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

Estimators / scoring cards

Scoring lecture

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 !!!

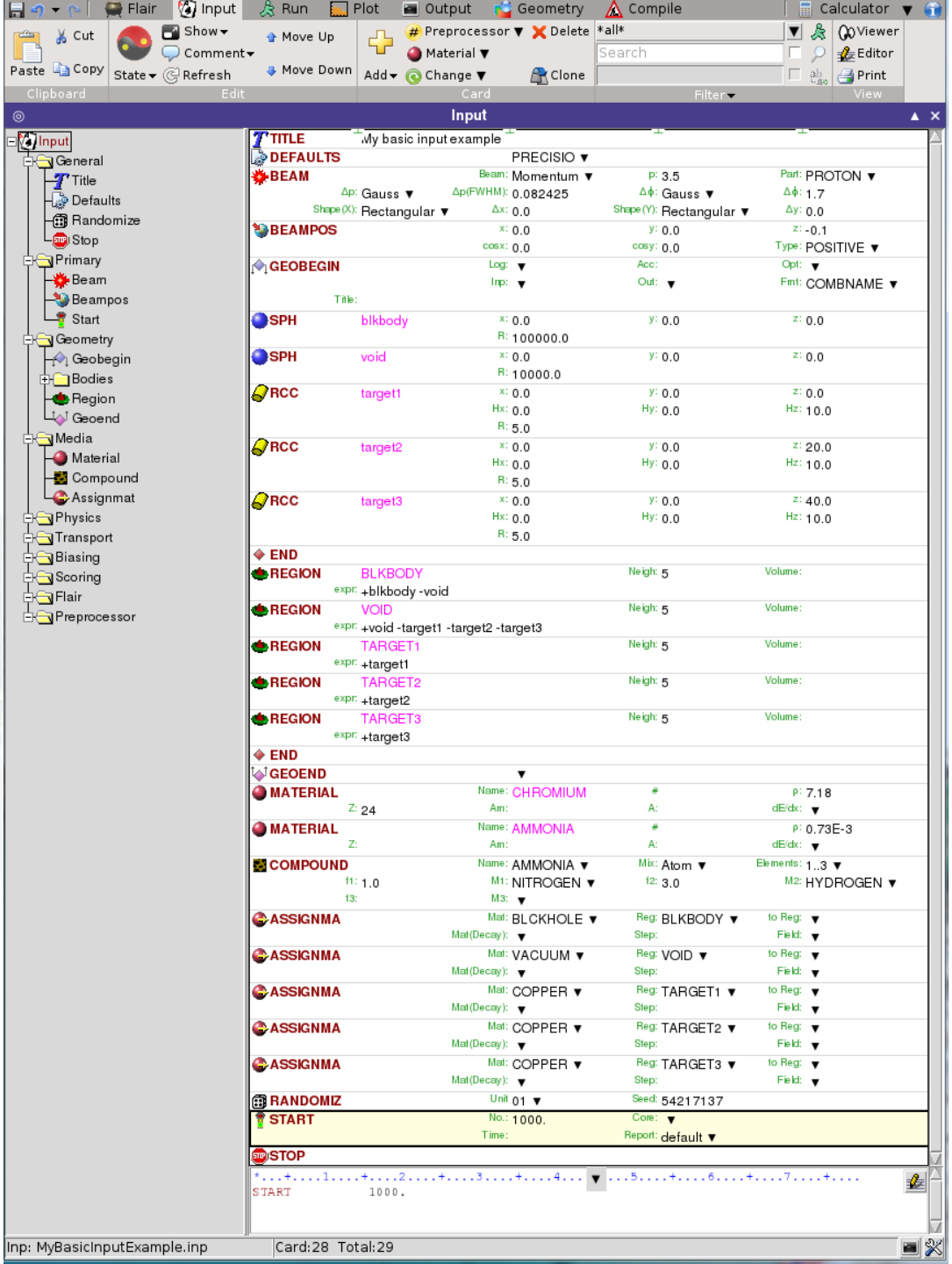
Names instead of numbers

- 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



A basic input card by card

A basic input: step 1: Physics settings

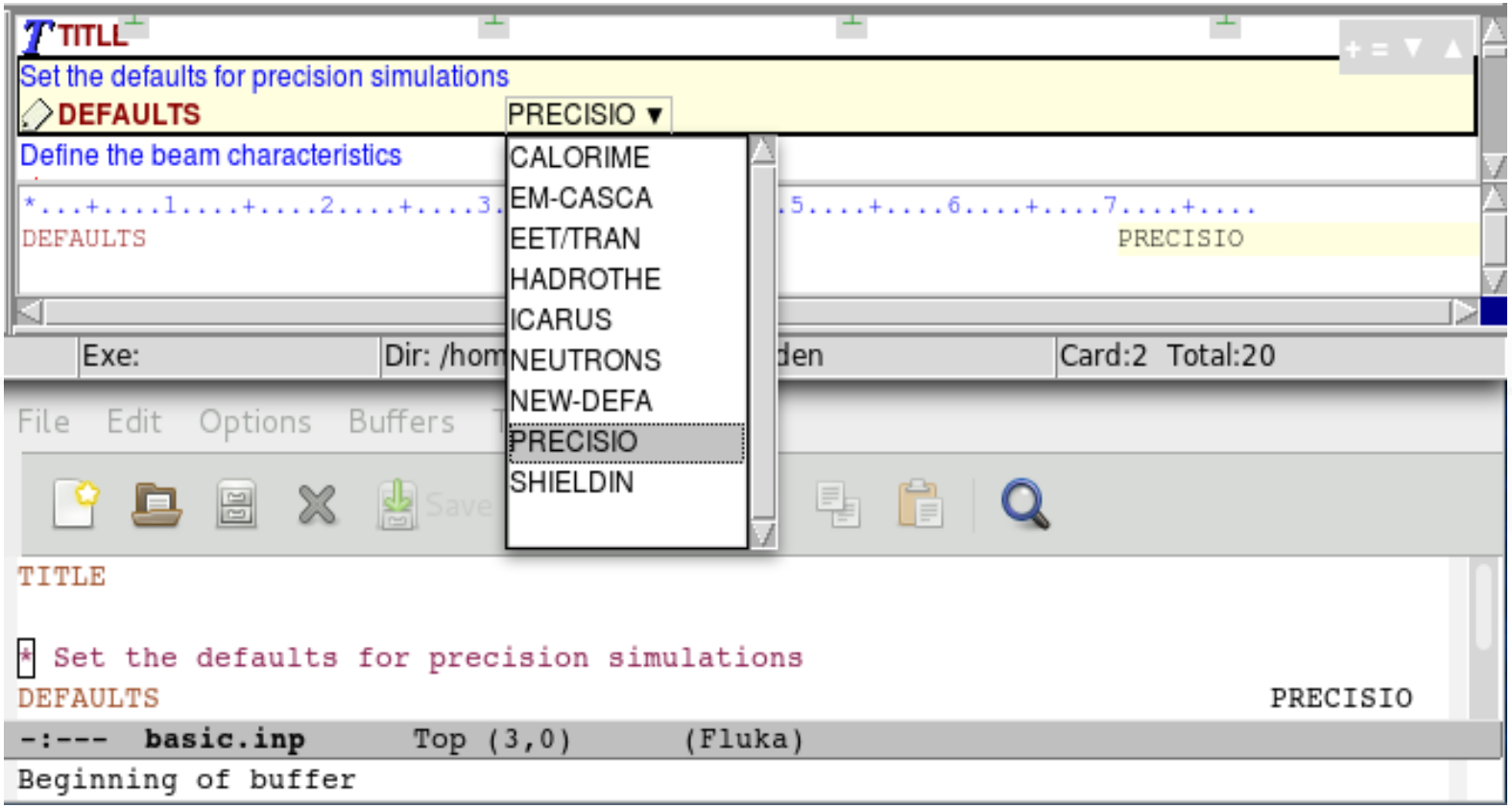
```
TITLE
My Basic Input example
* Set the defaults for precision simulations
DEFAULTS                                                              PRECISIO
* Define the beam characteristics
* ..+....1....+....2....+....3....+....4....+....5....+....6....+....7..
BEAM             3.5 -0.082425      -1.7       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
```

TITLE My Basic Input example
DEFAULTS PRECISIO ▼
BEAM Momentum ▼ p: 3.5 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
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 # ρ: 7.18
Z: 24.0 Am: A: dE/dx: ▼
MATERIAL Name: AMMONIA # ρ: 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
```

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                                                              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
```

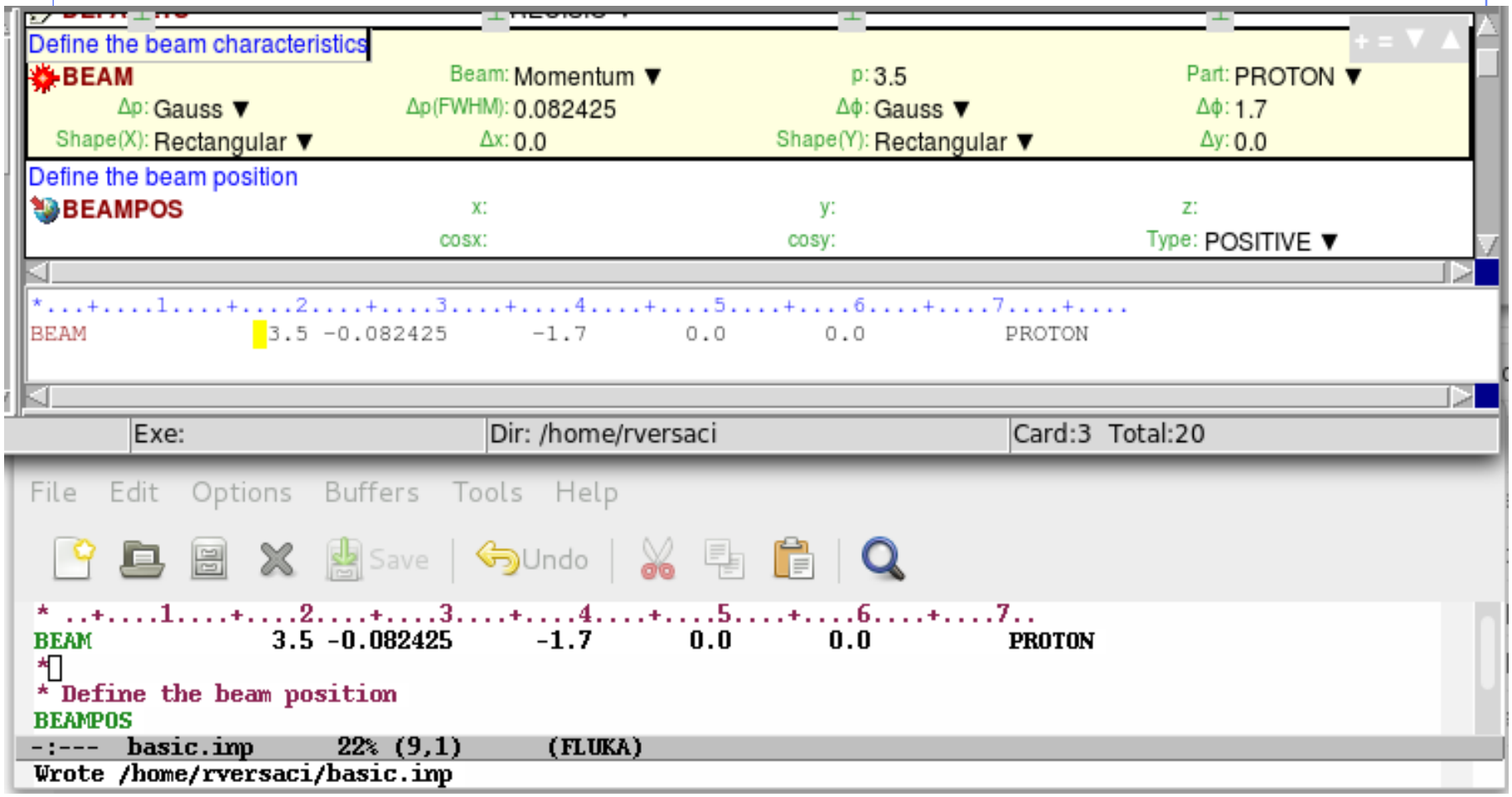
TITLE My Basic Input example
DEFAULTS PRECISIO
BEAM Beam: Momentum p: 3.5 Part: PROTON
Δp: Gauss Δp(FWHM): 0.082425 Δϕ: Gauss Δϕ: 1.7
Shape(X): Rectangular Δx: 0.0 Shape(Y): Rectangular Δy: 0.0
BEAMPOS x: 0.0 y: 0.0 z: -0.1
cosx: 0.0 cosy: 0.0 Type: POSITIVE
GEOBEGIN Log: Acc: Opt:
Inp: Out: Fmt: COMBNAME
Title:
SPH blkbody x: 0.0 y: 0.0 z: 0.0
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 # ρ: 7.18
Z: 24.0 Am: A: dE/dx:
MATERIAL Name: AMMONIA # ρ: 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
```

Beam definition: **BEAM**

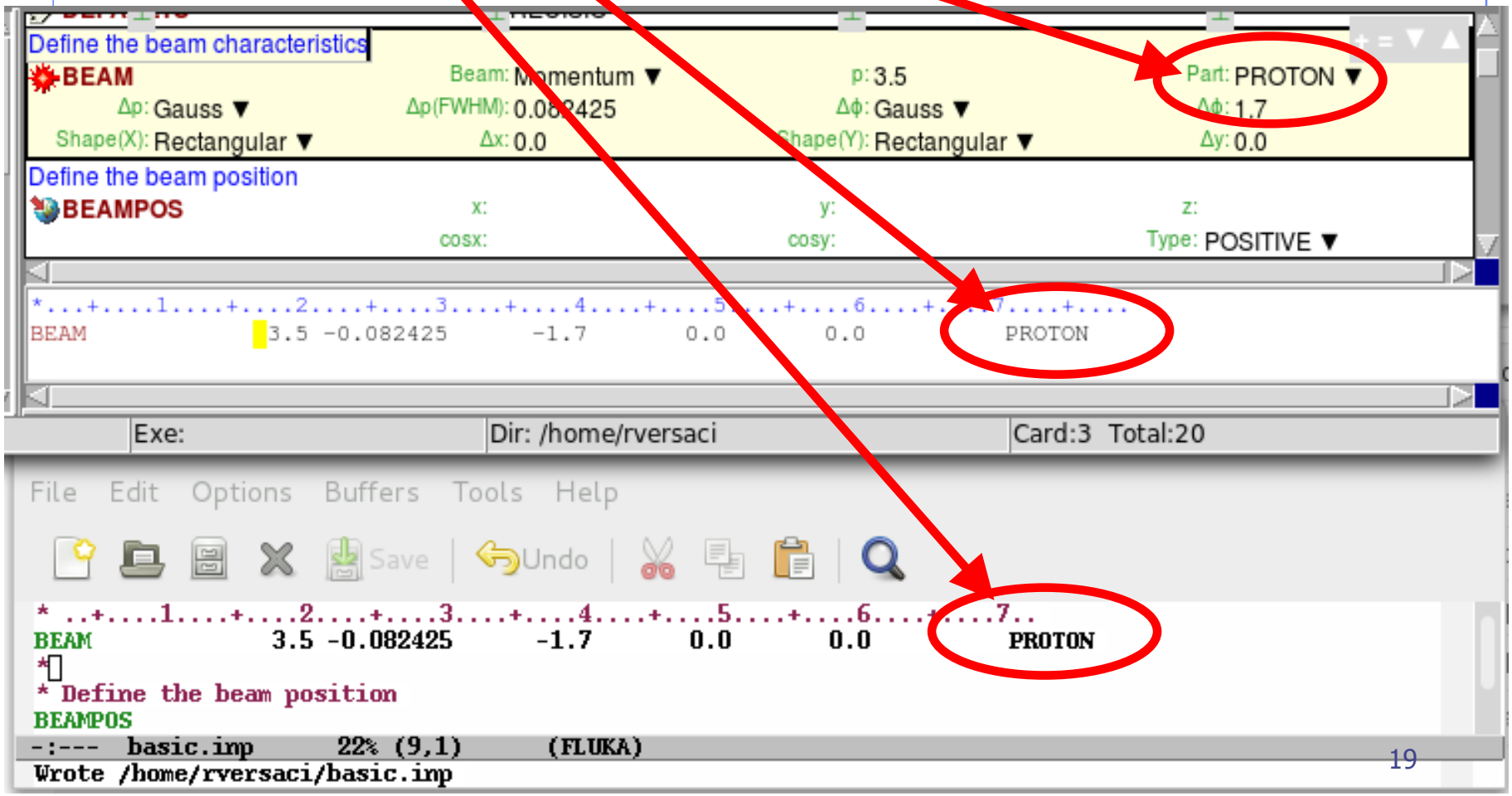
Defines beam characteristics: type of particle, energy or momentum, divergence, spatial profile....

Let's see an example



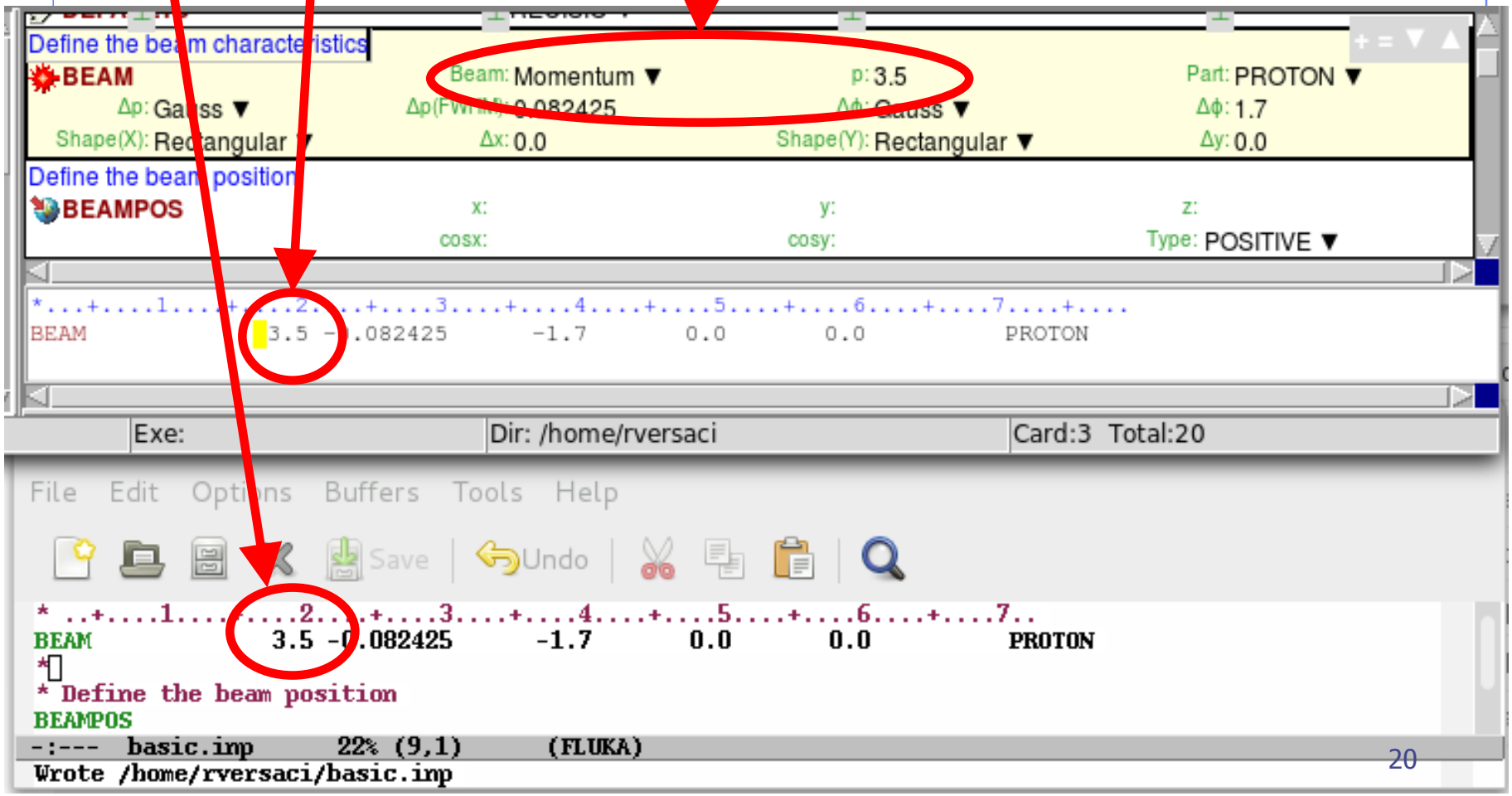
Beam definition: **BEAM**

[SDUM]: Proton beam



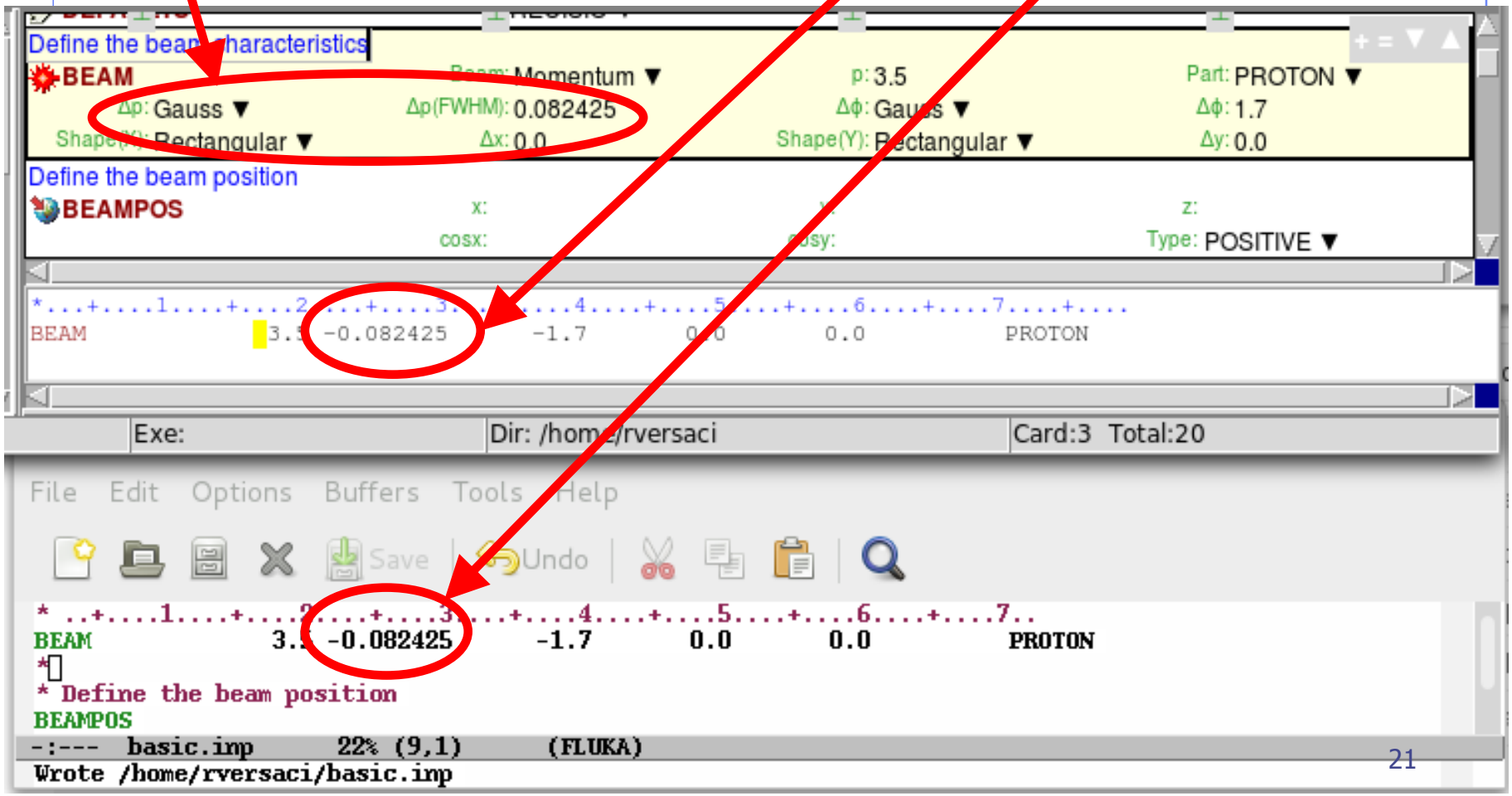
Beam definition: **BEAM**

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



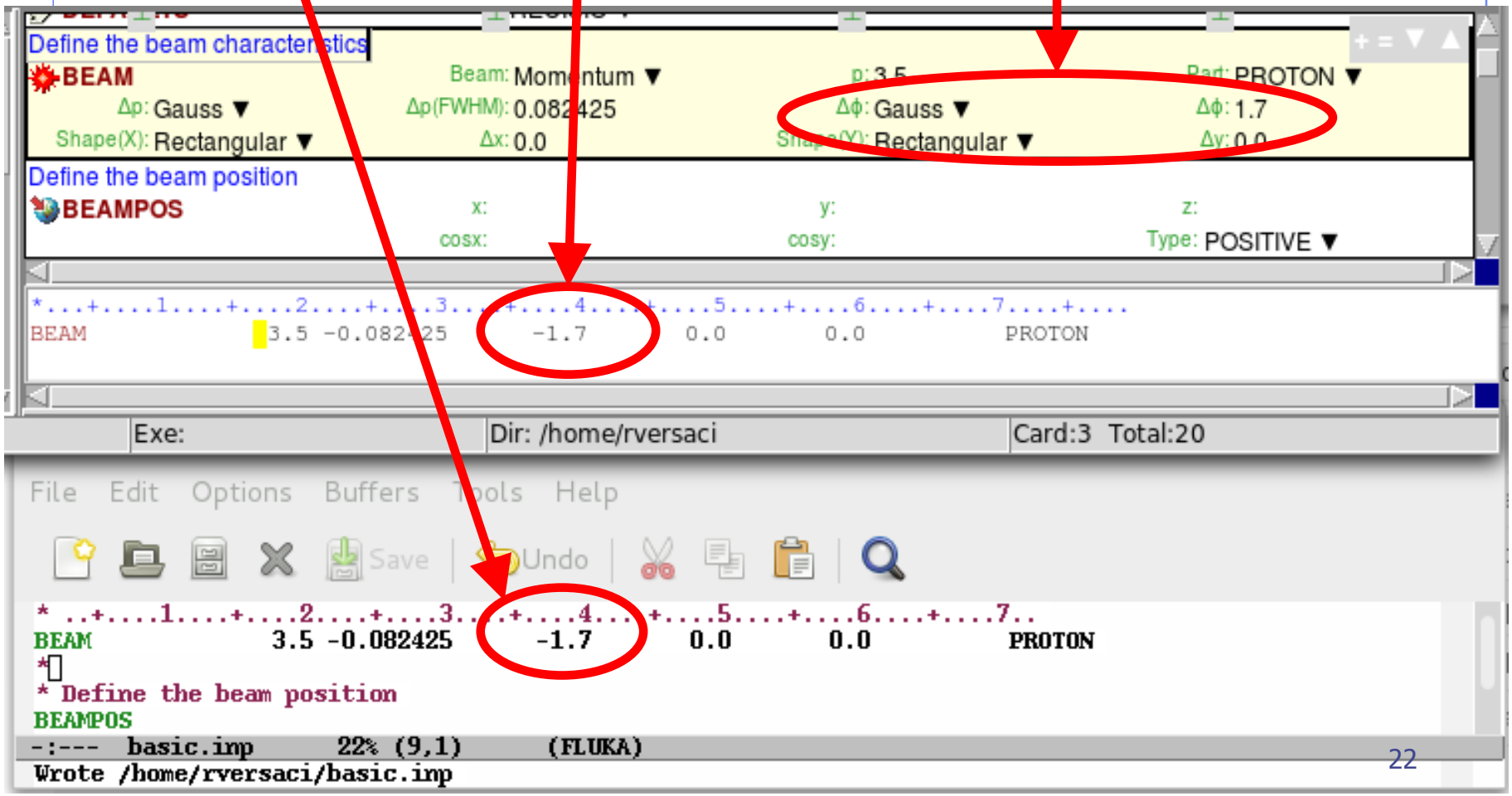
Beam definition: **BEAM**

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



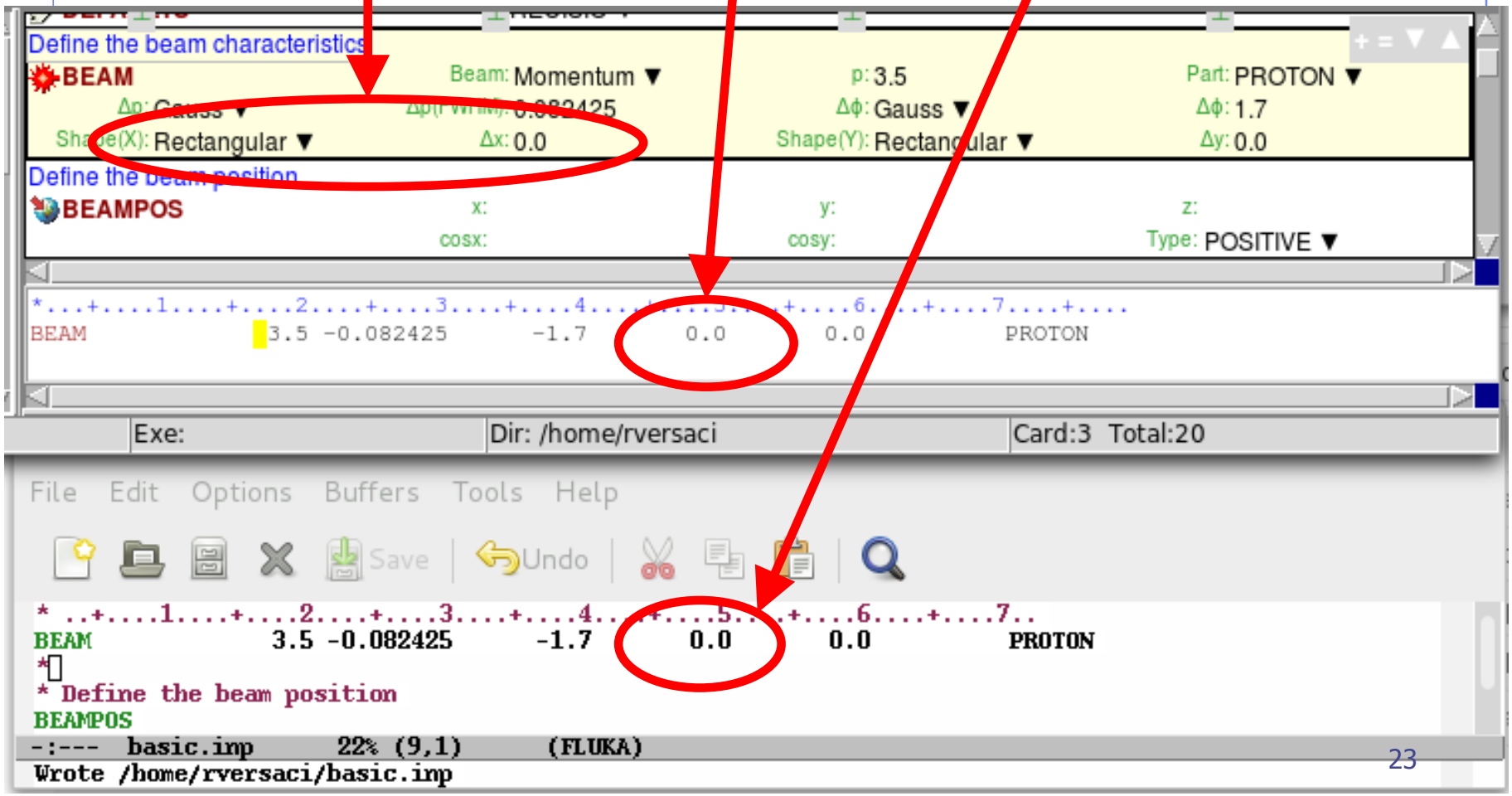
Beam definition: **BEAM**

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



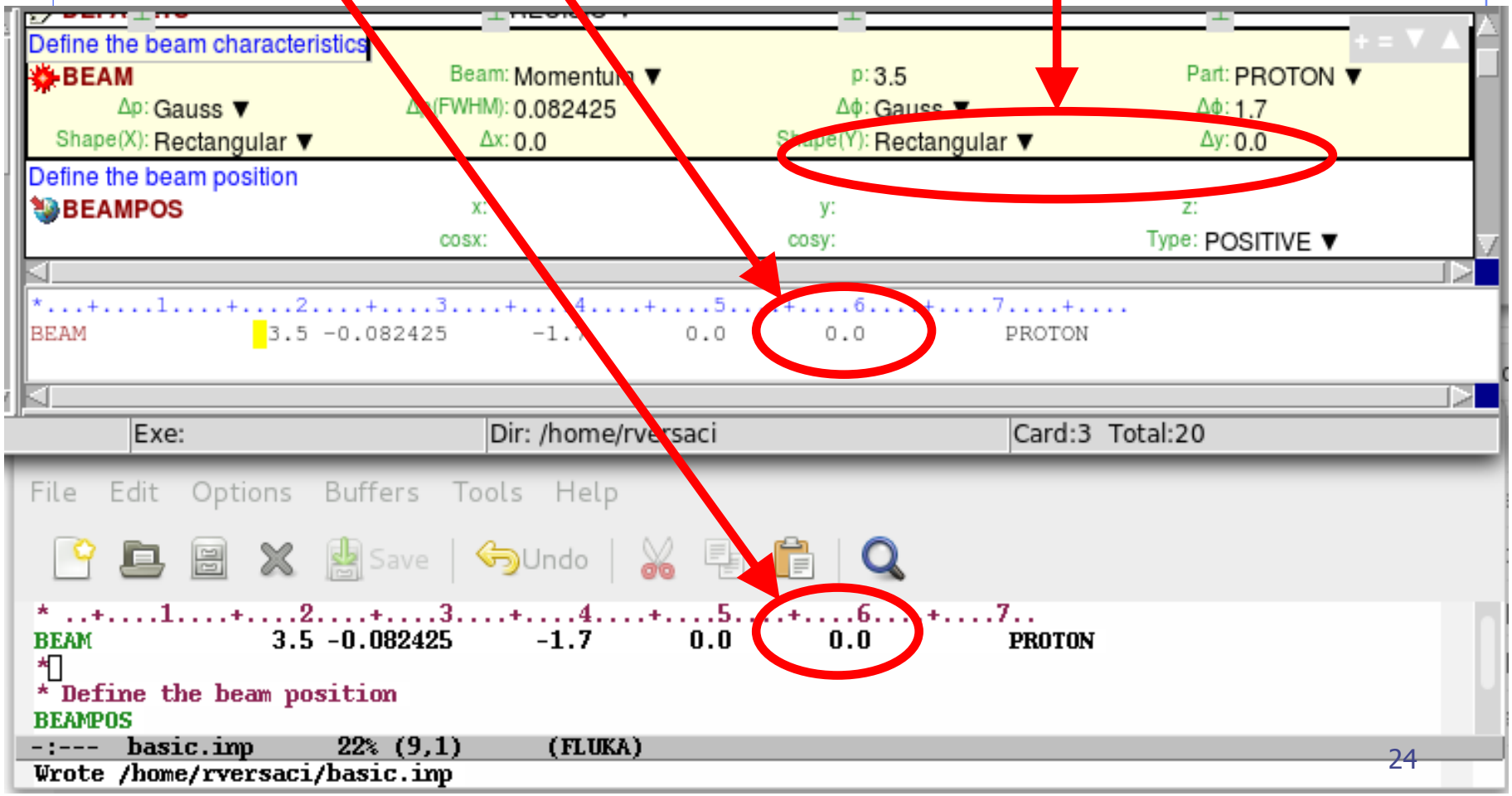
Beam definition: **BEAM**

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



Beam definition: **BEAM**

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

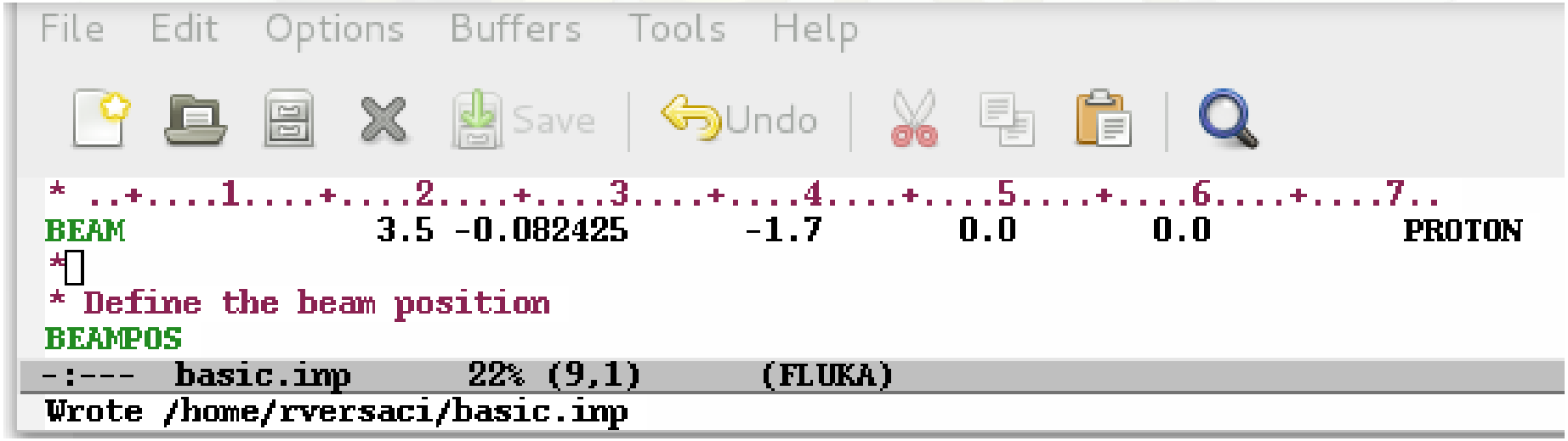


Beam definition: **BEAM**

defines beam characteristics:

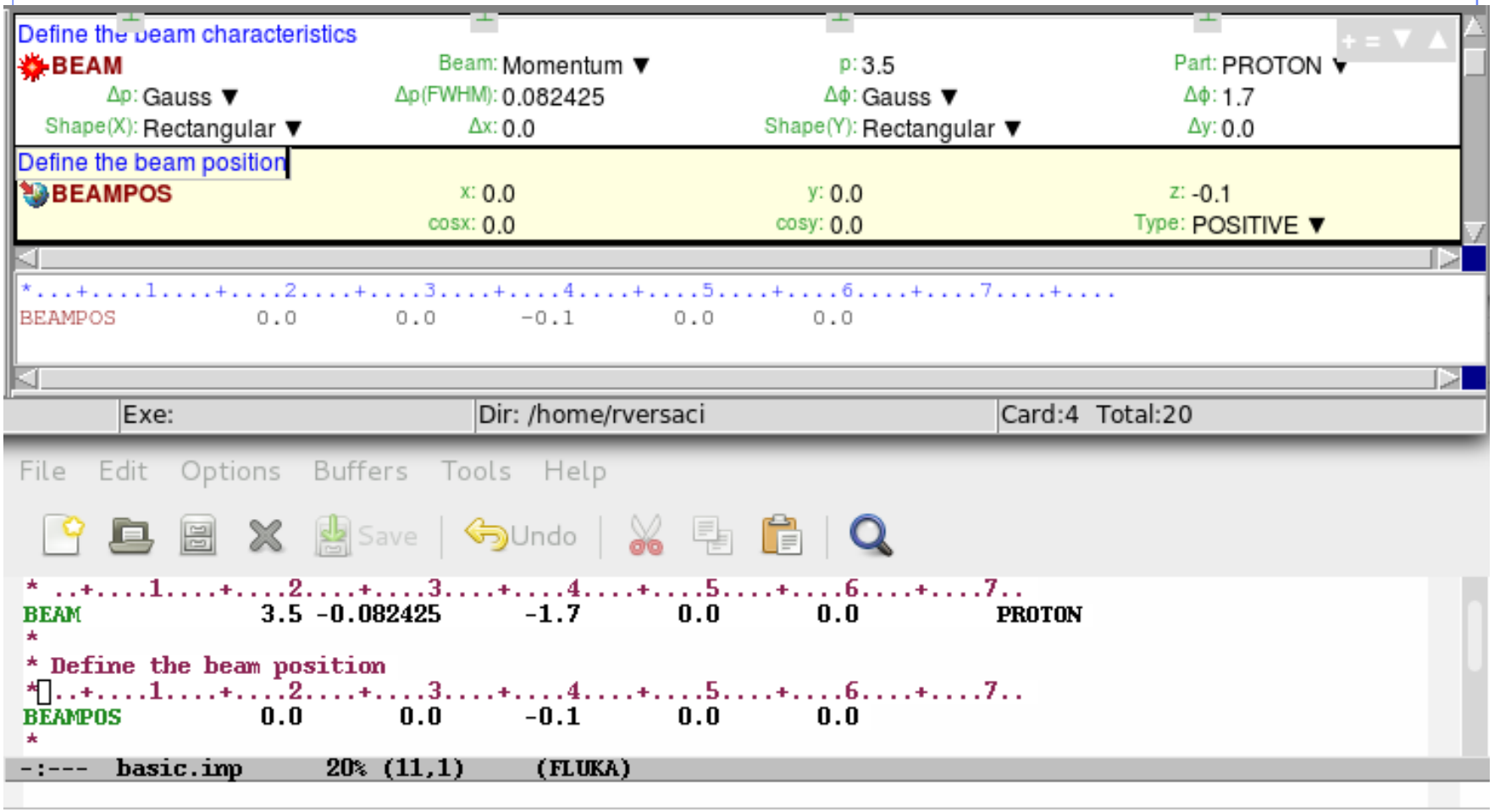
type of particle, energy, divergence, spatial profile....

- [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)



Beam definition: **BEAMPOS**

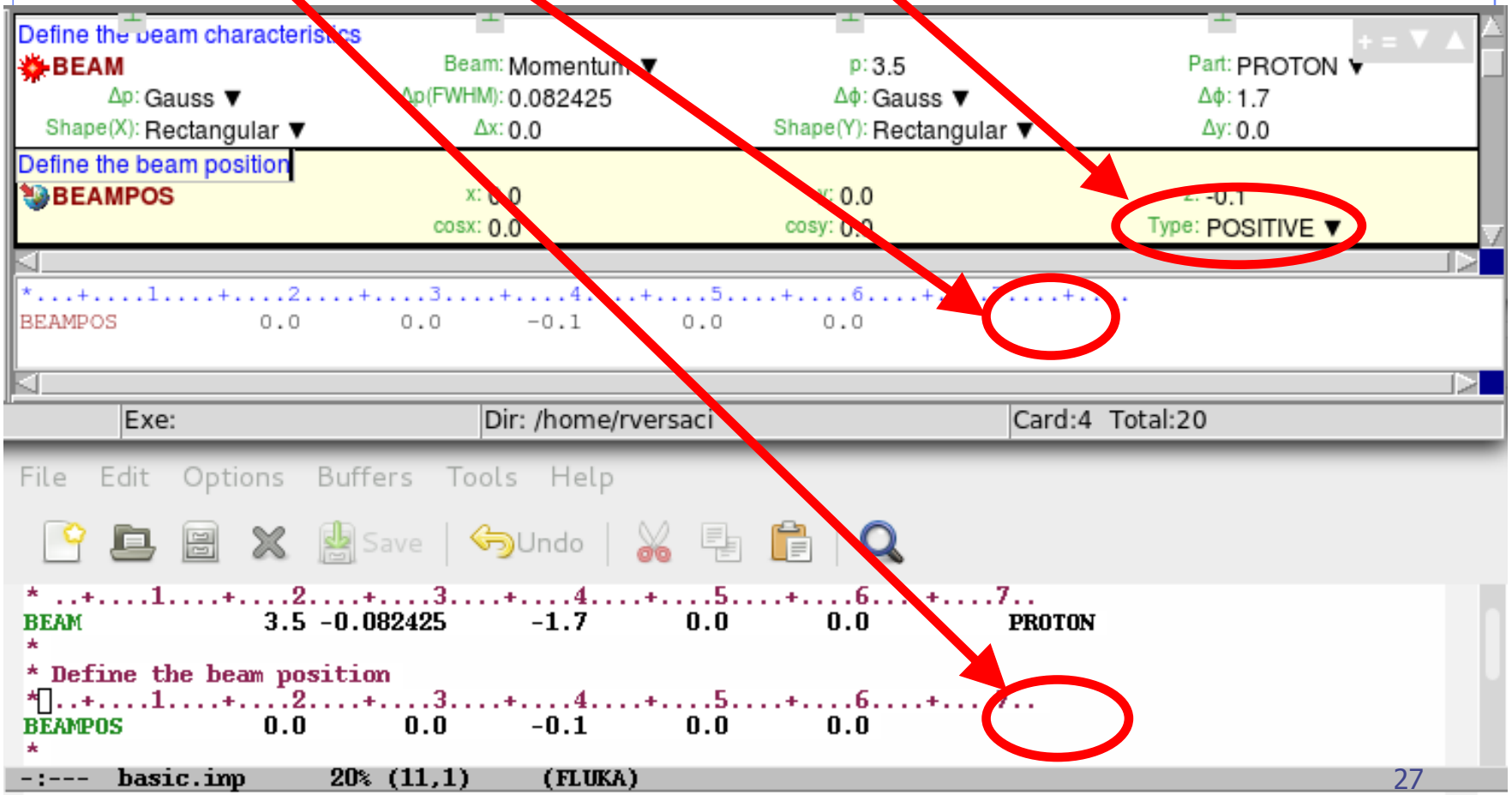
Defines beam position and direction



Beam definition: **BEAMPOS**

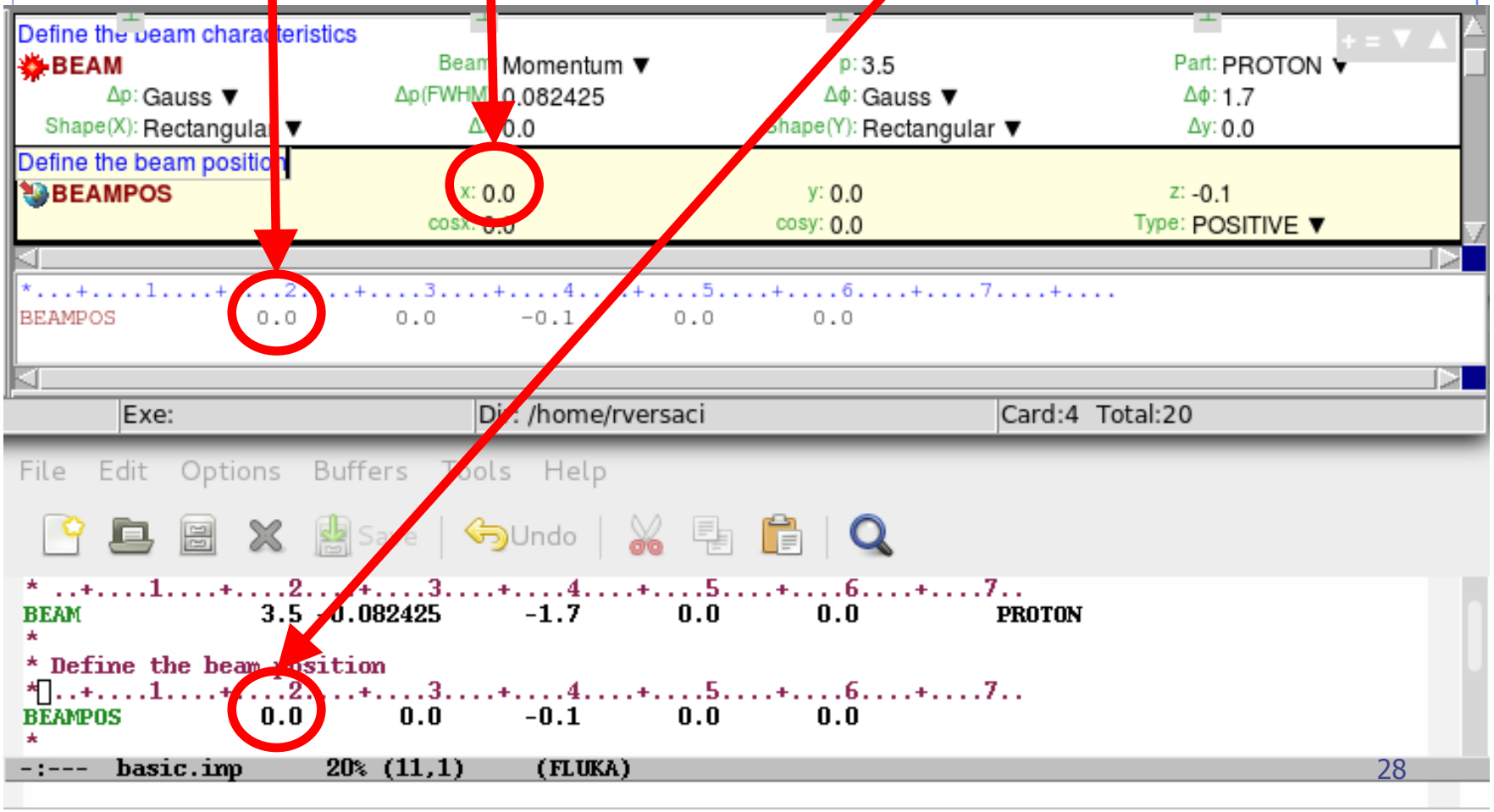
[SDUM]: beam direction along Z

By default toward positive Z



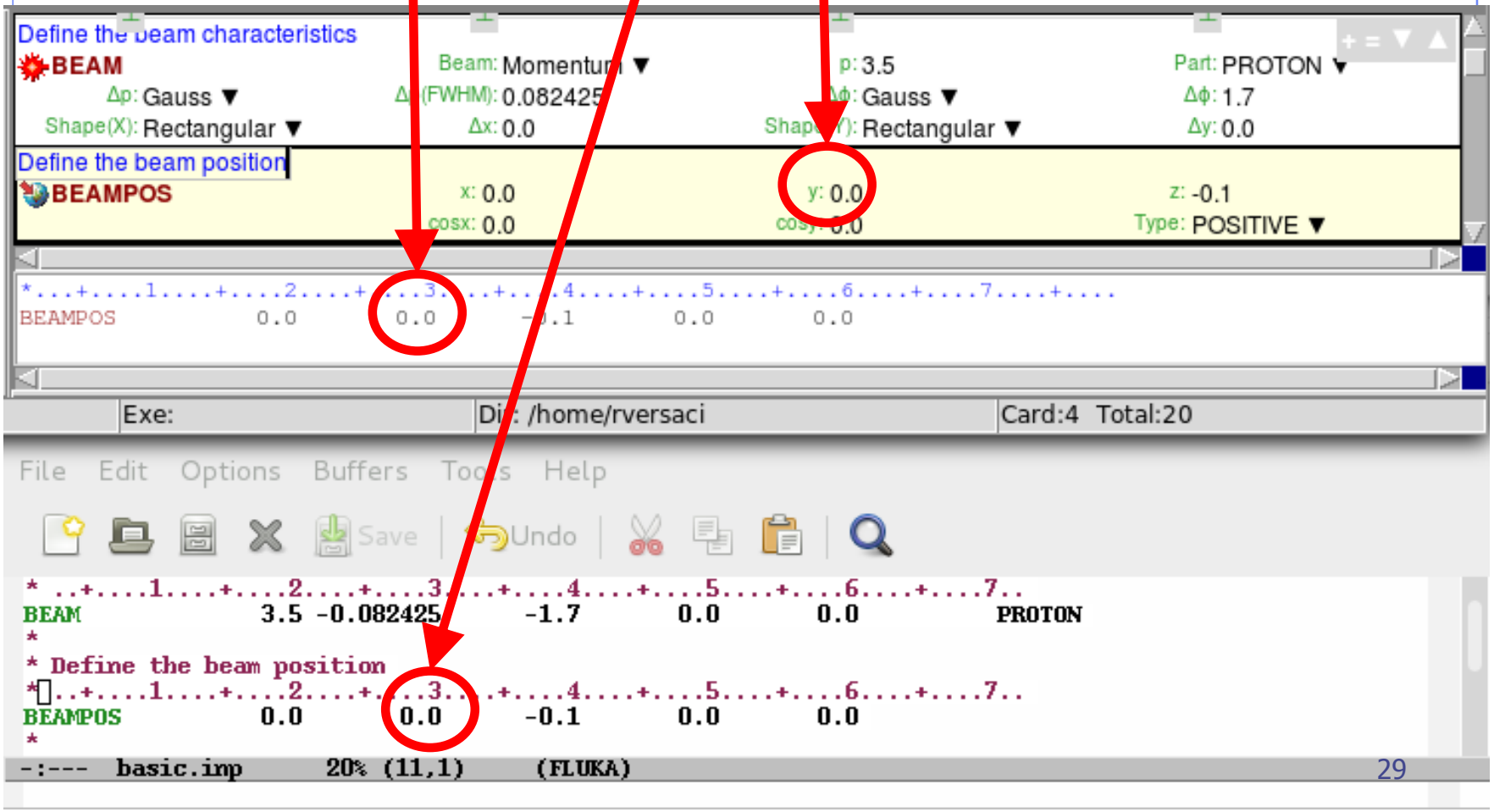
Beam definition: **BEAMPOS**

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



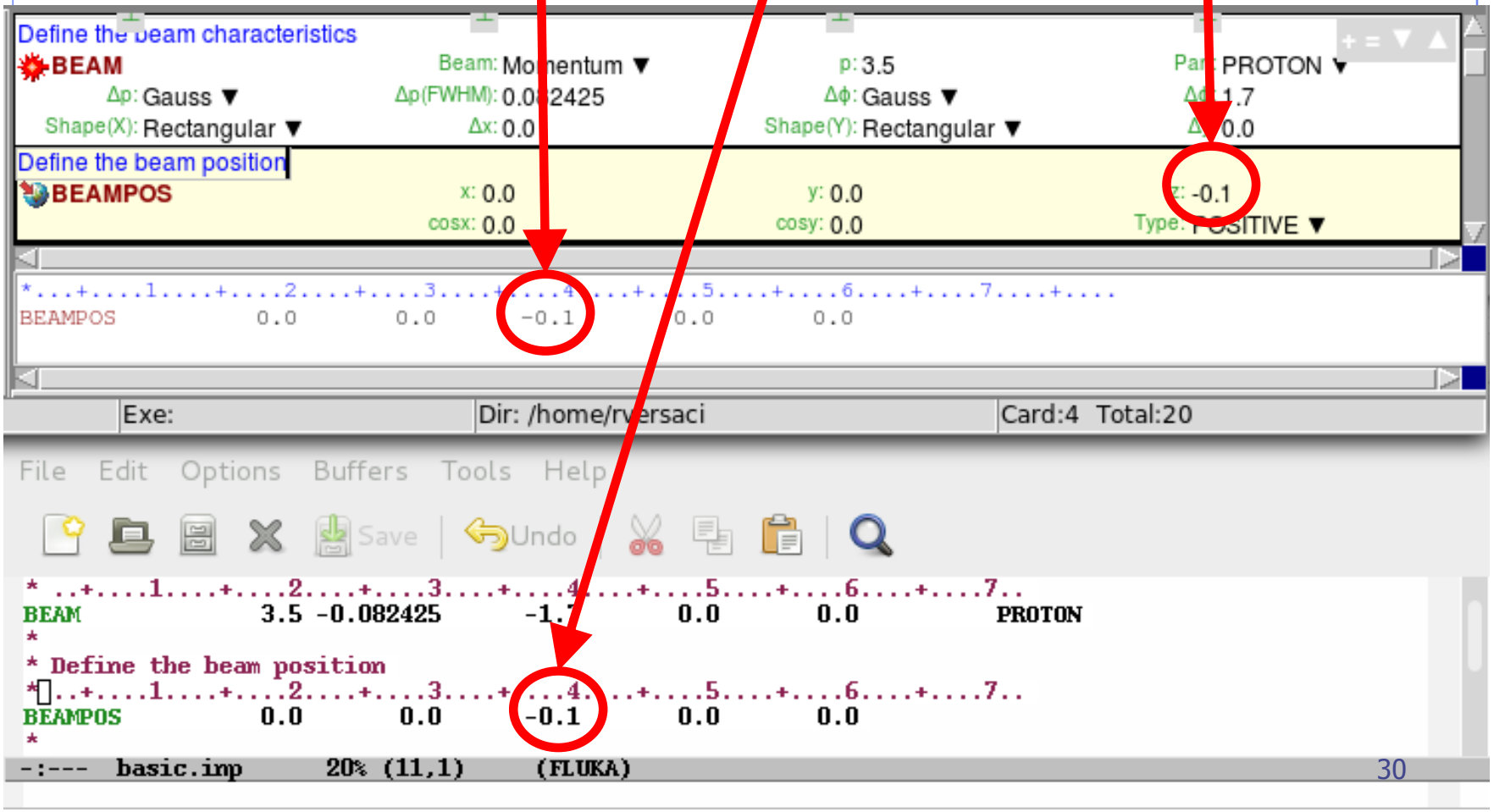
Beam definition: **BEAMPOS**

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



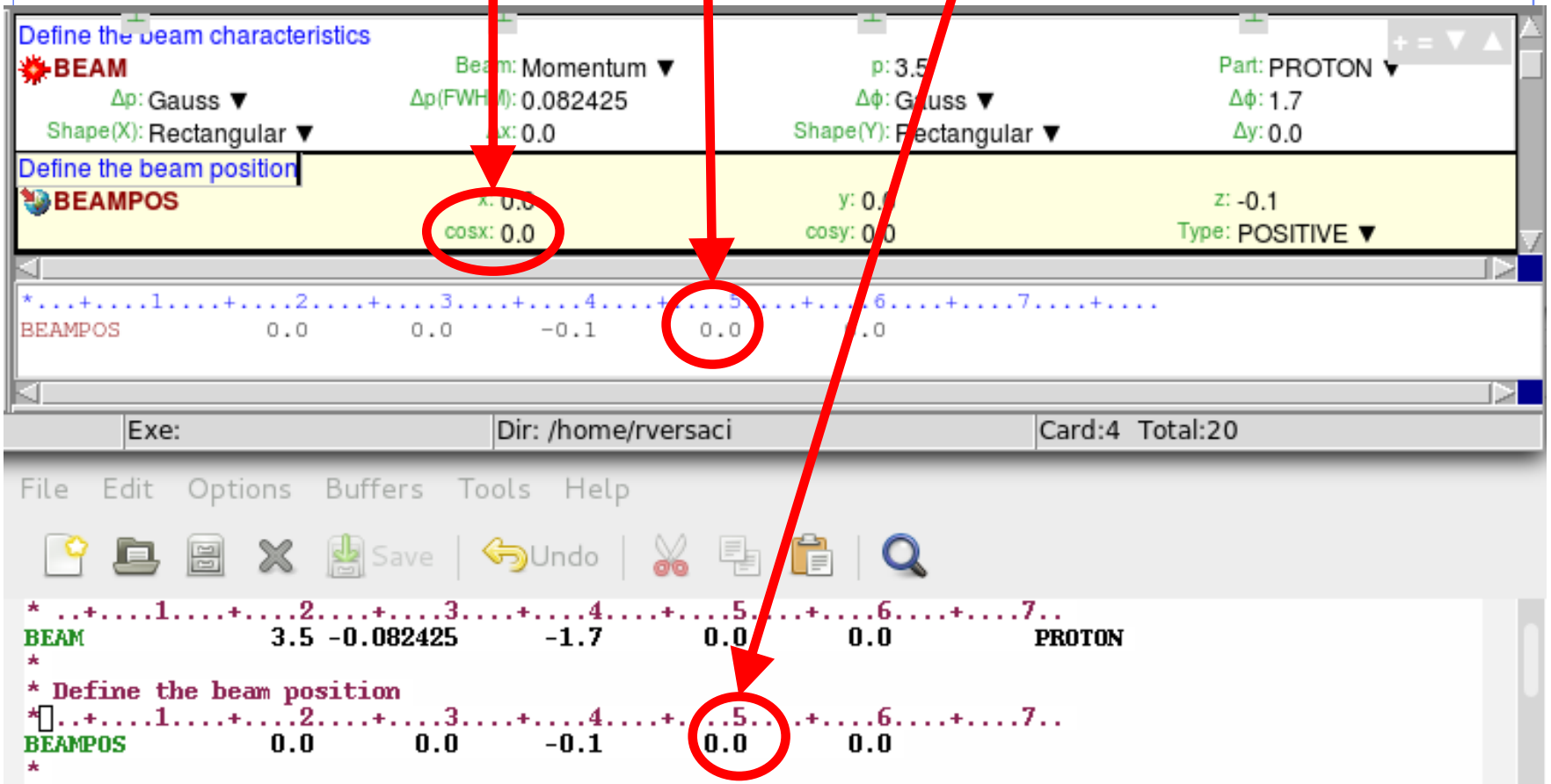
Beam definition: **BEAMPOS**

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



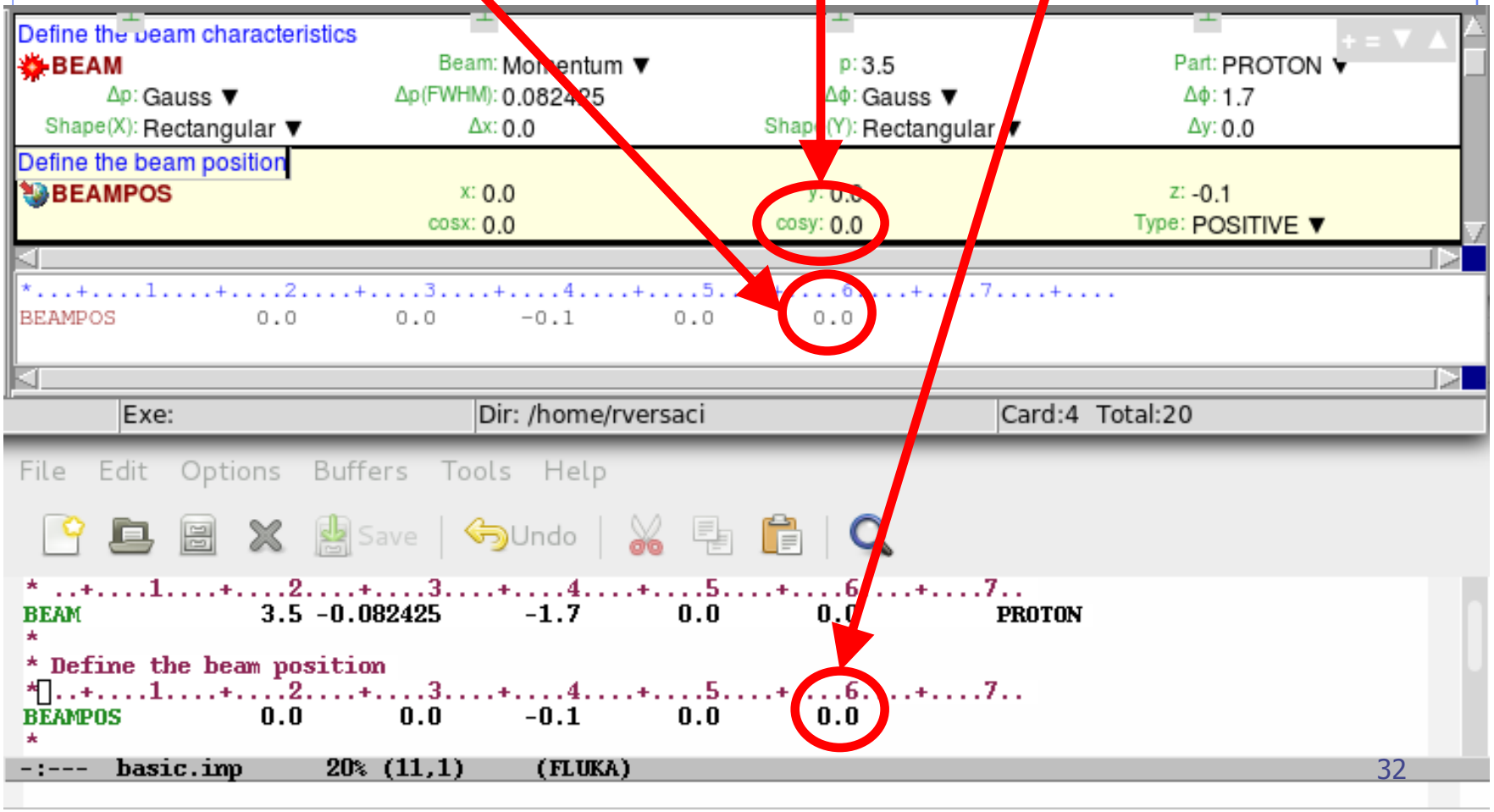
Beam definition: **BEAMPOS**

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



Beam definition: **BEAMPOS**

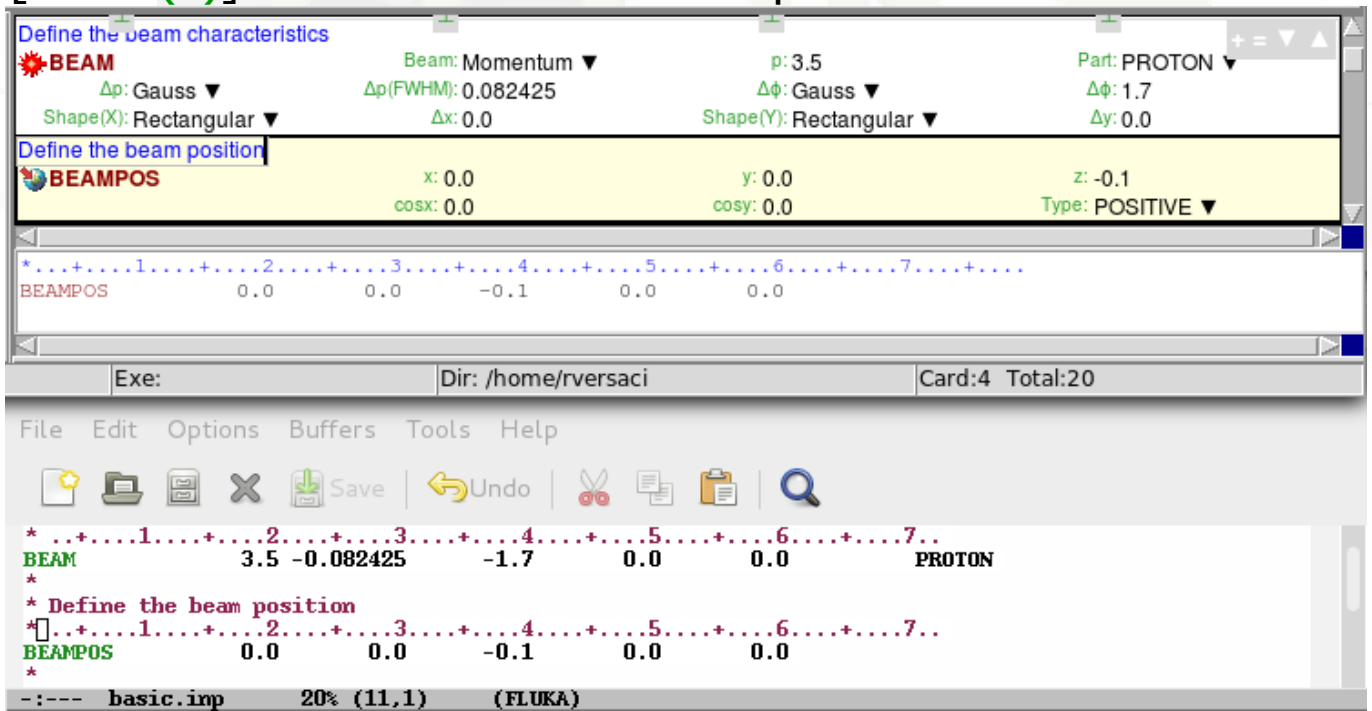
[WHAT(5)]: direction cosine with respect to the Y axis



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

* Set the random number seed
* ..+....1....+....2....+....3....+....4....+....5....+....6....+....7..
RANDOMIZ         1.0 54217137.
*
* Set the number of primary histories to be simulated in the run
* ..+....1....+....2....+....3....+....4....+....5....+....6....+....7..
START          1000.
STOP
```

TITLE My Basic Input example
DEFAULTS PRECISIO ▼
BEAM Beam: Momentum ▼ p: 3.5 Part: PROTON ▼
Δp: 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
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 # ρ: 7.18
Z: 24.0 Am: A: dE/dx: ▼
MATERIAL Name: AMMONIA # ρ: 0.73E-3
dE/dx: ▼
Elements: 1..3 ▼
M2: HYDROGEN ▼
to Reg: ▼
Field: ▼
to Reg: ▼
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

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                                                              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
```

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
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 # ρ: 7.18
Z: 24.0 Am: A: dE/dx: ▼
MATERIAL Name: AMMONIA # ρ: 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
```

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)

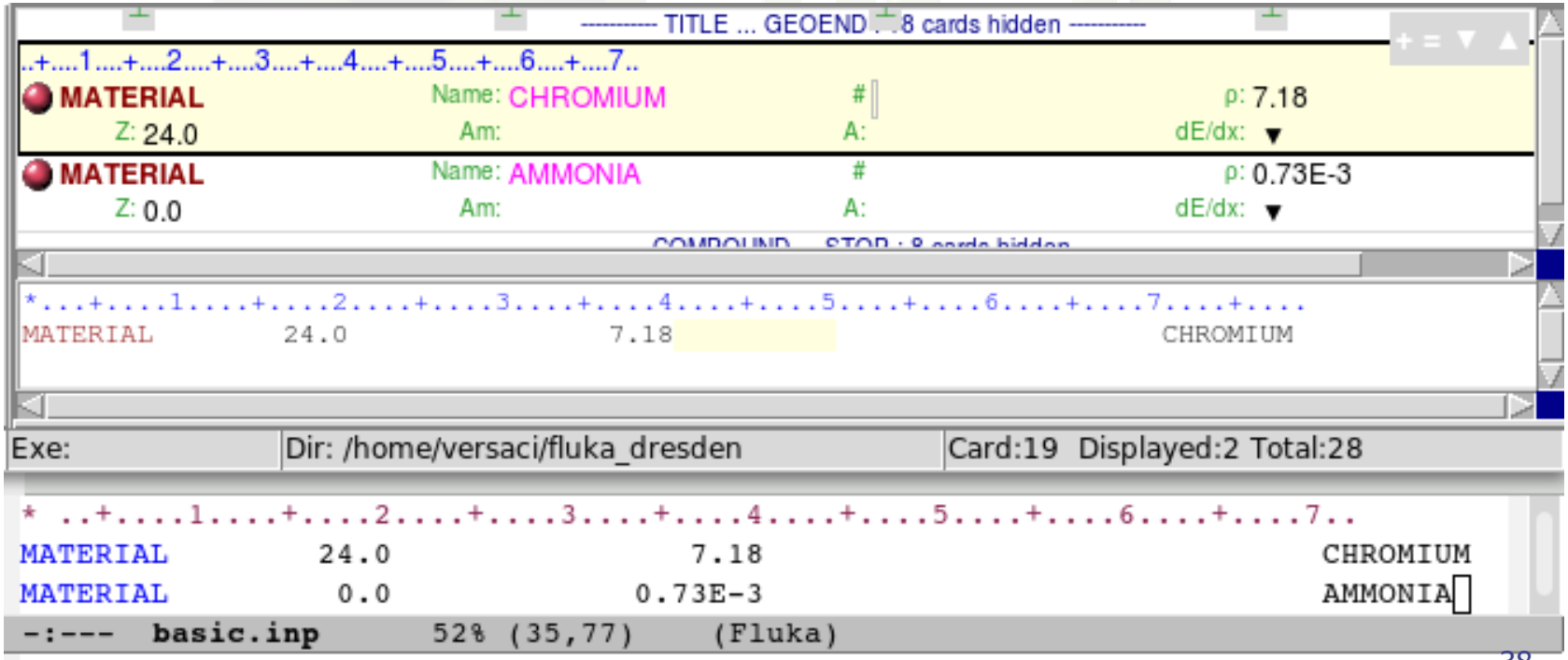
12 compound materials with the composition suggested by ICRU are predefined as well (again, check the manual!)

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**

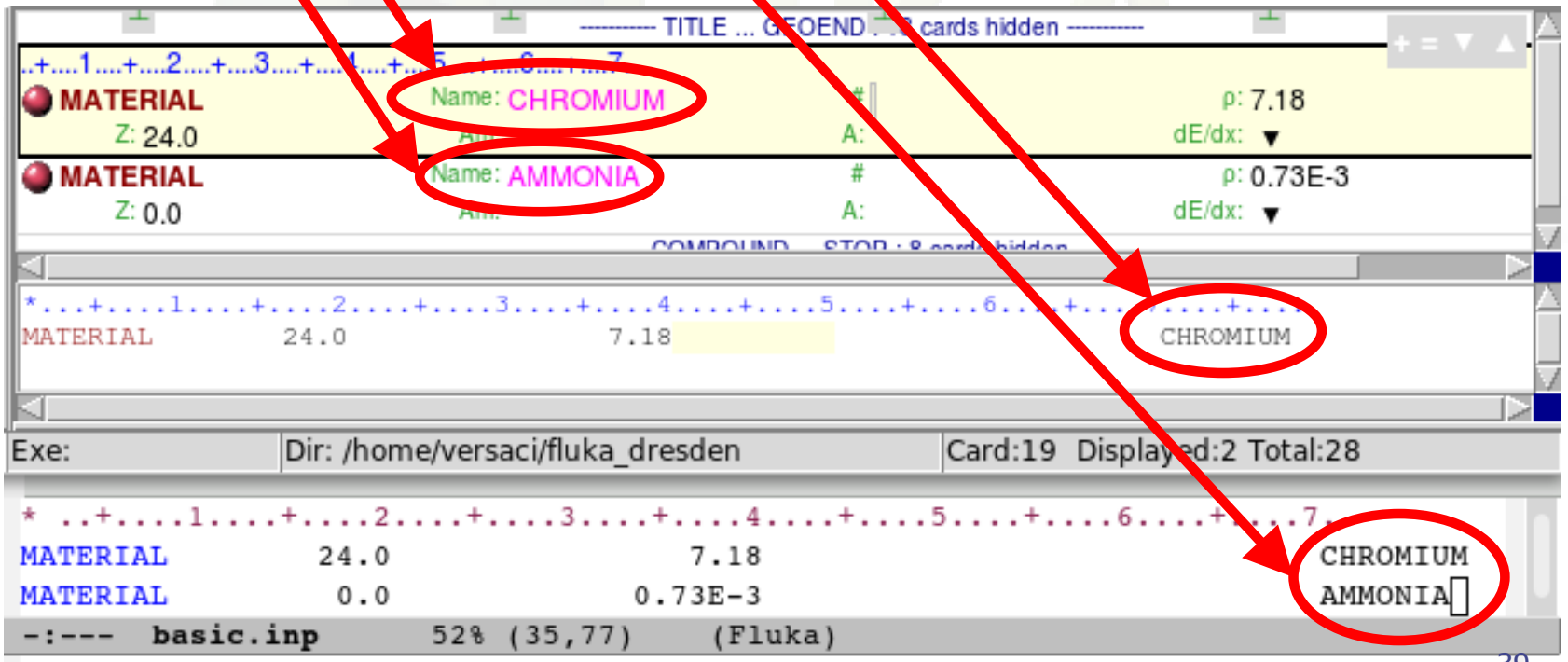
Defines a new material or override a previous one



Material definition: **MATERIAL**

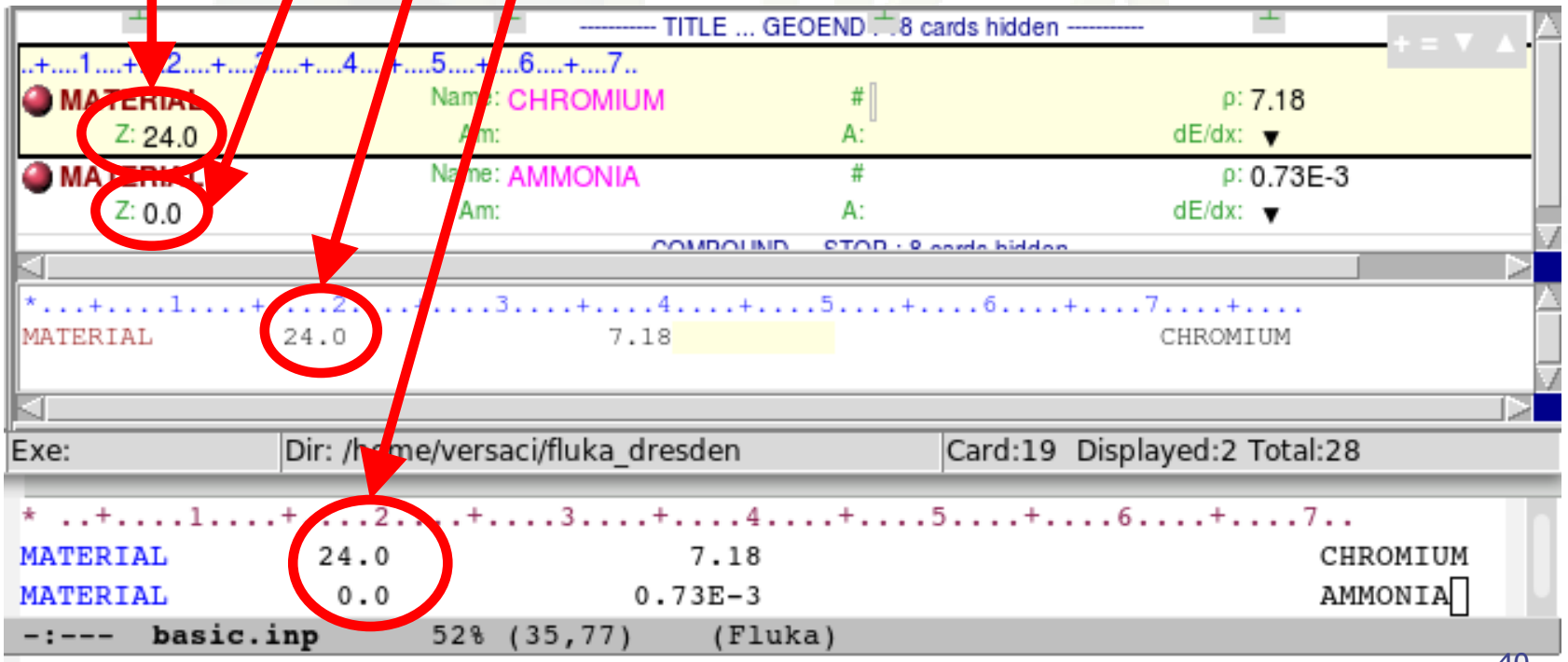
[SDUM]: material name

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



Material definition: **MATERIAL**

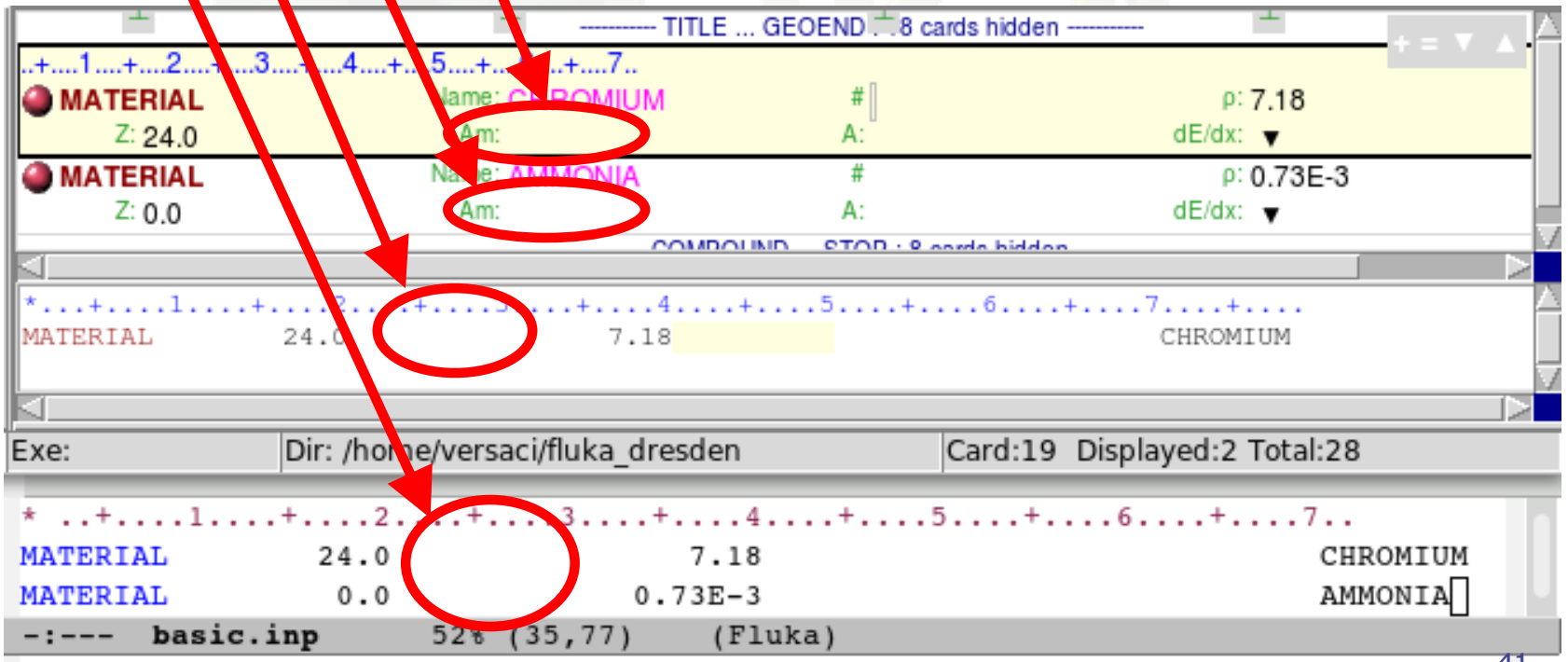
[WHAT(1)]: atomic number Z



Material definition: **MATERIAL**

[WHAT(2)]: atomic weight

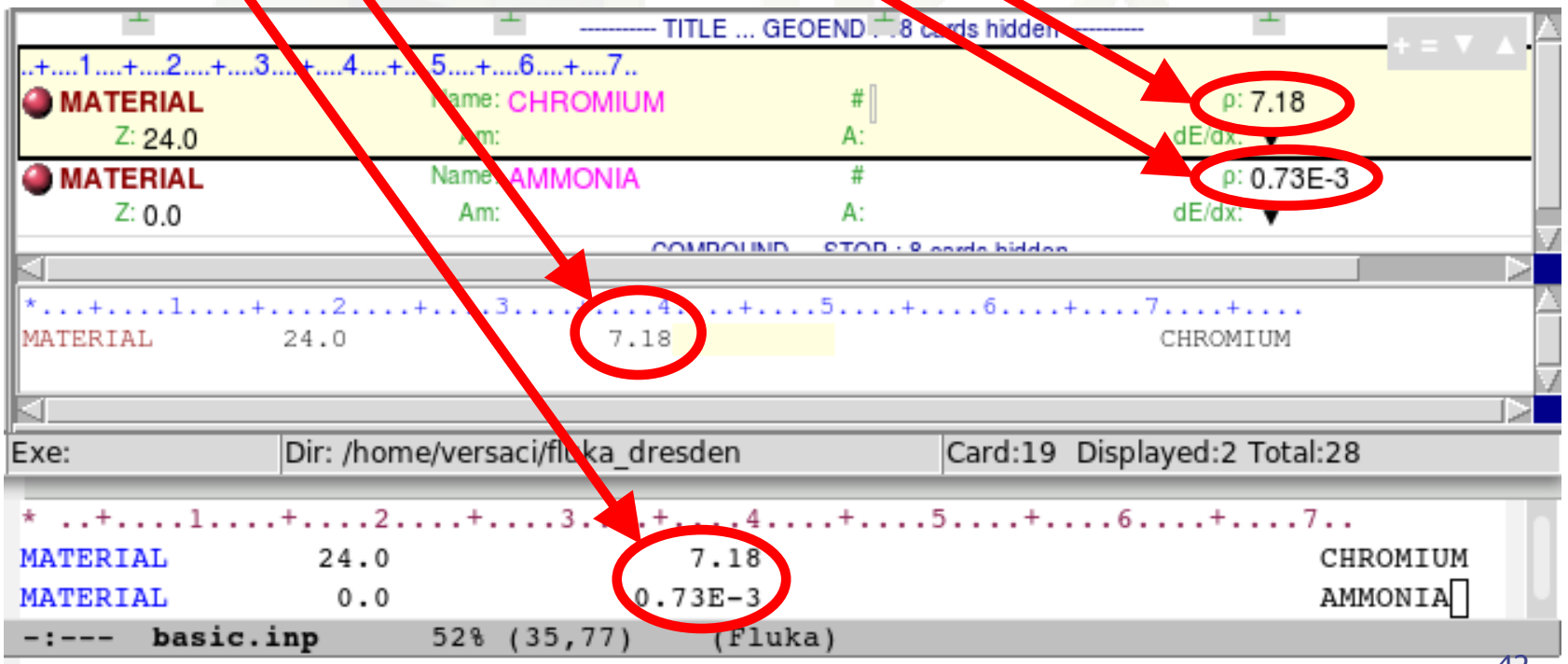
Calculated by the code using its internal database: **leave it empty**



Material definition: **MATERIAL**

[WHAT(3)]: density [g/cm³]

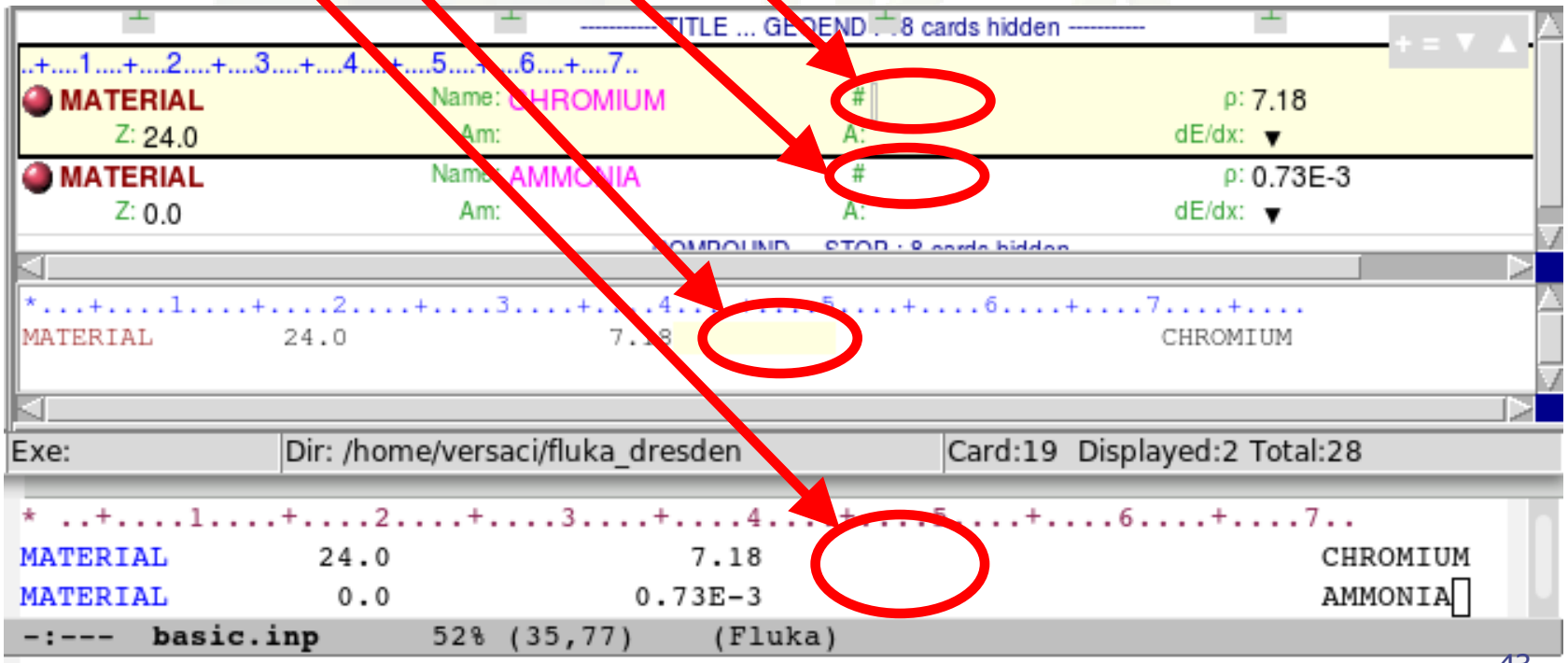
If $\rho < 0.01$ g/cm^3: the material is assumed to be a gas



Material definition: **MATERIAL**

[WHAT(4)]: material number

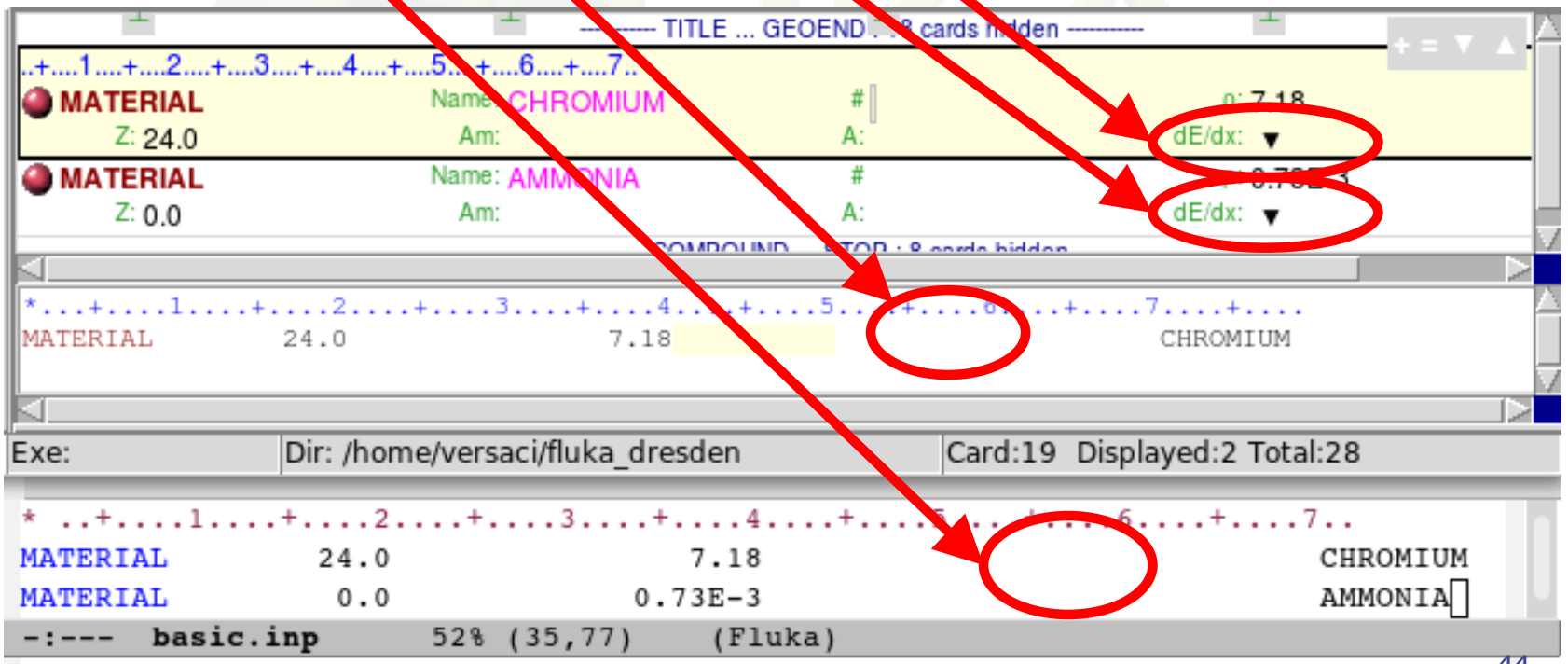
Available for backward compatibility:
leave it empty



Material definition: **MATERIAL**

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

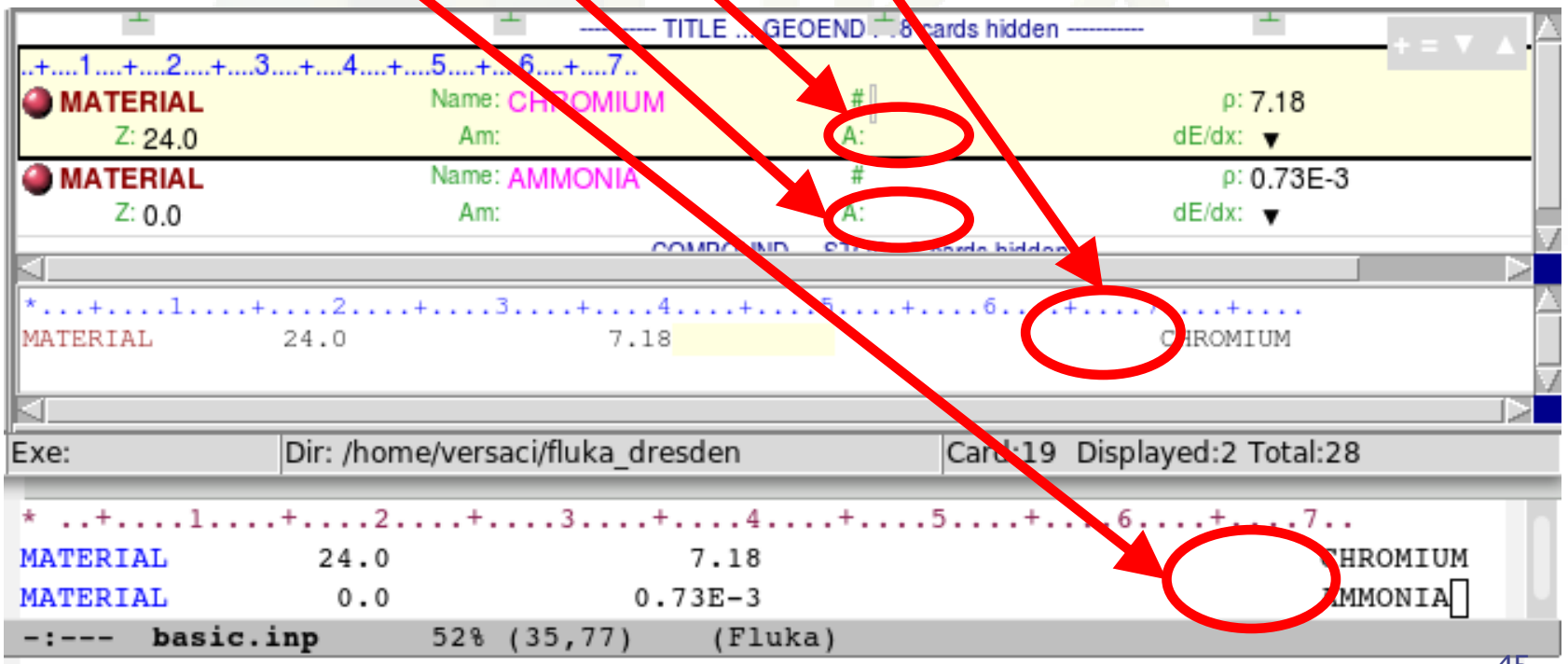
normally empty



Material definition: **MATERIAL**

[WHAT(6)]: mass number A

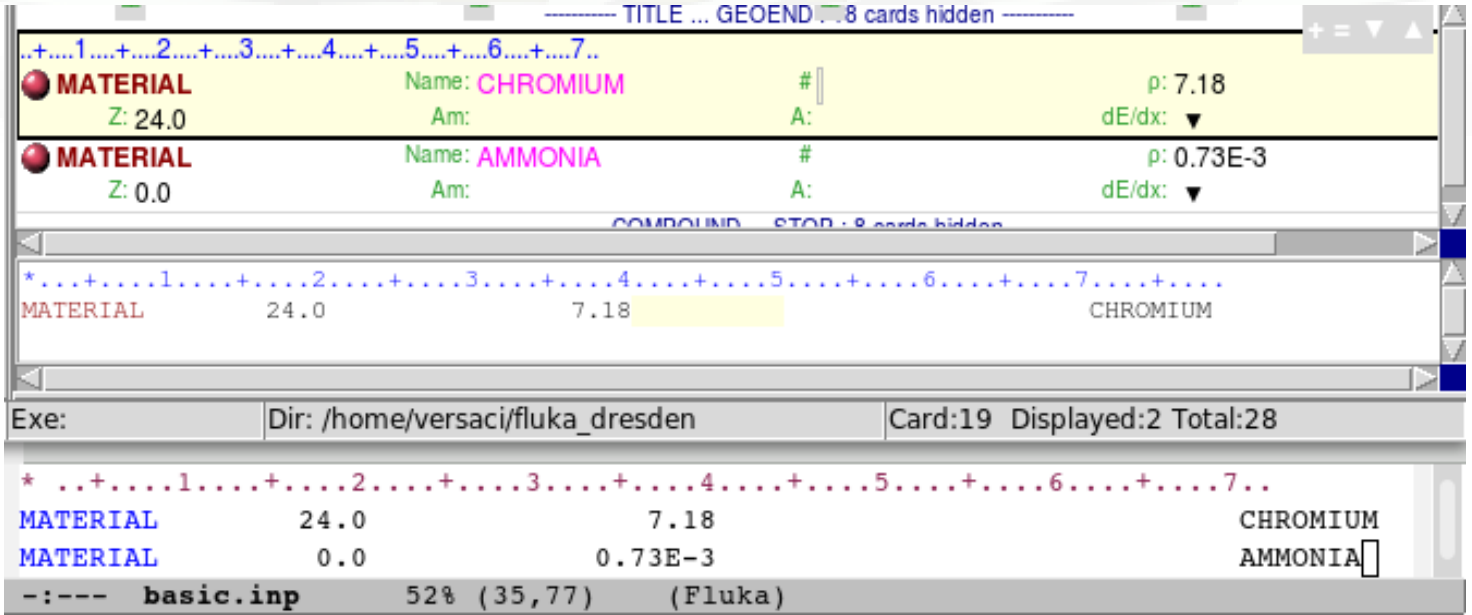
normally empty
unless a specific isotope is desired



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/cm^3]
- [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**)

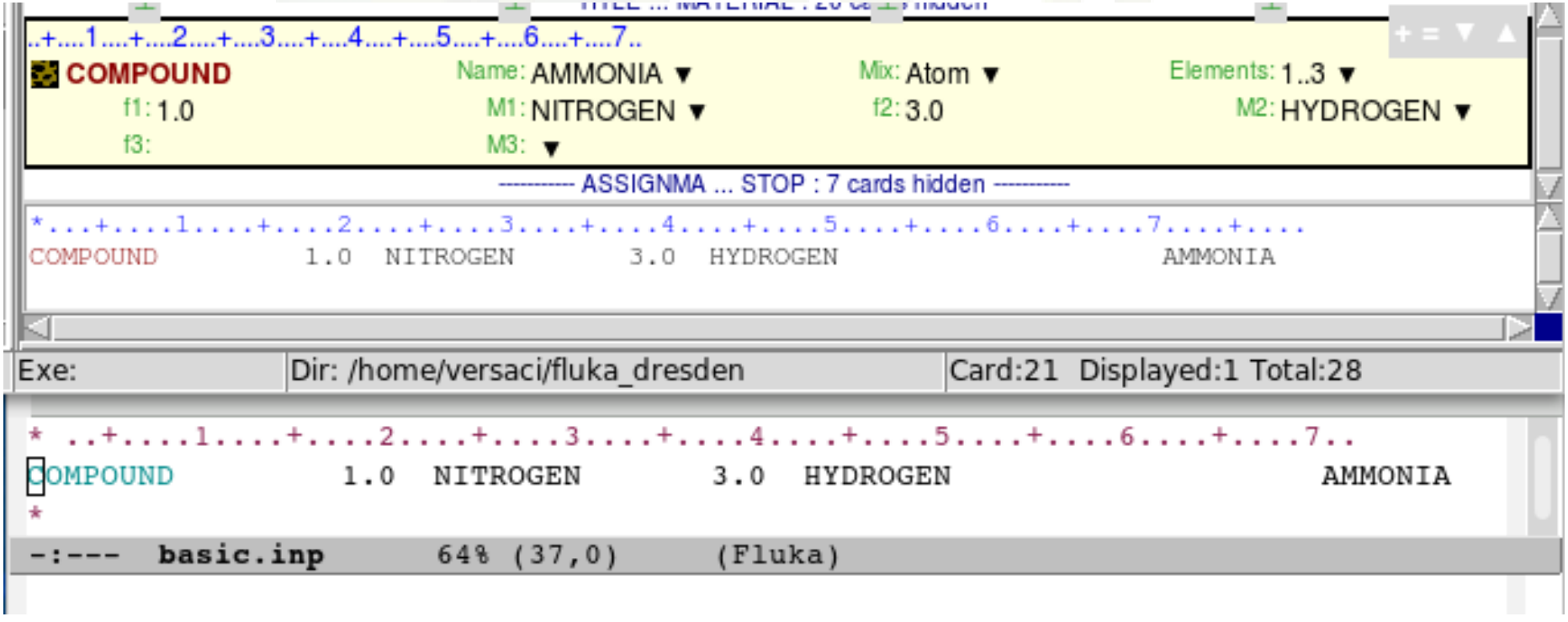


Material definition: COMPOUND

Defines a new compound

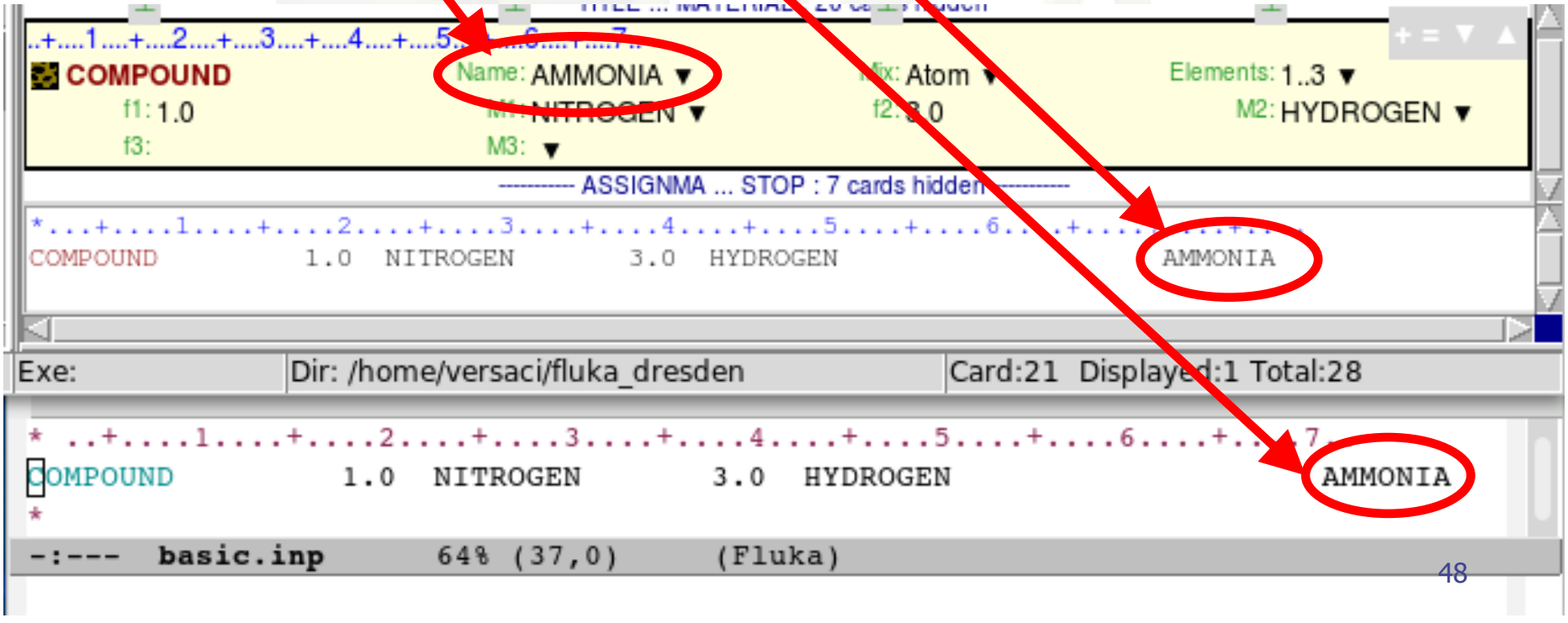
Each **COMPOUND** card must be associated to a **MATERIAL** card

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



Material definition: COMPOUND

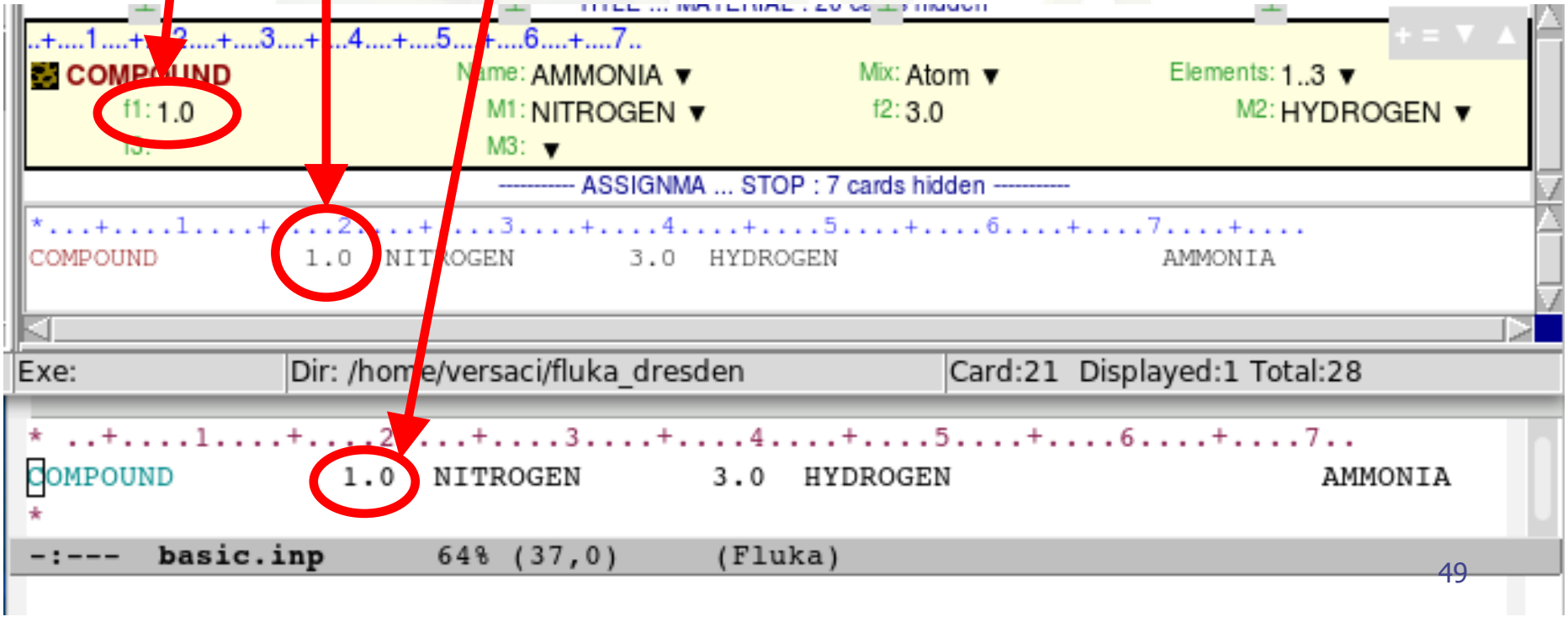
[SDUM]: compound name



Material definition: COMPOUND

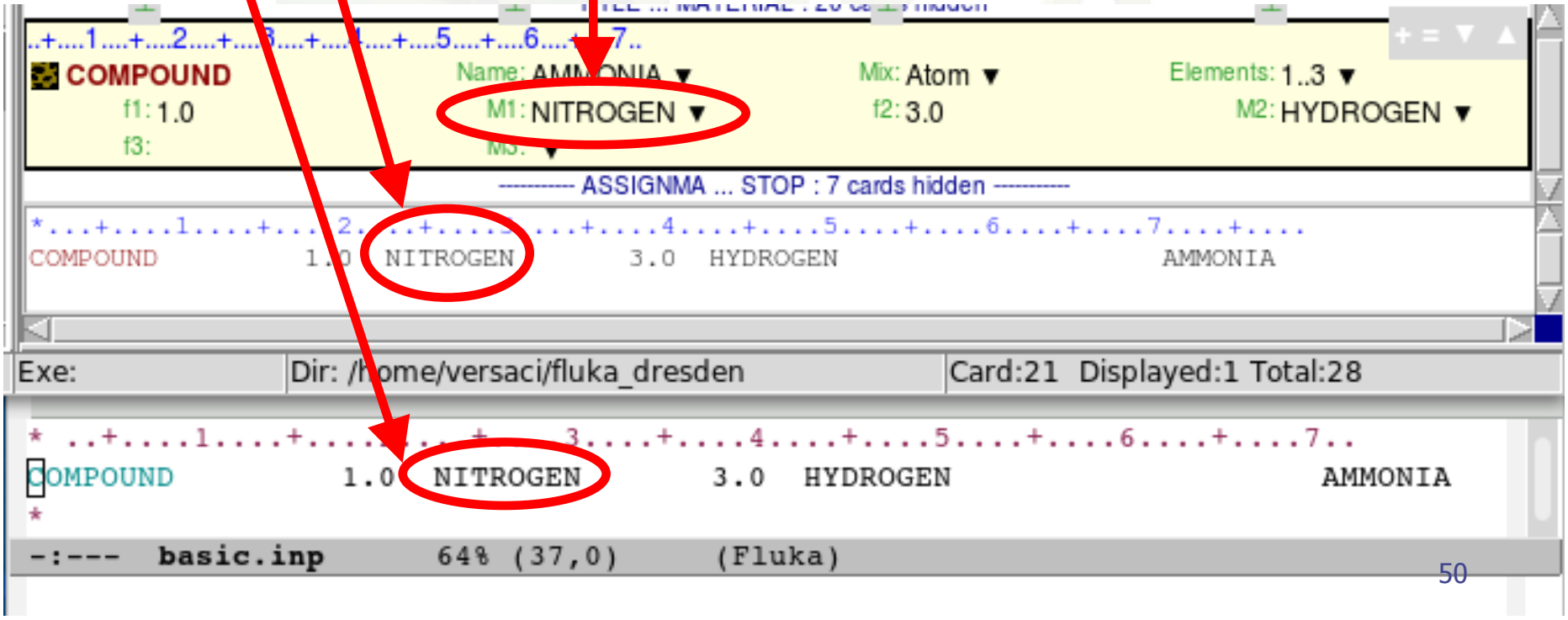
[WHAT(1)]: amount of the first component

Amount definition in few slides



Material definition: COMPOUND

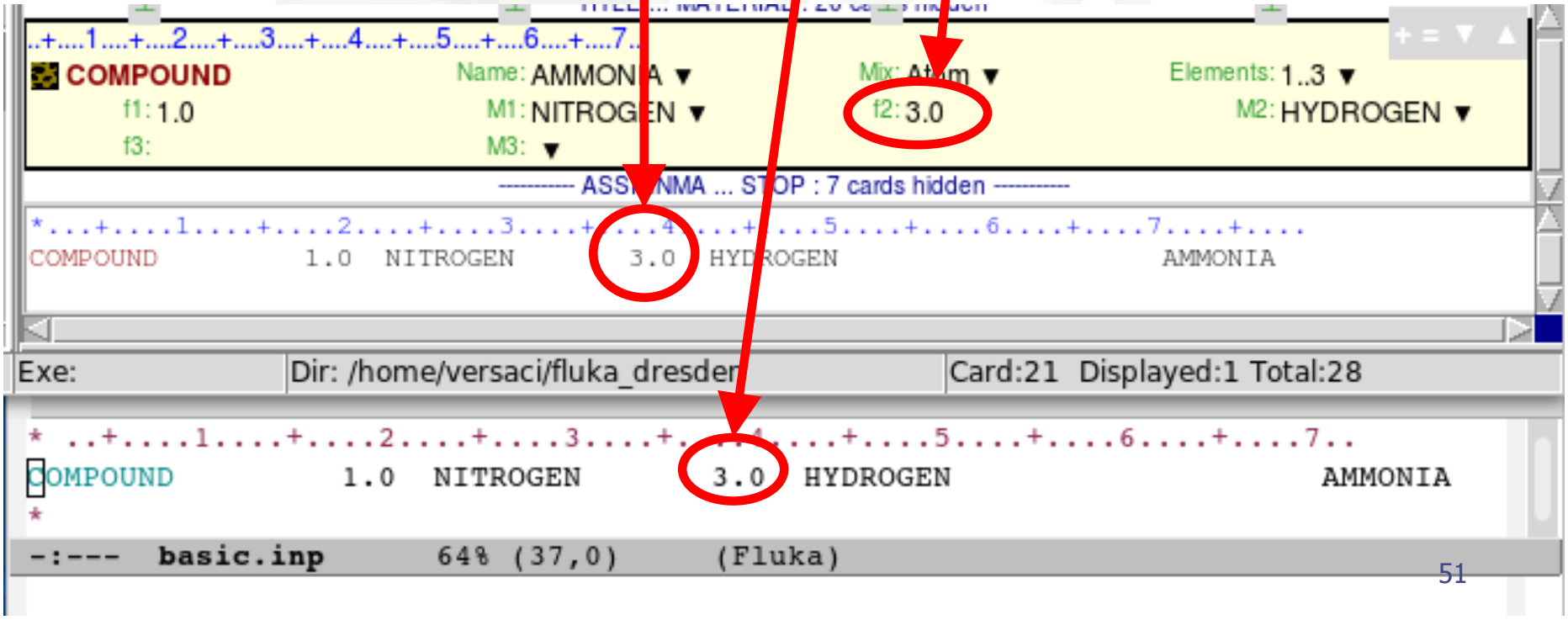
[WHAT(2)]: first component material



Material definition: COMPOUND

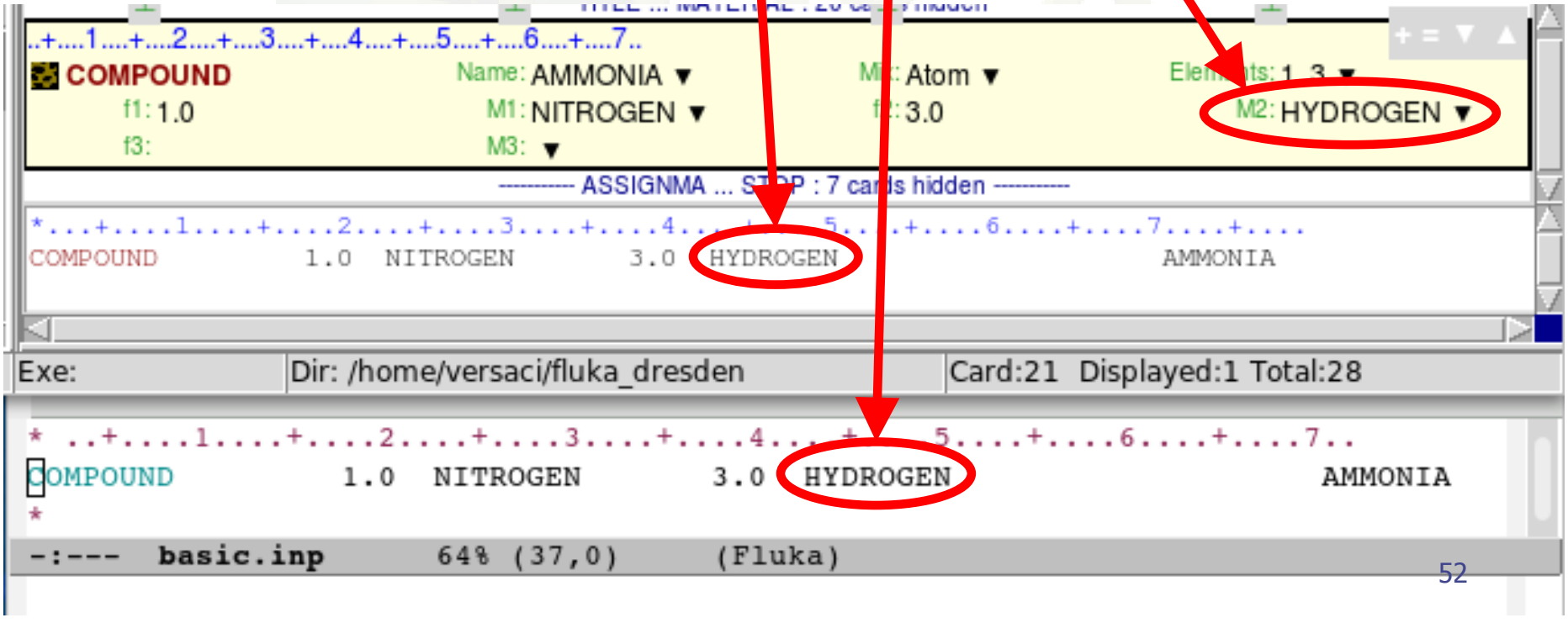
[WHAT(3)]: amount of the second component

Amount definition in few slides



Material definition: COMPOUND

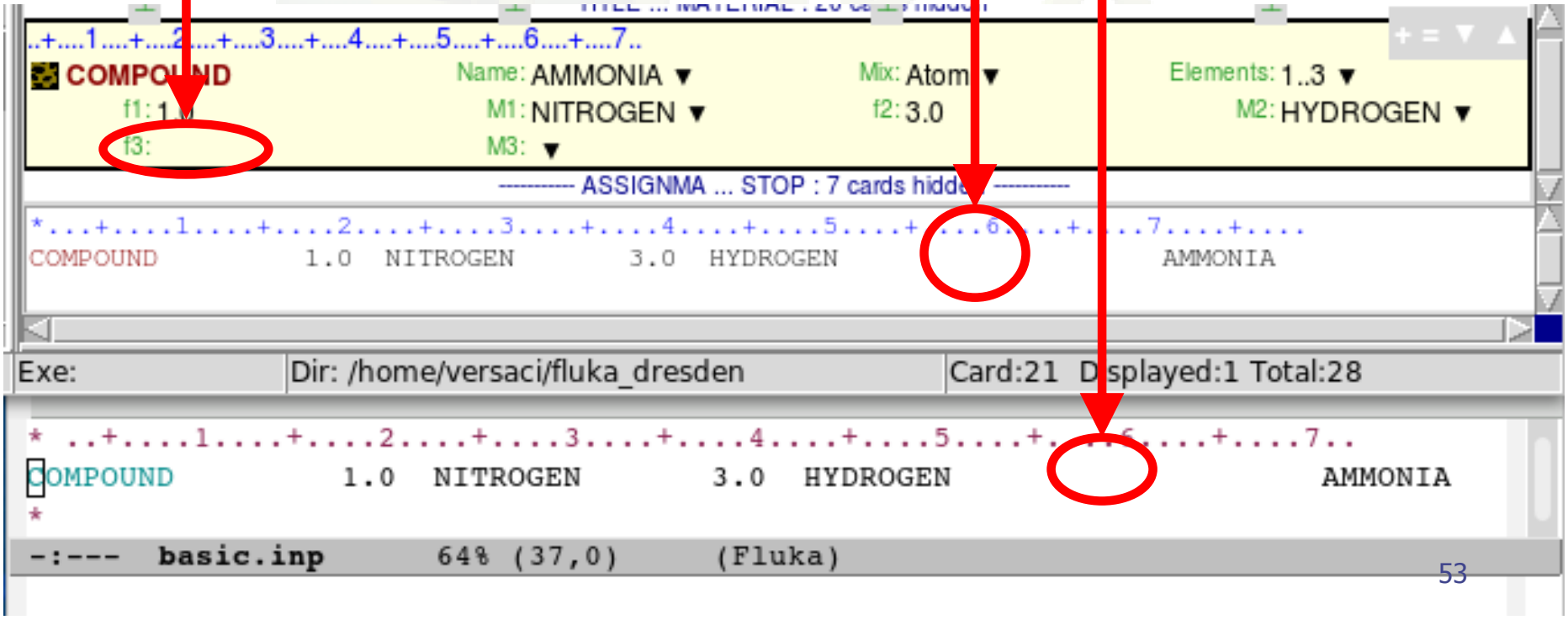
[WHAT(4)]: second component material



Material definition: COMPOUND

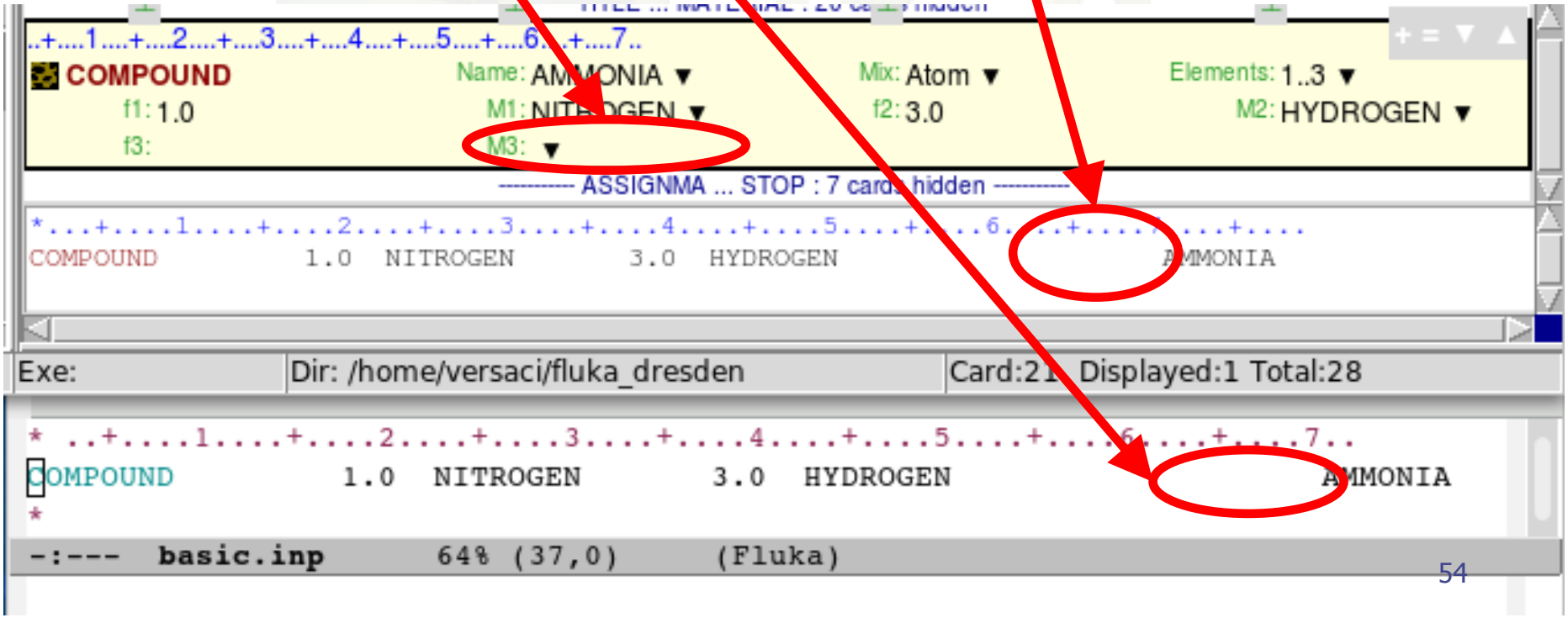
[WHAT(5)]: amount of the third component

Amount definition in few slides



Material definition: COMPOUND

[WHAT(6)]: third component material



Material definition: COMPOUND

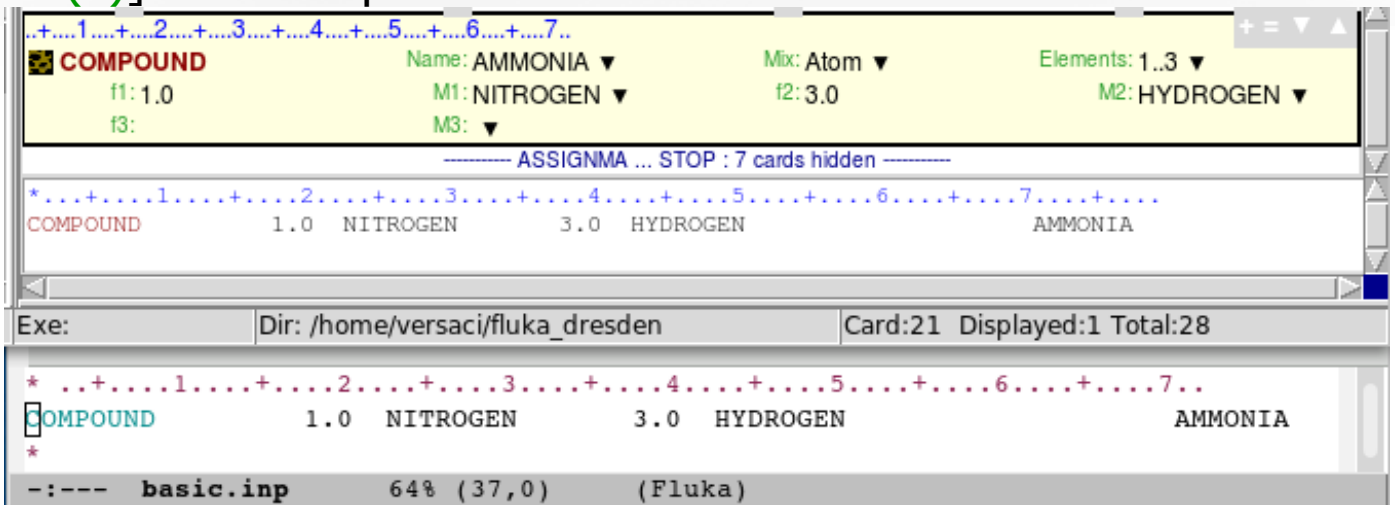
Defines a new compound

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

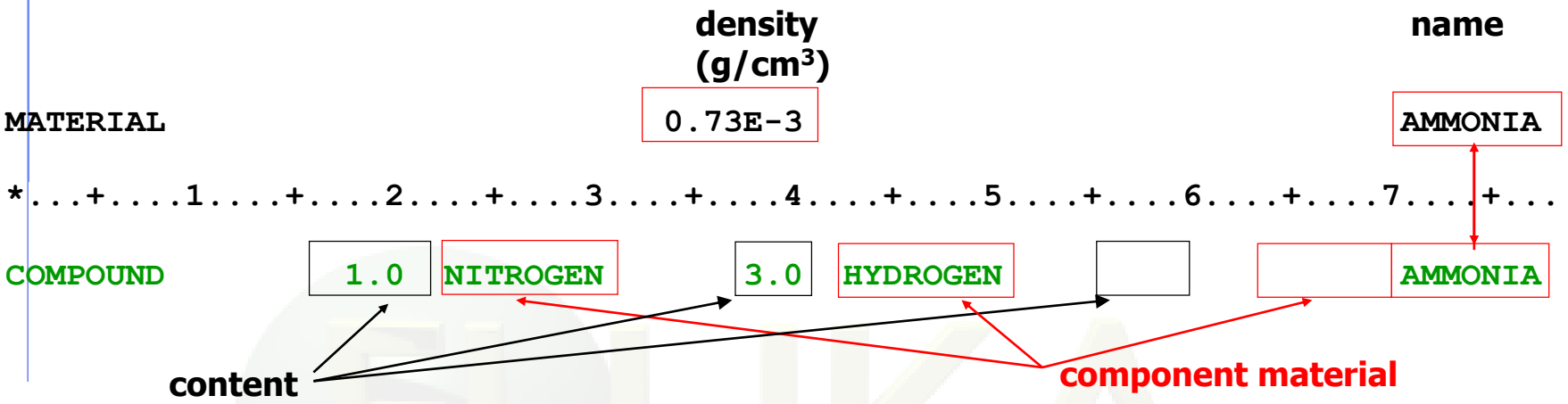
More **COMPOUND** card can be used to define a compound

- [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"?



Material definition: COMPOUND



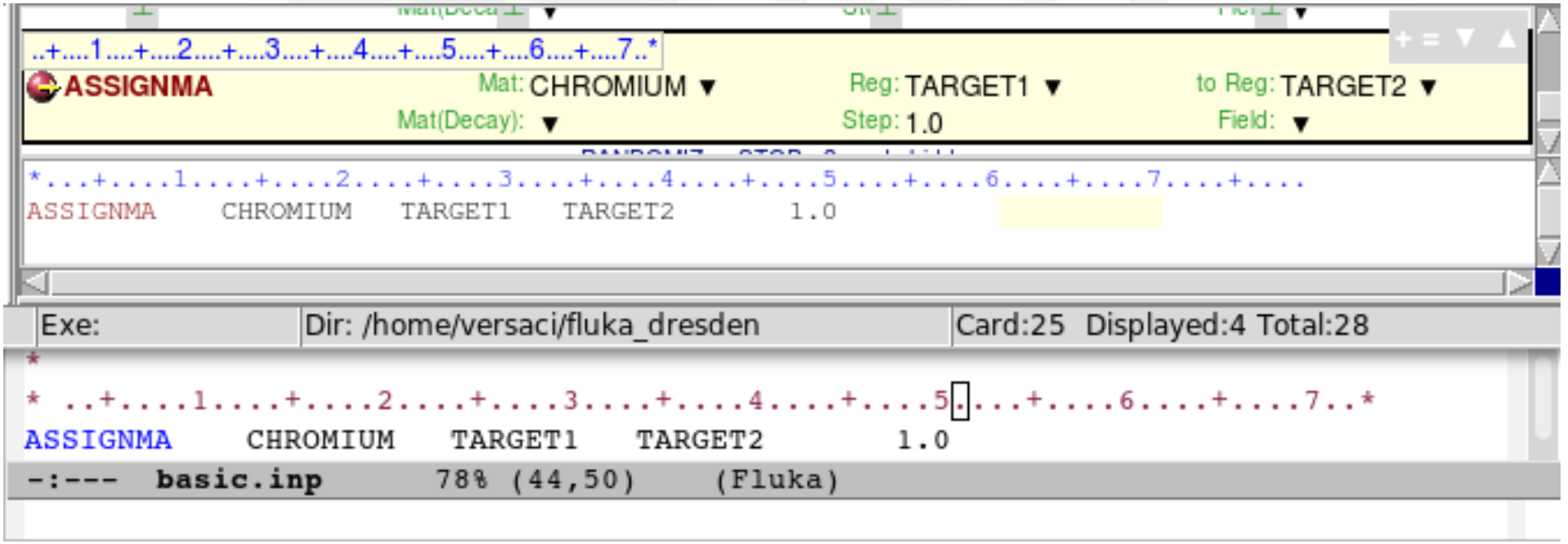
content > 0	component material > 0	⟹	**ATOM content**
content < 0	component material > 0	⟹	**MASS content**
content < 0	component material < 0	⟹	**VOLUME content**

Names can be preceded by a minus sign!

Material definition: **ASSIGNMA**

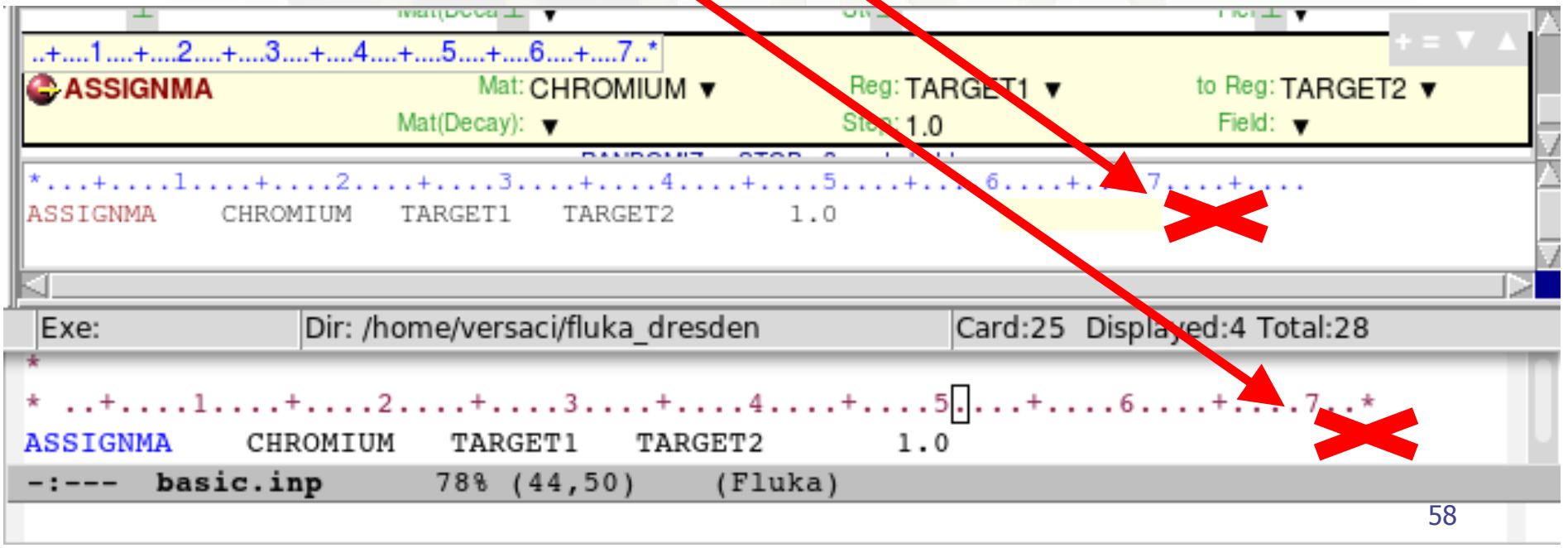
Assign a material to one (or more) region in the geometry
(for the region definition see the geometry lecture or the manual)

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



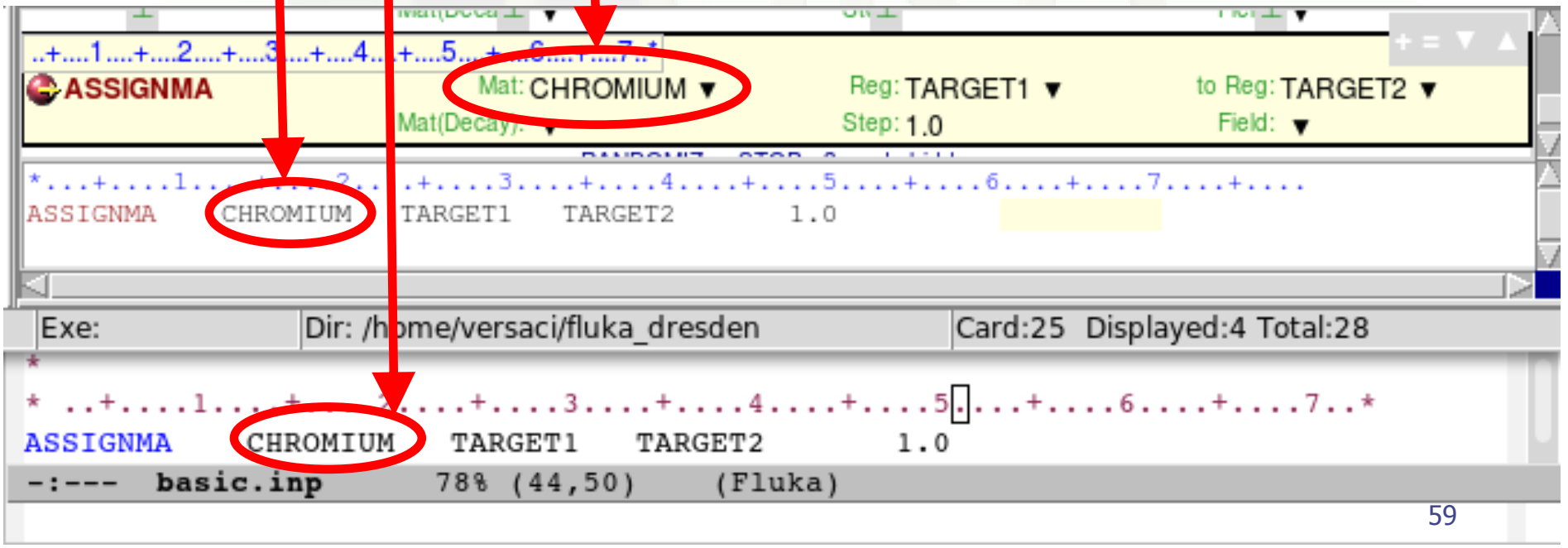
Material definition: **ASSIGNMA**

[SDUM]: not used



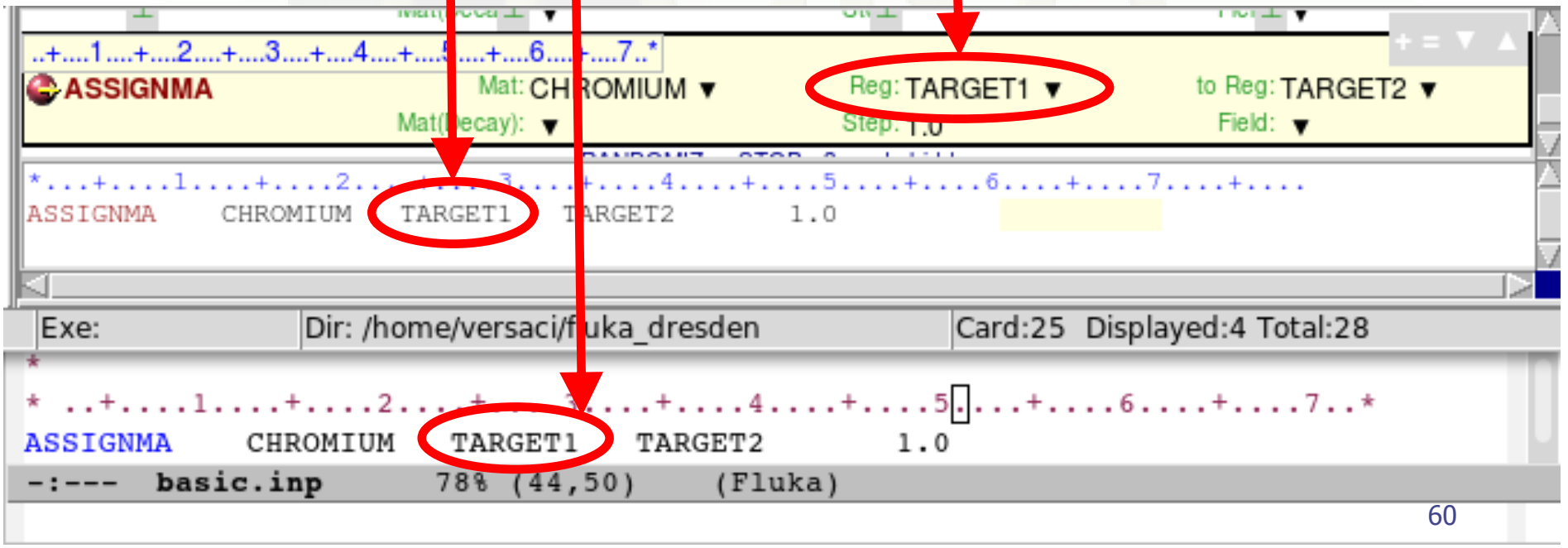
Material definition: **ASSIGNMA**

[WHAT(1)]: material to be assigned



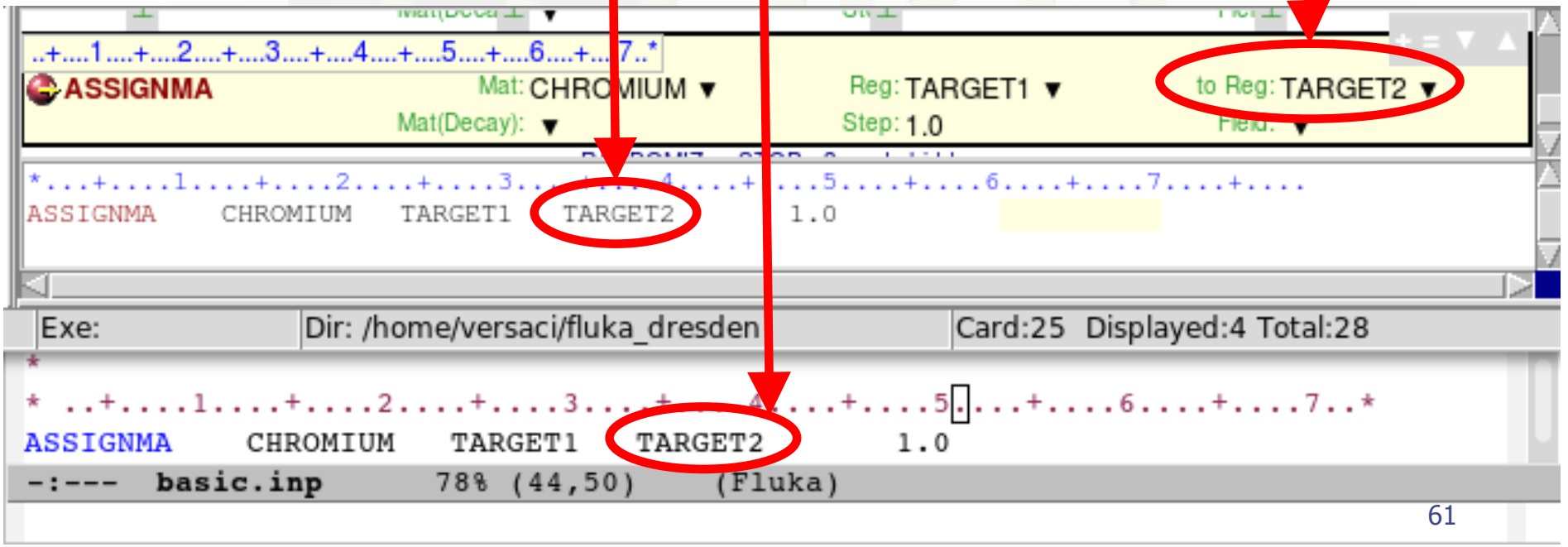
Material definition: **ASSIGNMA**

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



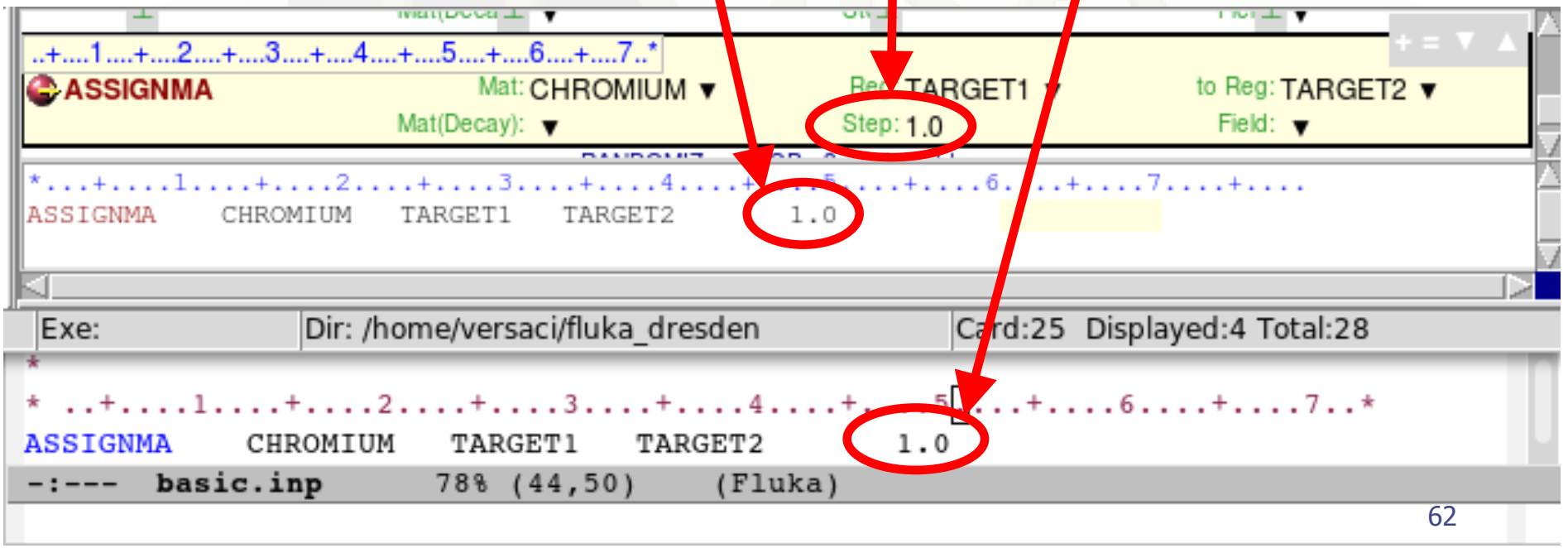
Material definition: ASSIGNMA

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



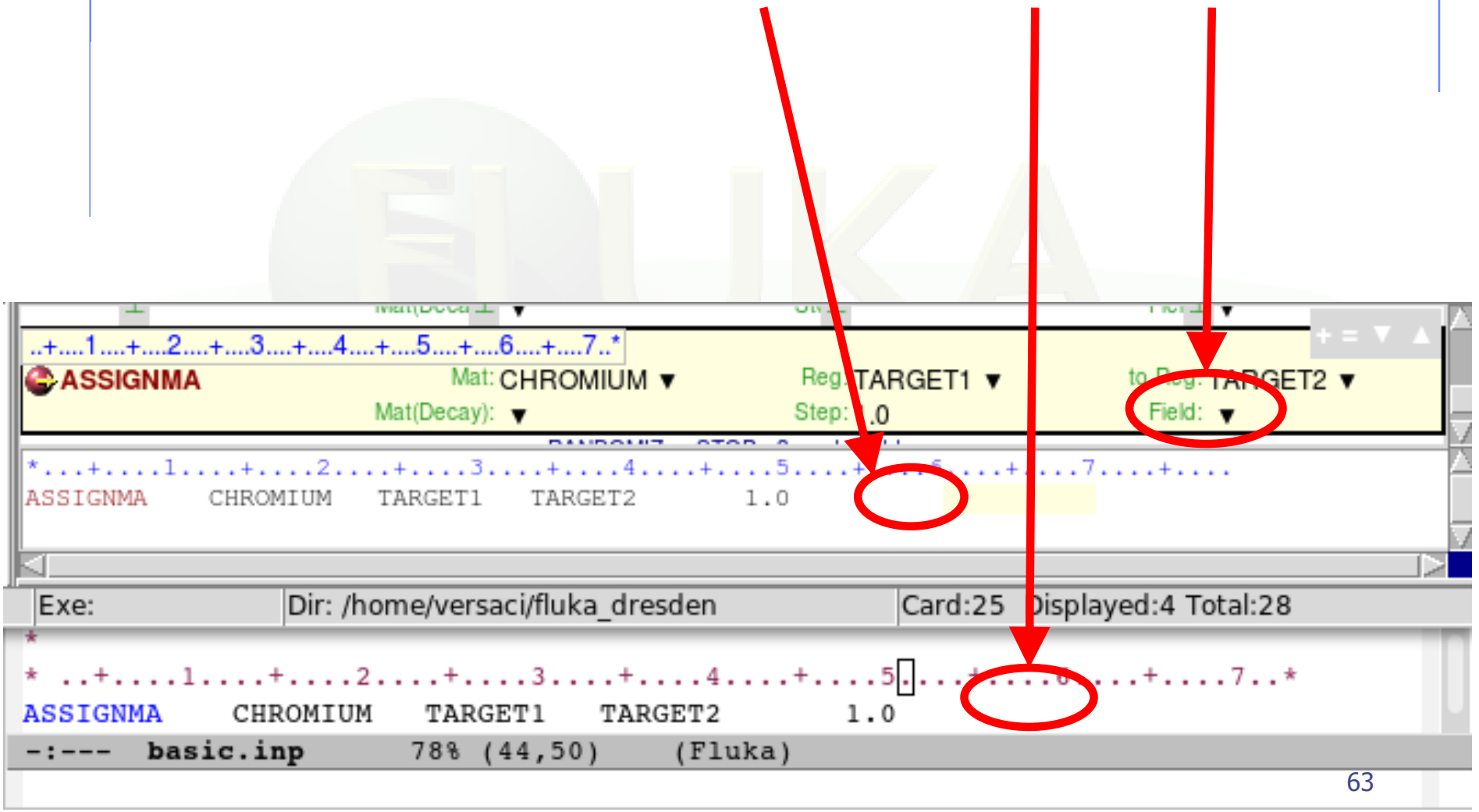
Material definition: **ASSIGNMA**

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



Material definition: **ASSIGNMA**

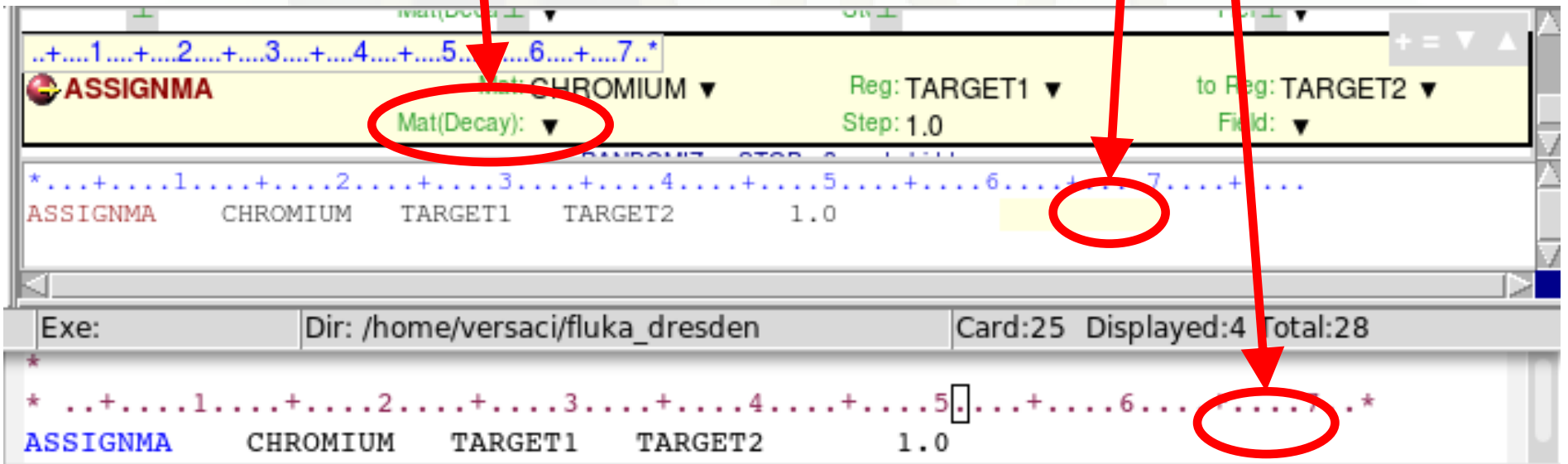
[WHAT(5)]: activate magnetic field in the concerned regions



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

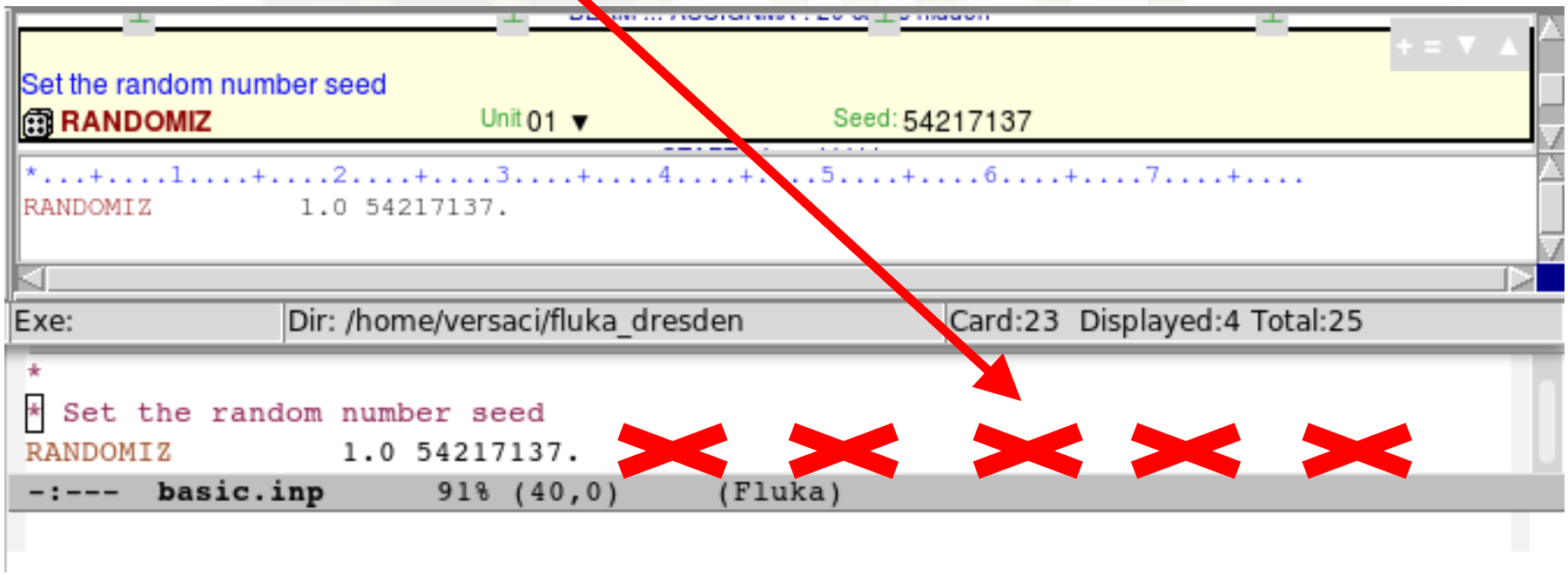
```
TITL
My B
* Se
DEFA
* Define the beam characteristics
* ..+....1....+....2....+....3....+....4....+....5....+....6....+....7..
BEAM          3.5 -0.082425      -1.7       0.0       0.0          PROTON
* Define the beam position
* ..+....1....+....2....+....3....+....4....+....5....+....6....+....7..
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	
	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	#	ρ: 7.18	
	Z: 24.0	Am:	A:	dE/dx:	
MATERIAL		Name: AMMONIA	#	ρ: 0.73E-3	
	Z: 0.0	Am:	A:	dE/dx:	
COMPOUND		Name: AMMONIA	Mix: Atom	Elements: 1..3	
	f1: 1.0	M1: NITROGEN	f2: 3.0	M2: HYDROGEN	
	f3:	M3:			
ASSIGNMA		Mat: BLCKHOLE	Reg: BLKBODY	to Reg:	
		Mat(Decay):	Step:	Field:	
ASSIGNMA		Mat: VACUUM	Reg: VOID	to Reg:	
		Mat(Decay):	Step:	Field:	
ASSIGNMA		Mat: AMMONIA	Reg: TARGET3	to Reg:	
		Mat(Decay):	Step:	Field:	
ASSIGNMA		Mat: CHROMIUM	Reg: TARGET1	to Reg: TARGET2	
		Mat(Decay):	Step: 1.0	Field:	
RANDOMIZ		Unit 01	Seed: 54217137.		
START		No.: 1000.	Core:		
		Time:	Report: default		
STOP					

```
TITLE
My Basic Input example
```

Random seed initialization: RANDOMIZ

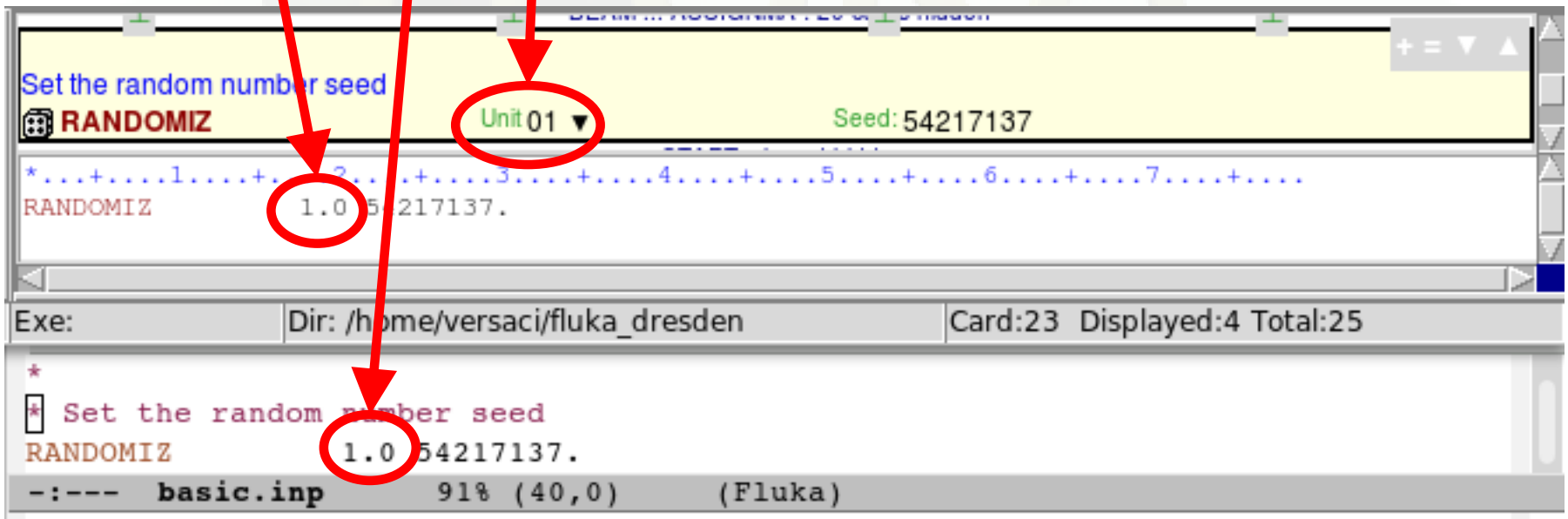
[SDUM]: not used
[WHAT(3-6)]: not used



Random seed initialization: RANDOMIZ

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

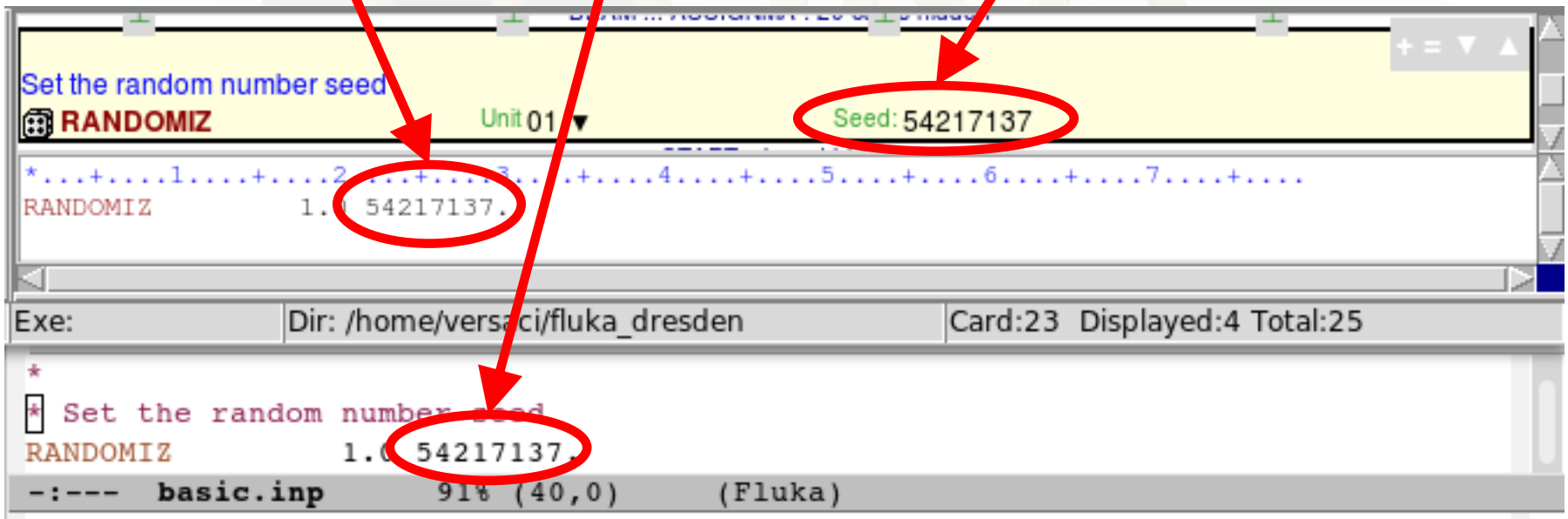
Do not touch! MUST be Unit 1



Random seed initialization: RANDOMIZ

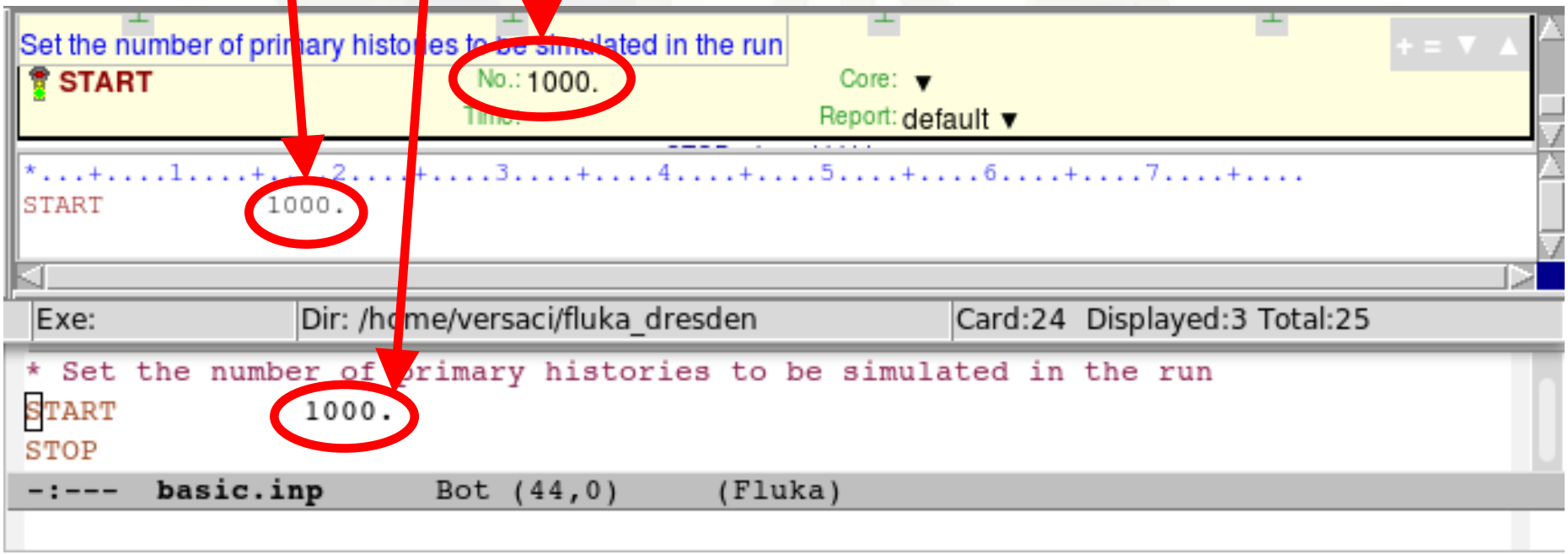
[WHAT(2)]: initialization of the random seed sequences

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



Starting the simulation: **START**

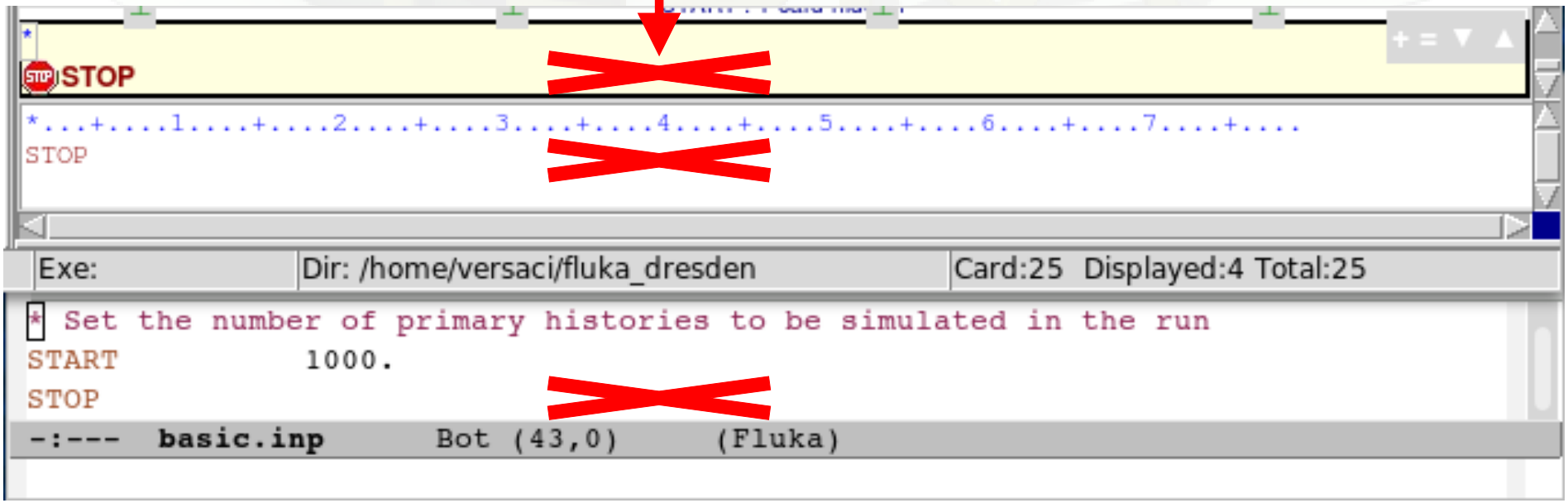
[WHAT(1)]: number of primaries to be simulated



Stopping the program: STOP

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

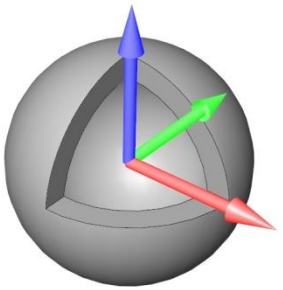
Inserted before **START** stops input reading and de-activates all following cards
No particle transport is performed, useful for geometry debugging
After **START**, its presence is optional and has no effect



Beyond a basic input

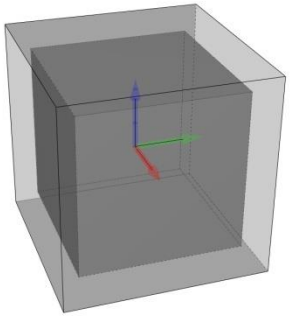
Special sources: 3D distributions

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



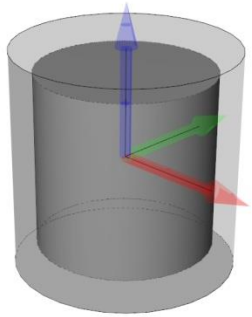
SDUM = SPHE-VOL:

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

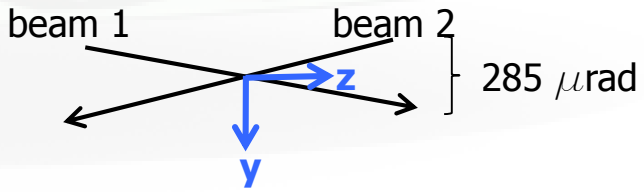
FLUKA allows the definitions of special sources for:

- 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



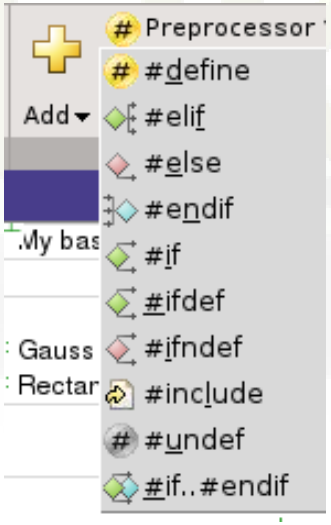
For all these special cases of source distributions, please, refer to the FLUKA manual!

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:

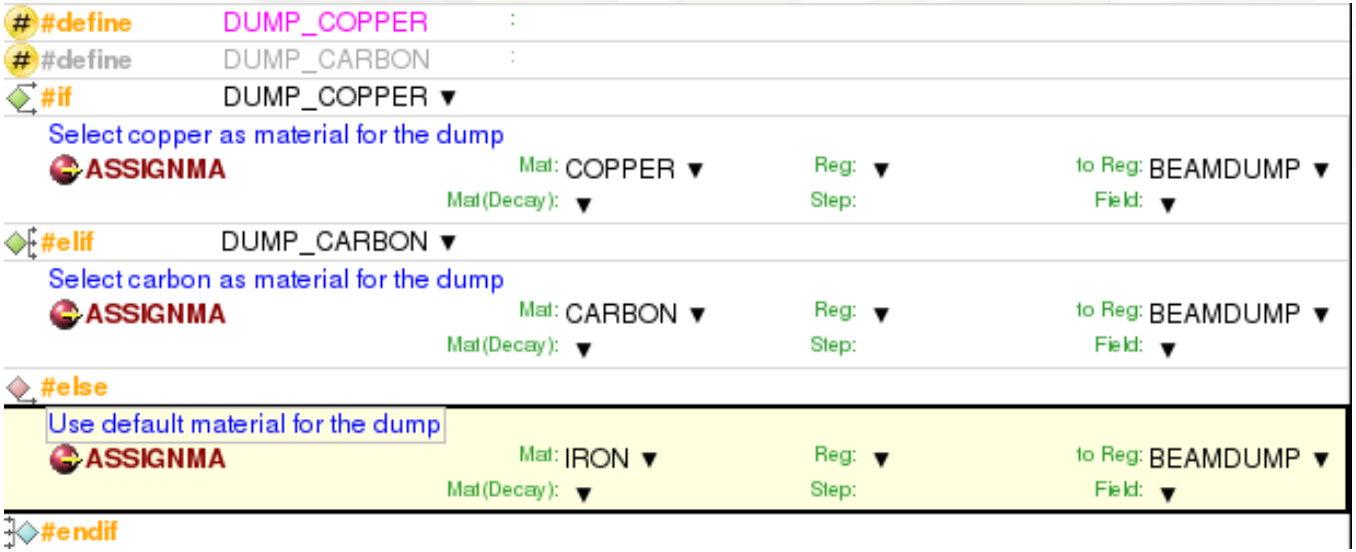
```
#include /home/geometries/target2.geom
```

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



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

  (**n**uclear **m**ass **u**nit, i.e. 1/12 of the ^{12}C nucleus mass)

  ^{2}H, ^{3}H, ^{3}He, and ^{4}He 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