



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 (Fast Light Accelerator Input and Runtime) software interface. The left sidebar shows a tree view of the input file structure, including sections like General, Title, Defaults, Randomize, Stop, Primary, Beam, Beampos, Start, Geometry, Geobegin, Bodies, Region, Geoend, Media, Material, Compound, Assignmat, Physics, Transport, Biasing, Scoring, Flair, and Preprocessor.

The main window shows the input file content, which is a text-based configuration for a proton beam simulation. The file is titled "my basic input example" and is saved as "MyBasicInputExample.inp".

The input file content is as follows:

```
TITLE my basic input example
PRECISIO
BEAM Beam: Momentum 3.5 Part: PROTON
    Ap: Gauss 0.082425 Delta: 1.7
    Shape(X): Rectangular Delta: 0.0 Shape(Y): Rectangular Delta: 0.0
    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: 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 Z: 24 Name: CHROMIUM # p: 7.18
    Am: A: dEdx:
MATERIAL Z: Name: AMMONIA # p: 0.73E-3
    Am: A: dEdx:
COMPOUND Name: AMMONIA M1: NITROGEN M2: HYDROGEN
    f1: 1.0 M3: M12: 3.0
ASSIGNMA Mat: BLKCHOLE 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 Cov:
    Time: Report: default
STOP
+...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
START 1000.
```

The bottom status bar indicates the input file is "MyBasicInputExample.inp" and shows "Card:28 Total:29".



A basic input card by card

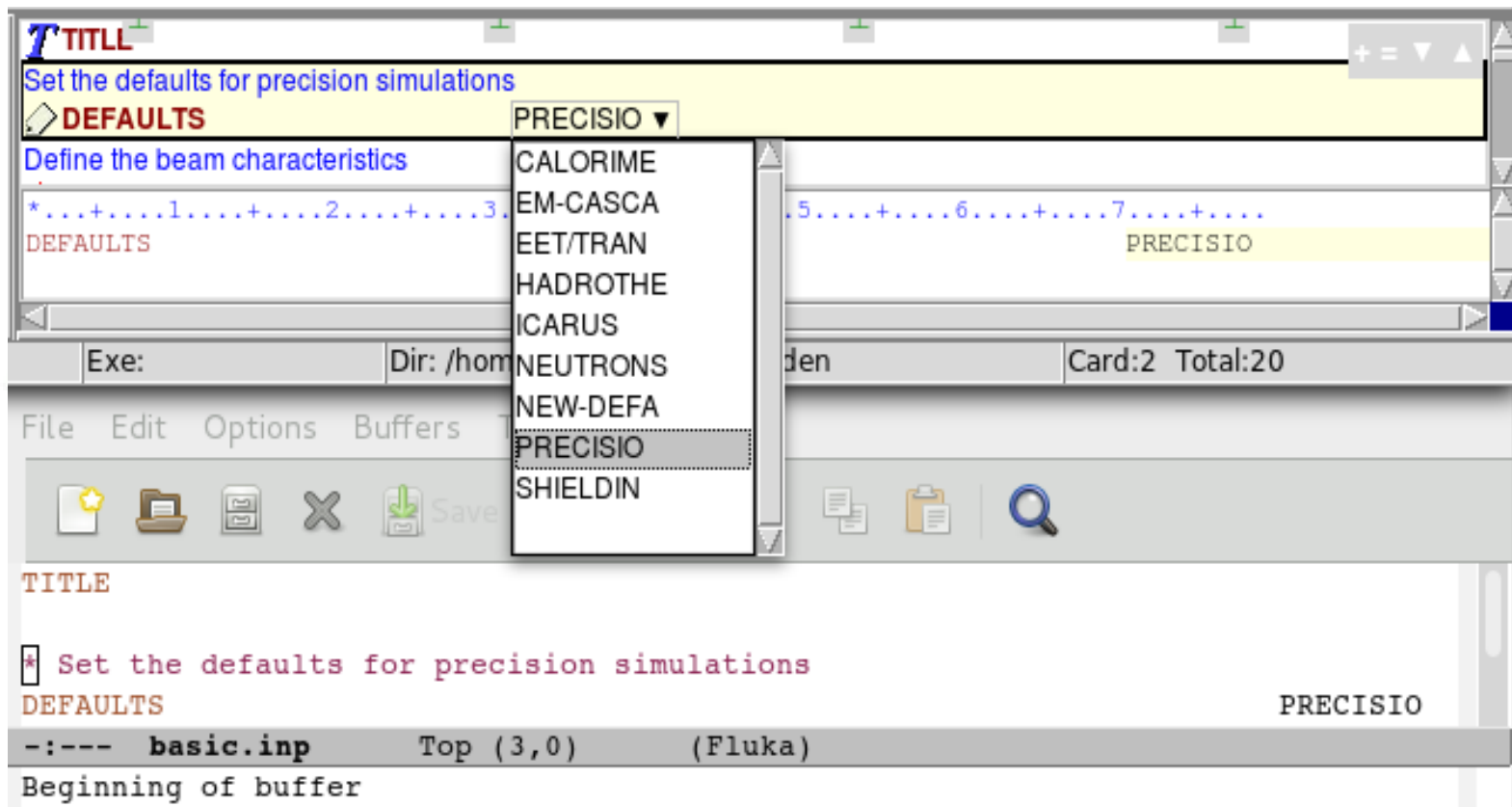
A basic input: step 1: Physics settings

```
TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS
PRECISIO
* Define the beam and targets
* ..+...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
```

```
TITLE My Basic Input example
> DEFAULTS PRECISIO
* BEAM Beam Momentum p: 3.5 Beam Proton
Delta: Gauss Delta(FWHM): 0.082425 Delta: Gauss Delta: 1.7
Shape(X): Rectangular Delta: 0.0 Shape(Y): Rectangular Delta: 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
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
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: Report: default
STOP
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
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   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 BLKHOLES 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
```

TITLE My Basic Input example			
DEFAULTS		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: Inp: Out:	Acc: 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	Hy: 0.0	Hx: 10.0
	R: 5.0		
RCC target2	x: 0.0	y: 0.0	z: 20.0
	Hx: 0.0	Hy: 0.0	Hx: 10.0
	R: 5.0		
RCC target3	x: 0.0	y: 0.0	z: 40.0
	Hx: 0.0	Hy: 0.0	Hx: 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: ▼			
ASSIGNMA	Mat: BLKHOLES	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			
*1.....2.....3.....4.....5.....6.....7.....			
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 shows a software window titled "BEAMPOS" with a yellow header bar. The header bar contains the text "Define the beam characteristics" and a red star icon. Below the header, the parameters for the beam are defined:

- 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

Below the parameters, the text "Define the beam position" is visible. The main area of the window displays the following parameters:

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

At the bottom of the window, there is a status bar with the following information:

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

The bottom of the window shows a command line interface with the following text:

```
* .....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: BEAM

[SDUM]: Proton beam

The screenshot displays the BEAMPOS window in FLUKA, used for defining beam characteristics and position. The window is divided into several sections:

- Define the beam characteristics:** This section contains parameters for the beam. The **BEAM** section is highlighted in yellow. Parameters include:
 - Beam: Momentum p : 3.5
 - Δp (FWHM): 0.082425
 - $\Delta \phi$: Gauss
 - Shape(X): Rectangular
 - Δx : 0.0
 - Shape(Y): Rectangular
 - Δy : 0.0
 - Part: PROTON (circled in red)
 - $\Delta \phi$: 1.7
- Define the beam position:** This section contains parameters for the beam position. The **BEAMPOS** section is highlighted in white. Parameters include:
 - x: cosx:
 - y: cosy:
 - z: Type: POSITIVE
- Data Table:** A table showing the beam parameters. The **PROTON** entry is circled in red.
- Command Line:** The command line shows the **BEAM** command with parameters. The **PROTON** entry is circled in red.

The status bar at the bottom indicates the file **basic.inp** is open, 22% (9,1) of the file is loaded, and the window title is **(FLUKA)**. The text **Wrote /home/rversaci/basic.inp** is also visible.

Beam definition: BEAM

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

The screenshot displays the FLUKA input editor interface. The top section, titled "Define the beam characteristics", contains the **BEAM** card. The "Beam: Momentum" field is set to 3.5, which is circled in red. Other parameters include "Part: PROTON", "Shape(X): Rectangular", "Shape(Y): Rectangular", and "Type: POSITIVE". Below this, the "Define the beam position" section contains the **BEAMPOS** card. The input deck at the bottom shows the corresponding text-based representation of these cards. The value 3.5 in the BEAM card is also circled in red. The status bar at the bottom indicates the file "basic.inp" is 22% complete (9,1) and was written to "/home/rversaci/basic.inp".

Define the beam characteristics

BEAM

Δp: Gauss ▼

Shape(X): Rectangular ▼

Beam: Momentum ▼ p: 3.5

Δp(FWHM): 0.082425 Δφ: Gauss ▼

Δx: 0.0 Shape(Y): Rectangular ▼

Part: PROTON ▼

Δφ: 1.7

Δy: 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 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 PROTON

* Define the beam position

BEAMPOS

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

Wrote /home/rversaci/basic.inp

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 interface is divided into several sections:

- Define the beam characteristics:** This section contains the **BEAM** card. The **Δp(FWHM): 0.082425** value is circled in red, with a red arrow pointing to it from the title bar. Other parameters shown include **Beam: Momentum** (p: 3.5), **Part: PROTON**, **Δφ: Gauss** (Δφ: 1.7), **Shape(X): Rectangular** (Δx: 0.0), and **Shape(Y): Rectangular** (Δy: 0.0).
- Define the beam position:** This section contains the **BEAMPOS** card. It shows parameters for **x**, **cosx**, **y**, **cosy**, **z**, and **Type: POSITIVE**.
- Input Deck:** The bottom section shows the input deck with the **BEAM** card highlighted. The value **-0.082425** is circled in red, with a red arrow pointing to it from the title bar. The input deck also shows the **BEAMPOS** card and the **Define the beam position** command.

The status bar at the bottom indicates the file **basic.inp** is open at 22% (9,1) in the **FLUKA** environment, and it shows the command **Wrote /home/rversaci/basic.inp**.

Beam definition: BEAM

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

The screenshot displays the FLUKA GUI for defining beam characteristics. The 'Define the beam characteristics' section shows the following parameters:

- Beam: Momentum Δp : Gauss $\Delta p(\text{FWHM})$: 0.082425 Δx : 0.0
- Shape(X): Rectangular
- $\Delta\phi$: Gauss $\Delta\phi$: 1.7
- Shape(Y): Rectangular Δy : 0.0
- Rad: PROTON
- Type: POSITIVE

The 'Define the beam position' section shows the following parameters:

- x: 3.5
- y: -0.082425
- z: -1.7
- cosx: 0.0
- cosy: 0.0
- cosz: 0.0

The 'BEAM' card is shown in the command window, with the value -1.7 circled in red. The 'BEAMPOS' card is also shown, with the value -1.7 circled in red. The status bar at the bottom indicates the file 'basic.inp' is open, 22% (9,1) of the file is loaded, and the program is FLUKA. The status bar also shows 'Wrote /home/rversaci/basic.inp'.

Beam definition: BEAM

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

The screenshot shows the BEAMPOS interface with the following sections:

- Define the beam characteristics:** Contains parameters for the beam. A red circle highlights 'Shape(X): Rectangular' and 'Δx: 0.0'. A red arrow points from the title bar to this section.
- Define the beam position:** Contains parameters for the beam position. A red arrow points from the title bar to this section.
- Table:** A table with 7 columns and 1 row. The values are: 3.5, -0.082425, -1.7, 0.0, 0.0, and PROTON. A red circle highlights the '0.0' value in the 4th column. A red arrow points from the title bar to this value.
- Footer:** Shows the file name 'basic.inp', the percentage '22% (9,1)', and the program name '(FLUKA)'. It also shows the path '/home/rversaci/basic.inp'.

The interface includes a menu bar (File, Edit, Options, Buffers, Tools, Help) and a toolbar with icons for file operations (Save, Undo, Cut, Copy, Paste, Find).

Beam definition: BEAM

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

The screenshot displays the BEAMPOS interface for defining beam characteristics and position. The top section, 'Define the beam characteristics', shows parameters for a proton beam: Momentum (p: 3.5), Part (PROTON), Shape(X): Rectangular, Shape(Y): Rectangular, and Delta y (Δy): 0.0. The bottom section, 'Define the beam position', shows the beam position parameters: x: 3.5, y: -0.082425, z: -1.7, and Type: POSITIVE. The BEAMPOS table at the bottom shows the beam parameters in a tabular format, with the '0.0' value in the WHAT(5) column circled in red. The status bar at the bottom indicates the file 'basic.inp' is open at 22% (9,1) in the FLUKA environment.

Beam	Momentum	Part	Shape(X)	Shape(Y)	Δy	Δx	Δφ	Δp	x	y	z	Type
BEAM	3.5	PROTON	Rectangular	Rectangular	0.0	0.0	1.7	Gauss	3.5	-0.082425	-1.7	POSITIVE

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 PROTON

* Define the beam position
BEAMPOS

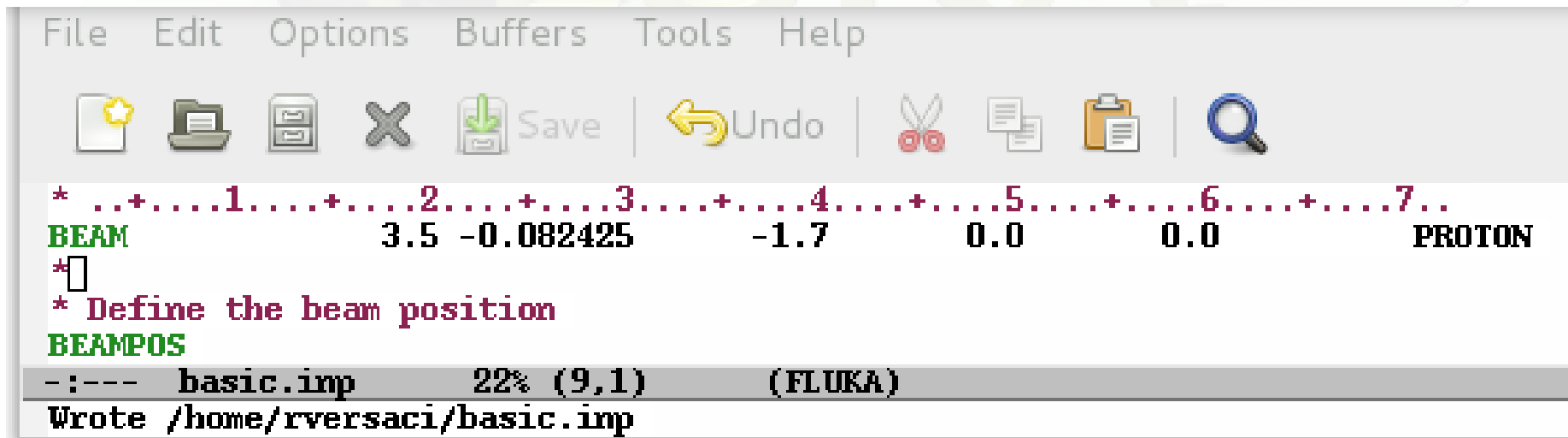
-- basic.inp 22% (9,1) (FLUKA)
Wrote /home/rversaci/basic.inp

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 input file 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**

Define the beam characteristics

BEAM

Δp : Gauss ▼ Beam: Momentum ▼ p: 3.5 Part: PROTON ▼
 $\Delta p(\text{FWHM})$: 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

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: Dir: /home/rversaci Card:4 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	PROTON

Define the beam position

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

basic.inp 20% (11,1) (FLUKA)

Beam definition: BEAMPOS

[SDUM]: beam direction along Z

By default toward positive Z

The screenshot shows the BEAMPOS beam definition window. Red arrows point from the text '[SDUM]: beam direction along Z' to three specific elements: the 'Type: POSITIVE' dropdown menu, the 'SDUM' parameter field in the parameter list, and the 'SDUM' parameter in the command line. The 'Type: POSITIVE' dropdown is circled in red. The 'SDUM' parameter field in the parameter list is also circled in red. The 'SDUM' parameter in the command line is circled in red.

Define the beam characteristics

BEAM

Δp : Gauss $\Delta p(\text{FWHM})$: 0.082425 p : 3.5 Part: PROTON $\Delta\phi$: Gauss $\Delta\phi$: 1.7 Δy : 0.0

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

Define the beam position

BEAMPOS

x : 0.0 y : 0.0 z : -0.1 $\cos x$: 0.0 $\cos y$: 0.0 **Type: POSITIVE**

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

Save Undo

* ... 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 shows the FLUKA input editor interface. The top section, 'Define the beam characteristics', contains parameters for the beam: **BEAM**, Δp : Gauss, Shape(X): Rectangular, Beam Momentum: 3.5, $\Delta p(\text{FWHM})$: 0.082425, $\Delta\phi$: Gauss, Shape(Y): Rectangular, Part: PROTON, $\Delta\phi$: 1.7, and Δy : 0.0. The middle section, 'Define the beam position', contains parameters for the beam position: **BEAMPOS**, x: 0.0, cosx: 0.0, y: 0.0, cosy: 0.0, z: -0.1, and Type: POSITIVE. The bottom section shows the input card definition: **BEAMPOS** 0.0 0.0 -0.1 0.0 0.0. Red arrows point from the text '[WHAT(1)]: X coordinate of the beam spot center' to the 'x: 0.0' parameter in the 'Define the beam position' section and to the '0.0' value in the 'BEAMPOS' card definition. The bottom status bar shows 'basic.inp', '20% (11,1)', and '(FLUKA)'.

Define the beam characteristics

BEAM

Δp : Gauss
Shape(X): Rectangular

Beam Momentum
 $\Delta p(\text{FWHM})$: 0.082425
 Δ : 0.0

p : 3.5
 $\Delta\phi$: Gauss
Shape(Y): Rectangular

Part: PROTON
 $\Delta\phi$: 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

* ...+...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

* ...+...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.inp 20% (11,1) (FLUKA)

Beam definition: BEAMPOS

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

The screenshot displays the BEAMPOS beam definition interface. It is divided into two main sections: "Define the beam characteristics" and "Define the beam position".

Define the beam characteristics:

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

Define the beam position:

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

Below the input fields is a summary table with 7 columns. The first column is labeled "BEAMPOS". The values in the subsequent columns are 0.0, 0.0, -0.1, 0.0, 0.0, 0.0, and 0.0. The second "0.0" is circled in red.

At the bottom, there is a menu bar (File, Edit, Options, Buffers, Tools, Help) and a toolbar with icons for Save, Undo, Cut, Copy, and Find. Below the toolbar is another summary table with 7 columns. The first column is labeled "BEAM". The values in the subsequent columns are 3.5, -0.082425, -1.7, 0.0, 0.0, 0.0, and PROTON. The third column value (-0.082425) is circled in red.

At the very bottom, there is a status bar showing "basic.inp", "20% (11,1)", and "(FLUKA)".

Beam definition: BEAMPOS

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

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

Define the beam characteristics:

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

Define the beam position:

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

Below the input fields, a summary table shows the values for the BEAMPOS card:

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

The bottom section of the window shows the output of the BEAMPOS card, with the Z coordinate value of -0.1 circled in red:

```
* .....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
*
```

The status bar at the bottom indicates the file is "basic.imp", the zoom is "20% (11,1)", and the version is "(FLUKA)".

Beam definition: BEAMPOS

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

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

Define the beam characteristics:

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

Define the beam position:

- x : 0.0
- y : 0.0
- z : -0.1
- $\cos x$: 0.0
- $\cos y$: 0.0
- Type: POSITIVE

The bottom section shows the input and output of the BEAMPOS card. The input is:

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

The output is:

```
* .....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 arrows and circles highlight the WHAT(4) parameter (cosx) in the input and output. The first arrow points to the "cosx: 0.0" field in the "Define the beam position" section. The second arrow points to the "0.0" value in the input line. The third arrow points to the "0.0" value in the output line.

File Edit Options Buffers Tools Help

Save Undo

basic.imp 20% (11,1) (FLUKA)

Beam definition: BEAMPOS

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

The screenshot shows the BEAMPOS beam definition interface. The top section, 'Define the beam characteristics', includes fields for Beam: Momentum (p: 3.5), Beam: Momentum (Δp(FWHM): 0.082425), Beam: Momentum (Δx: 0.0), Shape(X): Rectangular, Shape(Y): Rectangular, Part: PROTON, Δφ: Gauss (Δφ: 1.7), and Δy: 0.0. The bottom section, 'Define the beam position', includes fields for x: 0.0, cosx: 0.0, y: 0.0, cosy: 0.0, z: -0.1, and Type: POSITIVE. A red arrow points from the text '[WHAT(5)]: direction cosine with respect to the Y axis' to the 'cosy: 0.0' field. Another red arrow points from the same text to the '0.0' value in the 'cosy' column of the table below. A third red arrow points from the text to the '0.0' value in the 'cosy' column of the table below. The table below the interface shows the beam parameters for the BEAMPOS beam. The table has 7 columns and 2 rows. The first row is labeled 'BEAM' and the second row is labeled 'BEAMPOS'. The values in the first row are 3.5, -0.082425, -1.7, 0.0, 0.0, 0.0, and PROTON. The values in the second row are 0.0, 0.0, -0.1, 0.0, 0.0, 0.0, and 0.0. The '0.0' value in the fifth column of the second row is circled in red.

	1	2	3	4	5	6	7
BEAM	3.5	-0.082425	-1.7	0.0	0.0	0.0	PROTON
BEAMPOS	0.0	0.0	-0.1	0.0	0.0	0.0	0.0

File Edit Options Buffers Tools Help

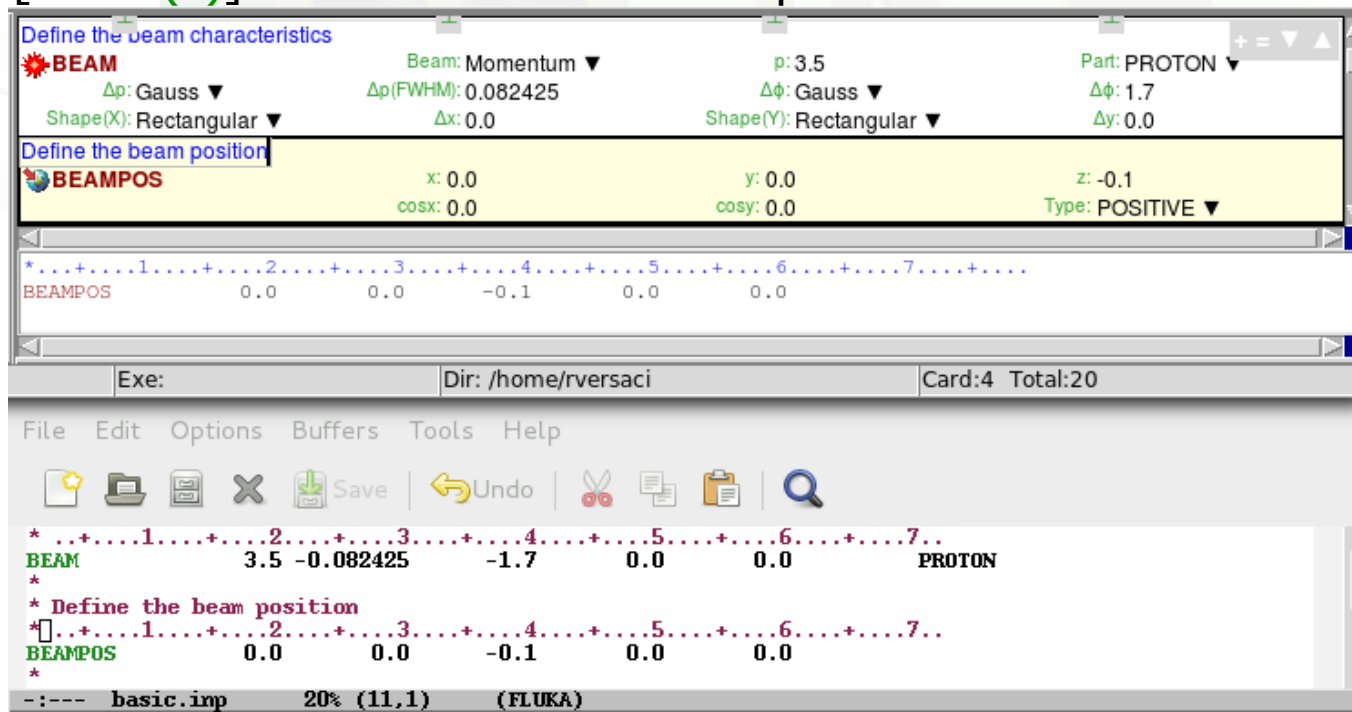
Save Undo

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



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

DEFAULTS		PRECISIO	
BEAM	Beam: Momentum	p: 3.5	Part: PROTON
Δp: Gauss	Δp(FWHM): 0.082425	Δφ: Gauss	Δφ: 1.7
Shape(X): Rectangular	Ax: 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: Out:	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	Hy: 0.0	Hx: 10.0
	R: 5.0		
RCC target2	x: 0.0	y: 0.0	z: 20.0
	Hx: 0.0	Hy: 0.0	Hx: 10.0
	R: 5.0		
RCC target3	x: 0.0	y: 0.0	z: 40.0
	Hx: 0.0	Hy: 0.0	Hx: 10.0
	R: 5.0		
END			
REGION BLKBODY	expr: +blkbody -void	Neigh: 5	Volume:
REGION VOID	expr: +void -target1 -target2 -target3	Neigh: 5	Volume:
REGION TARGET1	expr: +target1	Neigh: 5	Volume:
REGION TARGET2	expr: +target2	Neigh: 5	Volume:
REGION TARGET3	expr: +target3	Neigh: 5	Volume:
END			
GEOEND			
MATERIAL	Name: CHROMIUM	#	p: 7.18
	Z: 24.0	A:	dE/dx:
MATERIAL	Name: AMMONIA	#	p: 0.73E-3
	Z: 14.0	A:	dE/dx:
		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	

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

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```

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

```

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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

----- TITLE ... GEOEND ... 8 cards hidden -----

1	2	3	4	5	6	7
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 ... STOP ... 8 cards hidden -----

1	2	3	4	5	6	7
MATERIAL	24.0	7.18			CHROMIUM	

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

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

--- 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 the FLUKA input file editor with two material definitions. The first material is named 'CHROMIUM' with atomic number Z=24.0 and density p=7.18. The second material is named 'AMMONIA' with atomic number Z=0.0 and density p=0.73E-3. The input file is titled 'GEOEND'. The status bar at the bottom shows 'Exe: /home/versaci/fluka_dresden', 'Card:19 Displayed:2 Total:28', and 'basic.inp 52% (35,77) (Fluka)'.

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

Material definition: MATERIAL

[WHAT(1)]: atomic number Z

The screenshot displays the FLUKA input editor interface. At the top, a title bar reads "TITLE ... GEOEND ... 8 cards hidden". Below this, two material definition cards are visible:

- MATERIAL** (Card 1): Name: CHROMIUM, #, p: 7.18, dE/dx: ▼. The value **Z: 24.0** is circled in red.
- MATERIAL** (Card 2): Name: AMMONIA, #, p: 0.73E-3, dE/dx: ▼. The value **Z: 0.0** is circled in red.

Below the cards, a table shows the material properties for each material:

	1	2	3	4	5	6	7
MATERIAL	24.0	7.18					CHROMIUM

At the bottom, a status bar shows the execution directory: `Dir: /home/versaci/fluka_dresden`, and the card count: `Card:19 Displayed:2 Total:28`.

Below the status bar, another table shows the material properties for each material:

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

At the very bottom, the input file name and status are shown: `-- 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 the FLUKA input file editor with two material definitions. The top table shows the input data, and the bottom table shows the summary output. Red arrows indicate the mapping from the [WHAT(2)] label to the atomic weight fields.

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

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

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

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

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 the FLUKA input file editor with the following content:

```
TITLE ... GEOEND ... 8 cards hidden
```

...	1	2	3	4	5	6	7
MATERIAL							
Z: 24.0							
Name: CHROMIUM							
Am:							
A:							
p: 7.18							
dE/dx:							

...	1	2	3	4	5	6	7
MATERIAL							
Z: 0.0							
Name: AMMONIA							
Am:							
A:							
p: 0.73E-3							
dE/dx:							


```
COMPOUND STOP: 8 cards hidden
```

...	1	2	3	4	5	6	7
MATERIAL							
24.0							
7.18							
CHROMIUM							

...	1	2	3	4	5	6	7
MATERIAL							
24.0							
7.18							
CHROMIUM							

...	1	2	3	4	5	6	7
MATERIAL							
0.0							
0.73E-3							
AMMONIA							

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

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

Material definition: MATERIAL

[WHAT(4)]: material number

Available for backward compatibility:
leave it empty

The screenshot displays the FLUKA input deck editor with two material definitions. Red arrows point from the [WHAT(4)] label to the material number fields in the input deck, which are circled in red.

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

The input deck shows the following material definitions:

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

Material definition: MATERIAL

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

normally empty

The screenshot shows the FLUKA input file editor with the following content:

```
----- TITLE ... GEOEND ... 8 cards hidden -----
+...1...+...2...+...3...+...4...+...5...+...6...+...7...
MATERIAL      Name: CHROMIUM      #
Z: 24.0        Am:                A:                n: 7.18
MATERIAL      Name: AMMONIA      #
Z: 0.0         Am:                A:                n: 0.73E-3
COMPOUND      STOP: 8 cards hidden

*...+...1...+...2...+...3...+...4...+...5...+...6...+...7...
MATERIAL      24.0                7.18                CHROMIUM

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

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

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

Red arrows indicate the following fields:

- From the red box: **[WHAT(5)]: alternate material to be used for dE/dx** points to the empty field in the table below the material definitions.
- From the red text: **normally empty** points to the empty field in the table below the material definitions.
- From the red box: **[WHAT(5)]: alternate material to be used for dE/dx** points to the empty field in the table below the material definitions.
- From the red box: **[WHAT(5)]: alternate material to be used for dE/dx** points to the empty field in the table below the material definitions.

Material definition: MATERIAL

[WHAT(6)]: mass number A

normally empty
unless a specific isotope is desired

The screenshot displays the FLUKA input file editor with two material cards. The first card is for CHROMIUM (Z: 24.0, Name: CHROMIUM, Am:) and the second is for AMMONIA (Z: 0.0, Name: AMMONIA, Am:). The 'A' field is highlighted with a red circle. Below the cards, the output columns are shown, with the 'A' column highlighted by a red circle. The status bar at the bottom indicates the file is basic.inp, 52% (35,77) (Fluka).

Card	Name	Z	Am	p	dE/dx
1	CHROMIUM	24.0		7.18	
2	AMMONIA	0.0		0.73E-3	

Output columns: MATERIAL, 24.0, 7.18, CHROMIUM, MATERIAL, 0.0, 0.73E-3, AMMONIA

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 the FLUKA input file editor with the following content:

```

----- TITLE ... GEOEND ... 8 cards hidden -----
+...1...+...2...+...3...+...4...+...5...+...6...+...7..
● 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 ... STOP ... 8 cards hidden -----
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...
MATERIAL      24.0      7.18      CHROMIUM
MATERIAL      0.0      0.73E-3      AMMONIA

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

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

The screenshot displays the FLUKA input editor interface. The main window shows a list of cards, with the 'COMPOUND' card selected. The card details are as follows:

Card	Name	Mix	Elements
COMPOUND	AMMONIA	Atom	1..3

The card parameters are:

- f1: 1.0
- M1: NITROGEN
- f2: 3.0
- M2: HYDROGEN
- f3:
- M3:

Below the card details, a summary table is shown:

Card	1.0	NITROGEN	3.0	HYDROGEN	AMMONIA
COMPOUND					

The status bar at the bottom indicates: Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28

The command line at the bottom shows: -:--- basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND

[SDUM]: compound name

The screenshot displays the FLUKA material definition interface. The top panel shows the **COMPOUND** card with the following fields:

- Name:** AMMONIA (circled in red)
- Mix:** Atom
- Elements:** 1..3
- M1:** NITROGEN
- M2:** HYDROGEN
- M3:** (empty)

Below the card, the input file entry is shown:

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

The bottom panel shows the input file entry in a different format:

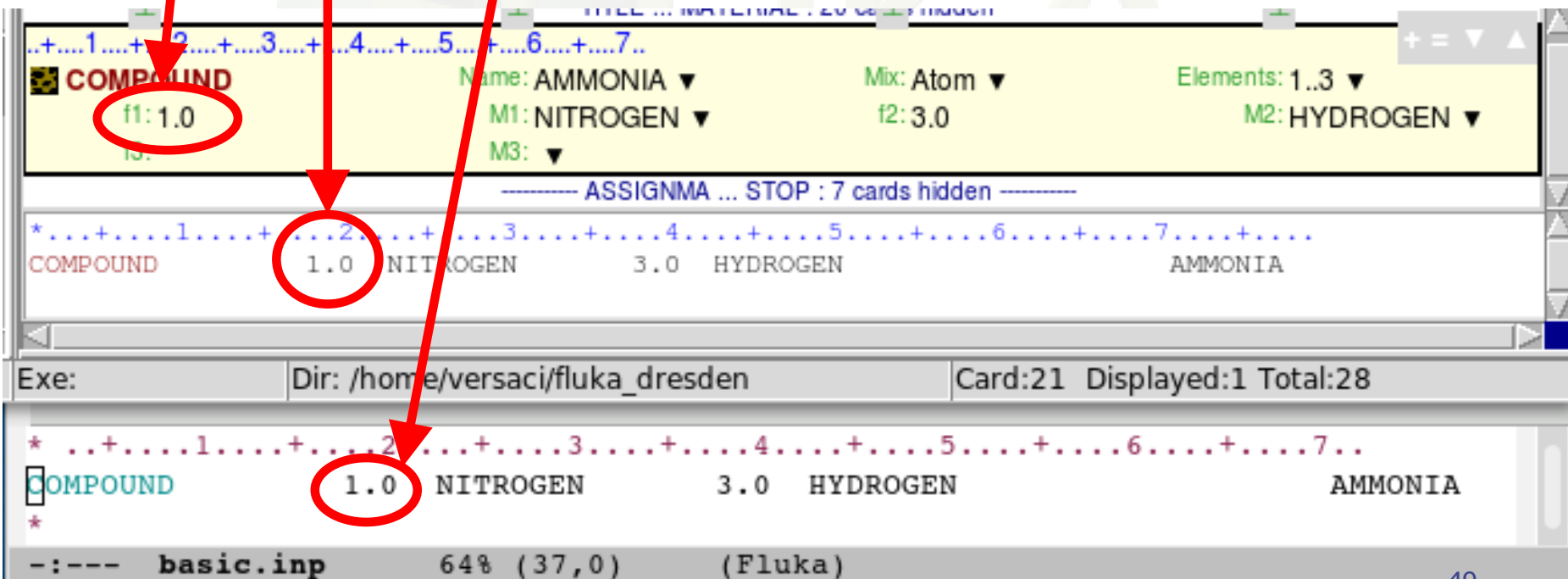
```
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
COMPOUND      1.0  NITROGEN      3.0  HYDROGEN      AMMONIA
*
```

Red arrows point from the text **[SDUM]: compound name** to the **Name: AMMONIA** field in the top panel and to the **AMMONIA** field in both the middle and bottom panels.

Material definition: COMPOUND

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

Amount definition
in few slides



The screenshot displays the FLUKA input deck editor with the following components:

- GUI Panel (Yellow Background):**
 - COMPUND** (Material Type)
 - Name:** AMMONIA
 - Mix:** Atom
 - Elements:** 1..3
 - f1:** 1.0 (Circled in red, with a red arrow pointing to the text box above)
 - M1:** NITROGEN
 - f2:** 3.0
 - M2:** HYDROGEN
 - M3:** (Empty)
- Input Deck (Text Area):**
 - Header: `----- ASSIGNMA ... STOP : 7 cards hidden -----`
 - Card 1: `* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...`
 - Card 2: `COMPOUND`
 - Card 3: `1.0` (Circled in red, with a red arrow pointing to the GUI's f1 field)
 - Card 4: `NITROGEN`
 - Card 5: `3.0`
 - Card 6: `HYDROGEN`
 - Card 7: `AMMONIA`
- Status Bar:**
 - Exe: /home/versaci/fluka_dresden
 - Dir: /home/versaci/fluka_dresden
 - Card:21 Displayed:1 Total:28
- Bottom Panel (Basic Input):**
 - Header: `* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...`
 - Card 1: `COMPOUND`
 - Card 2: `1.0` (Circled in red, with a red arrow pointing to the GUI's f1 field)
 - Card 3: `NITROGEN`
 - Card 4: `3.0`
 - Card 5: `HYDROGEN`
 - Card 6: `AMMONIA`
 - Card 7: `*`
- Footer:**
 - `--:--- basic.inp 64% (37,0) (Fluka)`

Material definition: COMPOUND

[WHAT(2)]: first component material

The screenshot displays the FLUKA input deck editor with the following sections:

- COMPONENT DEFINITION:** A yellow-highlighted section where a material is defined. It includes:
 - COMPONENT** (Material icon)
 - Name:** AMMONIA
 - Mix:** Atom
 - Elements:** 1..3
 - f1:** 1.0
 - f2:** 3.0
 - M1:** NITROGEN (circled in red)
 - M2:** HYDROGEN
- ASSIGNMA ... STOP : 7 cards hidden**
- COMPONENT DATA:** A table showing the composition of the material. The first row is circled in red.

	1	2	3	4	5	6	7
COMPONENT	1.0	NITROGEN	3.0	HYDROGEN			AMMONIA
- Execution Information:** Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28
- Input Deck Preview:** A preview of the input deck showing the material definition card, with the first row circled in red.

```
* ..+...1...+...2...+...3...+...4...+...5...+...6...+...7...
[COMPONENT] 1.0 NITROGEN 3.0 HYDROGEN AMMONIA
*
```
- Status Bar:** -:- basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND

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

Amount definition
in few slides

The screenshot displays the FLUKA material definition interface. The top panel shows the **COMPOUND** card with the following fields:

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

Below the card, a table lists the components and their amounts. The value 3.0 for the second component (HYDROGEN) is circled in red. A red arrow points from the **[WHAT(3)]** text to this value.

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

The bottom panel shows the same table with the value 3.0 circled in red. A red arrow points from the **[WHAT(3)]** text to this value.

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

COMPOUND 1.0 NITROGEN 3.0 HYDROGEN AMMONIA

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

Material definition: COMPOUND

[WHAT(4)]: second component material

The screenshot displays the FLUKA input editor interface. The top panel shows the definition of a compound material named 'AMMONIA' (M1: NITROGEN, M2: HYDROGEN). The bottom panel shows the 'ASSIGNMA' card and the 'COMPOUND' card, both defining the material composition. Red arrows highlight the 'M2: HYDROGEN' definition and its corresponding entries in the cards.

Compound Definition:

Field	Value
Name	AMMONIA
M1	NITROGEN
M2	HYDROGEN

ASSIGNMA Card:

Card	1.0	2.0	3.0	4.0	5.0	6.0	7.0
ASSIGNMA	1.0	NITROGEN	3.0	HYDROGEN			AMMONIA

COMPOUND Card:

Card	1.0	2.0	3.0	4.0	5.0	6.0	7.0
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 top section shows a 'COMPOUND' card with the following fields:

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

Below the 'COMPOUND' card is an 'ASSIGNMA ... STOP : 7 cards hidden' section. It contains a table with 7 columns and 1 row:

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

The 5th and 6th columns of this table are circled in red. Below this is another table with 7 columns and 1 row:

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

The 5th and 6th columns of this table are also circled in red. The bottom status bar shows 'Exe: /home/versaci/fluka_dresden', 'Card:21 Displayed:1 Total:28', and 'basic.inp 64% (37,0) (Fluka)'.

Material definition: COMPOUND

[WHAT(6)]: third component material

The screenshot displays the FLUKA input deck editor with the following content:

COMPONENT DEFINITION:

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

ASSIGNMA ... STOP : 7 cards hidden

COMPONENT LIST:

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

Output Summary:

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

COMPONENT LIST (Output):

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

Footer:

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

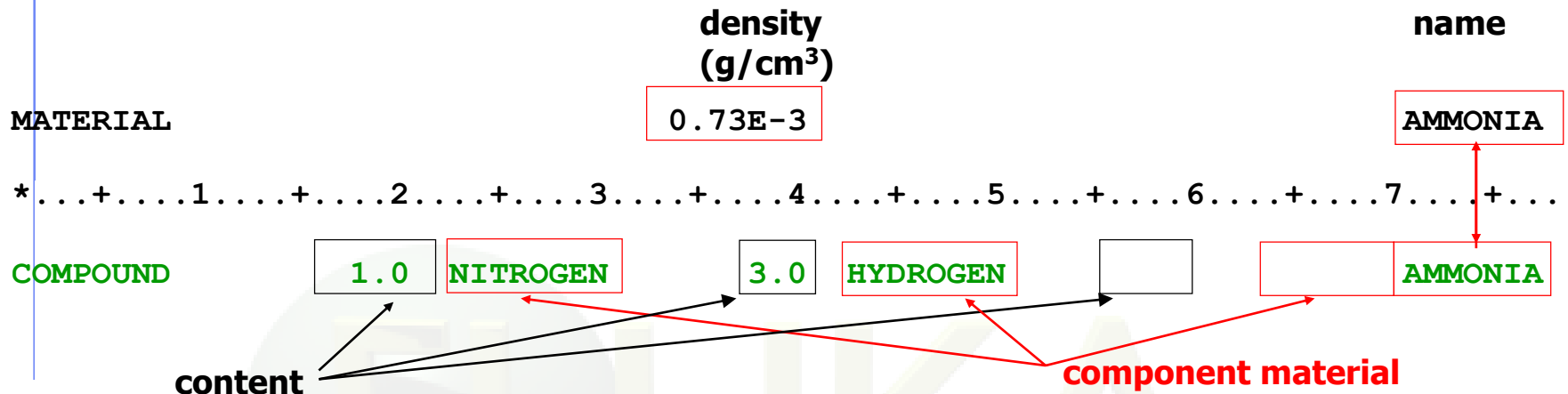
- [**SDUM**] compound name
- [**WHAT(1)**] amount of the first component
- [**WHAT(2)**] first component material
- [**WHAT(3)**] amount of the second component
- [**WHAT(4)**] second component material
- [**WHAT(5)**] amount of the third component
- [**WHAT(6)**] third component material



How to define
the "amount"?

The screenshot shows the FLUKA input card editor. The top section displays the **COMPOUND** card configuration for **AMMONIA**. The card is divided into three columns: **Name**, **Mix**, and **Elements**. The **Name** column shows **AMMONIA** with a dropdown arrow. The **Mix** column shows **Atom** with a dropdown arrow. The **Elements** column shows **1..3** with a dropdown arrow. Below these, the **f1**, **f2**, and **f3** fields are shown. **f1** is set to **1.0**, **f2** is set to **3.0**, and **f3** is empty. The **M1**, **M2**, and **M3** fields are also shown. **M1** is set to **NITROGEN**, **M2** is set to **HYDROGEN**, and **M3** is empty. The bottom section shows the **ASSIGNMA ... STOP : 7 cards hidden** message. Below this, the **COMPOUND** card is displayed in a table format with columns for **1.0**, **NITROGEN**, **3.0**, **HYDROGEN**, and **AMMONIA**. The bottom status bar shows **Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28**. The bottom left corner shows **basic.inp** and **64% (37,0) (Fluka)**.

Material definition: COMPOUND



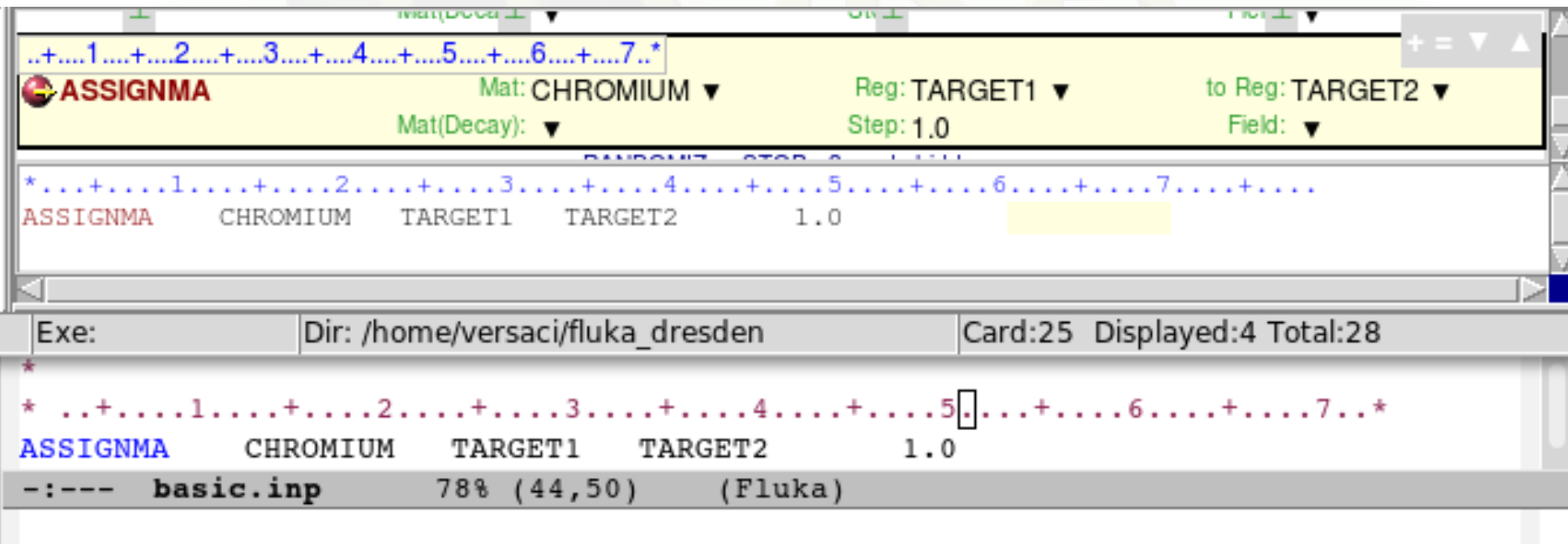
content > 0	component material > 0	⇒	ATOM content
content < 0	component material > 0	⇒	MASS content
content < 0	component material < 0	⇒	VOLUME content

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



Material definition: ASSIGNMA

[SDUM]: not used

The screenshot displays the FLUKA input editor interface. The main window shows the definition of the **ASSIGNMA** card. The card parameters are: **Mat: CHROMIUM**, **Reg: TARGET1**, **to Reg: TARGET2**, **Step: 1.0**, and **Field:**. A red box labeled **[SDUM]: not used** has two red arrows pointing to the **SDUM** field in the card definition and the input line. The input line shows **ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0** with a red 'X' over the **SDUM** field. The status bar at the bottom shows **basic.inp 78% (44,50) (Fluka)**.

Field	Value
Mat	CHROMIUM
Reg	TARGET1
to Reg	TARGET2
Step	1.0
Field	

Input line: **ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0**

Status bar: **basic.inp 78% (44,50) (Fluka)**

Material definition: ASSIGNMA

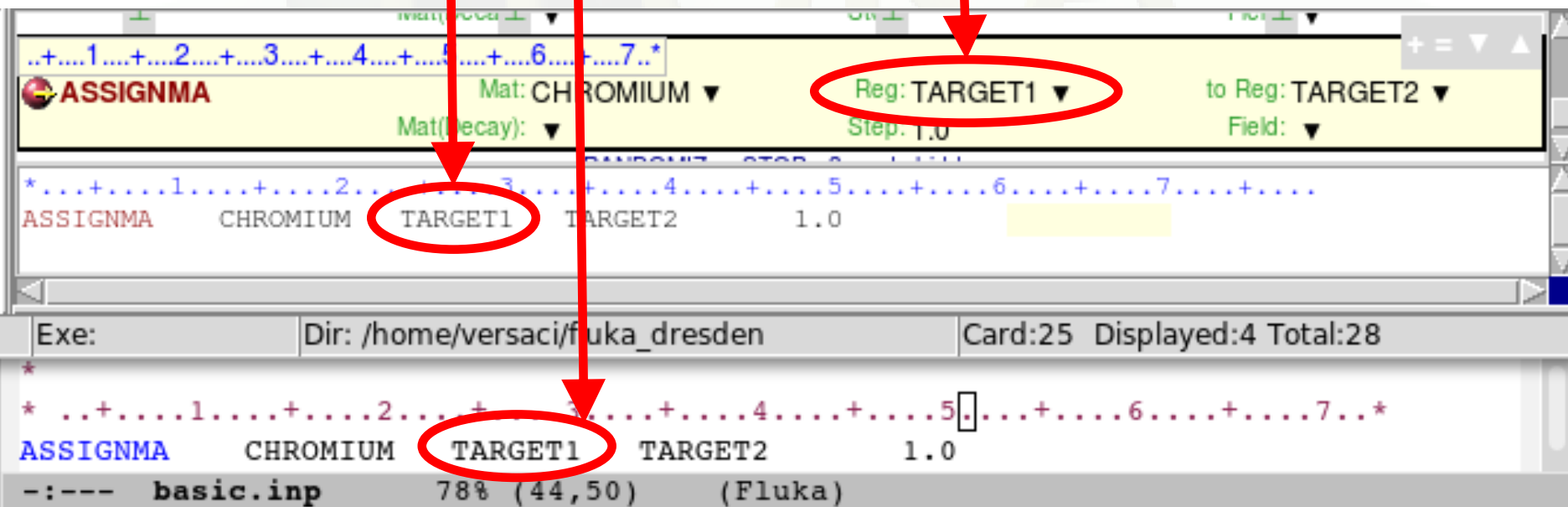
[WHAT(1)]: material to be assigned

The screenshot displays the FLUKA interface with the following components:

- Header Bar:** Shows progress indicators for various components: `mat[Decay]`, `SW 1`, and `Flu 1`.
- ASSIGNMA Card Configuration:**
 - Mat:** CHROMIUM (circled in red)
 - Reg:** TARGET1
 - to Reg:** TARGET2
 - Step:** 1.0
 - Field:** (dropdown menu)
- Command Line:** `ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0` (The word `CHROMIUM` is circled in red).
- Input File:** `basic.inp` (The word `CHROMIUM` is circled in red).
- Status Bar:** `78% (44,50) (Fluka)`

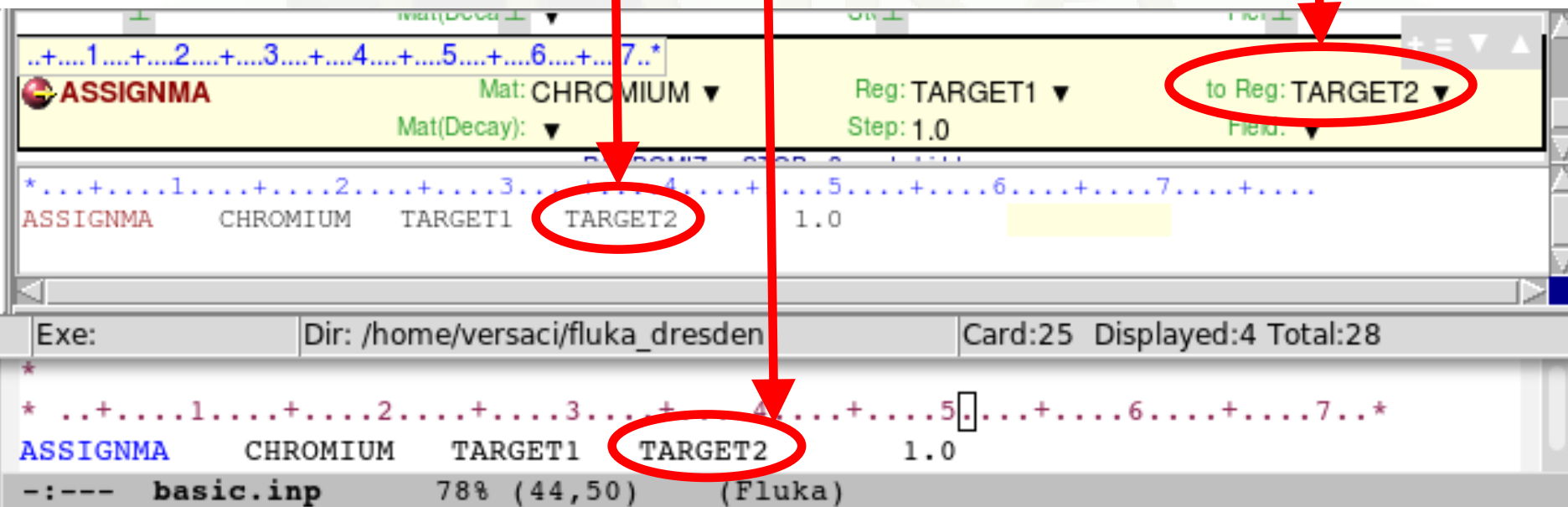
Material definition: ASSIGNMA

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



Material definition: ASSIGNMA

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



Material definition: ASSIGNMA

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

The screenshot displays the FLUKA material definition interface. A red box at the top contains the text "[WHAT(4)]: step to span region-to-be-filled range". Three red arrows point from this box to specific elements in the interface:

- The first arrow points to the "Step: 1.0" field in the "Region" section of the ASSIGNMA card.
- The second arrow points to the "1.0" value in the "WHAT(4)" column of the material definition table.
- The third arrow points to the "1.0" value in the "WHAT(4)" column of the material definition table in the bottom panel.

The interface shows the following material definition table:

Region	Material	Target 1	Target 2	WHAT(4)
1	CHROMIUM	TARGET1	TARGET2	1.0

The bottom panel shows the material definition table with the following entries:

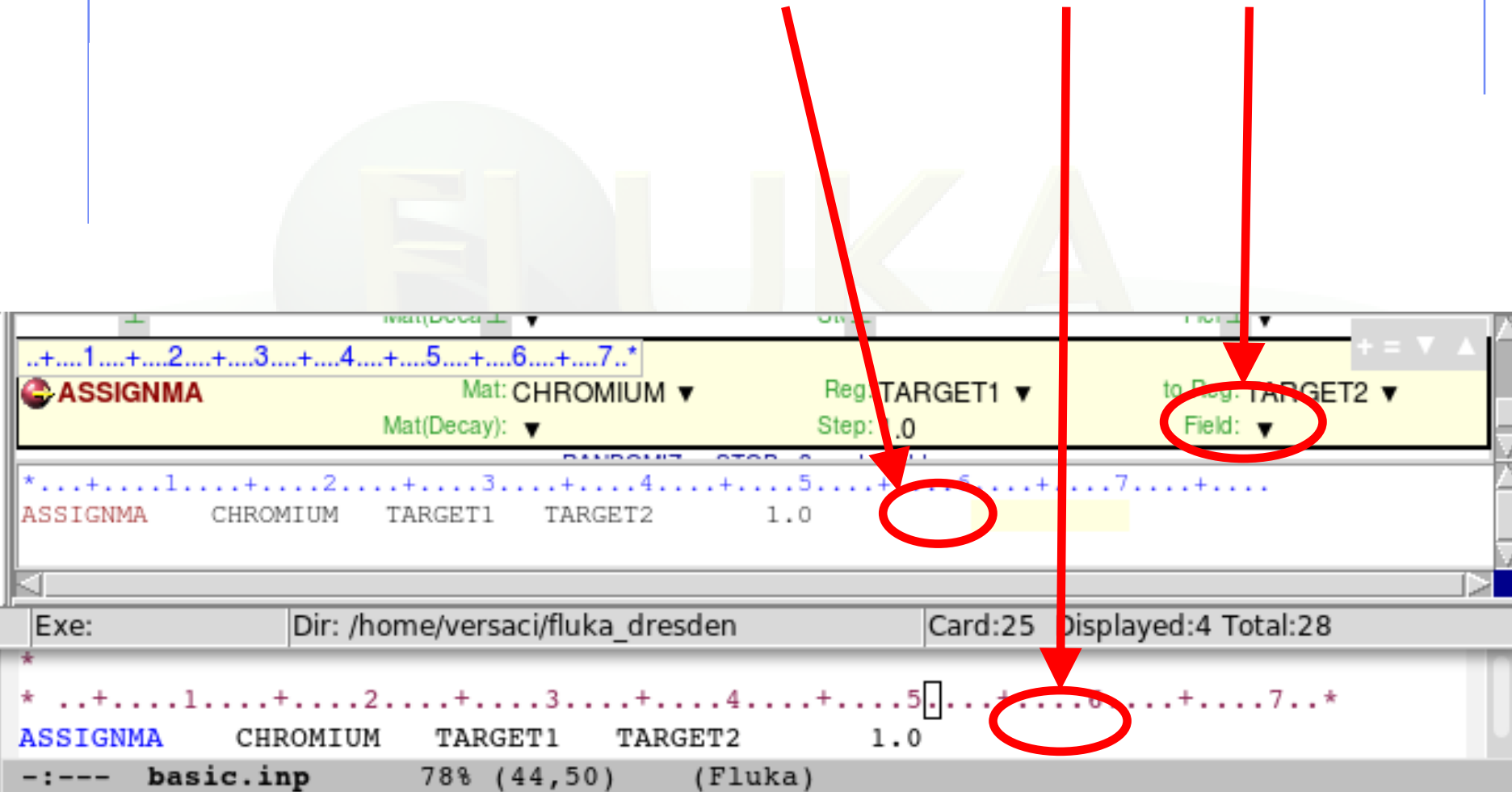
Region	Material	Target 1	Target 2	WHAT(4)
1	CHROMIUM	TARGET1	TARGET2	1.0

The bottom panel also displays the file name "basic.inp" and the coordinates "78% (44,50) (Fluka)".

Material

[WHAT(5)]

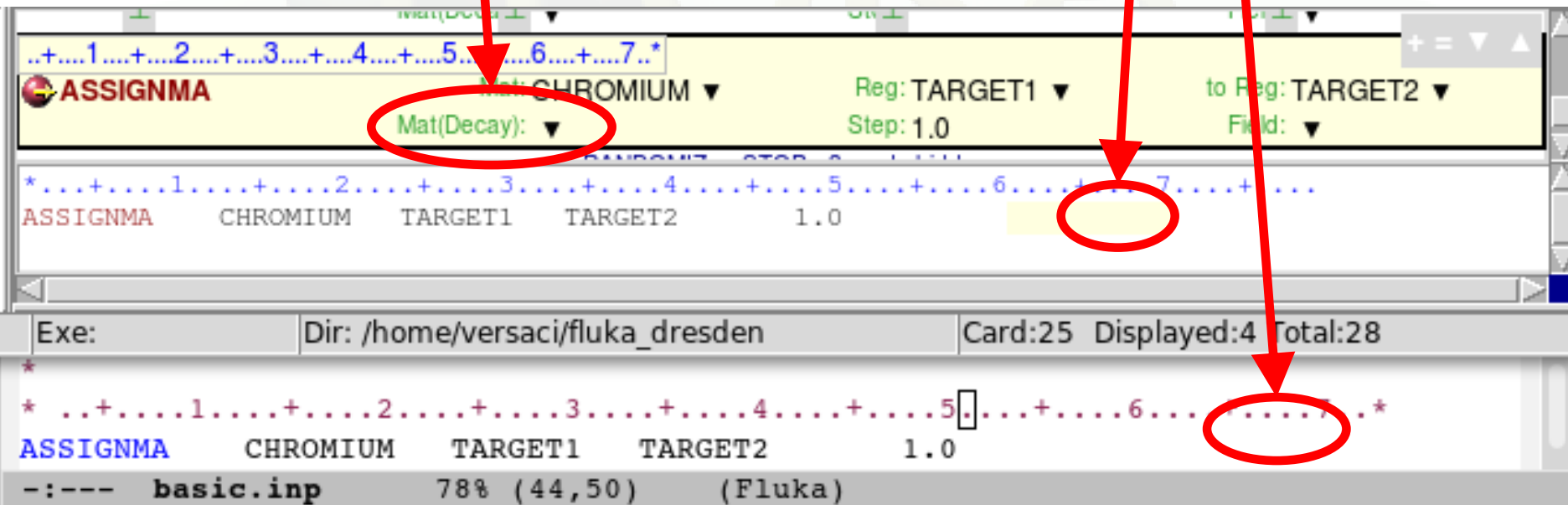
[WHAT(5)]: activate magnetic field in the concerned regions



Material definition: ASSIGNMA

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

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



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

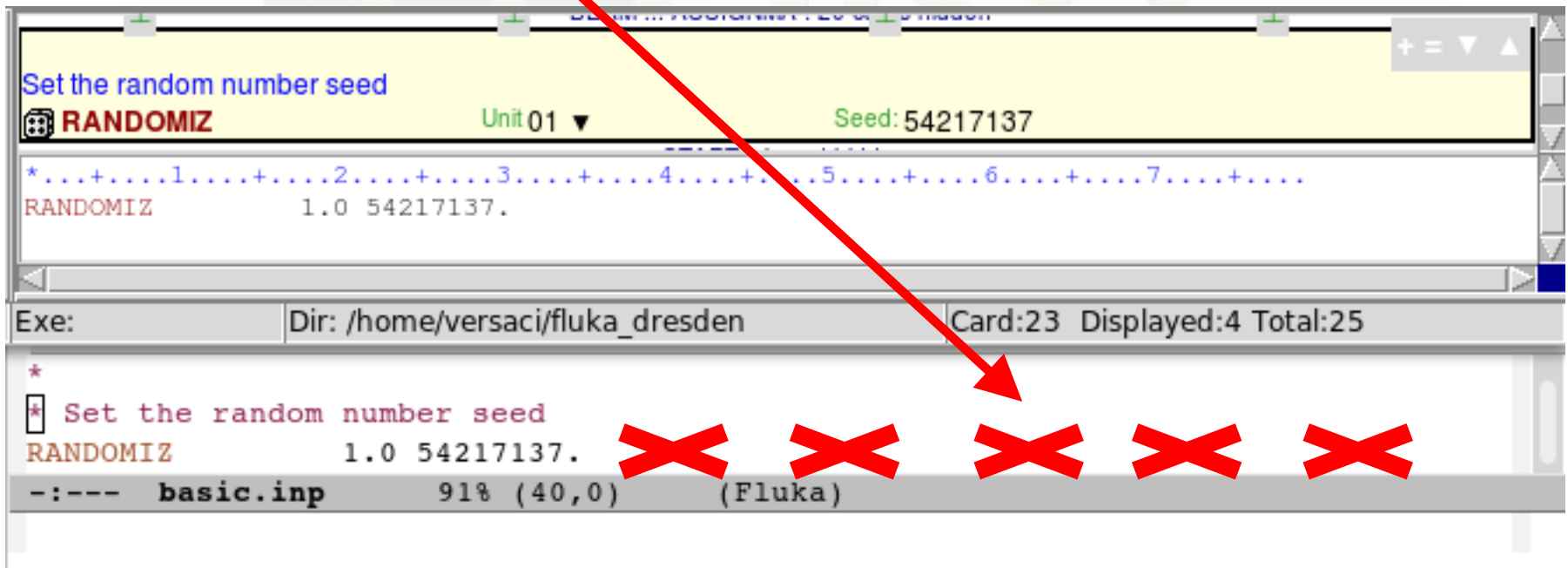
```

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
	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	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: ▼
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			

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.

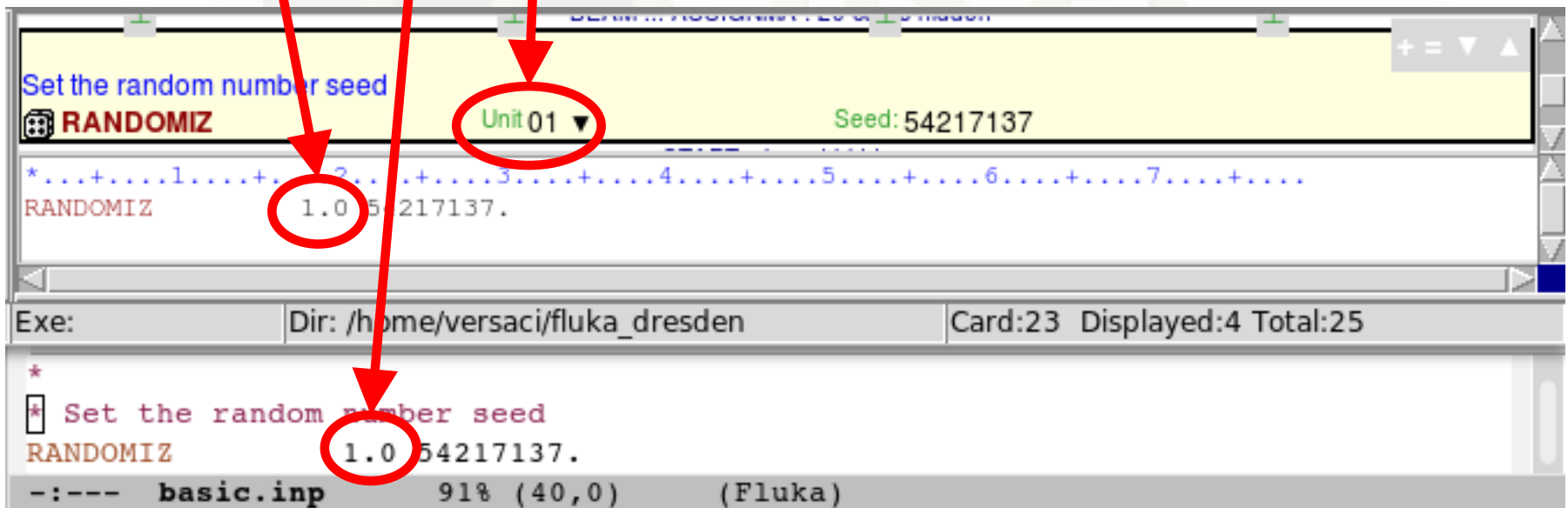
Exe: Dir: /home/versaci/fluka_dresden Card:23 Displayed:4 Total:25

*
* Set the random number seed
RANDOMIZ 1.0 54217137.
-:--- 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

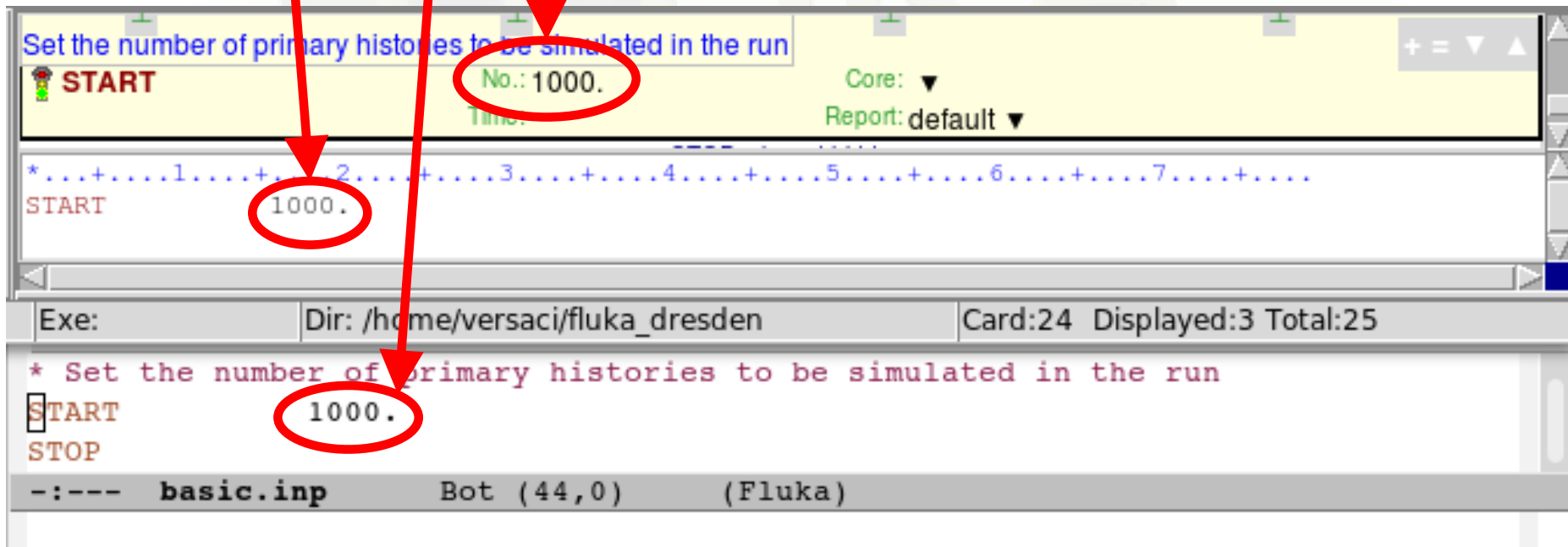
[WHAT(2)]: initialization of the random seed sequences

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

```
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)
```

Starting the simulation: START

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



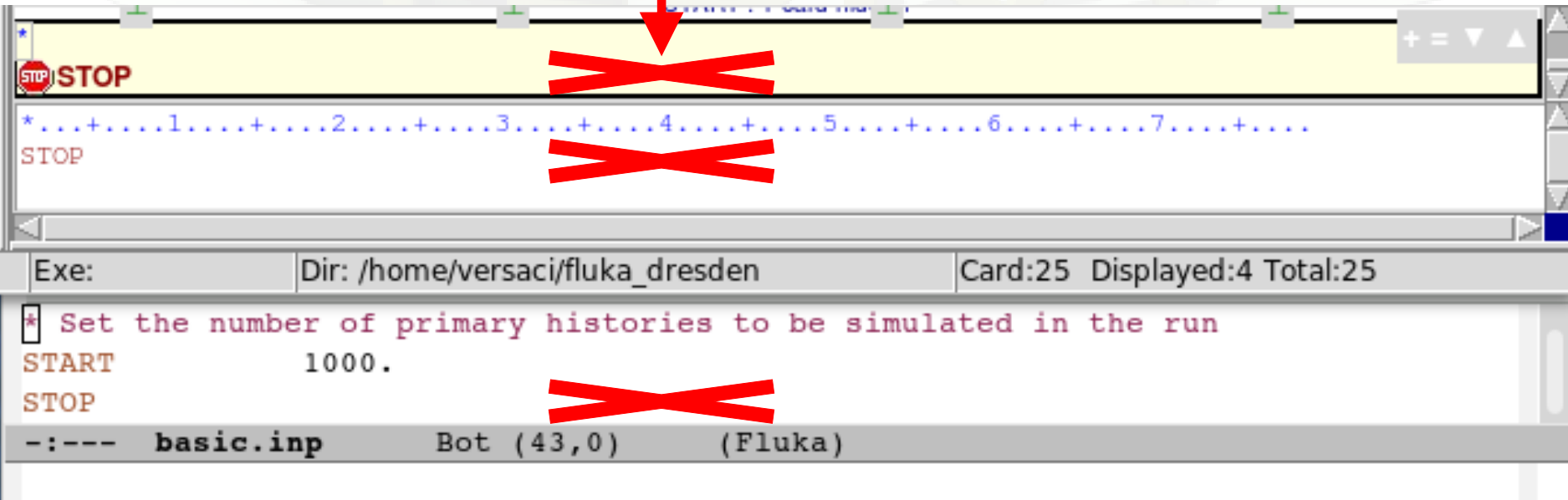
Stopping the program: STOP

[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





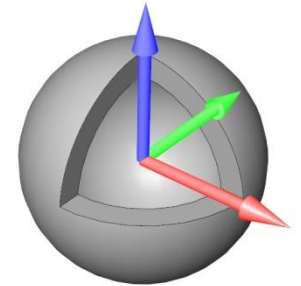
Beyond a basic input

Special sources: 3D distributions

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

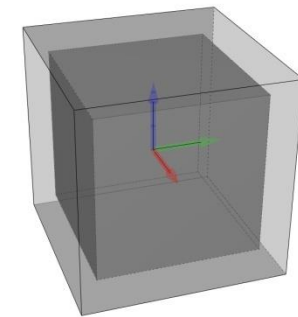
SDUM = SPHE-VOL:

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



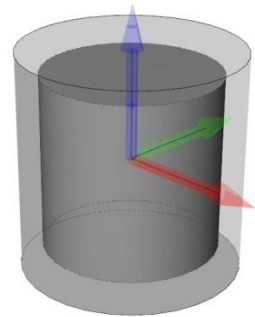
SDUM = CART-VOL:

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

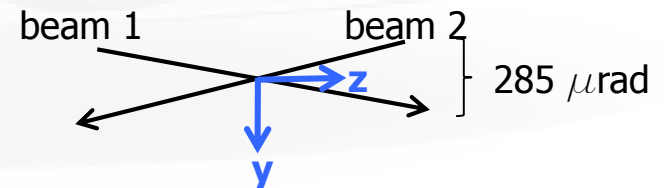
FLUKA allows the definitions of special sources for:

- 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



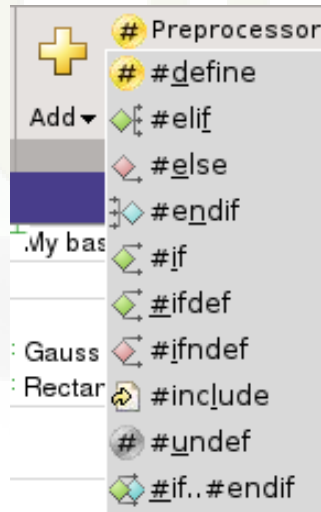
For all these special cases of source distributions,
please, **refer to the FLUKA manual!**

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
```



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

Include directive:

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

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 ▼ Mat(Decay): ▼	Reg: ▼ Step: ▼ to Reg: BEAMDUMP ▼ Field: ▼
#	elif	DUMP_CARBON	▼
	Select carbon as material for the dump		
	ASSIGNMA	Mat: CARBON ▼ Mat(Decay): ▼	Reg: ▼ Step: ▼ to Reg: BEAMDUMP ▼ Field: ▼
#	else		
	Use default material for the dump		
	ASSIGNMA	Mat: IRON ▼ Mat(Decay): ▼	Reg: ▼ Step: ▼ to Reg: BEAMDUMP ▼ 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 **IRRPROI**

- 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

