



# Standard output and plotting

FLUKA Beginner's Course

# The FLUKA Standard Output

- FLUKA provides a standard output file that contains plenty of useful information:

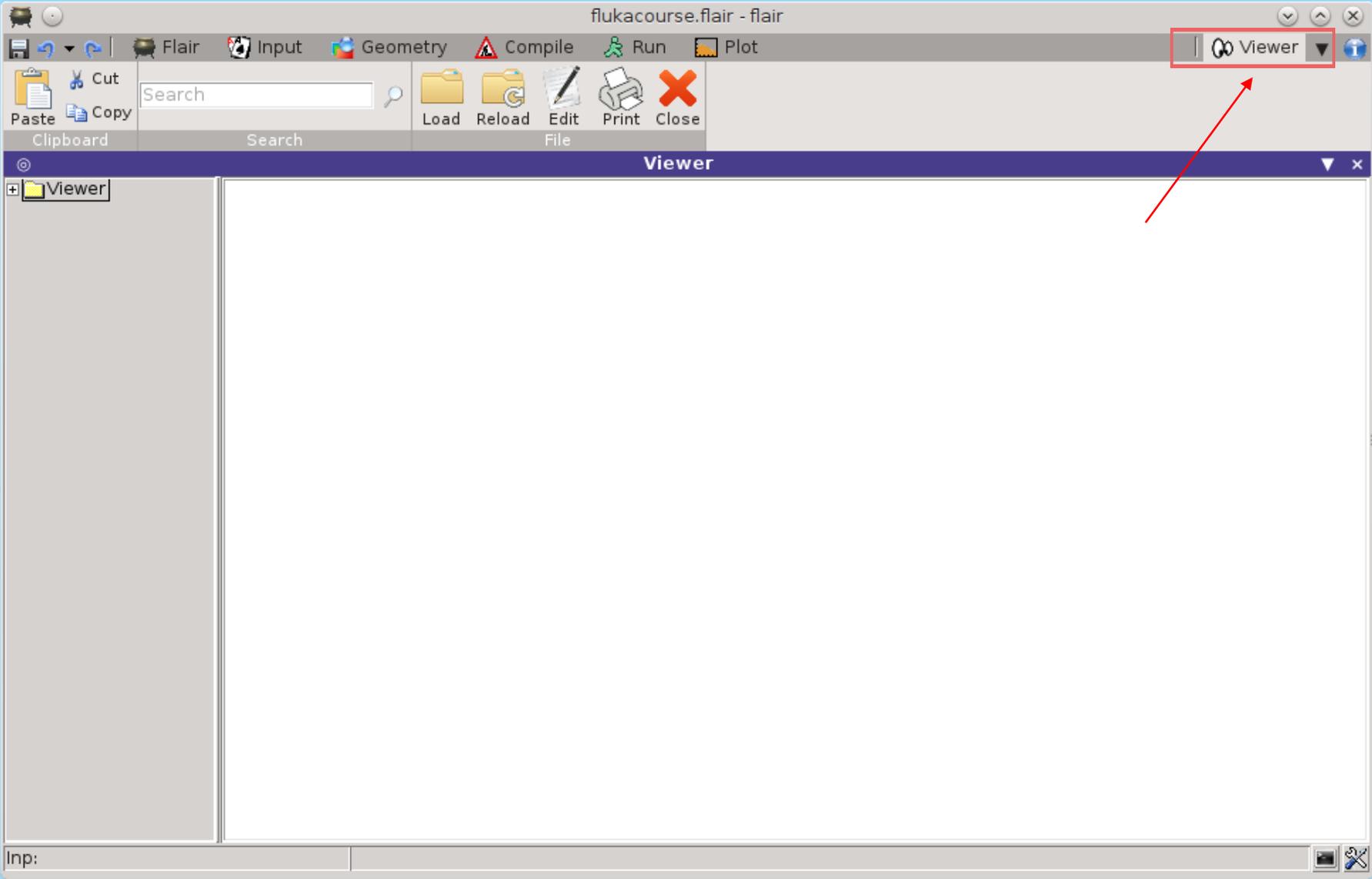
(fortran unit 11, *inp###.out* from rfluka)

- **It must be checked at least once when setting up a simulation and always in case of doubts/crashes (together with *inp###.err* and *inp###.log* files)**

- Let's have a look at *ex\_3001.out* (editor or flair output viewer:

**Process – Files – select *ex\_3001.out*** , or  
**fless *ex\_3001.out***)

# Output Viewer



# Input echo

The data cards are parsed in groups, and do not appear in same order as they are inserted in the input file...

- ex3001.out
  - License/version
  - Input Echo**
  - Nuclear Data
  - Mulmix Output
  - Requested Products/D
  - Neutron Data
  - dp/dx
  - Blank Common
  - Media Parameters
  - EMF-FLUKA
  - Fluka Particles
  - Beam Properties
  - Particle Thresholds
  - Termination Condition:
  - Mult. Coulomb Scatteri
  - EM Showers
  - Particle Importances
  - Scoring
  - Material Properties
  - Regions Summary
  - Initialization Time
  - Output During Transpc
  - Events by Region
  - Scattering Statistics
  - Run Summary

```
***** Next control card ***** TITLE 0.000 0.000 0.000 0.000 0.000 0.000
FLUKA Course Exercise
*-----
* use names everywhere and free format for geometry
*-----
***** Next control card ***** DEFAULTS 0.000 0.000 0.000 0.000 0.000 0.000 NEW-DEFA
*-----
* beam definitions
*-----
* Geometry
*-----
*
* Materials definition
*-----
***** Next control card ***** BEAM -3.500 -8.2425E-02 -1.700 0.000 0.000 1.000 PROTON
**** Density scaling factors start at location 1 and end at 4000 (I*4 addr.) ****
***** Next control card ***** BEAMPOS 0.000 0.000 -0.1000 0.000 0.000 0.000
***** Next control card ***** GEOBEGIN 0.000 0.000 0.000 0.000 0.000 0.000 COMBNAME
1
```

TITLE is the first to appear, then all comment cards are listed together, followed by the beam related cards, etc...

# Input echo – *Geometry output*

```

ex3001.out
├── License/version
├── Input Echo
│   ├── Body data
│   ├── Region data
│   └── Body echo
├── Region echo
├── Nuclear Data
├── Mulmix Output
├── Requested Products/Dec
├── Neutron Data
├── dp/dx
├── Blank Common
├── Media Parameters
├── EMF-FLUKA
├── Fluka Particles
├── Beam Properties
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├── Termination Conditions
├── Mult. Coulomb Scattering
├── EM Showers
├── Particle Importances
└── Scoring
    
```

Interpreted body echo

Body n.	1	SPH	BLK	Rot.	0				
	0.000000			0.000000		0.000000	10000.00		
Body n.	2	RPP	VOI	Rot.	0				
	-1000.000			1000.000		-1000.000	1000.000	-1000.000	1000.000
Body n.	3	ZCC	TARG	Rot.	0				
	2.718000			0.000000		25.00000	25.00000		
Body n.	4	XYP	ZTlow	Rot.	0				
	3.140000								
Body n.	5	XYP	ZThigh	Rot.	0				
	13.14000								
Body n.	6	XYP	Tlseg	Rot.	0				
	4.140000								
Body n.	7	XYP	T2seg	Rot.	0				
	5.140000								

Followed by the geometry output, if not redirected (see **GEOBEGIN** card). Echo of the commands is presented together with interpretation and correspondence between numbers and names

```

ex3001.out
├── License/version
├── Input Echo
│   ├── Body data
│   ├── Region data
│   ├── Body echo
│   └── Region echo
├── Nuclear Data
├── Mulmix Output
├── Requested Products/Dec
├── Neutron Data
├── dp/dx
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├── Media Parameters
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└── Scoring
    
```

Interpreted region echo

```

Region n.      1  BLKHOLE
                1  -2
Region n.      2  TARGS1
                3  -4          6
Region n.      3  TARGS2
                3  -6          7
Region n.      4  TARGS3
                3  -7          5
Region n.      5  INAIR
                OR  2  -3
                OR  2  4
                OR  2  -5
1  OPTION 0 WAS USED IN CALCULATING VOLUMES, FOR 5 REGIONS
3: INPUT VOLUMES, ANYTHING ELSE: VOLUMES = 1.0

          VOLUMES (CM**3)
1  REG      1          2          3          4          5
VOLUME  1.000E+00  1.000E+00  1.000E+00  1.000E+00  1.000E+00
*-----
*----- switch on to debug this geometry -----*
    
```

# Nuclear data [1/3]

- ex4001.out
  - License/version
  - Input Echo
  - Nuclear Data**
  - Mulmix Output
  - Requested Products/Decay
  - Neutron Data
  - dp/dx
  - Blank Common
  - Media Parameters
  - EMF-FLUKA
  - Fluka Particles
  - Beam Properties
  - Particle Thresholds
  - Termination Conditions
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```
*** Reading evaporation and nuclear data from unit: 14
**** Nuclear data file for Fluka9x-20xy ****
File version: 2011.1
Copyright (C) 1990-2011 by Alfredo Ferrari & Paola Sala

*** Evaporation: using NNDC (1996) data ***

Starting location in blank common of LVL data: 4522
Last location in blank common of LVL data: 9634777

Starting location in blank common of CE data: 9634778
Last location in blank common of CE data: 9685549

Starting location in blank common of alpha data: 9685550
Last location in blank common of alpha data: 9688309

Starting location in blank common of gamma data: 9688310
Last location in blank common of gamma data: 9819257

Starting location in blank common of beta data: 9819258
Last location in blank common of beta data: 9861545

Starting location in blank common of GDR data: 9861546
Last location in blank common of GDR data: 9916600

Starting location in blank common of (g,x) data: 9916601
Last location in blank common of (g,x) data: 10219521

**** RIPL2/Ign. self-cons. T=0 N,Z-dep. level density used ****
**** RIPL-2 / Ignyatuk level density en. dep. used ****
**** with Moller, Nix self-cons set of parameters for T=oo ****
**** Original Gilbert/Cameron pairing energy used ****

**** Maximum Fermi momentum : 0.268371314 GeV/c ****
**** Maximum Fermi energy : 0.0376013778 GeV ****
**** Average Fermi energy : 0.022676846 GeV ****
**** Average binding energy : 0.00768006314 GeV ****
**** Nuclear well depth : 0.04528144 GeV ****
**** Excess mass for 11-B : 0.00866803993 GeV ****
```

information about  
the basic nuclear  
data file used

Some memory  
allocation details

# Nuclear data [2/3]

The screenshot displays a software interface with a file tree on the left and a list of nuclear data on the right. The file tree includes folders such as 'ex4001.out', 'License/version', 'Input Echo', 'Nuclear Data', 'Mулmix Output', 'Requested Products/Decay', 'Neutron Data', 'dp/dx', 'Blank Common', 'Media Parameters', 'EMF-FLUKA', 'Fluka Particles', 'Beam Properties', 'Particle Thresholds', 'Termination Conditions', 'Mult. Coulomb Scattering', 'EM Showers', 'Particle Importances', 'Scoring', 'Material Properties', 'Regions Summary', 'Initialization Time', 'Output During Transport', 'Events by Region', 'Scattering Statistics', and 'Run Summary'. The 'Nuclear Data' folder is highlighted in red. The main window displays a list of nuclear data for various isotopes, including 40-Ca, 55-Fe, 56-Fe, 107-Ag, and 132-Xe. The data includes atomic mass, nuclear mass, excess mass, and Cameron E. m. for each isotope. A red box on the right contains the text 'Nuclear data used in the program'.

Isotope	Atomic mass (GeV)	Nuclear mass (GeV)	Excess mass (GeV)	Cameron E. m. (GeV)
40-Ca	37.224926	37.2147255	-	-
55-Fe	51.1747131	51.1614609	-0.0574751087	-0.0595041849
56-Fe	52.1030807	52.0898285	-0.0606013089	-0.0623576604
107-Ag	99.5814896	99.5576096	-0.088405259	-0.0891378522
132-Xe	-	-	-0.0892794058	-0.0898088515

# Nuclear data [3/3]

ex4001.out

- License/version
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```
**** My.&Sw. E. m. for 235-U : 0.0413222089 GeV ****
**** Atomic mass for 235-U : 218.942078 GeV ****
**** Nuclear mass for 235-U : 218.895767 GeV ****
**** Excess mass for 238-U : 0.0473045185 GeV ****
**** Cameron E. m. for 238-U : 0.0524553321 GeV ****
**** Cam.El. E. m. for 238-U : 0.0481762439 GeV ****
**** My.&Sw. E. m. for 238-U : 0.0473943055 GeV ****
**** Atomic mass for 238-U : 221.74295 GeV ****
**** Nuclear mass for 238-U : 221.696655 GeV ****

**** Evaporation from residual nucleus activated ****
**** Deexcitation gamma production activated ****
**** Evaporated "heavies" transport activated ****
**** High Energy fission requested & activated ****
**** Fermi Break Up requested & activated ****

**** Neutrino generators initialized F T T ****

*** Neutrino xsec file header: Neutrino Xsec file from ***
*** Neutrino xsec file generated on: DATE: 9/10/ 8, TIME: 19:48:1 ***

Minimum kinetic energy for BME : 1.0000E-03 (GeV/n)
Overall minimum kinetic energy for ion nuclear interactions: 1.0000E-03 (GeV/n)

*** Material WATER (# 26 automatically guessed by FLUKA, please check its correctness ***

*** Material AIR (# 27 automatically guessed by FLUKA, please check its correctness ***

**** Fluorescence data successfully retrieved from unit 13 ****
```

active options for the nuclear model

# Material properties

- ex4001.out
- License/version
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```
**** Subroutine Mulmix: medium n. 26 ****

Number of elements = 2, Density= 1.000000 (g/cm**3)
  O I Z Pa F_i Rho_i
Index Atomic Atomic Proportion Proportion
      Number Weight by Number by weight

      1 1.00000 1.00794 0.666667 0.111898
      2 8.00000 15.9994 0.333333 0.888102

ZTILDE,AE103,BLCGRA= 7.78788E+00 2.51981E+00 1.08102E-02
```

Material properties,  
multiple scattering  
parameters

```
**** Warning!!! Least square fit for blccre failed to keep max. rel. Blcce err. below 1% ****
**** Max. error is 1.1 %, for beta2 = 0.00358 ****
```

This warning is normal!

```
ZTILDE,AE103,BLCCRE= 6.63158E+00 2.51981E+00 1.07635E-02
BLCC,XCC,TFFLUO,XROFLU= 6.33212E+03 7.58200E-04 1.05734E-03 4.27023E-05
BLCCE,XCCE,TFEMF0,XROEMF= 7.52263E+03 8.13614E-01 2.65915E-03 8.90013E-02
Particle n.: -6 Ecutm (prim. & sec.) = 3.747 GeV 3.747 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: -5 Ecutm (prim. & sec.) = 2.828 GeV 2.828 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: -4 Ecutm (prim. & sec.) = 2.829 GeV 2.829 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: -3 Ecutm (prim. & sec.) = 1.896 GeV 1.896 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 1 Ecutm (prim. & sec.) = 0.9583 GeV 0.9583 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 2 Ecutm (prim. & sec.) = 0.9583 GeV 0.9583 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 3 Ecutm (prim. & sec.) = 2.0511E-02 GeV 2.0511E-02 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 4 Ecutm (prim. & sec.) = 2.0511E-02 GeV 2.0511E-02 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 10 Ecutm (prim. & sec.) = 0.1257 GeV 0.1257 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 11 Ecutm (prim. & sec.) = 0.1257 GeV 0.1257 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 13 Ecutm (prim. & sec.) = 0.1596 GeV 0.1596 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 14 Ecutm (prim. & sec.) = 0.1596 GeV 0.1596 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 15 Ecutm (prim. & sec.) = 0.5136 GeV 0.5136 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 16 Ecutm (prim. & sec.) = 0.5136 GeV 0.5136 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 20 Ecutm (prim. & sec.) = 1.217 GeV 1.217 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 21 Ecutm (prim. & sec.) = 1.209 GeV 1.209 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 31 Ecutm (prim. & sec.) = 1.209 GeV 1.209 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 33 Ecutm (prim. & sec.) = 1.217 GeV 1.217 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 36 Ecutm (prim. & sec.) = 1.341 GeV 1.341 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 37 Ecutm (prim. & sec.) = 1.341 GeV 1.341 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 38 Ecutm (prim. & sec.) = 1.692 GeV 1.692 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 39 Ecutm (prim. & sec.) = 1.692 GeV 1.692 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 41 Ecutm (prim. & sec.) = 1.797 GeV 1.797 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 42 Ecutm (prim. & sec.) = 1.797 GeV 1.797 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 45 Ecutm (prim. & sec.) = 1.889 GeV 1.889 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 46 Ecutm (prim. & sec.) = 1.889 GeV 1.889 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 49 Ecutm (prim. & sec.) = 1.988 GeV 1.988 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 50 Ecutm (prim. & sec.) = 1.988 GeV 1.988 GeV, Hthnsz = 1.0000E+30 GeV
Particle n.: 51 Ecutm (prim. & sec.) = 2.305 GeV 2.305 GeV, Hthnsz = 1.0000E+30 GeV
```

# Radiation Decay

- ex4001.out
  - License/version
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\*\*\*\* Isotope tabulation data start at location 10219522 and end at 10242872 (I\*4 addr.) \*\*\*\*

No radioactive products/decays requested

Flags for applying biasing to prompt and/or decay radiation:

	Hadr/muon		EM		Low en. Neut.	
	Prompt/Decay	Prompt/Decay	Prompt/Decay	Prompt/Decay	Prompt/Decay	Prompt/Decay
Inter./decay length:	T	F	T	F	T	F
Leading Particle :	T	F	T	F	T	F
Importance and WW :	T	F	T	F	T	F

EM transport threshold multipliers:

	prompt	decay
	1.00E+00	1.00E+00

info on the decay radiation options

Radiation biasing

# Neutron data

- ex4001.out
- License/version
- Input Echo
- Nuclear Data
- Mulmix Output
- Requested Products/Decays
- Neutron Data**
- dp/dx
- Blank Common
- Media Parameters
- EMF-FLUKA
- Fluka Particles
- Beam Properties
- Particle Thresholds
- Termination Conditions
- Mult. Coulomb Scattering
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Group cross sections storage starts at 10352413  
 Last location used for group xsecs 11784019

\*\*\* Values read from the cross section file \*\*\*  
 Panini independent Xsec

```

Number of primary groups           260
Number of primary downscatters     260
Number of primary upscatters       30
Number of secondary groups         42
Number of secondary downscatters   42
Number of neutron+gamma groups     302
Total xsec table length            335
Loc. of within group (g->g) xsec   34
Number of media read               269
Number of Leg. coefficients         6
Number of discrete angles          3
  
```

Low-energy neutron info, material correspondence.. More info on low energy neutron cross section if the **LOW-NEUT** card is specified

1 \*\*\* Fluka low energy group transport threshold: 261  
 corresponding to an energy threshold of: 1.00001E-14 GeV

1 \*\*\* Fluka to low en. xsec material correspondence: printed atomic densities are meaningless when used in a compo und \*\*\*

Fluka medium number	Name	Xsec medium number	atomic density ( at/(cm barn) )	Id. 1	Id. 2	Id. 3
1	BLCKHOLE	0	0.0000E+00	0	0	0
2	VACUUM	1000	0.0000E+00	0	0	0
3	HYDROGEN	1	0.0000E+00	1	-2	296
6	CARBON	2	0.0000E+00	6	-2	296
7	NITROGEN	3	0.0000E+00	7	-2	296
8	OXYGEN	4	0.0000E+00	8	16	296
10	ALUMINUM	5	6.0240E-02	13	27	296
17	LEAD	7	3.2988E-02	82	-2	296
20	ARGON	6	0.0000E+00	18	-2	296

# Material Parameters – $dp/dx$

- ex4001.out
- License/version
- Input Echo
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```
*** dp/dx tab. generated up to      11.74 GeV/c/n ***
*** Barkas Z^3 corrections accounted for ***
*** Bloch  Z^4 corrections accounted for ***
*** Mott Z - e corrections accounted for ***
*** Nuclear stopping power accounted for ***
**** Nuclear form factor 'a la Kelner' selected      ****
**** Standard Coulomb correction selected            ****
****   for charged hadron and muon bremsstrahlung    ****

***** dp/dx : material number 26 "WATER"          *****
**** Average excitation energy : 7.5000E+01 eV, weighted Z/A : 5.5508E-01      ****
**** Sternheimer density effect parameters:          ****
**** X0 = 0.2400, X1 = 2.8004, C = -3.5017, A = 0.0912 m = 3.4773 D0 = 0.0000 ****
**** Restricted energy loss tabulated in 54 intervals ****
**** Delta ray production activated above 1.0000E-03 GeV ****
**** dE/dx fluctuations activated for this medium, level 1 ****
**** (up to 2I discrete levels, up to 2 K-edges) ****
**** Restricted pair production energy loss added ****
**** Exp. pair production activated above 0.0000E+00 GeV ****
**** Restricted bremsstrahlung energy loss added ****
**** Exp. bremsstrahlung activated above 1.0000E-03 GeV ****

***** dp/dx : material number 10 "ALUMINUM" *****
**** Average excitation energy : 1.6600E+02 eV, weighted Z/A : 4.8181E-01      ****
**** Sternheimer density effect parameters:          ****
**** X0 = 0.1708, X1 = 3.0127, C = -4.2395, A = 0.0802 m = 3.6345 D0 = 0.1200 ****
**** Restricted energy loss tabulated in 54 intervals ****
**** Delta ray production activated above 1.0000E-03 GeV ****
**** dE/dx fluctuations activated for this medium, level 1 ****
**** (up to 2I discrete levels, up to 2 K-edges) ****
**** Restricted pair production energy loss added .. ****
```

Material-dependent parameters for ionization energy losses

Check  $\delta$ -ray and brems. threshold (DELTARAY, PAIRBREM)

# Material parameters – *Transport thresholds*

- ex4001.out
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1 Quantities/Biasing associated with each media:

WATER  
 Rho = 1.00000 g/cm\*\*3 Rlc= 36.0830 cm  
 Ae = 1.51100 MeV Ue = 11737.8 MeV  
 Ap = 0.333333 MeV Up = 11737.3 MeV  
 dE/dx fluctuations activated for this medium, level 1  
 below the threshold for explicit secondary electron production  
 (up to 2I discrete levels, up to 2 K-edges)

ALUMINUM  
 Rho = 2.69900 g/cm\*\*3 Rlc= 8.89633 cm  
 Ae = 1.51100 MeV Ue = 11737.8 MeV  
 Ap = 0.333333 MeV Up = 11737.3 MeV  
 dE/dx fluctuations activated for this medium, level 1  
 below the threshold for explicit secondary electron production  
 (up to 2I discrete levels, up to 2 K-edges)

LEAD  
 Rho = 11.3500 g/cm\*\*3 Rlc= 0.561207 cm  
 Ae = 1.51100 MeV Ue = 11737.8 MeV  
 Ap = 0.333333 MeV Up = 11737.3 MeV  
 dE/dx fluctuations activated for this medium, level 1  
 below the threshold for explicit secondary electron production  
 (up to 2I discrete levels, up to 2 K-edges)

AIR  
 Rho = 1.22500 g/cm\*\*3 Rlc= 9.96250 cm  
 Ae = 1.51100 MeV Ue = 11737.8 MeV  
 Ap = 0.333333 MeV Up = 11737.3 MeV  
 dE/dx fluctuations activated for this medium, level 1  
 below the threshold for explicit secondary electron production  
 (up to 2I discrete levels, up to 2 K-edges)

**ALUMINUM**  
 Rho = 2.69900 g/cm\*\*3 Rlc= 8.89633 cm  
 Ae = 1.51100 MeV Ue = 11737.8 MeV  
 Ap = 0.333333 MeV Up = 11737.3 MeV  
 dE/dx fluctuations activated for this medium, level 1  
 below the threshold for explicit secondary electron production  
 (up to 2I discrete levels, up to 2 K-edges)

production threshold for  $e^\pm$  in MeV (total energy, not only kinetic)

upper limit for  $e^\pm$  in MeV

**ZOOM**

same for photons

# Material parameters – *EMF-FLUKA*

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1 Correspondence of regions and EMF-FLUKA material numbers and names:

Region	EMF	FLUKA					
1	0	VACUUM	1	BLCKHOLE			
2	1	WATER	26	WATER			
Ecut = 1.5110E+00 MeV,			Pcut = 3.3333E-01 MeV,		BIAS = F,	Ray. = F,	S(q, Z) = T, Pz(q, Z) = F
<del>3</del>	<del>2</del>	<del>ALUMINUM</del>	<del>10</del>	<del>ALUMINUM</del>			
Ecut = 1.5110E+00 MeV,			Pcut = 3.3333E-01 MeV,		BIAS = F,	Ray. = F,	S(q, Z) = T, Pz(q, Z) = F
<del>4</del>	<del>3</del>	<del>LEAD</del>	<del>17</del>	<del>LEAD</del>			
Ecut = 1.5110E+00 MeV,			Pcut = 3.3333E-01 MeV,		BIAS = F,	Ray. = F,	S(q, Z) = T, Pz(q, Z) = F
<del>5</del>	<del>4</del>	<del>AIR</del>	<del>27</del>	<del>AIR</del>			
Ecut = 1.5110E+00 MeV,			Pcut = 3.3333E-01 MeV,		BIAS = F,	Ray. = F,	S(q, Z) = T, Pz(q, Z) = F

Starting location in blank common of binning data:12075833  
Last location in blank common of binning data: 12195835

Starting location in blank common of bdrx data:12195837  
Last location in blank common of bdrx data: 12196319

Starting location in blank common of track/coll data:12196321  
Last location in blank common of track/coll data: 12196321

Starting location in blank common of ...  
Last location in blank common of ...

Starting location in blank common of ...  
Last location in blank common of ...

transport threshold for  $e^\pm$  (Ecut) and photons (Pcut) in MeV (total energy, not only kinetic)

# FLUKA Particles

## exhaustive list of **FLUKA** particles

- ex4001.out
  - License/version
  - Input Echo
  - Nuclear Data
  - Mulmix Output
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  - dp/dx
  - Blank Common
  - Media Parameters
  - EMF-FLUKA
  - Fluka Particles**
  - Beam Properties
  - Particle Thresholds
  - Termination Conditions
  - Mult. Coulomb Scattering
  - EM Showers
  - Particle Importances
  - Scoring
  - Material Properties
  - Regions Summary
  - Initialization Time
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  - Scattering Statistics
  - Run Summary

```
=== Out
=== Transportable Fluka particles: ===
Particle Number      Mass      Mean Life  Charge  Baryon Discard  Decay  PDG id
              (GeV/c**2)      (s)
4-HELIUM      -6      3.7273803  1.000E+18    2      4      0      1      9999
3-HELIUM      -5      2.8083922  1.000E+18    2      3      0      1      9999
TRITON        -4      2.8089218  1.000E+18    1      3      0      1      9999
DEUTERON      -3      1.8756134  1.000E+18    1      2      0      1      9999
HEAVYION      -2      0.0000000  1.000E+18    0      0      0      1      9999
OPTIPHOT      -1      0.0000000  1.000E+18    0      0      0      1      9999
RAY           0      0.0000000  0.00         0      0      0      1      9999
PROTON        1      0.9382723  1.000E+18    1      1      0      1      2212
APROTON       2      0.9382723  1.000E+18   -1     -1      0      1     -2212
ELECTRON      3      0.0005110  1.000E+18   -1      0      0      1      11
POSITRON      4      0.0005110  1.000E+18    1      0      0      1     -11
NEUTRIE       5      0.0000000  1.000E+18    0      0      1      1      12
ANEUTRIE      6      0.0000000  1.000E+18    0      0      1      1     -12
PHOTON        7      0.0000000  1.000E+18    0      0      0      1      22
NEUTRON       8      0.9395656  889.         0      1      0      1      2112
ANEUTRON      9      0.9395656  889.         0     -1      0      1     -2112
MUON+        10     0.1056584  2.197E-06    1      0      0      1     -13
MUON-        11     0.1056584  2.197E-06   -1      0      0      1      13
```

...and many more

```
=== Generalised particles (201-233) (for scoring): ===
```

```
Generalised particle  Number
ALL-PART              201
ALL-CHAR              202
ALL-NEUT              203
ALL-NEGA              204
ALL-POSI              205
NUCLEONS              206
NUC&PI+-              207
ENERGY                208
PIONS+-              209
BEAMPART              210
EM-ENRGY              211
MUONS                 212
E+&E-                213
AP&AN                 214
```

...continues on your screen!

# Input interpreted summary – *Beam*

- ex4001.out
  - License/version
  - Input Echo
  - Nuclear Data
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  - dp/dx
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  - Fluka Particles
  - Beam Properties**
  - Particle Thresholds
  - Termination Conditions
  - Mult. Coulomb Scattering
  - EM Showers
  - Particle Importances
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  - Regions Summary
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  - Run Summary

=== Output before the actual run - Beam properties ===

Fluka incident beam properties:

```
Beam particle: PROTON   Id:   1 (Fluka)  2212 (PDG) Charge:   1 Baryon n.:   1
                Mass: 0.9383      (GeV/c^2) Mean life: 1.0000E+18 (s) Weight:  1.000
Average beam momentum      :                4.337961 (GeV/c)
Average beam kinetic energy:                3.500000 (GeV)
Momentum deviation at FWHM (gaussian):      0.0824250 (GeV/c)
Beam hit position          :   0.00000000      0.00000000      -0.10000000      cm
Beam direction cosines:    0.00000000      0.00000000      1.00000000
Beam spot FWHM X-width (Rectangular) :      0.0000      cm
Beam spot FWHM Y-width (Rectangular) :      0.0000      cm
Beam FWHM angular divergence (Gaussian)   :                1.7000 (mrad)
(Spatial distribution, polarization, and angular direction and distribution
are given in the beam frame of reference)
```

Beam reference frame (world coordinates):

```
Beam X axis:   1.00000000      0.00000000      0.00000000
Beam Y axis:   0.00000000      1.00000000      0.00000000
Beam Z axis:   0.00000000      0.00000000      1.00000000
```

The nominal beam position belongs to region: 5(INAIR ),  
lattice cell: 0( )

Check where the beam is starting

# Input interpreted summary – *Thresholds*

ex4001.out

- License/version
- Input Echo
- Nuclear Data
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- Neutron Data
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- Beam Properties
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- Termination Conditions
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```
=== Particle transport thresholds:  
  
Global cut-off kinetic energy for particle transport: 1.000E-02 GeV  
The cut-off kinetic energy is superseded by individual particle thresholds if set  
  
Cut-off kinetic energy for 4-HELIUM transport: 1.000E-02 GeV  
Cut-off kinetic energy for 3-HELIUM transport: 1.000E-02 GeV  
Cut-off kinetic energy for TRITON transport: 1.000E-02 GeV  
Cut-off kinetic energy for DEUTERON transport: 1.000E-02 GeV  
Cut-off kinetic energy for PROTON transport: 1.000E-02 GeV  
Cut-off kinetic energy for APROTON transport: 1.000E-02 GeV  
Cut-off kinetic energy for ELECTRON transport defined in the Emfcut card  
Cut-off kinetic energy for POSITRON transport defined in the Emfcut card  
Cut-off kinetic energy for NEUTRIE transport: 0.000E+00 GeV  
Cut-off kinetic energy for ANEUTRIE transport: 0.000E+00 GeV  
Cut-off kinetic energy for PHOTON transport defined in the Emfcut card  
Cut-off kinetic energy for NEUTRON transport: 1.000E-14 GeV  
Cut-off kinetic energy for ANEUTRON transport: 1.000E-05 GeV  
Cut-off kinetic energy for MUON+ transport: 1.000E-02 GeV  
Cut-off kinetic energy for MUON- transport: 1.000E-02 GeV  
Cut-off kinetic energy for KAONLONG transport: 1.000E-02 GeV  
Cut-off kinetic energy for PION+ transport: 1.000E-02 GeV  
Cut-off kinetic energy for PION- transport: 1.000E-02 GeV  
Cut-off kinetic energy for KAON+ transport: 1.000E-02 GeV  
Cut-off kinetic energy for KAON- transport: 1.000E-02 GeV  
Cut-off kinetic energy for LAMBDA transport: 1.000E-02 GeV
```

# Input interpreted summary – *TC, MCS, EM*

- ex4001.out
  - License/version
  - Input Echo
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  - Requested Products/Decays
  - Neutron Data
  - dp/dx
  - Blank Common
  - Media Parameters
  - EMF-FLUKA
  - Fluka Particles
  - Beam Properties
  - Particle Thresholds
  - Termination Conditions
  - Mult. Coulomb Scattering
  - EM Showers
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- Scoring
  - Material Properties
  - Regions Summary
  - Initialization Time
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```
=== Termination conditions: ===
Maximum cpu-time allocated for this run: 100000000000000000.00 sec
Minimum cpu-time reserved for output: 10000.00 sec
Maximum number of beam particles to be followed: 1000
Maximum number of stars to be generated: infinite

=== Multiple Coulomb scattering: ===
Moliere Coulomb scattering for primaries: T
Moliere Coulomb scattering for secondaries: T

Hadrons/muons:
Flag for MCS check with boundary normals: F
Flag for Coulomb single scattering(s) at boundaries: F
(# of Coulomb single scattering(s) at boundaries: 1)
Flag for single scatterings below min. (Moliere) energy: F

=== Electromagnetic Showers: ===
EM showers are treated by the EMF (A.Fasso`,A.Ferrari,P.R.Sala) code

Electrons/positrons:
Flag for MCS check with boundary normals: F
Flag for Coulomb single scattering(s) at boundaries: F
(# of Coulomb single scattering(s) at boundaries: 1)
Flag for single scatterings below min. (Moliere) energy: F

1
```

# Scoring

Complete description of  
each requested estimator

- ex4001.out
- License/version
- Input Echo
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- Run Summary

```
***** "usrbin" option:

R - Z   binning n.   1 "TargEne  ", generalized particle n.   208
R coordinate: from 0.0000E+00 to 1.0000E+01 cm,   100 bins ( 1.0000E-01 cm wide)
Z coordinate: from -5.0000E+00 to 1.5000E+01 cm,   200 bins ( 1.0000E-01 cm wide)
axis coordinates: X = 0.0000E+00, Y = 0.0000E+00 cm
data will be printed on unit  -40 (unformatted if < 0)
accurate deposition along the tracks requested
normalized (per unit volume) data will be printed at the end of the run

R - Z   binning n.   2 "TargChH  ", generalized particle n.   218
R coordinate: from 0.0000E+00 to 1.0000E+01 cm,   100 bins ( 1.0000E-01 cm wide)
Z coordinate: from -5.0000E+00 to 1.5000E+01 cm,   200 bins ( 1.0000E-01 cm wide)
axis coordinates: X = 0.0000E+00, Y = 0.0000E+00 cm
data will be printed on unit  -40 (unformatted if < 0)
accurate deposition along the tracks requested
normalized (per unit volume) data will be printed at the end of the run
this is a track-length binning

R - Z   binning n.   3 "TargN    ", generalized particle n.     8
R coordinate: from 0.0000E+00 to 1.0000E+01 cm,   100 bins ( 1.0000E-01 cm wide)
Z coordinate: from -5.0000E+00 to 1.5000E+01 cm,   200 bins ( 1.0000E-01 cm wide)
axis coordinates: X = 0.0000E+00, Y = 0.0000E+00 cm
data will be printed on unit  -40 (unformatted if < 0)
accurate deposition along the tracks requested
normalized (per unit volume) data will be printed at the end of the run
this is a track-length binning

***** "USRBDX" option:

Bdrx n.   1 "Sp1ChH  ", generalized particle n.   218, from region n.     2 to region n.     3
detector area: 7.8540E+01 cm**2
this is a one way only estimator
this is a fluence like estimator
logar. energy binning from 1.0000E-03 to 1.0000E+01 GeV,   40 bins (ratio : 1.2589E+00)
linear angular binning from 0.0000E+00 to 6.2832E+00 sr ,    1 bins ( 6.2832E+00 sr wide )
data will be printed on unit  -50 (unformatted if < 0)

Bdrx n.   2 "Sp2ChH  ", generalized particle n.   218, from region n.     3 to region n.     4
detector area: 7.8540E+01 cm**2
this is a one way only estimator
this is a fluence like estimator
logar. energy binning from 1.0000E-03 to 1.0000E+01 GeV,   40 bins (ratio : 1.2589E+00)
linear angular binning from 0.0000E+00 to 6.2832E+00 sr ,    1 bins ( 6.2832E+00 sr wide )
data will be printed on unit  -50 (unformatted if < 0)

Bdrx n.   3 "Sp3ChH  ", generalized particle n.   218, from region n.     4 to region n.     5
```



# Regions summary

- ex4001.out
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- Particle Thresholds
- Termination Conditions
- Mult. Coulomb Scattering
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- Scoring
- Material Properties
- Regions Summary**
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- Run Summary

=== Regions: materials and fields ===

Region N.	and Name	Material N.	and Name	Magn./El.	Field (on/off)	Minimum	and	Maximum	step size (cm)
(Mat. N. and Name Magn./El. Field (on/off) for radioactive products)									
1	BLKHOLE	1	BLCKHOLE	OFF		0.00000E+00		9.99852E+04	
		( 1	BLCKHOLE	OFF	)				
2	TARGS1	26	WATER	OFF		0.00000E+00		9.99852E+04	
		( 26	WATER	OFF	)				
3	TARGS2	10	ALUMINUM	OFF		0.00000E+00		9.99852E+04	
		( 10	ALUMINUM	OFF	)				
4	TARGS3	17	LEAD	OFF		0.00000E+00		9.99852E+04	
		( 17	LEAD	OFF	)				
5	INAIR	27	AIR	OFF		0.00000E+00		9.99852E+04	
		( 27	AIR	OFF	)				

Useful way to check material assignment

Minimum/Maximum step sizes  
(set with STEPSIZE option  
otherwise default values are set)

# Initialization time / Run informations

- ex4001.out
  - License/version
  - Input Echo
  - Nuclear Data
  - Mulmix Output
  - Requested Products/Decays
  - Neutron Data
  - dp/dx
  - Blank Common
  - Media Parameters
  - EMF-FLUKA
  - Fluka Particles
  - Beam Properties
  - Particle Thresholds
  - Termination Conditions
  - Mult. Coulomb Scattering
  - EM Showers
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  - Material Properties
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  - Run Summary

=== End of the output associated with the input ===

Total time used for initialization: 3.43 s

event number, time,  
random seed, average  
time used per primary  
available during the run

NUMBER OF BEAM PARTICLES HANDLED	NUMBER OF BEAM PARTICLES LEFT	APPROXIMATE NUMBER OF BEAM PARTICLES THAT CAN STILL BE HANDLED	AVERAGE TIME USED BY A BEAM PARTICLE	TIME LEFT (RESERVED 10000.0 SECONDS FOR PRINTOUT)	NUMBER OF STARS CREATED
NEXT SEEDS: 0	0	0	181CD 3039	0	
1	999	999	3.0002594E-03	1.0000000E+30	1
NEXT SEEDS: 063	0	0	181CD 3039	0	
20	980	980	4.1494131E-03	1.0000000E+30	19
NEXT SEEDS: 2D145	0	0	181CD 3039	0	
40	960	960	5.8991313E-03	1.0000000E+30	47
NEXT SEEDS: AE22F	0	0	181CD 3039	0	
60	940	940	6.7989667E-03	1.0000000E+30	94
NEXT SEEDS: 1407A3	0	0	181CD 3039	0	
80	920	920	6.2740505E-03	1.0000000E+30	124
NEXT SEEDS: 199F1E	0	0	181CD 3039	0	
100	900	900	6.8789625E-03	1.0000000E+30	172

# Results – *Scoring*

Results of SCORE options for all region:

**very useful** for debugging and for cross-check with estimators

Region #	name	volume in cubic cm	ALL-PART Star Density Stars/cm**3 /one beam particle	BEAMPART Star Density Stars/cm**3 /one beam particle	ENERGY GeV/cm**3 /one beam particle	Density	EM-ENERGY GeV/cm**3 /one beam particle	Density
1	BLKHOLE	1.000000000E+00	0.000000000E+00	0.000000000E+00	2.928199323E+00		4.557256612E-02	
2	TARGS1	1.000000000E+00	1.700000000E-02	8.000000000E-03	3.488408038E-03		1.713414203E-04	
3	TARGS2	1.000000000E+00	5.700000000E-02	3.100000000E-02	8.922057690E-03		7.317583684E-04	
4	TARGS3	1.000000000E+00	1.563000000E+00	3.820000000E-01	3.983831246E-01		1.144531387E-01	
5	INAIR	1.000000000E+00	8.500000000E-02	1.000000000E-02	9.016724646E-03		1.290495432E-03	
Total (integrated over volume):			1.722000000E+00	4.310000000E-01	3.348009638E+00		1.622193000E-01	
***** Next control card *****			STOP	0.000	0.000	0.000	0.000	0.000

# inelastic interactions of primary particles

The volume is not automatically evaluated, you have to specify it in the geom. description

# Results – *Statistics of Coulomb scattering*

- ex4001.out
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  - Input Echo
  - Nuclear Data
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  - Fluka Particles
  - Beam Properties
  - Particle Thresholds
  - Termination Conditions
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```
**** Total number of not-performed scatterings in FLUKA:      888
**** Total number of scatterings with no LDA in FLUKA:      12251
**** Ratio of rejected/accepted samplings from the Moliere's distribution in FLUKA:  0.0000
**** ( Total multiple scatterings: 9.5186E+04: Total single scatterings: 0.0000E+00 )

**** Total number of not-performed scatterings in EMF :      123
**** Total number of scatterings with no LDA in EMF :      666
**** Ratio of rejected/accepted samplings from the Moliere's distribution in EMF :  0.0000
**** ( Total multiple scatterings: 3.6342E+05: Total single scatterings: 0.0000E+00 )
```

# Results – *Statistics of the run*

- ex4001.out
  - License/version
  - Input Echo
  - Nuclear Data
  - Mulmix Output
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  - Neutron Data
  - dp/dx
  - Blank Common
  - Media Parameters
  - EMF-FLUKA
  - Fluka Particles
  - Beam Properties
  - Particle Thresholds
  - Termination Conditions
  - Mult. Coulomb Scattering
  - EM Showers
  - Particle Importances
  - Scoring
    - Material Properties
    - Regions Summary
    - Initialization Time
    - Output During Transport
    - Events by Region
    - Scattering Statistics
  - Run Summary
    - Totals/CPU time
    - # of stars
    - # of secondaries in stars
    - # of fissions
    - # of decay products
    - # of particles decayed
    - # of stopping particles
    - # of part. from low en. neutrons
    - Energy balance

```
Total number of primaries run:          1000 for a weight of: 1.000000E+03
!!! Please remember that all results are normalized per unit weight !!!
The main stack maximum occupancy was    81 out of    40000 available
```

```
Total number of inelastic interactions (stars):          1722
Total weight of the inelastic interactions (stars):    1.722000E+03
```

```
Total number of elastic interactions:          1582
Total weight of the elastic interactions:    1.582000E+03
```

```
Total number of low energy neutron interactions:          20821
Total weight of the low energy neutron interactions:    2.082621E+04
```

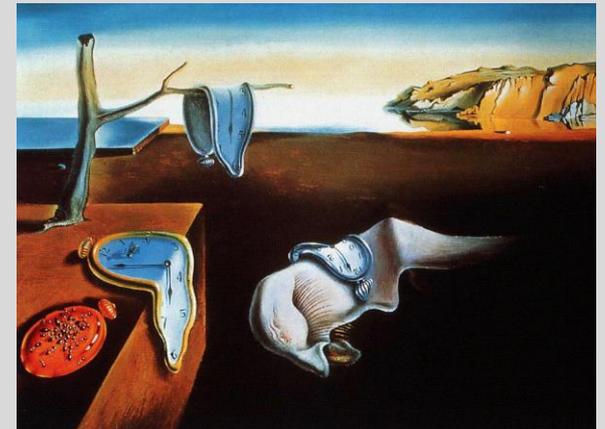
```
Total CPU time used to follow all primary particles:    6.843E+00 seconds of:
```

```
Average CPU time used to follow a primary particle:    6.843E-03 seconds of:
```

```
Maximum CPU time used to follow a primary particle:    4.699E-02 seconds of:
```

```
Residual CPU time left:                                1.000E+30 seconds of:
```

**CPU time is not  
real time!**



# Run summary: *detailed statistics*

- ex4001.out
  - License/version
  - Input Echo
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  - Mulmix Output
  - Requested Products/Decays
  - Neutron Data
  - dp/dx
  - Blank Common
  - Media Parameters
  - EMF-FLUKA
  - Fluka Particles
  - Beam Properties
  - Particle Thresholds
  - Termination Conditions
  - Mult. Coulomb Scattering
  - EM Showers
  - Particle Importances
  - Scoring
    - Material Properties
    - Regions Summary
    - Initialization Time
    - Output During Transport
    - Events by Region
    - Scattering Statistics
  - Run Summary
    - Totals/CPU time
    - # of stars
    - # of secondaries in stars
    - # of fissions
    - # of decay products
    - # of particles decayed
    - # of stopping particles
    - # of part. from low en. neutrons
    - Energy balance

Number of stars generated per beam particle:

Prompt radiation		Radioactive decays		
1.7220E+00	(100.%)	0.0000E+00	(100.%)	
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by 4-HELIUM
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by 3-HELIUM
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by TRITON
1.0000E-03	(0.1%)	0.0000E+00	(0.0%)	generated by DEUTERON
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by HEAVYION
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by OPTIPHOT
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by RAY
6.4300E-01	(37.3%)	0.0000E+00	(0.0%)	generated by PROTON
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by APROTON
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by ELECTRON
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by POSITRON
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by NEUTRIE
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by ANEUTRIE
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by PHOTON
8.9700E-01	(52.1%)	0.0000E+00	(0.0%)	generated by NEUTRON
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by ANEUTRON
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by MUON+
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by MUON-
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by KAONLONG
5.0000E-02	(2.9%)	0.0000E+00	(0.0%)	generated by PION+
1.3000E-01	(7.5%)	0.0000E+00	(0.0%)	generated by PION-
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by KAON+
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by KAON-
1.0000E-03	(0.1%)	0.0000E+00	(0.0%)	generated by LAMBDA
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by ALAMBDA
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by KAONSHRT
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by SIGMA-
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by SIGMA+
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by SIGMAZER
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by PIZERO
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by KAONZERO
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by AKAONZER
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by RESERVED
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by NEUTRIM
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by ANEUTRIM
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by RESERVED
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by RESERVED
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by ASIGMAZE
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by ASIGMA+
0.0000E+00	(0.0%)	0.0000E+00	(0.0%)	generated by XSIZERO

Detailed statistics per each particle

# Energy Balance

ex4001.out

- License/version
- Input Echo
- Nuclear Data
- Mulmix Output
- Requested Products/Decays
- Neutron Data
- dp/dx
- Blank Common
- Media Parameters
- EMF-FLUKA
- Fluka Particles
- Beam Properties
- Particle Thresholds
- Termination Conditions
- Mult. Coulomb Scattering
- EM Showers
- Particle Importances
- Scoring
- Material Properties
- Regions Summary
- Initialization Time
- Output During Transport
- Events by Region
- Scattering Statistics
- Run Summary
  - Totals/CPU time
  - # of stars
  - # of secondaries in stars
  - # of fissions
  - # of decay products
  - # of particles decayed
  - # of stopping particles
  - # of part. from low en. neutrons
  - Energy balance**

	3.5000E+00 (100.%)	GeV available per beam particle divided into	
	Prompt radiation	Radioactive decays	
	2.9309E-01 (8.4%)	0.0000E+00 (0.0%)	GeV hadron and muon dE/dx
	1.1665E-01 (3.3%)	0.0000E+00 (0.0%)	GeV electro-magnetic showers
	8.8952E-03 (0.3%)	0.0000E+00 (0.0%)	GeV nuclear recoils and heavy fragments
	0.0000E+00 (0.0%)	0.0000E+00 (0.0%)	GeV particles below threshold
	0.0000E+00 (0.0%)	0.0000E+00 (0.0%)	GeV residual excitation energy
	1.1821E-03 (0.0%)	0.0000E+00 (0.0%)	GeV low energy neutrons
	2.9282E+00 (83.7%)	0.0000E+00 (0.0%)	GeV particles escaping the system
	1.6105E-02 (0.5%)	0.0000E+00 (0.0%)	GeV particles discarded
	0.0000E+00 (0.0%)	0.0000E+00 (0.0%)	GeV particles out of time limit
	1.3589E-01 (3.9%)		GeV missing

**Particles below threshold:**

- Hadrons and muons below threshold are ranged out unless the threshold >100 MeV;
- $e^\pm/\gamma$  (EM- showers are not included).

**Escaping the system: going to *blackholes*.**

**Discarded particle (i.e. neutrinos).**

**Missing Energy: Calculated by difference:**

- pure EM problems it should be 0;
- in hadronic problems it is the energy spent in endothermic nuclear reactions ( $\approx 8$  MeV/n), or gained in exothermic (i.e. mostly neutron capture): it is  $-\text{total } Q$ .

# Error message

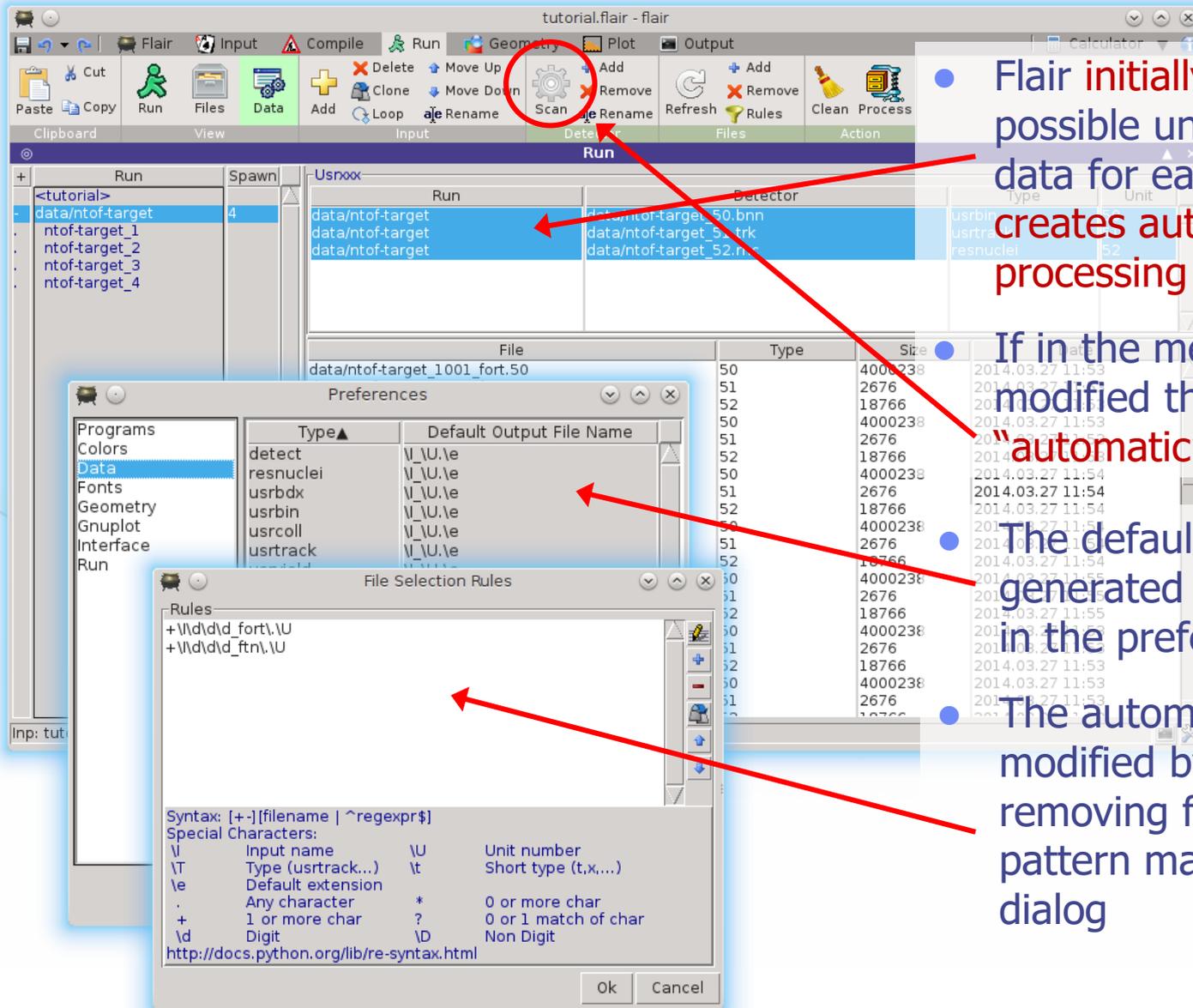
```
fluka_11407/ex4001.c
License/version
Input Echo
Scoring
Run Summary
ERROR

***** Next control card ***** USRBDX 10.00 1.0000E-03 40.00 0.000 0.000 0.000 &
***** Next control card ***** USRBDX 99.00 218.0 -50.00 4.000 5.000 329.9 Sp3ChH
***** Next control card ***** USRBDX 10.00 1.0000E-03 40.00 0.000 0.000 0.000 &
***** Next control card ***** USRBDX 99.00 218.0 -54.00 3.000 4.000 78.54 Sp2ChHA
***** Next control card ***** USRBDX 10.00 1.0000E-03 40.00 0.000 0.000 3.000 &
***** Next control card ***** USRTRACK -1.000 218.0 -55.00 4.000 628.3 40.00 TrChH
***** Next control card ***** USRTRACK 10.00 1.0000E-03 0.000 0.000 0.000 0.000 &
***** Next control card ***** USRYIELD 124.0 209.0 -57.00 4.000 5.000 1.000 YieAng
***** Next control card ***** USRYIELD 180.0 0.000 18.00 10.00 0.000 3.000 &
***** Next control card ***** RESNUCLE 3.000 -60.00 0.000 0.000 4.000 0.000 activ
***** Next control card ***** START 1000. 0.000 0.000 0.000 0.000 0.000

Total time used for input reading: 4.999E-03 s

**** Region n. 4 (TARGS3 ) has no assigned material, run stopped ****
Abort called from PRCHK reason NO MATERIAL ASSIGNED TO A REGION Run stopped!
STOP NO MATERIAL ASSIGNED TO A REGION
```

# Flair: Data Processing



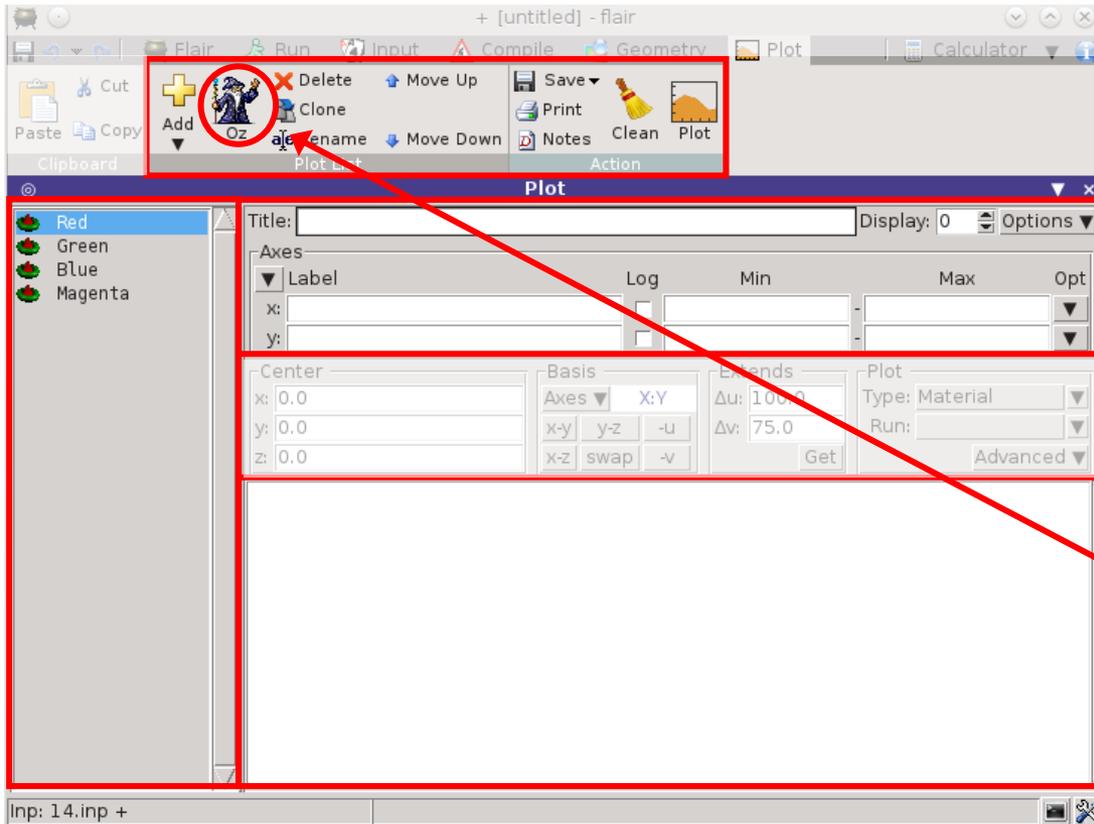
• Flair **initially** scans the input for possible unformatted output data for each scoring card. It **creates automatic rules for processing** (merging).

• If in the mean time you have **modified** the input click the **"automatic" scan**

• The default names are **generated** by the rules specified in the preference dialog

• The automatic rules can be **modified** by manually adding or removing files or by advanced pattern matching with the filter dialog

# Plot List

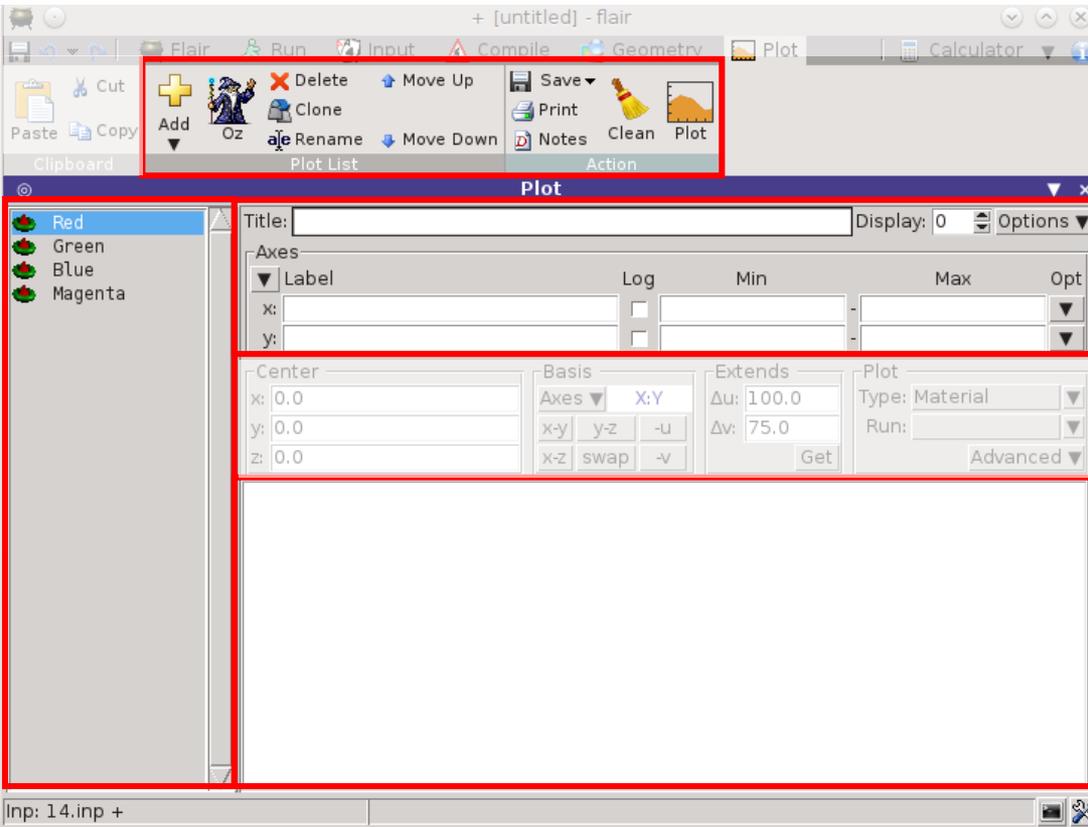


- Plots can be created in the “Plot” list frame. Either Add new plots or Clone from existing ones.
- It is important to set a unique filename for each plot. This filename will be used for every auxiliary file that the plot needs (with different extensions)
- The Wizard button creates automatically one plot for each processed unit
- **Double click** on a plot, or hit **Enter** or click the **Edit icon** to display the plotting dialog
- The list box is editable with a “**Slow Double Click**”
- **Right-click** brings a popup menu with all options

## Plot Types

- **Geometry** For geometry plots
- **USRBIN** For plotting the output of USRBIN
- **USR-1D** To plot single differential quantities from cards **USRBDX**, **USRTRACK**, **USRCOLL**, **USRYIELD**
- **USR-2D** To plot double differential from **USRBDX**
- **RESNUCLE** To plot 1d or 2d distributions of **RESNUCLEi**
- **USERDUMP** To plot the output of USERDUMP. Useful for visualizing the source distribution.

# Plotting Frames

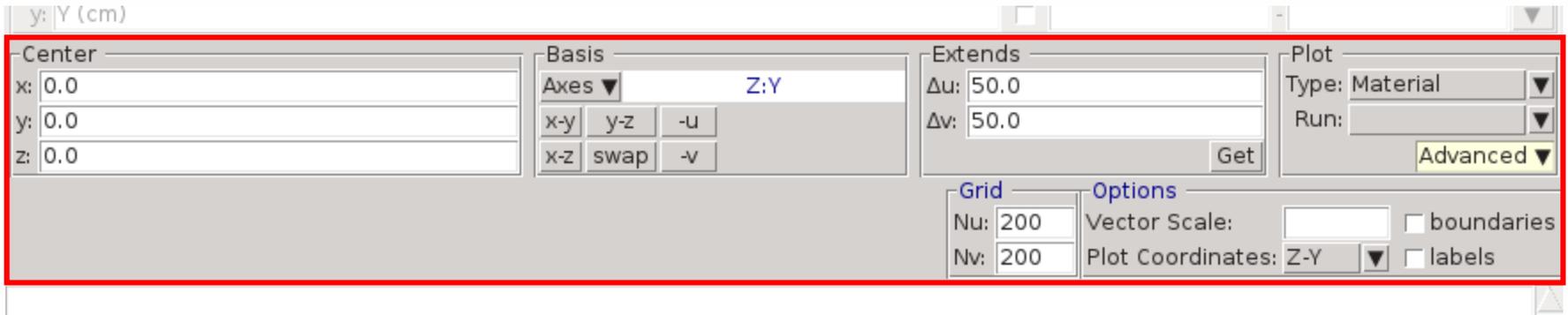


- All plot types share some common fields: Title + options, Filename, Axis Labels, Legends (Keys) and Gnuplot Commands.
- **Plot** button (Ctrl-Enter) will generate all the necessary files to display the plot, **ONLY** if they do not exist.
- All plots are listed in the **Plot List**
- **Notes** button adds selected plots to Notes frame at Flair Tab.
- **Clean** button will remove all files generated by Flair during plotting process.
- Check the Gnuplot manual to provide additional customization commands: e.g. To change the title font to Times size=20, add in the Opt: field the command: `font 'Times,20'`

# General Tips

- To set some default parameters for gnuplot, create a file called `~/.gnuplot`
- The output window displays all the commands sent to gnuplot as well as the errors. In case of a problem always consult the output window!
- In the **Gnuplot commands** you can fully customize the plot by adding manually commands. Please consult the gnuplot manual for available commands
- All buttons and fields have tool tips. Move the cursor on top of a field to get a short description

# Geometry Plotting



The screenshot shows a software interface for geometry plotting. The interface is divided into several sections:

- Center:** Fields for x: 0.0, y: 0.0, and z: 0.0.
- Basis:** A dropdown menu labeled "Axes" with "Z:Y" selected. Below it are buttons for "x-y", "y-z", "-u", "x-z", "swap", and "-v".
- Extends:** Fields for  $\Delta u$ : 50.0 and  $\Delta v$ : 50.0, with a "Get" button.
- Plot:** A dropdown menu for "Type" set to "Material", a "Run" field, and an "Advanced" dropdown.
- Grid:** Fields for "Nu: 200" and "Nv: 200".
- Options:** "Vector Scale" field, "Plot Coordinates" dropdown set to "Z-Y", and checkboxes for "boundaries" and "labels".

- For geometry plotting the following information is needed (Fields with white background):
  - Center (x,y,z) point defining the center of your plot
  - Basis (U,V): Two perpendicular axis vectors defining the new system
  - Extends (DU, DV) of the plot. The total width/height will be **twice** the extends
  - Scanning grid (NU, NV): how many points to scan
  - Plotting type (Only borders, Regions, Materials, ...)

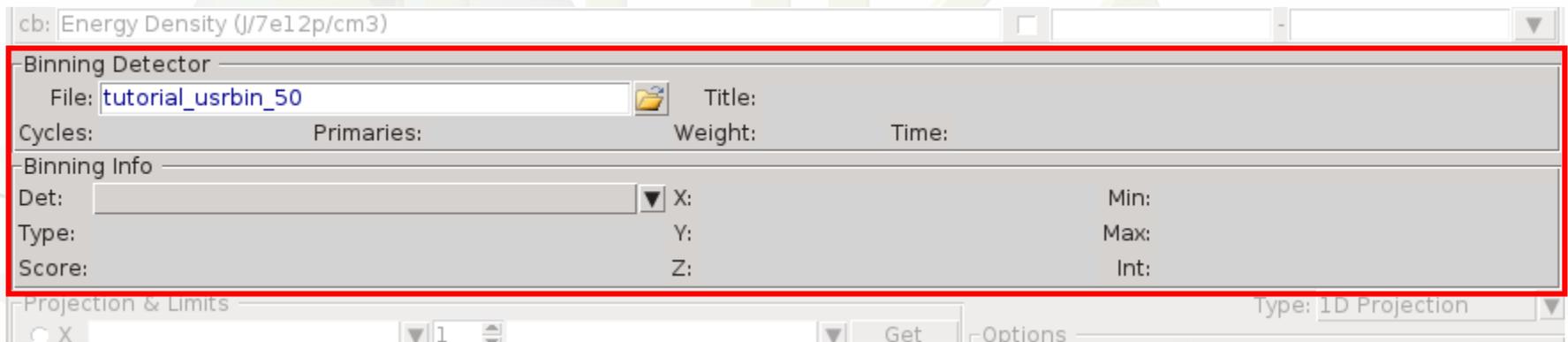
# Geometry Plotting

- When the "Plot" button is pressed, flair will create a temporary input file containing only the geometry and the related information together with the appropriate PLOTGEOM card. It will start a FLUKA run, and on exit it will convert the PLOTGEOM file in a format that gnuplot understands



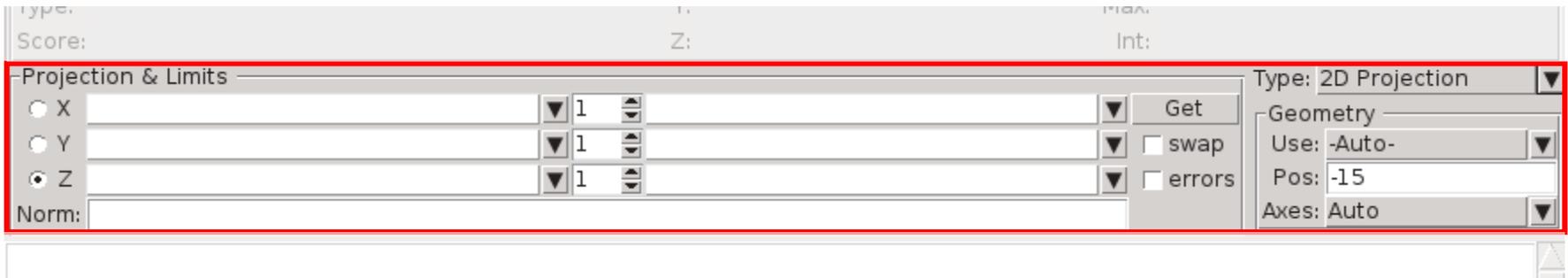
# USRBIN

- With the USRBIN plotting frame you can perform:
    - 2D projection or region/lattice plot
    - 1D projection or region/lattice plot
    - 1D maximum trace
    - 1D trace scan
- of the data or errors from USRBIN data.



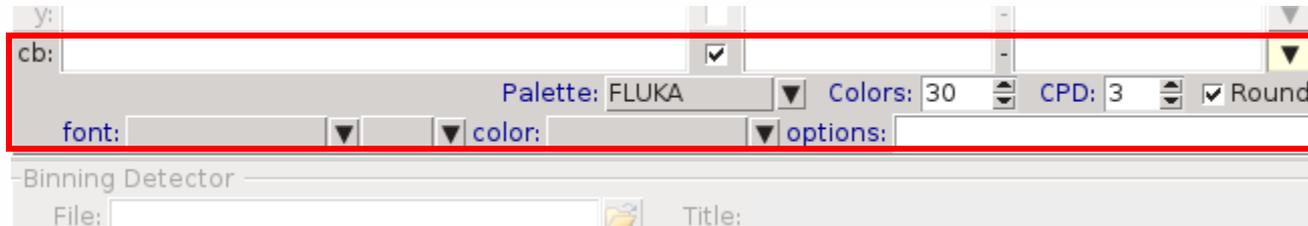
- Set the usrbins summary file in the **File:** field
- Select from **Det:** the detector to use.
- All the available detector information will be displayed
- The information **Minimum**, **Maximum** and **Integral** will be filled after the plot! *WARNING: it is always the projection min/max*

# USRBIN (2D plot)



- Select the "2D Projection" type
- Select the **projection axis, limits, and rebinning**
- swap: will exchange the plotting X and Y axis
- errors: will plot the (uncorrelated) error values as color plot
- **Get**: will get the projection limits from the gnuplot window
- Norm: is the **normalization value or expression**. You can even define a function to use as normalization using as argument **x**:  
e.g.  $5*x**2+4*x$
- log: select linear or log in the color bar axis

# USRBIN (2D plot) cont.



- The **Minimum**, **Maximum**, **Colors** and **CPD** (Colors Per Decade) are interconnected.

$$\log_{10}(\text{Max}) = \log_{10}(\text{Min}) + \text{Colors}/\text{CPD}$$

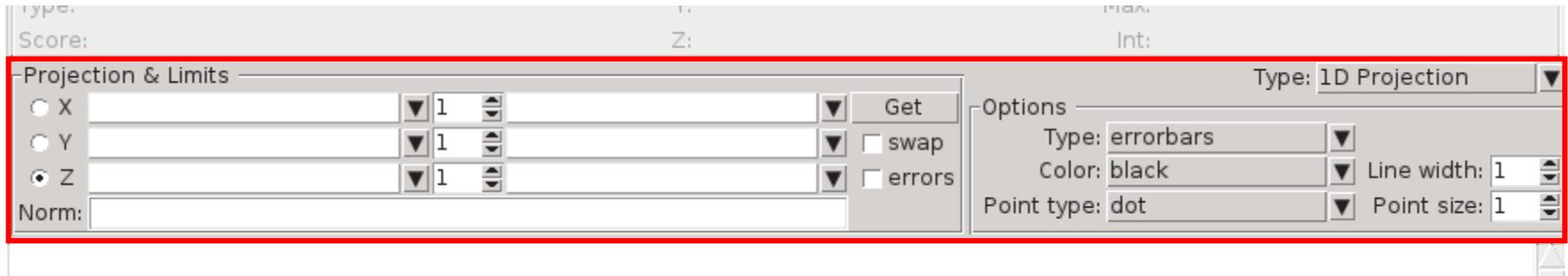
- Once the value is changed in one field, the **Max** will be calculated accordingly
- **Palette**: offers a possibility to the user to choose from various predefined palettes. The user can define his own palette using the "set palette" command from the "Gnuplot commands" text box

# USRBIN (2D plot) cont..

Superimposing the geometry can be done either automatically or manually

- **Auto:** Select **-Auto-** in the Use: field of the Geometry and the program will try to draw the geometry at the middle of the limits on the projection axis. To change the position modify the Pos: value
- **Manual:** The dropdown listbox will display also a list of all geometry plots in the flair project. Select the one you prefer and the plotting axis. The manual mode can be used in special cases when the **usrbin** file does not contain the absolute coordinates

# USRBIN (1D-plots)



## 1D Projection

- Select the projection axis from "Projection & Limits" as before  
WARNING: When making projections the error is typically underestimated.

## 1D Max

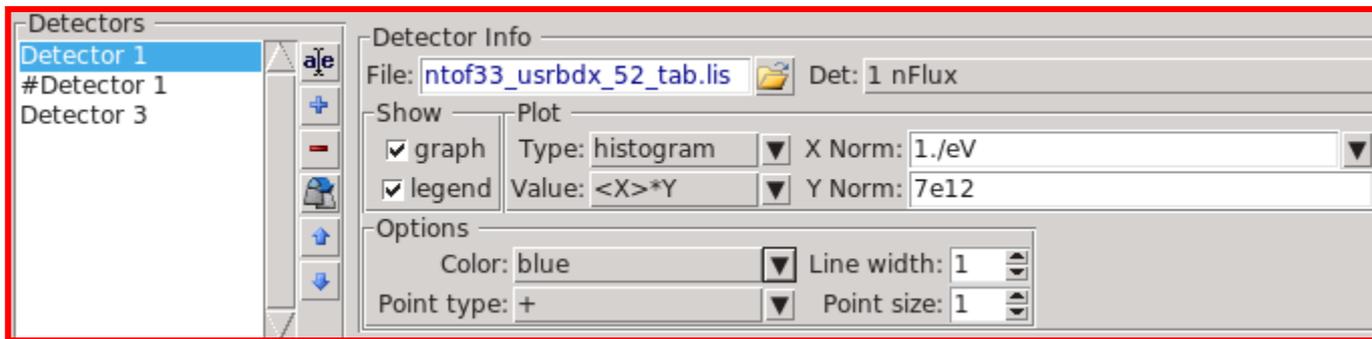
- Same as the 1D Projection, but displays only the maximum value on each slice. (eg. on a Z-projection, it will display the maximum on each X-Y slice)

## 1D Trace H or V

- Displays the position of the maximum and also the FWHM on either the horizontal or vertical plane (requires the **usbmax.c** prg)

Plotting Style: (see USR-1D)

# USR-1D Single Differential Plot



- USR-1D is able to plot the 1D single differential information from the **USRBDX**, **USRCOLL**, **USRTRACK** and **USRYIELD** cards (The 2D information is not handled).
- The file type in use should have the extension **\_tab.lis** and are generated by the FLUKA data merging tools (See Data Frame)
- You can superimpose many scoring output in a single plot.

# USR-1D Single Differential Plot

The basic steps to create a plot are:

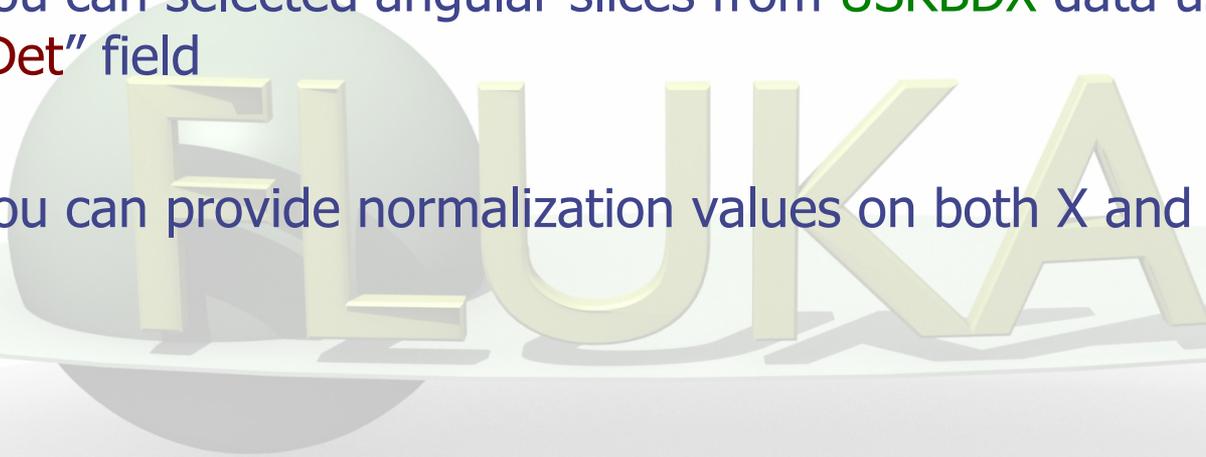
- Add or Clone a `_tab.lis` file, in the Detectors listbox.
- Select the detector to be used from the Det: dropdown listbox
- Set a name in the Name: field. Names starting with `#` will not be displayed as keys in the plot
- Select the Type: and Value: information to plot.  
**Note:** Different combination will be interpreted in different way from gnuplot, resulting in maybe unwanted results
- You have the possibility to select:
  - Plotting axes
  - Smoothing of the plot
  - Color, line type, width, point sizes etc.  
(Enter the command "test" in the **gnuplot** command and hit "Plot" you will get a plot of all possible types)
  - Predefined styles

# USR-1D Plots

- Type: choices:
  - histogram, histerror, lines, linespoints, dots, errorbars, yerrorbars, errorlines  
all valid types for gnuplot plus 'histerror'  
which is a combined plot of histogram + errorbars
- Value: choices:
  - Y Y-bin value as given by FLUKA
  - $\langle X \rangle \times Y$  Y-bin value multiplied by the mean X value of the bin (Isolethargic)

# USR-1D Plots

- You have the possibility to superimpose plots. Useful if you want to show histograms with error bars superimposed.
- You can selected angular slices from **USRBDX** data using the "Det" field
- You can provide normalization values on both X and Y axes



# Multiple Editing

In many places in flair you can multiple edit many fields e.g.:

- Input editor cards
- Runs (defines and override parameters)
- Geometry Editor
- Plots
- USR-1D detectors

During the multiple editing, when you modify one value the change is propagated to all selected items.

If the fields are “Disabled” during the multiple selection.

<Right-Click> with the mouse to enable them.

All enabled fields will copy their values to all selected items.