

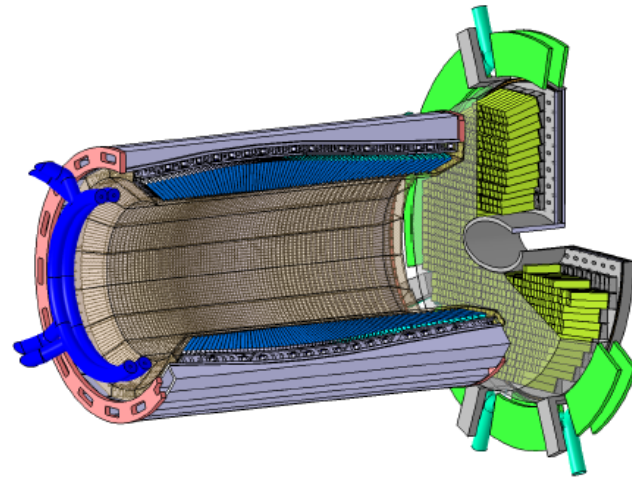
# Updated Barrel EMC Geometry

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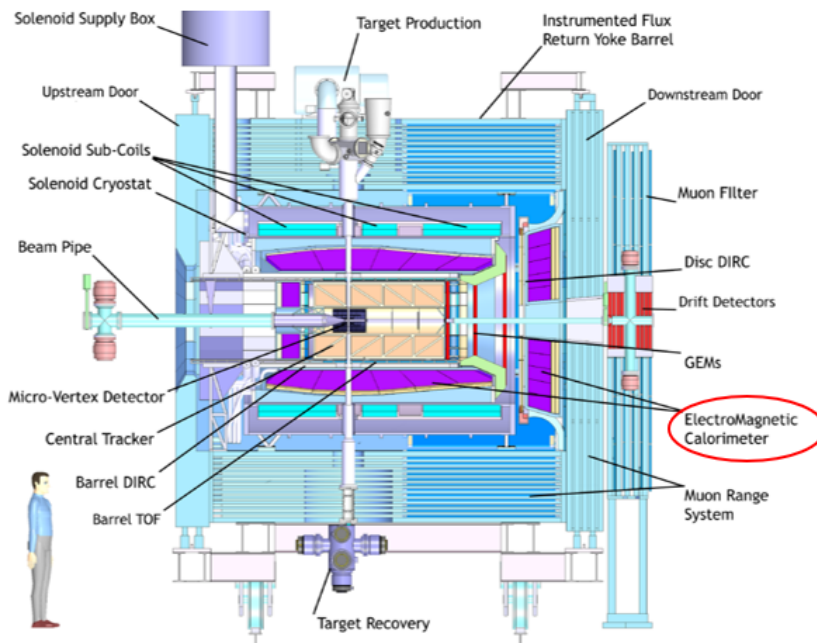


# Outline

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

# Introduction



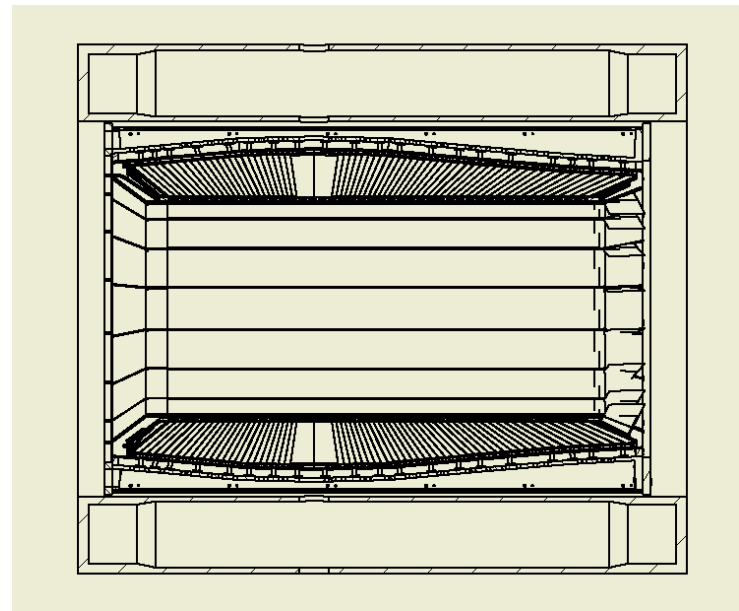
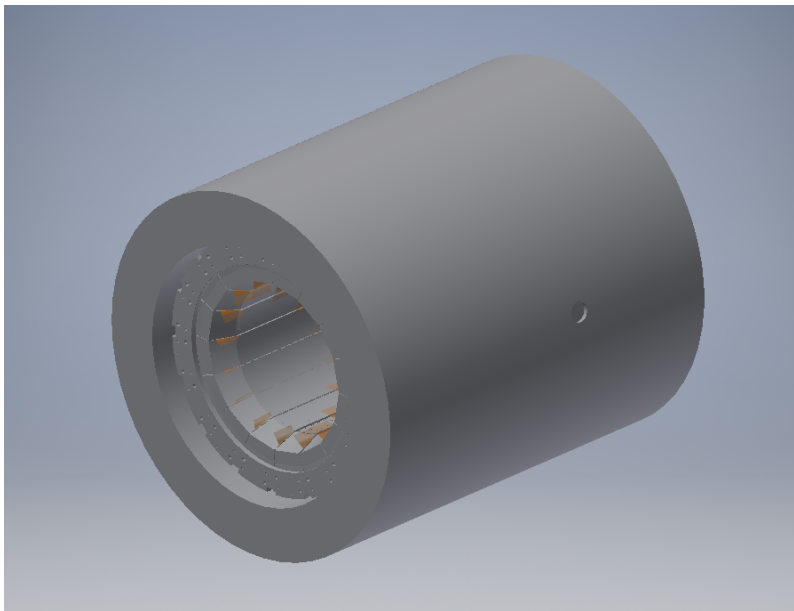
## Status of barrel EMC's geometry description

- ✓ 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  - ✓ # of crystals, parameters of crystals are out of date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

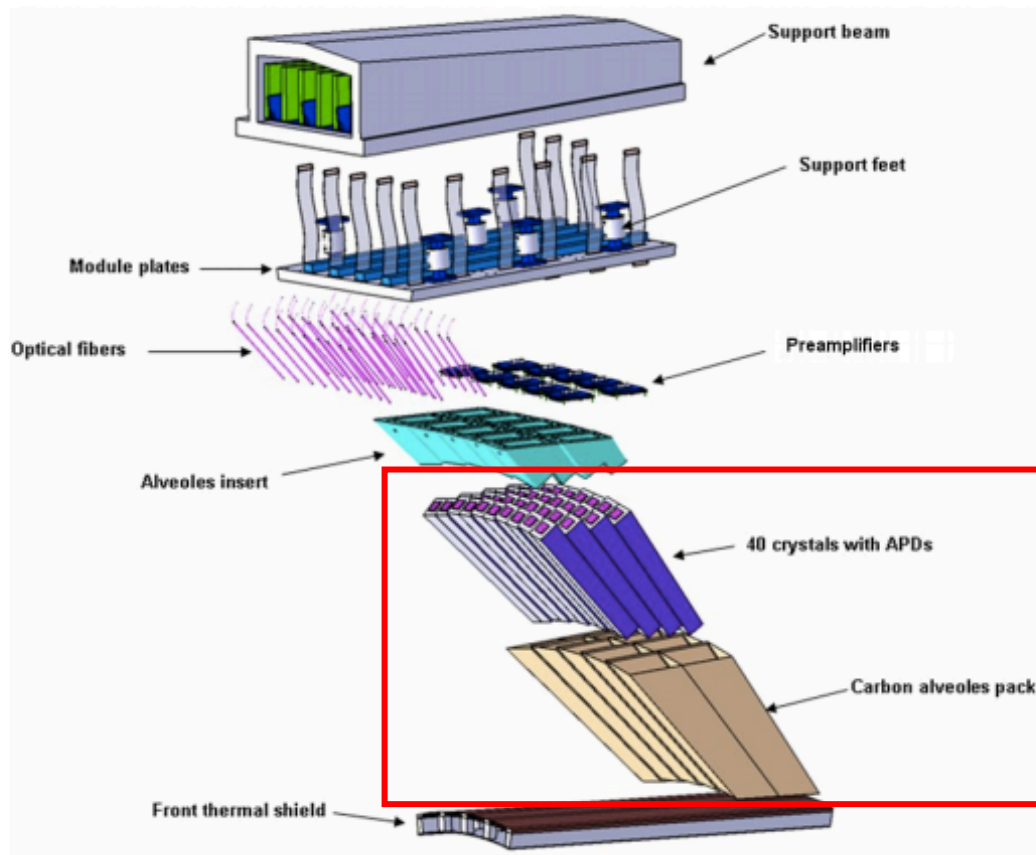
# The 3D CAD model

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- ✓ 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



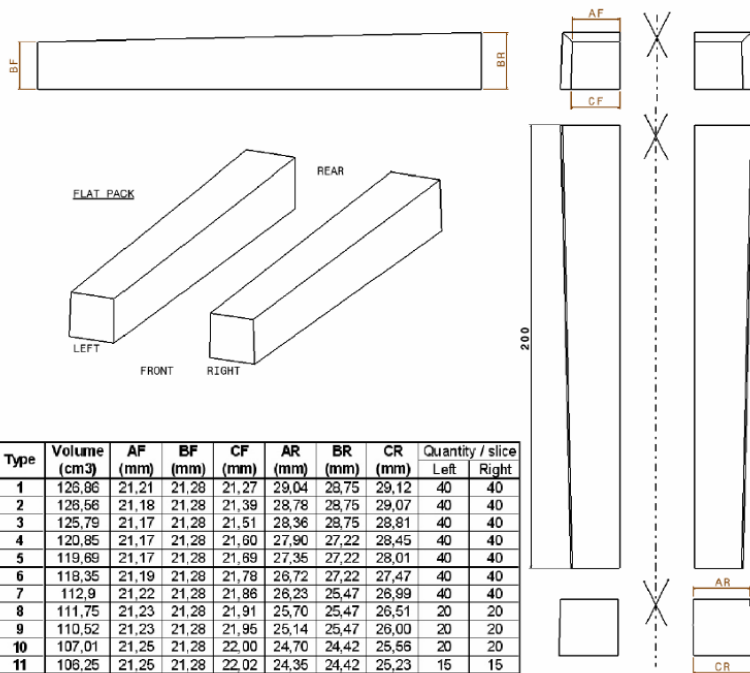
Bottom-to-top construction



In this work:

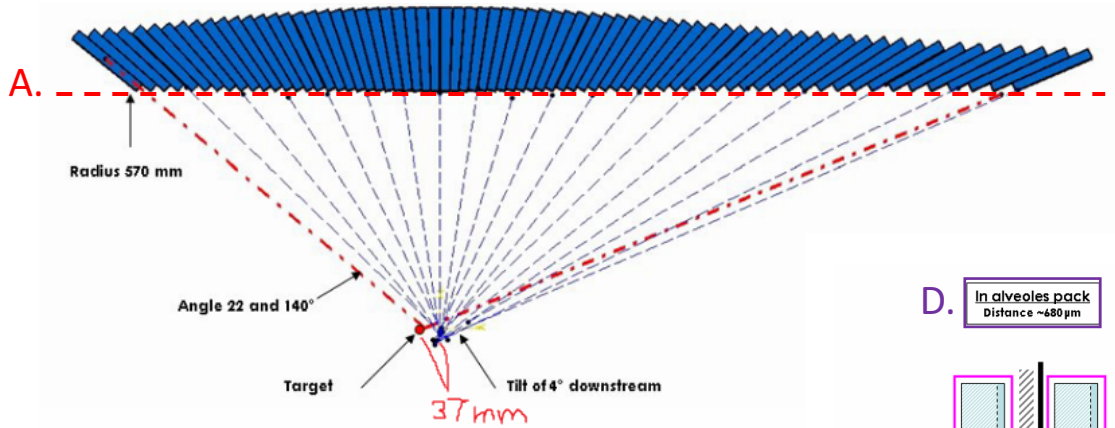
- Crystals (sensitive det)
- Wrappings
- Alveoles

# Crystals definitions

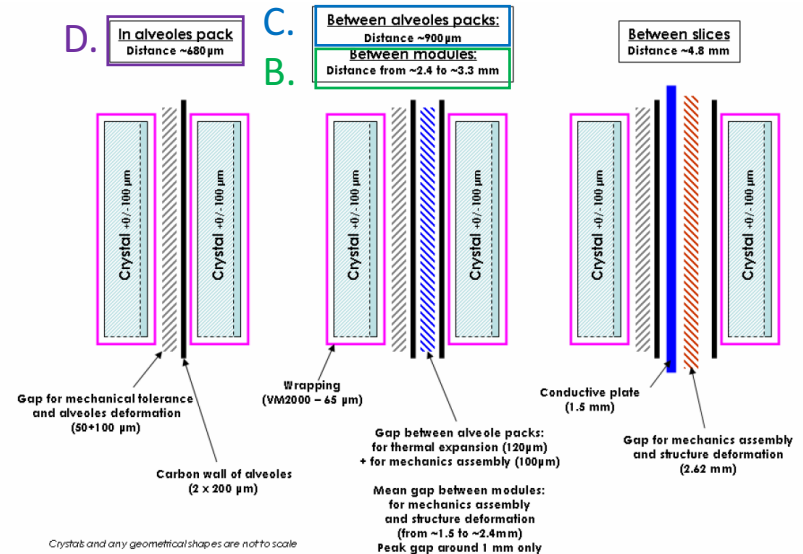


- ✓ Shape: tapered parallelepiped
- ✓ Material: PWO<sub>4</sub>
- ✓ Mass: 0.88-1.05 kg
- ✓ Dimensions: related to the global shape and to the discretization of the calorimeter
- ✓ Dimensions tolerances: +/- 100 um

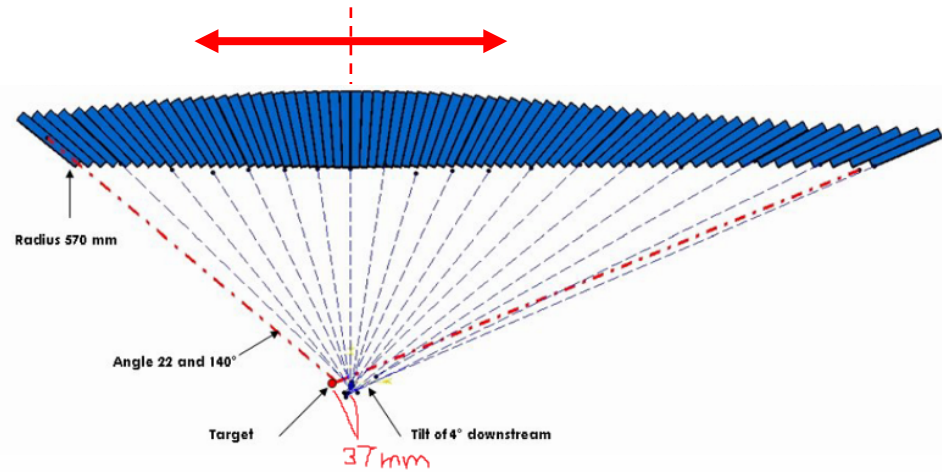
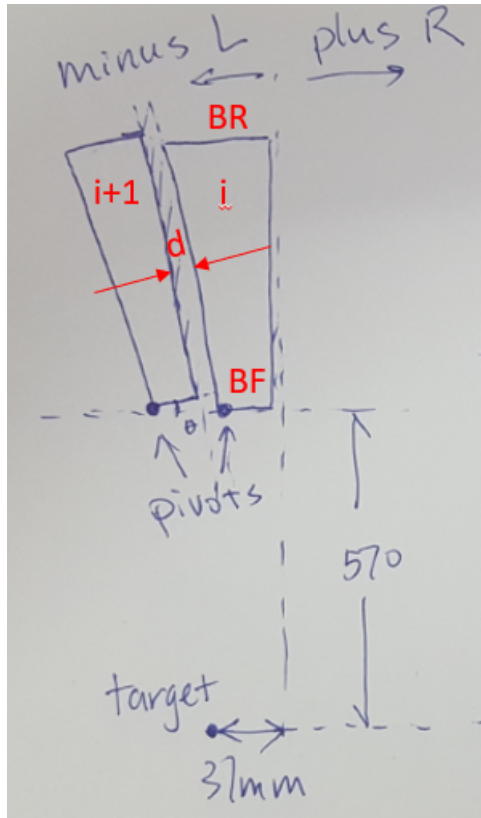
# Longitudinal parameters (I)



- 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)

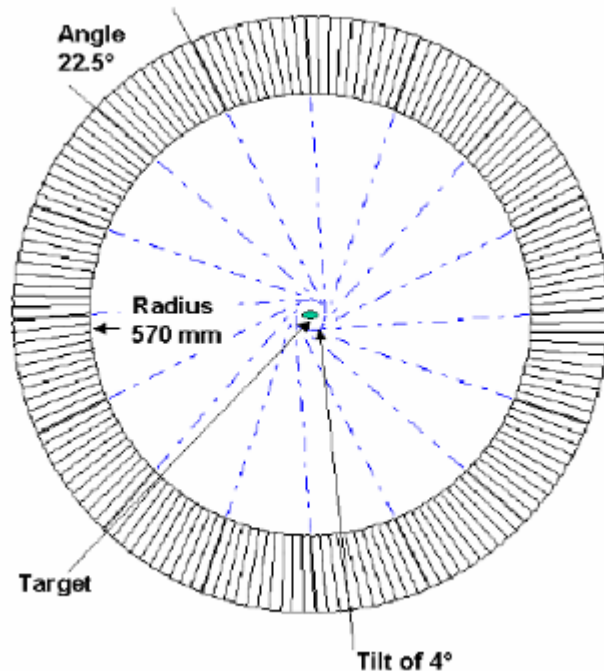


- ✓ z positions of the crystals are defined by the gap d and the crystal dimension
- ✓ For the  $(i+1)^{\text{th}}$  crystal (minus)
  - ✓  $z_{i+1} = z_i - (BF + d)/\cos\theta_i$
  - ✓ where  $\theta_{i+1} = \theta_i + \text{atan}\left(\frac{BR_i - BF_i}{L}\right)$
- ✓ Place the crystals from center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



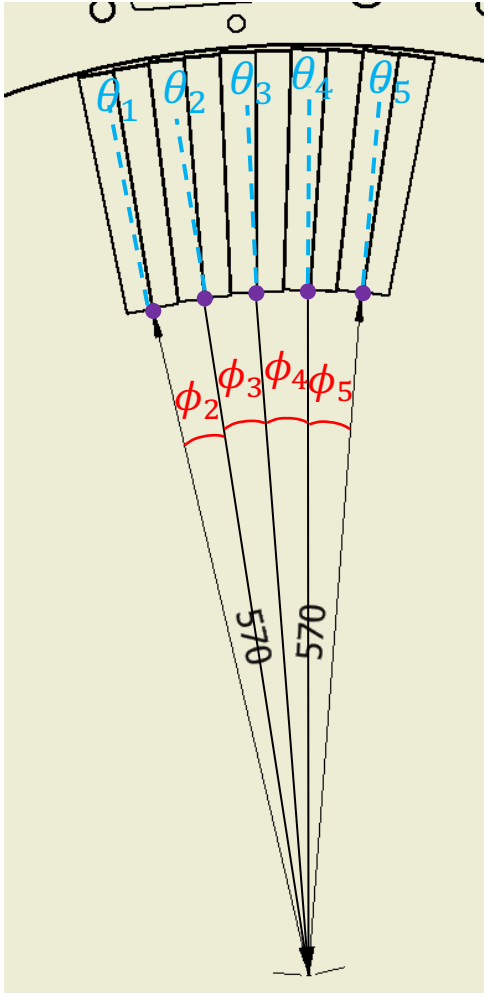
# Circumferential parameters (I)

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- ✓ 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

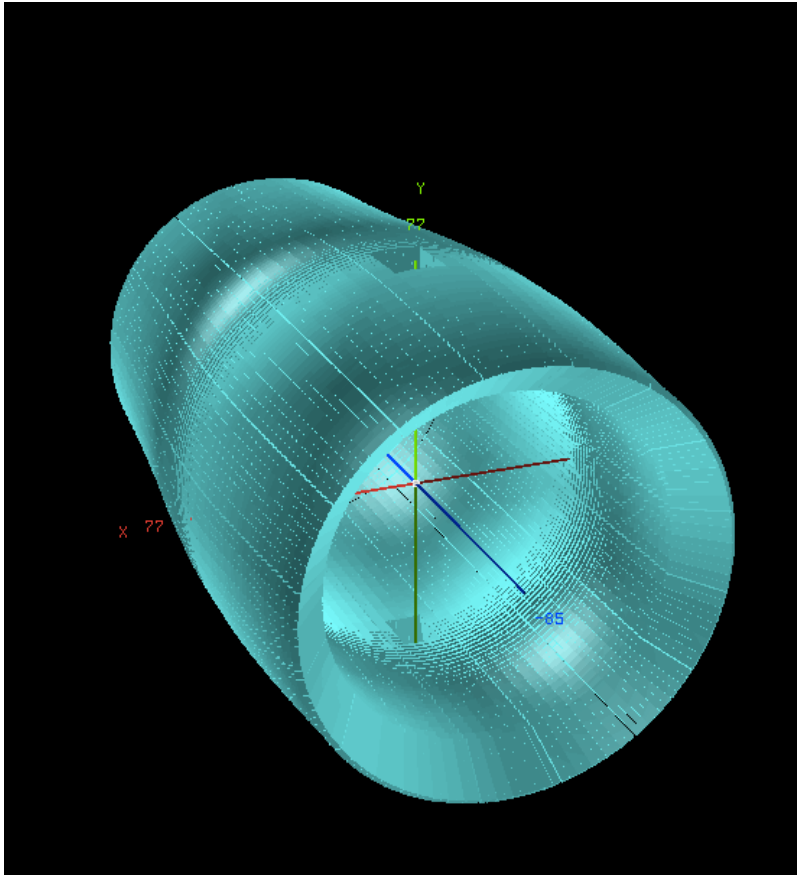
# Circumferential parameters (II)



- ✓ 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  $(i-1)^{th}$  crystal pairs
  - ✓  $\theta_i$ : tilt angle w.r.t. the radial direction ( $\sim 4\text{deg}$ )
- ✓ Extract  $\Phi_i$ s and  $\theta_i$ s from the CAD
- ✓ Place the crystals one by one

	azimuthal: $\Phi_i$ (degree)	tilt: $\theta_i$ (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

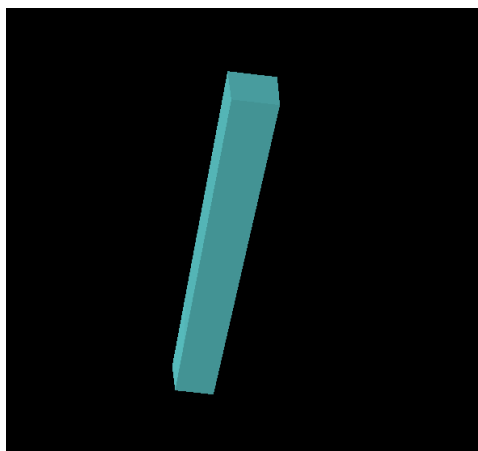


- ✓ Crystals:
  - ✓ Shape: TGeoTrap
  - ✓ Material:  $\text{PbWO}_4$
- ✓ Modules:
  - ✓ Shape: TGeoVolumeAssembly
  - ✓ Made up of 4 (or 3)\*10 crystals
- ✓ Super modules:
  - ✓ Shape: TGeoVolumeAssembly
  - ✓ Made up of up to 3 modules
- ✓ 16 slices
  - ✓ Shape: TGeoVolumeAssembly
  - ✓ Made up of 7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

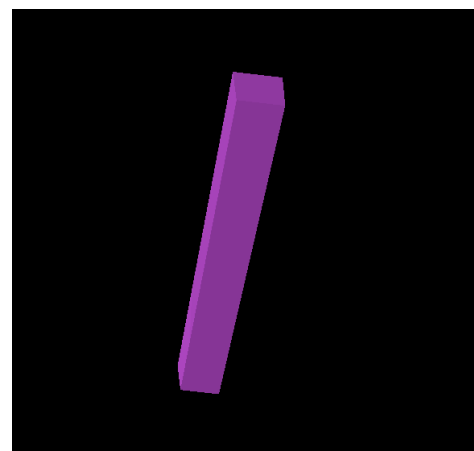
# Wrappings

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Crystal w/o wrapping



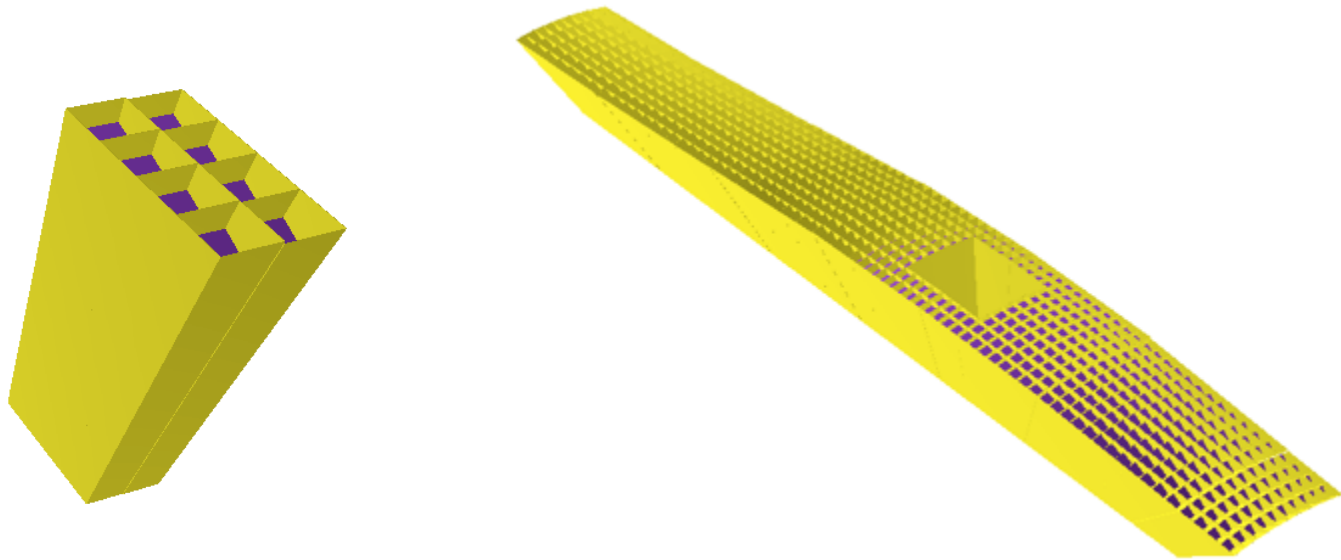
Crystal w/ wrapping



- ✓ 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  $\mu m$

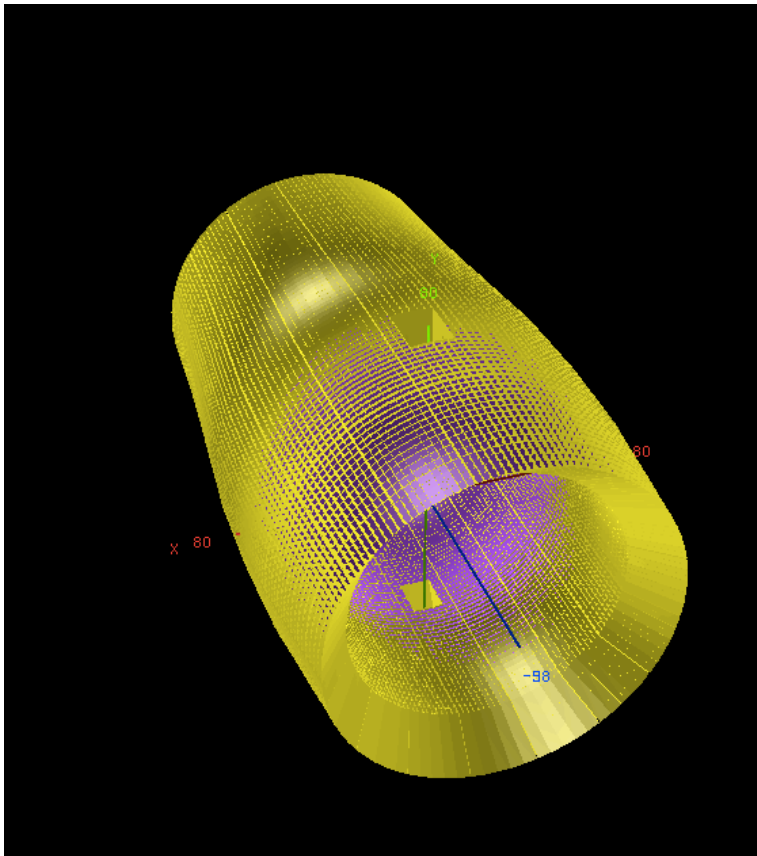
# Alveoles

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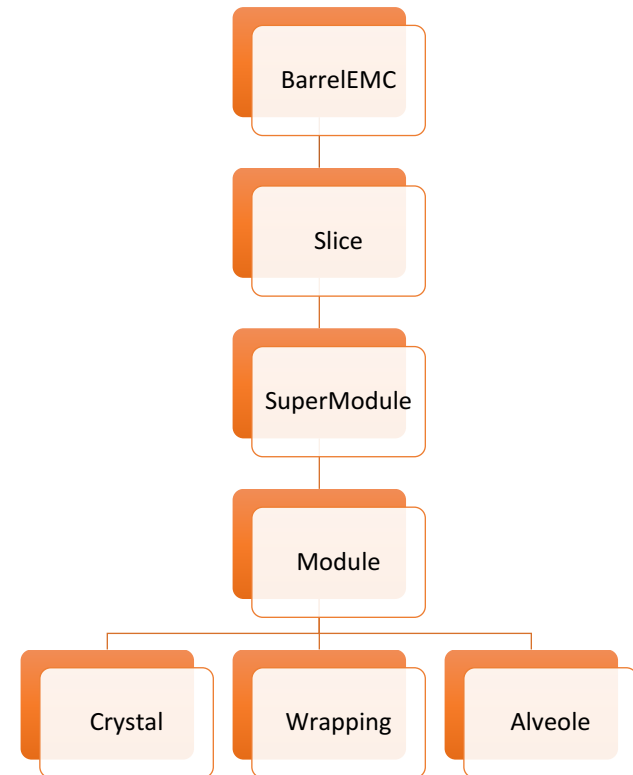


- ✓ Shape: TGeoTrap
- ✓ Material: Epoxy pre-impregnated carbon plain weave fabric
- ✓ Thickness:  $200 \mu m$
- ✓ Gap to the crystal:  $\sim 140 \mu m$

# Putting everything together



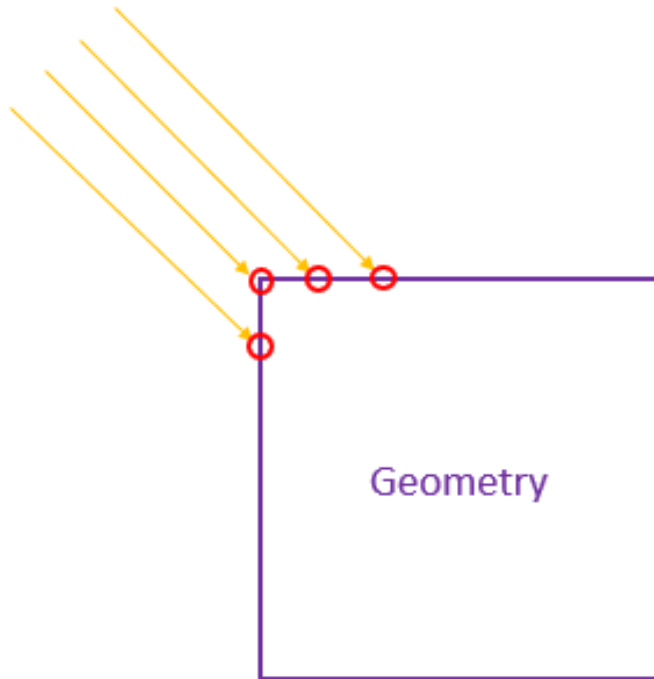
## Volumes hierarchy



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

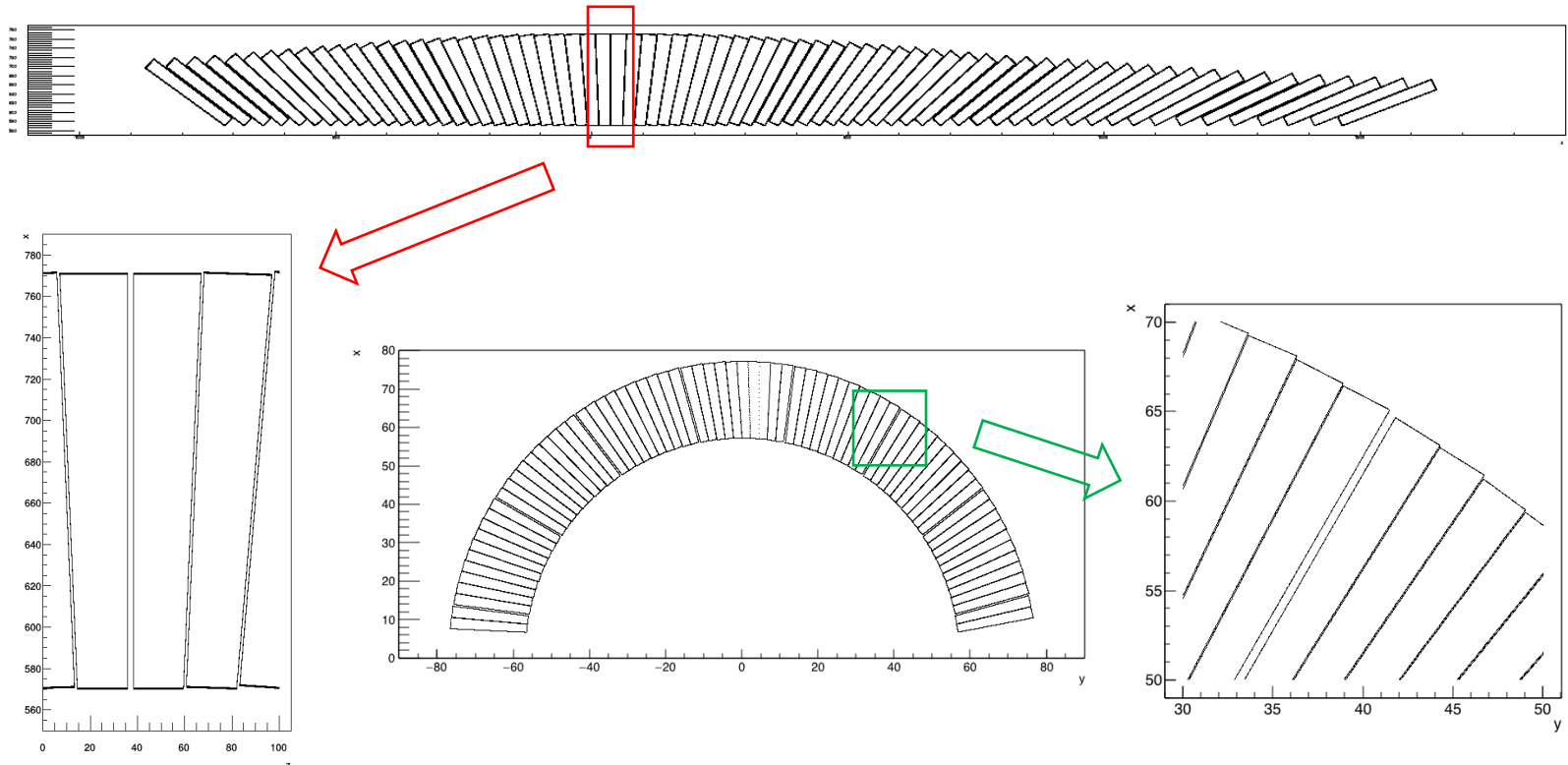
# Raytracing checks in ROOT

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- ✓ 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

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- 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													
		SM1		SM2		SM3		super modules				SM5		SM6		SM7					
		7m	6m	5m	4m	3m	2m	1m	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	alveole type	
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																				
	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	

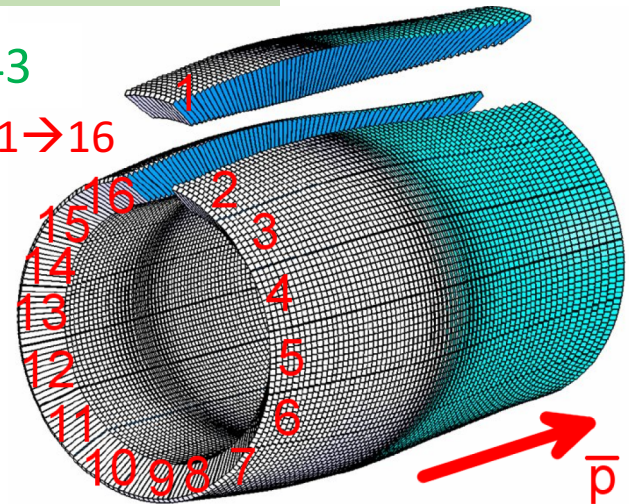
iCry: 10  
↑  
1

iRow: 28 ← 1

iRow: 1 → 43

iCopy: 1 → 16

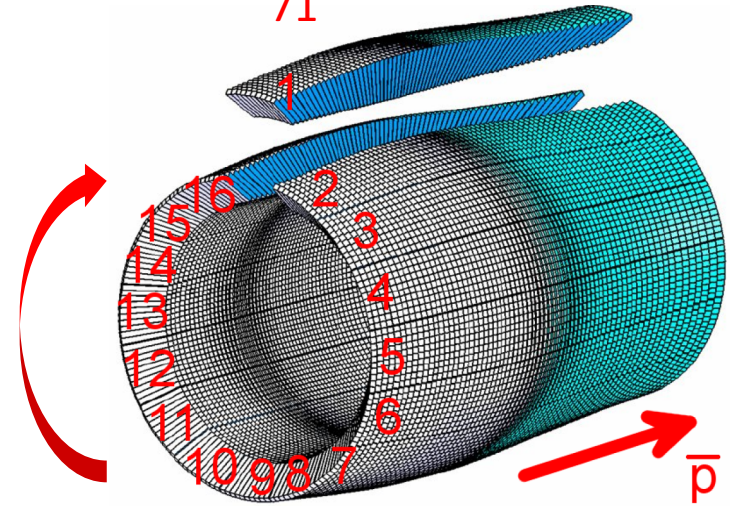
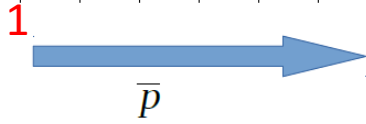
$$\text{detID} = \text{iMod} * 1\text{E}8 + \text{iRow} * 1\text{E}6 + \text{iCopy} * 1\text{E}4 + \text{iCry}$$



# 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	7m	6m	5m	4m	3m	2m	1m	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	
		alveole type																		



iPhi: 1->160

# Print out maps in pandaroot

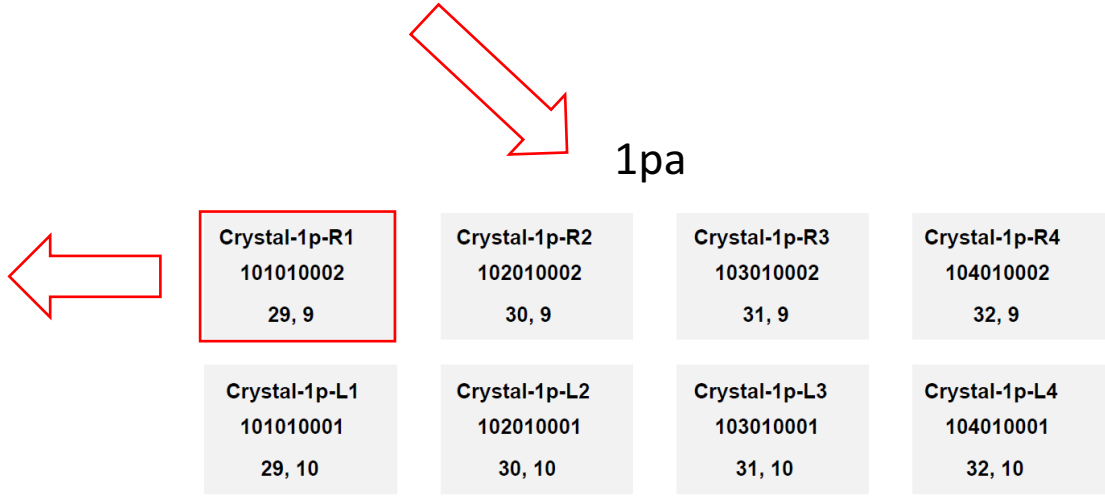
Crystal-1p-L1 101010001 29, 10	Crystal-1p-L2 102010001 30, 10	Crystal-1p-L3 103010001 31, 10	Crystal-1p-L4 104010001 32, 10	Crystal-1p-L1 101010002 29, 9	Crystal-1p-L2 102010002 30, 9	Crystal-1p-L3 103010002 31, 9	Crystal-1p-L4 104010002 32, 9	Crystal-1p-R1 101010002 29, 9	Crystal-1p-R2 102010002 30, 9	Crystal-1p-R3 103010002 31, 9	Crystal-1p-R4 104010002 32, 9
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DetID: 101010002

- ✓ iMod = 1
- ✓ iRow = 1
- ✓ iCopy = 1
- ✓ iCry = 2

Two coordinate index

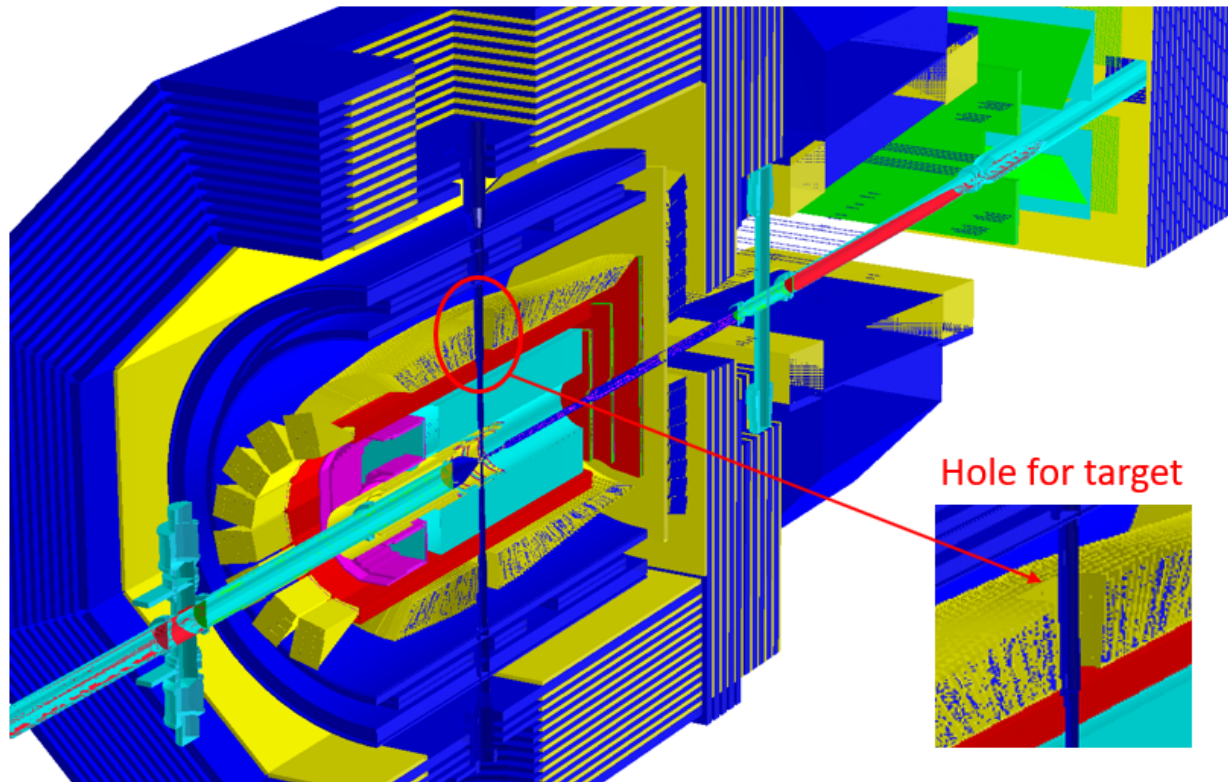
- ✓ iTheta = 29
- ✓ iPhi = 9



The detID to tci maps are correctly generated in pandaroot

# The new barrel geometry in pandaroot

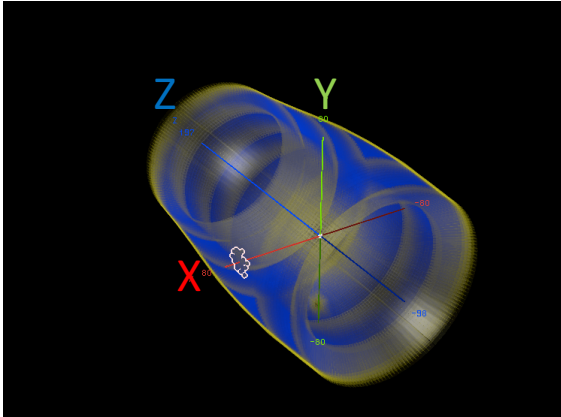
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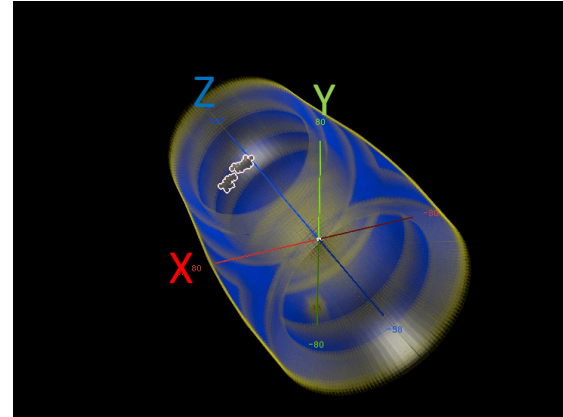
# Cluster reconstruction tests

Single photon @ 2 GeV

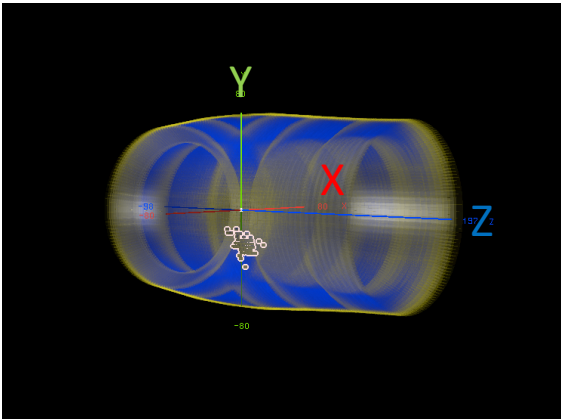
$\theta = 90^\circ, \phi = 0^\circ$



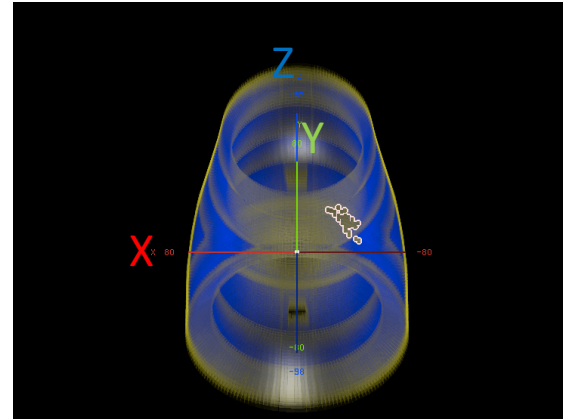
$\theta = 60^\circ, \phi = 45^\circ$



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



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



# Summary

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- ❑ **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**