Truncated pyramid implementation in Flair

Università degli Studi di Torino
FOOT Collaboration

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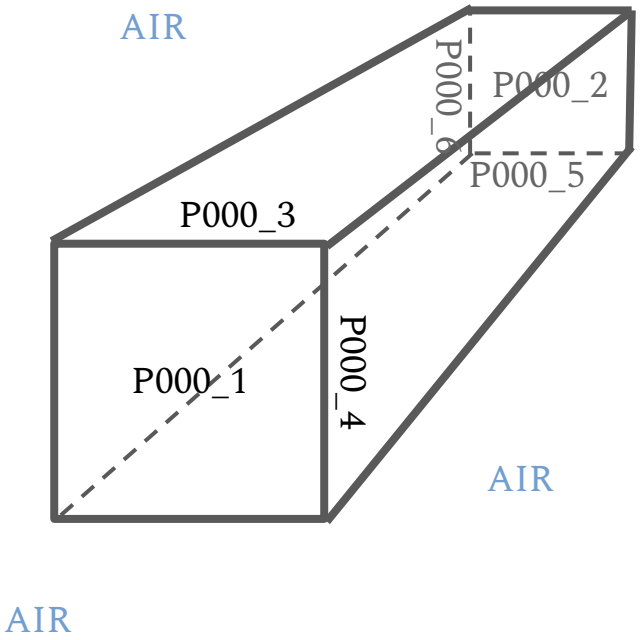
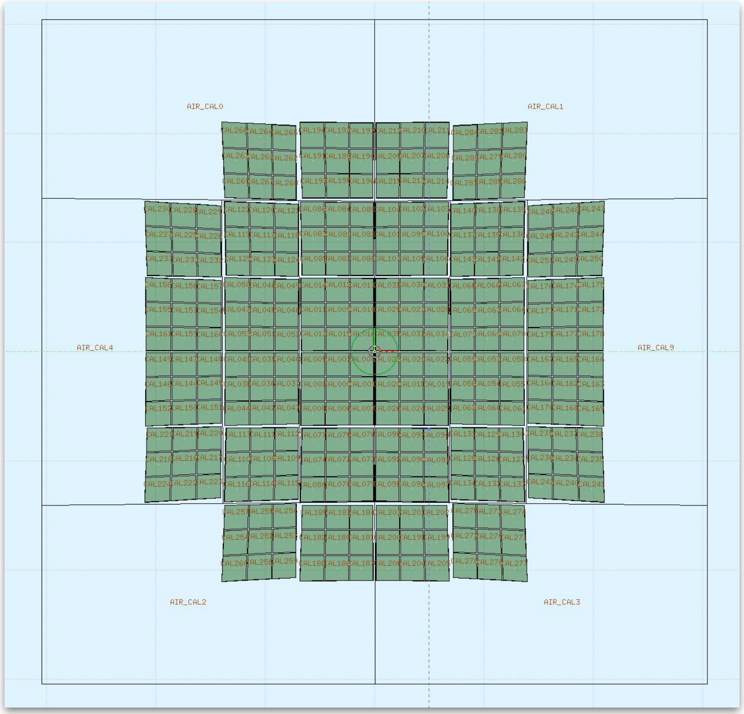
Previous Geometry concept




```
========================  GEOMETRY  begin  ==================================
GEOBEGIN                          Log:
                                  Geometry: 21
                                                  Acc:
                                                  Out:
                                                                  Opt:
                                                                  Fmt: COMBNAME
        File: bgo_v1.geo
        Title: geometry
$start_transform                  Trans: rot
  SPH    blkbody          x: 0                  y: 0                  z: 0
                          R: 2000
  SPH    air              x: 0                  y: 0                  z: 0
                          R: 199
  PLA    P000_1           Nx: 0                 Ny: 0                 Nz: -12
                          x: 0                  y: 0                  z: 0
  PLA    P000_2           Nx: 0                 Ny: 0                 Nz: 12
                          x: 0                  y: 0                  z: 24
  PLA    P000_3           Nx: 0.449683927069    Ny: 0                 Nz: -0.008428611490
                          x: 1                  y: 0                  z: 0
  PLA    P000_4           Nx: -0.449683927069   Ny: 0                 Nz: -0.008428611490
                          x: -1                 y: 0                  z: 0
  PLA    P000_5           Nx: 0                 Ny: 0.449683927069    Nz: -0.008428611490
                          x: 0                  y: 1                  z: 0
  PLA    P000_6           Nx: 0                 Ny: -0.449683927069   Nz: -0.008428611490
                          x: 0                  y: -1                 z: 0
$end_transform
END
************************************************************
***  REGIONS                                  ***
************************************************************
REGION   BLKBODY                                  Neigh: 5
         expr: +blkbody -air
REGION   AIR                                      Neigh: 5
         expr: +air - (+P000_1 +P000_2 +P000_3 +P000_4 +P000_5 +P000_6)
REGION   CRYST                                    Neigh: 5
         expr: +P000_1 +P000_2 +P000_3 +P000_4 +P000_5 +P000_6
END
GEOEND
```

Previous Geometry concept

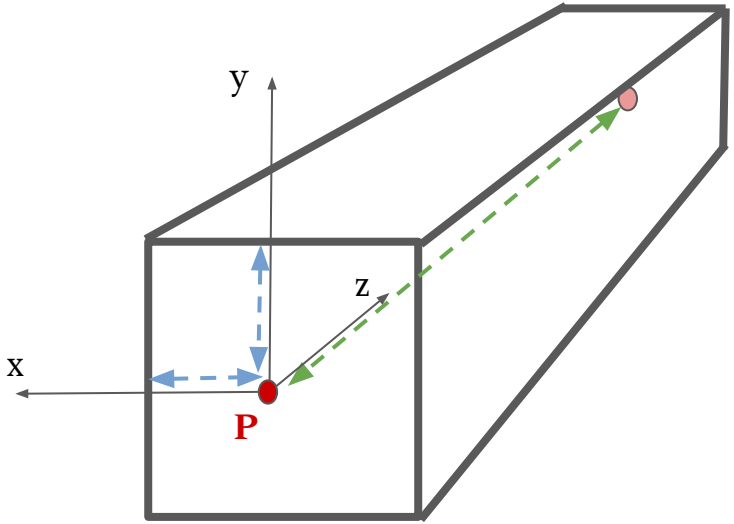



```
**Calorimeter
RPP   air_cal   Xmin: -30.466377000000   Xmax: 30.466377000000
                Ymin: -30.434222500000   Ymax: 30.434222500000
                Zmin: 101.031913004961   Zmax: 132.240733004961
PLA   P000_1    Nx: 0.747940767880    Ny: 0.749403547185    Nz: -11.953199526956
                x: -3.190592678692    y: -3.197223803798    z: 101.787842369237
PLA   P000_2    Nx: -0.747940767880   Ny: -0.749403547185   Nz: 11.953199526956
                x: -4.686474214452    y: -4.696030898168    z: 125.694241423149
PLA   P000_3    Nx: 0.499243593602    Ny: -0.001090730747   Nz: 0.020726648460
                x: -2.192537070180    y: -3.200707641724    z: 101.850074717659
PLA   P000_4    Nx: -0.497946773648   Ny: 0.002390086947    Nz: -0.041451749065
                x: -4.188648287205    y: -3.193739965871    z: 101.725610020816
PLA   P000_5    Nx: 0.000440501508    Ny: 0.499238060787    Nz: 0.020883343193
                x: -3.191008856426    y: -2.199181808963    z: 101.850388379048
PLA   P000_6    Nx: 0.000856318446    Ny: -0.497938704587   Nz: -0.041608443798
                x: -3.190176500959    y: -4.195265798632    z: 101.725296359427
PLA   P001_1    Nx: 0.248480489120    Ny: 0.750494468746    Nz: -11.973930662022
                x: -1.092773012998    y: -3.201675474871    z: 101.872836128688
PLA   P001_2    Nx: -0.248480489120   Ny: -0.750494468746   Nz: 11.973930662022
                x: -1.589733991238    y: -4.702664412363    z: 125.820697452732
PLA   P001_3    Nx: 0.499674797207    Ny: 0.000211081073    Nz: -0.000043396068
                x: -0.092987506470    y: -3.202555323187    z: 101.893528320532
PLA   P001_4    Nx: -0.499243968363   Ny: 0.001090166625    Nz: -0.020717649294
                x: -2.092558519526    y: -3.200795626556    z: 101.852143936844
PLA   P001_5    Nx: 0.000007505953    Ny: 0.499239006536    Nz: 0.020865370814
                x: -1.093189190732    y: -2.203633480037    z: 101.935382138498
PLA   P001_6    Nx: 0.000423322891    Ny: -0.497937758838   Nz: -0.041626416177
                x: -1.092356835265    y: -4.199717469706    z: 101.810290118878
```

```
******************************************************************
        REGIONS                    *
******************************************************************
REGION   BLACK                                              Neigh: 5
   expr: blk -air
REGION   AIR1                                               Neigh: 5
   expr: air +airpla
REGION   AIR2                                               Neigh: 5
   expr: air -airpla - air_cal
REGION   AIR_CAL0                                           Neigh: 5
   expr: +air_cal -MP009 +MP000 -(AP029_1 + AP029_2 +AP029_3 +AP029_4 +AP029_5 +AP029_6)
         +air_cal -MP009 +MP000 -(AP021_1 + AP021_2 +AP021_3 +AP021_4 +AP021_5 +AP021_6)
REGION   AIR_CAL1                                           Neigh: 5
   expr: | +air_cal -MP011 -MP000 -(AP023_1 + AP023_2 +AP023_3 +AP023_4 +AP023_5 +AP023_6)
         +air_cal -MP011 -MP000 -(AP031_1 + AP031_2 +AP031_3 +AP031_4 +AP031_5 +AP031_6)
REGION   AIR_CAL2                                           Neigh: 5
   expr: | +air_cal -MP008 +MP000 -(AP028_1 + AP028_2 +AP028_3 +AP028_4 +AP028_5 +AP028_6)
         +air_cal -MP008 +MP000 -(AP020_1 + AP020_2 +AP020_3 +AP020_4 +AP020_5 +AP020_6)
REGION   AIR_CAL3                                           Neigh: 5
   expr: | +air_cal -MP010 -MP000 -(AP022_1 + AP022_2 +AP022_3 +AP022_4 +AP022_5 +AP022_6)
         +air_cal -MP010 -MP000 -(AP030_1 + AP030_2 +AP030_3 +AP030_4 +AP030_5 +AP030_6)
REGION   AIR_CAL4                                           Neigh: 5
   expr: | +air_cal +MP016 +MP008 +MP009 -(AP025_1 + AP025_2 +AP025_3 +AP025_4 +AP025_5 +AP025_6)
         +air_cal +MP016 +MP008 +MP009 -(AP017_1 + AP017_2 +AP017_3 +AP017_4 +AP017_5 +AP017_6)
         +air_cal +MP016 +MP008 +MP009 -(AP016_1 + AP016_2 +AP016_3 +AP016_4 +AP016_5 +AP016_6)
         +air_cal +MP016 +MP008 +MP009 -(AP024_1 + AP024_2 +AP024_3 +AP024_4 +AP024_5 +AP024_6)
REGION   AIR_CAL5                                           Neigh: 5
```

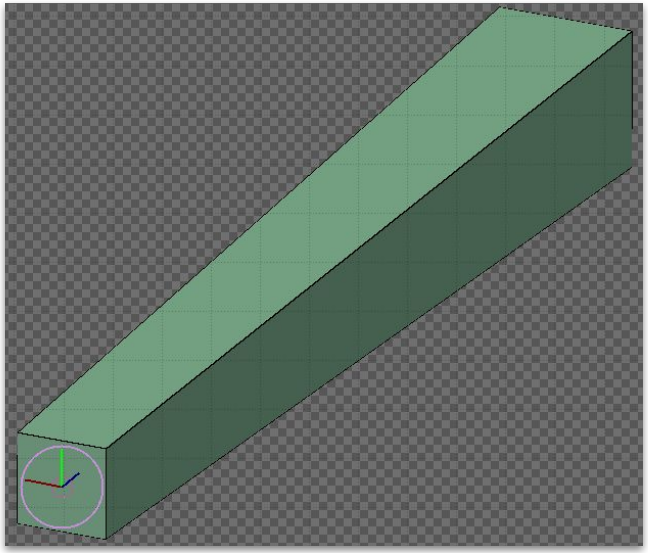
New Geometry concept

- PYX, PYY, PYZ
- 7 parameters:
  a. **P(x, y, z)**: central point of greater base: **Reference Frame** of the body;
  b. **semi-x**, **semi-y**, **height**;
  c. **ratio** between smaller and greater base areas (or ratio between edge of the greater and smaller base).

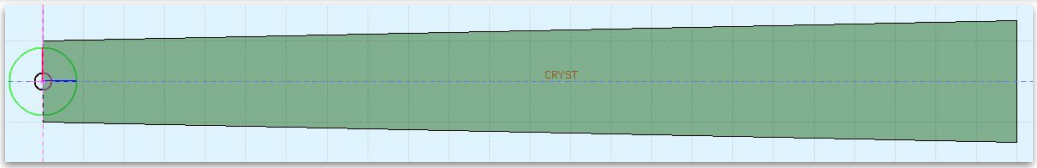


PYZ cry0 x: 0 y: 0 z: 0 semix: 1.5 semiy: 1.5 H: 24 ratio: 0.667

New Geometry concept



```
========================  GEOMETRY begin  ====================================
GEOBEGIN                          Log:
                                  Geometry: 21          Acc:          Opt:
                                                        Out:          Fmt: COMBNAME
        File: bgo_v2.geo
        Title: geometry
SPH     blkbody     x: 0          y: 0          z: 0
                    R: 2000
SPH     air         x: 0          y: 0          z: 0
                    R: 199
$start_transform    Trans: rotPYZ
  PYZ       cry     x: 0          y: 0          z: 0
                    semix: 1.5    semiy: 1.5    H: 24
                    ratio: 0.667
$end_transform
END
************************************************
*** REGIONS                 ***
************************************************
REGION    BLKBODY                               Neigh: 5
          expr: +blkbody -air
REGION    AIR                                   Neigh: 5
          expr: +air - cry
REGION    CRYST                                 Neigh: 5
          expr: +cry
END
GEOEND
========================  GEOMETRY end  ======================================
```



Building the 3x3 crystals module

- Macro in SHOE
  `.../Reconstruction/level0/BuildCaGeoFile.C`
  prints out
    - the **position of the center** of the crystal: PositionX, Y and Z
    - its **tilt** in x, y and z direction in degree

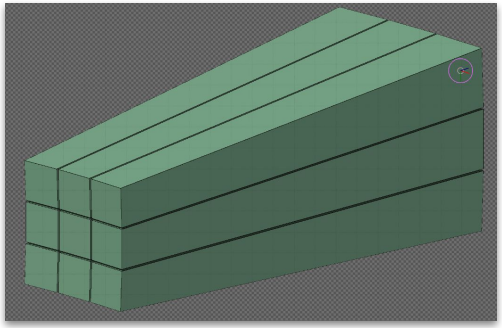
  with the respect of a reference crystal (central crystal of the module).

- We have to manipulate this output in order to fill the Input Card according to the new geometry:
    - Roto-translation needed due to the new implementation method: using **TACAparGeo.cxx/hxx**

```
CrystalId:  4
PositionX:  3.098611713666   PositionY:   3.095836345585   PositionZ:   -0.133217667901
TiltX:      -2.389049377105   TiltY:      2.384906519147   TiltZ:       -0.099471758232
```

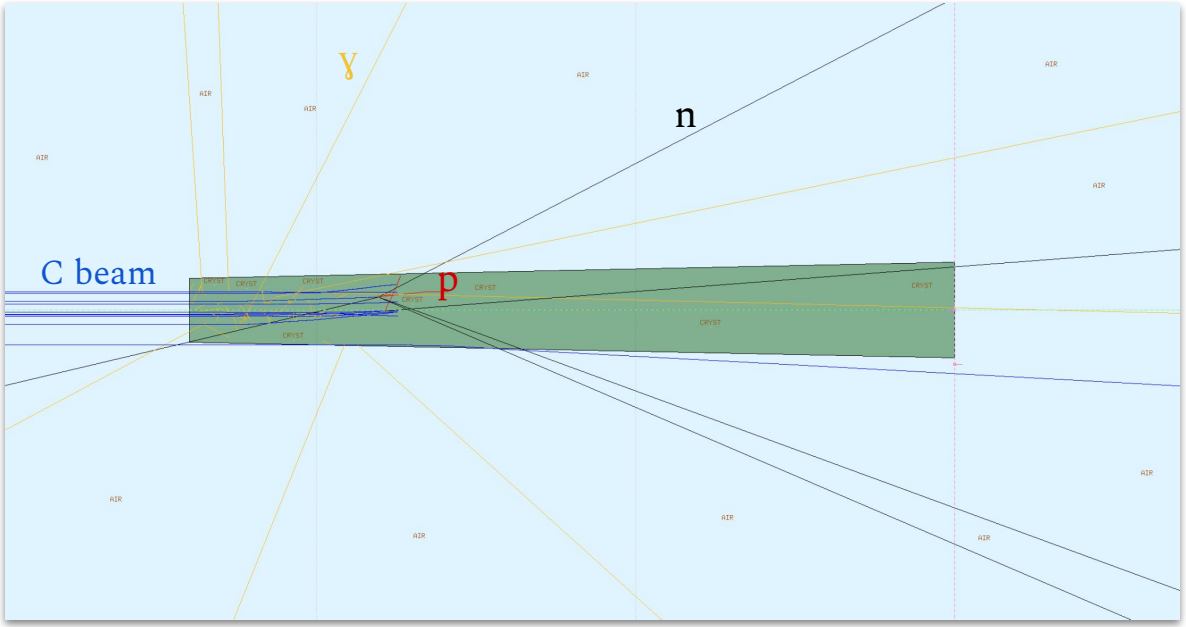
using TACAparGeo.cxx/hxx

```
ROT-DEFI        Axis: Y ▾   Id: 0          Name: rot4
                Polar: 177.612503  Azm: 2.38697885
                Δx: 0       Δy: 0          Δz: 0
$start_transform   Trans: -rot4 ▾
PYZ  cry4       x: 3.098611713666   y: -3.095836345585   z: -0.133217667901
                semix: 1.5          semiy: 1.5           H: 24
                ratio: 0.666666667
$end_transform
```



Simulation

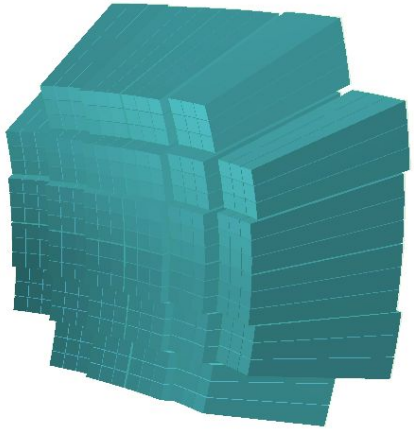
- 400 MeV/A Carbon on BGO
- The new geometry works properly on simulation



Next Steps...

NEXT STEPS IN SHOE

- **Change TACAparGeo.cxx/hxx according with the new geometry**
- Complete the FULL calo geometry



NEXT STEPS IN Flair CODE

- Improve or add features in Flair code

Backup

Truncated pyramid implementation in Flair

Building the Module: From BuildCaGeoFile.C to Flair Geometry

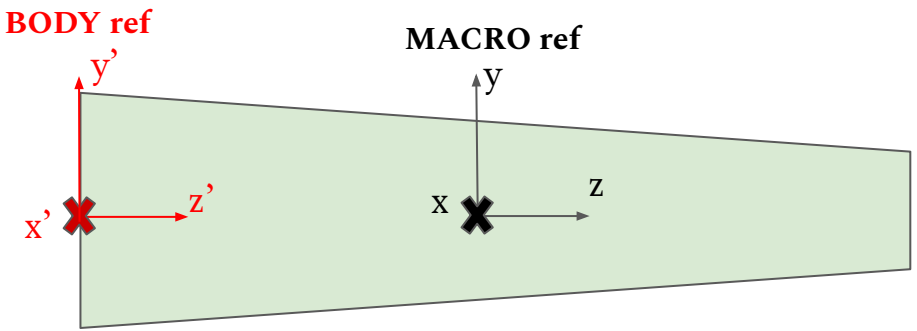
- Macro in `.../Reconstruction/level0/BuildCaGeoFile.C`
  a. It computes **α** angle and other useful quantities: height of the pyramid, position of the crystal and tilt taking into account the space of 0.1 cm between crystal...
  b. Macro prints out the **position of the center** of the crystal and its **tilt** in x, y and z direction in degree with the respect of a reference crystal (central cry if module of 9 crys).
- We have to use these informations to import and create our body in Flair
- Some precautions :
  a. The macro gives us the center of the crystal so we have to move to **BODY reference** (center of the greater base);
  b. Greater face is created first, then the smaller: PYZ oriented towards the positive z-axis; BGO crystal **must be ROTATE**!!!

```
// half open angle of the truncate piramide
double deltaX = (xdim2 - xdim1);
double trp_hipot = TMath::Sqrt( zdim * zdim * 4  + deltaX * deltaX );
double alfa = TMath::ASin (deltaX / trp_hipot);
double alfa_degree = alfa  * 180./ TMath::Pi();
cout << "alfa_degree " << alfa_degree << endl;

// compute some values of the full piramid dimensions
double piramid_hipot = xdim2 / TMath::Sin(alfa);

//cout << "piramid_hipot " << piramid_hipot << endl;
double piramid_base = piramid_hipot * TMath::Cos(alfa);
double piramid_base_c = piramid_base - zdim; // distance from center to the piramid vertex

// translation of crystal center after 2*alfa rotation about vetex piramid
double deltax = delta * TMath::Cos(alfa*2);
double deltaz = - delta * TMath::Sin(alfa*2);
double posx = TMath::Sin(alfa*2) * piramid_base_c + deltax;
double posz = TMath::Cos(alfa*2) * piramid_base_c + deltaz;
```

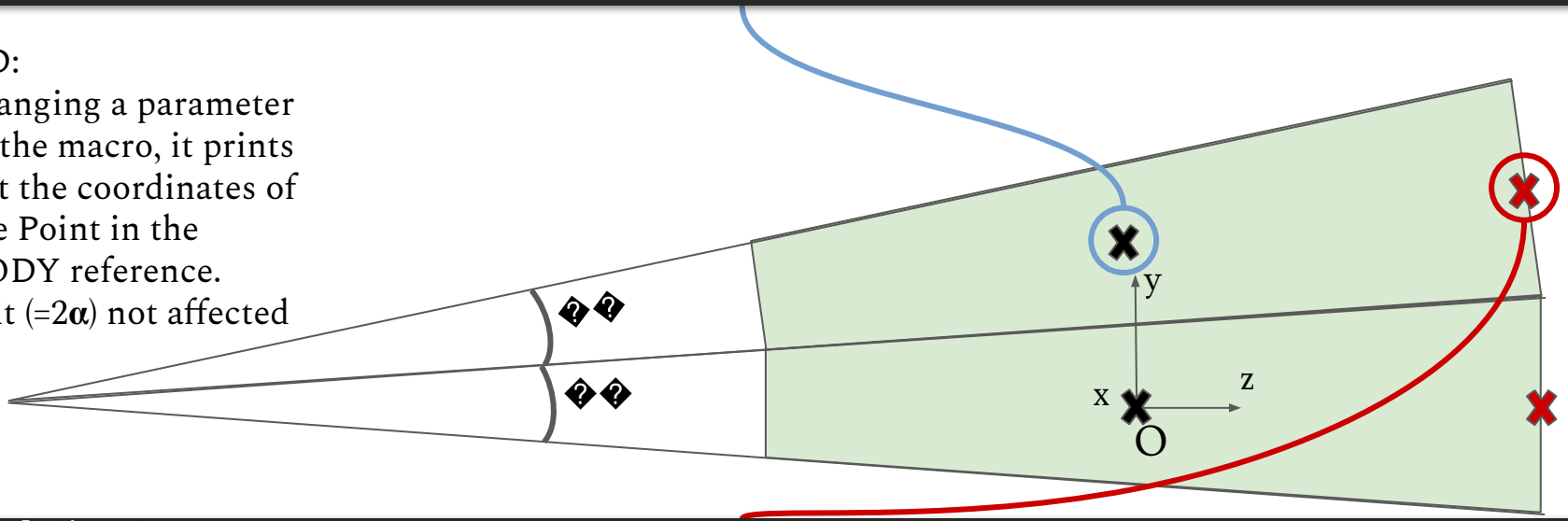


a. The reference issue

```
CrystalId:   3
PositionX:   0.000000000000   PositionY:   2.598828633406   PositionZ:   -0.056225596529
TiltX:       -2.386978847964   TiltY:       -0.000000000000   TiltZ:       0.000000000000
```

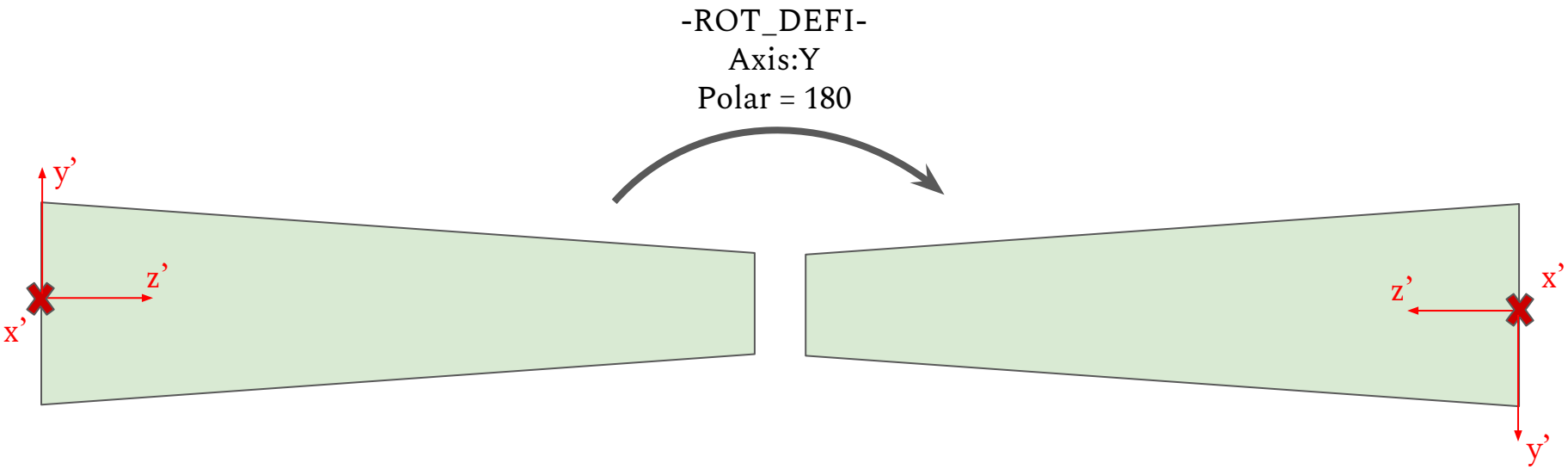
SOLVED:

- changing a parameter in the macro, it prints out the coordinates of the Point in the BODY reference.
- Tilt (=2α) not affected



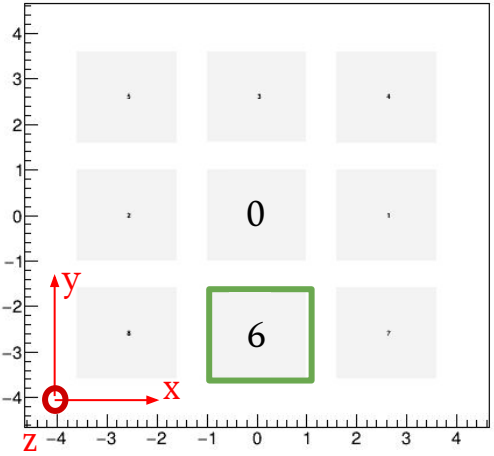

```
CrystalId:   3
PositionX:   0.000000000000   PositionY:   3.098611713666   PositionZ:   -0.066637744035
TiltX:       -2.386978847964   TiltY:       -0.000000000000   TiltZ:       0.000000000000
```

b. The rotation issue



- y-axis and z-axis invert their directions after the ROT-DEF rotation.
- The movement after rotation is done with the respect of the BODY reference!
- So data output from Macro will be manipulated and then entered in Input Card

From BuildCaGeoFile.C to Input Card

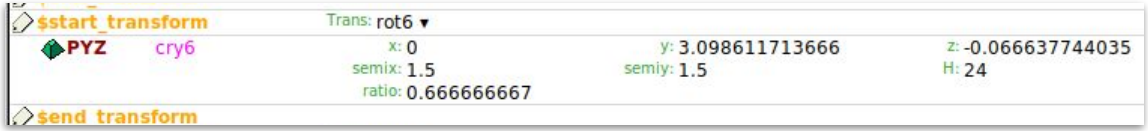



```
CrystalId:  6
PositionX:  0.000000000000   PositionY:   -3.098611713666   PositionZ:   -0.066637744035
TiltX:      2.386978847964   TiltY:       -0.000000000000   TiltZ:       0.000000000000
```

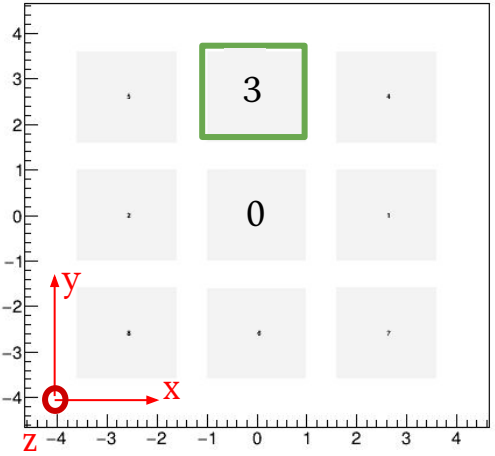
x = PositionX, y = -PositionY, z = PositionZ

Azm = TiltY

Polar = 180 - TiltX



From BuildCaGeoFile.C to Input Card



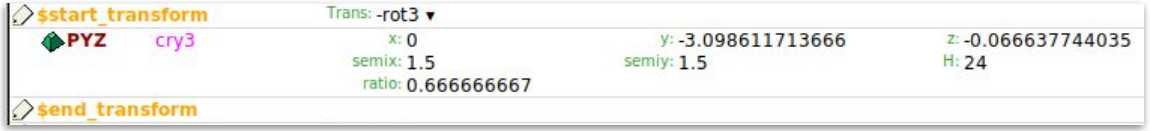

```
CrystalId:  3
PositionX:  0.000000000000   PositionY:   3.098611713666   PositionZ:   -0.066637744035
TiltX:      -2.386978847964   TiltY:      -0.000000000000   TiltZ:       0.000000000000
```

-ROT_DEFI-
0 < Polar < 180

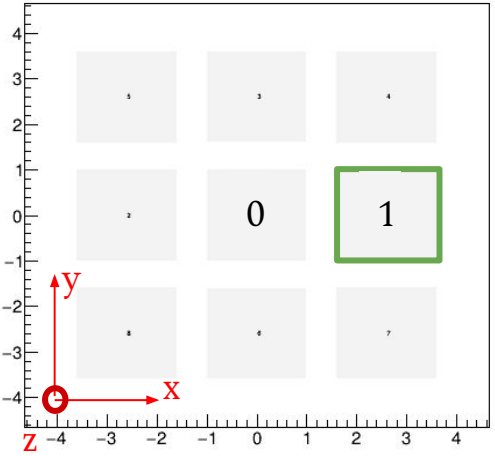
x = PositionX, y = **-**PositionY, z = PositionZ

Azm = TiltY

if(TiltX < 0.){
Polar = 180 + TiltX
ROT-DEFI = -rot }
else
Polar = 180 - TiltX



From BuildCaGeoFile.C to Input Card (some examples)




```
CrystalId:  0
PositionX:  0.000000000000   PositionY:   0.000000000000   PositionZ:   0.000000000000
TiltX:      0.000000000000   TiltY:      -0.000000000000   TiltZ:       0.000000000000
CrystalId:  1
PositionX:  3.098611713666   PositionY:   0.000000000000   PositionZ:   -0.066637744035
TiltX:      0.000000000000   TiltY:      2.386978847964    TiltZ:       0.000000000000
```

x = PositionX, y = -PositionY, z = PositionZ

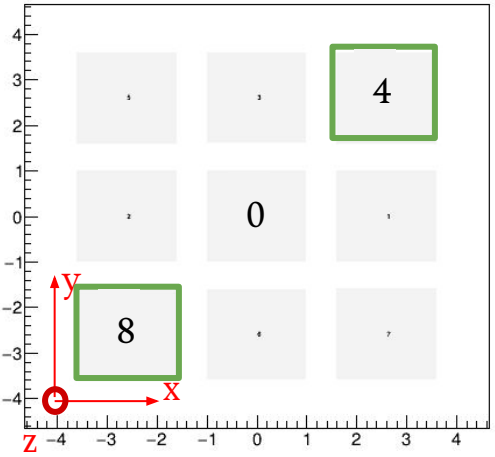
Azm = TiltY

if(TiltX < 0.){
    Polar = 180 + TiltX
    ROT-DEFI = -rot }
else
    Polar = 180 - TiltX

```
ROT-DEFI   Axis: Y   Id: 0   Name: rot0
           Polar: 180   Azm: 0
           Δx:   Δy:   Δz:
ROT-DEFI   Axis: Y   Id: 0   Name: rot1
           Polar: 180   Azm: 2.38697885
           Δx:   Δy: 0   Δz: 0
```

```
$start_transform   Trans: rot0
PYZ cry0   x: 0   y: 0   z: 0
           semix: 1.5   semiy: 1.5   H: 24
           ratio: 0.666666667
$end_transform
$start_transform   Trans: rot1
PYZ cry1   x: 3.098611713666   y: 0   z: -0.066637744035
           semix: 1.5   semiy: 1.5   H: 24
           ratio: 0.666666667
$end_transform
```

From BuildCaGeoFile.C to Input Card (some examples)




```
CrystalId:  4
PositionX:  3.098611713666   PositionY:   3.095836345585   PositionZ:   -0.133217667901
TiltX:      -2.389049377105   TiltY:       2.384906519147   TiltZ:       -0.099471758232
CrystalId:  8
PositionX:  -3.098611713666   PositionY:   -3.095836345585   PositionZ:   -0.133217667901
TiltX:      2.389049377105   TiltY:       -2.384906519147   TiltZ:       -0.099471758232
```

x = PositionX, y = -PositionY, z = PositionZ

Azm = TiltY

if(TiltX < 0.){
    Polar = 180 + TiltX
    ROT-DEFI = -rot }
else
    Polar = 180 - TiltX

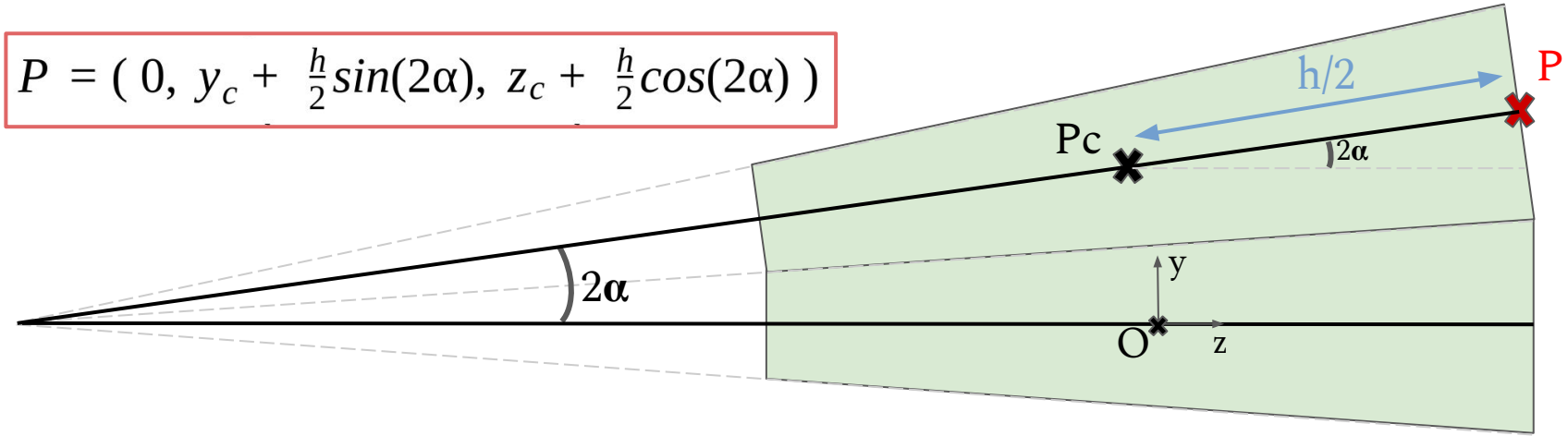
```
ROT-DEFI   Axis: Y ▾   Id: 0   Name: rot4
           Polar: 177.612503   Azm: 2.38697885
           Δx: 0   Δy: 0   Δz: 0
ROT-DEFI   Axis: Y ▾   Id: 0   Name: rot8
           Polar: 177.612503   Azm: -2.3869788
           Δx:   Δy:   Δz:
```

```
$start_transform   Trans: -rot4 ▾
  PYZ  cry4   x: 3.098611713666   y: -3.095836345585   z: -0.133217667901
              semix: 1.5   semiy: 1.5   H: 24
              ratio: 0.666666667
$send_transform
$start_transform   Trans: rot8 ▾
  PYZ  cry8   x: -3.098611713666   y: 3.095836345585   z: -0.133217667901
              semix: 1.5   semiy: 1.5   H: 24
              ratio: 0.666666667
$send_transform
```

a. The reference issue - Verifying the results

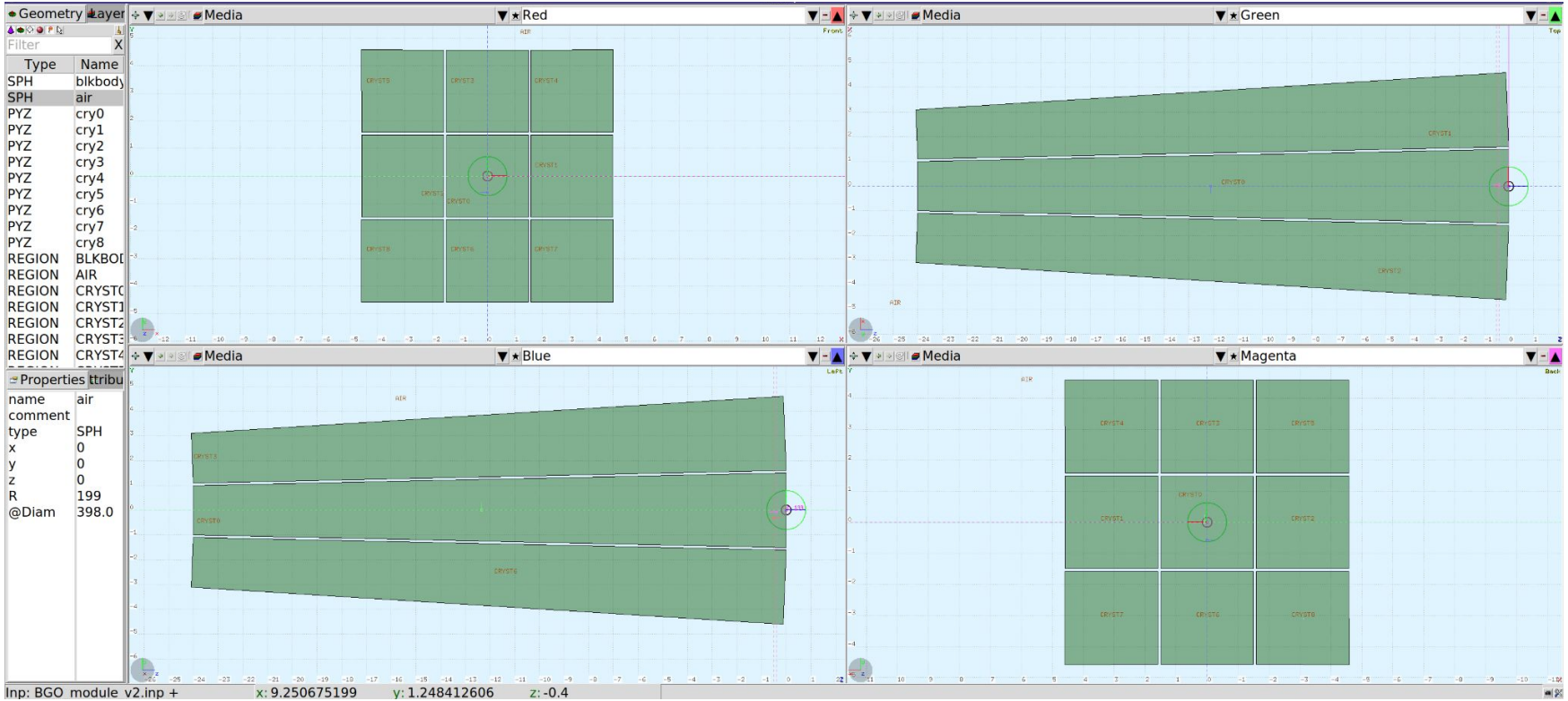
$$P_c = (x_c,\ y_c,\ z_c)$$

$$P = (\ 0,\ y_c + \tfrac{h}{2}sin(2\alpha),\ z_c + \tfrac{h}{2}cos(2\alpha)\ )$$



Se lo spostamento del BGO ha componente anche in x => $P = (\ x_c + \tfrac{h}{2}sin(2\alpha),\ y_c + \tfrac{h}{2}sin(2\alpha),\ z_c + \tfrac{h}{2}cos(2\alpha)\ )$

Flair GeoViewer



Flair GeoViewer 3D