Standard output and plotting

The FLUKA Standard Output

- FLUKA provides a standard output file that contains plenty of useful information:
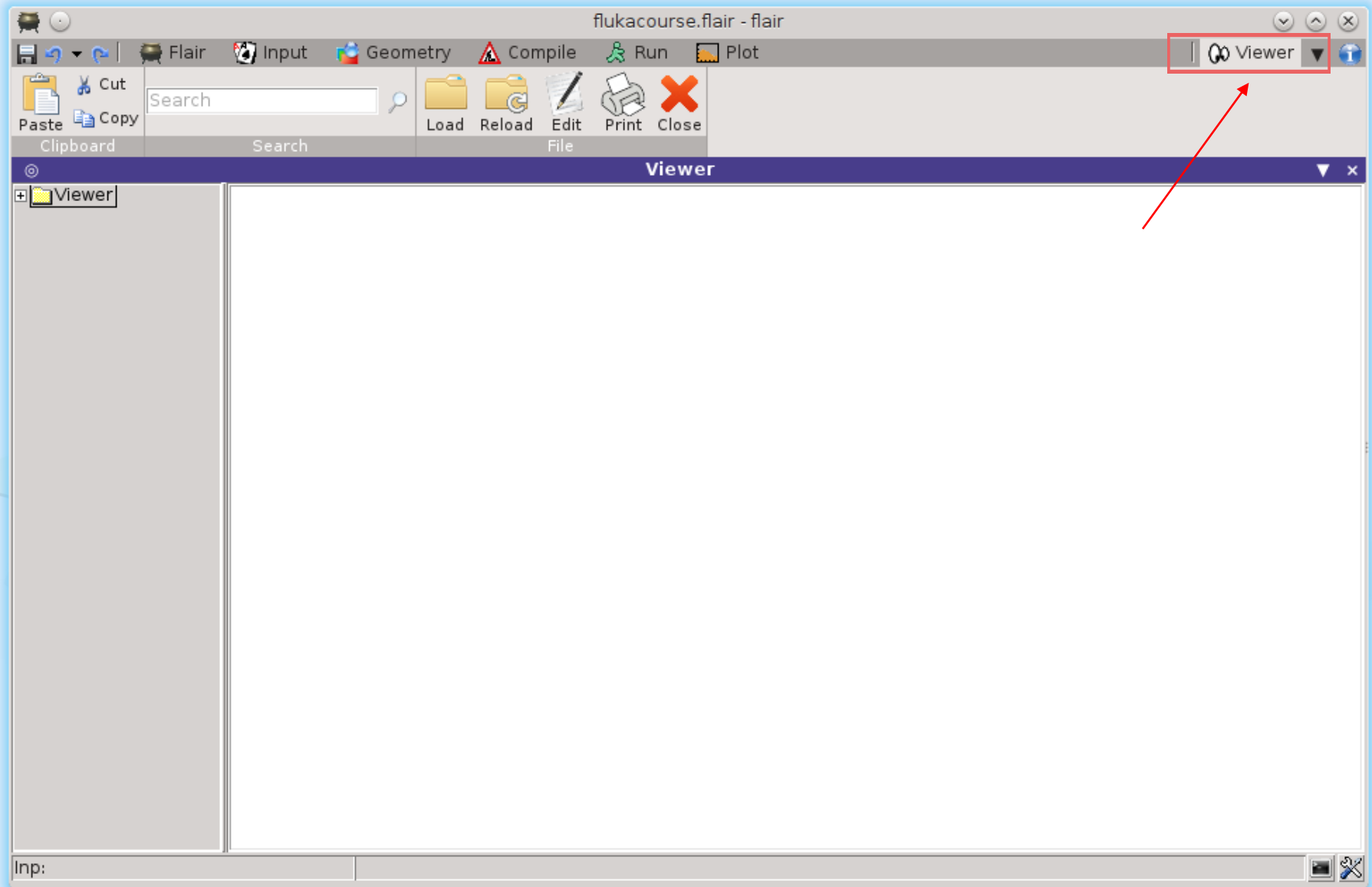
  (fortran unit 11, *inp###*.out from rfluka)

- **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)**

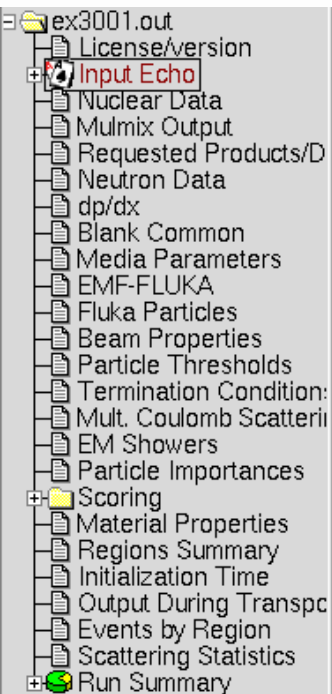- Let's have a look at ex_3001.out (editor or flair output viewer:

  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 Transpo
- Events by Region
- Scattering Statistics
- Run Summary

```
*---------------      ..+....1....+....2....+....3....+....4....+....5....+....6....+....7...    ---------------*

***** 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…

4

Input echo – *Geometry output*


```
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  T1seg      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

```
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]


```
*** 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]

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- License/version
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```
**** Atomic  mass  for 40-Ca :    37.224926 GeV   ****

**** Nuclear mass  for 40-Ca :    37.2147255 GeV   ****

**** Excess  mass  for 55-Fe :   -0.0574751087 GeV   ****

**** Cameron E. m.  for 55-Fe :   -0.0595041849 GeV   ****

**** Cam.El. E. m.  for 55-Fe :   -0.0580860823 GeV   ****

**** My.&Sw. E. m.  for 55-Fe :   -0.0575032495 GeV   ****

**** Atomic  mass  for 55-Fe :    51.1747131 GeV   ****

**** Nuclear mass  for 55-Fe :    51.1614609 GeV   ****

**** Excess  mass  for 56-Fe :   -0.0606013089 GeV   ****

**** Cameron E. m.  for 56-Fe :   -0.0623576604 GeV   ****

**** Cam.El. E. m.  for 56-Fe :   -0.0608849637 GeV   ****

**** My.&Sw. E. m.  for 56-Fe :   -0.0604862086 GeV   ****

**** Atomic  mass  for 56-Fe :    52.1030807 GeV   ****

**** Nuclear mass  for 56-Fe :    52.0898285 GeV   ****

**** Excess  mass  for 107-Ag:   -0.088405259 GeV   ****

**** Cameron E. m.  for 107-Ag:   -0.0891378522 GeV   ****

**** Cam.El. E. m.  for 107-Ag:   -0.0886852369 GeV   ****

**** My.&Sw. E. m.  for 107-Ag:   -0.0882571116 GeV   ****

**** Atomic  mass  for 107-Ag:    99.5814896 GeV   ****

**** Nuclear mass  for 107-Ag:    99.5576096 GeV   ****

**** Excess  mass  for 132-Xe:   -0.0892794058 GeV   ****

**** Cameron E. m.  for 132-Xe:   -0.0898088515 GeV   ****

**** Cam.El. E. m.  for 132-Xe:   -0.0892864987 GeV   ****

**** My.&Sw. E. m.  for 132-Xe:   -0.0894251093 GeV   ****
```

Nuclear data used
in the program

Nuclear data [3/3]


```
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
  Mult. Coulomb Scattering
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  Particle Importances
  Scoring
  Material Properties
  Regions Summary
  Initialization Time
  Output During Transport
  Events by Region
  Scattering Statistics
  Run Summary
```

```
**** 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 fronm  ***
*** 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

Radiation Decay

Neutron data

File tree (left panel):
- ex4001.out
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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
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      Name      Xsec medium  atomic density     Id. 1      Id. 2      Id. 3
        number                     number     ( at/(cm barn) )

           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
```

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

Material Parameters – *dp/dx*

```
*** 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 bremmstrahlung   ****


*****   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      *****
        eimer density effect parameters:                                          *****
        0.1708, X1 =   3.0127, C =  -4.2395, A =   0.0802 m =   3.6345 D0 =   0.1200 *****

        cted energy loss tabulated in    54 intervals *****
        ray production activated above  1.0000E-03 GeV *****

        fluctuations activated for this medium, level  1 *****
        p to  2I discrete levels, up to   2 K-edges)    *****

  ***** Restricted pair production energy loss added        *****
```

Tree navigation panel:
```
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
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  Mult. Coulomb Scattering
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  Run Summary
```

Material-dependent parameters for ionization energy losses

Check δ-ray and bremss. threshold (DELTARAY,PAIRBREM)

Material parameters – *Transport thresholds*


```
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
```

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

upper limit for $e^{\pm}$ in MeV

zoom

```
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)
```

same for photons

Navigation tree (left panel):
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Material parameters – *EMF-FLUKA*

```
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
           3        2   ALUMINUM         10  ALUMINUM
    Ecut =  1.5110E+00 MeV,    Pcut =  3.3333E-01 MeV,    BIAS = F,   Ray. = F,   S(q,Z) = T,   Pz(q,Z) = F
           4        3   LEAD             17  LEAD
    Ecut =  1.5110E+00 MeV,    Pcut =  3.3333E-01 MeV,    BIAS = F,   Ray. = F,   S(q,Z) = T,   Pz(q,Z) = F
           5        4   AIR              27  AIR
    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 c

Starting location in bla
Last location in blank c

Starting location in bla
Last location in blank c
1
```

File tree (left panel):
- ex4001.out
  - License/version
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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
  - 📄 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

```
=== Out

   === Transportable Fluka particles: ===

Particle  Number      Mass      Mean Life  Charge Baryon Discard Decay  PDG id
                    (GeV/c**2)     (s)            number Flag(=1) Flag

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*


```
=== 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     -0.100000000      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(        )
```
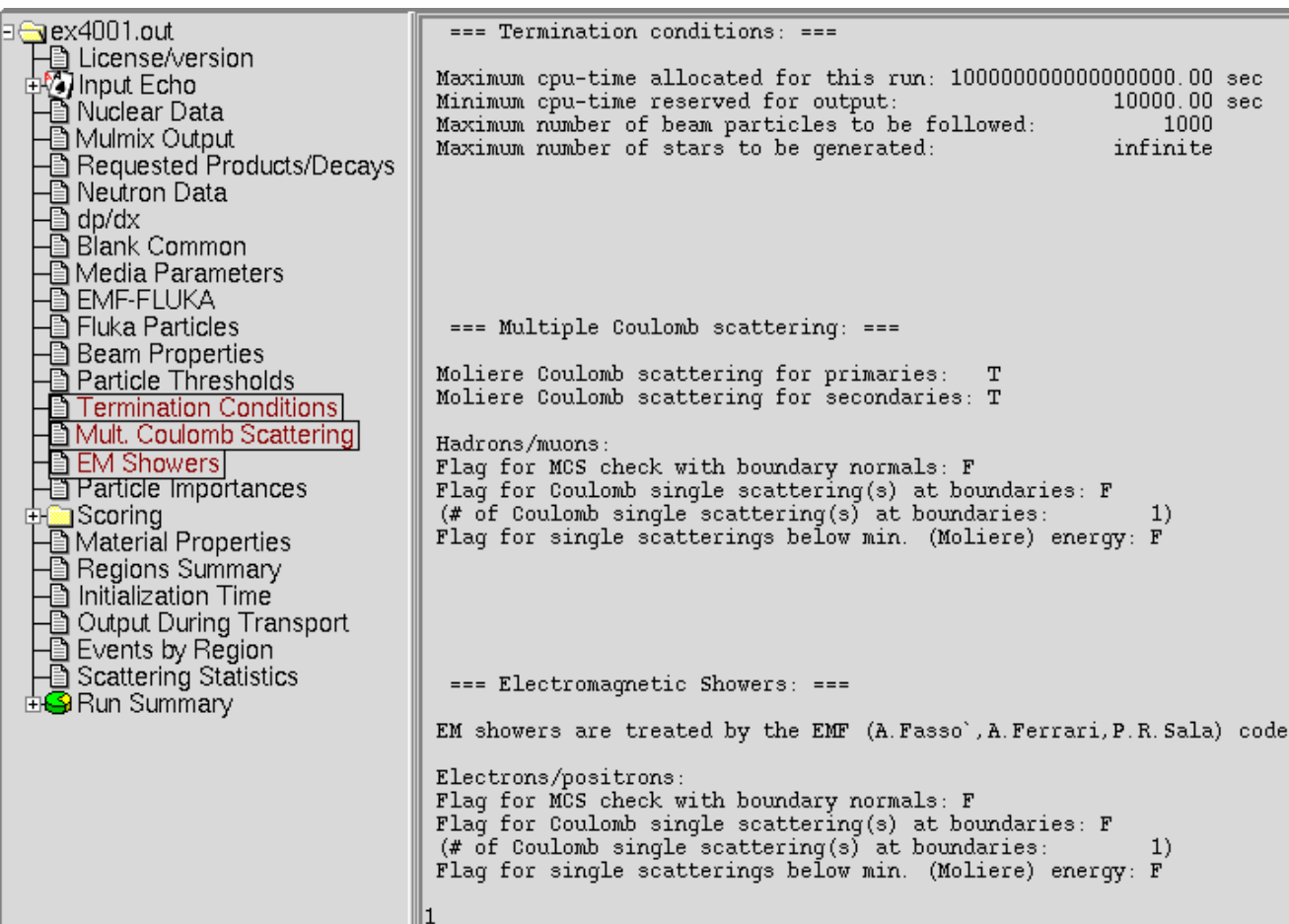
Check where the beam is starting

Tree items (left panel):
- ex4001.out
  - License/version
  - Input Echo
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  - dp/dx
  - Blank Common
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  - EMF-FLUKA
  - Fluka Particles
  - **Beam Properties**
  - Particle Thresholds
  - Termination Conditions
  - Mult. Coulomb Scattering
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  - Scoring
  - Material Properties
  - Regions Summary
  - Initialization Time
  - Output During Transport
  - Events by Region
  - Scattering Statistics
  - Run Summary

Input interpreted summary – *Thresholds*

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

```
=== 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
  📄 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
```

```
 === 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

- 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
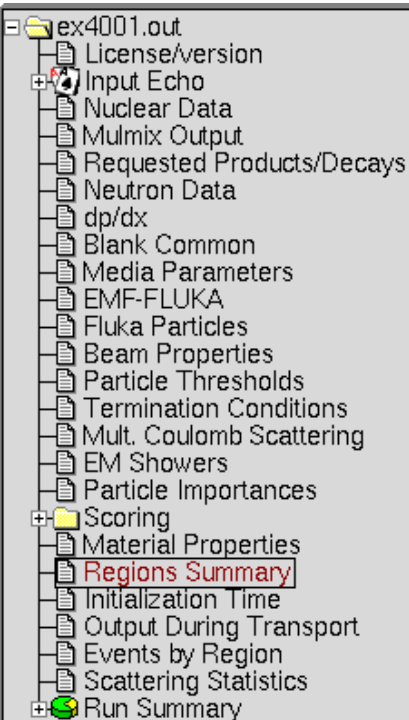 - Output During Transport
  - Events by Region
  - Scattering Statistics
  - Run Summary

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

 R - Z      binning n.   1  "TargEne   " , generalized particl  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
```

Materials – *Scattering lengths*

=== Material compositions: ===

Material Number&Name	Atomic Number	Atomic Weight	Density	Inelastic Scattering Length for PROTON at Beam energy	Elastic Scattering Length for PROTON at Beam energy	Radiation Length	Inelastic Scattering Length for neutrons at Threshold Momentum
			g/cm**3	cm	cm	cm	cm

Data related to the beam particle type specified in the BEAM card

			.000	0.1000E+31	0.1000E+31	0.1000E+31	0.1000E+31
			.000	0.1000E+31	0.1000E+31	0.1000E+31	0.1000E+31
3 HYDROGEN	1.000	1.008	8370E-04	0.7040E+06	0.1418E+07	0.7532E+06	0.8508E+09
			1660E-03	0.3506E+06	0.6310E+07	0.5682E+06	0.6024E+34
			848	39.41	77.65	35.28	17.26
6 CARBON	6.000	12.01	000	39.52	110.5	21.35	18.23
		14.01	1170E-02	0.7054E+05	0.1872E+06	0.3247E+05	0.3319E+05
		16.00	1330E-02	0.6438E+05	0.1624E+06	0.2574E+05	0.3013E+05
9 MAGNESIU	12.00	24.30	740	55.31	117.7	14.39	26.58
10 ALUMINUM	13.00	26.98	2.699	36.71	75.04	8.896	17.24
11 IRON	26.00	55.84	7.874	15.55	25.41	1.757	9.128
12 COPPER	29.00	63.55	8.960	13.97	23.26	1.436	8.423
13 SILVER	47.00	107.9	10.50	14.12	21.47	0.8543	10.59
14 SILICON	14.00	28.09	2.329	43.04	86.54	9.370	20.38
15 GOLD	79.00	197.0	19.32	9.239	13.14	0.3344	7.012
16 MERCURY	80.00	200.6	13.55	13.25	18.79	0.4752	9.852
17 LEAD	82.00	207.2	11.35	15.97	22.54	0.5612	12.03
18 TANTALUM	73.00	180.9	16.65	10.44	15.03	0.4094	7.390
19 SODIUM	11.00	22.99	0.9710	97.58	212.4	28.56	47.77
20 ARGON	18.00	39.95	0.1660E-02	0.6692E+05	0.1186E+06	0.1178E+05	0.3754E+05
21 CALCIUM	20.00	40.08	1.550	71.73	127.1	10.42	36.39
22 TIN	50.00	118.7	7.310	20.91			
23 TUNGSTEN	74.00	183.8	19.30	9.055			
24 TITANIUM	22.00	47.87	4.540	25.79			
25 NICKEL	28.00	58.69	8.902	13.87			
26 WATER	3.333	6.005	1.000	81.49			

Material	Number	Atom content	Partial Densities
HYDROGEN	3	0.66667	0.11190
OXYGEN	8	0.33333	0.88810

| 27 AIR | 7.262 | 14.55 | 0.1205E-02 | 0.6931E+05 | 0.1810E+06 | 0.3039E+05 | 0.3262E+05 |

Compound interpreted composition

Material	Number	Atom content	Partial Densities
CARBON	6	0.15019E-03	0.14939E-06
NITROGEN	7	0.78443	0.90994E-03
OXYGEN	8	0.21075	0.27925E-03
ARGON	20	0.46712E-02	0.15454E-04

Tree navigation:
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

Regions summary


```
=== Regions: materials and fields ===

Region N. and Name Material N. and Name  Magn./El. Field (on/off)
        (Mat. N. and Name Magn./El. Field (on/off) for radioactive products)
                                      Minimum  and  Maximum step size (cm)
    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 )
```

Tree panel:
- 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

Useful way to check material assignment

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

Initialization time / Run informations
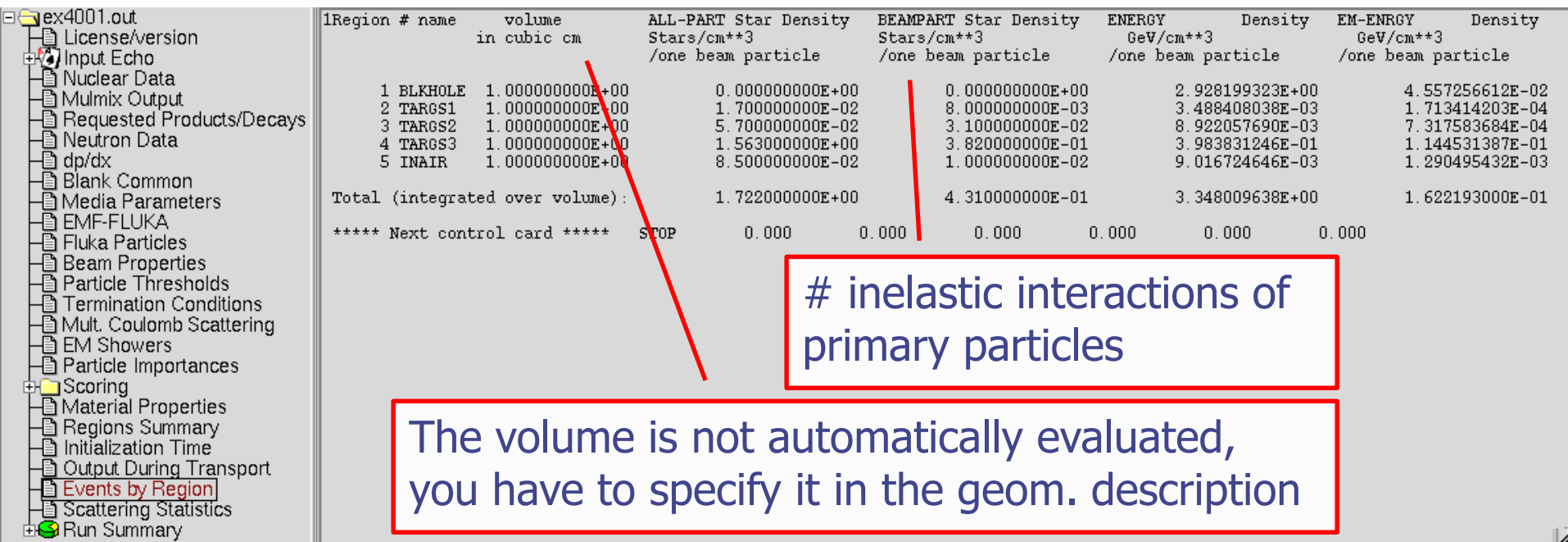
event number, time, random seed, average time used per primary available during the run

Results – *Scoring*

Results of SCORE options for all region:
very useful for debugging and for cross-check with estimators

```
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
```

```
1Region # name      volume      ALL-PART Star Density   BEAMPART Star Density   ENERGY        Density   EM-ENRGY        Density
                 in cubic cm     Stars/cm**3             Stars/cm**3            GeV/cm**3                GeV/cm**3
                                 /one beam particle      /one beam particle     /one beam particle       /one beam particle

      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     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
  ├─📄 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
```

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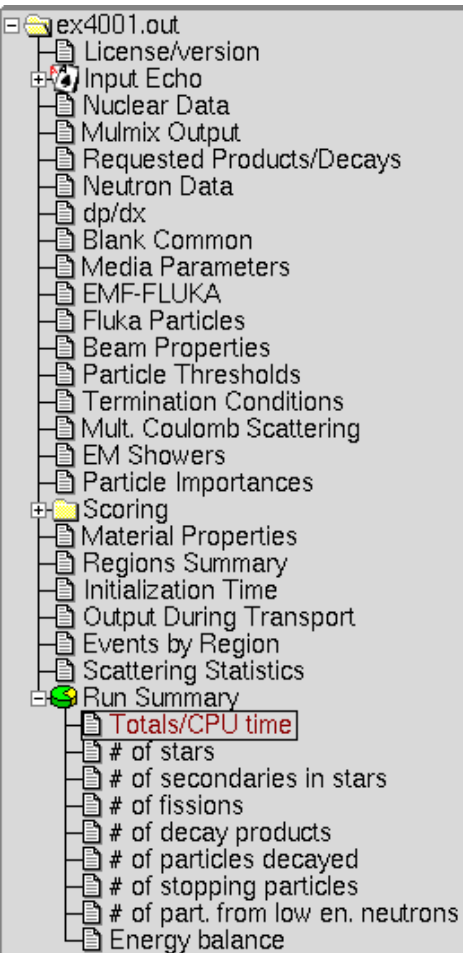
```
Total number of primaries run:            1000 for a weight of: 1.000000E+03
!!! Please remember that all results are normalized  per unit weight !!!
The main stack maximum occupancy was           81 out of      40000 available


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:
```
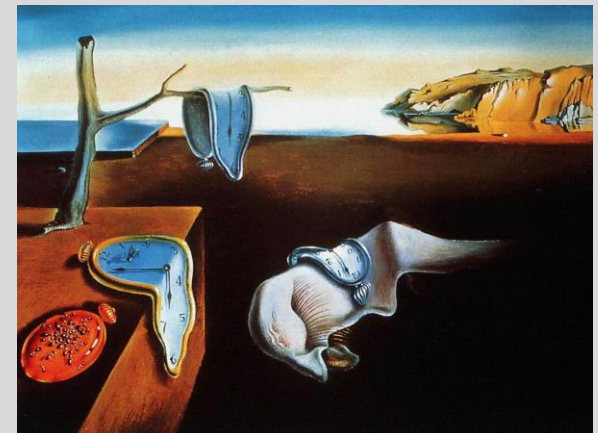
CPU time is not real time!
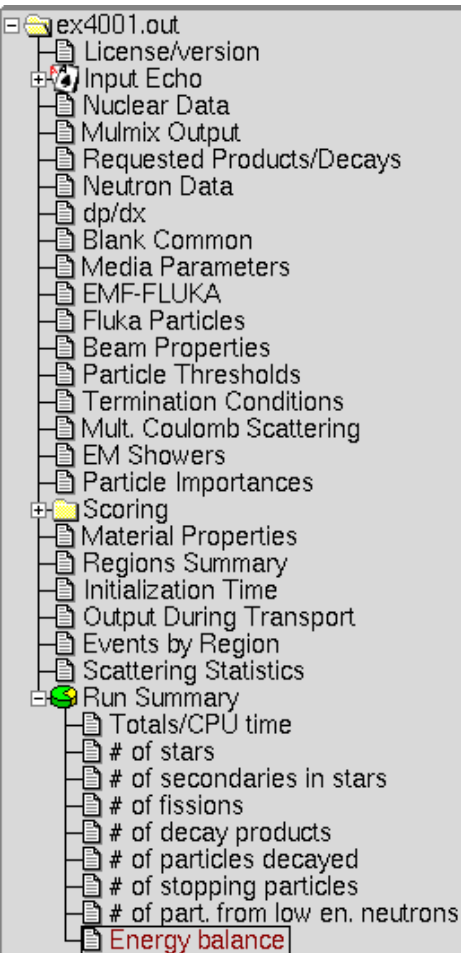
Run summary: *detailed statistics*


```
ex4001.out
   License/version
   Input Echo
   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
```

```
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
  0.0000E+00 ( 0.0%)
  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 –total Q.

Error message

```
  fluka_11407/ex4001.
    License/version     ***** Next control card *****   USRBDX    10.00    1.0000E-03   40.00      0.000      0.000      0.000     &
    Input Echo
    Scoring             ***** Next control card *****   USRBDX    99.00     218.0      -50.00      4.000      5.000      329.9     Sp3ChH
    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      -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 PRCHCK reason NO MATERIAL ASSIGNED TO A REGION Run stopped!
                        STOP NO MATERIAL ASSIGNED TO A REGION
```

Flair: Data Processing
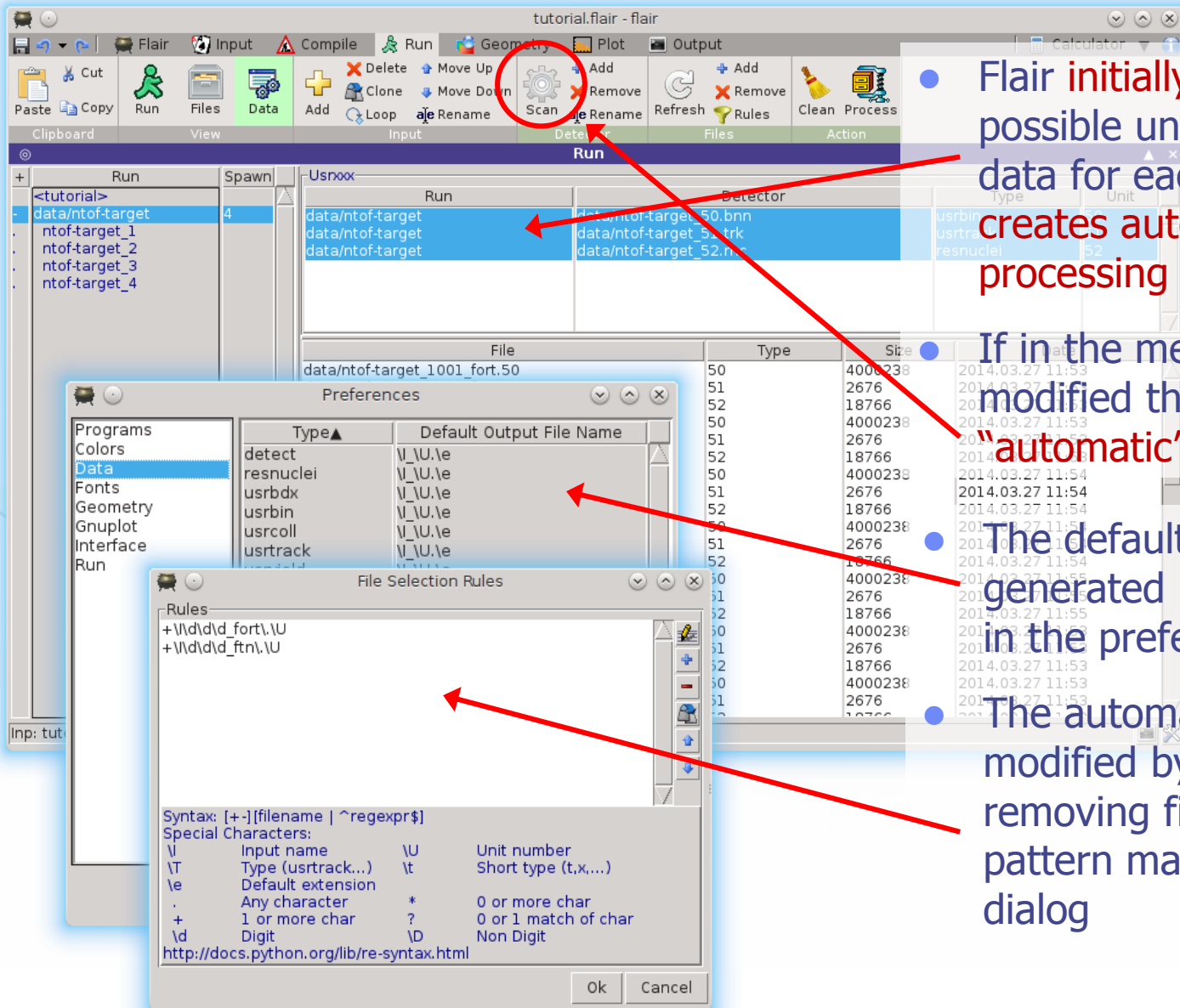
- Flair initially scans the input for possible unformatted output data for each scoring card. It creates automatic rules for processing (merging).

- 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
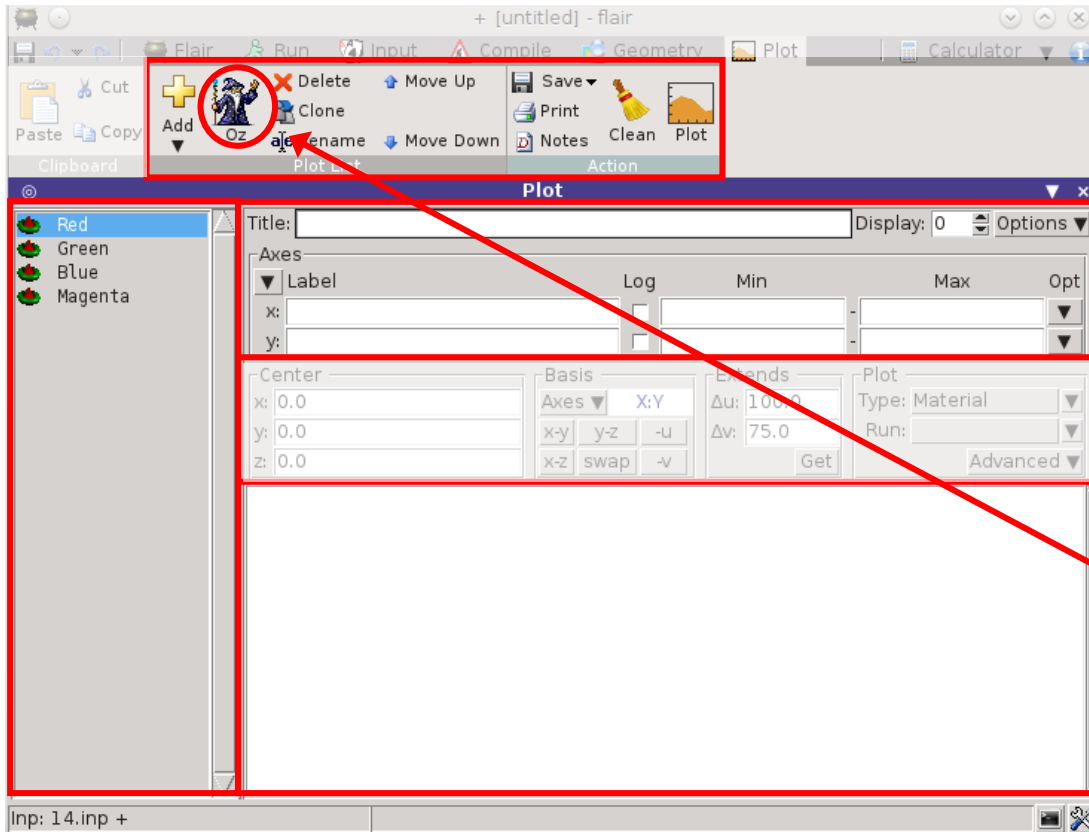
- Plots can be created in the "Plot" list frame. Either Add new plots or Clone from existing ones.

- 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 (ToDo)

Plotting Frames
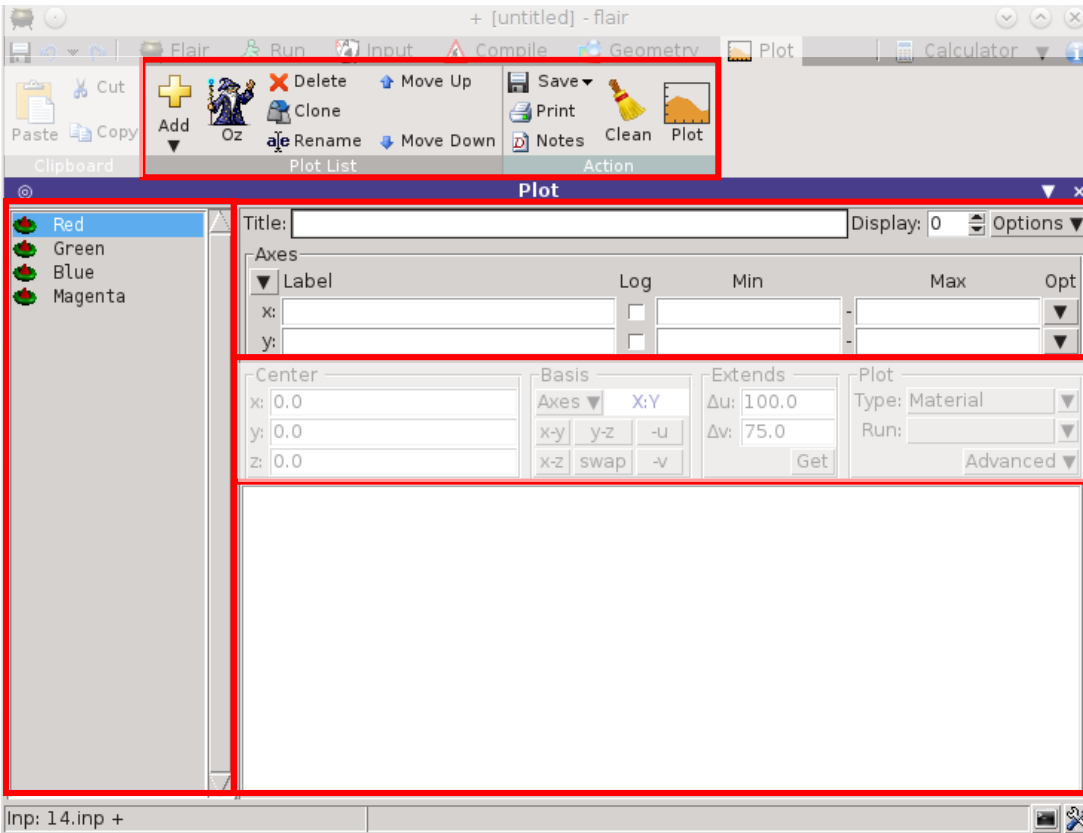
- All plot types share some common fields:
  Title + options, Filename, Axis Labels, Legends (Keys) and Gnuplot Commands.

- 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

- 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

- All input fields with light-yellow background are used to perform operations on the previous fields. e.g. to rotate the basis-vectors

- 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
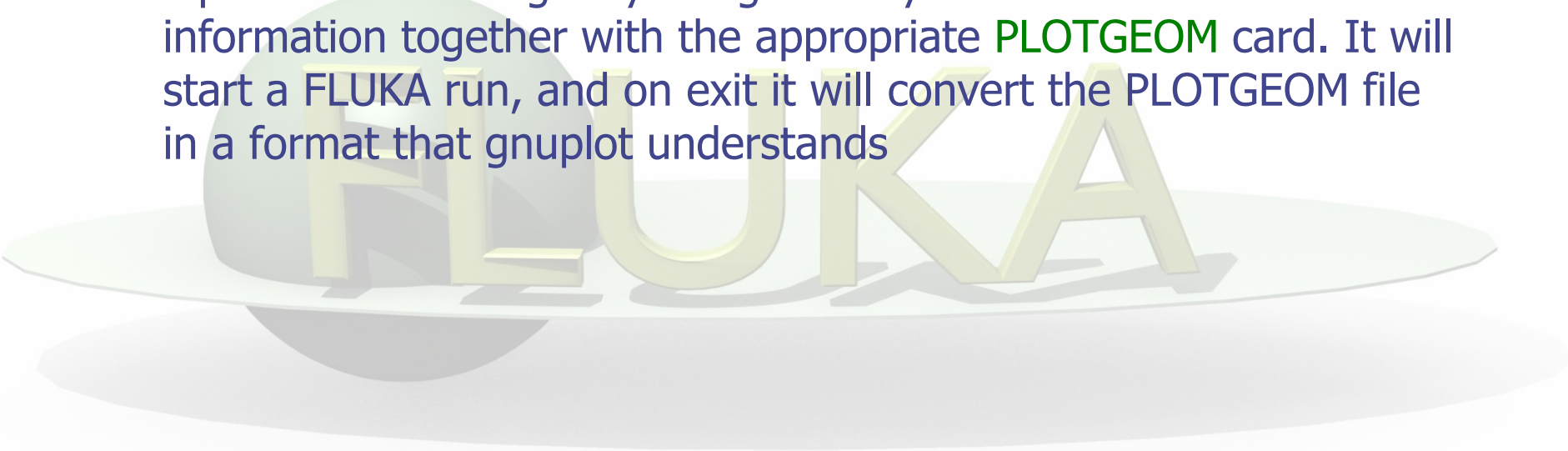
USRBIN

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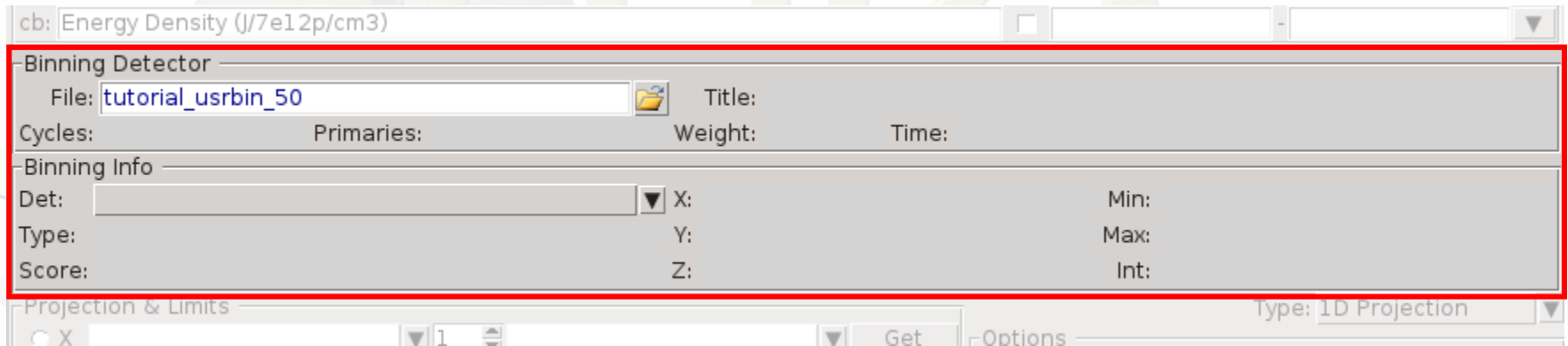
- Set the usrbin summary file in the **File:** field
- Select from **Det:** the detector to use.
- All the available detector information will be displayed
- The information Mininum, Maximum and Integral will be filled after the plot! *WARNING: it is always the projection min/max*

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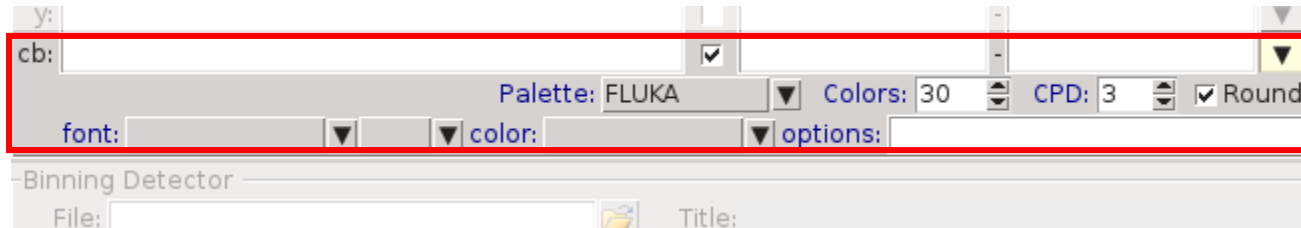
- The Minimum, Maximum, Colors and CPD (Colors Per Decade) are interconnected.

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

- 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)
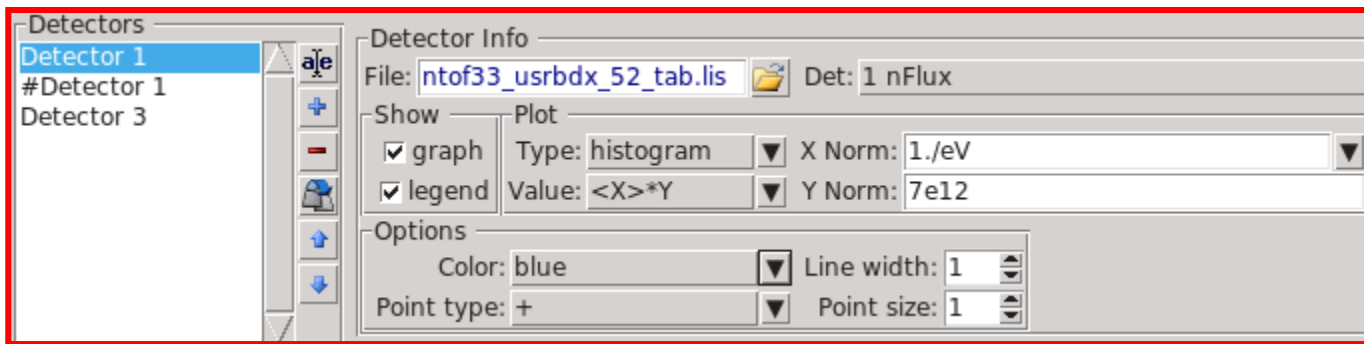
1D Trace H or V

- 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
  - $<X> \times Y$ — 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
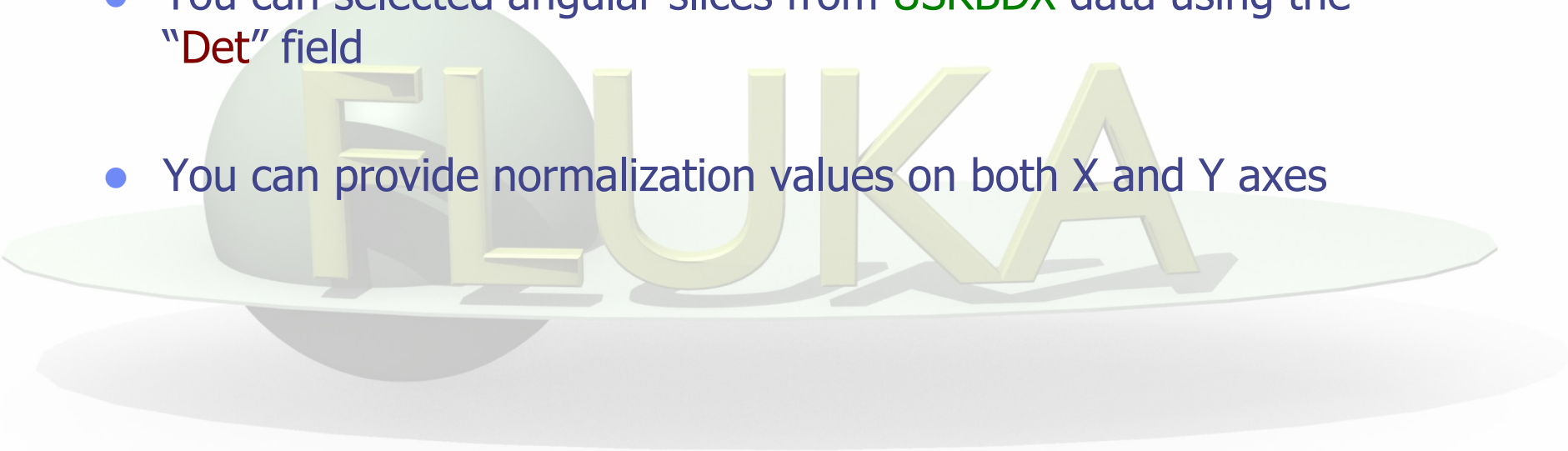
Multiple Editing

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.