

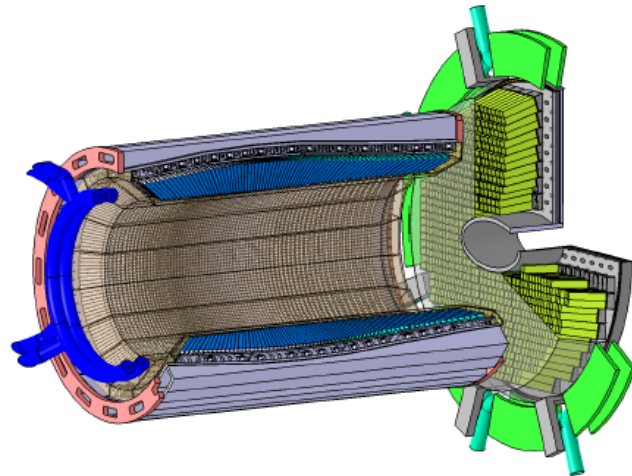
# Updated Barrel EMC Geometry

Guang Zhao ([zhaog@ihep.ac.cn](mailto:zhaog@ihep.ac.cn))

Institute of High Energy Physics, CAS

PANDA Collaboration Meeting 18/1

March 6<sup>th</sup>, 2018



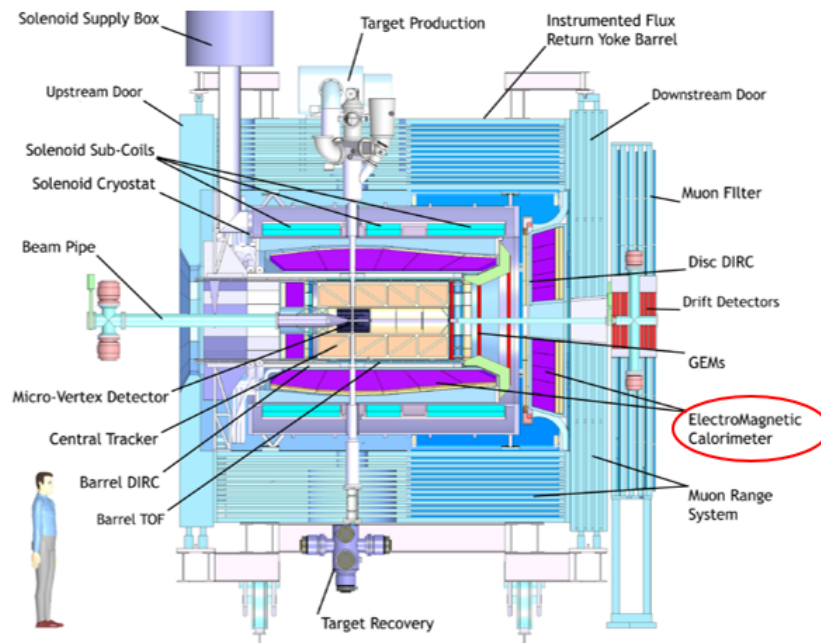
Institute of High Energy Physics  
Chinese Academy of Sciences

# Outline

---

- **Geometry construction in ROOT**
- **Updates and tests in pandaroot for the new ROOT geometry**

# Introduction



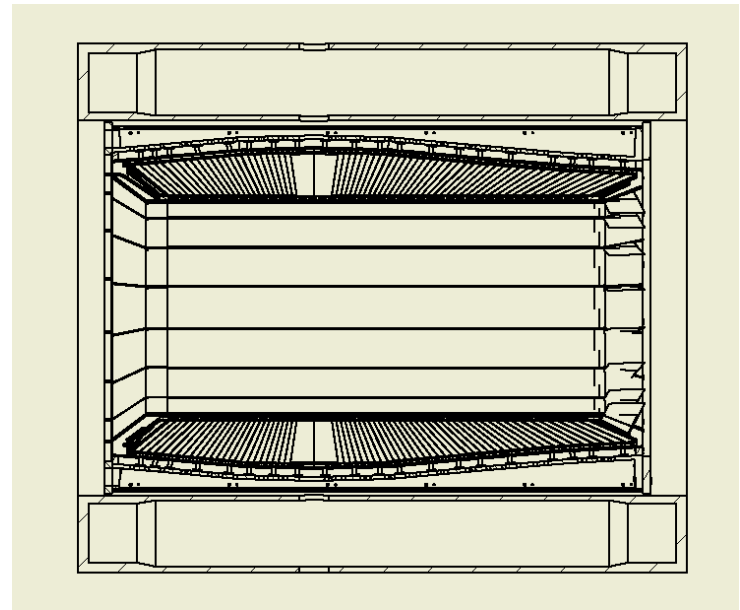
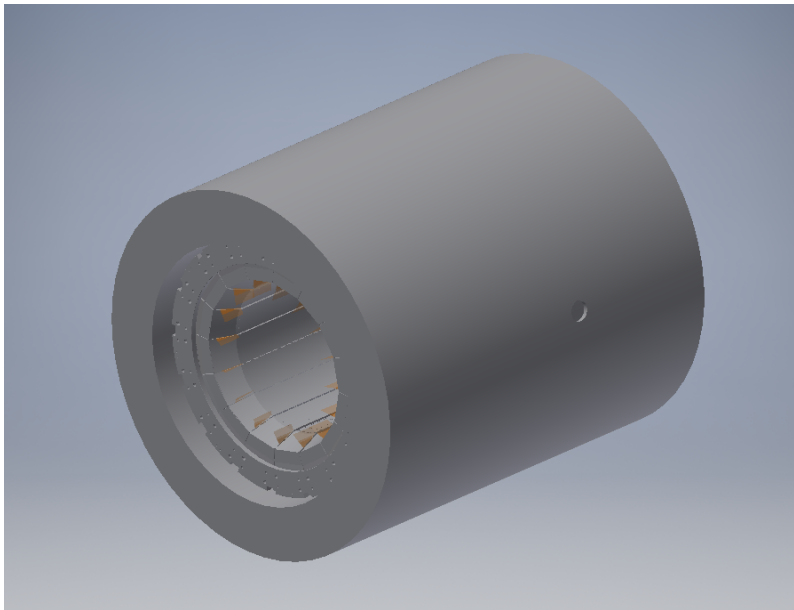
## Status of barrel EMC's geometry description

- ✓ Last update: 2009 by Spataro
  - ✓ Only crystals
  - ✓ # of crystals, parameters of crystals are out of date
- ✓ Need to do
  - ✓ Update detailed geometry
  - ✓ Using ROOT geometry class

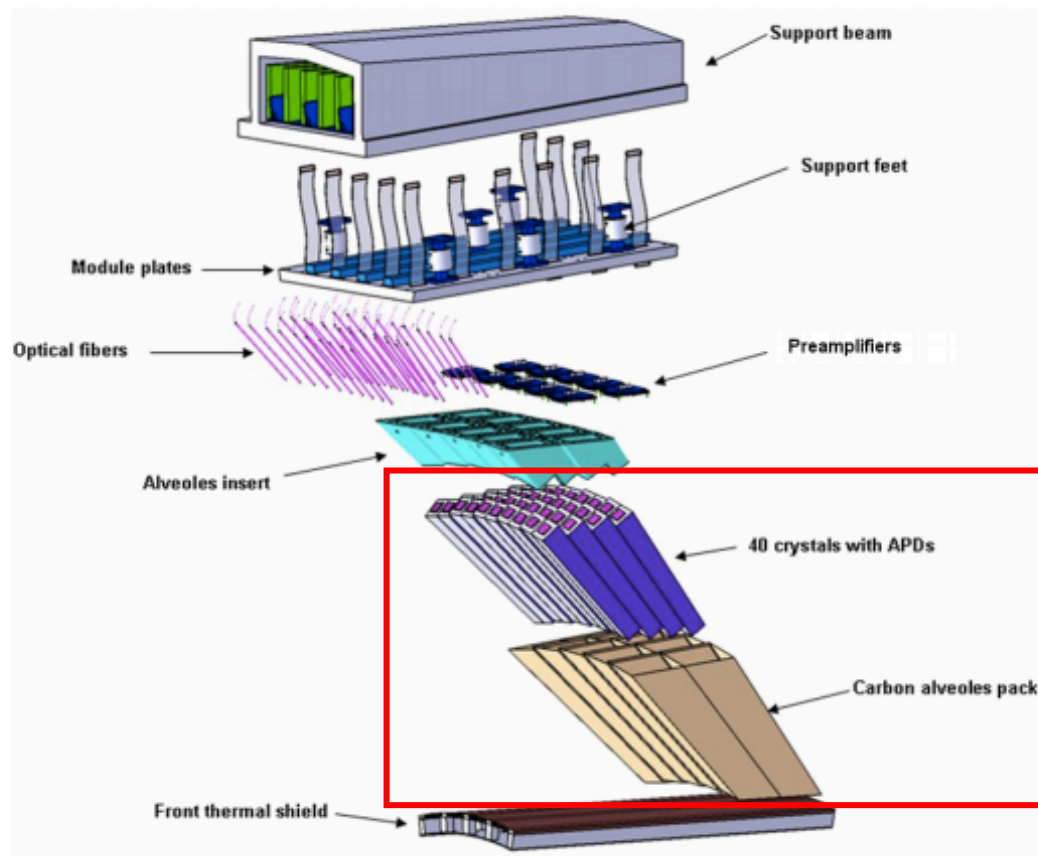
# The 3D CAD model

---

- ✓ This work is based on the 3D CAD file from Markus and Hans
- ✓ The CAD file contains all the detector and mechanics details
- ✓ The geometry parameters are extracted from the CAD file



# Geometry construction overview



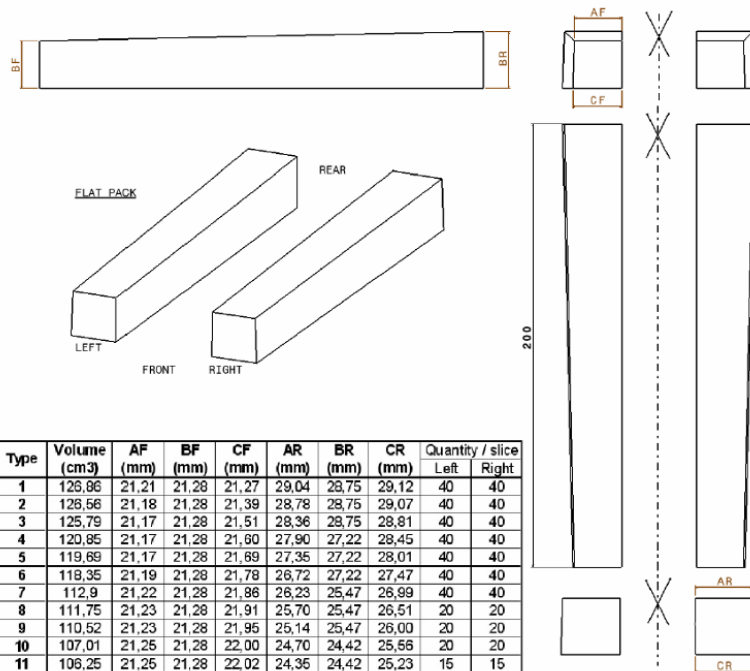
Bottom-to-top construction



In this work:

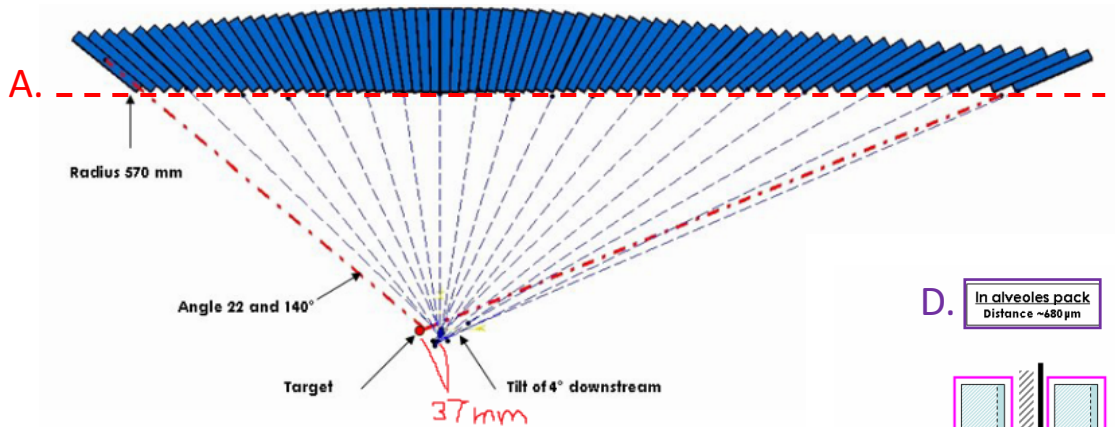
- Crystals (sensitive det)
- Wrappings
- Alveoles

# Crystals definitions

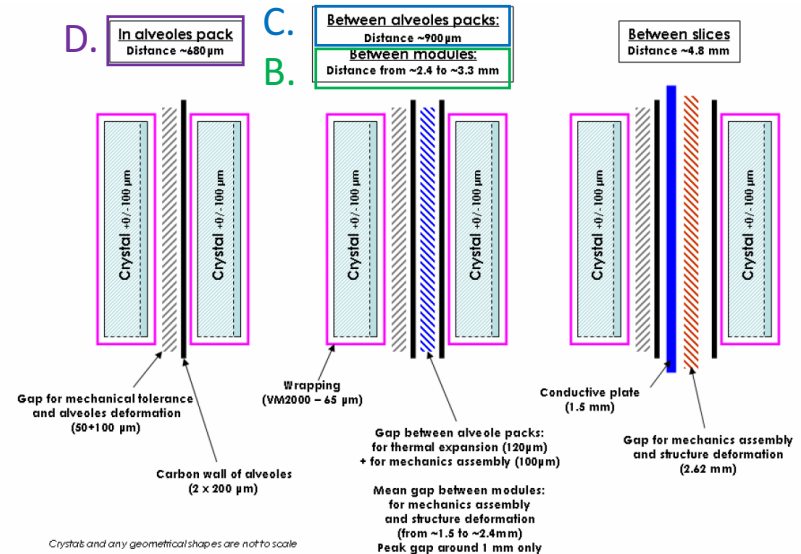


- ✓ Shape: tapered parallelepiped
- ✓ Material: PWO<sub>4</sub>
- ✓ Mass: 0.88-1.05 kg
- ✓ Dimensions: related to the global shape and to the discretization of the calorimeter
- ✓ Dimensions tolerances: +/- 100 μm

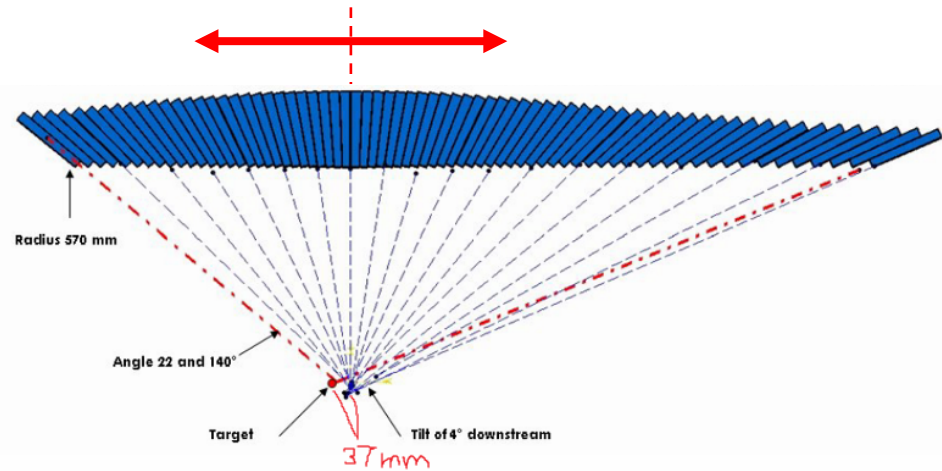
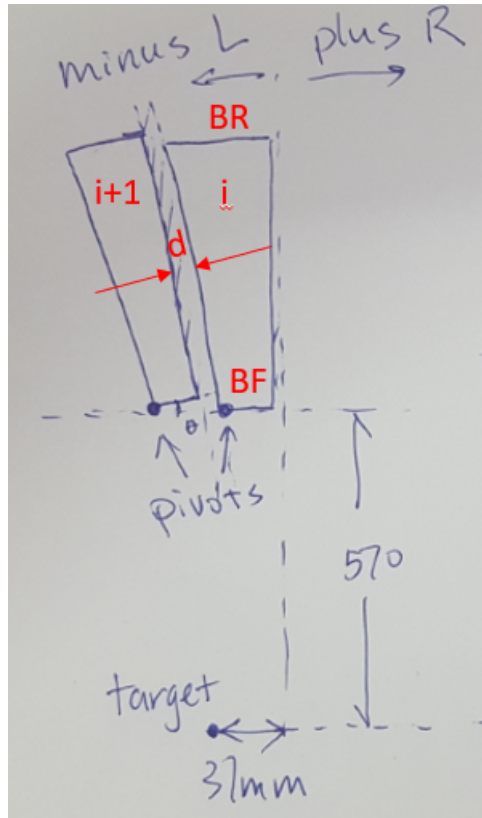
# Longitudinal parameters (I)



- A. Crystals are aligned by the bottom edge
- B. Gaps between Super-Models: 2.4-3.3 mm
- C. Gaps between alveoles: 0.9 mm
- D. Gaps between crystals: 0.68 mm



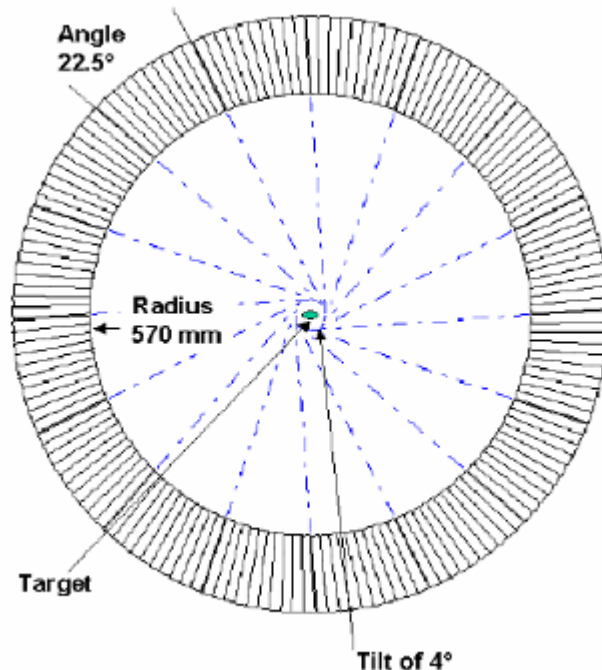
# Longitudinal parameters (II)



- ✓ z positions of the crystals are defined by the gap d and the crystal dimension
- ✓ For the  $(i+1)^{\text{th}}$  crystal (minus)
  - ✓  $z_{i+1} = z_i - (BF + d)/\cos\theta_i$
  - ✓ where  $\theta_{i+1} = \theta_i + \text{atan}\left(\frac{BR_i - BF_i}{L}\right)$
- ✓ Place the crystals from center to side one by one

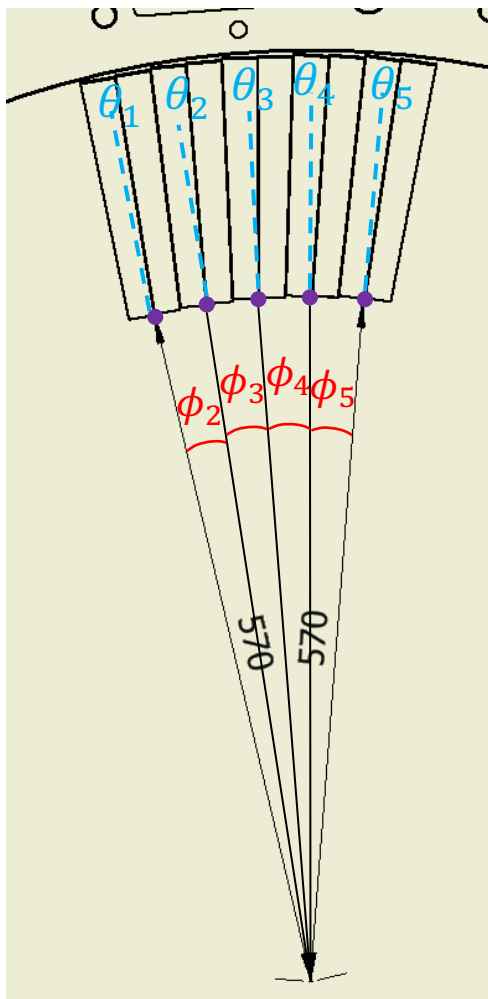


# Circumferential parameters (I)



- ✓ Front size of an individual crystal close to 20 mm at a radius of 570 mm
- ✓ Grouped into packs of 4\*10 (one alveole pack) leading to 16 slices of 22.5 deg coverage
- ✓ A tilt of 4 deg is added on the focal axis of the slice to reduce the dead zone effect

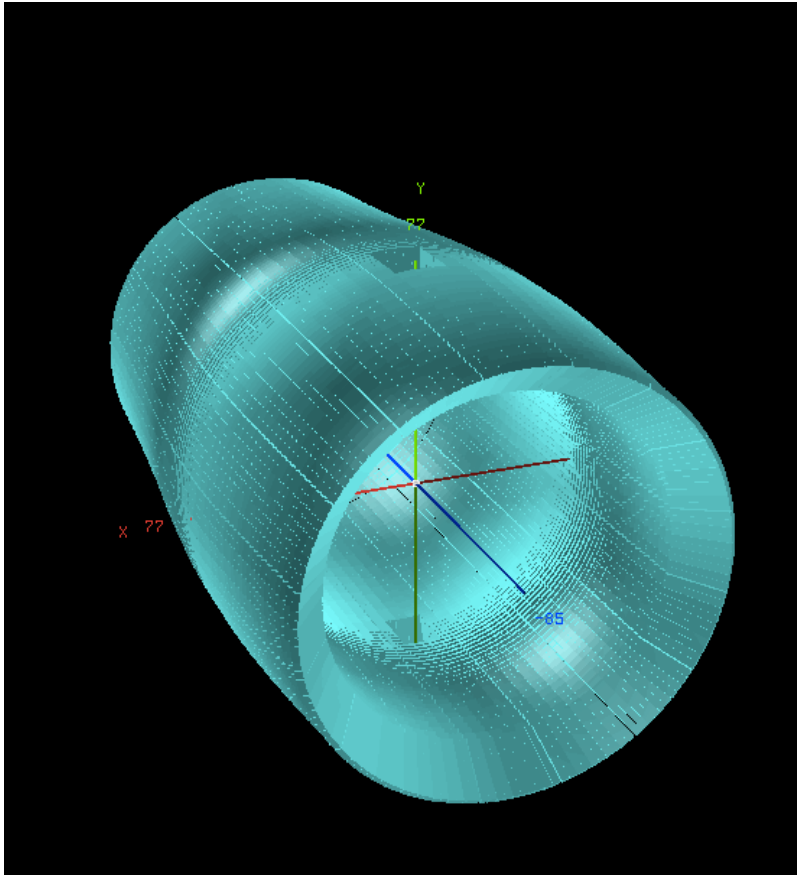
# Circumferential parameters (II)



- ✓ Each 2 adjacent crystals form an alveole (5 alveoles for a slice)
- ✓ The positions of the alveoles are defined by the azimuthal angle  $\Phi_i$ , the tilt angle  $\theta_i$  and the inner radius of the barrel EMC
  - ✓  $\Phi_i$ : azimuthal angle w.r.t. the (i-1)<sup>th</sup> crystal pairs
  - ✓  $\theta_i$ : tilt angle w.r.t. the radial direction (~4deg)
- ✓ Extract  $\Phi_i$ s and  $\theta_i$ s from the CAD
- ✓ Place the crystals one by one

|   | azimuthal: $\Phi_i$<br>(degree) | tilt: $\theta_i$<br>(degree) |
|---|---------------------------------|------------------------------|
| 1 | 0. (reference)                  | 3.8622                       |
| 2 | 4.4164                          | 3.9458                       |
| 3 | 4.4168                          | 4.0290                       |
| 4 | 4.4173                          | 4.1117                       |
| 5 | 4.4178                          | 4.1939                       |

# Constructing crystals in ROOT

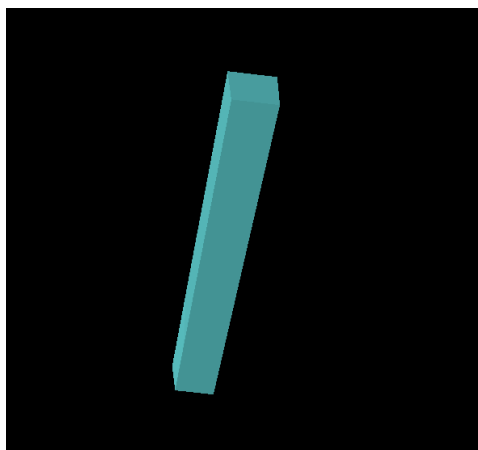


- ✓ Crystals:
  - ✓ Shape: TGeoTrap
  - ✓ Material:  $\text{PbWO}_4$
- ✓ Modules:
  - ✓ Shape: TGeoVolumeAssembly
  - ✓ Made up of 4 (or 3)\*10 crystals
- ✓ Super modules:
  - ✓ Shape: TGeoVolumeAssembly
  - ✓ Made up of up to 3 modules
- ✓ 16 slices
  - ✓ Shape: TGeoVolumeAssembly
  - ✓ Made up of 7 super modules
  - ✓ Slice 1/9: slice for target

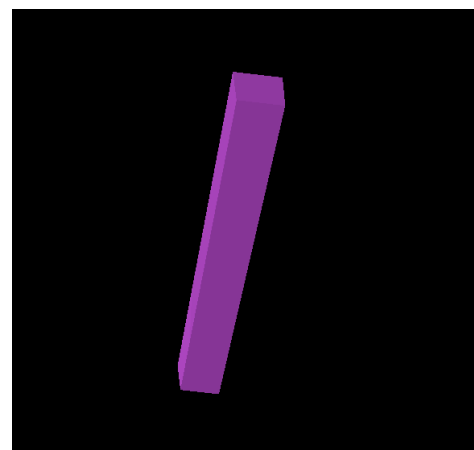
# Wrappings

---

Crystal w/o wrapping



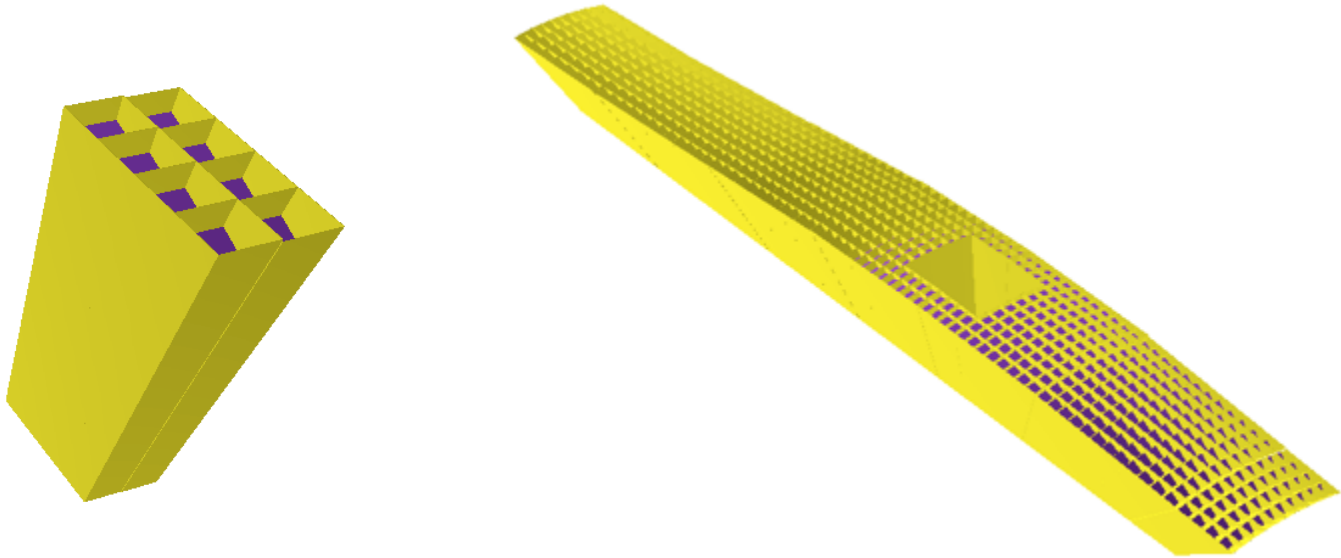
Crystal w/ wrapping



- ✓ Shape: TGeoTrap (outside the crystals)
- ✓ Material: Radiant Mirror Film ESR from 3M (VM2000)
  - ✓ Reflective material to
    - ✓ optimize light collection
    - ✓ reduce optical cross talk
- ✓ Thickness: 65  $\mu m$

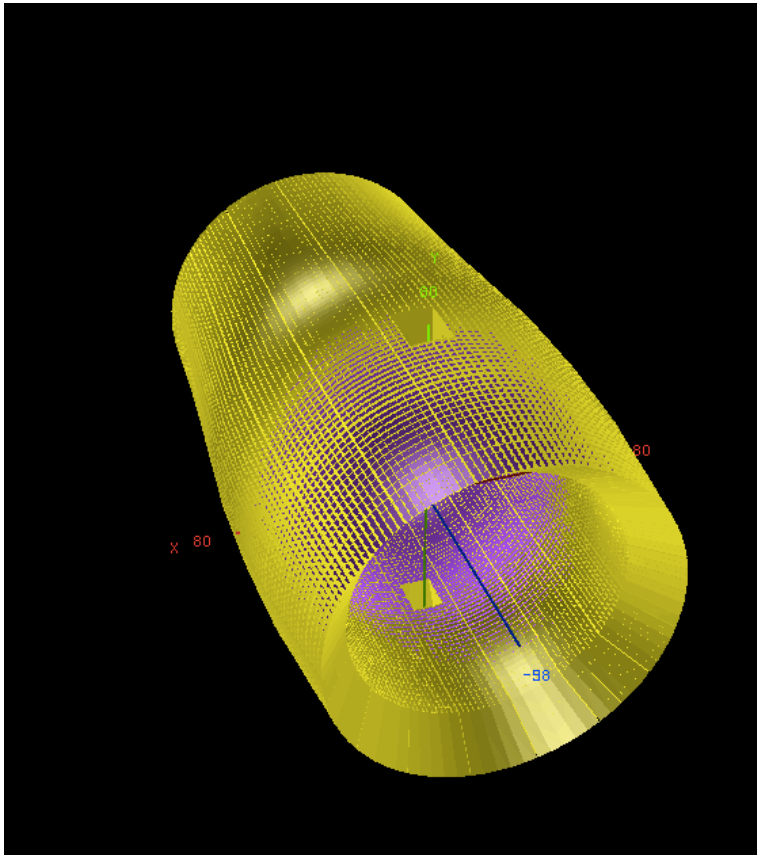
# Alveoles

---

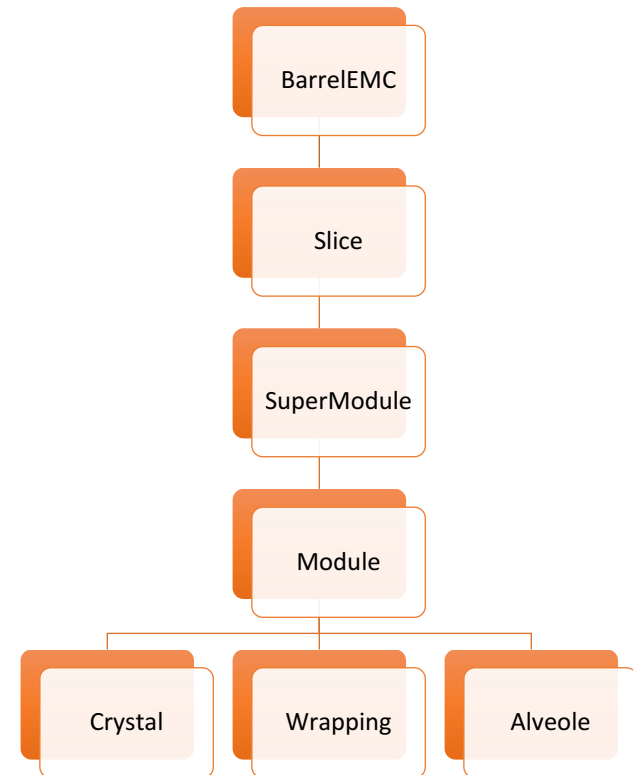


- ✓ Shape: TGeoTrap
- ✓ Material: Epoxy pre-impregnated carbon plain weave fabric
- ✓ Thickness:  $200\ \mu\text{m}$
- ✓ Gap to the crystal:  $\sim 140\ \mu\text{m}$

# Putting everything together



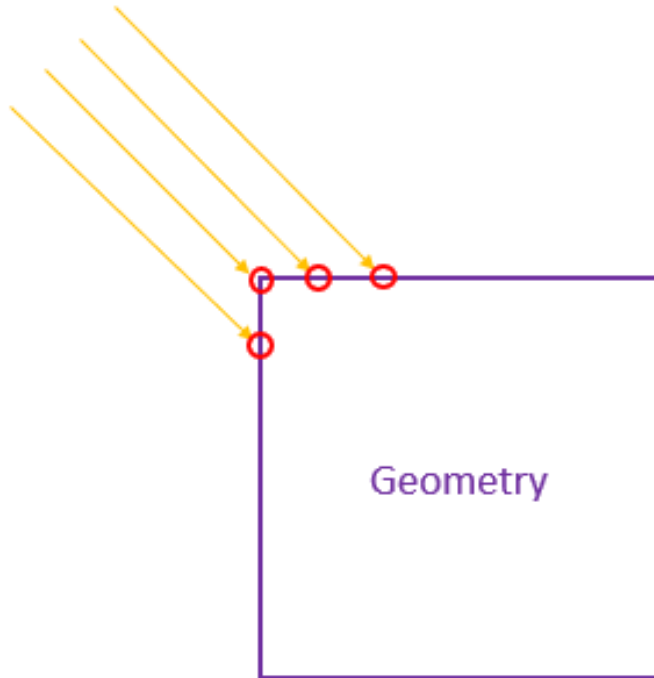
Volumes hierarchy



Modularized design - easy to plug-in and plug-out

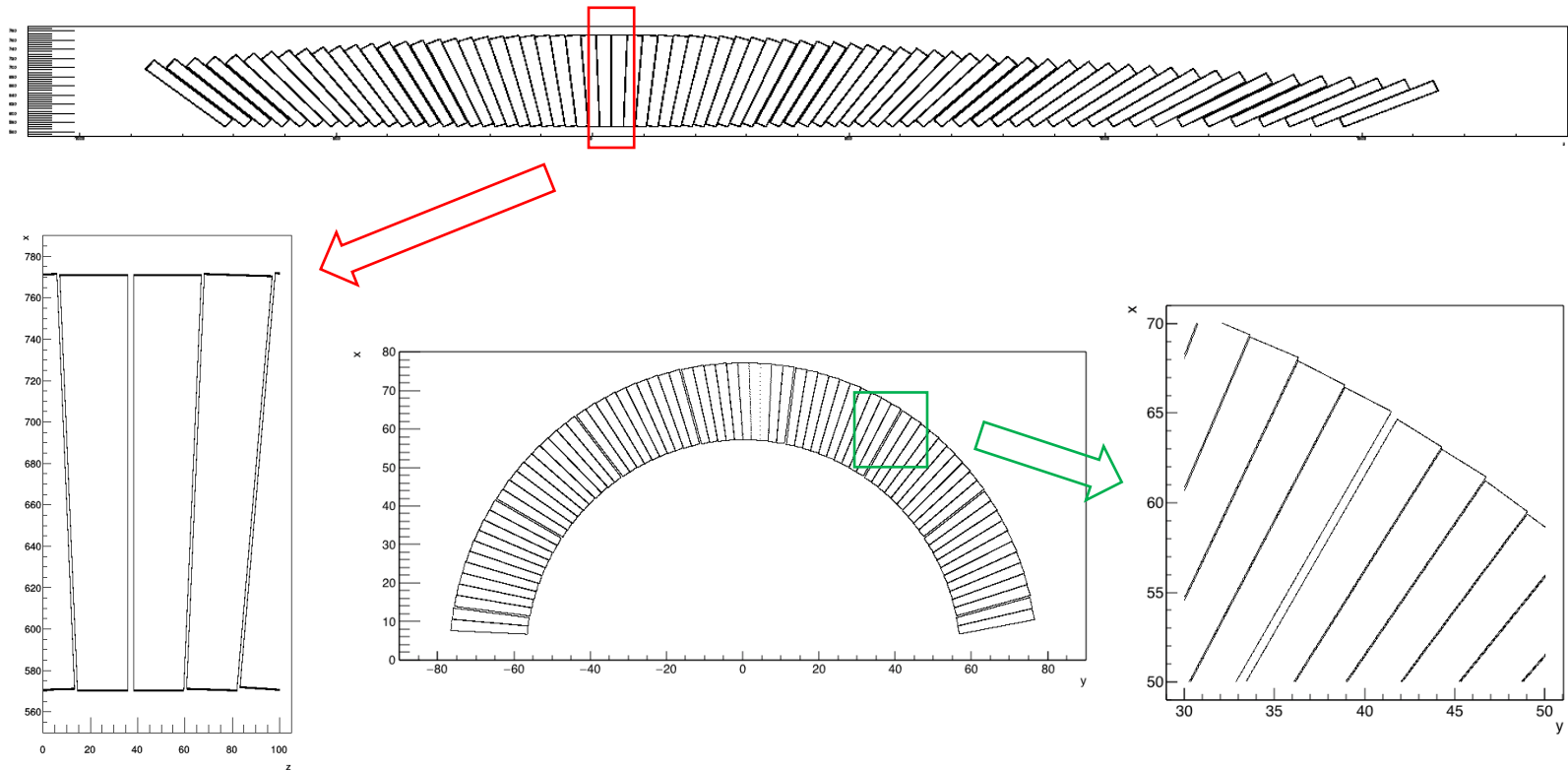
# Raytracing checks in ROOT

---



- ✓ Using the navigation feature of ROOT
- ✓ Shoot ghost particles (no interactions) to the geometry, and keep track of the geometry boundaries
- ✓ Debug and check the geometry by viewing the 2D cross-section view of the geometry

# Raytracing views



Geometry can be correctly visualized in real tracking,  
which means there is no overlapping issue



# Code updates in pandaroot

---

- ❑ PndEmc: Update the logic to handle the new ROOT file
  - ❑ SetGeometryVersion()
  - ❑ ConstructRootGeometry()
  - ❑ ProcessHits()
- ❑ PndEmcMapper: Update the map of detector ID to tci (PndEmcTwoCoordIndex)
  - ❑ New class PndEmcMapperGeo12Root
- ❑ PndEmcStructure: Update the map of tci to xtal (PndEmcXtal)
  - ❑ Crystal\_name\_analysis()

# Crystals' detector IDs

| iMod: 2                  |     |     |     |     |     |     |     | iMod: 1       |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |
|--------------------------|-----|-----|-----|-----|-----|-----|-----|---------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|-----|--|--|--|
|                          |     |     |     |     |     |     |     | super modules |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |
|                          |     |     |     |     |     |     |     | SM4           |     |     |     | SM5 |     |     |     | SM6 |      |      |      | SM7 |  |  |  |
| crystal shape left/right | SM1 | SM2 |     |     |     | SM3 |     |               | 1pe | 2pe | 3pe | 4pe | 5pe | 6pe | 7pe | 8pe | 9pe  | 10pe | 11pe | e   |  |  |  |
|                          | L   | 7me | 6me | 5me | 4me | 3me | 2me | 1me           | 1pe | 2pe | 3pe | 4pe | 5pe | 6pe | 7pe | 8pe | 9pe  | 10pe | 11pe | e   |  |  |  |
|                          | R   |     |     |     |     |     |     |               |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |
|                          | L   | 7md | 6md | 5md | 4md | 3md | 2md | 1md           | 1pd | 2pd | 3pd | 4pd | 5pd | 6pd | 7pd | 8pd | 9pd  | 10pd | 11pd | d   |  |  |  |
|                          | R   |     |     |     |     |     |     |               |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |
|                          | L   | 7mc | 6mc | 5mc | 4mc | 3mc | 2mc | 1mc           | 1pc | 2pc | 3pc | 4pc | 5pc | 6pc | 7pc | 8pc | 9pc  | 10pc | 11pc | c   |  |  |  |
|                          | R   |     |     |     |     |     |     |               |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |
|                          | L   | 7mb | 6mb | 5mb | 4mb | 3mb | 2mb | 1mb           | 1pb | 2pb | 3pb | 4pb | 5pb | 6pb | 7pb | 8pb | 9pb  | 10pb | 11pb | b   |  |  |  |
|                          | R   |     |     |     |     |     |     |               |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |
| L                        | 7ma | 6ma | 5ma | 4ma | 3ma | 2ma | 1ma | 1pa           | 2pa | 3pa | 4pa | 5pa | 6pa | 7pa | 8pa | 9pa | 10pa | 11pa | a    |     |  |  |  |
| R                        |     |     |     |     |     |     |     |               |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |
|                          | 7m  | 6m  | 5m  | 4m  | 3m  | 2m  | 1m  | 1p            | 2p  | 3p  | 4p  | 5p  | 6p  | 7p  | 8p  | 9p  | 10p  | 11p  |      |     |  |  |  |
|                          |     |     |     |     |     |     |     | alveole type  |     |     |     |     |     |     |     |     |      |      |      |     |  |  |  |

iCry:

10

↑

1

alveole position

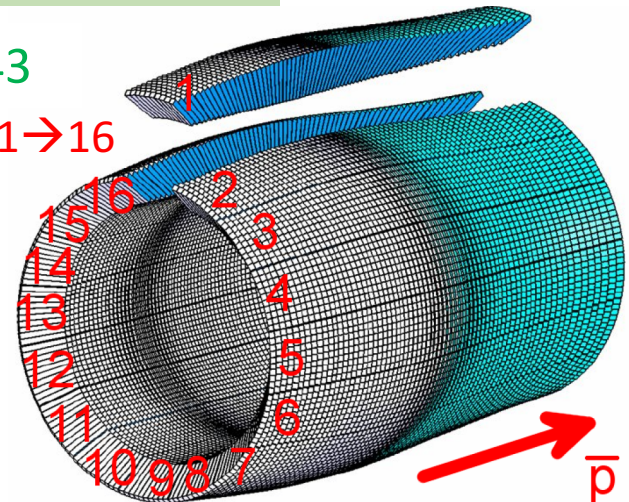
iCry: 10  
↑  
1

iRow: 28←1

iRow: 1→43

iCopy: 1→16

detID = iMod\*1E8+iRow\*1E6+iCopy\*1E4+iCry



# Crystals' two coordinate indexes

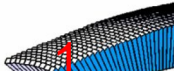
iTheta: 1->71 (28+43)

|                          |   | super modules |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |      |   |  |  |
|--------------------------|---|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|---|--|--|
|                          |   | SM1           | SM2 |     | SM3 |     |     | SM4 |     |     | SM5 |     | SM6 |     |     | SM7 |     |      |      |   |  |  |
| crystal shape left/right | L | 7me           | 6me | 5me | 4me | 3me | 2me | 1me | 1pe | 2pe | 3pe | 4pe | 5pe | 6pe | 7pe | 8pe | 9pe | 10pe | 11pe | e |  |  |
|                          | R | 7md           | 6md | 5md | 4md | 3md | 2md | 1md | 1pd | 2pd | 3pd | 4pd | 5pd | 6pd | 7pd | 8pd | 9pd | 10pd | 11pd | d |  |  |
|                          | L | 7mc           | 6mc | 5mc | 4mc | 3mc | 2mc | 1mc | 1pc | 2pc | 3pc | 4pc | 5pc | 6pc | 7pc | 8pc | 9pc | 10pc | 11pc | c |  |  |
|                          | R | 7mb           | 6mb | 5mb | 4mb | 3mb | 2mb | 1mb | 1pb | 2pb | 3pb | 4pb | 5pb | 6pb | 7pb | 8pb | 9pb | 10pb | 11pb | b |  |  |
|                          | L | 7ma           | 6ma | 5ma | 4ma | 3ma | 2ma | 1ma | 1pa | 2pa | 3pa | 4pa | 5pa | 6pa | 7pa | 8pa | 9pa | 10pa | 11pa | a |  |  |
|                          | R |               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |      |   |  |  |
|                          | L | 7m            | 6m  | 5m  | 4m  | 3m  | 2m  | 1m  | 1p  | 2p  | 3p  | 4p  | 5p  | 6p  | 7p  | 8p  | 9p  | 10p  | 11p  |   |  |  |
|                          | R |               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |      |   |  |  |
|                          | L |               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |      |   |  |  |
|                          | R |               |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |      |   |  |  |
|                          |   | 7m            | 6m  | 5m  | 4m  | 3m  | 2m  | 1m  | 1p  | 2p  | 3p  | 4p  | 5p  | 6p  | 7p  | 8p  | 9p  | 10p  | 11p  |   |  |  |

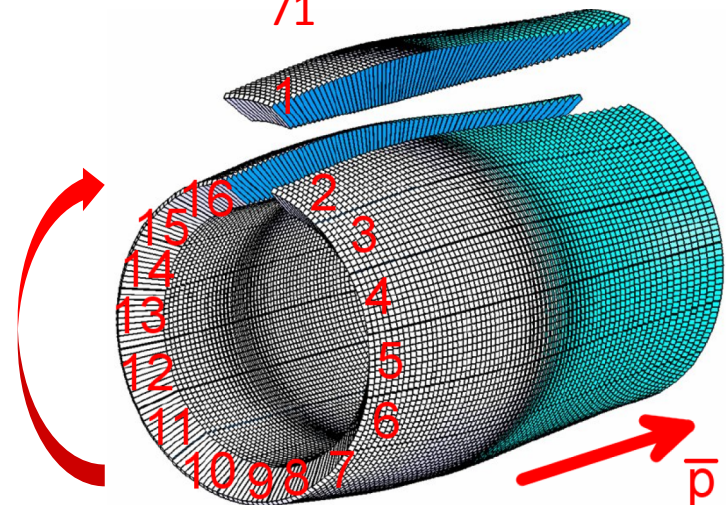
1

$\overline{p}$

71



iPhi: 1->160



...

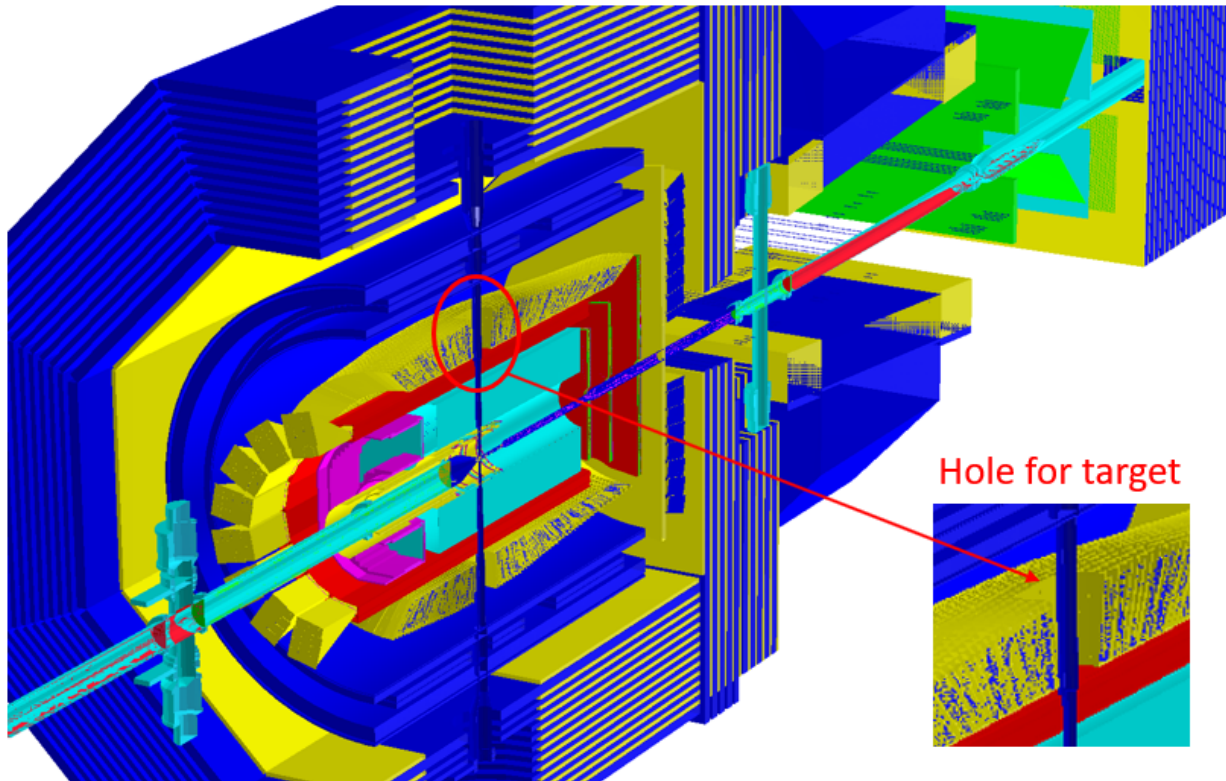


Crystal-1p-L4  
104010001  
32, 10

20

# The new barrel geometry in pandaroot

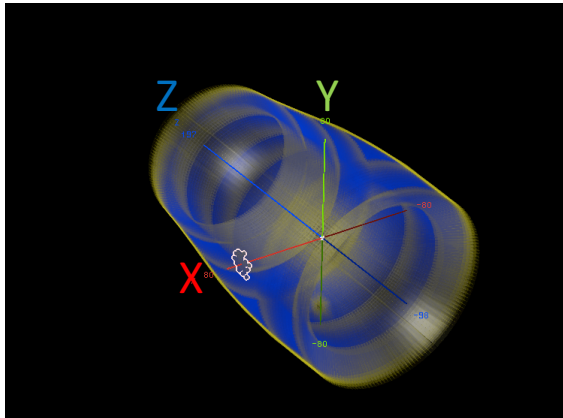
---



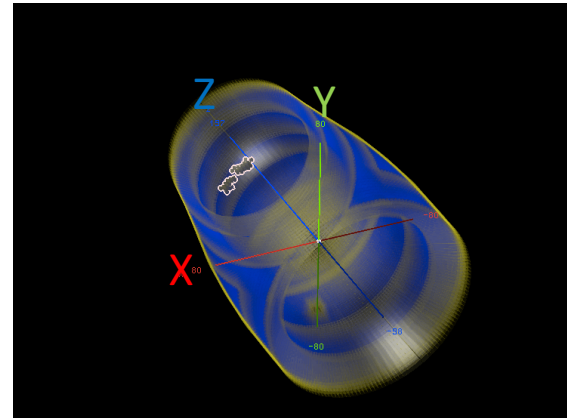
# Cluster reconstruction tests

Single photon @ 2 GeV

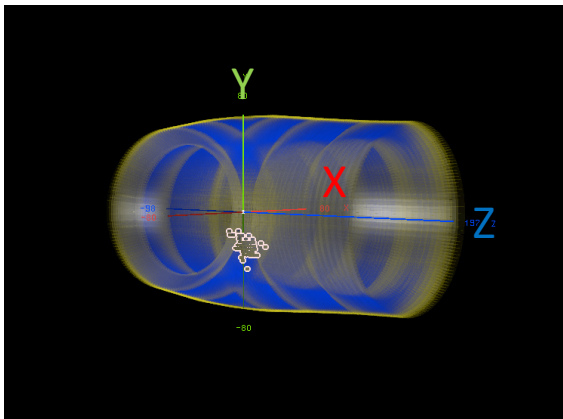
$\theta = 90^\circ, \phi = 0^\circ$



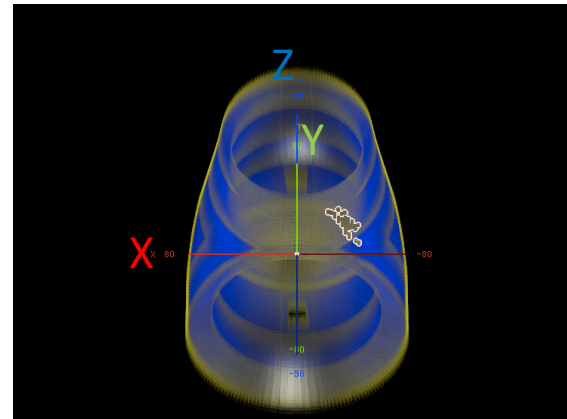
$\theta = 60^\circ, \phi = 45^\circ$



$\theta = 45^\circ, \phi = 200^\circ$



$\theta = 120^\circ, \phi = 120^\circ$



# Summary

---

- ❑ **Barrel EMC geometry are updated. The first round of updates include the crystals, wrappings and alveoles.**
- ❑ **Codes in padaroot are updated to handle the new ROOT file.**
- ❑ **Several tests are performed and the new geometry is validated by these results.**
- ❑ **Next to do**
  - ❑ More tests will be done
  - ❑ Implement the rest of the geometry