CURSO INTRODUTÓRIO

FLUKA

23 DE JANEIRO A 8 DE MARÇO DE 2023

Tópicos essenciais

FLUKA

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AULA 03
Geometria

Iniciaremos em breve

Código Monte Carlo de interação e transporte de partículas

23 FLUKA 2023

08

CNPEM
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Geometry – Basic

Introduction to the combinatorial geometry package in FLUKA

Introduction

- Principle of Combinatorial Geometry (CG)
  - Basic objects called **bodies** (such as cylinders, spheres, parallelepipeds, etc.) are combined to form more complex objects called **regions**
  - This combination is done using **Boolean operations**

Operation	Math	FLUKA
Union	∪	|
Intersection	∩	+
Subtraction	-	-

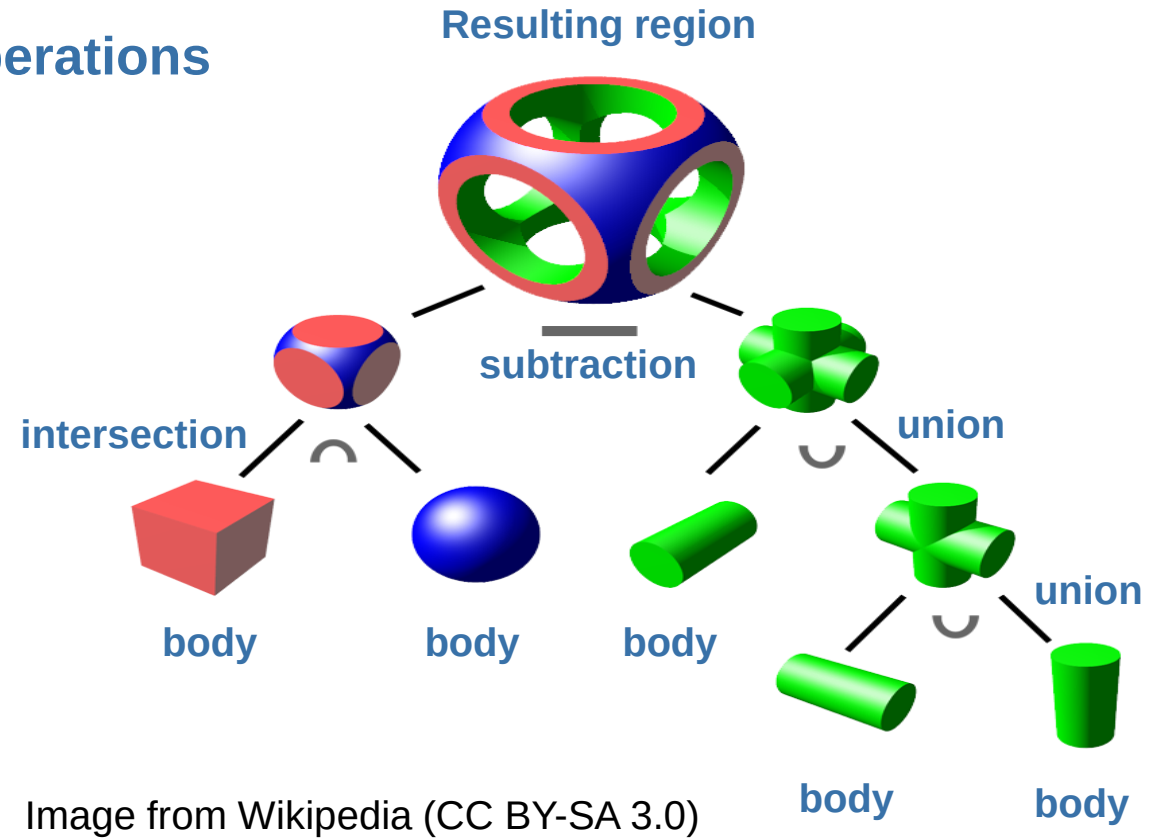
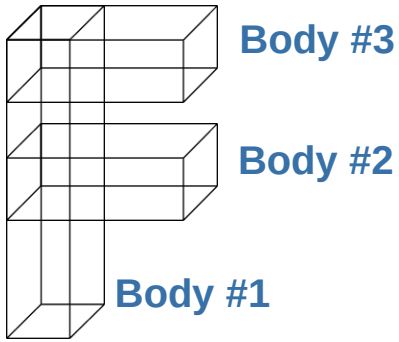
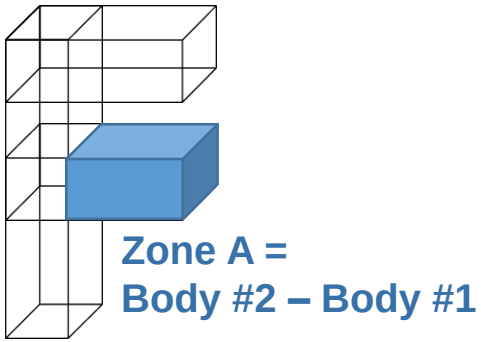


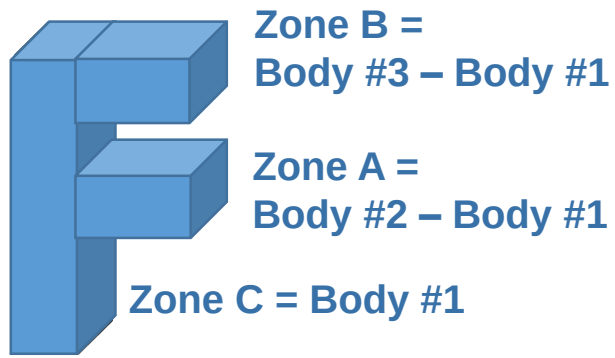
Image from Wikipedia (CC BY-SA 3.0)

Basic concepts and terminology

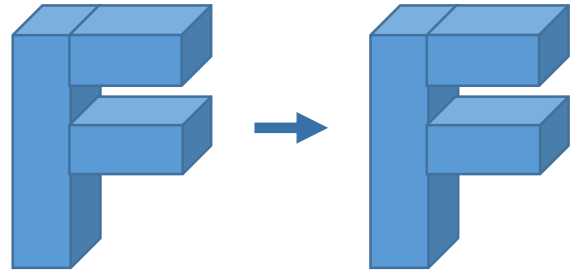
- Four concepts are fundamental in the FLUKA CG
  - **Bodies**: basic geometrical objects which are placed somewhere in the coordinate system
    - These include: **basic convex objects**, plus **infinite planes** (half-spaces), **infinite cylinders** (circular and elliptical), and **generic quadric surfaces** (surfaces described by 2nd degree equations)
  - **Zones**: sub-regions defined only via the intersection and subtraction of bodies
  - **Regions**: union of zones
    - In the simplest case a region consists of a single zone (no union operation needed in this case …)
  - **Lattices**: duplication of existing objects (regions) confined in a container volume
    - Container can be translated and rotated, multiple duplications are possible







Region = Zone A | Zone B | Zone C



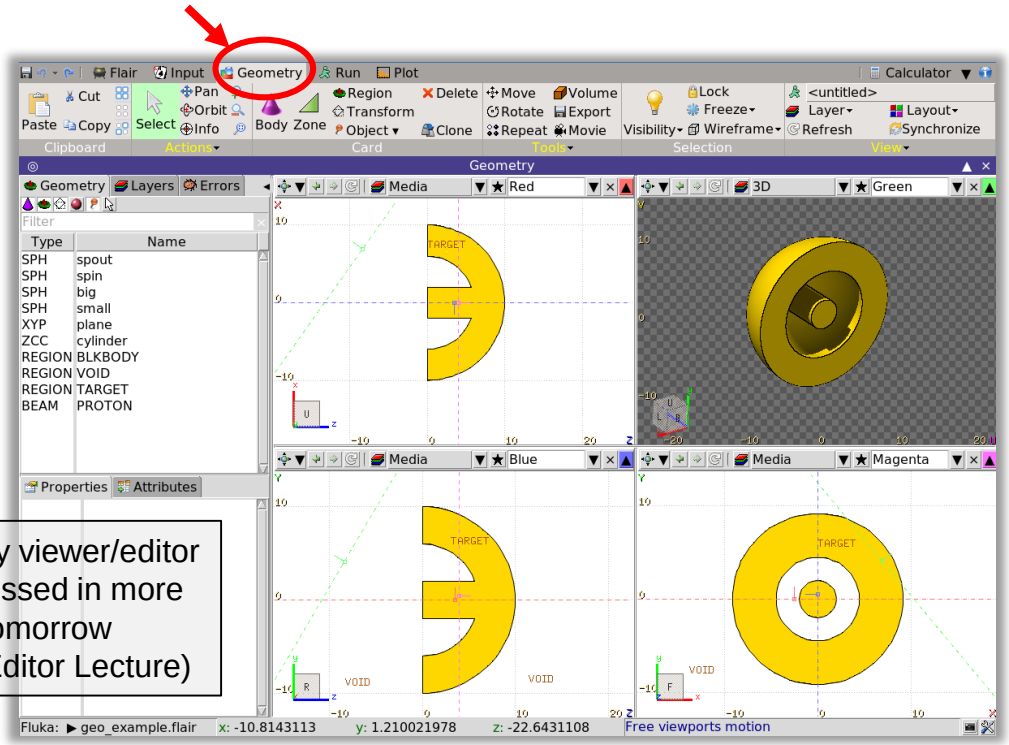
Geometry input

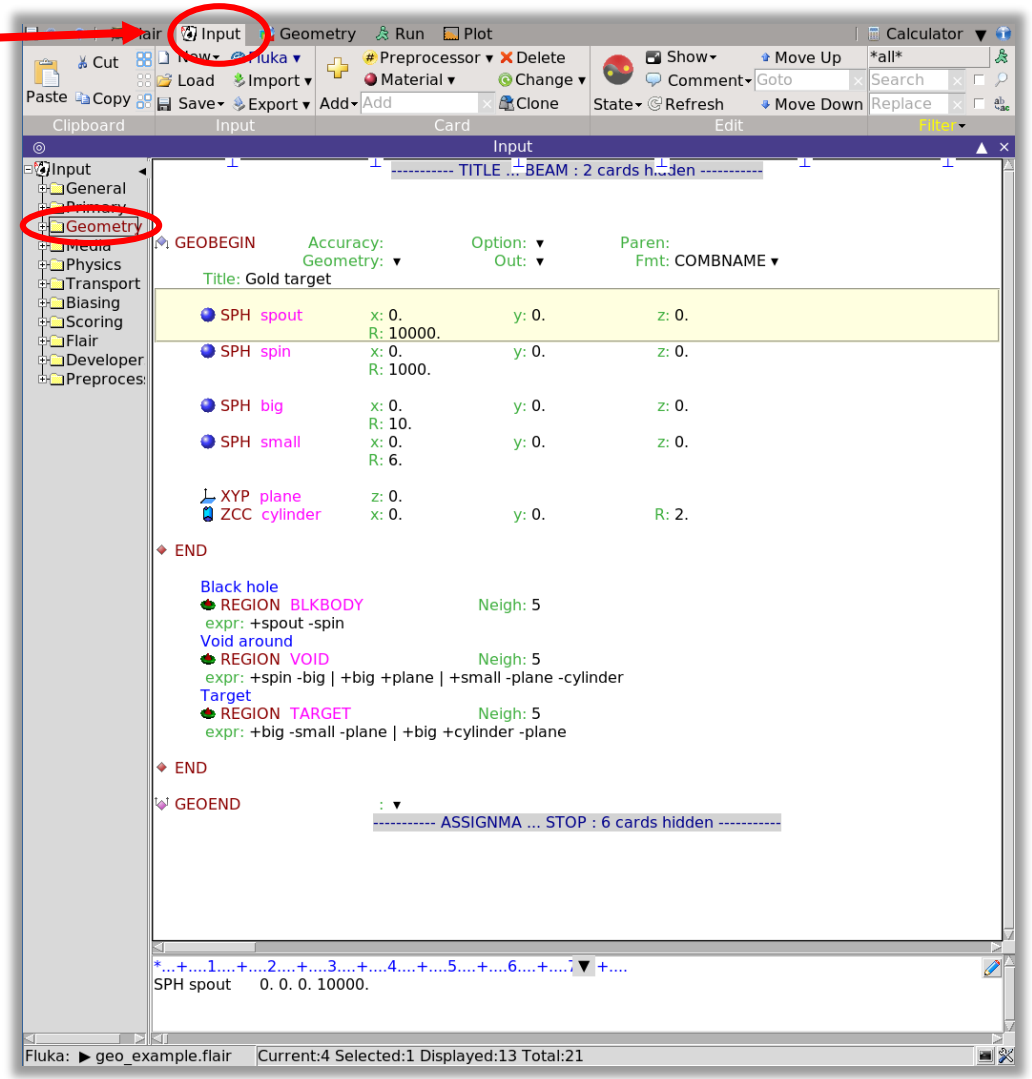
How to structure the geometry definition

Geometry input in Flair

The geometry input (bodies, zones/regions, lattices) is defined under the **“Geometry”** branch of the **Input** tab

The resulting geometry can be viewed under the **Geometry** tab





The geometry viewer/editor will be discussed in more detail tomorrow (Geometry Editor Lecture)

Structure of the geometry input

The geometry definition must be enclosed by the **GEOBEGIN** and **GEOEND** cards

```
GEOBEGIN   Accuracy:              Option: ▾          Paren:
           Geometry: ▾            Out: ▾             Fmt: COMBNAME ▾
  Title: Gold target
 SPH  spout      x: 0.        y: 0.        z: 0.
                 R: 2000.
 SPH  spin       x: 0.        y: 0.        z: 0.
                 R: 1000.
 SPH  big        x: 0.        y: 0.        z: 0.
                 R: 10.
 SPH  small      x: 0.        y: 0.        z: 0.
                 R: 6.
 XYP  plane      z: 0.
 ZCC  cylinder   x: 0.        y: 0.        R: 2.
END
 Black hole
 REGION  BLKBODY              Neigh: 5
  expr: +spout -spin
 Void around
 REGION  VOID                 Neigh: 5
  expr: +spin -big | +big +plane | +small -plane -cylinder
 Target
 REGION  TARGET               Neigh: 5
  expr: +big -small -plane | +big +cylinder -plane
END
GEOEND                   : ▾
```

Bodies are defined right after the **GEOBEGIN** card; the body definition must be terminated by an **END** card

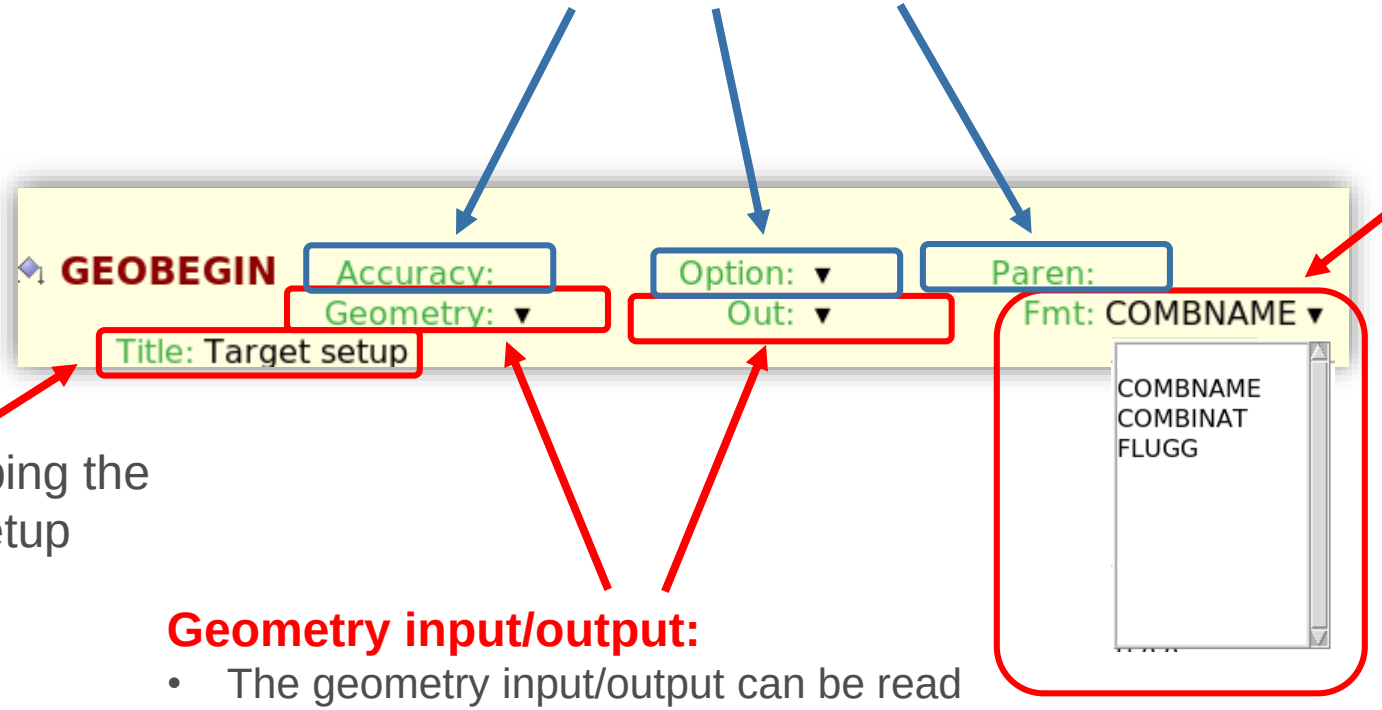
Regions (zones) are defined after the bodies; the region definition must be terminated by an **END** card

Lattices would be defined after the regions, right before the **GEOEND** card (not covered in this lecture)

Note: material definition/assignments and transformations are defined outside of GEOBEGIN-GEOEND

The GEOBEGIN card

Will be explained later in this lecture or can be found in backup



Title describing the geometry setup

Geometry input/output:

- The geometry input/output can be read from/written to another file.
- Here the logical I/O units can be chosen
- By default, output is writing to standard .out file

Geometry input format:

This option allows choosing how the geometry description is formatted.

Default is **COMBNAT**, which selects an obsolete formatting style (e.g. bodies and regions are identified via numbers) **- no longer supported by Flair!**

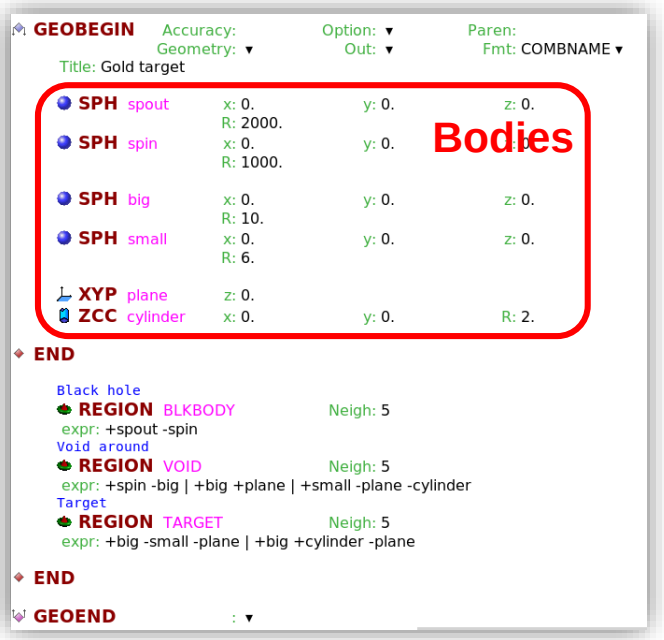
Choose **COMBNAME**, which is the name-based format and also features other improvements compared to **COMBNAT**.

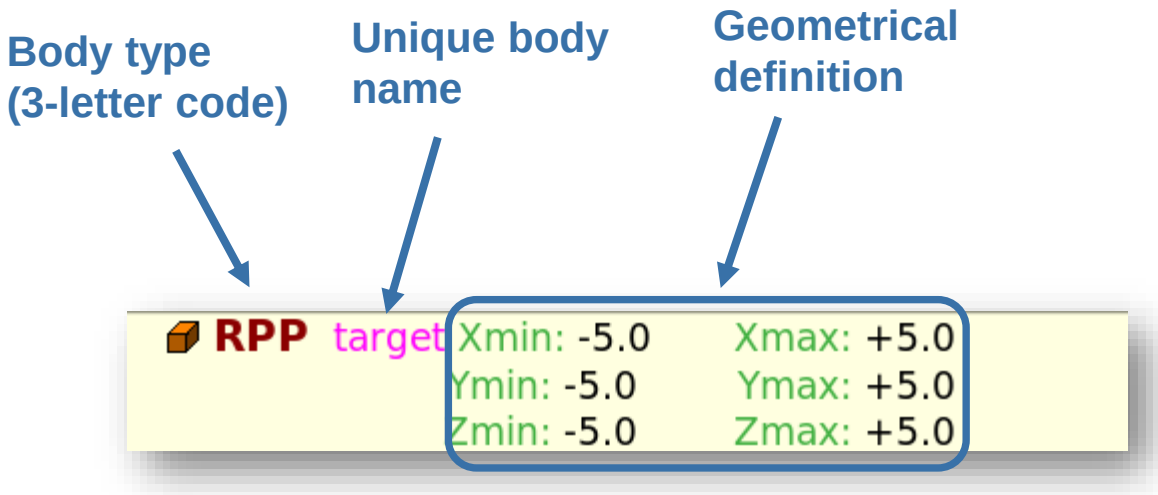
Bodies

The basic objects of the FLUKA CG

Body definitions

- A body definition in FLUKA consists of:
  - A **3-letter code** indicating the **body type**
  - A **unique body name** (alphanumeric identifier, 8 character maximum, case sensitive)
  - A **set of geometrical quantities** defining the body, e.g. the body dimensions and the position in the coordinate system (the numbers depend on the body type, see next slides)



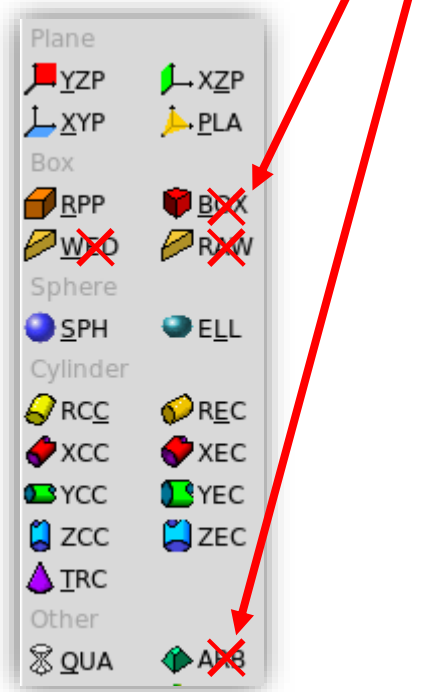


Note: all values are in cm!

List of bodies

- Following bodies are presently available in FLUKA:
  - **Planes**
    - **XYP**, **XZP**, **YZP**: Infinite half space delimited by a coordinate plane
    - **PLA**: Generic infinite half-space, delimited by a **PLA**ne
  - **Boxes**
    - **RPP**: **R**ectangular **P**arallele**P**iped
  - **Sphere and spheroid**
    - **SPH**: **SPH**ere
    - **ELL**: **ELL**ipsoid of revolution
  - **Cylinders and cones**
    - **XCC**, **YCC**, **ZCC**: Infinite **C**ircular **C**ylinder, parallel to coordinate axis
    - **RCC**: **R**ight **C**ircular **C**ylinder
    - **XEC**, **YEC**, **ZEC**: Infinite **E**lliptical **C**ylinder, parallel to coordinate axis
    - **REC**: **R**ight **E**lliptical **C**ylinder
    - **TRC**: **T**runcated **R**ight angle **C**one
  - **Other**
    - **QUA**: **QUA**dric

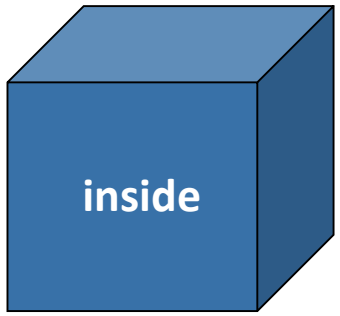
Note: BOX, WED, RAW, ARB are deprecated. Do not use them, because they can cause rounding problems.



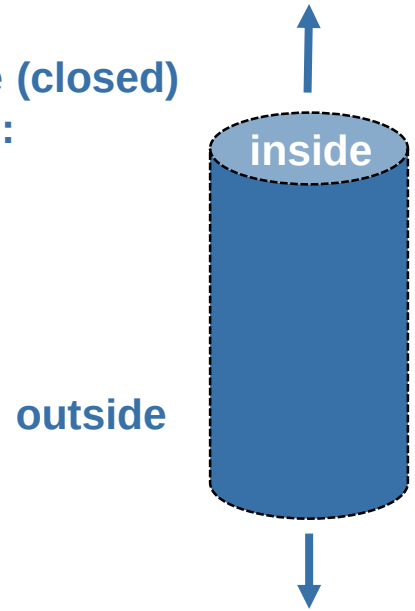
Division of space

- Each body splits the space into two domains: **inside** and **outside**
  - This concept will be later used when defining zones and regions
    - **+body** refers to the volume **inside** of the body
    - **-body** refers to the volume **outside** of the body
  - The concept of inside and outside is applied to all bodies including infinite planes

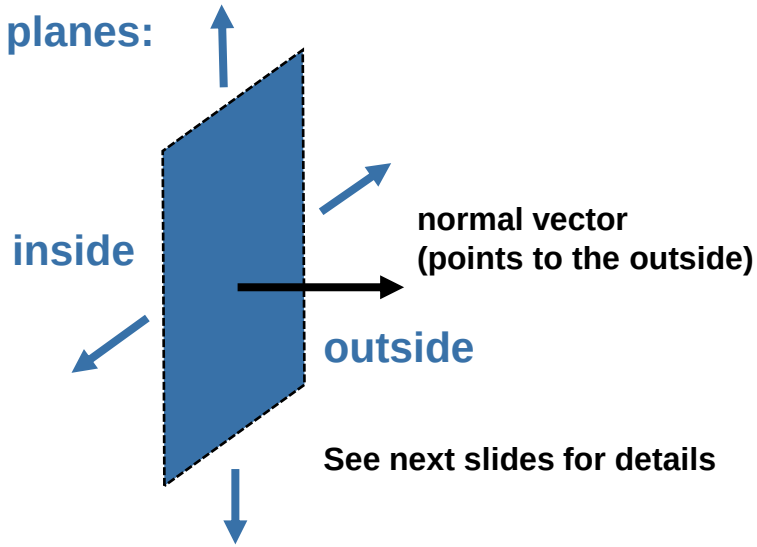
Finite bodies:



Infinite (closed) bodies:



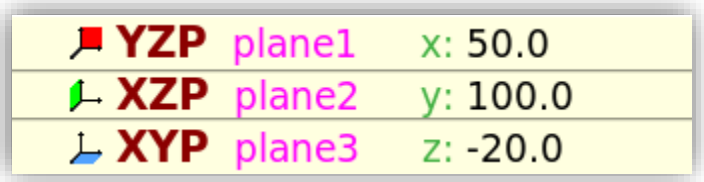
Infinite planes:



Infinite planes parallel to coordinate axes

- Divide space in two half spaces parallel to coordinate axes
  - **Three possibilities**:
    - Plane ⊥ to the x-axis → 3-letter code: **YZP**
    - Plane ⊥ to the y-axis → 3-letter code: **XZP**
    - Plane ⊥ to the z-axis → 3-letter code: **XYP**

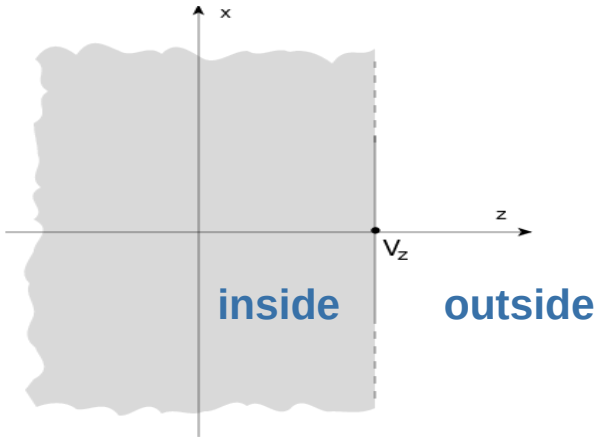
In Flair:



(note, in Flair V_x, V_y, V_z is labelled x, y, z)

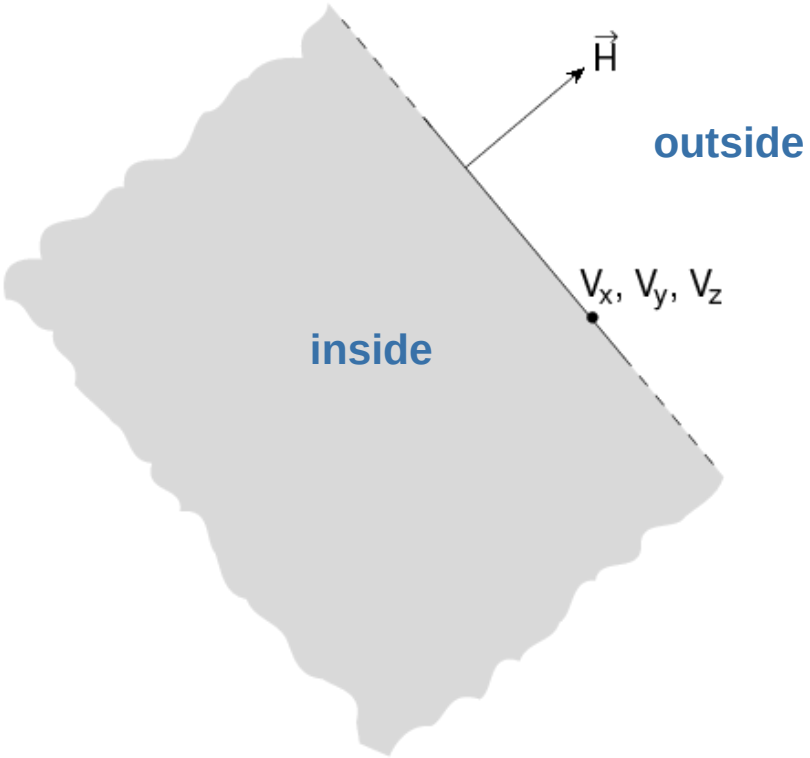
  - **All defined by a single number** (coordinate of the plane on the perpendicular axis):
    - x-coordinate **V_x** for YZP
    - y-coordinate **V_y** for XZP
    - z-coordinate **V_z** for XYP
  - **Inside vs outside**:
    - Points for which **$x < V_x$** (resp. **$y < V_y$**, or **$z < V_z$**) are “inside the body”
    - Points for which **$x > V_x$** (resp. **$y > V_y$**, or **$z > V_z$**) are “outside the body”

Example XYP:



Arbitrarily orientated infinite plane

- Divides space in two arbitrarily oriented half spaces
  - **3-letter code: PLA**
  - **A PLA is defined by 6 numbers:**
    - H_x, H_y, H_z (vector $\perp$ to the plane, arbitrary length)
    - V_x, V_y, V_z (any point lying on the plane)
  - **Inside vs outside**:
    - The half-space “inside the body” is that from which the vector H_x, H_y, H_z is pointing (i.e. the vector points "outside").



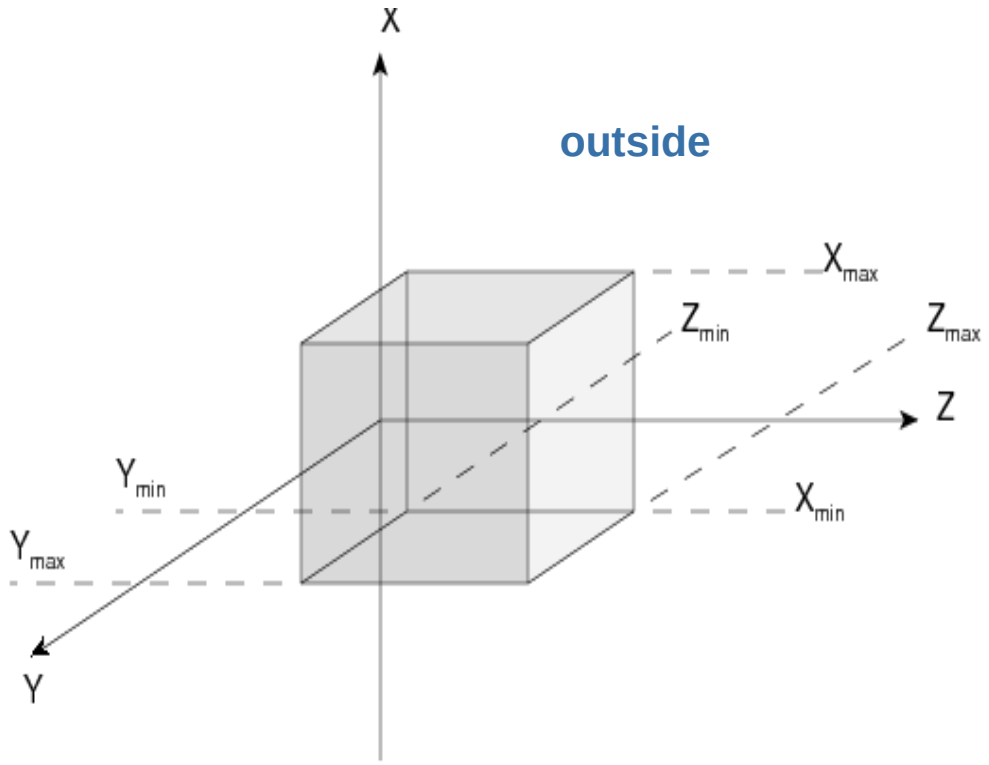
In Flair:

(note, in Flair H_x, H_y, H_z is labelled Nx, Ny, Nz)

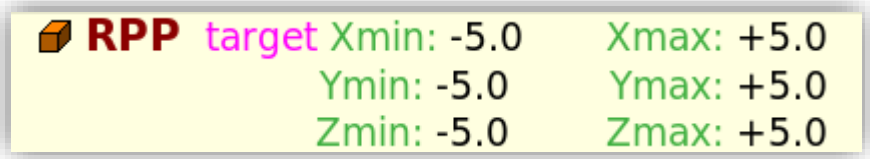
PLA	plane4	Nx: 1.0	Ny: 5.0	Nz: 4.0
		x: 0.0	y: 3.0	z: 2.0

Rectangular parallelepiped

- Box with faces parallel to the coordinate axis
  - **3-letter code: RPP**
  - **A RPP is defined by 6 numbers:**
    - X_{min}, X_{max} (positions of the two ZY faces of the RPP)
    - Y_{min}, Y_{max} (positions of the two XZ faces of the RPP)
    - Z_{min}, Z_{max} (positions of the two XY faces of the RPP)
  - **Inside vs outside**:
    - A point **x**, **y**, **z** is “inside the body” if it is contained in the RPP (i.e. $X_{min} < x < X_{max}$ and $Y_{min} < y < Y_{max}$ and $Z_{min} < z < Z_{max}$)



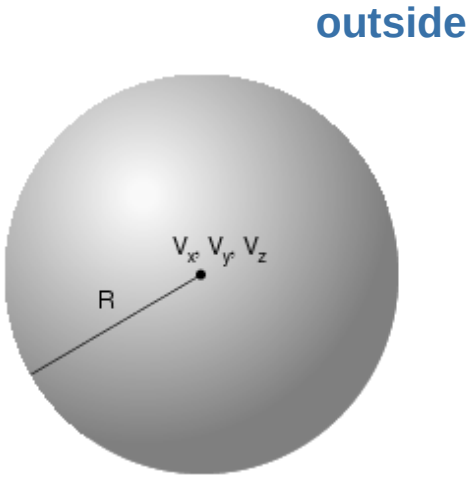
In Flair:



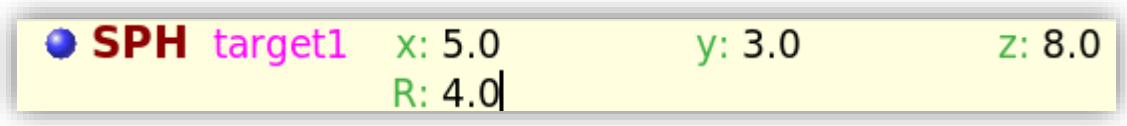
Do not use the deprecated body BOX

Sphere

- Sphere at arbitrary location
  - **3-letter code: SPH**
  - **A SPH is defined by 4 numbers:**
    - **V_x, V_y, V_z** (origin of the sphere)
    - **R** (radius of the sphere)
  - **Inside vs outside**:
    - A point **x**, **y**, **z** is defined as “inside the body” if it is contained inside the sphere

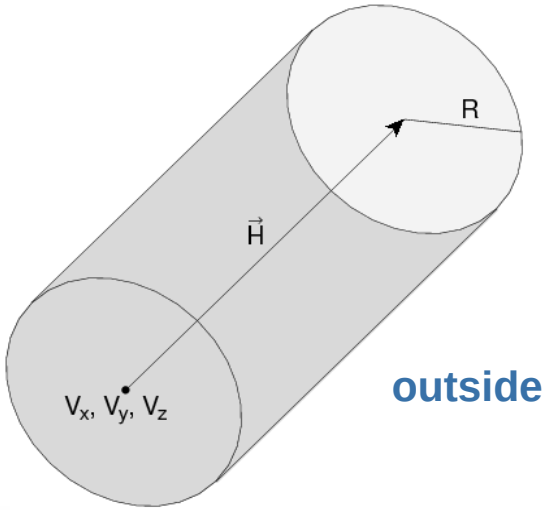


In Flair: (note, in Flair V_x, V_y, V_z is labelled x, y, z)



Right circular cylinder

- Finite cylinder at arbitrary position and with arbitrary orientation, limited by a cylindrical surface and two plane faces $\perp$ to its axis
  - **3-letter code: RCC**
  - **A RCC is defined by 7 numbers:**
    - **V_x, V_y, V_z** (base of the cylinder, i.e., center of one cylinder face)
    - **H_x, H_y, H_z** (vector corresponding to the cylinder height, pointing to the center of the other face)
    - **R** (radius of the cylinder)
  - **Inside vs outside**:
    - A point **x**, **y**, **z** is defined as "inside the body" if it is contained inside the cylinder



In Flair: (note, in Flair V_x, V_y, V_z is labelled x, y, z)

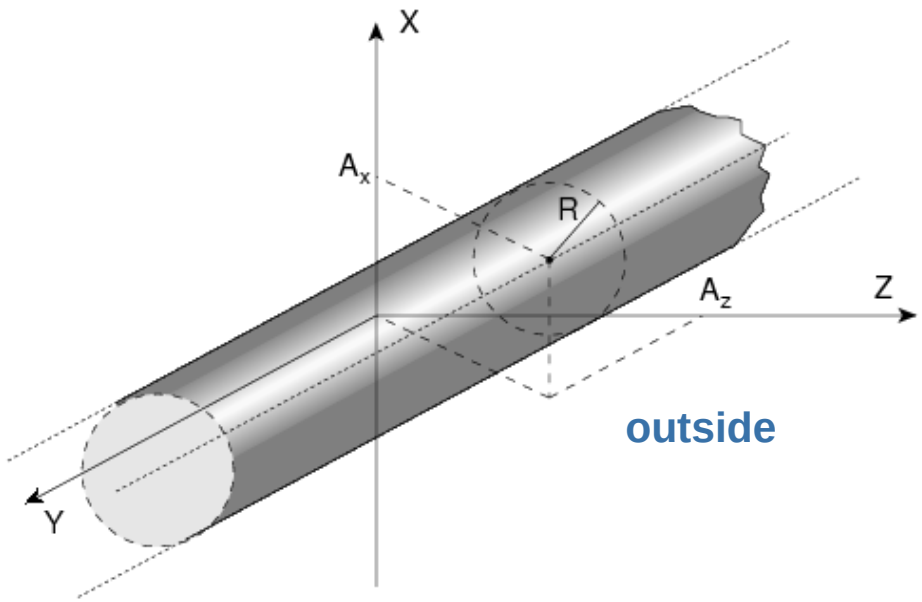
RCC	target2	x: 5.0	y: 2.0	z: 8.0
		Hx: 3.0	Hy: 3.0	Hz: 0.0
		R: 2.0		

Infinite circular cylinders

- Infinite circular cylinder parallel to one of the coordinate axis, at arbitrary position
  - **Three possibilities**:
    - Cylinder parallel to the x-axis → 3-letter code: **XCC**
    - Cylinder parallel to the y-axis → 3-letter code: **YCC**
    - Cylinder parallel to the z-axis → 3-letter code: **ZCC**
  - **An XCC/YCC/ZCC is defined by 3 numbers:**
    - **A_y**, **A_z** for XCC, **A_x**, **A_z** for YCC, **A_x**, **A_y** for ZCC (coordinates of the cylinder axis)
    - **R** (radius of the cylinder)
  - **Inside vs outside**:
    - A point **x**, **y**, **z** is defined as “inside the body” if it is contained inside the cylinder

In Flair: (note, in Flair A_x, A_y, A_z is labelled x, y, z)

XCC	cyl1	y: 4.0	z: 3.0	R: 1.0
YCC	cyl2	z: 2.0	y: -5.0	R: 2.0
ZCC	cyl3	x: -3.0	y: 2.0	R: 5.0

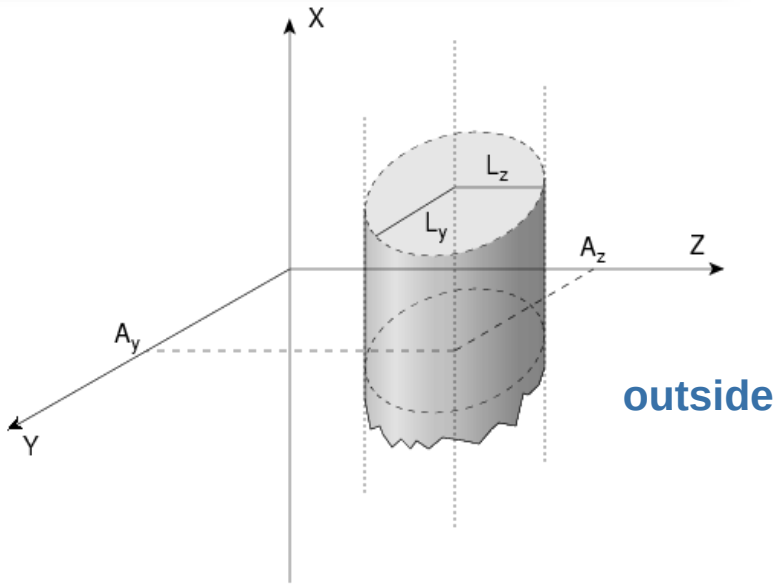


Infinite elliptical cylinders

- Infinite elliptical cylinder parallel to one of the coordinate axis, at arbitrary position
  - **Three possibilities**:
    - Cylinder parallel to the x-axis → 3-letter code: **XEC**
    - Cylinder parallel to the y-axis → 3-letter code: **YEC**
    - Cylinder parallel to the z-axis → 3-letter code: **ZEC**
  - **An XCC/YCC/ZCC is defined by 4 numbers:**
    - A_y, A_z for XCC, A_x, A_z for YCC, A_x, A_y for ZCC (coordinates of the cylinder axis)
    - L_y, L_z for XCC, L_x, L_z for YCC, L_x, L_y for ZCC (semi-axes of the cylinder)
  - **Inside vs outside**:
    - A point **x**, **y**, **z** is defined as “inside the body” if it is contained inside the cylinder

In Flair: (note, in Flair A_x, A_y, A_z is labelled x, y, z)

XEC	cyl4	y: 3.0 Ly: 2.0	z: 2.0 Lz: 5.0
YEC	cyl5	z: 1.0 Lz: 3.0	x: 0.0 Lx: 1.0
ZEC	cyl6	x: 4.0 Lx: 0.5	y: -2.0 Ly: 1.0



Arbitrary generic quadric

- A quadric surface defined by a 2nd degree equation F(x,y,z) = 0
  - **3-letter code: QUA**
  - **Each QUA is defined by 10 numbers:**

$$C_{xx}, C_{yy}, C_{zz}, C_{xy}, C_{xz}, C_{yz}, C_x, C_y, C_z, C_0$$

  - Corresponding to the equation:

$$C_{xx}\,x^2 + C_{yy}\,y^2 + C_{zz}\,z^2 + C_{xy}\,xy + C_{xz}\,xz + C_{yz}\,yz + C_x\,x + C_y\,y + C_z\,x + C_0 = 0$$

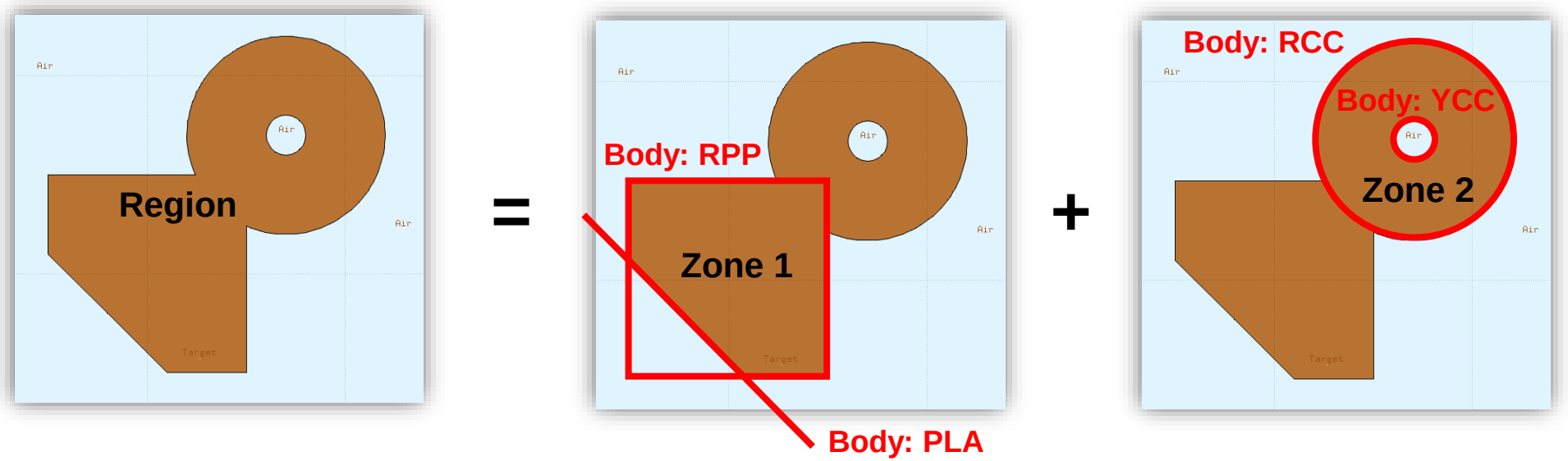
In Flair:

Regions (and zones)

Combining bodies to create your geometry model

Concept of zones and regions

- Regions are defined by combining FLUKA bodies using Boolean operations, more precisely:
  - Regions are obtained by the **union of sub-regions** (called **zones**); in the simplest case a region consists of a single zone
  - Zones are defined by **intersections** and/or **subtractions** of **bodies (Boolean zone expressions)**



Zones belonging to the same region can overlap!!

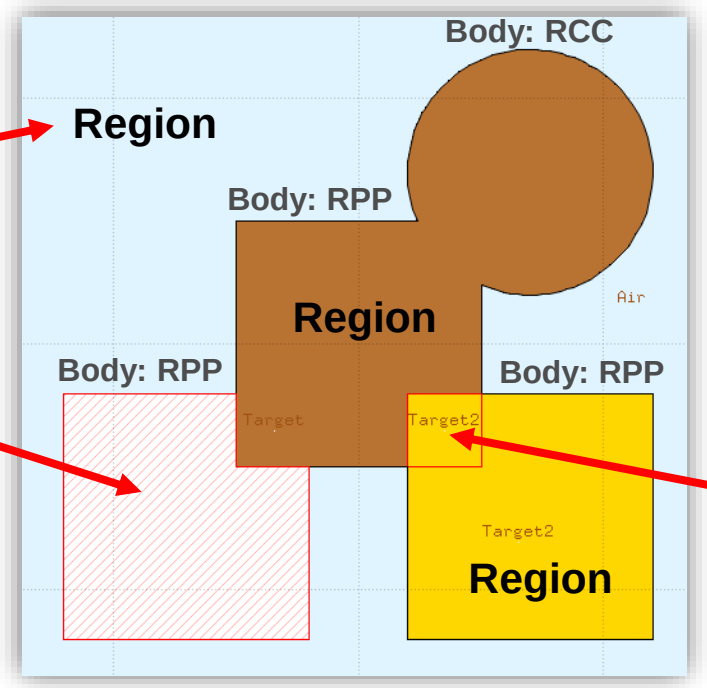
On the other hand, zones belonging to the same region must not necessarily be connected.

Basic principles …

- … when building geometries:
  - Zones and hence regions must be finite
  - Each point in space must belong to one (and only one) region
    - Note that also the region surrounding your principal geometry must be defined (e.g. air region)
  - Regions are of **homogeneous material composition** (i.e. only one material can be assigned to a region)

Note: do not forget to define the surrounding region

Error: volume does not belong to any region



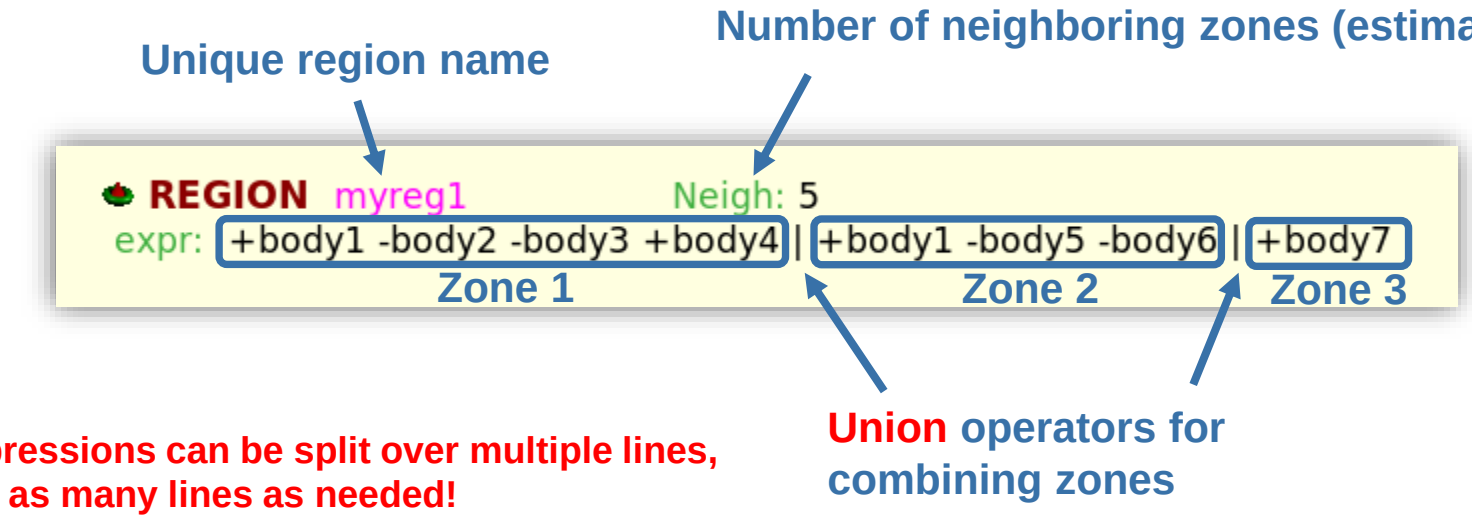
Error: volume belongs to two regions

Region definitions

- A region definition in FLUKA consists of:
  - A **unique region name** (alphanumeric identifier, 8 character maximum, case sensitive, must start with an alphabetical character)
  - An estimate of the **number of neighboring zones** (see backup)
  - A single **Boolean zone expression** or a **series of Boolean zone expressions** combined via the **union operator**

```
GEOBEGIN  Accuracy:        Option:        Paren:
          Geometry:        Out:           Fmt: COMBNAME
 Title: Gold target
 SPH  spout   x: 0.   y: 0.   z: 0.
                R: 2000.
 SPH  spin    x: 0.   y: 0.   z: 0.
                R: 1000.
 SPH  big     x: 0.   y: 0.   z: 0.
                R: 10.
 SPH  small   x: 0.   y: 0.   z: 0.
                R: 6.
 XYP  plane   z: 0.
 ZCC  cylinder  x: 0.   y: 0.   R: 2.
END
Black hole
 REGION  BLKBODY                Neigh: 5
  expr: +spout -spin
Void around
 REGION  VOID                   Neigh: 5
  expr: +spin -big | +big +plane | +small -plane -cylinder
Target
 REGION  TARGET                 Neigh: 5
  expr: +big -small -plane | +big +cylinder -plane
END
GEOEND
```

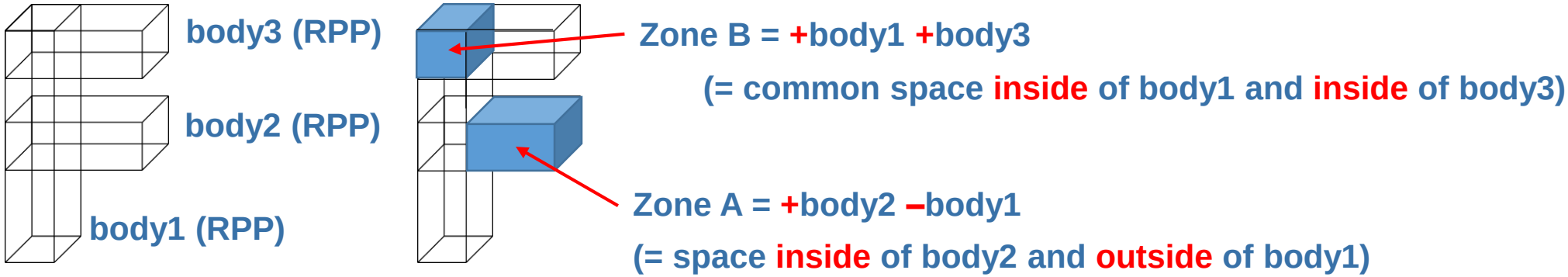
Regions



Expressions can be split over multiple lines, use as many lines as needed!

Boolean zone expressions

- Zones are a described by a sequence of one or more bodies each being preceded by a **+** or **-** sign (remember: **+/-** means **inside/outside** a body)
  - **+body:** only the inner part of the body can belong to the zone (means that the zone being described is fully contained inside this body)
  - **-body:** only the outside of the body can belong to the zone (means that the zone being described is fully outside this body)

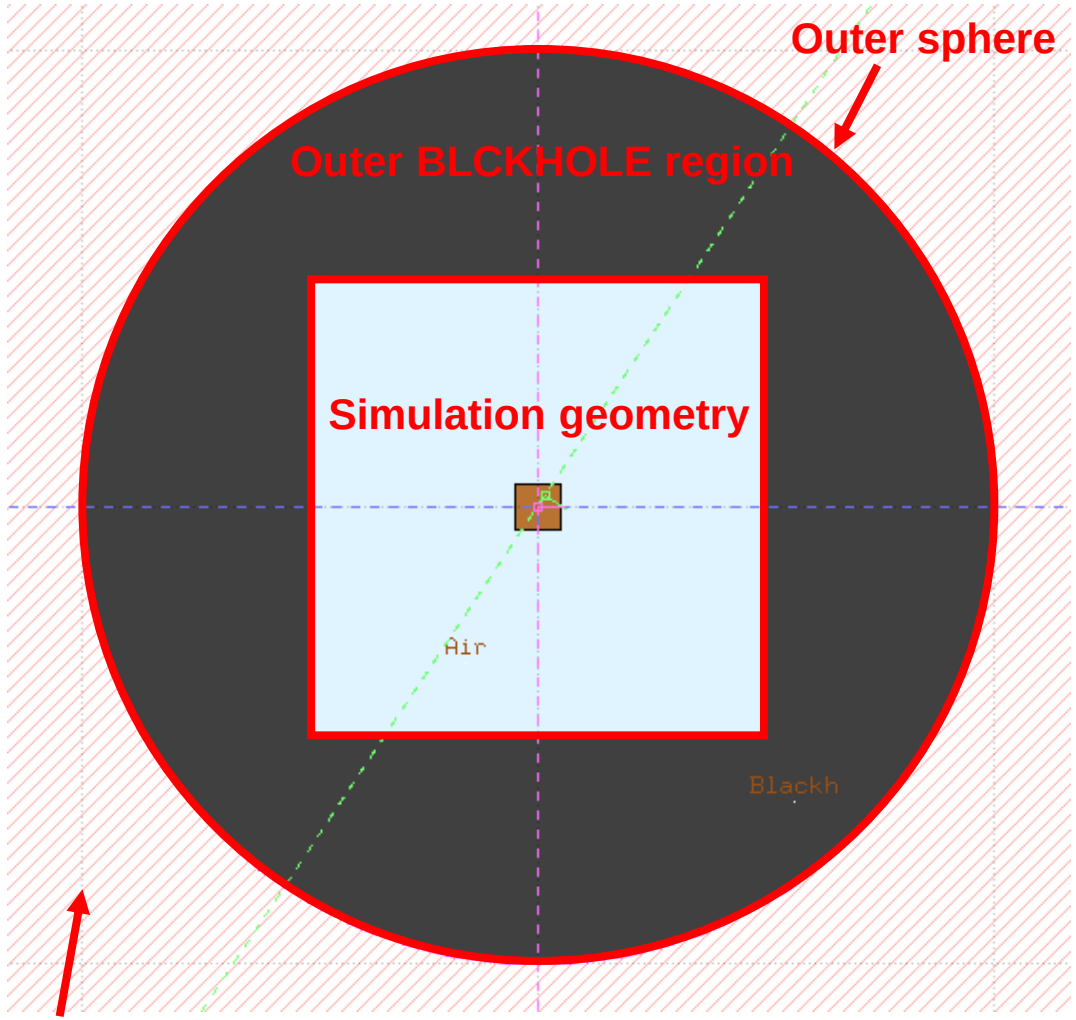


Parenthesis in region definitions

- Parentheses can be used to perform complex Boolean operations in the description of regions
- In evaluating the expressions, the highest operator precedence is given to parentheses, followed by +, - and the | operator
- Still, the extensive use of parenthesis is discouraged and can create unreadable and inefficient code
  - It is perfectly possible to implement (complex) geometries without using parenthesis
- In case you use parentheses, pay attention to the respective parameters on the GEOBEGIN card (optimization level and runtime evaluation of parenthesis)
  - See backup for details

Special region: the outer black hole confinement

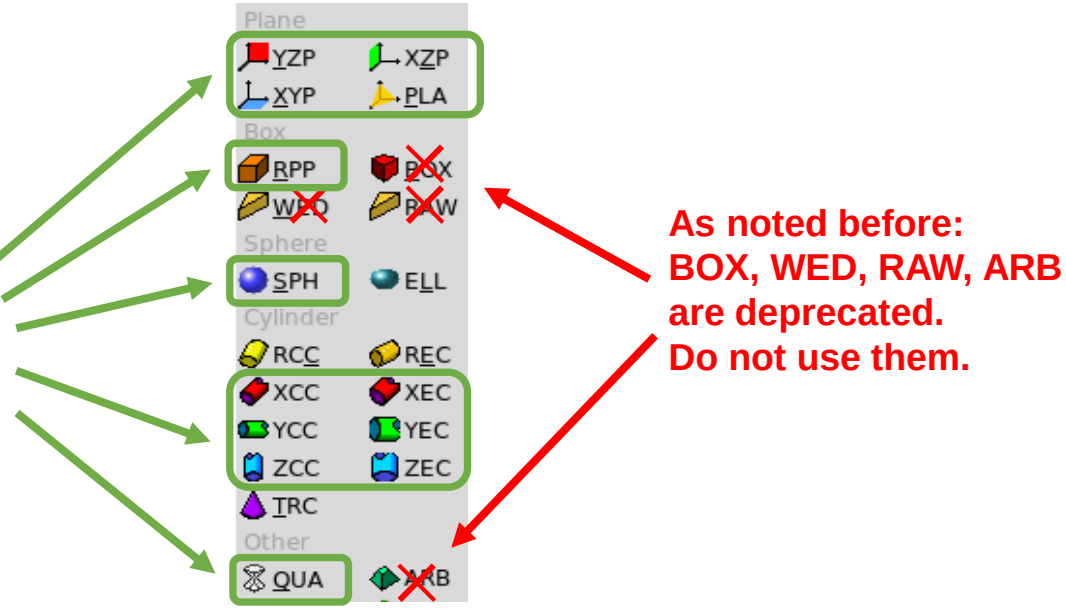
- FLUKA defines a special material called BLCKHOLE:
  - BLCKHOLE is an **all-absorbing material**
  - Particles vanish when entering a region filled with BLCKHOLE
- The entire geometry must be embedded in a region filled with BLCKHOLE
  - This avoids tracking particles to infinity
  - The outer surface of this BLCKHOLE region must be a single closed body (e.g. a sphere)



Tracking speed

- Number of bodies per zone:
  - If the number of bodies *per zone definition* becomes large this slows down the tracking
  - Rather segment in more zones than using too many bodies per zone (rule of thumb: not more than 10 bodies per zone definition)
  - Overlapping zones (for the same regions) can even be beneficial since particles may remain longer in one zone
- Recommendations on the use of bodies:

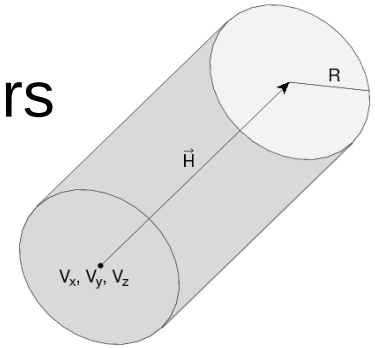
Prefer the bodies shown in green – tracking is faster since unnecessary boundary intersection calculations are avoided when the particle step is shorter than the distance to the region boundary.



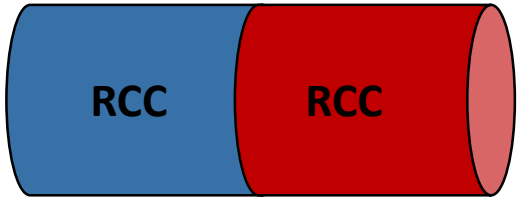
As noted before:
BOX, WED, RAW, ARB are deprecated.
Do not use them.

Precision errors in region definitions

- Always use as many digits as possible in the definition of body parameters
  - Particularly for body heights (RCC, REC, TRC)
- Avoid touching surfaces when floating point operations are involved
  - For the above bodies, the position of the opposite face is calculated using the height vector
  - This can lead to precision errors during tracking in case two such bodies touch each other

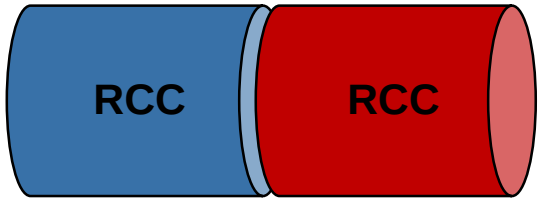


Example:
2 touching RCCs

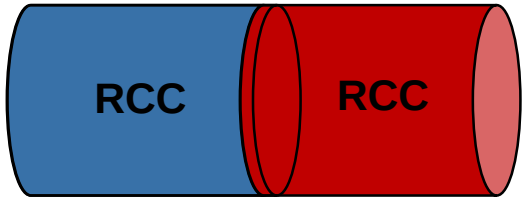


Possible precision errors:

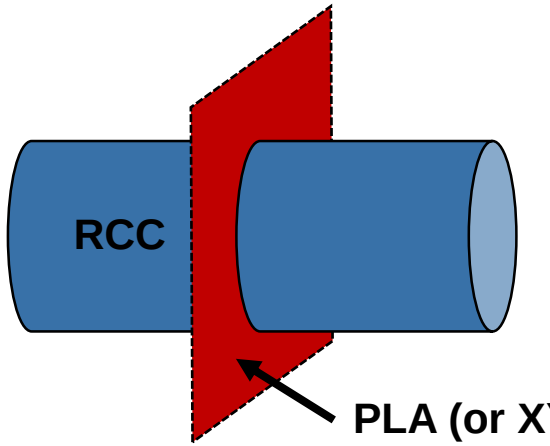
Small gap between regions



Small overlap between regions



Better:
define only one RCC and cut it with plane

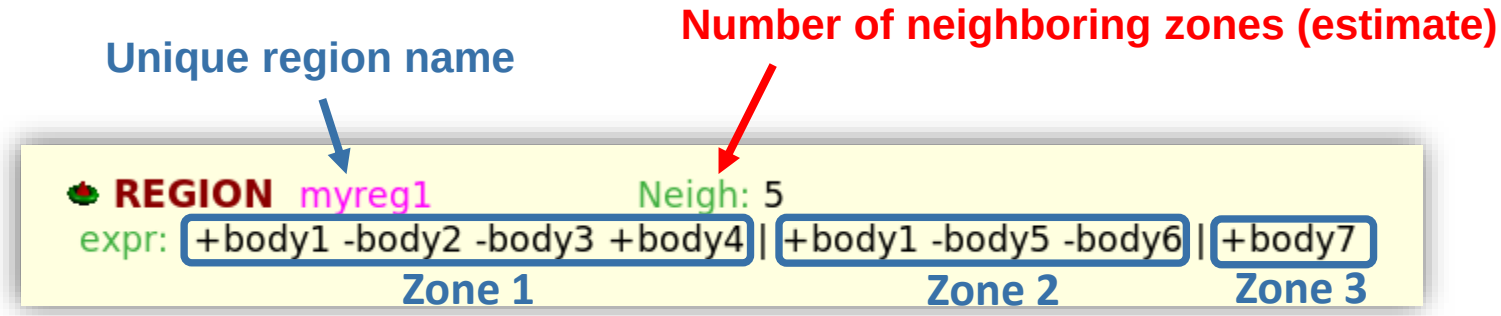


Some remarks on geometry errors

- During execution, the code always needs to know the region where a particle is located at every step:
  - The program **will stop** only if a particle position **does not belong to any region**. An error message will be printed in the **.err** file with the particle position.
  - **IMPORTANT:** the code **will NOT stop** if a particle position **belongs to more than one region**. It will accept the first region it finds but the results will be completely unreliable.
- Further types of errors:
  - Problem space not enclosed by a BLCKHOLE region
  - Never start a primary particle along a surface. You could get a geometry error even if the geometry is correct because FLUKA cannot determine the region.
  - Precision errors (see remarks on the choice of bodies in the previous section)
  - Lattice replica and basic cell mismatch (see advanced topics)

The number of adjacent zones (REGION card)

- "**Neigh**" parameter on the **REGION** card:
  - Is a rough estimate of the number of zones a particle can enter when leaving the current region zones (**5 by default**). What actually matters is the sum over all regions, defining the size of the contiguity list. **Note: for many simulation cases, the default value is fine.**
  - While tracking, the program searches in the contiguity list for the neighboring zones of each zone. If the zone is not yet in the list, the whole geometry is scanned and it is added to the list with its neighboring zones.
  - When the limit is reached (i.e. the list is full) the code prints a warning: **GEOMETRY SEARCH ARRAY FULL**. **This is not lethal: the calculation continues but with a reduced efficiency**.
  - If you have more than 1000 regions, you must issue a GLOBAL card putting in WHAT(1) a higher limit (not beyond 10000).



CURSO INTRODUTÓRIO

FLUKA

23 DE JANEIRO
A 8 DE MARÇO
DE 2023

Código Monte Carlo de interação e transporte de partículas

Pausa

Voltamos em 15 minutos

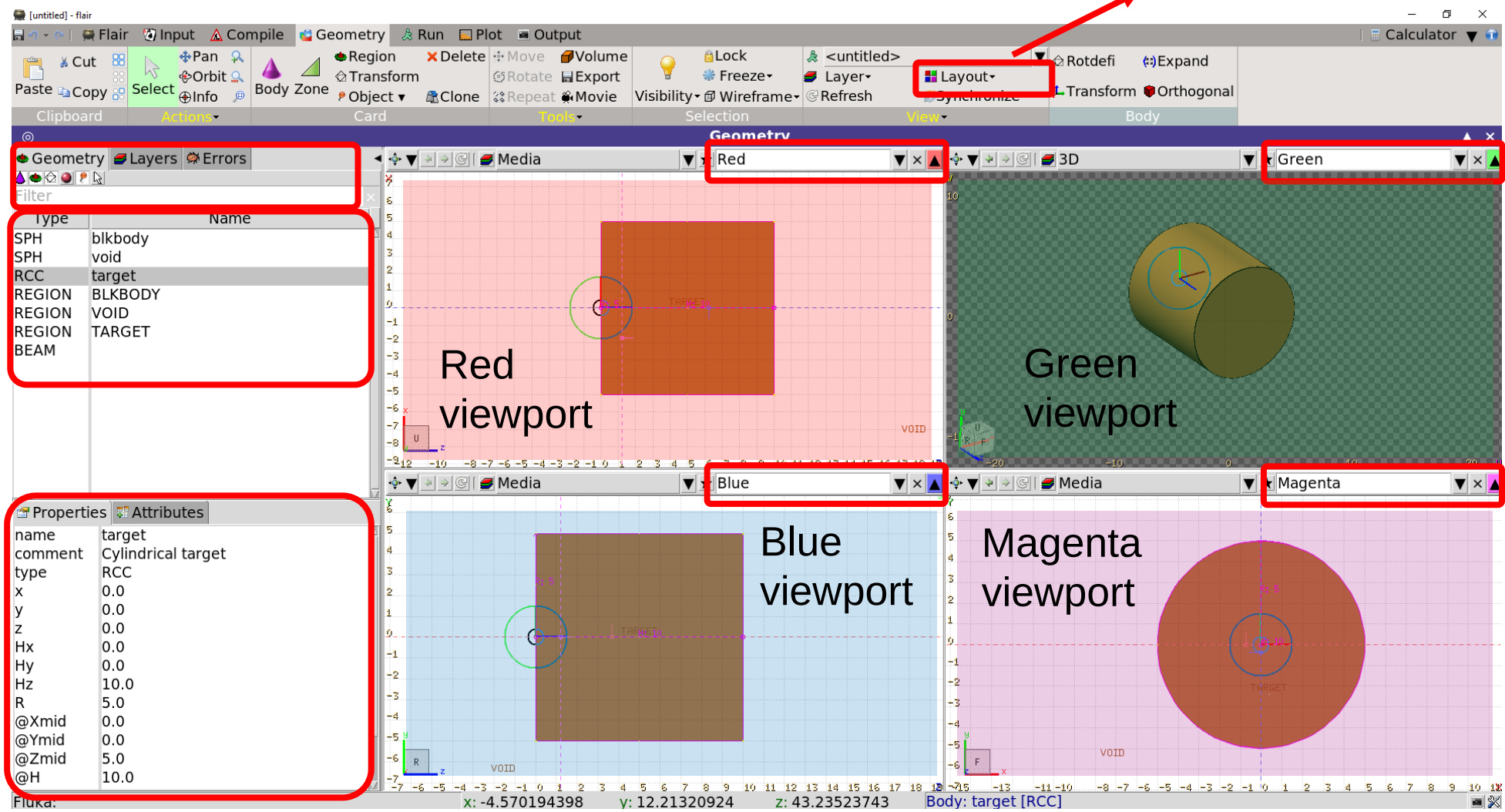
CNPEM
ORGANIZAÇÃO SOCIAL DO MCTI

Flair Geometry Editor

Creating and graphically editing the FLUKA geometry

Geometry tab – Recap

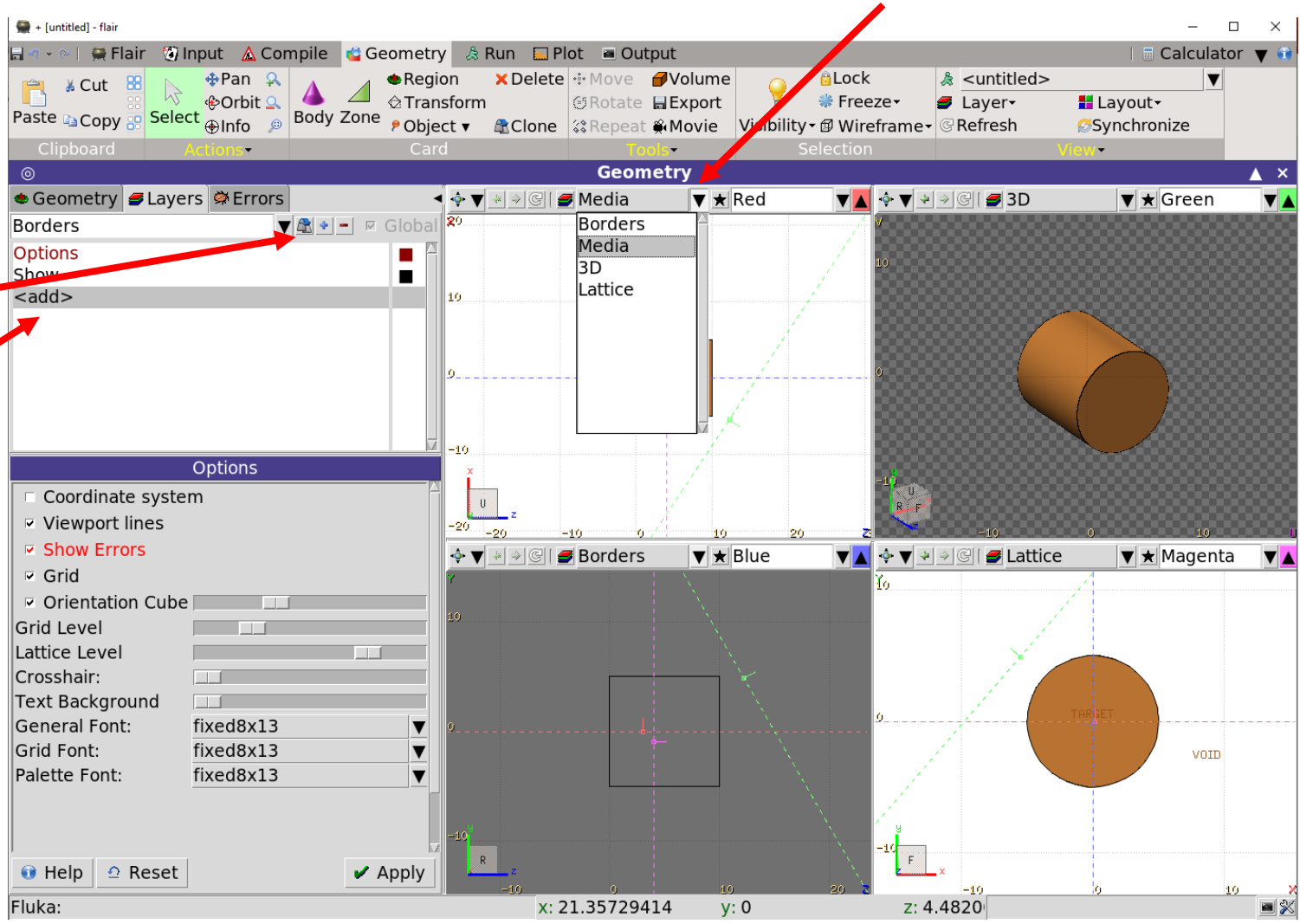
- Viewports automatically refreshed when input is changed



Layers

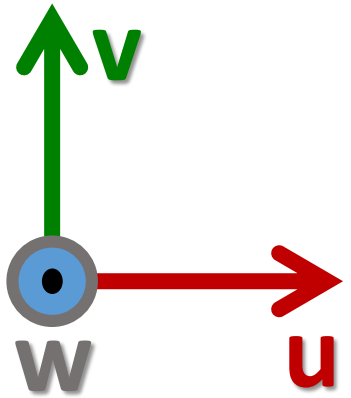
- Four default layers:
  - Borders
  - Media
  - 3D
  - Lattice (advanced topics)
- User can create (clone) layers

  e.g.: scoring layers
- Layers are customizable

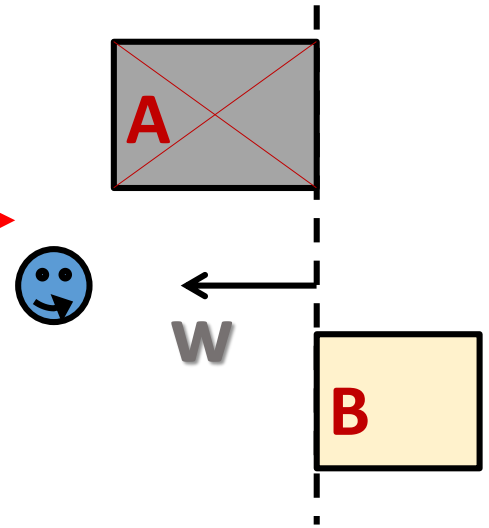


Viewports

- Each viewport is defined by:
  - **Origin**: center of the viewport
  - **Basis**: relative axis system **u**, **v**, **w**
    (**w** is coming of the screen toward the user)
  - **Extent**: zoom



- Important note: each viewport is facing towards negative w
  - If A and B are touching the viewport
    only B would be visible
  - Test it on the basic input and
    compare red and magenta viewports



Viewport lines – 1

- Dashed lines represent other viewports

  (their intersections with the current one)

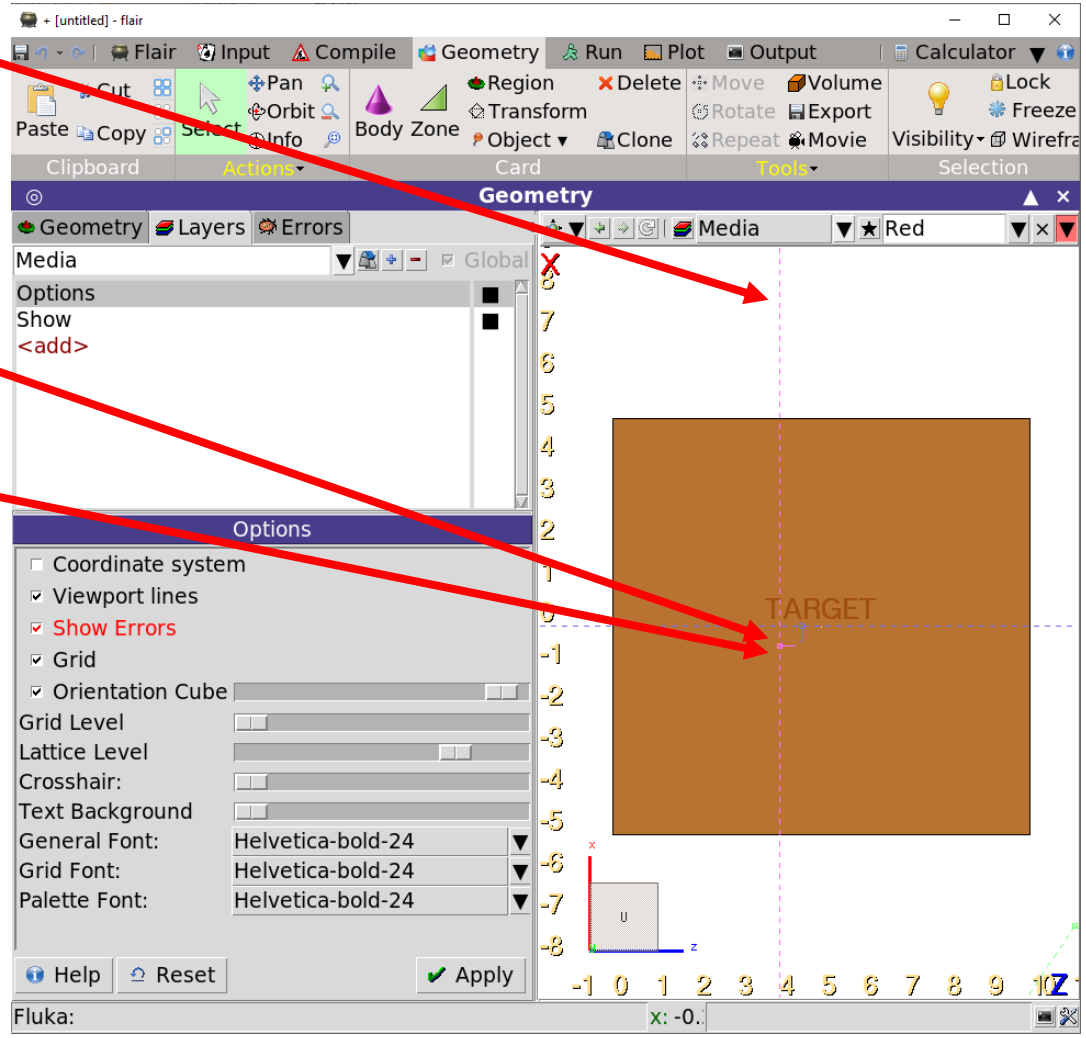
- The center is indicated by a square

- The w direction is indicated by a short line

- Viewports outside the current one

  are displayed on the closest edge

  of the current viewport window



Viewport lines – 2

- Dashed lines represent other viewports

  (their intersections with the current one)

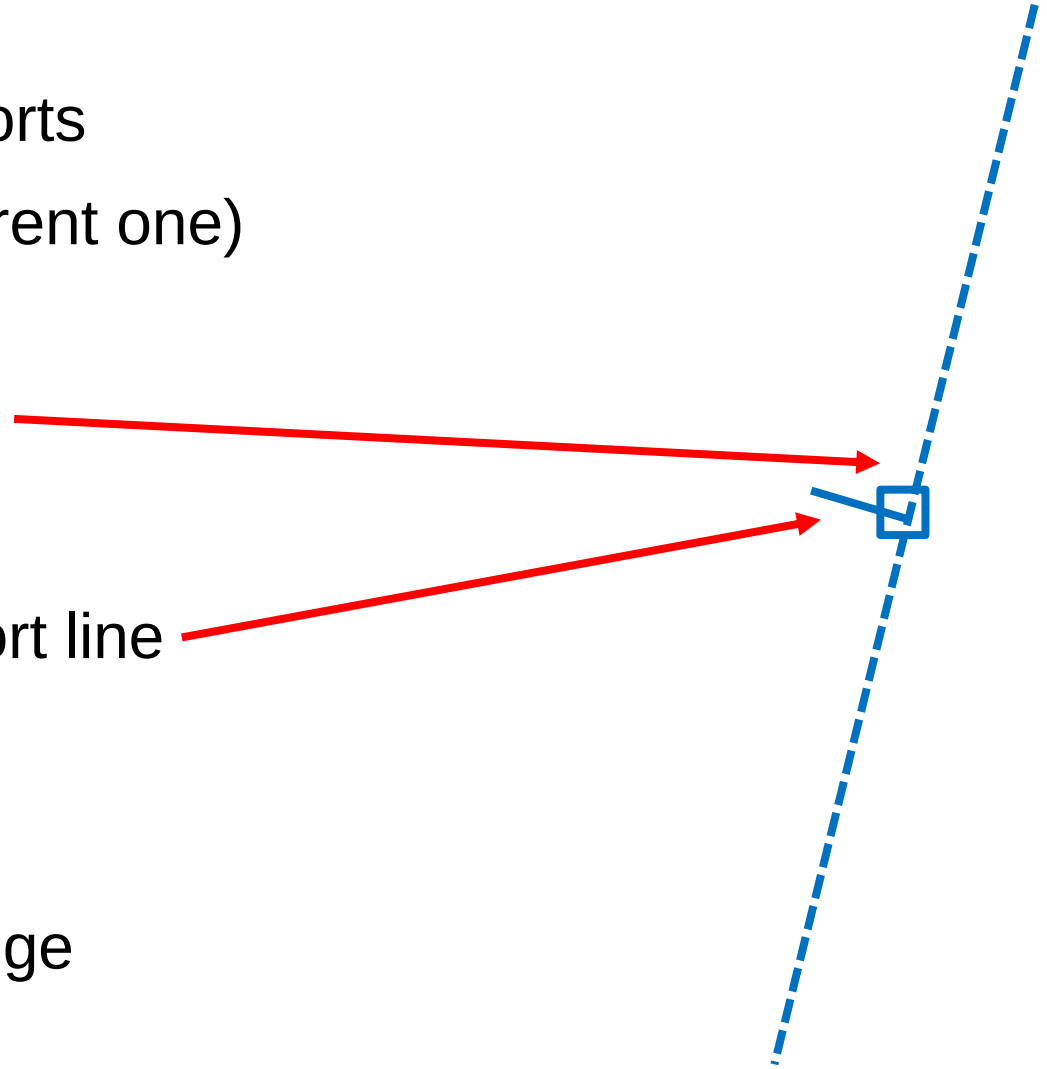
- The center is indicated by a square

- The w direction is indicated by a short line

- Viewports outside the current one

  are displayed on the closest edge

  of the current viewport window



Viewport lines actions

Select + left mouse button:

- Drag the center square

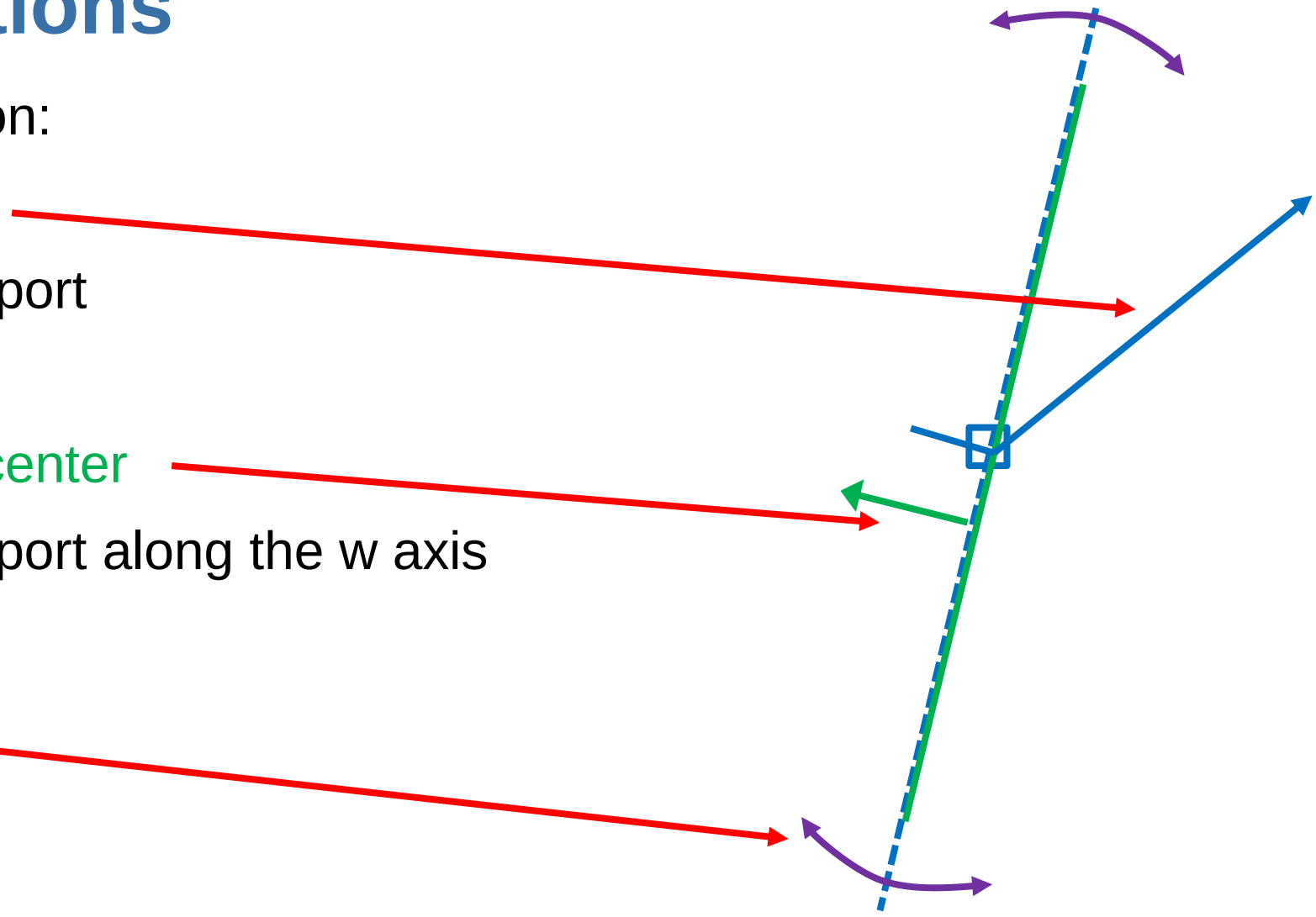
  to reposition the viewport

- Drag the line close to the center

  to reposition the viewport along the w axis

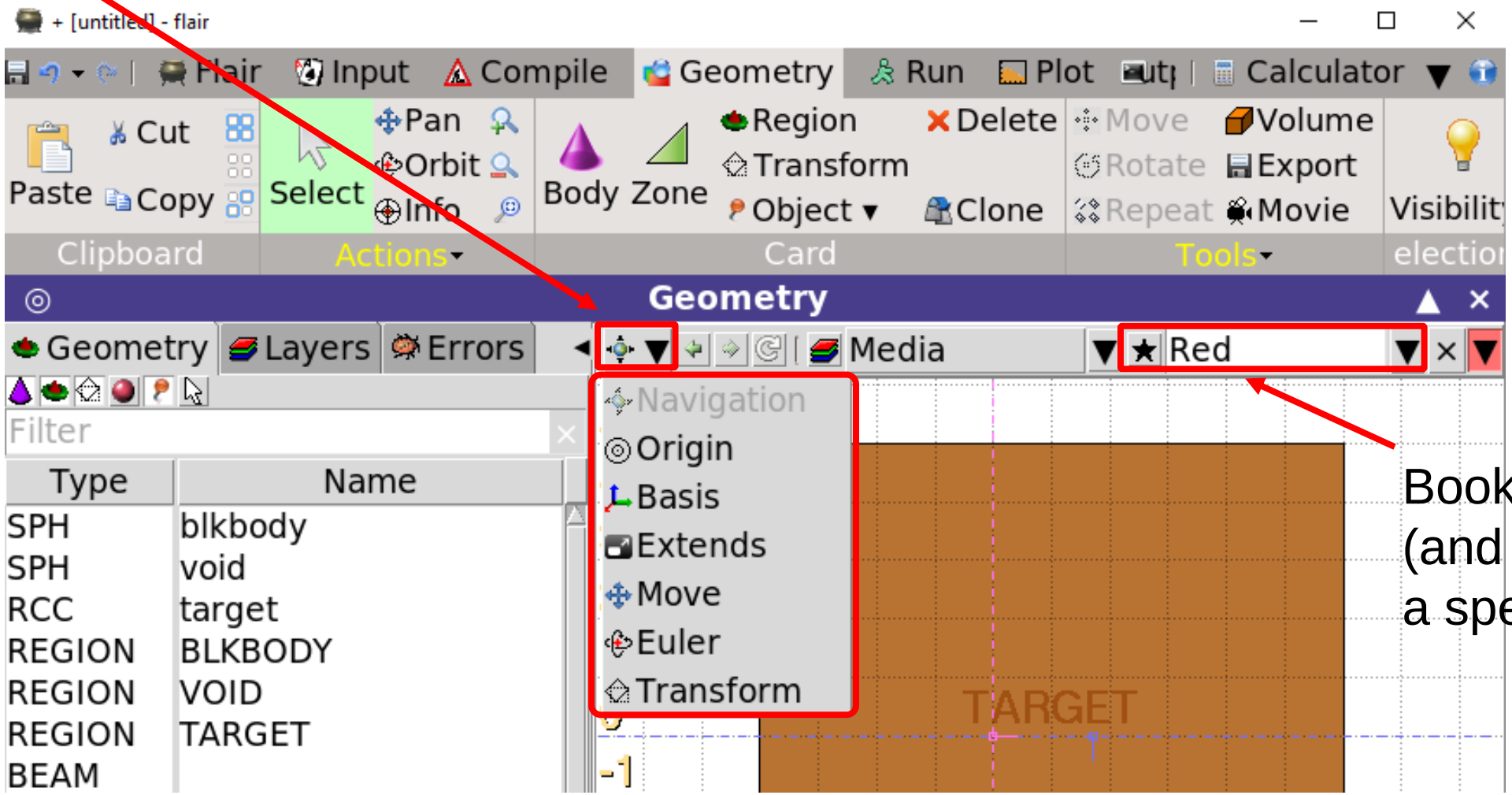
- Drag the extremities

  to rotate it



Projection dialog

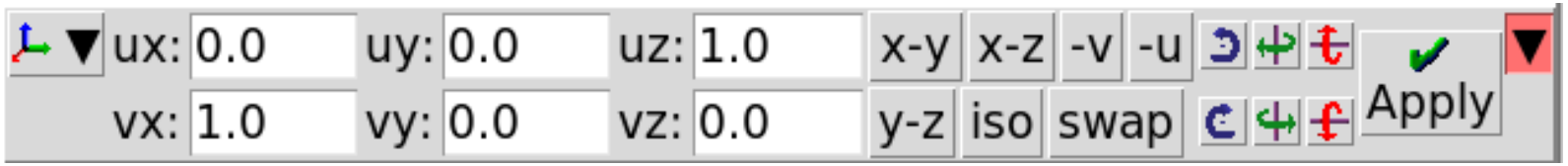
- The projection button allow to change, move, shift, rotate a viewport



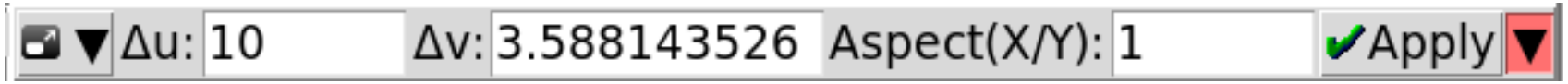
Projection dialog

- Set the viewport's center

- Change the reference axes



- Change the extent



- Shift the view

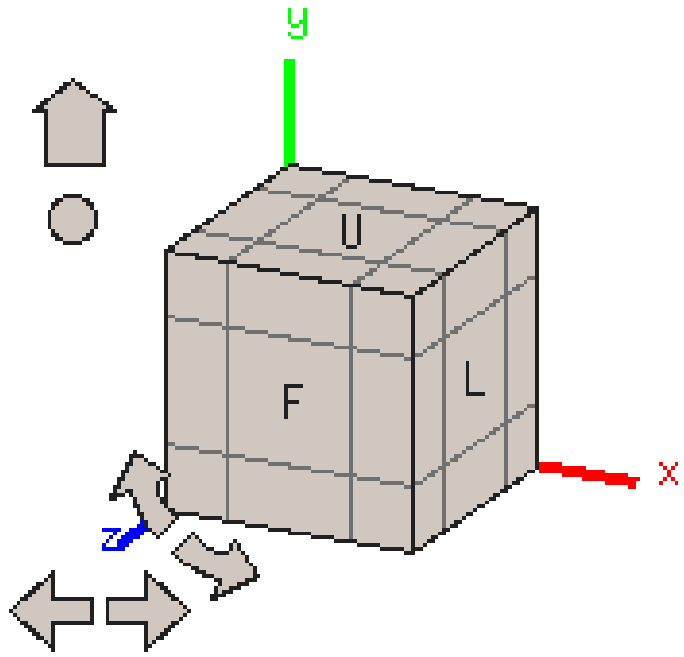
- Rotate around Cartesian axes

- Apply a ROT-DEFI to the viewport

Orientation cube

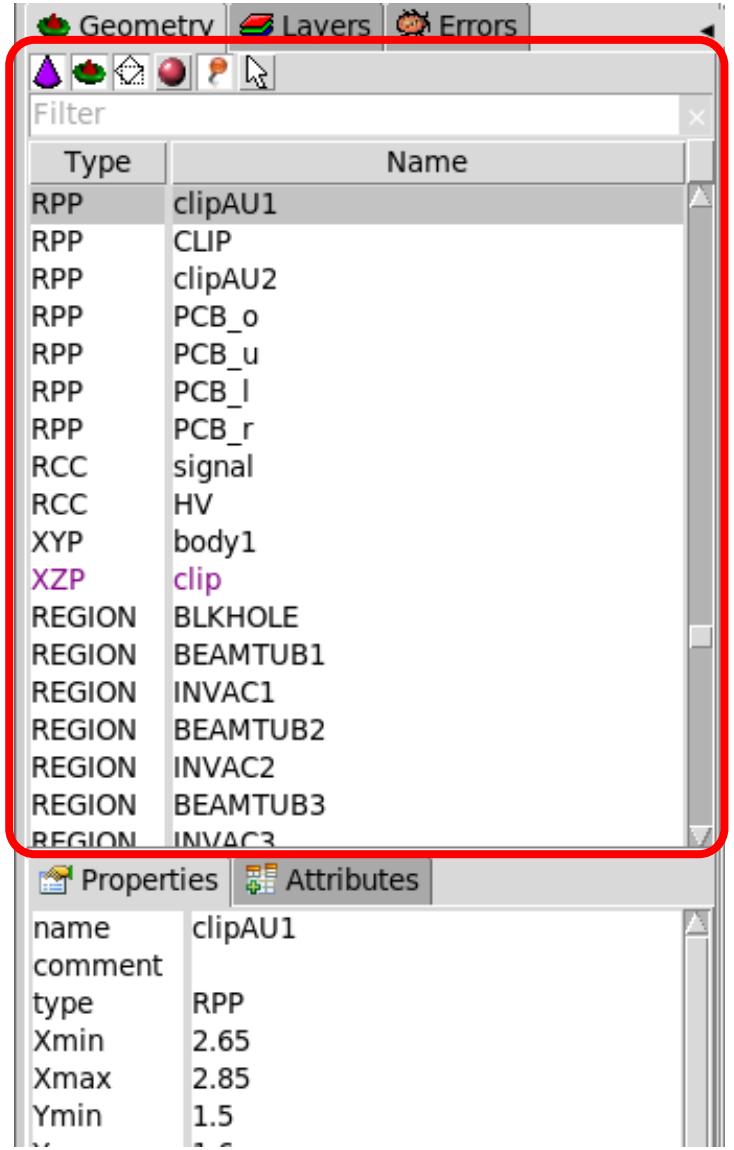
- In the bottom-left corner of each viewport
- Shows the axis system
- Allows to rotate the axes
- Similar to some CAD programs

Name	Side description
Front	X-Y plane towards the positive Z
Back	X-Y plane towards the negative Z
Up	X-Z plane towards the positive Y
Down	X-Z plane towards the negative Y
Left	Y-Z plane towards the positive X
Right	Y-Z plane towards the negative Y



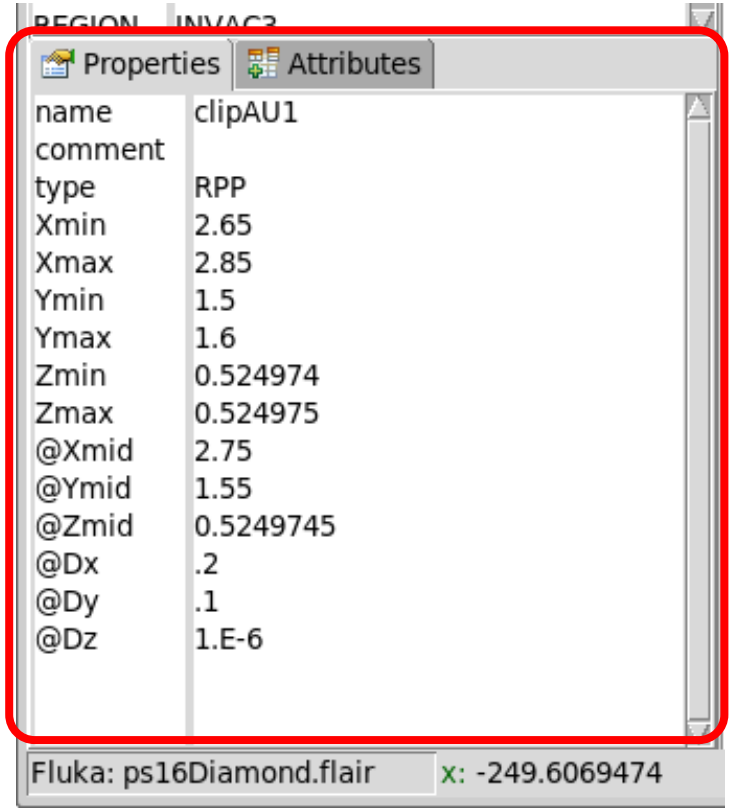
Object listbox

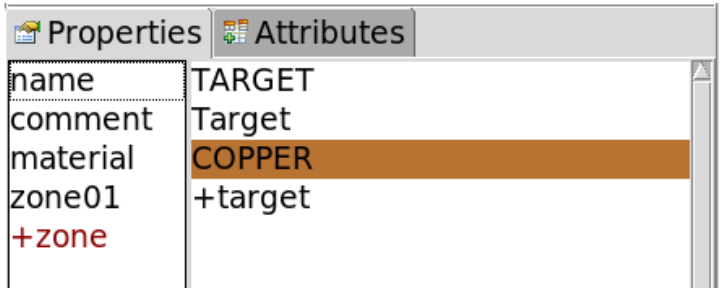
- List type/name of bodies, regions, and objects
- Allows text filtering
- Text color-code:
  - **Red** Error in the card description
  - **Magenta** Visible body/object
  - **Orange** Selection locked
- Buttons to turn on/off the display of:
  - Bodies
  - Regions
  - Transformations
  - Materials
  - Object
  - Selected or visible items



Property and Attributes listbox

- Displays the common WHATs of the selected card
- Allows to add comments
- Allows regions editing
- Allows to assign materials (ASSIGNMA card created)
  - WARNING: it does not work if the region is within an #if…#endif statement
- Extra info are displayed in “Attributes”
  - Bodies: visibility, selection-locking, etc.
  - Regions: transparency, ROT-DEFI, etc.





Selection – 1

- Objects / Bodies / Zones / Regions can be selected using:
  - Object and/or Property listboxes
  - Graphically with the left mouse button on the viewport

- [**CTRL**]+left mouse button toggles the selection

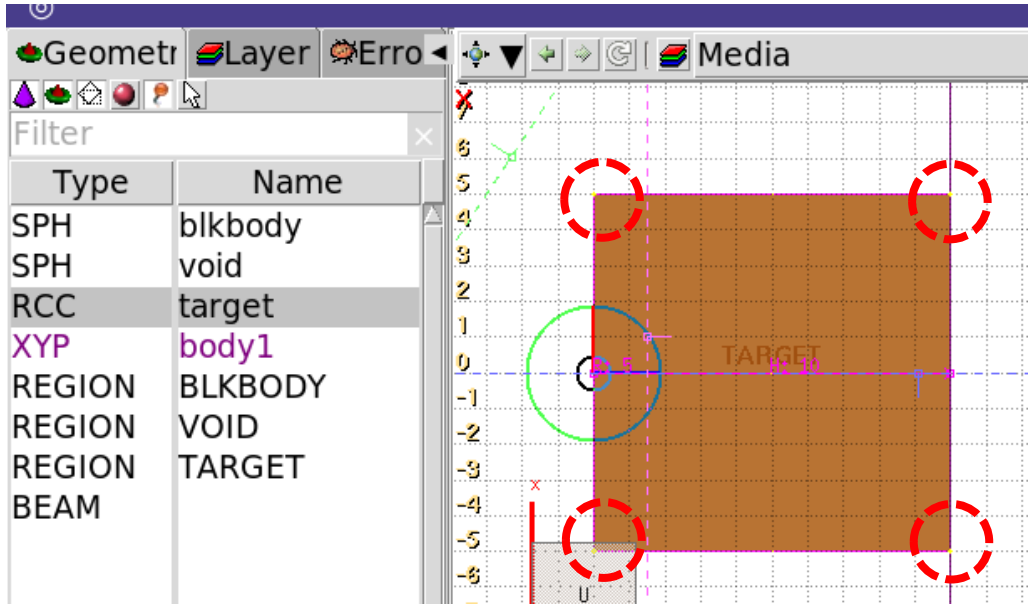
- Area selection is also possible (click-and-drag)

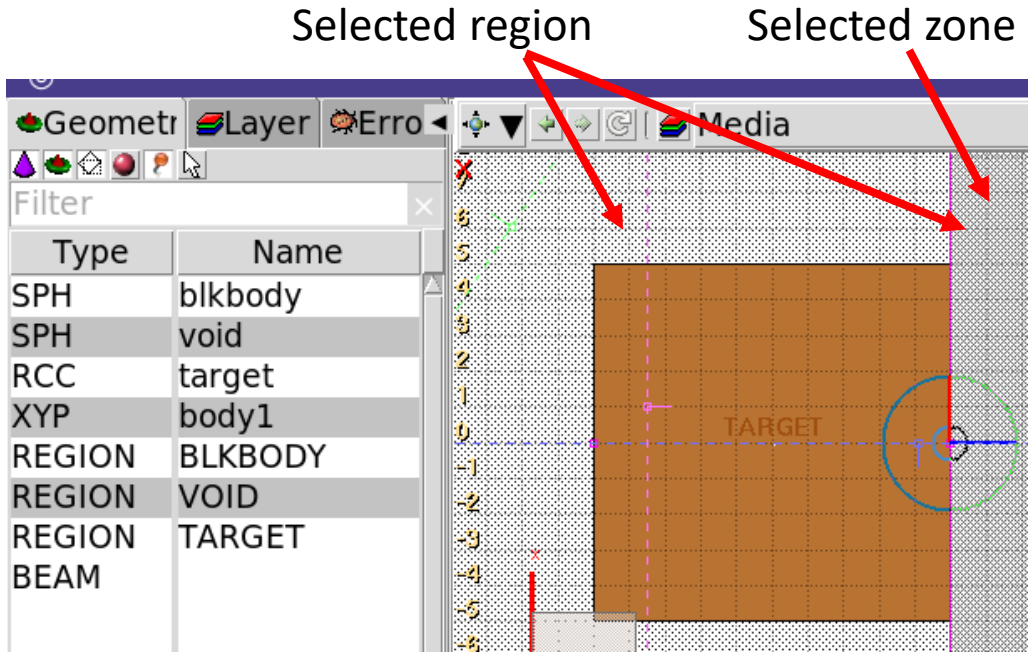
  Everything inside the area is selected

- [**ESC**ape] cancels the selection

Selection – 2

- Selected bodies are:
  - Highlighted in magenta in the viewport
  - Yellow dots appear on their vertices
  - Highlighted in the listbox
- Selected regions are shaded
- Selected zones are shaded with hast pattern
- Zones can be selected after selecting a region
- [ESCape] cancels the selection





Adding a new body

- Right-click or [b] or [Space] or [INS]
- Menus are organized in sub-categories
- Capital [B] to repeat last add-body
- Left-click on the desired location of the new body
- Extended bodies require to left-click each characteristic
- New bodies are named after the last body renamed
  - e.g. john → john1 → john2 → john3 → etc.
- [n] allows to fast edit object name
- IMPORTANT: Renaming a body will automatically rename

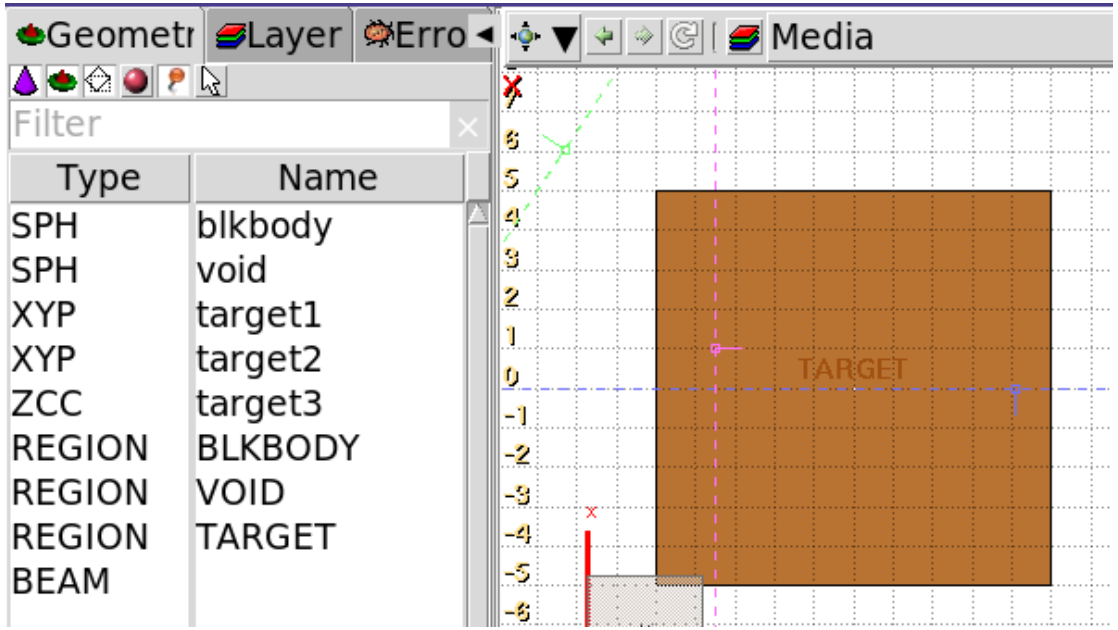
  any reference to it, without asking the user

  e.g. a body used in a region definition

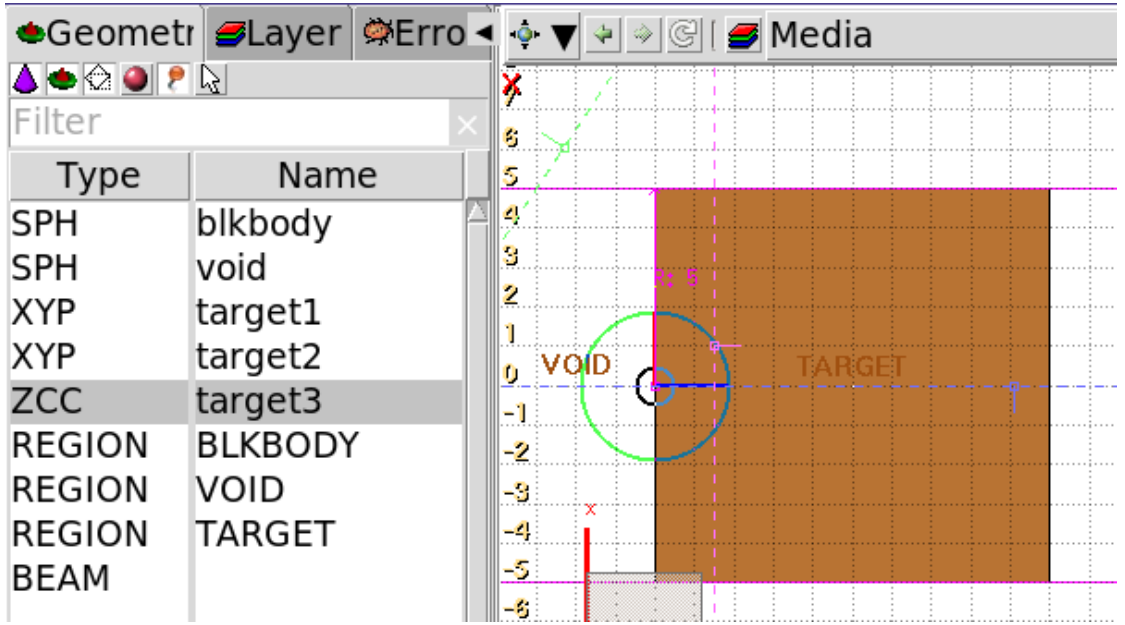
Body visibility – 1

- Default: body segments are only visible when they represent borders of REGIONs
- Bodies become visible when selected

ZCC target 3
Not selected → Not visible

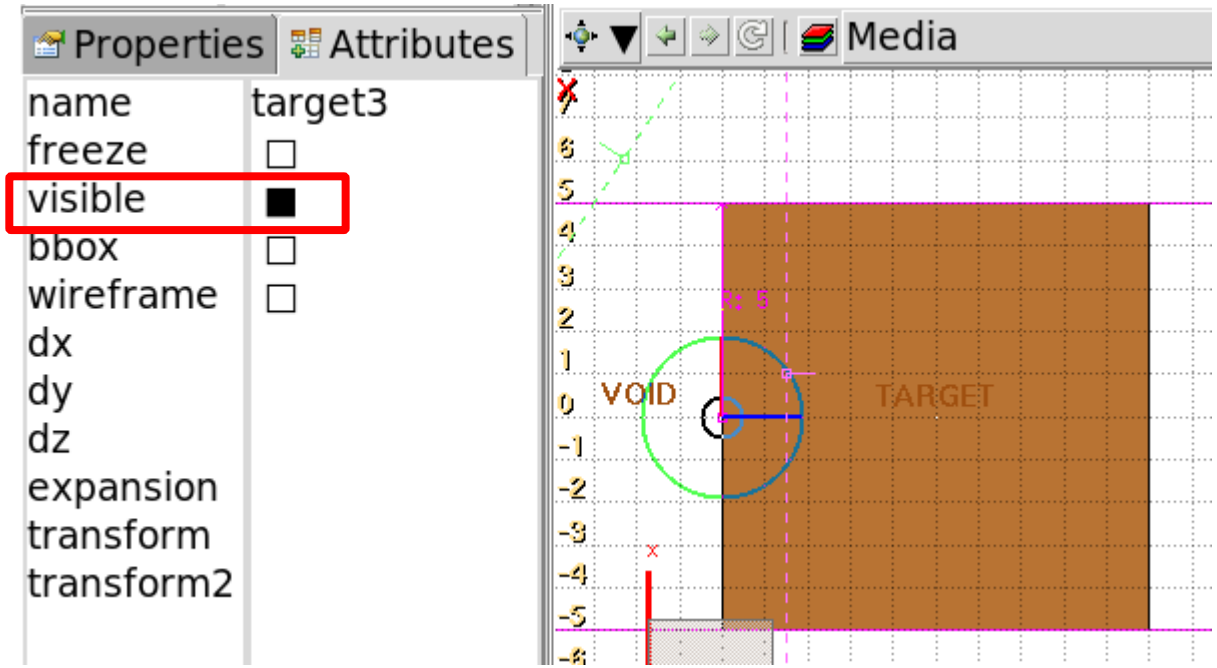


ZCC target 3
Selected → Visible



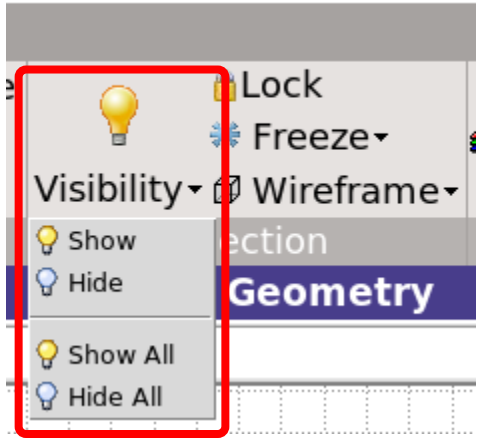
Body visibility – 2

- Visibility default can be changed in the “Attributes” of each body



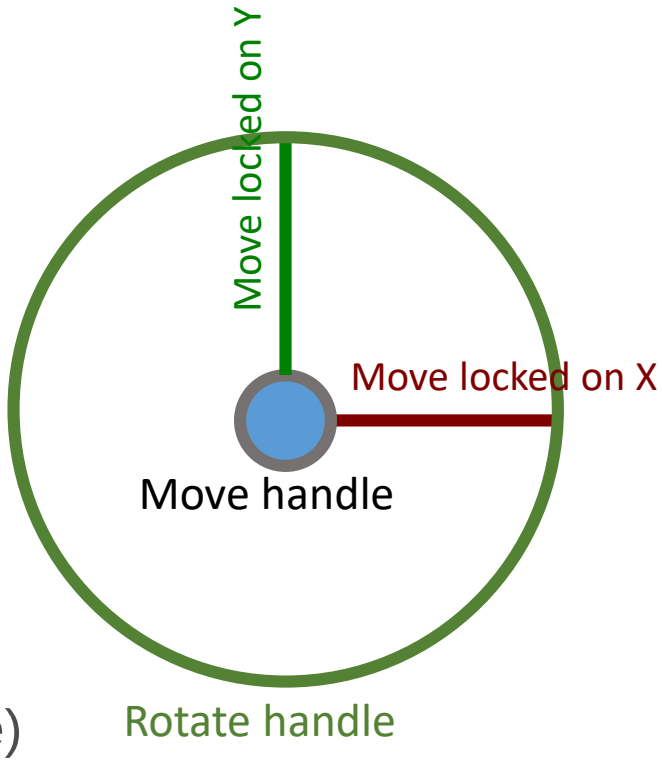
ZCC target 3
Not selected but visible!

- Shortcut [v] or Toolbar button



Body editing – 1

- Bodies can be edited typing their coordinates/values
  - in the Properties or
  - in the Flair input editor



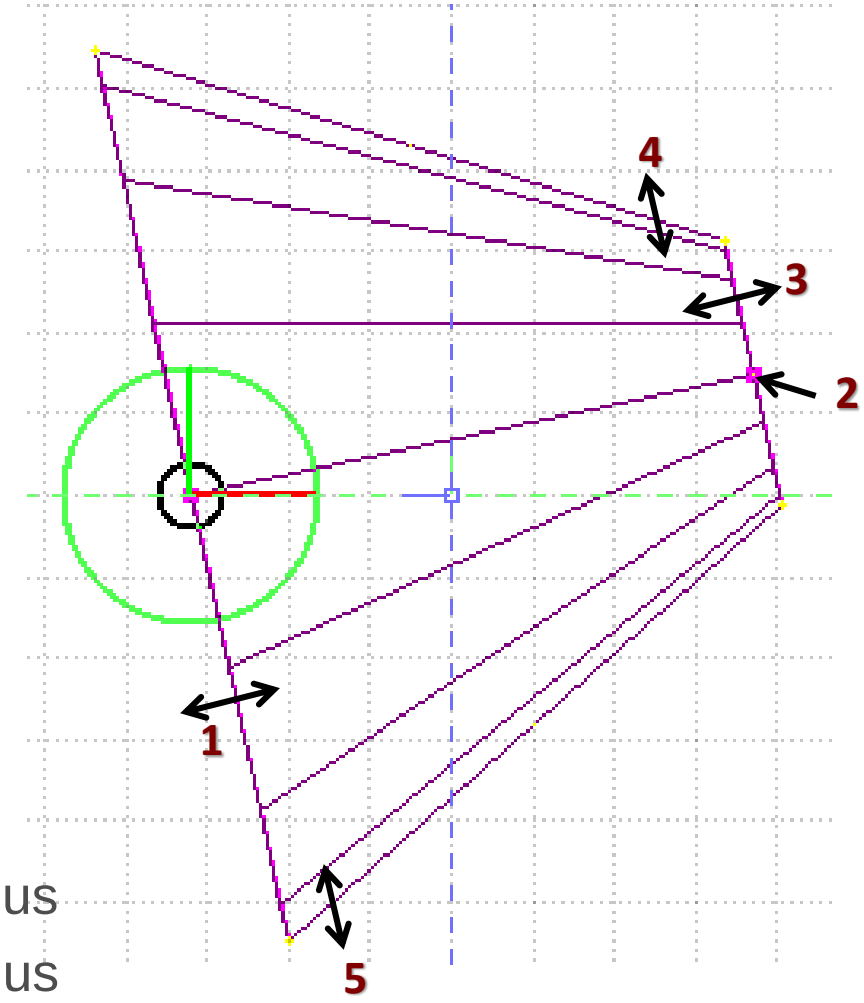
- Graphically
  - Selecting a body the action handle is displayed
  - Right-click the small circle to freely move (shortcut: [g]-grab)
  - Right-click the big circle to rotate around the w axis (shortcut: [r]-rotate)
  - Right-click the red/green/blue lines to move along the X, Y, or Z axis
  - While moving a body, hit [x], [y], or [z] to lock movement along the selected axis

Body editing – 2

- When a body is selected and the handles are shown,

  it's possible to click-and-drag the handler

  to move, rotate, and resize the object



- TRC example
  1. On the base plane, to move it normally to the height vector
  2. On the small square on the apex plane,

     to move the height vector
  3. On the apex plane, to move it normally to the height vector
  4. On the conic surface close to the apex, to resize the apex radius
  5. On the conic surface close to the base, to resize the base radius

Adding a new region

- Right-click or [R] or [Space] or [INS]
- Immediately, the property listbox is activated to edit the name
- Assigning a material to a region, automatically generated the ASSIGNMA card
- However, deleting a region does not remove the corresponding ASSIGNMA card
- IMPORTANT: Renaming a region will automatically rename

  any reference to it, without asking the user

  e.g. in the ASSIGNMA card

Zone editing

IMPORANT REMINDER:

- A zone is a subregion expressed in terms of “+” and “-” only, e.g.

REGION “+a +b | +c –d”

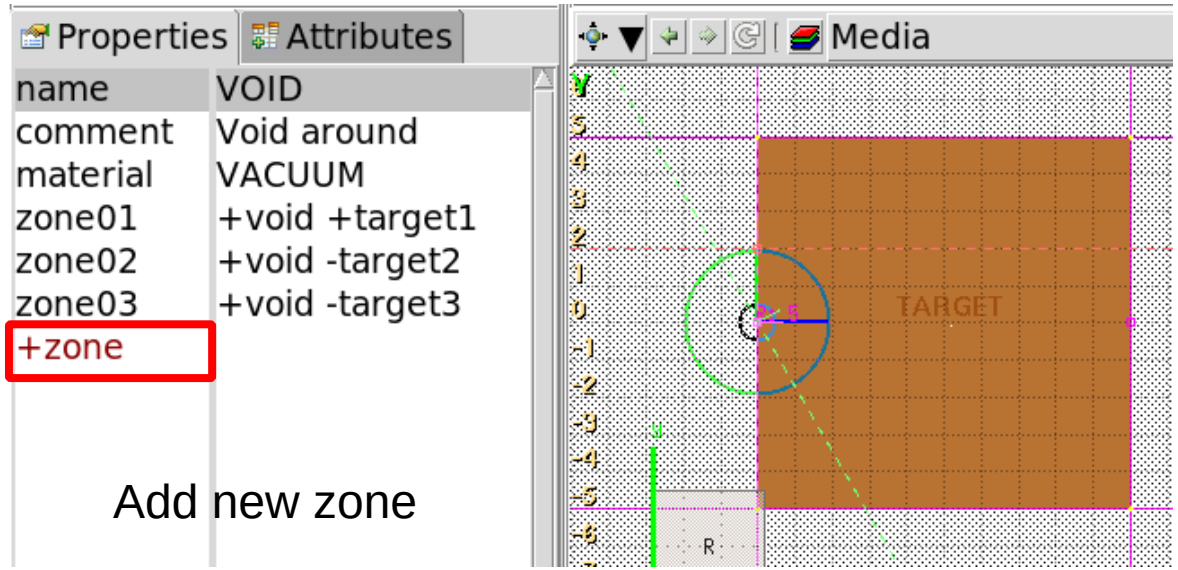
contains 2 zones

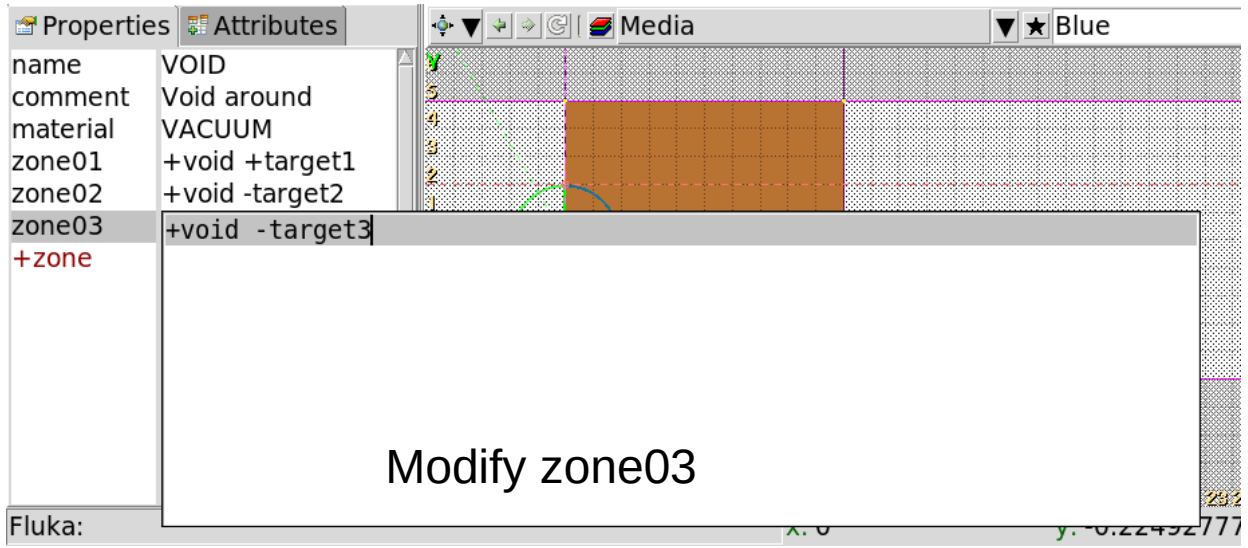
zone1: +a +b

zone2: +c -d

Zone editing – with the keyboard

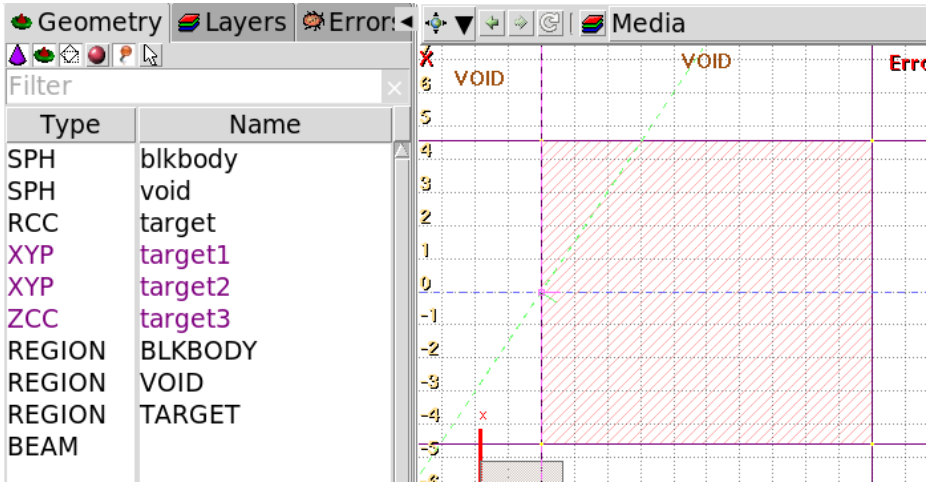
- Add a zone: enter the expression in the “+zone” field
- Modify a zone: select the zone to modify and edit its expression
- Delete a zone: select the zone to delete either:
  1. Right-click → Delete or
  2. Hit [Del] while the pointer is inside the Property Listbox

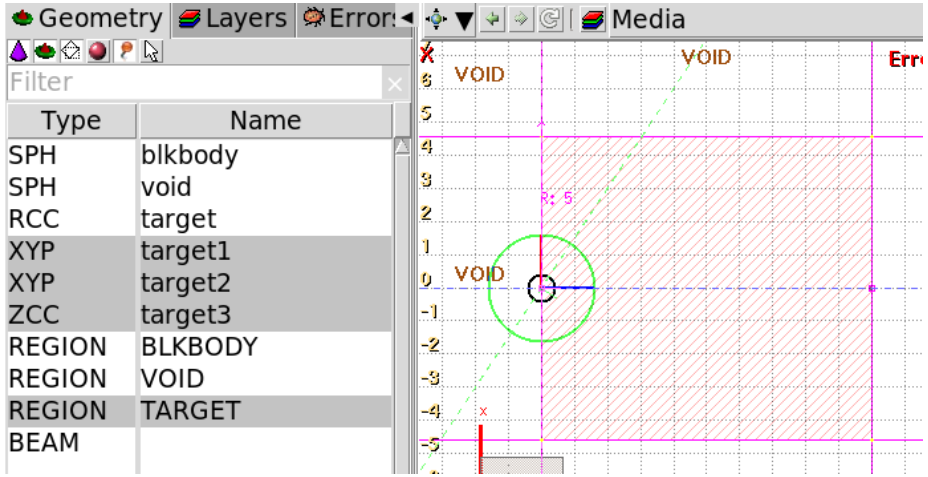




Zone editing – graphically

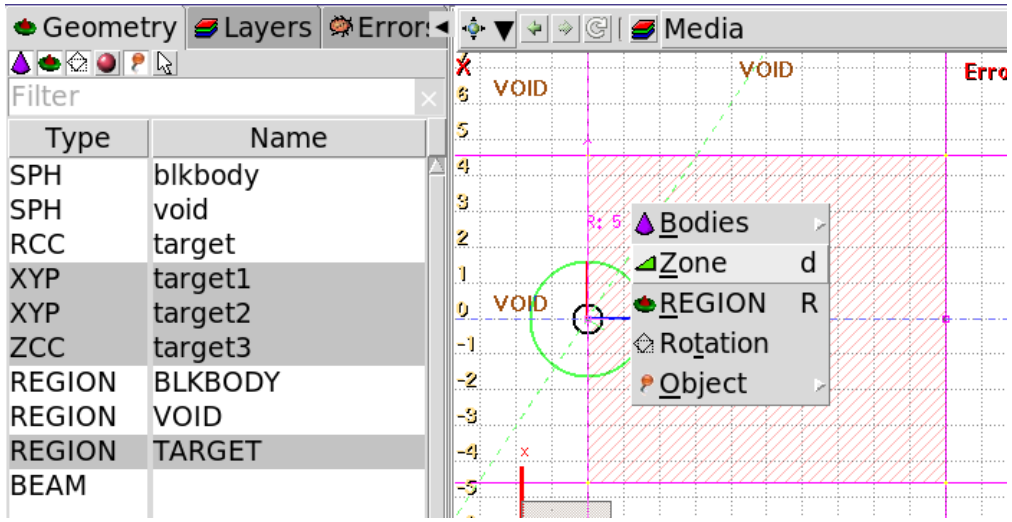
- First, select the REGION to which the zone to add/modify belongs
- Add a new zone
  - Verify that no zone is selected in the property listbox (unselect using [ESC])
  - Add on the selection ONLY the bodies representing the zone borders

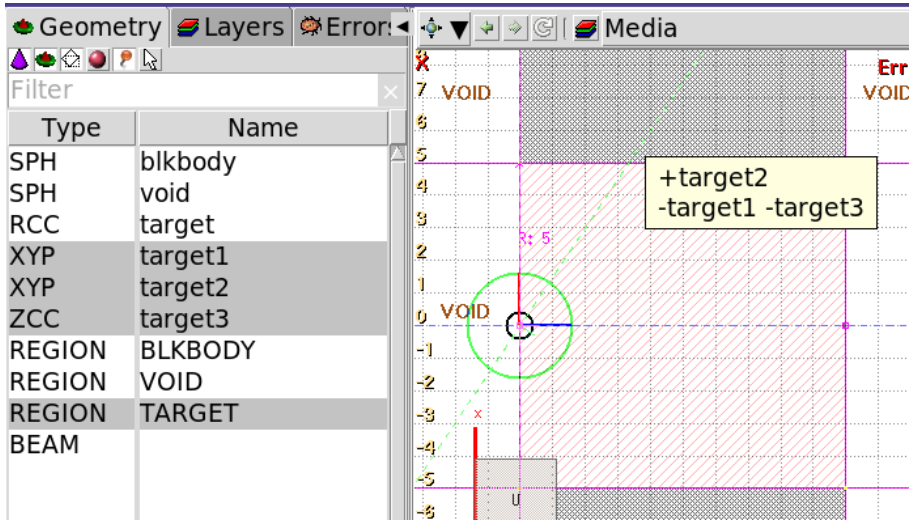




Zone editing – graphically

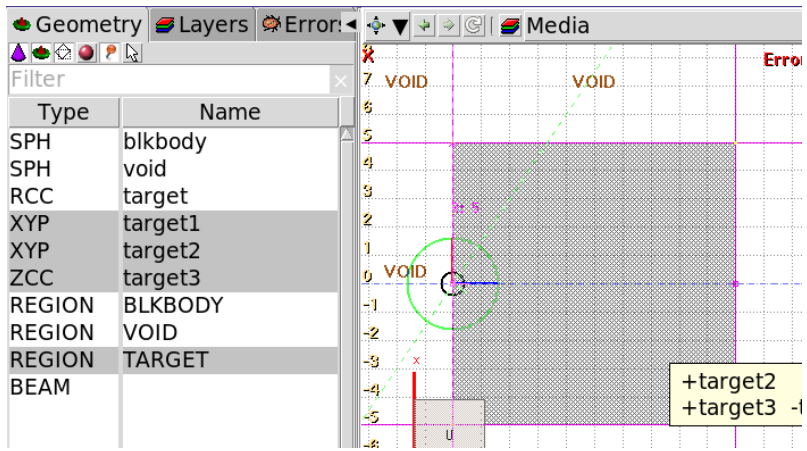
- First, select the REGION to which the zone to add/modify belongs
- Add a new zone
  - Verify that no zone is selected in the property listbox (unselect using [ESC])
  - Add on the selection ONLY the bodies representing the zone borders
  - Right-click or [Space] to open a pull-down menu
  - Select Zone (shortcut [d])

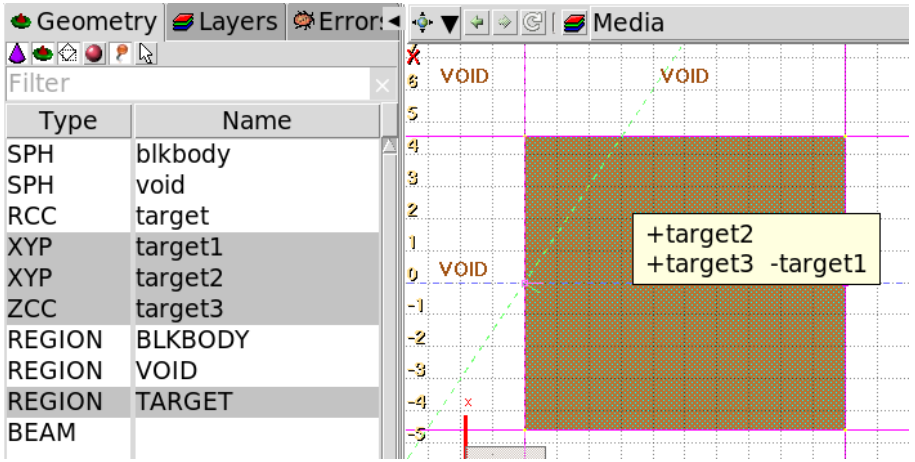




Zone editing – graphically

- First, select the REGION to which the zone to add/modify belongs
- Add a new zone
  - Verify that no zone is selected in the property listbox (unselect using [ESC])
  - Add on the selection ONLY the bodies representing the zone borders
  - Right-click or [Space] to open a pull-down menu
  - Select Zone  (shortcut [d])
  - Left-click over a point in any viewport that should belong to the new zone
  - The zone is automatically created



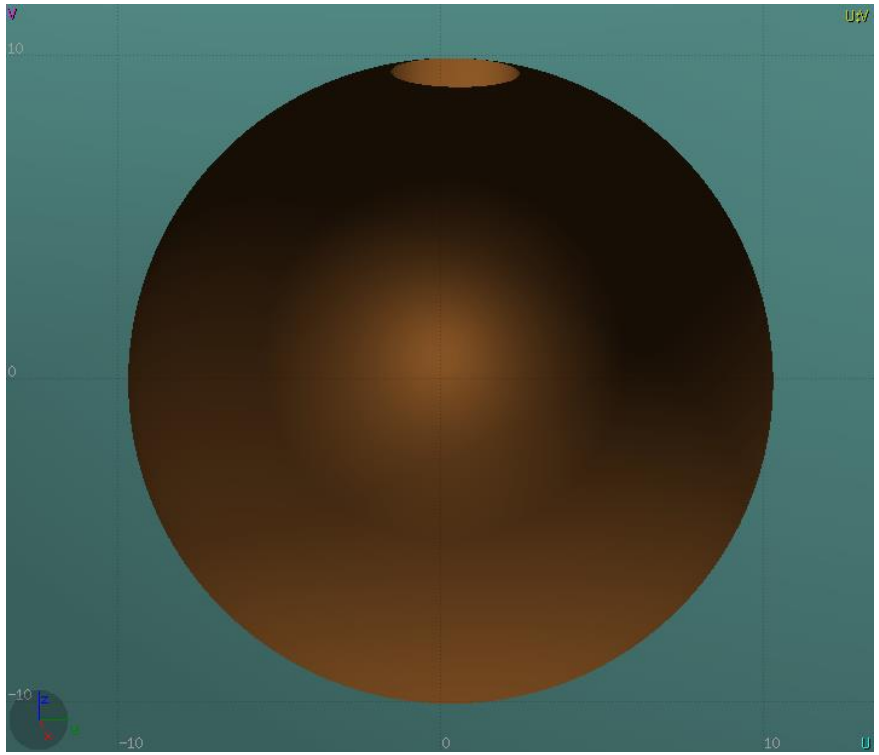


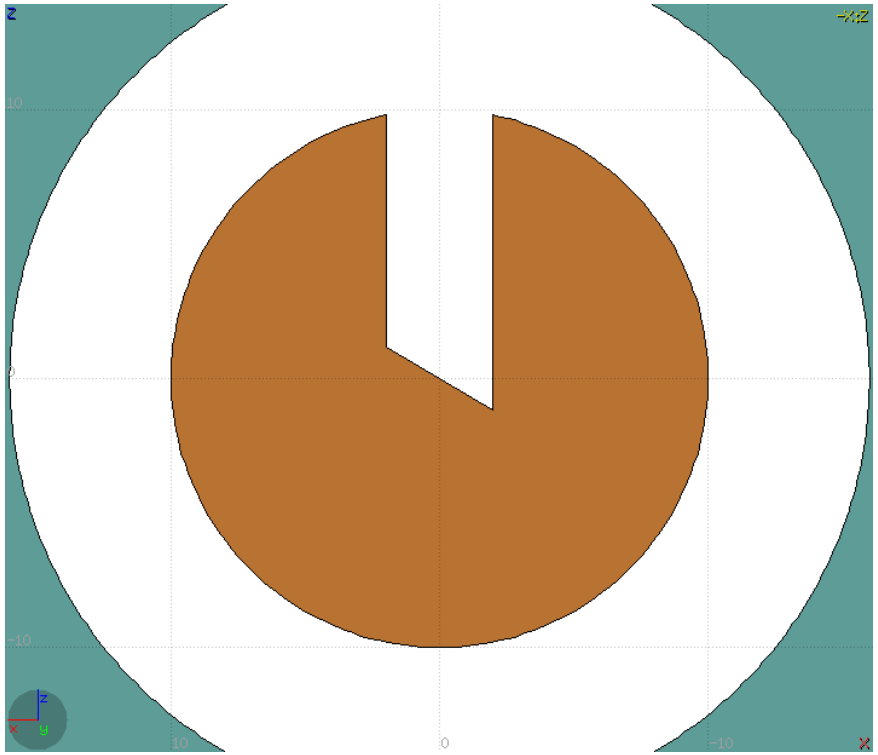
Zone editing – graphically

- First, select the REGION to which the zone to add/modify belongs
- Edit an existing zone
  - Select a zone either graphically or on the property listbox
  - All bodies involved in the zone definition are automatically selected
  - While the zone is selected, (un-)select bodies (not) needed for the zone definition
  - Then proceed as for adding a new zone
  - Right-click or [Space] to open a pull-down menu
  - Select Zone  (shortcut [d])
  - In any of the viewports, left-click on a point that should belong to the zone
  - The zone is automatically updated
- IMPORTANT: select only needed bodies (extra bodies slow down simulations)

Zone editing – Example [1/9]

- How to create a sphere with a cylindrical hole cut with a tilted plane (@30º)

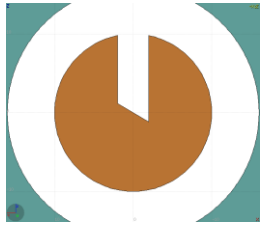




- First, create all necessary bodies: sphere, infinite cylinder, tilted plane

Zone editing – Example [2/9]

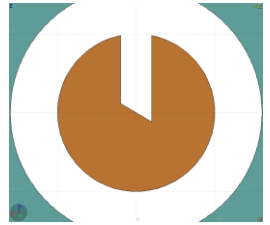
Reference image



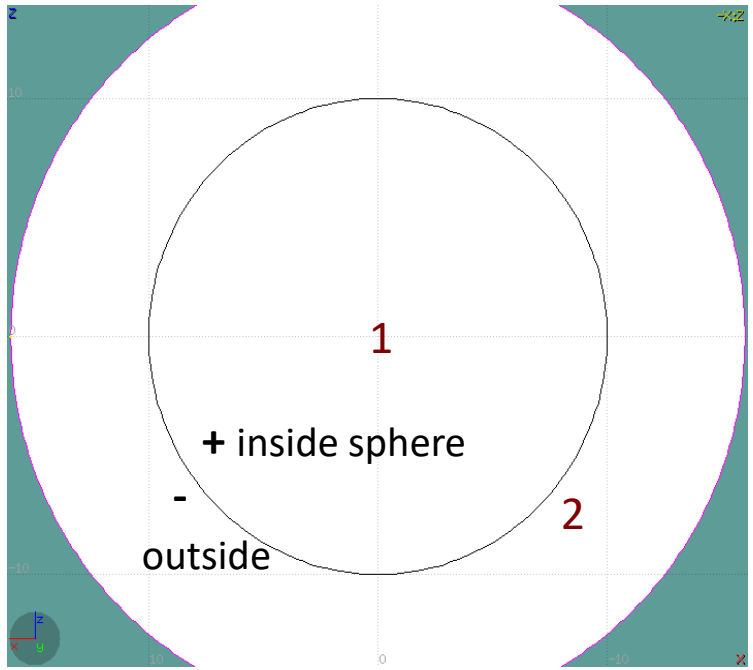
- Add a new region
  - [Space] → REGION
  - Shortcut [R]
- The region expression is empty
- Type the region name
- Select the material (or leave default VACUUM)
- Press [ESC]
- The region remains selected

Zone editing – Example [3/9]

Reference image

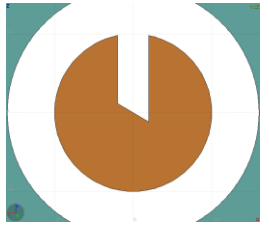


- Add the sphere to the selection
  - Holding [CTRL] pressed
- The sphere outline is highlighted
- The sphere divides the space into 2 zones:
  1. +sphere (inside the sphere)
  2. -sphere (outside the sphere)



Zone editing – Example [4/9]

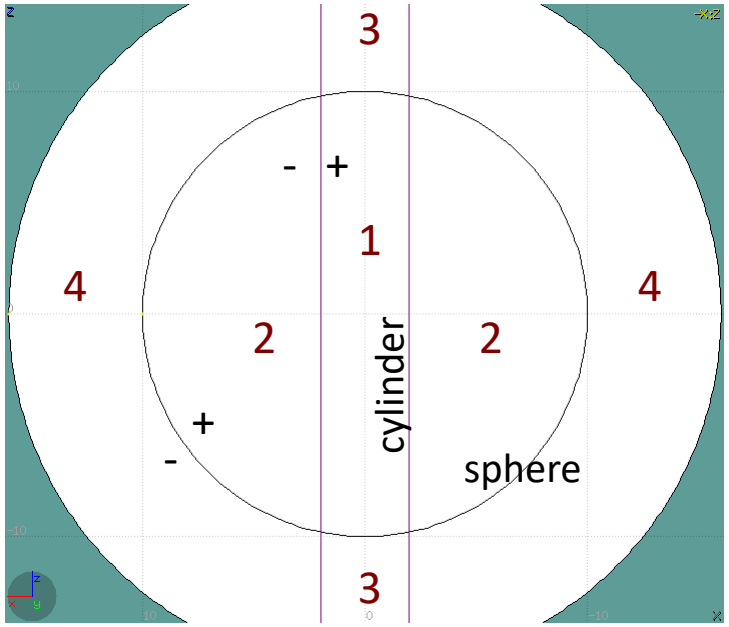
Reference image



- Add the cylinder to the selection
  - Holding [CTRL] pressed
- The cylinder outline is highlighted
- The sphere and the cylinder

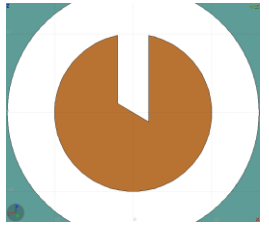
  divide the space into 4 zones:

  1. +sphere +cylinder (inside the sphere, inside the cylinder)
  2. +sphere -cylinder (inside the sphere, outside the cylinder)
  3. -sphere +cylinder (outside the sphere, inside the cylinder)
  4. -sphere -cylinder (outside the sphere, outside the cylinder)

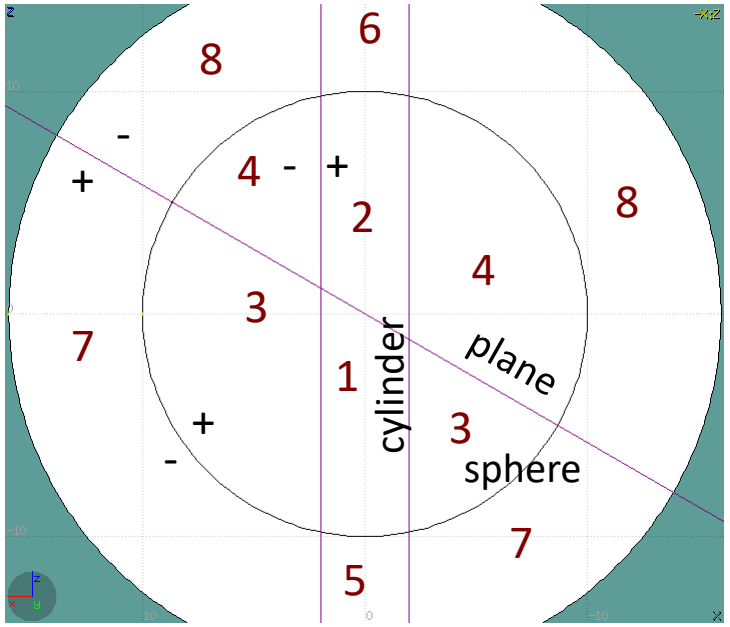


Zone editing – Example [5/9]

Reference image

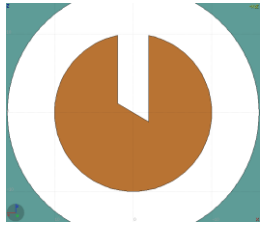


- Add the tilted plane to the selection
  - Holding [CTRL] pressed
- The tilted plane outline is highlighted
- The 3 bodies divide the space into 8 zones:
  1. +sphere +cylinder +plane
  2. +sphere +cylinder -plane
  3. +sphere -cylinder +plane
  4. +sphere -cylinder -plane
  5. -sphere +cylinder +plane
  6. -sphere +cylinder -plane
  7. -sphere -cylinder +plane
  8. -sphere -cylinder –plane
- Number of valid zones $\leq 2^{\text{bodies}}$



Zone editing – Example [6/9]

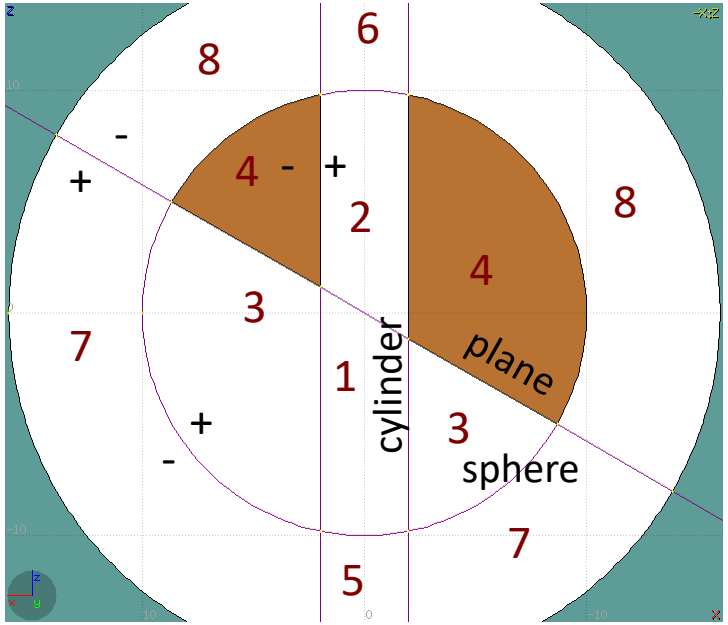
Reference image

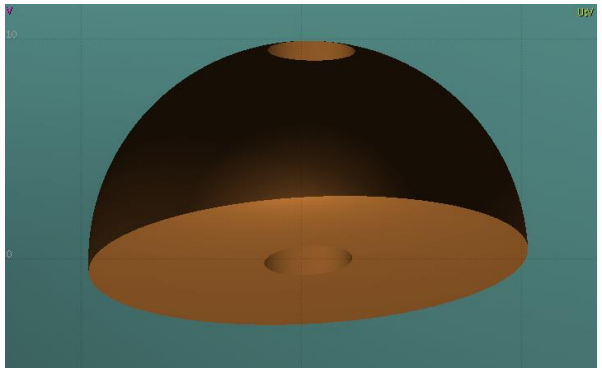


- Press [d] to define the zone
- While moving the mouse, the various subdivision of the space are shown
- Click inside zone 4
- Automatically, the zone expression

  +sphere -cylinder -plane

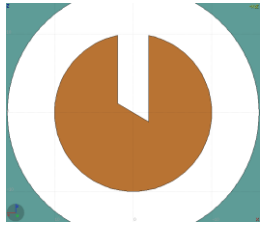
  will be added to the region definition



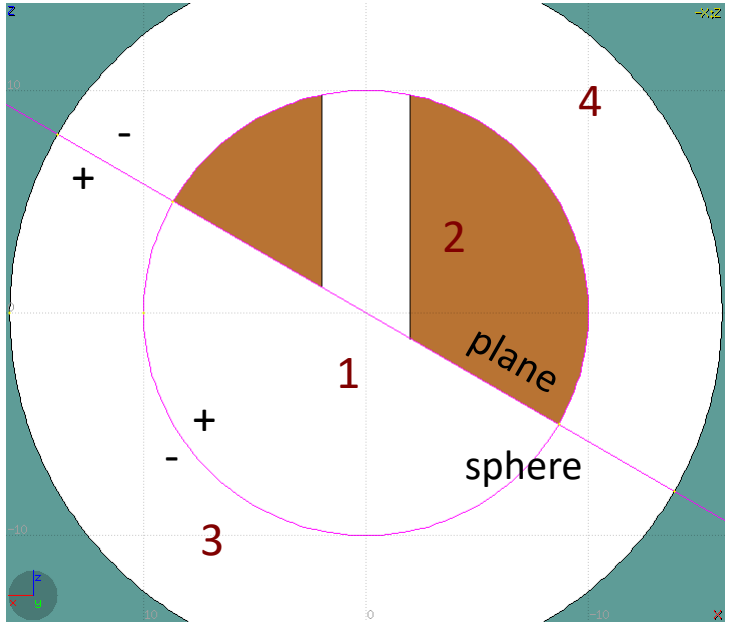


Zone editing – Example [7/9]

Reference image

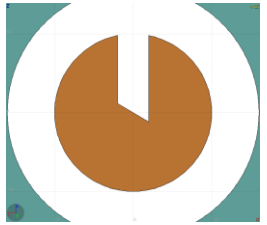


- Adding the bottom part of the sphere
- Press [ESC] to unselect the bodies while keeping the region selected
- Select the sphere and the plane
- Space is divided in 4 zones
  1. +sphere +plane
  2. +sphere -plane
  3. -sphere +plane
  4. -sphere -plane



Zone editing – Example [8/9]

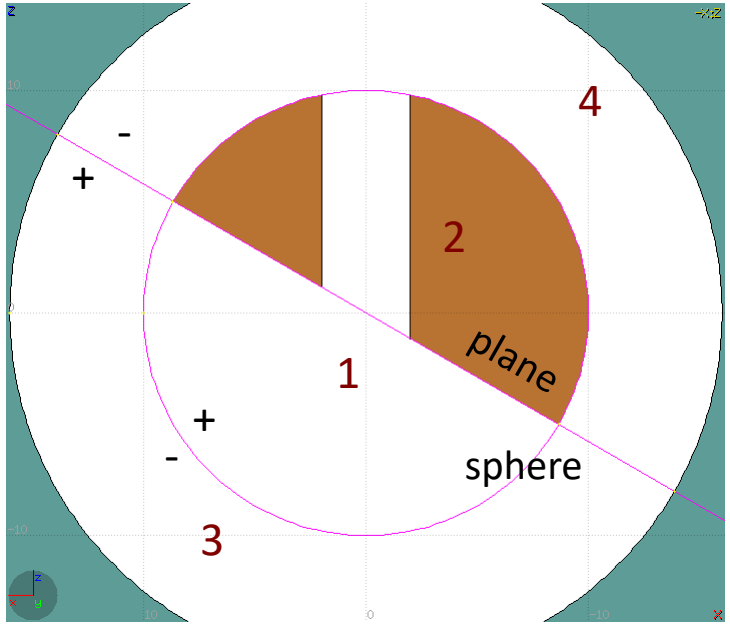
Reference image



- Press [d] to define the zone
- Click inside zone 1
- Automatically, the zone expression

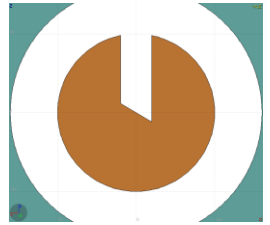
  +sphere +plane

  will be appended to the region definition



Zone editing – Example [9/9]

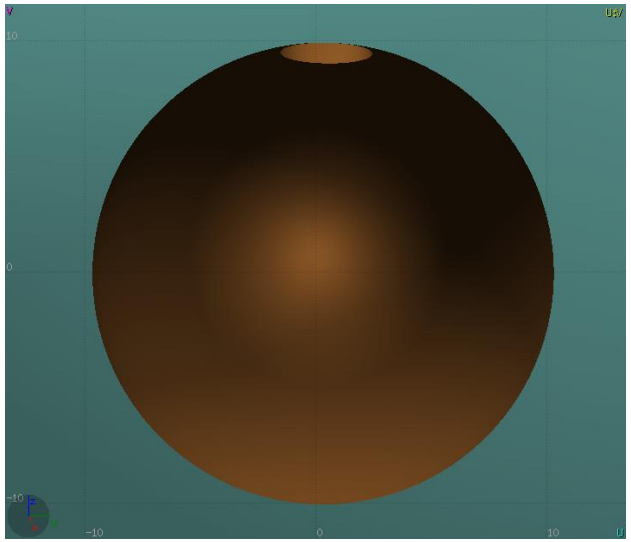
Reference image

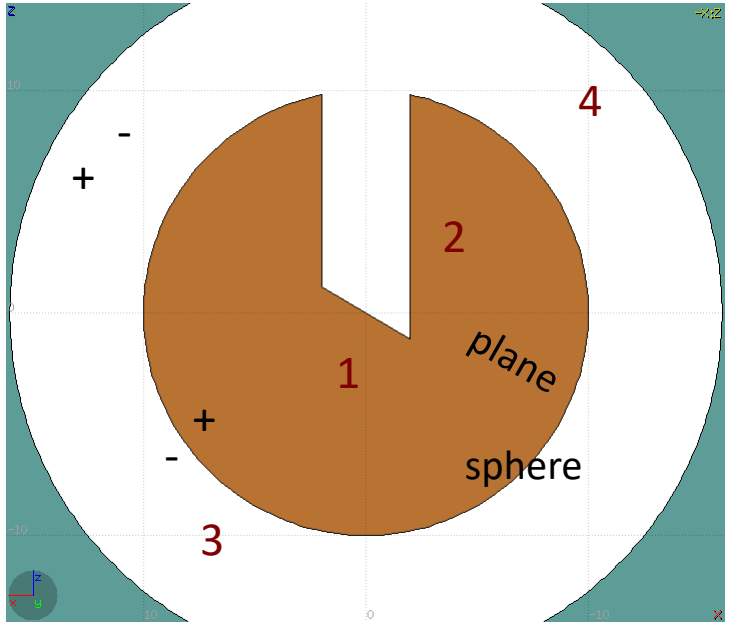


- Press [d] to define the zone
- Click inside zone 1
- Automatically, the zone expression

  +sphere +plane

  will be appended to the region definition





Summary: Region and Zone editing

- Golden sequence
  1. Select the REGION
  2. Select the zone to modify or none to add a new one
  3. Add to the selection the bodies needed for the zone definition
  4. Define a zone with [d] or right-click on “ Zone”
  5. Move the mouse over a point that belongs to the zone to be and left-click
- Repeat the sequence as many times as needed

Summary: Region and Zone editing

- The selection shall contain
  1. The REGION to edit
  2. Optionally, the zone to be modified
  3. The bodies representing the boundaries of the zone to be defined

- The selection shall not contain any unnecessary body

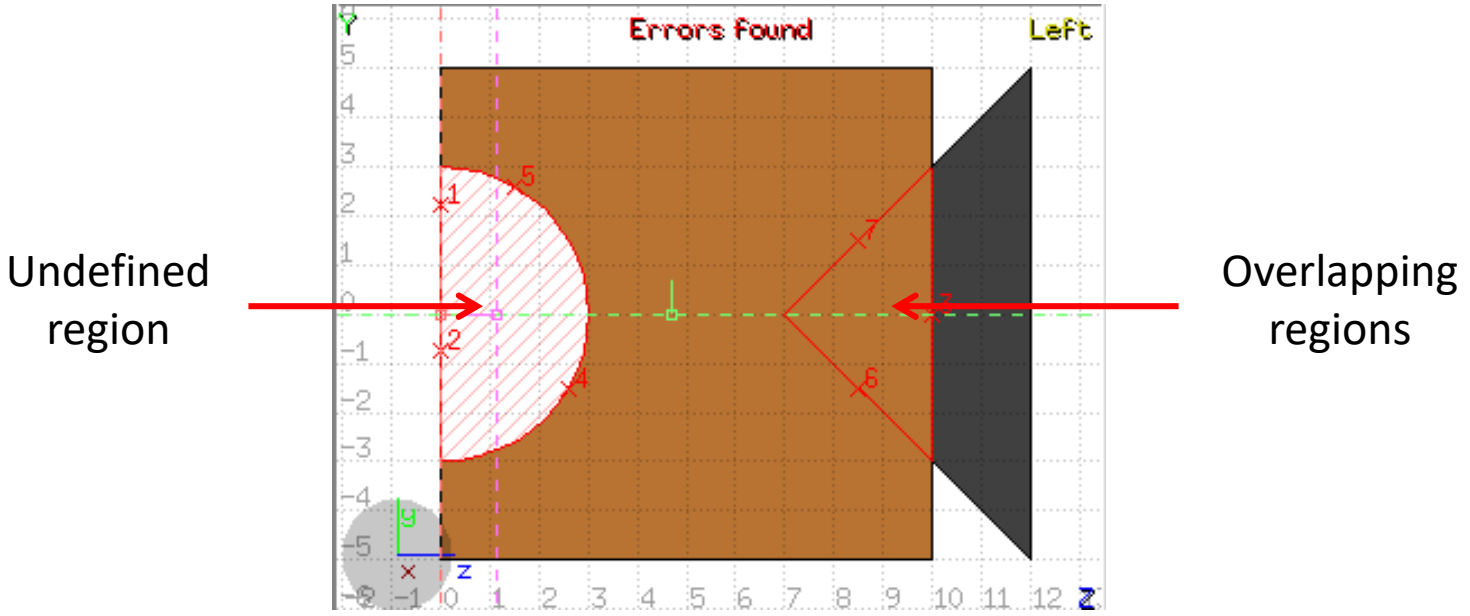
  because extra bodies mean extra operations and slower simulations

ESCape

- [ESC] will stop/unselect in the following order, one item at a time:
  1. Stop the current action, e.g. during rotation
  2. If a zone is selected, unselect the zone
  3. Unselect any selected body
  4. Unselect any selected region

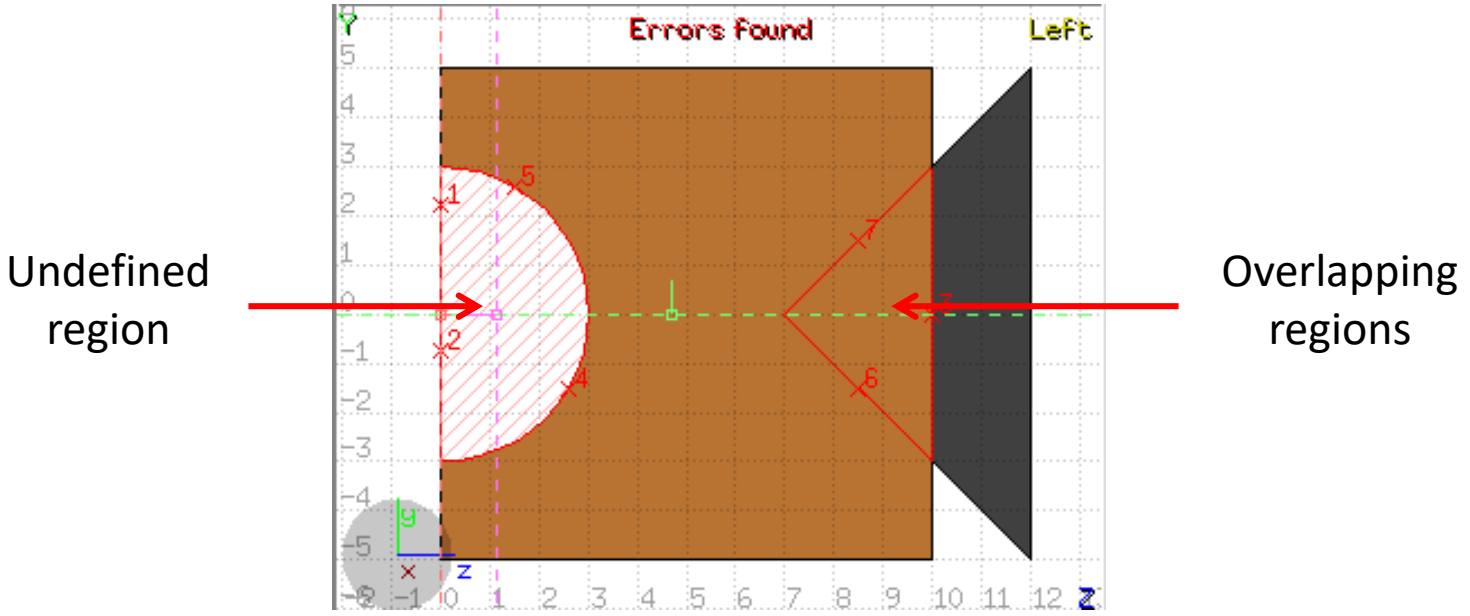
Debugging Geometry Errors

- The “Errors found” message indicated that there are errors on the current projection
- Areas affected by errors are outlined with a red line
- Areas filled with a full color correspond to overlapping region
- Areas dashed with red lines correspond to missing region definition
- Body segments involved in the errors are numbered



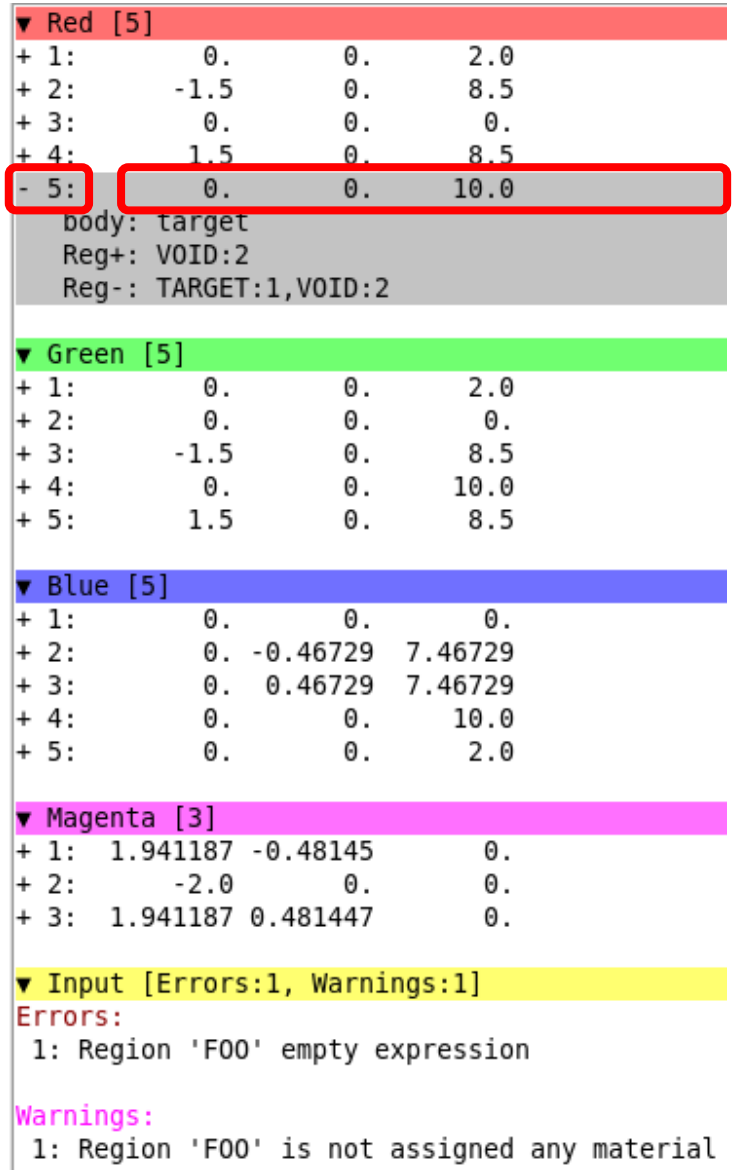
Debugging Geometry Errors

- Touching surfaces are checked against 10 significant digits
- Non strictly geometrical errors are also notified, e.g.:
  - missing material assignment to a region
  - non-recognized cards
- Clicking on the “ Errors” tab (on the left) displays the recognized errors



Geometry Errors Tab

- +n error index in the viewport
  - click to expand and get more info
- x, y, z position of the error
  - click to zoom on the error
- Body body involved in the error
- Reg+ regions on the +side of the body
- Reg- regions on the -side of the body
- Errors click to focus on the problematic card
- Warnings click to focus on the problematic card



Spare slides

Navigation with the keyboard

• [*arrows*]	pan viewport
• Ctrl + [*arrows*] + [Shift]	orbit viewport around **u,v** axes rotates by 90º
• Page Up/ Page Down	pan viewport front/back
• Ctrl + PgUp/PgDn	rotate viewport around **w** axis
• = / -	zoom in / zoom out
• o	open projection dialog to set the **o**rigin/basis/save/recall etc…
• Ctrl-0 (zero)	Center to origin
• C-1, C-2	**front [X:Y] / back [-X:Y]**
• C-3, C-4	**left [Z:Y] / right [-Z:Y]**
• C-5, C-6	**top [Z:X] / bottom [-Z:X]**

Assuming: *Z = direction of the beam (horizontal)*
X = horizontal
Y = vertical

Navigation with the mouse

With the left mouse button:

1. Select the appropriate action pan/orbit/zoom with:
   I. Menu → Tools
   II. Toolbar
   III. Keyboard shortcut
2. Click and drag the desired viewport

	function	key	description
	Pan	x	Pan viewport
	Orbit	t	Orbit viewport using a virtual **t**rackball
	Zoom	z	Drag area to **z**oom In ([**Ctrl**] to zoom out)
		Shift-Z	Zoom viewport on selected items
		Alt-Left	Go to previous in history projection
		Alt-Right	Go to next in history projection

Navigation with the mouse

- With the middle mouse button
  - alone Pan/Move viewport
  - Ctrl orbit projection using a virtual trackball
  - Ctrl-Middle-Shift orbit projection using a virtual trackball with steps of 15 degrees
  - Shift select rectangle region and zoom into
  - Shift-Middle-Ctrl select rectangle region and zoom out
- Wheel (if any) zoom in/zoom out
  - Ctrl-Wheel pan/move forward or backward
  - Ctrl-Shift-Wheel smoother pan/move forward/backward
- With the right mouse button
  - alone opens popup menu
  - Shift pan/move viewport
  - Ctrl orbit projection using a virtual trackball

When laptop mode is enabled in the Preferences/Geometry then the middle and right buttons are swapped

Tarefa – Aula 03

Montem uma geometria de alguma coisa!

Um objeto de sua casa, um objeto sentimental, um objeto imaginário.

Pensem em simplificações, pensem em complexidades, utilizem diferentes corpos.

Nossa proposta:

Construam um copo com algo dentro.

CURSO INTRODUTÓRIO FLUKA

23 DE JANEIRO A 8 DE MARÇO DE 2023

Tópicos essenciais

FLUKA

FLUKA

FLUKA

FLUKA

FLUKA

AULA 03
Geometria

Obrigado pela participação

Código Monte Carlo de interação e transporte de partículas

23 FLUKA 2023

08

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ORGANIZAÇÃO SOCIAL DO MCTI