BLOCK 1: CELLS **********
1  0           (12 -1 -15)
2  1  -5.323   (12 -3 -16) (1:15)
3  0           (-12:16:3) (13 -18 -4)
4  2  -2.7     (14 -19 -5) (-13:18:4)
5  0           (25 -24 -26) (-14:19:5)
6  4  -11.35   (28 -27 -29) (-25:24:26)
7  0           -30 (-28:27:29)
8  0  30
```



Title Card | **Cells Card** | Surface Card | Data Card

Input file – Geometry (7)

Visual Editor - VISED



http://www.mcnpvised.com/visualeditor/visualeditor.html

Title Card	**Cells Card**	**Surface Card**	Data Card

Input file – Data Cards

- Anything that isn't a surface or cell card!
- The third "chunk" of information in an MCNP input file
- Includes everything else is needed for the radiation transport:
  - ✓mode → MODE
  - ✓cell and surface parameters → IMP:N
  - ✓**source specification** → SDEF
  - ✓**tally specification** → Fn, En
  - ✓material specification → Mm

Title Card	Cells Card	Surface Card	**Data Card**

Input file – Data Cards

- **MODE**

Form MODE $x_1\ x_2 \ldots x_n$

x_i:

N	for neutrons transport (default)
P	for photons transport
E	for electrons transport
P E	**for photons and electrons transport**

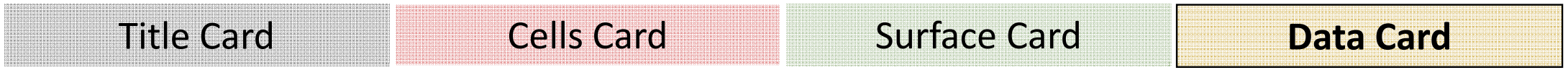
- **IMP: N**

Importance of each simulated "particle" within every cell of the geometry:

1→ important 0→not important

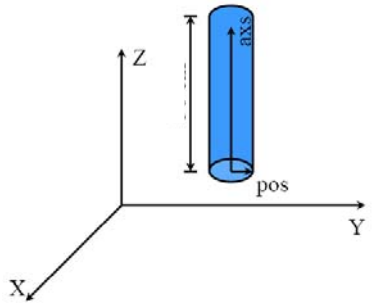
e.g. imp: p 1 1 1 1 1 1 1 1 1 0 or **imp: p 1 8r 0**

8



Input file – Data Cards

- **SDEF** : Source Definition



Example: Source distributed in a cylindrical volume

SDEF CEL=6 ERG=0.050 PAR=2 POS=0 0 8.7 AXS=0 0 1 RAD=D2 EXT=D3

- EXT=D3 → Distance from POS along AXS
- RAD=D2 → Radial distance from POS
- AXS=0 0 1 → Reference vector of the cylinder
- POS=0 0 8.7 → x, y, z vector for reference point for position sampling
- PAR=2 → **1**:neutron, **2**:photon, or **3**:electron
- ERG=0.050 → Source energy: 0.050 MeV
- CEL=6 → Starting source cell : 6

Title Card	Cells Card	Surface Card	**Data Card**

Input file – Data Cards

- **TALLY**

MCNP builds up a picture of the radiation field by using tallies:

- position
- direction
- energy
- weight

Application

- Energy deposition of photons in 1000 channels (0.001 ÷ 0.505 MeV)
- Detector: Cell 2

```
E0  0  1E-5  0.001  998i  0.505
F8:P 2
```

Title Card	Cells Card	Surface Card	**Data Card**

Content

- Installation
- Input file mcnp5 n=*(input file)*
- Output file - Results
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Output file

Several information are given:

- Cells: density, volume, mass, fluxes
- Random numbers information
- Cross section tables
- Statistical tests concerning the tally fluctuations
- Energy deposition:

cell 2

energy	eff. (en/p)	Rel. unc. (1σ)
0.0000E+00	0.00000E+00	0.0000
1.0000E-05	1.59155E-02	0.0065
1.0000E-03	9.65026E-05	0.0836
1.2012E-03	2.42944E-05	0.1667
1.4024E-03	2.29447E-05	0.1715
1.6036E-03	2.96931E-05	0.1508
1.8048E-03	3.77912E-05	0.1336
2.0060E-03	2.42944E-05	0.1667
2.2072E-03	3.91409E-05	0.1313
.....		
1.9918E-01	4.52145E-05	0.1222
1.9938E-01	4.25151E-05	0.1260
1.9959E-01	5.19630E-05	0.1140
1.9979E-01	4.11655E-05	0.1280
1.9999E-01	3.57667E-05	0.1374
2.0019E-01	4.05574E-02	0.0040
2.0039E-01	0.00000E+00	0.0000
total	9.85622E-02	0.0025

Peak eff. : 4.05574 e-02 ± 0.40%

Total eff. : ~~9.85622 e-02 ± 0.25%~~

8.26467 e-02 ± 0.28%

Detector A, Water, 200 keV

Content

- Installation
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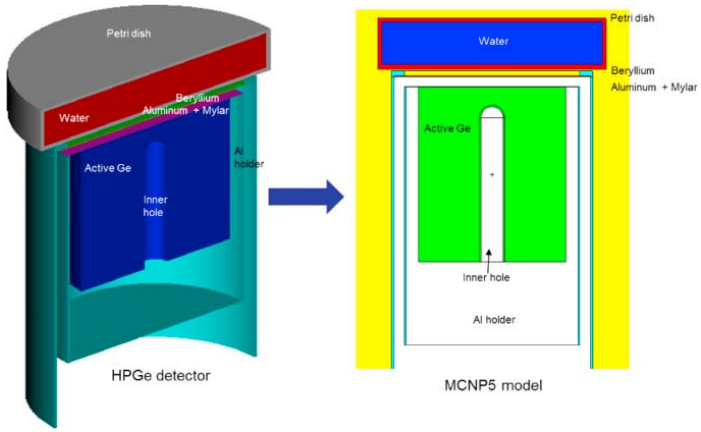
Conclusions - Comments

- 1 input file controls the simulation;
- 1 output file rich of information;
- Vised software can be used for both input and output files;
- User friendly even for new users
  - Input files prepared for this action were easily understandable



Thank you very much for your attention!

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