



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 Fluka software interface with a project named 'Fluka'. The left sidebar shows a tree view of the project structure, with 'Input' selected. The main window shows the input file configuration for 'My Basic Input example'.

File Edit Card Input View Tools Help

TITLE My Basic Input example

DEFAULTS PRECISIO

BEAM Beam: Momentum Δp : Gauss Δp (FWHM): 0.082425 $\Delta \phi$: Gauss $\Delta \phi$: 1.7 p: 3.5 Part: PROTON Δy : 0.0

BEAMPOS Shape(X): Rectangular Δx : 0.0 Shape(Y): Rectangular y : 0.0 z : -0.1 Type: POSITIVE $\cos x$: 0.0 $\cos y$: 0.0

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:

REGION VOID Neigh: 5 Volume:

REGION TARGET1 Neigh: 5 Volume: expr: +blkbody -void

REGION TARGET2 Neigh: 5 Volume: expr: +void -target1 -target2 -target3

REGION TARGET3 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

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

TITLE
My Basic Input example



A basic input card by card

A basic input: step 1: Physics settings

```

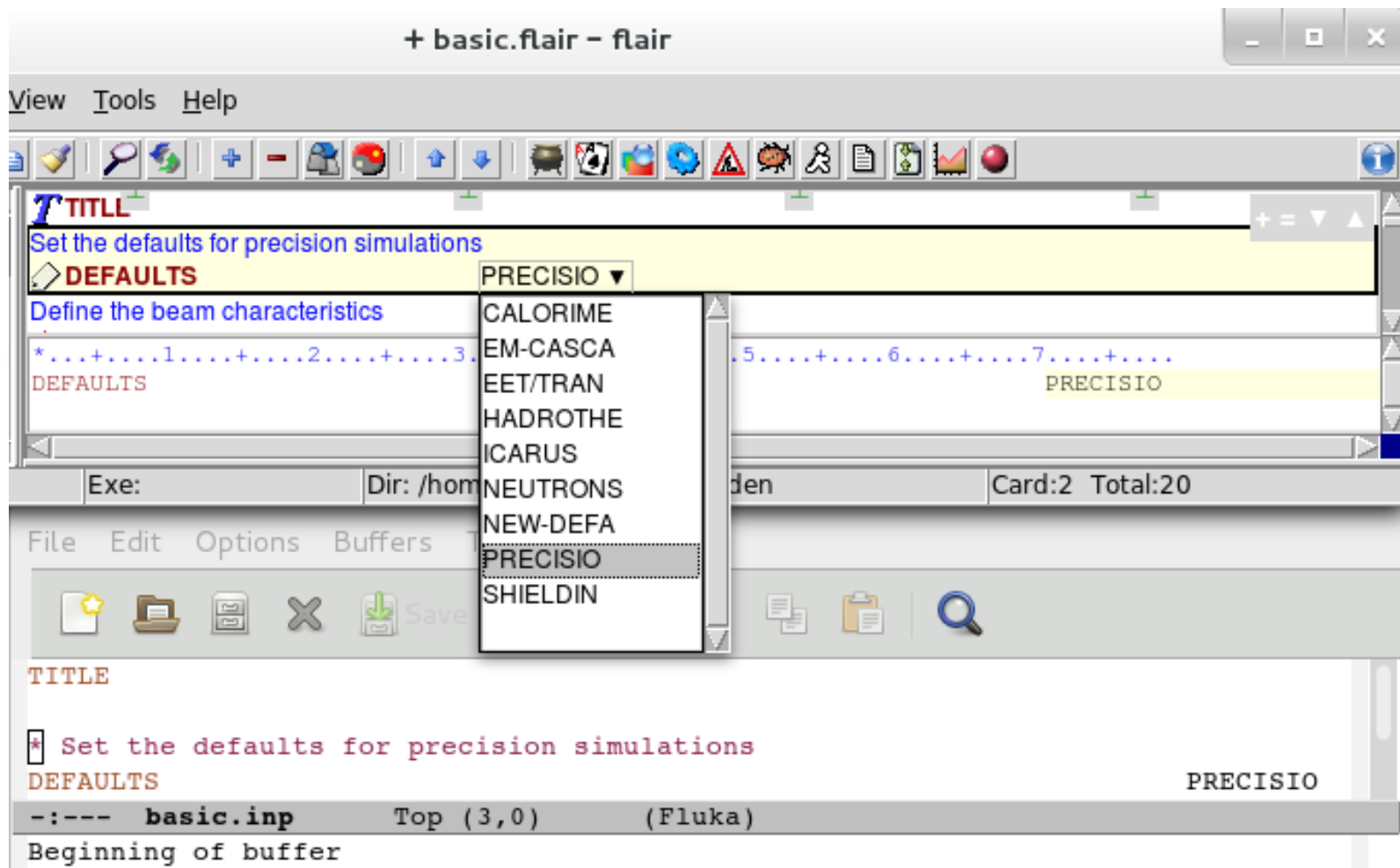
TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS
PRECISIO
* .....1.....2.....3.....4.....5.....6.....7..
BEAM      3.5 -0.082425  -1.7  0.0  0.0  PROTON
* Define the beam position
* .....1.....2.....3.....4.....5.....6.....7..
BEAMPOS   0.0  0.0  -0.1  0.0  0.0
*
GEOBEGIN                                     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
    
```

The screenshot shows a software interface for configuring simulation physics settings. The main window is titled "My Basic Input example" and contains a table of parameters. A red box highlights the "DEFAULTS" and "PRECISIO" sections at the top of the main window.

Component	Parameter	Value	Parameter	Value	Parameter	Value
BEAM	Beam Momentum	3.5	Beam Angle	-0.082425	Beam Position	-1.7
BEAM	Beam Energy	0.0	Beam Direction	0.0	Beam Type	PROTON
BEAMPOS	x	0.0	y	0.0	z	-0.1
BEAMPOS	cosx	0.0	cosy	0.0	Type	POSITIVE
GEOBEGIN	Log		Acc		Opt	
GEOBEGIN	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			
RCC	target2	x:0.0, y:0.0, z:20.0	Hx:0.0, Hy:0.0, Hz:10.0			
RCC	target3	x:0.0, y:0.0, z:40.0	Hx:0.0, Hy:0.0, Hz:10.0			
REGION	BLKBODY	Neigh: 5	Volume:			
REGION	VOID	Neigh: 5	Volume:			
REGION	TARGET1	Neigh: 5	Volume:			
REGION	TARGET2	Neigh: 5	Volume:			
REGION	TARGET3	Neigh: 5	Volume:			
MATERIAL	CHROMIUM	#	p: 7.18			
MATERIAL	AMMONIA	#	p: 0.73E-3			
COMPOUND	AMMONIA	Mix: Atom	Elements: 1..3			
ASSIGNMA	BLCKHOLE	Reg: BLKBODY	Field:			
ASSIGNMA	VACUUM	Reg: VOID	Field:			
ASSIGNMA	AMMONIA	Reg: TARGET3	Field:			
ASSIGNMA	CHROMIUM	Reg: TARGET1	Field:			
RANDOMIZ	Unit01	Seed: 54217137.				
START	No.: 1000.	Core:				
START	Time:	Report: default				

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), threshold set by **EMFCUT** (default: *100keV* for e^-/e^+ and *33keV* for γ)
- 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
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
  
```

The screenshot shows a software interface for configuring a simulation. The 'BEAM' section is highlighted with a red box and contains the following parameters:

- BEAM**: Beam: Momentum, p: 3.5, Part: PROTON
- BEAMPOS**: Δp(FWHM): 0.082425, Δφ: Gauss, Δφ: 1.7, Δx: 0.0, Δy: 0.0, Δz: -0.1, Type: POSITIVE
- SHAPE**: 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

The 'GEOBEGIN' section lists various objects and their properties:

- 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: 20.0, Hx: 0.0, Hy: 0.0, Hz: 10.0, R: 5.0
- RCC target2**: x: 0.0, y: 0.0, z: 40.0, 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

The 'END' section lists various regions and materials:

- 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:

The 'GEOEND' section lists various materials and compounds:

- MATERIAL CHROMIUM**: Name: CHROMIUM, #, p: 7.18, Z: 24.0, Am, A, dE/dx:
- MATERIAL AMMONIA**: Name: AMMONIA, #, p: 0.73E-3, Z: 0.0, Am, A, dE/dx:
- COMPOUND AMMONIA**: Name: AMMONIA, Mix: Atom, Elements: 1,3, M1: NITROGEN, M2: HYDROGEN, i1: 1.0, i3: 3.0

The 'ASSIGNMA' section lists various assignments:

- ASSIGNMA**: Mat: BLCKHOLE, Reg: BLKBODY, to Reg: Field:
- ASSIGNMA**: Mat: VACUUM, Reg: VOID, to Reg: Field:
- ASSIGNMA**: Mat: AMMONIA, Reg: TARGET3, to Reg: Field:
- ASSIGNMA**: Mat: CHROMIUM, Reg: TARGET1, to Reg: TARGET2, Step: 1.0, Field:

The 'RANDOMIZ' section lists various randomization parameters:

- RANDOMIZ**: Unit 01, Seed: 54217137, No.: 1000, Core:, Time:, Report: default

The 'STOP' section lists various stopping parameters:

- STOP**: Title: My Basic Input example

Beam definition: **BEAM**

[SDUM]: Proton beam

The screenshot displays the FLUKA GUI interface for defining a beam. The main window is titled "basic.flair - flair". The "Define the beam characteristics" section is active, showing the following parameters:

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

The "Define the beam position" section is also visible, showing parameters for x, y, z, cosx, cosy, and z. The z parameter is set to "Type: POSITIVE ▾".

Below the GUI, the command line shows the following input:

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

The "PROTON" entry in the command line is circled in red. A red arrow points from the text "[SDUM]: Proton beam" to this entry. Another red arrow points from the "Part: PROTON" dropdown in the GUI to the same entry. A third red arrow points from the "Part: PROTON" dropdown to the "PROTON" entry in the command line.

The status bar at the bottom of the GUI shows "Exe:", "Dir: /home/rversaci", and "Card:3 Total:20". The bottom-most part of the image shows the terminal output, which includes the command line input and the status of the file "basic.inp" (22% (9,1) (FLUKA)).

Beam definition: **BEAM**

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

The screenshot shows the FLUKA GUI with the following parameters defined:

- Beam: Momentum** (circled in red) set to **p: 3.5**
- Part: PROTON**
- Shape(X): Rectangular**
- Shape(Y): Rectangular**
- Delta p (FWHM): 0.002425**
- Delta phi: Gauss**
- Delta phi: 1.7**
- Delta x: 0.0**
- Delta y: 0.0**
- Type: POSITIVE**

The parameter list at the bottom shows the following values (the '3.5' is circled in red):

Parameter	Value
BEAM	3.5 -0.082425 -1.7 0.0 0.0 PROTON

The status bar at the bottom indicates: **basic.inp 22% (9,1) (FLUKA)** and **Wrote /home/rversaci/basic.inp**

Beam definition: BEAM

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

The screenshot displays the FLUKA GUI interface for defining a beam. The main window is titled '+ basic.flair - flair'. The 'Define the beam characteristics' section is highlighted in yellow and contains the following parameters:

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

The 'Define the beam position' section is titled 'BEAMPOS' and includes parameters for X, Y, Z, COSX, COSY, and Type: POSITIVE.

Below the GUI, the input file content is shown in a terminal window. The 'BEAM' card is defined as follows:

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

Red arrows and circles highlight the 'Define the beam characteristics' section in the GUI and the corresponding 'BEAM' card in the input file, specifically pointing to the Gaussian momentum distribution parameter Δp (FWHM) of 0.082425 GeV/c.

At the bottom of the terminal window, the status bar indicates: '-:--- basic.inp 22% (9,1) (FLUKA) Write /home/rversaci/basic.inp'.

Beam definition: BEAM

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

The screenshot displays the FLUKA GUI interface for defining a beam. The main window is titled '+ basic.flair - flair'. The interface is divided into several sections:

- Define the beam characteristics:** This section contains the **BEAM** definition. It shows:
 - Beam: Momentum (dropdown)
 - Δp : Gauss (dropdown)
 - Shape(X): Rectangular (dropdown)
 - Δp (FWHM): 0.082425
 - Δx : 0.0
 - $\Delta \phi$: Gauss (dropdown)
 - Shape(Y): Rectangular (dropdown)
 - $\Delta \phi$: 1.7 (highlighted with a red circle)
 - Part: PROTON (dropdown)
 - Δy : 0.0
- Define the beam position:** This section contains the **BEAMPOS** definition. It shows:
 - x: (input field)
 - y: (input field)
 - z: (input field)
 - cosx: (input field)
 - cosy: (input field)
 - Type: POSITIVE (dropdown)
- Beam Parameters Table:** A table at the bottom of the main window lists the parameters for the BEAM. The value **-1.7** in the fourth column is circled in red.

The bottom panel shows the 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)
Write /home/rversaci/basic.inp
```

Beam definition: **BEAM**

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

The screenshot shows the FLUKA GUI with the following parameters for the BEAM card:

- Beam: Momentum $p: 3.5$
- Part: PROTON
- Shape(X): Rectangular $\Delta x: 0.0$
- Shape(Y): Rectangular $\Delta y: 0.0$
- Beam position: $x: 3.5$, $y: -0.082425$, $z: -1.7$
- Beam type: POSITIVE

The BEAM card in the input file is shown as:

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

The status bar at the bottom indicates: `basic.inp 22% (9,1) (FLUKA)` and `Wrote /home/rversaci/basic.inp`.

Beam definition: **BEAM**

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

The screenshot shows the FLUKA GUI with the following parameters for the BEAM card:

Parameter	Value
Beam: Momentum	p: 3.5
Delta p (FWHM)	Delta p (FWHM): 0.082425
Delta x	Delta x: 0.0
Shape(X)	Shape(X): Rectangular
Delta y	Delta y: 0.0
Shape(Y)	Shape(Y): Rectangular
Delta z	Delta z: 1.7
Part	Part: PROTON
Type	Type: POSITIVE

The BEAMPOS card parameters are:

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

The BEAM card data in the console is:

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

The BEAMPOS card data in the console is:

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

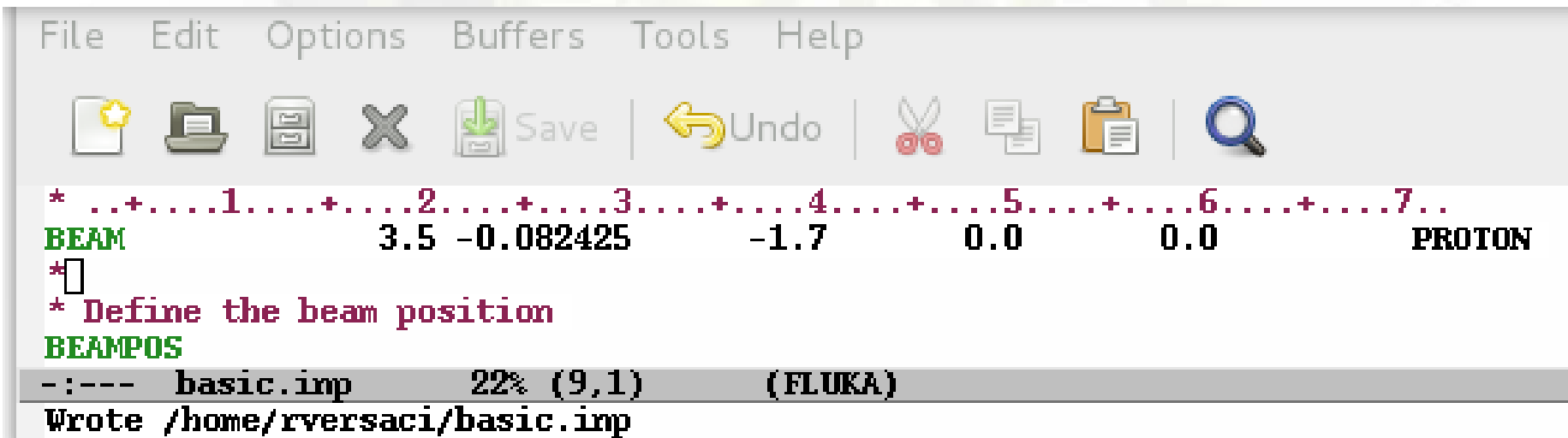
Red circles and arrows highlight the 'Delta y' parameter and the corresponding value '0.0' in both the GUI and the console output.

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 Save, Undo, Cut, Copy, and Find. The main text area contains the following code:

```
* .....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 shows the FLUKA GUI interface. The main window is titled '+ basic.flair - flair'. It features a menu bar with 'Tools' and 'Help', and a toolbar with various icons. The main content area is divided into two sections:

- Define the beam characteristics:** This section defines the **BEAM** parameters:
 - Beam: Momentum p : 3.5
 - Part: PROTON
 - Δp : Gauss, $\Delta p(\text{FWHM})$: 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:** This section defines the **BEAMPOS** parameters:
 - x: 0.0, y: 0.0, z: -0.1
 - cosx: 0.0, cosy: 0.0, Type: POSITIVE

Below these sections is a coordinate system with axes 1 through 7. The values for BEAMPOS are: 0.0, 0.0, -0.1, 0.0, 0.0.

At the bottom, there is a status bar showing 'Exe: /home/rversaci', 'Dir: /home/rversaci', and 'Card:4 Total:20'. Below this is another menu bar with 'File', 'Edit', 'Options', 'Buffers', 'Tools', and 'Help', and a toolbar with icons for Save, Undo, and other functions. The bottom-most part of the window shows a terminal-like output:

```
* .....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 FLUKA GUI interface for defining beam parameters. The top window, titled '+ basic.flair - flair', contains the following sections:

- Define the beam characteristics:** BEAM parameters include $p: 3.5$, $\Delta p: \text{Gauss}$, $\Delta p(\text{FWHM}): 0.082425$, $\Delta\phi: \text{Gauss}$, $\Delta\phi: 1.7$, Part: PROTON , $\Delta y: 0.0$, $\Delta x: 0.0$, and $\text{Shape}(X): \text{Rectangular}$.
- Define the beam position:** BEAMPOS parameters include $x: 0.0$, $y: 0.0$, $\text{cosx}: 0.0$, $\text{cosy}: 0.0$, and **Type: POSITIVE**.

Below the GUI, a table displays the parameters for BEAM and BEAMPOS. The BEAMPOS table has a circled 'SDUM' field with the value '-0.1'. The BEAM table has a circled 'SDUM' field with the value '-1.7'.

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

At the bottom, the status bar shows 'basic.inp', '20% (11,1)', and '(FLUKA)'.

Beam definition: BEAMPOS

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

The screenshot displays the FLUKA GUI interface for defining beam characteristics and position. The window title is "+ basic.flair - flair".

Define the beam characteristics:

- BEAM
- Δp: Gauss
- Shape(X): Rectangular
- Beam Momentum: 3.5
- Δp(FWHM): 0.082425
- Δ: 0.0
- Part: PROTON
- Δφ: Gauss
- Shape(Y): Rectangular
- 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

The parameter list at the bottom shows the following values for BEAMPOS:

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

The terminal window at the bottom shows the 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
* .....1.....2.....3.....4.....5.....6.....7..
BEAMPOS   0.0    0.0   -0.1    0.0    0.0
*
```

Red circles and arrows highlight the X coordinate values (0.0) in both the GUI and the terminal output.

Beam definition: BEAMPOS

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

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

Parameter	Value
Beam: Momentum	3.5
Δ (FWHM)	0.082425
Δx	0.0
Beam: Momentum	3.5
$\Delta\phi$	1.7
Part	PROTON
Δy	0.0
x	0.0
y	0.0
z	-0.1
cosx	0.0
cosy	0.0
Type	POSITIVE

```
* .....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(3)]: Z coordinate of the beam center

The screenshot displays the FLUKA GUI interface for defining beam characteristics and position. The window title is "+ basic flair - flair".

Define the beam characteristics (BEAM):

- Beam: Momentum: 3.5
- Δp (FWHM): 0.082425
- $\Delta\phi$: Gauss
- Shape(X): Rectangular
- Shape(Y): Rectangular
- Particle: PROTON
- $\Delta\phi$: 1.7
- Δ : 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 terminal output at the bottom shows the following parameters:

```
* .....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 highlight the value -0.1 for the Z coordinate in both the GUI and the terminal output. Red arrows point from the text above to these circles.

Beam definition: BEAMPOS

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

The screenshot displays the FLUKA GUI interface for defining beam characteristics. The main window is titled "+ basic.flair - flair". The interface is divided into several sections:

- Define the beam characteristics:** This section includes parameters for the beam's momentum and shape. The "Beam: Momentum" is set to 3.5, and the "Part" is "PROTON". The "Shape(X)" is "Rectangular" with a width of 0.0. The "Shape(Y)" is also "Rectangular" with a width of 0.0. The "Delta p (FWHM)" is 0.082425, and the "Delta phi" is 1.7.
- Define the beam position:** This section is highlighted in yellow and contains the "BEAMPOS" parameters. The "x" position is 0.0, the "y" position is 0.0, and the "z" position is -0.1. The "Type" is "POSITIVE". The "cosx" parameter is highlighted with a red circle, and a red arrow points to it from the text above.

Below the GUI, the command line shows the parameters for the "BEAM" and "BEAMPOS" sections. The "BEAM" section parameters are: 3.5 -0.082425 -1.7 0.0 0.0 PROTON. The "BEAMPOS" section parameters are: 0.0 0.0 -0.1 0.0 0.0. The "cosx" parameter (0.0) is highlighted with a red circle, and a red arrow points to it from the text above.

```
Exe: /home/rversaci 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(5)]: direction cosine with respect to the Y axis

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

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

The BEAMPOS table below shows the following values:

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

The bottom 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
*
* 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**

defines beam **position and momentum**

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

```
File Edit Options Buffers Tools Help
[Icons: New, Open, Save, Undo, Cut, Copy, Paste, 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.inp      20% (11,1)      (FLUKA)
```

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
```

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
  
```

iew Tools Help

My Basic Input example

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: Acc: Opt:

Inp: Out: Fmt: COMBNAME

Title:

SPH blkbody x: 0.0 y: 0.0 z: 0.0

SPH void x: 0.0 y: 0.0 z: 0.0

RCC target1 x: 0.0 y: 0.0 z: 0.0

RCC target2 x: 0.0 y: 0.0 z: 20.0

RCC target3 x: 0.0 y: 0.0 z: 40.0

END

REGION BLKBODY Neigh: 5 Volume:

REGION VOID Neigh: 5 Volume:

REGION TARGET1 Neigh: 5 Volume:

REGION TARGET2 Neigh: 5 Volume:

REGION TARGET3 Neigh: 5 Volume:

END

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

i1: 1.0 M1: NITROGEN i2: 3.0 M2: HYDROGEN

i3: M3:

ASSIGNMA Mat: BLCKHOLE Reg: BLKBODY to Reg:

Step: Field:

ASSIGNMA Mat: VACUUM Reg: VOID to Reg:

Step: Field:

ASSIGNMA Mat: AMMONIA Reg: TARGET3 to Reg:

Step: Field:

ASSIGNMA Mat: CHROMIUM Reg: TARGET1 to Reg: TARGET2

Step: 1.0 Field:

RANDOMIZ Unit 01 Seed: 54217137.

START No.: 1000. Core: Report: default

STOP

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 shows the FLUKA GUI window titled "basic.flair - flair". The main display area shows two material definitions:

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

Below the main display, a summary table shows the material definitions:

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

The status bar at the bottom indicates: Exe: /home/versaci/fluka_dresden, Dir: /home/versaci/fluka_dresden, Card:19 Displayed:2 Total:28. The bottom-most status bar shows: 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 shows the FLUKA input editor interface. The main window displays the input file content, which includes two material definitions:

```
..... TITLE ... GEOEND ..... cards hidden .....  
.....1.....2.....3.....4.....5.....6.....7.....  
MATERIAL Name: CHROMIUM #| p: 7.18  
Z: 24.0 A: dE/dx: ▾  
MATERIAL Name: AMMONIA # p: 0.73E-3  
Z: 0.0 A: dE/dx: ▾  
..... COMPOUND STOP: 8 cards hidden .....
```

Below the input editor, a table shows the processed material data:

*	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 window, the status bar indicates: `Exe: Dir: /home/versaci/fluka_dresden Card:19 Displayed:2 Total:28`

Material definition: MATERIAL

[WHAT(1)]: atomic number Z

The screenshot shows a software interface with a menu bar (View, Tools, Help) and a toolbar. The main window displays a list of material definitions. Two materials are visible: CHROMIUM and AMMONIA. The CHROMIUM card shows Name: CHROMIUM, #, Am, A, p: 7.18, and dE/dx. The AMMONIA card shows Name: AMMONIA, #, Am, A, p: 0.73E-3, and dE/dx. Below the cards, there is a table of material definitions. The table has columns for material name, atomic number Z, and density p. The CHROMIUM entry has Z: 24.0 and p: 7.18. The AMMONIA entry has Z: 0.0 and p: 0.73E-3. At the bottom, there is a status bar showing the file name 'basic.inp', the percentage '52% (35,77)', and the application '(Fluka)'. Red arrows point from the text '[WHAT(1)]: atomic number Z' to the 'Z' values in the material definition cards and the input file.

Material Name	Atomic Number (Z)	Density (p)
CHROMIUM	24.0	7.18
AMMONIA	0.0	0.73E-3

Material definition: MATERIAL

[WHAT(2)]: atomic weight

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

The screenshot shows a software window titled "basic.flair - flair" with a menu bar (View, Tools, Help) and a toolbar. The main area displays a list of materials with columns for Name, #, A, p, and dE/dx. Two materials are visible: CHROMIUM (Z: 24.0, p: 7.18) and AMMONIA (Z: 0.0, p: 0.73E-3). Below the list, there are two summary rows. Red circles highlight empty fields in the summary rows, and red arrows point from the text "[WHAT(2)]: atomic weight" and "leave it empty" to these fields.

Name	#	A	p	dE/dx
CHROMIUM			7.18	▼
AMMONIA			0.73E-3	▼

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

Material definition: MATERIAL

If $\rho < 0.01$ assumed to be a gas

[WHAT(3)]: density [g/cm³]

The screenshot displays a software interface with a menu bar (View, Tools, Help) and a toolbar. The main window shows a list of materials with their properties. The materials listed are CHROMIUM and AMMONIA. The density values are highlighted with red circles and red arrows pointing from the text '[WHAT(3)]: density [g/cm³]'. The density for CHROMIUM is 7.18 and for AMMONIA is 0.73E-3. The interface also shows a table of material properties and a status bar.

Name	Z	Am	#	A	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

Name	Z	Am	#	A	dE/dx
CHROMIUM	24.0				7.18
AMMONIA	0.0				0.73E-3

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

Material definition: MATERIAL

[WHAT(4)]: material number

Available for backward compatibility:
leave it empty

The screenshot shows a software interface with a graphical view and a terminal view. The graphical view displays two material definitions:

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

The terminal view shows the same material definitions in a text-based format:

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

Red arrows point from the text "leave it empty" to empty input fields in the graphical view (the # and A columns) and the terminal view (the empty field after 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
dE/dx: ▼
MATERIAL      Name: AMMONIA      #
Z: 0.0        Am:                 A:                               n: 0.73E-3
dE/dx: ▼
----- COMPOUND ... TOP ... 8 cards hidden -----
*...1...+...2...+...3...+...4...+...5...+...6...+...7...
MATERIAL      24.0                7.18
MATERIAL      0.0                0.73E-3
CHROMIUM
AMMONIA
```

Red arrows indicate the following:

- From the red box to the `dE/dx` field in the material definition.
- From the red box to the empty field in the `WHAT(5)` column of the material definition table.
- From the red box to the empty field in the `WHAT(5)` column of the material definition table in the summary section.

At the bottom, the status bar shows: `Exe: /home/versaci/fluka_dresden Dir: /home/versaci/fluka_dresden Card:19 Displayed:2 Total:28`

Material definition: MATERIAL

[WHAT(6)]: mass number A

normally empty
unless a specific isotope is desired

The screenshot shows the FLUKA interface with the following material definitions:

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

The summary table below shows the material definitions in a compact format:

Material	Z	Am	p	A
MATERIAL	24.0		7.18	
MATERIAL	0.0		0.73E-3	

Red arrows in the image point from the text annotations to the 'A' field in the material definition cards and the corresponding columns in the summary table.

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**)

```
* ..+....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 shows the 'basic.flair - flair' application window. The main area displays a 'COMPOUND' card for 'AMMONIA' with the following parameters:

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

Below the card, a table shows the material composition:

Material	1.0	NITROGEN	3.0	HYDROGEN	AMMONIA
COMPOUND	1.0	NITROGEN	3.0	HYDROGEN	AMMONIA

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

Material definition: COMPOUND

[SDUM]: compound name

The screenshot shows a software interface for material definition. The window title is "basic.flair - flair". The interface includes a menu bar (View, Tools, Help) and a toolbar with various icons. The main area displays a material definition for a compound. The compound name "AMMONIA" is highlighted in a red oval. The material is defined with the following parameters:

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

Below the material definition, there is a table of data. The table has 7 columns and 1 row. The data is as follows:

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

At the bottom of the interface, there is a command line showing the material definition command:

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

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

Material definition: COMPOUND

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

Amount definition
in few slides

The screenshot displays a software window titled "basic.flair - flair" with a menu bar (View, Tools, Help) and a toolbar. The main area shows a material 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 this, there are two input cards. The first card is titled "COMPOUND" and contains the following data:

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

The second card is also titled "COMPOUND" and contains the following data:

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

At the bottom of the window, the status bar shows "Exe: /home/versaci/fluka_dresden", "Dir: /home/versaci/fluka_dresden", "Card:21 Displayed:1 Total:28", and "basic.inp 648 (37,0) (Fluka)".

Material definition: COMPOUND

[WHAT(2)]: first component material

The screenshot displays the FLAIR software interface for defining a material. The main window shows the following details for the material 'AMMONIA':

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

Below the main window, the 'ASSIGNMA ... STOP : 7 cards hidden' table shows the following data:

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

The bottom window shows the 'COMPOUND' table with the following data:

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

Red circles and arrows highlight the 'M1: NITROGEN' field in the main window and the 'NITROGEN' entries in the ASSIGNMA and COMPOUND tables, indicating that the first component material is Nitrogen.

Material definition: COMPOUND

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

Amount definition
in few slides

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

- GUI Panel:** Displays material definition for a **COMPOUND**.
 - Name: AMMONIA
 - Mix: Atom
 - Elements: 1..3
 - f1: 1.0
 - M1: NITROGEN
 - f2: 3.0 (circled in red)
 - M2: HYDROGEN
 - f3: (empty)
 - M3: (empty)
- Input File (basic.inp):** Shows the material definition in a table format.
 - Row 1: COMPOUND, 1.0, NITROGEN, 3.0, HYDROGEN, AMMONIA
 - Row 2: COMPOUND, 1.0, NITROGEN, 3.0, HYDROGEN, AMMONIA

Red arrows point from the text **[WHAT(3)]: amount of the second component** to the circled **f2: 3.0** in the GUI and the circled **3.0** in the input file. Another red arrow points from the text **Amount definition in few slides** to the circled **3.0** in the input file.

Material definition: COMPOUND

[WHAT(4)]: second component material

The screenshot shows the FLUKA interface with the following details:

- Window title: basic.flair - flair
- Menu: View Tools Help
- Toolbar: Contains various icons for navigation and simulation control.
- Material Card (highlighted in yellow):
 - Name: AMMONIA
 - M1: NITROGEN
 - M2: HYDROGEN
 - f1: 1.0
 - f3:
- ASSIGNMA Table (STOP: 7 cards hidden):

1.0	NITROGEN	3.0	HYDROGEN	AMMONIA
-----	----------	-----	----------	---------
- Output Table:

1.0	NITROGEN	3.0	HYDROGEN	AMMONIA
-----	----------	-----	----------	---------
- Status Bar: Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28
- Footer: basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND

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

Amount definition
in few slides

The screenshot shows the FLAIR software interface with the following details:

- Window title: basic.flair - flair
- Menu: View Tools Help
- Toolbar: Contains various icons for file operations, navigation, and simulation.
- Card Editor: Shows a 'COMPOUND' card for 'AMMONIA' with the following parameters:
 - Name: AMMONIA
 - Mix: Atom
 - Elements: 1..3
 - f1: 1.0
 - M1: NITROGEN
 - f2: 3.0
 - M2: HYDROGEN
 - M3: (empty)
- Table Editor: Shows a table with columns for 'COMPOUND', 'NITROGEN', 'HYDROGEN', and 'AMMONIA'. The 'COMPOUND' row has values 1.0, 3.0, and an empty cell under 'AMMONIA'.
- Status Bar: Shows 'Card:21 Displayed:1 Total:28'.
- Bottom Panel: Shows a terminal window with the following text:

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

Red arrows and circles highlight the 'f3' field in the 'COMPOUND' card and the empty cell under 'AMMONIA' in the table.

Material definition: COMPOUND

[WHAT(6)]: third component material

The screenshot shows the FLUKA interface with the following details:

- Title Bar:** basic.flair - flair
- Menu Bar:** View Tools Help
- Toolbar:** Contains various icons for file operations, navigation, and simulation control.
- Material Definition Panel:**
 - COMPONENT:** COMPOUND
 - Name:** AMMONIA
 - Mix:** Atom
 - Elements:** 1..3
 - f1:** 1.0
 - M1:** NITROGEN
 - f2:** 3.0
 - M2:** HYDROGEN
 - M3:** (highlighted with a red circle)
- Input Window (STOP card):**

```
COMPONENT 1.0 NITROGEN 3.0 HYDROGEN AMMONIA
```
- Output Window:**

```
COMPONENT 1.0 NITROGEN 3.0 HYDROGEN AMMONIA
```
- Status Bar:** Exe: Dir: /home/versaci/fluka_dresden Card:21 Displayed:1 Total:28
- Footer:** -:--- basic.inp 64% (37,0) (Fluka)

Material definition: COMPOUND

Defines a new **compound**

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

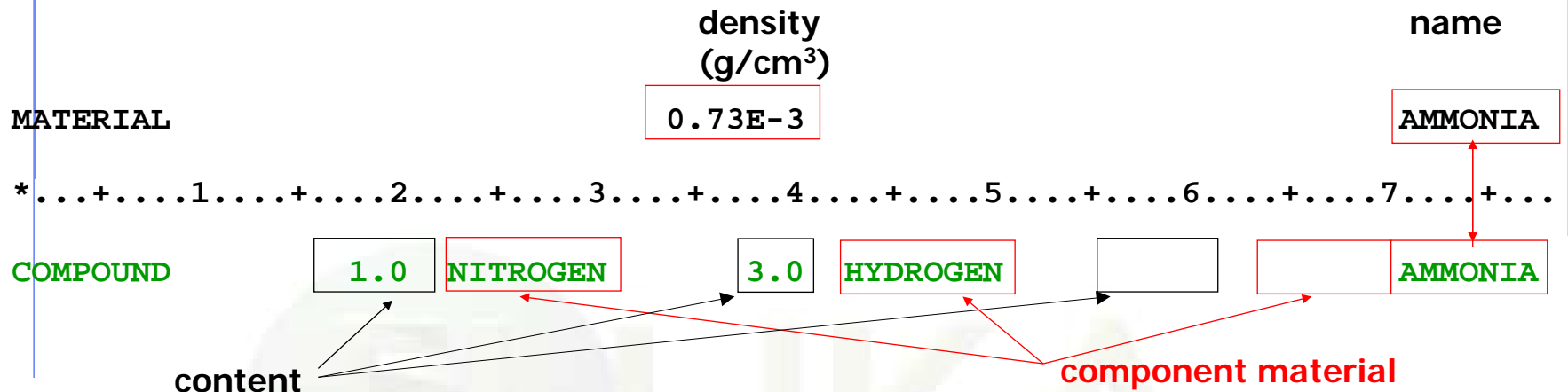
More **COMPOUND** card can be used to define a compound

- [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"?

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

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 GUI window titled '+ basic.flair - flair'. The interface includes a menu bar (View, Tools, Help), a toolbar with various icons, and a main workspace. The workspace displays a material definition for 'ASSIGNMA' with the following parameters:

- Mat: COPPER
- Reg: TARGET
- to Reg: (dropdown)
- Mat(Decay): (dropdown)
- Step: (dropdown)
- Field: (dropdown)

Below the main workspace, there is a status bar showing 'Exe: /home/versaci/fluka_dresden', 'Card:20', 'Displayed:6', and 'Total:23'. At the bottom, a terminal window displays the following text:

```
*...+...1...+...2...+...3...+...4...+...5...+...6...+...7...
ASSIGNMA      COPPER      TARGET
*
-:--- basic.inp      25% (26,1)      (Fluka Ovwrt)
```

Material definition: ASSIGNMA

[SDUM]: not used

The screenshot shows a software window titled '+ basic.flair - flair'. The interface includes a menu bar with 'View', 'Tools', and 'Help'. Below the menu is a toolbar with various icons. The main display area shows a parameter list for 'ASSIGNMA' with the following fields: 'Mat: CHROMIUM', 'Reg: TARGET1', 'to Reg: TARGET2', 'Mat(Decay):', 'Step: 1.0', and 'Field:'. Below the parameter list is a table of values:

ASSIGNMA	CHROMIUM	TARGET1	TARGET2	1.0
ASSIGNMA	CHROMIUM	TARGET1	TARGET2	1.0

At the bottom of the window, there is a status bar with the following information: 'Exe: /home/versaci/fluka_dresden', 'Dir: /home/versaci/fluka_dresden', 'Card:25', 'Displayed:4', 'Total:28'. Below the status bar is a command prompt showing the command 'basic.inp' and its output: '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 parameter table with the following data:

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

Below the parameter table, a command line window shows the following command:

```
ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0
```

Red arrows indicate the mapping from the text "[WHAT(1): material to be assigned]" to the "Mat: CHROMIUM" dropdown menu and the "CHROMIUM" text in the command line.

Material definition: ASSIGNMA

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

The screenshot displays a software interface for material definition. The main window shows a toolbar and a list of parameters for the material 'ASSIGNMA'. The parameters are:

- Mat: CHROMIUM
- Mat(decay):
- Reg: TARGET1
- to Reg: TARGET2
- Step: 1.0
- Field:

Below the main window, a command line shows the material definition parameters in a text-based format:

```
ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0
```

Red arrows indicate the mapping between the text above and the GUI elements: one arrow points to 'Reg: TARGET1' in the GUI, another points to 'TARGET1' in the command line, and a third points to the first region '1' in the command line.

Material definition: ASSIGNMA

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

The screenshot shows a software interface with a toolbar and a parameter list. The parameter list includes:

- ASSIGNMA
- Mat: CHROMIUM
- Reg: TARGET1
- Step: 1.0
- to Reg: TARGET2

The parameter list also shows a table of values:

	1	2	3	4	5	6	7
ASSIGNMA	CHROMIUM	TARGET1	TARGET2		1.0		

The command line at the bottom shows:

```
ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0
```

Red arrows point from the text above to the 'TARGET2' in the 'to Reg' dropdown, the 'TARGET2' in the parameter list, and the 'TARGET2' in the command line.

Material definition: ASSIGNMA

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

The screenshot displays a software interface for material definition. The main window shows a configuration for 'ASSIGNMA' with the following parameters:

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

The command line below the GUI shows the following parameters:

```
ASSIGNMA CHROMIUM TARGET1 TARGET2 1.0
```

At the bottom of the interface, a status bar displays the following information:

```
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)
```

Red arrows from the text above point to the 'Step: 1.0' parameter in the GUI and the '1.0' value in the command line.

Material definition: ASSIGNMA

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

The screenshot shows the FLUKA input file editor interface. The main window displays the configuration for the ASSIGNMA card. The configuration is as follows:

Card	Material	Region	Field	Value
ASSIGNMA	CHROMIUM	TARGET1	to Reg. TARGET2	1.0

Below the main configuration, a table shows the card's position in the input file:

Card	Material	Region	Field	Value
ASSIGNMA	CHROMIUM	TARGET1	TARGET2	1.0

Red arrows and circles highlight the following elements:

- The 'Field' dropdown menu in the main configuration, which is currently set to 'to Reg. TARGET2'.
- The '1.0' value in the main configuration.
- The '5' in the table below, which corresponds to the column index of the '1.0' value.

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 GUI interface for defining materials. The main window displays the 'ASSIGNMA' material definition panel. The 'Mat(Decay):' dropdown menu is highlighted with a red circle. A red arrow points from the text '[WHAT(6)]: assign another material for radioactive decay products transport' to this dropdown. Another red arrow points from the text 'As of now, only BLCKHOLE and VACUUM supported' to a yellow highlight in the 'Mat(Decay):' dropdown menu. A third red arrow points from the text '[WHAT(6)]: assign another material for radioactive decay products transport' to a field in the input table below the dropdown, which is also circled in red. The input table shows the following data:

Mat	Decay	Reg	Step	Field
ASSIGNMA	CHROMIUM	TARGET1	TARGET2	1.0

The status bar at the bottom of the window shows the following information:

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

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
    
```

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	z: -0.1	
	cosx: 0.0	cosy: 0.0	Type: POSITIVE	
GEOBEGIN		Log: ↓	Acc: ↓	Opt: ↓
	Inp: ↓	Out: ↓	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	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	A:	dE/dx: ↓	
MATERIAL	Name: AMMONIA	#	p: 0.73E-3	
	Z: 0.0	A:	dE/dx: ↓	
COMPOUND	Name: AMMONIA	Mix: Atom	Elements: 1..3	
	i1: 1.0	M1: NITROGEN	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: AMMONIA	Reg: TARGET3	to Reg: ↓	
	Mat(Decay): ↓	Step: ↓	Field: ↓	
ASSIGNMA	Mat: CHROMIUM	Reg: TARGET1	to Reg: TARGET2	
	Mat(Decay): ↓	Step: ↓	Field: ↓	
RANDOMIZ				
	Unit 01	Seed: 54217137.		
START	No.: 1000.	Core: ↓		
	Time: ↓	Report: default		
STOP				

TITLE
My Basic Input example

Random seed initialization: RANDOMIZ

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

The screenshot shows the FLAIR interface for a simulation. The main window displays the configuration for the **RANDOMIZ** card. The card is set to **Unit 01** with a **Seed: 54217137**. Below the configuration, a preview of the card's output is shown, including a header line with dots and the command **RANDOMIZ 1.0 54217137.**

At the bottom of the interface, the execution status is shown. The command **RANDOMIZ 1.0 54217137.** is listed with five red 'X' marks next to it, indicating that the parameters are not used. The status bar shows the file **basic.inp** is 91% complete (40,0) for the **(Fluka)** engine.

Random seed initialization: RANDOMIZ

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

Do not touch! MUST be Unit 1

The screenshot shows the Flair GUI interface for editing a card. The card is titled "Set the random number seed" and contains the following configuration:

```
RANDOMIZ  
Unit 01 Seed: 54217137
```

The "Unit 01" dropdown menu is circled in red. Below the card, the command line shows the card being executed:

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

The "1.0" value is also circled in red. At the bottom of the window, the status bar shows the card is being executed from the file "basic.inp" with a 91% completion rate (40,0) for the Fluka simulation.

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 the Flair GUI interface. At the top, the window title is "basic.flair - flair". Below the title bar is a menu bar with "View", "Tools", and "Help". A toolbar with various icons is visible. The main workspace contains a yellow-highlighted command line: "Set the random number seed" followed by "RANDOMIZ" and "Unit01". To the right of "Unit01", the text "Seed: 54217137" is displayed and circled in red. Below this, a grid of cards is shown, with the first card containing "RANDOMIZ" and "1.0 54217137.", also circled in red. At the bottom, a status bar shows "Exe: /home/versaci/fluka_dresden", "Card:23", "Displayed:4", and "Total:25". Below the status bar, a log window shows the command being executed: "* Set the random number seed" followed by "RANDOMIZ" and "1.0 54217137.", with the seed value circled in red. The bottom status bar of the log window shows "---- basic.inp 91% (40,0) (Fluka)".

Starting the simulation: **START**

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

The screenshot shows a graphical user interface for a simulation. At the top, a window title bar reads '+ basic.flair - flair'. Below it is a menu bar with 'View', 'Tools', and 'Help'. A toolbar contains various icons for navigation and simulation control. The main display area is divided into several sections:

- A yellow header bar with the text 'Set the number of primary histories to be simulated in the run'. Below this, it shows 'START' with a red key icon, 'No.: 1000.', 'Core: ▼', and 'Report: default ▼'. The value '1000.' is circled in red.
- A status bar below the header with a progress indicator: '*...+...1...+...2...+...3...+...4...+...5...+...6...+...7...+...'. Below this, it shows 'START' and '1000.', with '1000.' circled in red.
- A bottom status bar with 'Exe: Dir: /home/versaci/fluka_dresden Card:24 Displayed:3 Total:25'.
- A terminal window at the bottom showing the command sequence: '* Set the number of primary histories to be simulated in the run', 'START', '1000.', and 'STOP'. The value '1000.' is circled in red.
- The bottom-most bar shows the file name 'basic.inp', coordinates 'Bot (44,0)', and the program '(Fluka)'.

Red arrows point from the text '[WHAT(1)]: number of primaries to be simulated' to the three circled '1000.' values in the interface.

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

The screenshot shows a window titled '+ basic.flair - flair' with a menu bar (View, Tools, Help) and a toolbar. The main text area contains the following input cards:

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

Below the text area, a status bar displays: 'Exe: Dir: /home/versaci/fluka_dresden Card:25 Displayed:4 Total:25'. The bottom panel shows the simulation output:

```
* Set the number of primary histories to be simulated in the run  
START      1000.  
STOP
```

At the bottom of the window, the command line shows: '-:--- basic.inp Bot (43,0) (Fluka)'. A red arrow points from the text 'Inserted before START' to the STOP card in the input file. Three red 'X' marks are placed over the STOP card, the card numbers 1-7, and the START card in the output, indicating that these cards are not used or have no effect.



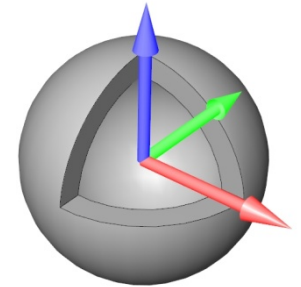
Beyond a basic input

Special sources: 3D distributions

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

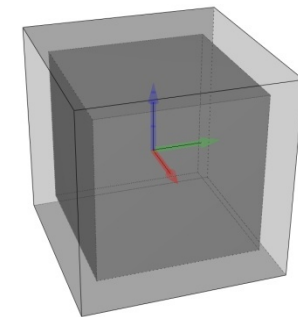
SDUM = SPHE-VOL:

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



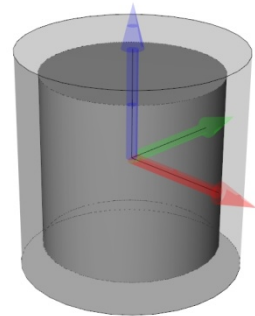
SDUM = CART-VOL:

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**

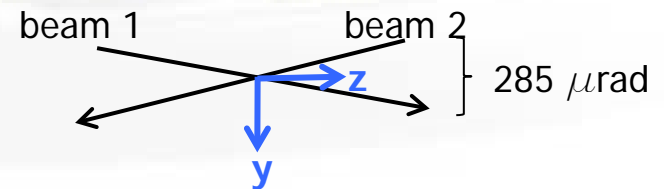
FLUKA allows the definitions of special sources for:

- 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:

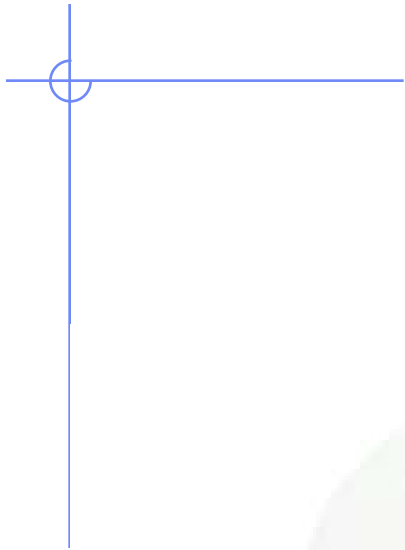
```
#include /home/geometries/target2.geom
```

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



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 **CORRFACT**

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

