



Your First Input and beyond

FLUKA Beginner's Course

Before starting: FLUKA Manual

in *continuous* development (as the program)!
More a User Guide than a Reference Manual
(only a short summary about physics)

FM.pdf

update of the published CERN yellow report
ToC, cross-references, and citations are active links
analytical index at the end

ASCII

`fluka2011.manual` (no figures)
Tk interface accessible through FLAIR or
from command line `/usr/local/bin/fm`
(HTML version is available on FLUKA website)

Before starting: FLUKA Manual

Short description of FLUKA

program and its capabilities, implemented physics models, installation...

User guide

- detailed description of input options
- available particles and materials
- combinatorial geometry
- low-energy neutrons library
- how to write/compile/link user routines
-and much more!

REMEMBER!

The first place to look at when puzzled!

...and the very best friend of a beginner user!

FLUKA and FLAIR

FLUKA users can....

- prepare their own input with a text editor
- use their own tools for plotting results
- submit jobs by command line

FLAIR (Fluka Advanced InteRface) can be used as well
It helps the users with the aforementioned tasks
(see FLAIR lecture)

You can choose your favorite way...

...but a good user should be able to go both ways!

Structure of the input file

General definitions

Beam definition
Materials: definition and assignment
Random number initialization
Start/Stop of simulation

This lecture

Physics settings

Defaults
Physical processes
Transport thresholds
Low energy neutrons
Induced radioactivity

This lecture and
many others

Geometry

Geometry lecture

Output settings

Scoring lecture

Estimators / scoring cards

FLUKA input file commands

Commands aka cards, aka options, aka directives, aka definitions

One keyword (command), 6 floating point numbers (WHATs), one string (SDUM)

Example of a FLUKA command (text editor style)

```
*...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
BEAM          1.E+04          0.0          0.0          0.0          0.0          0.0PROTON
*keyword      momentum mom.spread  diverg.    X-width   Y-width   ignored particle
*             WHAT (1)    WHAT (2)   WHAT (3)   WHAT (4)  WHAT (5)  WHAT (6)  SDUM
```

- Command keywords MUST be uppercase, numbers MUST have the decimal point
- Some commands require more than one "card"
- Some special commands (like **TITLE** and **OPEN**) are/may be followed by a text line
- With few exceptions, the order of commands is irrelevant
- Most commands can be repeated several times
- Repeated command can add themselves or override previous commands
- A line with a * character in column 1 is a comment
- Text after an exclamation mark (!) is ignored (does not work within the geometry)
- Almost all the WHAT() have a default value
- Commands can be issued in fixed or free format

Fixed vs free format [1/2]

Fixed format:

```
*...+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....  
BEAM           1.E+04   0.0D+00           0.0           0.0           0.0           0.0PROTON  
*keyword      momentum mom.spread   diverg.    X-width    Y-width    ignored particle  
*             WHAT (1)   WHAT (2)   WHAT (3)   WHAT (4)   WHAT (5)   WHAT (6)   SDUM
```

- The “traditional” FLUKA format is (A8, 2X, 6E10.0, A8)
Numbers: 9 digits at most can be used!
- All WHAT fields are in floating point format, *even integers*
They must always be written with the decimal point
- Exponential notation numbers (e.g. 1.234E+5), must be right aligned
- Double precision format (e.g. 1.234D+5) is allowed
- Blank numerical fields are read as 0.0
In most cases (*not all!*) such values are ignored and the corresponding default values are used
- Blank lines **NOT ALLOWED** in geometry declaration (tolerated elsewhere)
- **FLAIR** takes care of all the alignment problems for you

Fixed vs free format [2/2]

Free format:

- Free format can be made *locally* available issuing option **FREE** (without any parameter), until the option **FIXED** restores the fixed format; the opposite can be done either
- Option **GLOBAL** provides free format also for the geometry input
- In free format input, the different fields are separated by blanks and/or separators (usually commas). All fields must be present or at least represented by two successive separators
- Character fields (command name, SDUM) must be input without quotes

```
*...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
BEAM , 1.234567890E+04 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , PROTON
*
*keyword      momentum mom.spread  diverg.    X-width   Y-width   weight particle
*              WHAT (1)      WHAT (2)   WHAT (3)   WHAT (4)   WHAT (5)   WHAT (6)  SDUM
```

Temporarily switching to FREE format is particularly helpful when more than 10 digits are required for precision reasons !!!

Names instead of numbers

- FLUKA also allows to use keywords (names) - **8 characters maximum length** - instead of numbers inside FLUKA commands
- Examples later (for instance materials, or geometrical region, can be inserted using their name instead of numbers)
- This *helps* the user, improving the *readability* of the input FLUKA file, and is again managed by the FLAIR graphical interface



A basic input

```
TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS                                     PRECISIO
* Define the beam characteristics
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
BEAM      3.5 -0.082425      -1.7      0.0      0.0      PROTON
* Define the beam position
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
BEAMPOS   0.0      0.0      -0.1      0.0      0.0
*
GEOBEGIN                                     COMBNAME
      0      0
* Black body
SPH blkbody  0.0 0.0 0.0 100000.0
* Void sphere
SPH void     0.0 0.0 0.0 10000.0
* Cylindrical target
RCC target1  0.0 0.0  0.0 0.0 0.0 10.0 5.0
RCC target2  0.0 0.0 20.0 0.0 0.0 10.0 5.0
RCC target3  0.0 0.0 40.0 0.0 0.0 10.0 5.0
END
* Black hole
BLKBODY     5 +blkbody -void
* Void around
VOID        5 +void -target1 -target2 -target3
* Target
TARGET1     5 +target1
TARGET2     5 +target2
TARGET3     5 +target3
END
GEOEND
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
MATERIAL    24.0      7.18                                     CHROMIUM
MATERIAL    0.0      0.73E-3                                    AMMONIA
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
COMPOUND    1.0 NITROGEN      3.0 HYDROGEN      AMMONIA
*
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
ASSIGNMA    BLCKHOLE  BLKBODY
ASSIGNMA    VACUUM   VOID
ASSIGNMA    AMMONIA  TARGET3
*
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
ASSIGNMA    CHROMIUM  TARGET1  TARGET2      1.0
*
* Set the random number seed
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
RANDOMIZ     1.0 54217137.
*
* Set the number of primary histories to be simulated in the run
* ..+...1....+...2....+...3....+...4....+...5....+...6....+...7..
START       1000.
STOP
```

A basic input

The screenshot displays the FLAIR software interface with the following components:

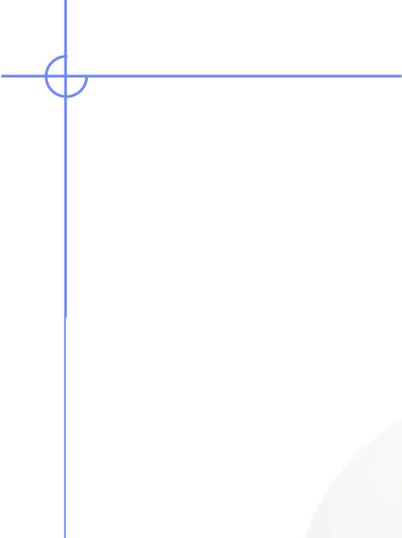
- Menu Bar:** Includes options like Run, Output, Plot, Compile, Geometry, Delete, and Preprocessor.
- Tree View (Left):** Shows a hierarchical structure of the input file, including General, Title, Defaults, Primary, Geometry, Media, Physics, and Preprocessor.
- Main Text Editor:** Contains the input file content, which is a series of commands for defining a simulation setup.

Input File Content:

```

TITLE my basic input example
DEFAULTS PRECISIO
BEAM Beam: Momentum p: 3.5 Part: PROTON
    Ap: Gauss Δφ: 0.082425 Δφ: Gauss Δφ: 1.7
    Shape(X): Rectangular Δx: 0.0 Shape(Y): Rectangular Δy: 0.0
    BEAMPOS x: 0.0 y: 0.0 z: -0.1
            coex: 0.0 cosy: 0.0 Type: POSITIVE
GEOBEGIN Log: Acc: Opt:
          Imp: Out: Fmt: COMBNAME
SPH blkbody x: 0.0 y: 0.0 z: 0.0
          R: 100000.0
SPH void x: 0.0 y: 0.0 z: 0.0
          R: 100000.0
RCC target1 x: 0.0 y: 0.0 z: 0.0
            Hx: 0.0 Hy: 0.0 Hz: 10.0
            R: 5.0
RCC target2 x: 0.0 y: 0.0 z: 20.0
            Hx: 0.0 Hy: 0.0 Hz: 10.0
            R: 5.0
RCC target3 x: 0.0 y: 0.0 z: 40.0
            Hx: 0.0 Hy: 0.0 Hz: 10.0
            R: 5.0
END
REGION BLKBODY Neigh: 5 Volume:
  expr: +blkbody -void
REGION VOID Neigh: 5 Volume:
  expr: +void -target1 -target2 -target3
REGION TARGET1 Neigh: 5 Volume:
  expr: +target1
REGION TARGET2 Neigh: 5 Volume:
  expr: +target2
REGION TARGET3 Neigh: 5 Volume:
  expr: +target3
END
GEOEND
MATERIAL Name: CHROMIUM # p: 7.18
  Z: 24 Am: A: dEdx:
MATERIAL Name: AMMONIA # p: 0.73E-3
  Z: Am: A: dEdx:
COMPOUND Name: AMMONIA Mix: Atom Elements: 1,3
  I1: 1.0 M1: NITROGEN I2: 3.0 M2: HYDROGEN
  I3: M3:
ASSIGNMA Mat: BLCKHOLE Reg: BLKBODY to Reg:
  Mat(Decay): Step: Field:
ASSIGNMA Mat: VACUUM Reg: VOID to Reg:
  Mat(Decay): Step: Field:
ASSIGNMA Mat: COPPER Reg: TARGET1 to Reg:
  Mat(Decay): Step: Field:
ASSIGNMA Mat: COPPER Reg: TARGET2 to Reg:
  Mat(Decay): Step: Field:
ASSIGNMA Mat: COPPER Reg: TARGET3 to Reg:
  Mat(Decay): Step: Field:
RANDOMIZ Unit 01 Seed: 54217137
START No.: 1000. Core:
  Time: Report: default
STOP
  
```

Status Bar: Shows 'Inp: MyBasicInputExample.inp' and 'Card:28 Total:29'.



A basic input card by card

A basic input: step 1: Physics settings

```

TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS
PRECISIO
* Define the beam shape and position
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
BEAM      3.5 -0.082425   -1.7      0.0      0.0      PROTON
* Define the beam position
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
BEAMPOS   0.0      0.0      -0.1      0.0      0.0
*
GEOBEGIN                                     COMBNAME
0 0
* Black body
SPH blkbody 0.0 0.0 0.0 100000.0
* Void sphere
SPH void 0.0 0.0 0.0 10000.0
* Cylindrical target
RCC target1 0.0 0.0 0.0 0.0 0.0 10.0 5.0
RCC target2 0.0 0.0 20.0 0.0 0.0 10.0 5.0
RCC target3 0.0 0.0 40.0 0.0 0.0 10.0 5.0
END
* Black hole
BLKBODY 5 +blkbody -void
* Void around
VOID 5 +void -target1 -target2 -target3
* Target
TARGET1 5 +target1
TARGET2 5 +target2
TARGET3 5 +target3
END
GEOEND
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
MATERIAL 24.0      7.18      CHROMIUM
MATERIAL 0.0      0.73E-3      AMMONIA
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
COMPOUND 1.0 NITROGEN 3.0 HYDROGEN AMMONIA
*
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
ASSIGNMA BLCKHOLE BLKBODY
ASSIGNMA VACUUM VOID
ASSIGNMA AMMONIA TARGET3
*
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..*
ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0
*
* Set the random number seed
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
RANDOMIZ 1.0 54217137.
*
* Set the number of primary histories to be simulated in the run
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
START 1000.
STOP
    
```

My Basic Input example

DEFAULTS PRECISIO

BEAM: Δp : Gauss Δp (FWHM): 0.082425 $\Delta \phi$: Gauss $\Delta \phi$: 1.7
 Shape(X): Rectangular Δx : 0.0 Shape(Y): Rectangular Δy : 0.0
 BEAMPOS: x: 0.0 y: 0.0 z: -0.1
 cosx: 0.0 cosy: 0.0 Type: POSITIVE
 Log: Inp: Acc: Out: Opt: Fmt: COMBNAME

GEOBEGIN

Title:

SPH blkbody x: 0.0 y: 0.0 z: 0.0
 R: 100000.0

SPH void x: 0.0 y: 0.0 z: 0.0
 R: 10000.0

RCC target1 x: 0.0 y: 0.0 z: 0.0
 Hx: 0.0 Hz: 10.0
 R: 5.0

RCC target2 x: 0.0 y: 0.0 z: 20.0
 Hx: 0.0 Hz: 10.0
 R: 5.0

RCC target3 x: 0.0 y: 0.0 z: 40.0
 Hx: 0.0 Hz: 10.0
 R: 5.0

END

REGION BLKBODY Neigh: 5 Volume:
 expr: +blkbody -void

REGION VOID Neigh: 5 Volume:
 expr: +void -target1 -target2 -target3

REGION TARGET1 Neigh: 5 Volume:
 expr: +target1

REGION TARGET2 Neigh: 5 Volume:
 expr: +target2

REGION TARGET3 Neigh: 5 Volume:
 expr: +target3

END

GEOEND

MATERIAL Name: CHROMIUM # p: 7.18
 Z: 24.0 Am: A: dE/dx: ∇

MATERIAL Name: AMMONIA # p: 0.73E-3
 Z: 0.0 Am: A: dE/dx: ∇

COMPOUND Name: AMMONIA Mix: Atom Elements: 1,3
 f1: 1.0 M1: NITROGEN f2: 3.0 M2: HYDROGEN
 f3: M3: ∇

ASSIGNMA Mat: BLCKHOLE Reg: BLKBODY to Reg: ∇
 Mat(Decay): ∇ Step: Field: ∇

ASSIGNMA Mat: VACUUM Reg: VOID to Reg: ∇
 Mat(Decay): ∇ Step: Field: ∇

ASSIGNMA Mat: AMMONIA Reg: TARGET3 to Reg: ∇
 Mat(Decay): ∇ Step: Field: ∇

ASSIGNMA Mat: CHROMIUM Reg: TARGET1 to Reg: TARGET2
 Mat(Decay): ∇ Step: 1.0 Field: ∇

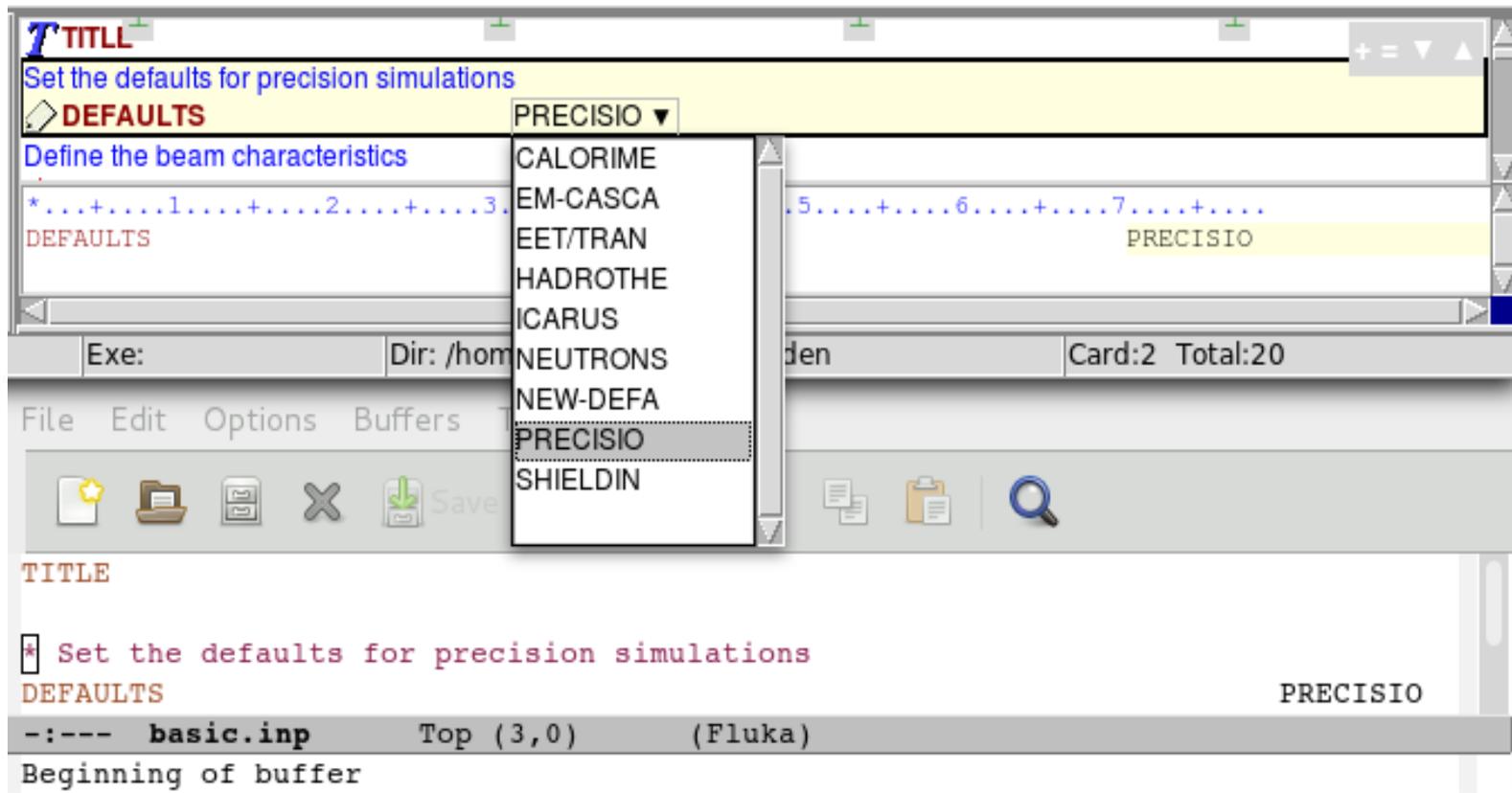
RANDOMIZ Unit 01 Seed: 54217137.
 START No.: 1000. Core: ∇
 Time: Report: default

STOP

TITLE
 My Basic Input example

Physics settings: DEFAULTS

Select predefined physics settings (e.g. transport thresholds)



Physics settings: **DEFAULTS**

Select predefined physics settings (e.g. transport thresholds)

- **CALORIME** : calorimeter simulations
- **EM-CASCA** : pure EM cascades
- **EET/TRAN** : Energy Transformer or transmutation calculations
- **HADROTHE** : hadrotherapy calculations
- **ICARUS** : studies related to the ICARUS experiment
- **NEW-DEFA** : minimal set of generic defaults (default of **DEFAULTS**)
- **PRECISIO** : precision simulations (**recommended**)

avoid **NEUTRONS** and **SHIELDIN**

Physics settings: DEFAULTS : PRECISIO

- EM transport on (**EMF** on), production/transport thresholds should always be set by the **EMFCUT!**
- Inelastic form factor correction to Compton scattering on (**EMFRAY** on)
- Detailed photoelectric edge treatment and fluorescence photons activated
- Low energy neutron transport on (**LOW-NEUT** on), threshold 20 MeV, with fully analogue absorption
- All transport threshold = 100keV, but neutrons (10^{-5} eV) and neutrinos (0, but they are discarded)
- Multiple Scattering threshold at minimum allowed energy, for both primary and secondary charged particles
- Delta rays production on, threshold 100keV (**DELTARAY**)
- Restricted ionization energy loss fluctuations for all particles (**IONFLUCT**)
- Tabulation ratio for hadron/muon dp/dx set at 1.04, fraction of the kinetic energy to be lost in a step set at 0.05, number of dp/dx tabulation points set at 80 (**DELTARAY**, **EMFFIX**, **FLUKAFIX**)
- e+e- pair production and bremsstrahlung by heavy particles on (**PAIRBREM**)
Pair threshold = $2 m_e$, bremsstrahlung threshold = 300keV
- Muon photonuclear interactions on (**MUPHOTON**)

* . . . + . . . 1 . . . + . . . 2 . . . + . . . 3 . . . + . . . 4 . . . + . . . 5 . . . + . . . 6 . . . + . . . 7 . . . +
DEFAULTS **PRECISIO**

A basic input: step 2: Beam

```

TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS
* Define the beam characteristics
PRECISIO
BEAM          3.5 -0.082425   -1.7   0.0   0.0   PROTON
* Define the beam position
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
BEAMPOS       0.0   0.0   -0.1   0.0   0.0
GEOBEGIN
0 0
* Black body
SPH blkbody   0.0 0.0 0.0 100000.0
* Void sphere
SPH void      0.0 0.0 0.0 10000.0
* Cylindrical target
RCC target1   0.0 0.0 0.0 0.0 0.0 10.0 5.0
RCC target2   0.0 0.0 20.0 0.0 0.0 10.0 5.0
RCC target3   0.0 0.0 40.0 0.0 0.0 10.0 5.0
END
* Black hole
BLKBODY      5 +blkbody -void
* Void around
VOID         5 +void -target1 -target2 -target3
* Target
TARGET1      5 +target1
TARGET2      5 +target2
TARGET3      5 +target3
END
GEOEND
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
MATERIAL      24.0           7.18
MATERIAL      0.0           0.73E-3
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
COMPOUND      1.0 NITROGEN   3.0 HYDROGEN
*
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
ASSIGNMA      BLCKHOLE   BLKBODY
ASSIGNMA      VACUUM     VOID
ASSIGNMA      AMMONIA    TARGET3
*
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..*
ASSIGNMA      CHROMIUM   TARGET1   TARGET2   1.0
*
* Set the random number seed
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
RANDOMIZ       1.0 54217137.
*
* Set the number of primary histories to be simulated in the run
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
START         1000.
STOP
    
```

My Basic Input example

PRECISIO

BEAM Beam: Momentum p: 3.5 Part: PROTON
 Δp: Gauss Δp(FWHM): 0.082425 Δφ: Gauss Δφ: 1.7
 Shape(X): Rectangular Δx: 0.0 Shape(Y): Rectangular Δy: 0.0
 BEAMPOS x: 0.0 y: 0.0 z: -0.1
 cosx: 0.0 cosy: 0.0 Type: POSITIVE

GEOBEGIN Log: Acc: Opt:
 Inp: Out: Fmt: COMBNAME

SPH blkbody x: 0.0 y: 0.0 z: 0.0
 R: 100000.0

SPH void x: 0.0 y: 0.0 z: 0.0
 R: 10000.0

RCC target1 x: 0.0 y: 0.0 z: 0.0
 Hx: 0.0 Hz: 10.0
 R: 5.0

RCC target2 x: 0.0 y: 0.0 z: 20.0
 Hx: 0.0 Hz: 10.0
 R: 5.0

RCC target3 x: 0.0 y: 0.0 z: 40.0
 Hx: 0.0 Hz: 10.0
 R: 5.0

END

REGION BLKBODY Neigh: 5 Volume:
 expr: +blkbody -void

REGION VOID Neigh: 5 Volume:
 expr: +void -target1 -target2 -target3

REGION TARGET1 Neigh: 5 Volume:
 expr: +target1

REGION TARGET2 Neigh: 5 Volume:
 expr: +target2

REGION TARGET3 Neigh: 5 Volume:
 expr: +target3

END

GEOEND

MATERIAL Name: CHROMIUM # p: 7.18
 Z: 24.0 Am: A: dE/dx: ▼

MATERIAL Name: AMMONIA # p: 0.73E-3
 Z: 0.0 Am: A: dE/dx: ▼

COMPOUND Name: AMMONIA Mix: Atom Elements: 1,3
 f1: 1.0 M1: NITROGEN f2: 3.0 M2: HYDROGEN
 f3: M3: ▼

ASSIGNMA Mat: BLCKHOLE Reg: BLKBODY to Reg: Field:
 Mat(Decay): Step: ▼

ASSIGNMA Mat: VACUUM Reg: VOID to Reg: Field:
 Mat(Decay): Step: ▼

ASSIGNMA Mat: AMMONIA Reg: TARGET3 to Reg: Field:
 Mat(Decay): Step: ▼

ASSIGNMA Mat: CHROMIUM Reg: TARGET1 to Reg: TARGET2
 Mat(Decay): Step: 1.0 Field: ▼

RANDOMIZ Unit 01 Seed: 54217137.
 No.: 1000. Core: Report: default

STOP

TITLE
 My Basic Input example

Beam definition: **BEAM**

Defines beam characteristics: type of particle, energy or momentum, divergence, spatial profile....

Let's see an example

The screenshot displays a software interface for defining beam characteristics. The main window is divided into two sections: "Define the beam characteristics" and "Define the beam position".

Define the beam characteristics:

- BEAM** (with a red star icon)
- Beam: Momentum ▼
- p: 3.5
- Part: PROTON ▼
- Δp : Gauss ▼
- Δp (FWHM): 0.082425
- $\Delta \phi$: Gauss ▼
- $\Delta \phi$: 1.7
- Shape(X): Rectangular ▼
- Δx : 0.0
- Shape(Y): Rectangular ▼
- Δy : 0.0

Define the beam position:

- BEAMPOS** (with a globe icon)
- x: _____
- y: _____
- z: _____
- cosx: _____
- cosy: _____
- Type: POSITIVE ▼

Below the main window, a terminal window shows the following output:

```
* .....1.....2.....3.....4.....5.....6.....7.....
BEAM          3.5 -0.082425      -1.7      0.0      0.0      PROTON
```

The terminal window also shows a menu bar (File, Edit, Options, Buffers, Tools, Help) and a toolbar with icons for Save, Undo, and other functions. At the bottom, it displays the status bar: "basic.inp 22% (9,1) (FLUKA)" and "Wrote /home/rversaci/basic.inp".

Beam definition: BEAM

[SDUM]: Proton beam

The screenshot displays the FLUKA GUI interface for defining a beam. The top panel, titled "Define the beam characteristics", shows the following parameters for the BEAM:

- Beam: Momentum p : 3.5
- Δp : Gauss Δp (FWHM): 0.082425
- Shape(X): Rectangular Δx : 0.0
- $\Delta \phi$: Gauss $\Delta \phi$: 1.7
- Shape(Y): Rectangular Δy : 0.0
- Part: PROTON

The middle panel, titled "Define the beam position", shows the BEAMPOS parameters:

- x: cosx: y: cosy: z: Type: POSITIVE

The bottom panel shows the terminal output, which includes the following lines:

```
* .....1.....2.....3.....4.....5.....6.....7.....  
BEAM 3.5 -0.082425 -1.7 0.0 0.0 PROTON  
* .....1.....2.....3.....4.....5.....6.....7.....  
BEAM 3.5 -0.082425 -1.7 0.0 0.0 PROTON  
*  
* Define the beam position  
BEAMPOS  
-:--- basic.inp 22% (9,1) (FLUKA)  
Wrote /home/rversaci/basic.inp
```

Red arrows indicate the mapping from the text box to the GUI elements: one arrow points to the "Part: PROTON" dropdown in the BEAM panel, another points to the "PROTON" text in the BEAMPOS panel, and a third points to the "PROTON" text in the terminal output.

Beam definition: BEAM

[WHAT(1)]: 3.5 GeV/c momentum

The screenshot displays the FLUKA GUI interface for defining beam characteristics. The 'BEAM' section is highlighted in yellow and contains the following parameters:

- Beam: Momentum (highlighted with a red circle)
- p: 3.5 (highlighted with a red circle)
- Part: PROTON
- Δp: Gauss
- Δp(FWHM): 0.082425
- Δφ: Gauss
- Δφ: 1.7
- Shape(X): Rectangular
- Δx: 0.0
- Shape(Y): Rectangular
- Δy: 0.0

The 'BEAMPOS' section is visible below, showing the beam position parameters (x, y, z, cosx, cosy, Type: POSITIVE).

The input table below the GUI shows the following data for the BEAM card:

Card	1	2	3	4	5	6	7
BEAM	3.5	-0.082425	-1.7	0.0	0.0		PROTON

The '3.5' value in the input table is also highlighted with a red circle. The status bar at the bottom indicates the file 'basic.inp' is open at 22% (9,1) in the FLUKA environment, and the command 'Wrote /home/rversaci/basic.inp' has been executed.

Beam definition: BEAM

[WHAT(2)]: Gaussian momentum distribution 0.082425 GeV/c FWHM

The screenshot displays the FLUKA graphical user interface for defining beam parameters. The top panel, titled "Define the beam characteristics", shows the **BEAM** card configuration. The **BEAM** card is highlighted with a red circle, and its parameters are as follows:

Parameter	Value
Beam: Momentum	p: 3.5
Part	PROTON
Δp	Gauss
Δp (FWHM)	0.082425
Shape(X)	Rectangular
Δx	0.0
$\Delta \phi$	Gauss
$\Delta \phi$	1.7
Shape(Y)	Rectangular
Δy	0.0

The bottom panel, titled "Define the beam position", shows the **BEAMPOS** card configuration. The **BEAMPOS** card is also highlighted with a red circle, and its parameters are as follows:

Parameter	Value
x	3.5
cosx	-0.082425
y	-1.7
cosy	0.0
z	0.0
Type	POSITIVE

Red arrows point from the text above to the highlighted values in the GUI. The value **0.082425** is circled in red in both the **BEAM** card (under Δp (FWHM)) and the **BEAMPOS** card (under cosx).

At the bottom of the window, the status bar shows the file name **basic.inp**, the zoom level **22% (9,1)**, and the program name **(FLUKA)**. The text **Wrote /home/rversaci/basic.inp** is displayed at the bottom left.

Beam definition: BEAM

[WHAT(3)]: Gaussian angular distribution 1.7 mrad FWHM

The screenshot displays the FLUKA GUI interface for defining beam parameters. The **BEAM** card is configured with the following settings:

- Beam: Momentum
- Δp : Gauss
- Shape(X): Rectangular
- Δp (FWHM): 0.082425
- Δx : 0.0
- $\Delta \phi$: Gauss
- Shape(Y): Rectangular
- $\Delta \phi$: 1.7
- Δy : 0.0
- Part: PROTON

The **BEAMPOS** card is configured with the following settings:

- x: 3.5
- y: -0.082425
- z: -1.7
- cosx: 0.0
- cosy: 0.0
- Type: POSITIVE

The terminal output at the bottom shows the following card definitions:

```
* .....1.....2.....3.....4.....5.....6.....7..
BEAM      3.5 -0.082425 -1.7 0.0 0.0 PROTON
*
* Define the beam position
BEAMPOS
-:--- basic.inp 22% (9,1) (FLUKA)
Wrote /home/rversaci/basic.inp
```

Red circles and arrows highlight the value **-1.7** in the GUI and the terminal output, indicating the Gaussian angular distribution parameter.

Beam definition: BEAM

[WHAT(4)]: No beam width in X (point-like source)

The screenshot displays the FLUKA GUI interface for defining beam characteristics. The 'BEAM' section is highlighted in yellow and contains the following parameters:

- Beam: Momentum $p: 3.5$
- Part: PROTON
- Shape(X): Rectangular $\Delta x: 0.0$
- Shape(Y): Rectangular $\Delta y: 0.0$
- $\Delta\phi: \text{Gauss}$ $\Delta\phi: 1.7$
- $\Delta p(p \text{ width}): 0.082425$

The 'BEAMPOS' section shows the beam position parameters:

- x: cosx
- y: cosy
- z: Type: POSITIVE

The 'BEAM' table at the bottom of the GUI shows the following values:

Beam	Momentum	Δp	Δx	Δy	Particle
BEAM	3.5	-0.082425	0.0	0.0	PROTON

Red circles and arrows highlight the 'Shape(X): Rectangular' parameter and the '0.0' value in the 'BEAM' table, indicating a point-like source with no beam width in X.

Beam definition: BEAM

[WHAT(5)]: No beam width in Y (point-like source)

Define the beam characteristics

BEAM Beam: Momentum $p: 3.5$ Part: PROTON
 Δp : Gauss $\Delta \phi$ (FWHM): 0.082425 $\Delta \phi$: Gauss $\Delta \phi: 1.7$
Shape(X): Rectangular $\Delta x: 0.0$ Shape(Y): Rectangular $\Delta y: 0.0$

Define the beam position

BEAMPOS x: y: z:
cosx: cosy: Type: POSITIVE

	1	2	3	4	5	6	7
BEAM	3.5	-0.082425	-1.7	0.0	0.0	0.0	PROTON

Exe: Dir: /home/rversaci Card:3 Total:20

File Edit Options Buffers Tools Help

Save Undo

	1	2	3	4	5	6	7
BEAM	3.5	-0.082425	-1.7	0.0	0.0	0.0	PROTON

* Define the beam position

BEAMPOS

--- basic.inp 22% (9,1) (FLUKA)

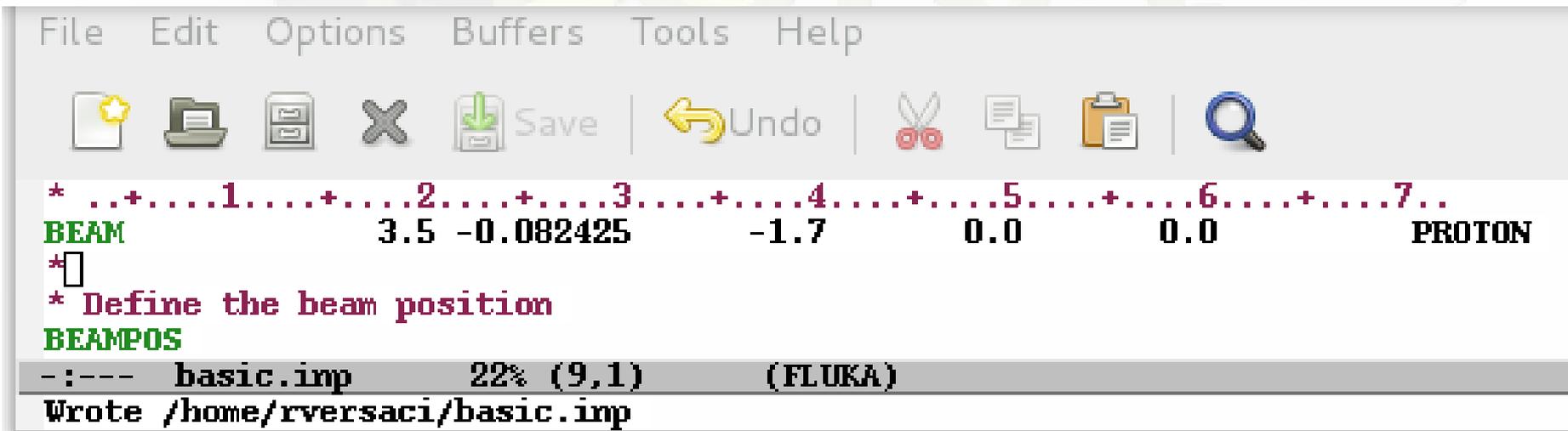
Wrote /home/rversaci/basic.inp

Beam definition: **BEAM**

defines beam characteristics:

type of particle, energy, divergence, spatial profile....

- [SDUM] proton beam
- [WHAT(1)] 3.5 GeV/c momentum
- [WHAT(2)] Gaussian momentum distribution 0.082425 GeV/c FWHM
- [WHAT(3)] Gaussian angular distribution 1.7 mrad FWHM
- [WHAT(4)] No beam width in X (point-like source)
- [WHAT(5)] No beam width in Y (point-like source)



The screenshot shows a text editor window with a menu bar (File, Edit, Options, Buffers, Tools, Help) and a toolbar with icons for file operations and editing. The main text area contains the following content:

```
* .....1.....2.....3.....4.....5.....6.....7..
BEAM                3.5 -0.082425      -1.7      0.0      0.0      PROTON
*
* Define the beam position
BEAMPOS
-:--- basic.inp      22% (9,1)      (FLUKA)
Wrote /home/rversaci/basic.inp
```

Beam definition: BEAMPOS

Defines beam **position** and **direction**

The screenshot displays the BEAMPOS software interface. The top section, titled "Define the beam characteristics", shows parameters for a beam: **BEAM**, Δp : Gauss, Shape(X): Rectangular, Beam: Momentum, $\Delta p(\text{FWHM})$: 0.082425, $\Delta \phi$: Gauss, p : 3.5, Shape(Y): Rectangular, Part: PROTON, $\Delta \phi$: 1.7, and Δy : 0.0. The middle section, titled "Define the beam position", shows parameters for the beam position: **BEAMPOS**, x : 0.0, y : 0.0, z : -0.1, $\cos x$: 0.0, $\cos y$: 0.0, and Type: POSITIVE. Below these sections is a terminal window showing the command line: `* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
BEAMPOS 0.0 0.0 -0.1 0.0 0.0`. The bottom section shows a menu bar (File, Edit, Options, Buffers, Tools, Help) and a toolbar with icons for Save, Undo, Cut, Copy, and Find. The terminal window also shows the output of the command: `* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
BEAM 3.5 -0.082425 -1.7 0.0 0.0 PROTON
* Define the beam position
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
BEAMPOS 0.0 0.0 -0.1 0.0 0.0
*
-:--- basic.imp 20% (11,1) (FLUKA)`

Beam definition: BEAMPOS

[SDUM]: beam direction along Z

By default toward positive Z

The screenshot shows the BEAMPOS configuration window with the following parameters:

Define the beam characteristics		Define the beam position	
BEAM	Momentum: 3.5	x: 0.0	z: -0.1
Δp : Gauss	Δp (FWHM): 0.082425	cosx: 0.0	Type: POSITIVE
Shape(X): Rectangular	Δx : 0.0	y: 0.0	
	Shape(Y): Rectangular	cosy: 0.0	
	$\Delta \phi$: Gauss		
	$\Delta \phi$: 1.7		
	Δy : 0.0		

The table below the window shows the SDUM parameter for BEAMPOS:

SDUM	1	2	3	4	5	6	7
BEAMPOS	0.0	0.0	-0.1	0.0	0.0		

The terminal output at the bottom shows the configuration for BEAM and BEAMPOS:

```
* .....1.....2.....3.....4.....5.....6.....7...
BEAM          3.5 -0.082425    -1.7    0.0    0.0    PROTON
*
* Define the beam position
* .....1.....2.....3.....4.....5.....6.....7...
BEAMPOS       0.0    0.0    -0.1    0.0    0.0
*
-:--- basic.imp    20% (11,1)    (FLUKA)
```

Beam definition: BEAMPOS

[WHAT(1)]: X coordinate of the beam spot center

The screenshot displays the FLUKA GUI interface for defining beam characteristics and position. The top section, titled "Define the beam characteristics", shows parameters for the **BEAM** card: Δp : Gauss, Shape(X): Rectangular, Beam Momentum: 3.5, Δp (FWHM): 0.082425, $\Delta\phi$: Gauss, Shape(Y): Rectangular, Part: PROTON, $\Delta\phi$: 1.7, and Δy : 0.0. The middle section, titled "Define the beam position", shows parameters for the **BEAMPOS** card: x: 0.0, y: 0.0, z: -0.1, cosx: 0.0, cosy: 0.0, and Type: POSITIVE. Below these sections is a parameter list for the **BEAMPOS** card, with the first value (0.0) circled in red. At the bottom, a terminal window shows the input file content, with the **BEAMPOS** card parameters (0.0, 0.0, -0.1, 0.0, 0.0) also circled in red. Red arrows point from the text box above to the circled values in the GUI and terminal.

```
Define the beam characteristics
* BEAM
  Δp: Gauss
  Shape(X): Rectangular
  Beam Momentum: 3.5
  Δp(FWHM): 0.082425
  Δφ: Gauss
  Shape(Y): Rectangular
  Part: PROTON
  Δφ: 1.7
  Δy: 0.0

Define the beam position
* BEAMPOS
  x: 0.0
  y: 0.0
  z: -0.1
  cosx: 0.0
  cosy: 0.0
  Type: POSITIVE

* ...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
BEAMPOS 0.0 0.0 -0.1 0.0 0.0

Exe: /home/rversaci Dir: /home/rversaci Card:4 Total:20

File Edit Options Buffers Tools Help
[Icons: Save, Undo, Cut, Copy, Find]

* ...+...1...+...2...+...3...+...4...+...5...+...6...+...7...
BEAM 3.5 0.082425 -1.7 0.0 0.0 PROTON
*
* Define the beam position
* ...+...1...+...2...+...3...+...4...+...5...+...6...+...7...
BEAMPOS 0.0 0.0 -0.1 0.0 0.0
*

-:--- basic.imp 20% (11,1) (FLUKA)
```

Beam definition: BEAMPOS

[WHAT(2)]: Y coordinate of the beam spot center

The screenshot displays the BEAMPOS configuration window in FLUKA. The window is divided into two main sections: "Define the beam characteristics" and "Define the beam position".

Define the beam characteristics:

- Beam: Momentum $p: 3.5$
- Beam: Δp : Gauss $\Delta p: 0.082425$
- Beam: $\Delta\phi$: Gauss $\Delta\phi: 1.7$
- Shape(X): Rectangular $\Delta x: 0.0$
- Shape(Y): Rectangular $\Delta y: 0.0$
- Part: PROTON

Define the beam position:

- x: 0.0
- y: 0.0
- z: -0.1
- cosx: 0.0
- cosy: 0.0
- Type: POSITIVE

The input file content is shown at the bottom of the window:

```
* .....1.....2.....3.....4.....5.....6.....7.....  
BEAMPOS      0.0      0.0      -0.1      0.0      0.0
```

Below the input file content, the parameters are summarized:

```
* .....1.....2.....3.....4.....5.....6.....7.....  
BEAM      3.5 -0.082425      -1.7      0.0      0.0      PROTON  
*  
* Define the beam position  
* .....1.....2.....3.....4.....5.....6.....7.....  
BEAMPOS      0.0      0.0      -0.1      0.0      0.0  
*
```

Red circles and arrows highlight the y-coordinate values in the GUI and the corresponding WHAT(2) parameter in the input file.

Beam definition: BEAMPOS

[WHAT(3)]: Z coordinate of the beam spot center

The screenshot displays the BEAMPOS interface with the following parameters and settings:

- Define the beam characteristics:**
 - BEAM: Δp : Gauss, Shape(X): Rectangular
 - Beam: Momentum: 3.5, $\Delta p(\text{FWHM})$: 0.082425, Δx : 0.0
 - Part: PROTON, $\Delta \phi$: Gauss, Shape(Y): Rectangular, $\Delta \phi$: 1.7, Δy : 0.0
- Define the beam position:**
 - BEAMPOS: x: 0.0, cosx: 0.0, y: 0.0, cosy: 0.0, z: -0.1, Type: POSITIVE

The text-based input area shows the following parameters for BEAM and BEAMPOS:

```
* .....1.....2.....3.....4.....5.....6.....7.....
BEAM      3.5 -0.082425 -1.7 0.0 0.0 PROTON
*
* Define the beam position
* .....1.....2.....3.....4.....5.....6.....7.....
BEAMPOS   0.0 0.0 -0.1 0.0 0.0
```

Red circles and arrows highlight the Z coordinate value of -0.1 in both the graphical interface and the text-based input area.

Beam definition: BEAMPOS

[WHAT(4)]: direction cosine with respect to the X axis

The screenshot shows the BEAMPOS configuration window in FLUKA. The interface is divided into several sections:

- Define the beam characteristics:** BEAM, Beam: Momentum, Δp : Gauss, Shape(X): Rectangular, Δp (FWHM): 0.082425, $\Delta\phi$: Gauss, Shape(Y): Rectangular, Part: PROTON, $\Delta\phi$: 1.7, Δy : 0.0.
- Define the beam position:** BEAMPOS, x: 0.0, y: 0.0, z: -0.1, cosx: 0.0, cosy: 0.0, Type: POSITIVE.

Below the configuration window, a terminal window displays the input and output of the BEAMPOS command. The input line is:

```
BEAMPOS 0.0 0.0 -0.1 0.0 0.0
```

The output line is:

```
BEAM 3.5 -0.082425 -1.7 0.0 0.0 PROTON
```

Red circles and arrows highlight the 'cosx' parameter and its value '0.0' in both the configuration window and the terminal output.

Beam definition: BEAMPOS

[WHAT(5)]: direction cosine with respect to the Y axis

The screenshot displays the FLUKA GUI for defining beam characteristics and position. The 'BEAM' section shows parameters: Δp : Gauss, Shape(X): Rectangular, Beam: Momentum, $\Delta p(\text{FWHM})$: 0.082425, p : 3.5, $\Delta\phi$: Gauss, Shape(Y): Rectangular, Part: PROTON, $\Delta\phi$: 1.7, Δy : 0.0. The 'BEAMPOS' section shows: x : 0.0, cosx : 0.0, y : 0.0, cosy : 0.0, z : -0.1, Type: POSITIVE. The terminal window shows the corresponding input cards: BEAM 3.5 -0.082425 -1.7 0.0 0.0 PROTON and BEAMPOS 0.0 0.0 -0.1 0.0 0.0. Red arrows and circles highlight the 'cosy' parameter in both the GUI and the terminal output.

Parameter	Value
Beam: Momentum	p : 3.5
$\Delta p(\text{FWHM})$	0.082425
Shape(X)	Rectangular
Δx	0.0
Shape(Y)	Rectangular
Δy	0.0
Part	PROTON
$\Delta\phi$	1.7
Beam position x	0.0
Beam position y	0.0
Beam position z	-0.1
Beam position cosx	0.0
Beam position cosy	0.0
Type	POSITIVE

```
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
BEAMPOS      0.0      0.0      -0.1      0.0      0.0

Exe:          Dir: /home/rversaci          Card:4 Total:20

File Edit Options Buffers Tools Help
[Icons: Save, Undo, Cut, Copy, Find]

* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
BEAM          3.5 -0.082425 -1.7 0.0 0.0 PROTON
*
* Define the beam position
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
BEAMPOS      0.0      0.0      -0.1      0.0      0.0
*

-:--- basic.imp      20% (11,1)      (FLUKA)
```

Beam definition: BEAMPOS

Defines beam **position** and **direction**

- [SDUM] blank, therefore beam towards positive Z
- [WHAT(1)] X coordinate of the beam spot center
- [WHAT(2)] Y coordinate of the beam spot center
- [WHAT(3)] Z coordinate of the beam spot center
- [WHAT(4)] Direction cosine with respect to the X axis
- [WHAT(5)] Direction cosine with respect to the Y axis

The screenshot shows a software window titled "Define the beam characteristics" and "Define the beam position". The "Define the beam position" section is highlighted in yellow and contains the following parameters:

Parameter	Value
x	0.0
y	0.0
z	-0.1
cosx	0.0
cosy	0.0
Type	POSITIVE

The "Define the beam characteristics" section contains the following parameters:

Parameter	Value
Beam: Momentum	p: 3.5
Part	PROTON
Δp	Gauss
Δp(FWHM)	0.082425
Δφ	Gauss
Δφ	1.7
Shape(X)	Rectangular
Δx	0.0
Shape(Y)	Rectangular
Δy	0.0

The window also shows a command line with the following input:

```
BEAMPOS 0.0 0.0 -0.1 0.0 0.0
```

The status bar at the bottom indicates "Exe: /home/rversaci" and "Card:4 Total:20". The menu bar includes "File", "Edit", "Options", "Buffers", "Tools", and "Help". The toolbar contains icons for Save, Undo, Cut, Copy, Paste, and Search.

A basic input: step 3: Geometry

```
TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS
* Define the beam characteristics
* .....1.....2.....3.....4.....5.....6.....7..
BEAM          3.5 -0.082425   -1.7   0.0   0.0   PROTON
* Define the beam position
BEAMPOS       0.0   0.0   -0.1   0.0   0.0
*
GEOBEGIN
0 0
* Black body
SPH blkbody  0.0 0.0 0.0 100000.0
* Void sphere
SPH void      0.0 0.0 0.0 10000.0
* Cylindrical target
RCC target1  0.0 0.0 0.0 0.0 0.0 10.0 5.0
RCC target2  0.0 0.0 20.0 0.0 0.0 10.0 5.0
RCC target3  0.0 0.0 40.0 0.0 0.0 10.0 5.0
END
* Black hole
BLKBODY      5 +blkbody -void
* Void around
VOID         5 +void -target1 -target2 -target3
* Target
TARGET1      5 +target1
TARGET2      5 +target2
TARGET3      5 +target3
END
GEOEND
* .....1.....2.....3.....4.....5.....6.....7..
MATERIAL      24.0           7.18           CHROMIUM
MATERIAL      0.0           0.73E-3          AMMONIA
* .....1.....2.....3.....4.....5.....6.....7..
COMPOUND
* .....1.....
ASSIGNMA
ASSIGNMA
ASSIGNMA
* .....1.....2.....3.....4.....5.....6.....7..*
ASSIGNMA      CHROMIUM  TARGET1  TARGET2      1.0
*
* Set the random number seed
* .....1.....2.....3.....4.....5.....6.....7..
RANDOMIZ       1.0 54217137.
*
* Set the number of primary histories to be simulated in the run
* .....1.....2.....3.....4.....5.....6.....7..
START         1000.
STOP
```

```
TITLE My Basic Input example
DEFAULTS
PRECISIO
BEAM          Beam: Momentum          p: 3.5          Part: PROTON
              Δp(FWHM): 0.082425      Δφ: Gauss      Δφ: 1.7
              Shape(X): Rectangular    Ax: 0.0         Shape(Y): Rectangular  Ay: 0.0
              BEAMPOS                  x: 0.0         y: 0.0             z: -0.1
              cosx: 0.0                 cosy: 0.0        Type: POSITIVE
              Log:                       Inp:           Acc:               Opt:
              Out:                       Fmt: COMBNAME
GEOBEGIN
Title:
SPH blkbody  x: 0.0           y: 0.0           z: 0.0
              R: 100000.0
SPH void     x: 0.0           y: 0.0           z: 0.0
              R: 10000.0
RCC target1  x: 0.0           y: 0.0           z: 0.0
              Hx: 0.0         Hy: 0.0          Hz: 10.0
              R: 5.0
RCC target2  x: 0.0           y: 0.0           z: 20.0
              Hx: 0.0         Hy: 0.0          Hz: 10.0
              R: 5.0
RCC target3  x: 0.0           y: 0.0           z: 40.0
              Hx: 0.0         Hy: 0.0          Hz: 10.0
              R: 5.0
END
REGION BLKBODY      Neigh: 5          Volume:
  expr: +blkbody -void
REGION VOID        Neigh: 5          Volume:
  expr: +void -target1 -target2 -target3
REGION TARGET1    Neigh: 5          Volume:
  expr: +target1
REGION TARGET2    Neigh: 5          Volume:
  expr: +target2
REGION TARGET3    Neigh: 5          Volume:
  expr: +target3
END
GEOEND
MATERIAL          Name: CHROMIUM      #           p: 7.18
                  Am:                 A:         dE/dx:
                  Z: 24.0
MATERIAL          Name: AMMONIA       #           p: 0.73E-3
                  Am:                 A:         dE/dx:
                  Z: 0.0
                  Elements: 1,3
                  M2: HYDROGEN
ASSIGNMA          Mat: AMMONIA        Reg: TARGET3  to Reg:
                  Mat(Decay):         Step:         Field:
ASSIGNMA          Mat: CHROMIUM       Reg: TARGET1  to Reg: TARGET2
                  Mat(Decay):         Step: 1.0     Field:
RANDOMIZ           Unit 01             Seed: 54217137.
START            No.: 1000.           Core:
STOP            Time:                 Report: default
* .....1.....2.....3.....4.....5.....6.....7..+.....
TITLE
My Basic Input example
```

Geometry definition: please, wait for the Geometry lecture but notice the structure

A basic input: step 4: Materials

```

TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS
* Define the beam characteristics
* .....1.....2.....3.....4.....5.....6.....7..
BEAM          3.5 -0.082425   -1.7      0.0      0.0      PROTON
* Define the beam position
* .....1.....2.....3.....4.....5.....6.....7..
BEAMPOS       0.0      0.0      -0.1     0.0      0.0
*
GEOBEGIN
0 0
* Black body
SPH blkbody   0.0 0.0 0.0 100000.0
* Void sphere
SPH void      0.0 0.0 0.0 10000.0
* Cylindrical target
RCC target1  0.0 0.0 0.0 0.0 0.0 10.0 5.0
RCC target2  0.0 0.0 20.0 0.0 0.0 10.0 5.0
RCC target3  0.0 0.0 40.0 0.0 0.0 10.0 5.0
END
* Black hole
BLKBODY      5 +blkbody -void
* Void around
VOID         5 +void -target1 -target2 -target3
* Target
TARGET1      5 +target1
TARGET2      5 +target2
TARGET3      5 +target3
END
GEOEND
* .....1.....2.....3.....4.....5.....6.....7..
MATERIAL      24.0      7.18      CHROMIUM
MATERIAL      0.0      0.73E-3      AMMONIA
* .....1.....2.....3.....4.....5.....6.....7..
COMPOUND      1.0 NITROGEN 3.0 HYDROGEN AMMONIA
*
* .....1.....2.....3.....4.....5.....6.....7..
ASSIGNMA      BLCKHOLE  BLKBODY
ASSIGNMA      VACUUM    VOID
ASSIGNMA      AMMONIA   TARGET3
*
* .....1.....2.....3.....4.....5.....6.....7..*
ASSIGNMA      CHROMIUM  TARGET1  TARGET2  1.0
*
* Set the random number seed
* .....1.....2.....3.....4.....5.....6.....7..
RANDOMIZ       1.0 54217137.
*
* Set the number of primary histories to be simulated in the run
* .....1.....2.....3.....4.....5.....6.....7..
START         1000.
STOP
    
```

My Basic Input example

PRECISIO

Beam: Momentum p: 3.5 Part: PROTON

Δp(FWHM): 0.082425 Δφ: Gauss Δφ: 1.7

Shape(X): Rectangular Δx: 0.0 Shape(Y): Rectangular Δy: 0.0

BEAMPOS x: 0.0 y: 0.0 z: -0.1

cosx: 0.0 cosy: 0.0 Type: POSITIVE

GEOBEGIN Log: Inp: Acc: Out: Opt: Fmt: COMBNAME

SPH blkbody x: 0.0 y: 0.0 z: 0.0 R: 100000.0

SPH void x: 0.0 y: 0.0 z: 0.0 R: 10000.0

RCC target1 x: 0.0 y: 0.0 z: 0.0 Hx: 0.0 Hz: 10.0 R: 5.0

RCC target2 x: 0.0 y: 0.0 z: 20.0 Hx: 0.0 Hz: 10.0 R: 5.0

RCC target3 x: 0.0 y: 0.0 z: 40.0 Hx: 0.0 Hz: 10.0 R: 5.0

END

REGION BLKBODY Neigh: 5 Volume:

expr: +blkbody -void

REGION VOID Neigh: 5 Volume:

expr: +void -target1 -target2 -target3

REGION TARGET1 Neigh: 5 Volume:

expr: +target1

REGION TARGET2 Neigh: 5 Volume:

expr: +target2

REGION TARGET3 Neigh: 5 Volume:

expr: +target3

END

GEOEND

MATERIAL Name: CHROMIUM # p: 7.18

Z: 24.0 Am: A: dE/dx:

MATERIAL Name: AMMONIA # p: 0.73E-3

Z: 0.0 Am: A: dE/dx:

COMPOUND Name: AMMONIA Mix: Atom Elements: 1,3

f1: 1.0 M1: NITROGEN f2: 3.0 M2: HYDROGEN

f3: M3:

ASSIGNMA Mat: BLCKHOLE Reg: BLKBODY to Reg: Field:

Mat(Decay): Step:

ASSIGNMA Mat: VACUUM Reg: VOID to Reg: Field:

Mat(Decay): Step:

ASSIGNMA Mat: AMMONIA Reg: TARGET3 to Reg: Field:

Mat(Decay): Step:

ASSIGNMA Mat: CHROMIUM Reg: TARGET1 to Reg: TARGET2

Mat(Decay): Step: 1.0 Field:

RANDOMIZ Unit: 01 Seed: 54217137.

START No.: 1000. Core: Report: default

Time:

STOP

35

TITLE My Basic Input example

Materials

FLUKA handles:

- **elemental materials** (by default natural composition, the user can set a specific isotope, being aware of low energy neutron cross sections availability)
- **compounds** (chemical molecules, alloys, mixtures...)

Each material is uniquely identified by an index/name

FLUKA has a set of **predefined** materials

Users can both use/modify these and define their own ones

Basic cards:

MATERIAL	material declaration
COMPOUND	compound definition (a MATERIAL card is mandatory for a compound declaration)
ASSIGNMA	material assignment to regions of geometry

Predefined materials

In FLUKA **2 special materials +23 natural elements** of most common use, e.g. Oxygen, Carbon, Iron... (check them out in the manual, Chap. 5), are predefined

The first two are very important:

- **BLCKHOLE** (mat #1): material with infinite absorbance;
- **VACUUM** (mat #2)

12 compound materials with the composition suggested by **ICRU** are predefined as well (again, check the manual!)

All predefined materials can be used **WITHOUT** explicit **MATERIAL / COMPOUND** cards

WARNING: user defined **MATERIAL** cards **OVERRIDE PREDEFINED** materials having the same name

Material definition: MATERIAL

Defines a new **material** or override a previous one

The screenshot displays a software window titled "TITLE ... GEOEND ... 8 cards hidden". It shows two material definitions in a table-like format:

Material	Z	Name	#	A	ρ	dE/dx
MATERIAL	24.0	CHROMIUM	#	A	7.18	▼
MATERIAL	0.0	AMMONIA	#	A	0.73E-3	▼

Below this, a summary table is shown:

Material	Z	ρ	Name
MATERIAL	24.0	7.18	CHROMIUM
MATERIAL	0.0	0.73E-3	AMMONIA

The interface also shows a status bar with "Exe:", "Dir: /home/versaci/fluka_dresden", "Card:19 Displayed:2 Total:28", and a footer with "basic.inp 52% (35,77) (Fluka)".

Material definition: MATERIAL

Chemical elements names should correspond to an entry in the LOW-ENERGY neutrons database (see manual section 10.4 & neutrons lecture)

[SDUM]: material name

The screenshot displays a software interface with a table of material definitions. The table has columns for material name, atomic number (Z), and density (ρ). The first two rows are highlighted in yellow. The first row is for 'CHROMIUM' with Z=24.0 and ρ=7.18. The second row is for 'AMMONIA' with Z=0.0 and ρ=0.73E-3. Below the table, there is a section for 'COMPOUND' definitions. The first row is for 'CHROMIUM' with Z=24.0 and ρ=7.18. The second row is for 'AMMONIA' with Z=0.0 and ρ=0.73E-3. At the bottom, there is a status bar showing 'basic.inp' and '52% (35,77) (Fluka)'. The page number '39' is in the bottom right corner.

Material Name	Z	ρ
CHROMIUM	24.0	7.18
AMMONIA	0.0	0.73E-3

Compound Name	Z	ρ
CHROMIUM	24.0	7.18
AMMONIA	0.0	0.73E-3

Material definition: MATERIAL

[WHAT(1)]: atomic number Z

The screenshot displays a software interface for material definition. It shows two material entries: CHROMIUM and AMMONIA. The atomic number Z is highlighted in red circles and pointed to by red arrows from the text above. The interface includes a title bar, a main display area with a grid, and a status bar at the bottom.

Material Name	Atomic Number (Z)	Density (ρ)	Other Properties
CHROMIUM	24.0	7.18	dE/dx: ▼
AMMONIA	0.0	0.73E-3	dE/dx: ▼

Exe: Dir: /home/versaci/fluka_dresden Card:19 Displayed:2 Total:28

basic.inp 52% (35,77) (Fluka)

Material definition: MATERIAL

[WHAT(2)]: atomic weight

Calculated by the code using its internal database: **leave it empty**

The screenshot displays a software interface for defining materials. It features a graphical view at the top and a table view at the bottom. Red arrows highlight the 'Am:' field, which is left empty, as instructed by the text above.

Material	Z	Am	ρ	Compound
CHROMIUM	24.0		7.18	CHROMIUM
AMMONIA	0.0		0.73E-3	AMMONIA

Material definition: MATERIAL

[WHAT(3)]: density [g/cm³]

If $\rho < 0.01$ g/cm³: the material is assumed to be a gas

The screenshot displays a software interface with a table of material definitions. The table has columns for material name, atomic number (Z), atomic mass (Am), and density (rho). The density values are circled in red, and red arrows point from the text box to these values.

Material Name	Z	Am	Density (rho)
CHROMIUM	24.0		7.18
AMMONIA	0.0		0.73E-3

The interface also shows a command window with the following text:

```
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...  
MATERIAL 24.0 7.18 CHROMIUM  
MATERIAL 0.0 0.73E-3 AMMONIA
```

At the bottom of the interface, the file name 'basic.inp' and the percentage '52% (35,77)' are visible.

Material definition: MATERIAL

[WHAT(4)]: material number

Available for backward compatibility:
leave it empty

The screenshot shows a software interface with two panels. The top panel displays material definitions for CHROMIUM and AMMONIA. The bottom panel shows a summary table of these materials. Red arrows point from the text above to empty input fields in the interface.

Name	Z	A	ρ	dE/dx
CHROMIUM	24.0	7.18	7.18	▼
AMMONIA	0.0	0.73E-3	0.73E-3	▼

Summary Table:

Material	Z	A	ρ	dE/dx
MATERIAL	24.0	7.18		
MATERIAL	0.0	0.73E-3		

Material definition: MATERIAL

[WHAT(5)]: alternate material to be used for dE/dx

normally empty

The screenshot displays a software interface for material definition. It features a table with columns for material properties and a status bar at the bottom. Red arrows point from a text box to specific fields in the interface, including dE/dx dropdowns and empty input boxes.

Material	Z	Am	dE/dx
CHROMIUM	24.0	7.18	▼
AMMONIA	0.0	0.73E-3	▼

Exe: Dir: /home/versaci/fluka_dresden Card:19 Displayed:2 Total:28

Material	Z	Am	Material
MATERIAL	24.0	7.18	CHROMIUM
MATERIAL	0.0	0.73E-3	AMMONIA

--:-- basic.inp 52% (35,77) (Fluka)

Material definition: MATERIAL

[WHAT(6)]: mass number A

normally empty
unless a specific isotope is desired

The screenshot displays a software interface for material definition. It shows two material cards: CHROMIUM (Z: 24.0, p: 7.18) and AMMONIA (Z: 0.0, p: 0.73E-3). The 'A' field for both is empty. Below the cards is a summary table with columns for material name, Z, and p. The 'A' column is also empty. Red arrows point from the text above to the 'A' field in the material definition cards and the corresponding columns in the summary table.

Material	Z	p	A
CHROMIUM	24.0	7.18	
AMMONIA	0.0	0.73E-3	

Material definition: MATERIAL

Defines a new **material** or override a previous one

- [SDUM] material name
- [WHAT(1)] atomic number Z
- [WHAT(2)] atomic weight (**leave it empty**)
- [WHAT(3)] density [g/cm³]
- [WHAT(4)] material number (**leave it empty**)
- [WHAT(5)] alternate material to be used for dE/dx (**normally empty**)
- [WHAT(6)] mass number A (**leave it empty unless you want a specific isotope**)

The screenshot shows a software window titled "TITLE ... GEOEND ... 8 cards hidden". It displays two material definitions in a table-like format:

Material Name	Z	Atomic Weight	Density	Material Number	Alternate Material	Mass Number A
CHROMIUM	24.0		7.18			
AMMONIA	0.0		0.73E-3			

Below the table, a command line shows the definition of CHROMIUM: `MATERIAL 24.0 7.18 CHROMIUM`. At the bottom, a status bar indicates "Exe: /home/versaci/fluka_dresden", "Card:19 Displayed:2 Total:28", and a footer shows "basic.inp 52% (35,77) (Fluka)".

Material definition: COMPOUND

Defines a new **compound**

Each **COMPOUND** card must be associated to a **MATERIAL** card

More **COMPOUND** card can be used to define a compound

----- ASSIGNMA ... STOP : 7 cards hidden -----

Card	f1	Element	f2	Element	Material
1	1.0	NITROGEN	3.0	HYDROGEN	AMMONIA

Card	f1	Element	f2	Element	Material
1	1.0	NITROGEN	3.0	HYDROGEN	AMMONIA

Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28

basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND

[SDUM]: compound name

The screenshot displays a software interface for material definition. At the top, a yellow panel shows the 'Name: AMMONIA' field, which is circled in red. Below this, a table lists the compound's composition: 'COMPOUND', '1.0 NITROGEN', '3.0 HYDROGEN', and 'AMMONIA'. The 'AMMONIA' label in the table is also circled in red. At the bottom, a command line shows the material definition: 'COMPOUND 1.0 NITROGEN 3.0 HYDROGEN AMMONIA', with the 'AMMONIA' label circled in red. The interface also shows a status bar with 'Exe: /home/versaci/fluka_dresden', 'Card:21 Displayed:1 Total:28', and 'basic.inp 64% (37,0) (Fluka)'.

Card	1	2	3	4	5	6	7
COMPOUND	1.0	NITROGEN	3.0	HYDROGEN			AMMONIA

```
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
COMPOUND 1.0 NITROGEN 3.0 HYDROGEN AMMONIA
```

Exe: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28

```
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
COMPOUND 1.0 NITROGEN 3.0 HYDROGEN AMMONIA
*
```

basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND

[WHAT(1)]: amount of the first component

Amount definition
in few slides

The screenshot displays a software interface for material definition. The main window shows a compound definition for AMMONIA with the following parameters:

- Name: AMMONIA
- Mix: Atom
- Elements: 1..3
- M1: NITROGEN
- M2: HYDROGEN
- M3: (empty)
- f1: 1.0
- f2: 3.0

Below the definition, there are two tables. The first table, labeled "ASSIGNMA ... STOP : 7 cards hidden", shows the following data:

Component	Value
COMPOUND	1.0
NITROGEN	3.0
HYDROGEN	3.0
AMMONIA	1.0

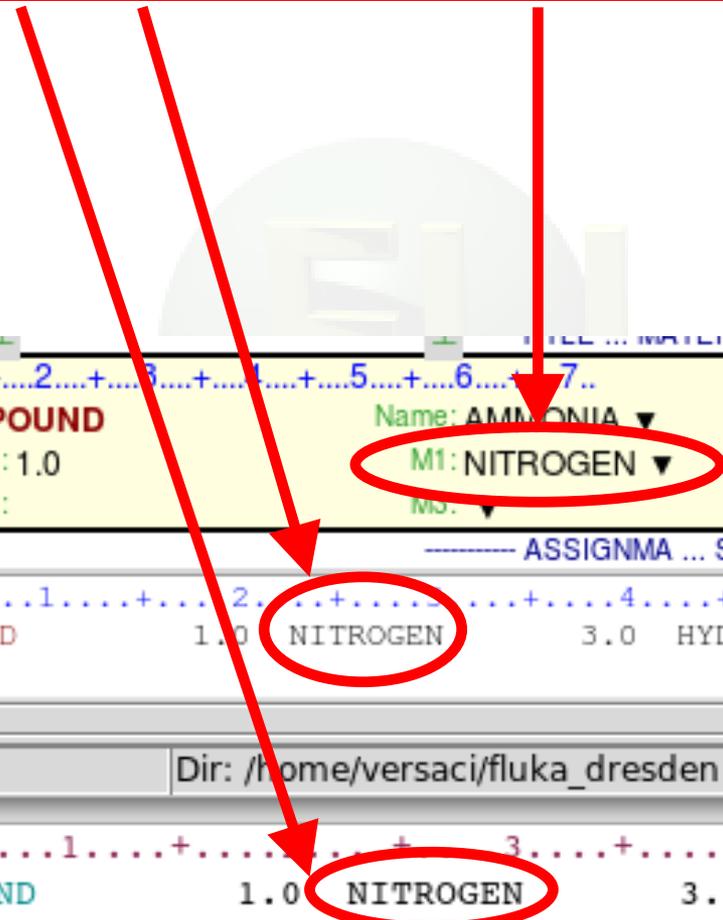
The second table, labeled "COMPOUND", shows the following data:

Component	Value
COMPOUND	1.0
NITROGEN	3.0
HYDROGEN	3.0
AMMONIA	1.0

Red circles and arrows highlight the 'f1: 1.0' value in the compound definition and its corresponding '1.0' values in both tables.

Material definition: COMPOUND

[WHAT(2)]: first component material



----- ASSIGNMA ... STOP : 7 cards hidden -----

COMPUND	1.0	NITROGEN	3.0	HYDROGEN	AMMONIA
---------	-----	----------	-----	----------	---------

Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28

COMPUND	1.0	NITROGEN	3.0	HYDROGEN	AMMONIA
---------	-----	----------	-----	----------	---------

--:--- basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND

[WHAT(3)]: amount of the second component

Amount definition
in few slides

The screenshot displays a software interface for defining a material. The main window shows a yellow panel for 'COMPOUND' with the following fields:

- Name: AMMONIA
- Mix: Atom
- Elements: 1..3
- f1: 1.0
- M1: NITROGEN
- f2: 3.0 (circled in red)
- M2: HYDROGEN
- f3:
- M3:

Below this panel is a table titled 'ASSIGNMA ... STOP : 7 cards hidden' with the following data:

Card	1	2	3	4	5	6	7
COMPOUND	1.0	NITROGEN	3.0 (circled in red)	HYDROGEN			AMMONIA

At the bottom, a status bar shows 'Card:21 Displayed:1 Total:28'. Below that is another table with the following data:

Card	1	2	3	4	5	6	7
COMPOUND	1.0	NITROGEN	3.0 (circled in red)	HYDROGEN			AMMONIA

The bottom status bar shows 'basic.inp 64% (37,0) (Fluka)'. The slide number '51' is in the bottom right corner.

Material definition: COMPOUND

[WHAT(4)]: second component material

The screenshot displays a software interface for material definition. The main window shows the material properties for 'AMMONIA'. The 'Elements' field is set to '1 3', and 'M2: HYDROGEN' is selected. Below this, the 'ASSIGNMA ... STOP : 7 cards hidden' table shows the composition: 1.0 NITROGEN and 3.0 HYDROGEN. The 'COMPOUND' table also shows 1.0 NITROGEN and 3.0 HYDROGEN. The status bar at the bottom indicates 'Card:21 Displayed:1 Total:28' and 'basic.inp 64% (37,0) (Fluka)'. Red arrows and circles highlight the 'M2: HYDROGEN' field, the 'HYDROGEN' entry in the 'ASSIGNMA' table, and the 'HYDROGEN' entry in the 'COMPOUND' table.

Material	1	2	3	4	5	6	7
ASSIGNMA ... STOP : 7 cards hidden		1.0	NITROGEN	3.0	HYDROGEN		AMMONIA
COMPOUND		1.0	NITROGEN	3.0	HYDROGEN		AMMONIA

Material definition: COMPOUND

[WHAT(5)]: amount of the third component

Amount definition
in few slides

The screenshot displays a software interface for material definition. The main window shows a compound named 'AMMONIA' with the following properties:

- Name: AMMONIA
- Mix: Atom
- Elements: 1..3
- f1: 1.0
- M1: NITROGEN
- f2: 3.0
- M2: HYDROGEN
- M3: (empty)

Below this, there is a table labeled 'ASSIGNMA ... STOP : 7 cards hidden'. The table has 7 columns and 1 row. The first row contains the following data:

	1	2	3	4	5	6	7
COMPOUND	1.0	NITROGEN	3.0	HYDROGEN			AMMONIA

At the bottom, there is another table with 7 columns and 1 row. The first row contains the following data:

	1	2	3	4	5	6	7
COMPOUND	1.0	NITROGEN	3.0	HYDROGEN			AMMONIA

Red arrows and circles highlight the following elements:

- The 'f3:' field in the compound definition.
- The empty field in the 'ASSIGNMA' table at column 5.
- The empty field in the main table at column 6.

Material definition: COMPOUND

[WHAT(6)]: third component material

The screenshot displays a software interface for defining a material. The main window shows a yellow panel with the following details:

- COMPOUND** (with a small icon)
- Name:** AMMONIA
- Mix:** Atom
- Elements:** 1..3
- f1:** 1.0
- M1:** NITROGEN
- f2:** 3.0
- M2:** HYDROGEN
- f3:** (empty)
- M3:** (empty)

Below this panel, a table lists the components and their weights. The table has 7 columns and 1 row of data:

	1	2	3	4	5	6	7
COMPOUND	1.0	NITROGEN	3.0	HYDROGEN			AMMONIA

At the bottom, a status bar shows: Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28

Below the status bar, another table is visible, which is a duplicate of the one above:

	1	2	3	4	5	6	7
COMPOUND	1.0	NITROGEN	3.0	HYDROGEN			AMMONIA

Red arrows from the text box point to the following elements in the interface:

- The **M3:** dropdown menu in the yellow panel.
- The **AMMONIA** entry in the 7th column of the first table.
- The **AMMONIA** entry in the 7th column of the second table.

Material definition: COMPOUND

Defines a new **compound**

Each **COMPOUND** card must be associated to a **MATERIAL** card

More **COMPOUND** card can be used to define a compound

- [SDUM] compound name
- [WHAT(1)] amount of the first component
- [WHAT(2)] first component material
- [WHAT(3)] amount of the second component
- [WHAT(4)] second component material
- [WHAT(5)] amount of the third component
- [WHAT(6)] third component material



How to define the "amount"?

COMPONENT CARD DEFINITION:

Parameter	Value
Name	AMMONIA
Mix	Atom
Elements	1..3
f1	1.0
M1	NITROGEN
f2	3.0
M2	HYDROGEN
f3	
M3	

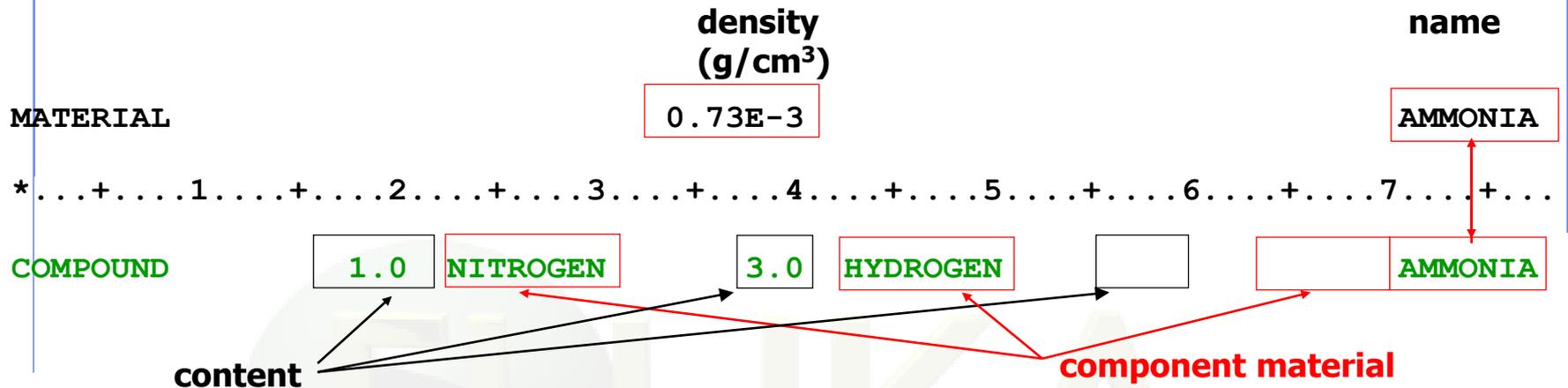
ASSIGNMENT TABLE:

Component	Amount	Material
1.0	NITROGEN	
3.0	HYDROGEN	
		AMMONIA

Interface Status: Exe: /home/versaci/fluka_dresden Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28

File: basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND



- content > 0 component material > 0 ⇒⇒⇒ **ATOM content**
- content < 0 component material > 0 ⇒⇒⇒ **MASS content**
- content < 0 component material < 0 ⇒⇒⇒ **VOLUME content**

Names can be preceded by a minus sign!

Material definition: ASSIGNMA

Assign a material to one (or more) region in the geometry
(for the region definition see the geometry lecture or the manual)

The assigned material could be
either a single element material or a compound



The screenshot shows the FLUKA input file editor interface. The main window displays the following configuration for the ASSIGNMA command:

- Command: **ASSIGNMA**
- Material: **Mat: CHROMIUM**
- Region: **Reg: TARGET1**
- Target Region: **to Reg: TARGET2**
- Decay Material: **Mat(Decay):**
- Step: **Step: 1.0**
- Field: **Field:**

Below the configuration, a list of regions is shown:

Region	Material	Target 1	Target 2	Step
ASSIGNMA	CHROMIUM	TARGET1	TARGET2	1.0

The status bar at the bottom indicates the current file is **basic.inp**, located at **/home/versaci/fluka_dresden**, with **788 (44,50)** lines and **(Fluka)** as the application.

Material definition: ASSIGNMA

[SDUM]: not used

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

ASSIGNMA Mat: CHROMIUM ▼ Reg: TARGET1 ▼ to Reg: TARGET2 ▼
Mat(Decay): ▼ Step: 1.0 Field: ▼

...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...

ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0

Exe: Dir: /home/versaci/fluka_dresden Card:25 Displayed:4 Total:28

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

ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0

-:--- basic.inp 78% (44,50) (Fluka)

Material definition: ASSIGNMA

[WHAT(1)]: material to be assigned

The screenshot displays a software interface for material assignment. The main window shows a command line with the following text: `ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0`. The word `CHROMIUM` is circled in red. Above the command line, a dropdown menu is open, showing `Mat: CHROMIUM` selected, also circled in red. A red arrow points from the text `[WHAT(1): material to be assigned]` to the `CHROMIUM` text in the command line. Another red arrow points from the same text to the `Mat: CHROMIUM` dropdown menu. The interface also shows a status bar at the bottom with the text `basic.inp 78% (44,50) (Fluka)`.

Material definition: ASSIGNMA

[WHAT(2)]: first region to be "filled" with the material

The screenshot displays a software interface for material assignment. The top section shows a parameter list for 'ASSIGNMA' with the following values: Mat: CHROMIUM, Mat(decay):, Reg: TARGET1, to Reg: TARGET2, and Step: 1.0. Below this is a table with the following data:

Material Name	Material	Region 1	Region 2	Fraction
ASSIGNMA	CHROMIUM	TARGET1	TARGET2	1.0

The bottom section shows the execution path: Exe: /home/versaci/fluka_dresden, Card:25, Displayed:4, Total:28. The table below this shows the material assignment for 'ASSIGNMA' with the same parameters as the table above.

Material Name	Material	Region 1	Region 2	Fraction
ASSIGNMA	CHROMIUM	TARGET1	TARGET2	1.0

At the bottom, the file path is shown as basic.inp, with coordinates 788 (44,50) and the source (Fluka).

Material definition: ASSIGNMA

[WHAT(3)]: last region to be "filled" with the material

The screenshot displays a software interface for material assignment. The top section shows a configuration bar with the following fields: **ASSIGNMA**, **Mat: CHROMIUM**, **Reg: TARGET1**, **to Reg: TARGET2**, **Mat(Decay):**, and **Step: 1.0**. The **to Reg: TARGET2** field is circled in red. Below this is a table with columns for material name, material, region, and step. The row for **ASSIGNMA** shows **CHROMIUM**, **TARGET1**, **TARGET2**, and **1.0**. The **TARGET2** cell is circled in red. At the bottom, a status bar shows **Exe:**, **Dir: /home/versaci/fluka_dresden**, **Card:25**, **Displayed:4**, and **Total:28**. Below the status bar is a table with columns for material name, material, region, and step. The row for **ASSIGNMA** shows **CHROMIUM**, **TARGET1**, **TARGET2**, and **1.0**. The **TARGET2** cell is circled in red. At the bottom left, the file **basic.inp** is shown with coordinates **788 (44,50)** and the name **(Fluka)**.

Material definition: ASSIGNMA

[WHAT(4)]: step to span region-to-be-filled range

The screenshot displays a software interface for material definition. The top panel shows a GUI with the following fields: **ASSIGNMA**, **Mat: CHROMIUM**, **Mat(Decay):**, **Reg: TARGET1**, **to Reg: TARGET2**, and **Field:**. The **Step: 1.0** field is circled in red. Below the GUI, a command line shows the parameters: `ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0`, with the `1.0` value circled in red. At the bottom, a status bar shows `Exe: Dir: /home/versaci/fluka_dresden Card:25 Displayed:4 Total:28` and a command line with `ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0`, where the `1.0` value is also circled in red. The bottom status bar includes `basic.inp 78% (44,50) (Fluka)`.

Material definition: ASSIGNMA

[WHAT(5)]: activate magnetic field in the concerned regions

The screenshot displays the FLUKA material definition interface. The main window shows the configuration for the ASSIGNMA card. The material is set to CHROMIUM, and the region is TARGET1. The field is set to 'to Reg. TARGET2'. The step is 1.0. The interface is annotated with red arrows and circles highlighting key elements:

- A red arrow points to the 'Field:' dropdown menu, which is circled in red.
- A red arrow points to the 'Step: 1.0' field, which is circled in red.
- A red arrow points to the 'to Reg. TARGET2' dropdown menu, which is circled in red.

The bottom status bar shows the file name 'basic.inp', the percentage of completion '78%', and the coordinates '(44,50)'. The total number of cards is 28, with 4 displayed and 25 remaining.

Material definition: ASSIGNMA

[WHAT(6)]: assign another material for radioactive decay products transport

As of now, only **BLCKHOLE** and **VACUUM** supported

The screenshot shows the FLUKA interface with the following elements:

- Header:** ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..*
- Material Definition:** ASSIGNMA, Mat: CHROMIUM, Reg: TARGET1, to Reg: TARGET2, Step: 1.0, Field: ▾. The **Mat(Decay):** dropdown is circled in red.
- Table:** A table with columns 1-7. The value '1.0' is in column 5. Column 7 is circled in red.
- Status Bar:** Exe: Dir: /home/versaci/fluka_dresden Card:25 Displayed:4 Total:28
- Footer:** -:--- basic.inp 78% (44,50) (Fluka)

A basic input: step 5: Random Seed, START, and STOP

```

TITL
My B
* Se
DEFA
* Define the beam characteristics
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
BEAM      3.5 -0.082425   -1.7   0.0   0.0   PROTON
* Define the beam position
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
BEAMPOS   0.0   0.0   -0.1   0.0   0.0
*
GEOBEGIN                                     COMBNAME
0 0
* Black body
SPH blkbody 0.0 0.0 0.0 100000.0
* Void sphere
SPH void 0.0 0.0 0.0 10000.0
* Cylindrical target
RCC target1 0.0 0.0 0.0 0.0 0.0 10.0 5.0
RCC target2 0.0 0.0 20.0 0.0 0.0 10.0 5.0
RCC target3 0.0 0.0 40.0 0.0 0.0 10.0 5.0
END
* Black hole
BLKBODY 5 +blkbody -void
* Void around
VOID 5 +void -target1 -target2 -target3
* Target
TARGET1 5 +target1
TARGET2 5 +target2
TARGET3 5 +target3
END
GEOEND
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
MATERIAL 24.0 7.18 CHROMIUM
MATERIAL 0.0 0.73E-3 AMMONIA
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
COMPOUND 1.0 NITROGEN 3.0 HYDROGEN AMMONIA
*
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
ASSIGNMA BLCKHOLE BLKBODY
ASSIGNMA VACUUM VOID
ASSIGNMA AMMONIA TARGET3
*
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..*
ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0
*
* Set the random number seed
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
RANDOMIZ 1.0 54217137.
*
* Set the number of primary histories to be simulated in the run
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7..
START 1000.
STOP

```

BEAMPOS	x: 0.0	y: 0.0	z: -0.1
	cosy: 0.0	cosy: 0.0	Type: POSITIVE
GEOBEGIN	Log: v	Acc: v	Opt: v
	Inp: v	Out: v	Fmt: COMBNAME
SPH blkbody	x: 0.0	y: 0.0	z: 0.0
	R: 100000.0		
SPH void	x: 0.0	y: 0.0	z: 0.0
	R: 10000.0		
RCC target1	x: 0.0	y: 0.0	z: 0.0
	Hx: 0.0	Hy: 0.0	Hz: 10.0
	R: 5.0		
RCC target2	x: 0.0	y: 0.0	z: 20.0
	Hx: 0.0	Hy: 0.0	Hz: 10.0
	R: 5.0		
RCC target3	x: 0.0	y: 0.0	z: 40.0
	Hx: 0.0	Hy: 0.0	Hz: 10.0
	R: 5.0		
END			
REGION BLKBODY		Neigh: 5	Volume:
expr: +blkbody -void			
REGION VOID		Neigh: 5	Volume:
expr: +void -target1 -target2 -target3			
REGION TARGET1		Neigh: 5	Volume:
expr: +target1			
REGION TARGET2		Neigh: 5	Volume:
expr: +target2			
REGION TARGET3		Neigh: 5	Volume:
expr: +target3			
END			
GEOEND			
MATERIAL	Name: CHROMIUM	#	p: 7.18
Z: 24.0	Am:	A:	dE/dx: v
MATERIAL	Name: AMMONIA	#	p: 0.73E-3
Z: 0.0	Am:	A:	dE/dx: v
COMPOUND	Name: AMMONIA	Mix: Atom	Elements: 1,3
f1: 1.0	M1: NITROGEN	f2: 3.0	M2: HYDROGEN
f3:	M3: v		
ASSIGNMA	Mat: BLCKHOLE	Reg: BLKBODY	to Reg: v
	Mat(Decay): v	Step:	Field: v
ASSIGNMA	Mat: VACUUM	Reg: VOID	to Reg: v
	Mat(Decay): v	Step:	Field: v
ASSIGNMA	Mat: AMMONIA	Reg: TARGET3	to Reg: v
	Mat(Decay): v	Step:	Field: v
ASSIGNMA	Mat: CHROMIUM	Reg: TARGET1	to Reg: TARGET2
	Mat(Decay): v	Step: 1.0	Field: v
RANDOMIZ	Unit: 01	Seed: 54217137.	
START	No.: 1000.	Core: v	
	Time:	Report: default	
STOP			

Random seed initialization: RANDOMIZ

[SDUM]: not used
[WHAT(3-6)]: not used

Set the random number seed
RANDOMIZ Unit01 Seed: 54217137

```
*...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...  
RANDOMIZ      1.0 54217137.
```

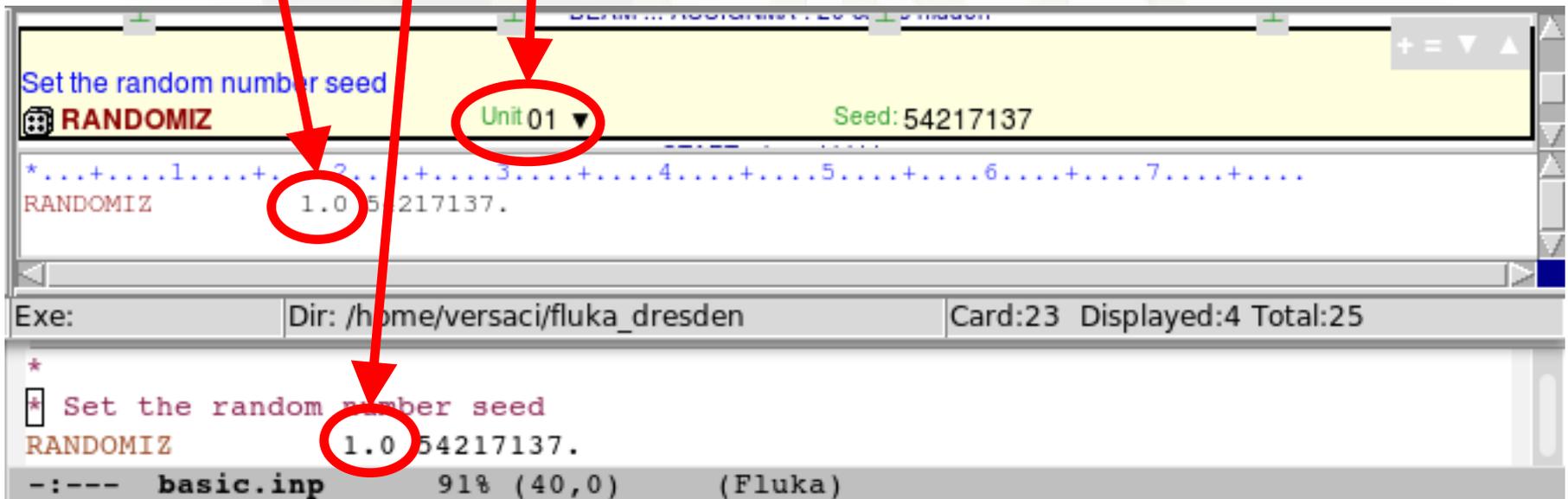
Exe: Dir: /home/versaci/fluka_dresden Card:23 Displayed:4 Total:25

```
*  
* Set the random number seed  
RANDOMIZ      1.0 54217137. X X X X X  
-:--- basic.inp      91% (40,0)      (Fluka)
```

Random seed initialization: RANDOMIZ

[WHAT(1)]: logical file unit where to read the seed

Do not touch! MUST be Unit 1



```
Set the random number seed
RANDOMIZ                               Unit 01 ▼                               Seed: 54217137
*...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
RANDOMIZ                                1.0 54217137.

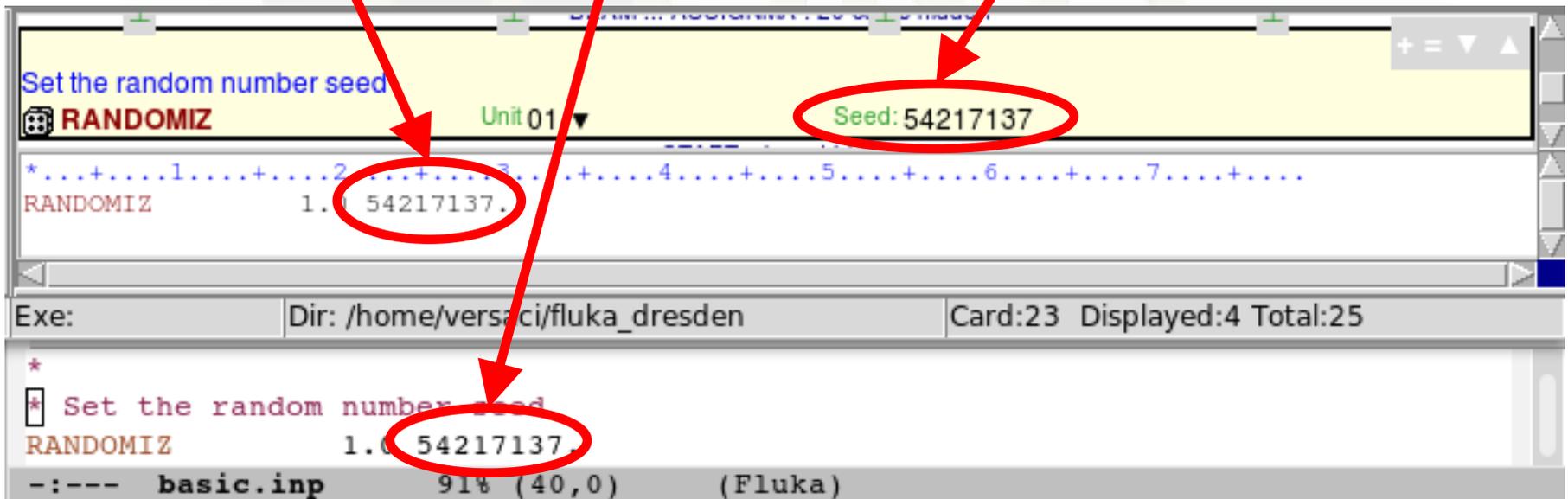
Exe:                                     Dir: /home/versaci/fluka_dresden          Card:23  Displayed:4  Total:25

*
* Set the random number seed
RANDOMIZ                                1.0 54217137.
-:--- basic.inp                          91% (40,0)          (Fluka)
```

Random seed initialization: RANDOMIZ

[WHAT(2)]: initialization of the random seed sequences

Different WHAT(2) lead to different sequences
allowing to run parallel jobs



The screenshot shows a text editor window with a yellow header bar. The header bar contains the text "Set the random number seed" and "RANDOMIZ" in red. Below the header bar, the text "Unit01" is visible. The main content of the editor shows a line of code: "RANDOMIZ 1.0 54217137.". The number "54217137." is circled in red. Below the editor window, there is a status bar with the text "Exe: Dir: /home/versaci/fluka_dresden Card:23 Displayed:4 Total:25". At the bottom of the image, there is a line of text: "* Set the random number seed RANDOMIZ 1.0 54217137." with "54217137." circled in red. The bottom of the image shows a line of text: "--:--- basic.inp 91% (40,0) (Fluka)".

Starting the simulation: **START**

[WHAT(1)]: number of primaries to be simulated

Set the number of primary histories to be simulated in the run

START No.: 1000. Core: ▼ Report: default ▼

*1.....2.....3.....4.....5.....6.....7.....

START 1000.

Exe: Dir: /home/versaci/fluka_dresden Card:24 Displayed:3 Total:25

* Set the number of primary histories to be simulated in the run

START 1000.

STOP

--- basic.inp Bot (44,0) (Fluka)

Stopping the program: STOP

[SDUM] & [WHAT(1-6)]: not used

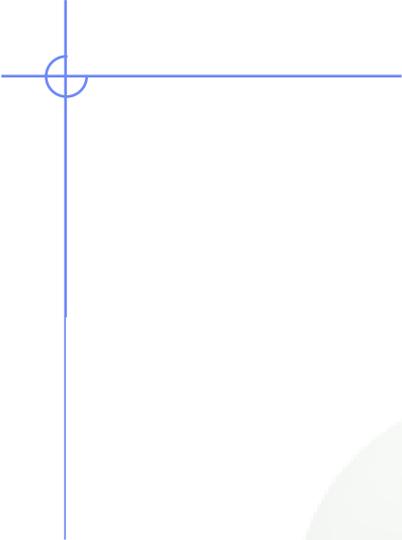
Inserted **before START** stops input reading and de-activates all following cards
No particle transport is performed, useful for geometry debugging
After START, its presence is optional and has no effect



```
* STOP
* .....1.....2.....3.....4.....5.....6.....7.....
STOP
* Set the number of primary histories to be simulated in the run
START      1000.
STOP
```

Exe: Dir: /home/versaci/fluka_dresden Card:25 Displayed:4 Total:25

basic.inp Bot (43,0) (Fluka)



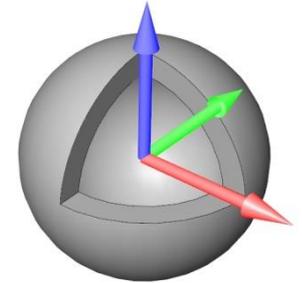
Beyond a basic input

Special sources: 3D distributions

BEAMPOS card allows the user to define some 3D *spatial* distributions of source particles

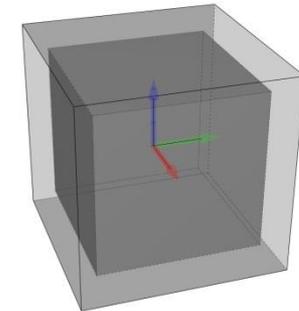
SDUM = SPHE-VOL:

defines a spatially extended source in a **spherical shell**



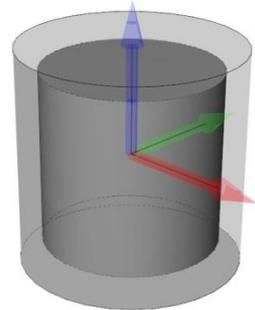
SDUM = CART-VOL:

defines a spatially extended source in a **Cartesian shell** with the sides parallel to the beam frame axes



SDUM = CYLI-VOL:

defines a spatially extended source in a **cylindrical shell** with the height parallel to the z-axis of the beam frame



SDUM = FLOOD:

defines a source distribution on a **spherical surface**, such as to produce a uniform and isotropic fluence within the sphere

Special sources: SPECSOUR

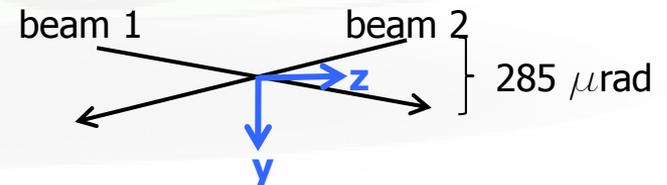
FLUKA allows the definitions of special sources for:

- two colliding beams
- galactic cosmic rays
- solar particles events

Various SDUM allow plenty of opportunities:

PPSOURCE, CROSSASY, CROSSSYM; GCR-IONF, GCR-SPEC, GCR-ALLF;
SPE-SPEC, SPE-2003, SPE-2005

Example: LHC proton-proton collision
7 TeV/c, full crossing angle of 285 mrad in yz-plane



For all these special cases of source distributions,
please, **refer to the FLUKA manual!**

FLUKA Preprocessor

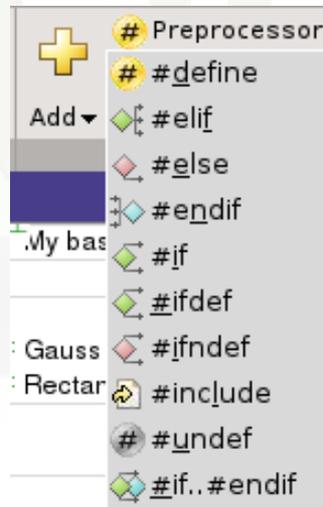
- FLUKA supports preprocessing instructions like those used in C or C++
- This useful feature allows to keep different setups and configurations in a single input file, selecting the desired one when starting a run
- FLAIR supports this feature and allows to run different configurations in an easy way
- The `#include` directive can ease the handling of large input files

Conditional directives:

```
#define VARIABLE1  
#undef VARIABLE2  
#if VARIABLE1  
#elif VARIABLE2  
#else  
#endif
```

Include directive:

```
#include /home/geometries/target2.geom
```



Up to **10 nested** levels of conditional statements (`#if/#else/#endif`) are supported

FLUKA Preprocessor example

```

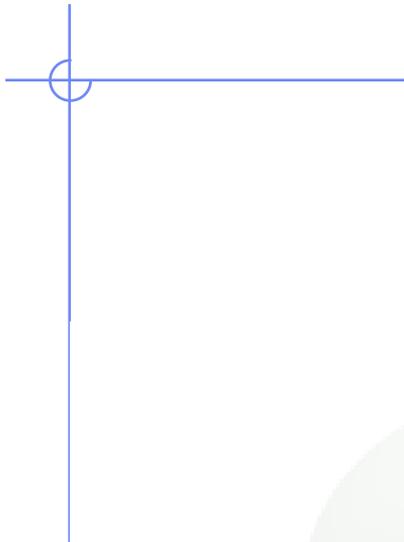
#define DUMP_COPPER
*#define DUMP_CARBON
*
#if DUMP_COPPER
* Select copper as material for the dump
*...+....1....+....2....+....3....+....4....+....5....+....6
ASSIGNMA      COPPER  BEAMDUMP
#elif DUMP_CARBON
* Select carbon as material for the dump
ASSIGNMA      CARBON  BEAMDUMP
#else
* Use default material for the dump
ASSIGNMA      IRON    BEAMDUMP
#endif

```

#define can be either commented out or undefined
e.g.: **#undef DUMP_COPPER**

Depending on the active define (**DUMP_COPPER** or **DUMP_CARBON**) different **ASSIGNMA** card are used

#	#define	DUMP_COPPER	:				
#	#define	DUMP_CARBON	:				
◇	#if	DUMP_COPPER	▼				
		Select copper as material for the dump					
	ASSIGNMA	Mat: COPPER	▼	Reg: ▼	to Reg: BEAMDUMP	▼	
		Mat(Decay): ▼		Step: ▼	Field: ▼		
◇	#elif	DUMP_CARBON	▼				
		Select carbon as material for the dump					
	ASSIGNMA	Mat: CARBON	▼	Reg: ▼	to Reg: BEAMDUMP	▼	
		Mat(Decay): ▼		Step: ▼	Field: ▼		
◇	#else						
		Use default material for the dump					
	ASSIGNMA	Mat: IRON	▼	Reg: ▼	to Reg: BEAMDUMP	▼	
		Mat(Decay): ▼		Step: ▼	Field: ▼		
◇	#endif						



Spare

More Physics settings

Input card **PHYSICS**

Allows to override standard FLUKA defaults for some processes:

- activates **coalescence** (critical for calculation of residual nuclei)
- activates the **new fragmentation model** ("evaporation" of fragments up to $A=24$, critical for calculation of residual nuclei)
- activates **PEANUT** above 5 GeV
- activates **electromagnetic dissociation** of heavy ions
- activates **charmed particle transport**

Input card **PHOTONUC**

- activates **photo-nuclear interactions**
- activates **muon pair production by photons**

The use of the **LAM-BIAS** card (see Biasing lecture) coupled to the **PHOTONUC** card is recommended, in order to artificially *increase* the probability to have photonuclear reactions

Transport thresholds

Input card **PART-THR**

- Defines transport cut-offs for **hadrons, muons, and neutrinos**
- Setting done **by particle type**, overriding the selected **DEFAULTS**
- For **neutrons**, a <20.0 MeV cut-off is internally translated into the corresponding group energy; **On a region basis**, the neutron cut-off can be *increased* by the **LOW-BIAS** card (see Neutrons lecture)
- Charged particles (but electrons) are **not stopped, but ranged out** to rest in an approximate way (if the threshold is < 100 MeV)

Input card **EMFCUT**

For electron, positron, and photon, sets:

- Energy thresholds for **production** in the **selected materials**
- **Transport** cut-offs in the **selected regions**.
- Use **STRONGLY** recommended

Input card **DELTARAY**

- Activates delta ray production by muons and charged hadrons
- Sets energy threshold for their production

Low energy neutrons ($E < 20.0$ MeV)

FLUKA transports neutrons with energies lower than 20 MeV by means of a multi-group algorithm, based on 260 groups (See Neutrons lecture)

Input card **LOW-NEUT**

- Activates low-energy neutron transport
(by default off only in EM-CASCA)
- Requests **point-wise cross sections**
(only available for a few elements, see manual)

Input card **LOW-MAT**

- Sets the correspondence between FLUKA materials and low-energy neutron cross-sections
- By default, the link is between the FLUKA material and the first material of the same name present in the library. Therefore, the option is **not needed in many cases**

Heavy ions: beams and transport

Input card **HI-PROPE**

- When **BEAM**'s SDUM is **ISOTOPE**...
 - ...specifies the isotope of a radioactive source
 - ...requires a **RADDECAY** card
- When **BEAM**'s SDUM is **HEAVYION**...
 - ...specifies the properties of an ion beam:
 - in the **BEAM** card, the beam energy is given in GeV/nmu
(**nuclear mass unit**, i.e. 1/12 of the ^{12}C nucleus mass)
 - ^2H , ^3H , ^3He , and ^4He beams have dedicated SDUM in the **BEAM** card

Heavy ions: beams and transport

Input card **IONTRANS**

- Is not required when using an heavy ion beam **HEAVYION**
- Activates the ions transport
- Allows to limit it to a subset of light ions ($A < 5$)
- Switches between approximate and full transport
...(including nuclear interactions)
- Nucleus-nucleus interactions above 125 MeV/n
...can be performed **only if** the event generators
DPMJET and RQMD are linked to the FLUKA executable
- Below 125 MeV/n...
...the **BME** event generator is **already linked** in the standard executable

Materials special cards

Input card **MAT-PROP**

Allows to provide extra information about materials

(e.g.: gas pressure, effective density, average ionization potential)

Input card **CORRFAC**

Allows to change material density for dE/dx and nuclear processes
on a region-by-region basis

(used in connection with voxel geometries derived from a CT scan)

Induced radioactivity

Input card **RADDECAY**

- Activates the simulation of the decay of generated radioactive nuclides
- Allows to set biasing for radioactive decay products

Input card **IRRPROFI**

- Defines an irradiation profile (i.e. irradiation time and intensity)

Input card **DCYTIMES**

- Defines the decay (cooling) time

Input card **DCYSCORE**

- Associates scoring detectors (radio-nuclides, fluence, dose) with different cooling times

