

IHEP工作进展

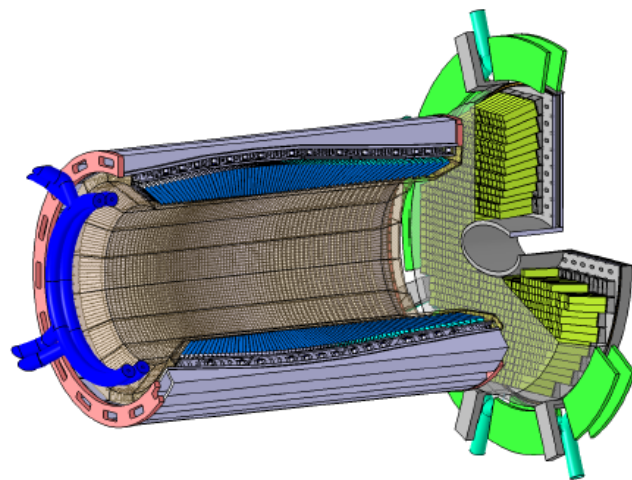
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中国科学院高能物理研究所

PANDA实验中方协调会

2018年4月26日



报告内容

□ PANDA实验介绍

□ 主要工作

- 在ROOT中，对量能器几何的构建
- 在panda软件框架(pandaroot)中，对ROOT几何的检查和更新

□ 总结和展望

The PANDA experiment

□ PANDA at FAIR

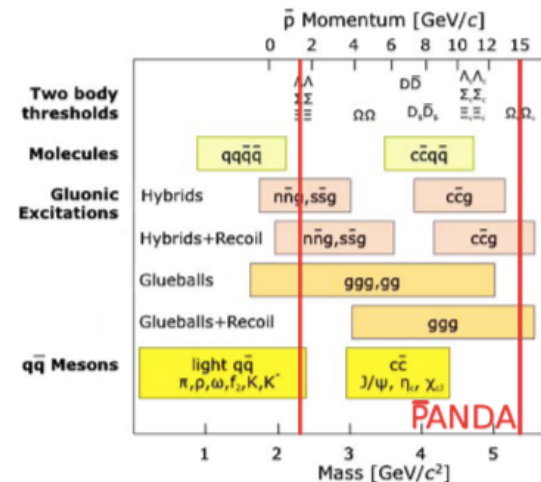
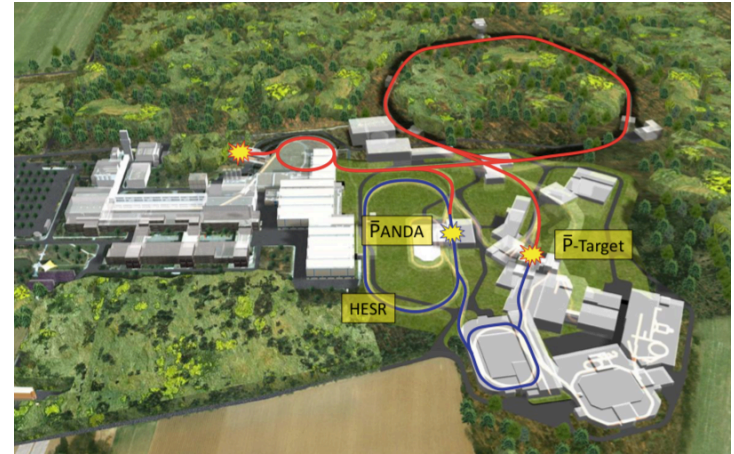
- Located at slow ramping synchrotron storage ring for internal target (HESR)
- Cooled pbar beam

□ PANDA experiment

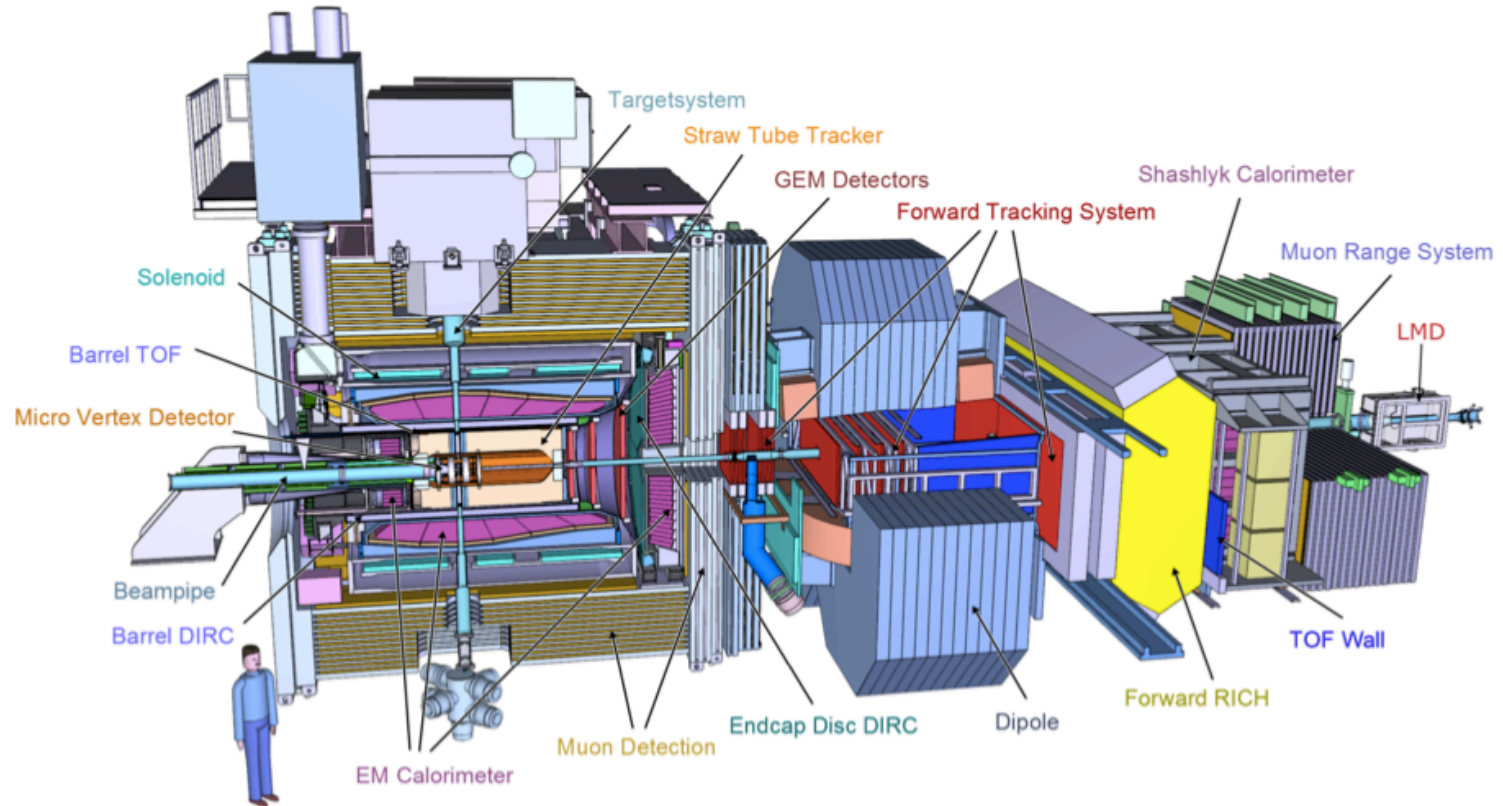
- ppbar annihilation, fixed hydrogen target
- pbar momenta: 1.5-15 GeV/c

□ Strong interaction studies

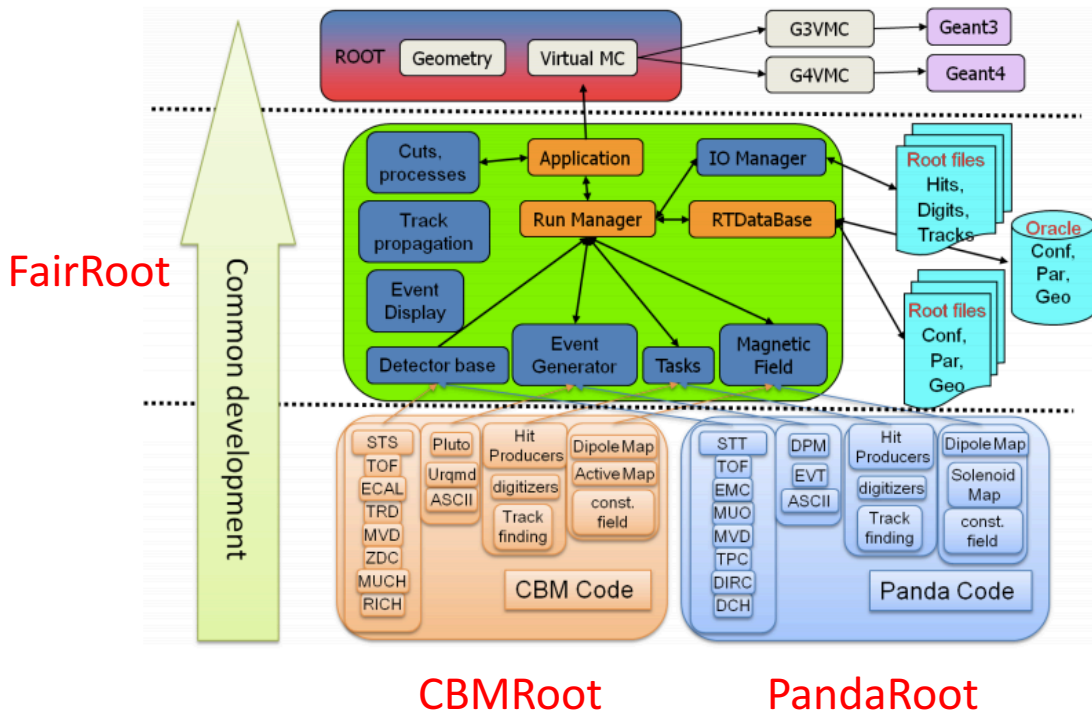
- Hadron spectroscopy
- Proton structure
- Mesons in nuclei
- Hypernuclei
- ...



The detectors

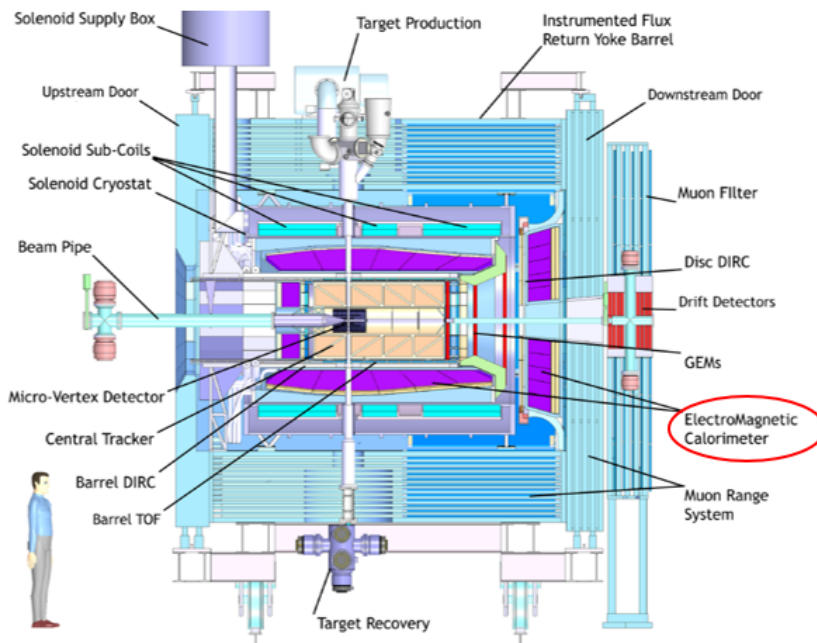


The software framework



- ✓ Based on ROOT and Virtual MC
- ✓ FairRoot: manages the general infrastructure with simulation and tasks
- ✓ PandaRoot: the implementation of the PANDA detector simulation and reconstruction code inside the FairRoot framework

The barrel EMC

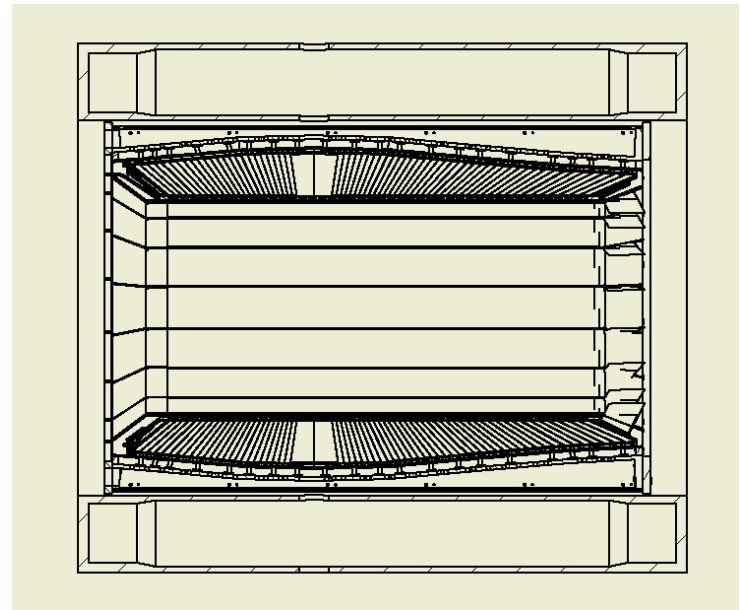
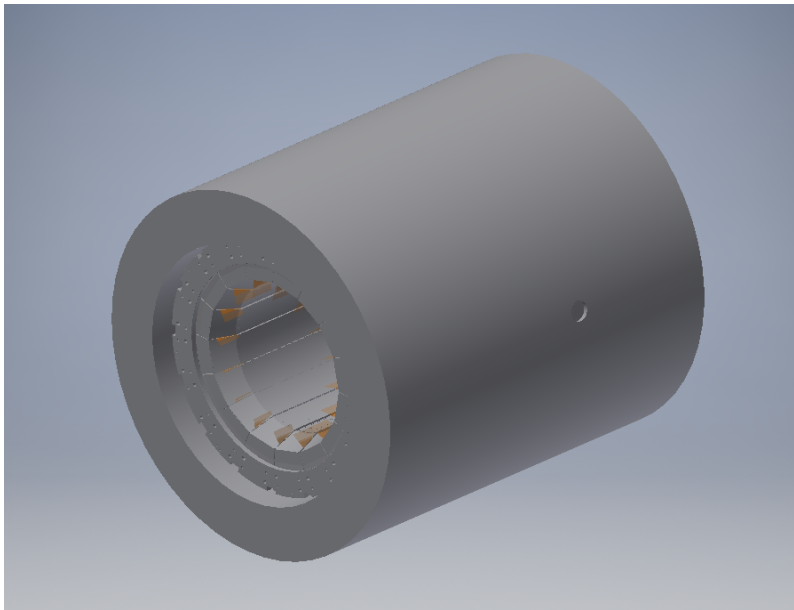


Status of barrel EMC's geometry description

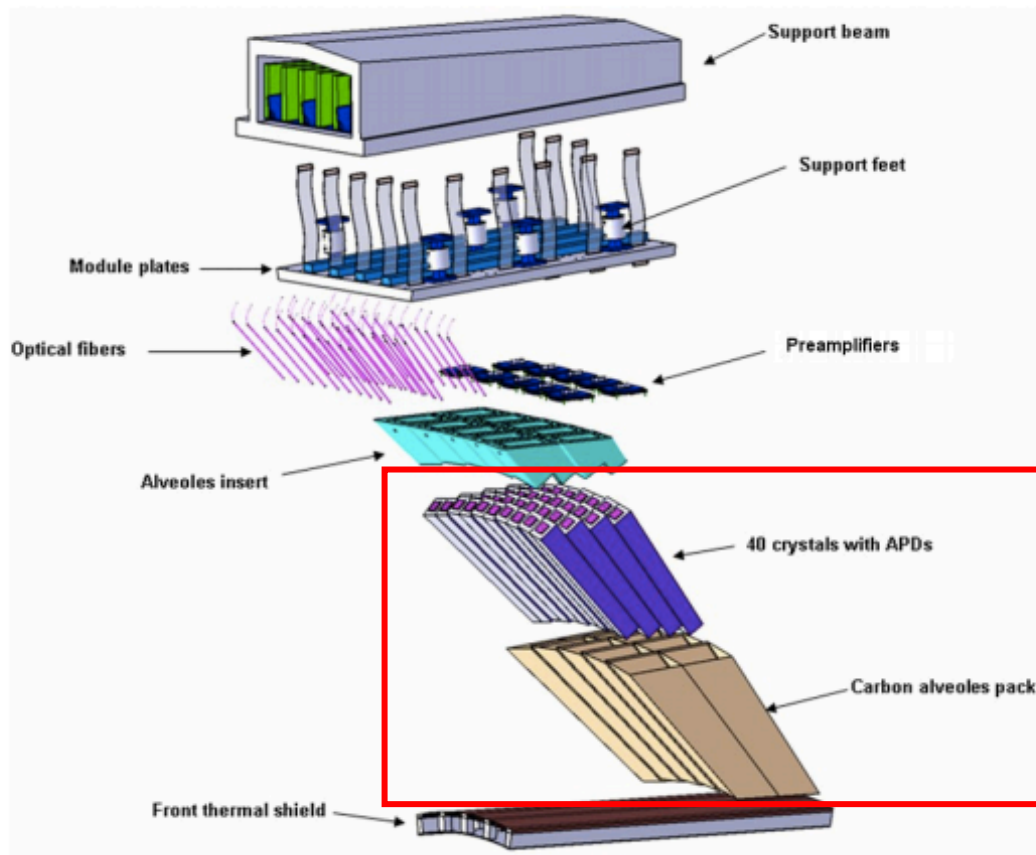
- ✓ Last update: 2009 by Spataro
 - ✓ Only crystals
 - ✓ # of crystals, parameters of crystals are out of date
- ✓ Need to do
 - ✓ Update detailed geometry
 - ✓ Using ROOT geometry class

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



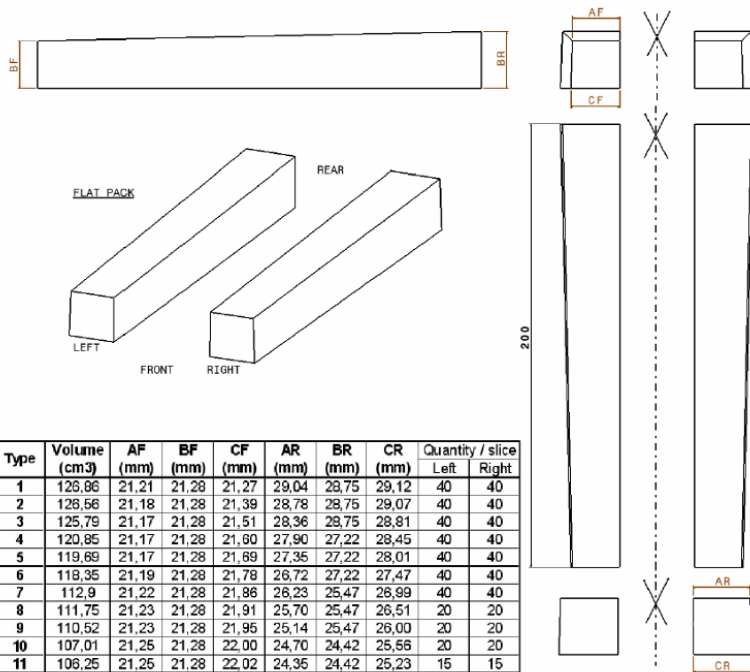
Bottom-to-top construction



In this work:

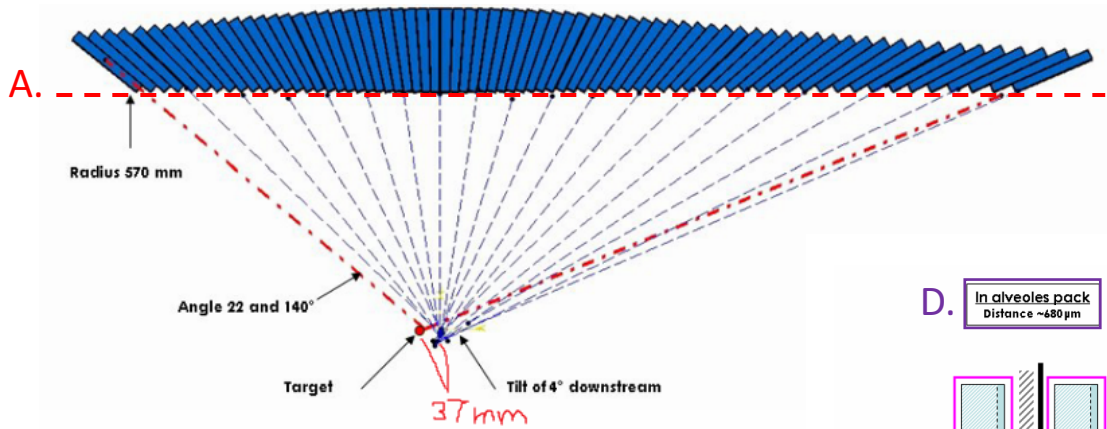
- Crystals (sensitive det)
- Wrappings
- Alveoles

Crystals definitions

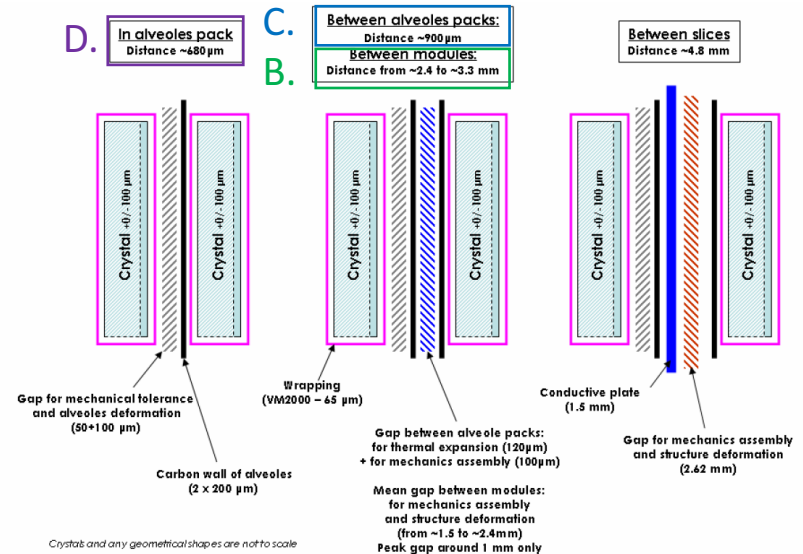


- ✓ Shape: tapered parallelepiped
- ✓ Material: PWO_4
- ✓ Mass: 0.88-1.05 kg
- ✓ Dimensions: related to the global shape and to the discretization of the calorimeter
- ✓ Dimensions tolerances: +/- 100 μm

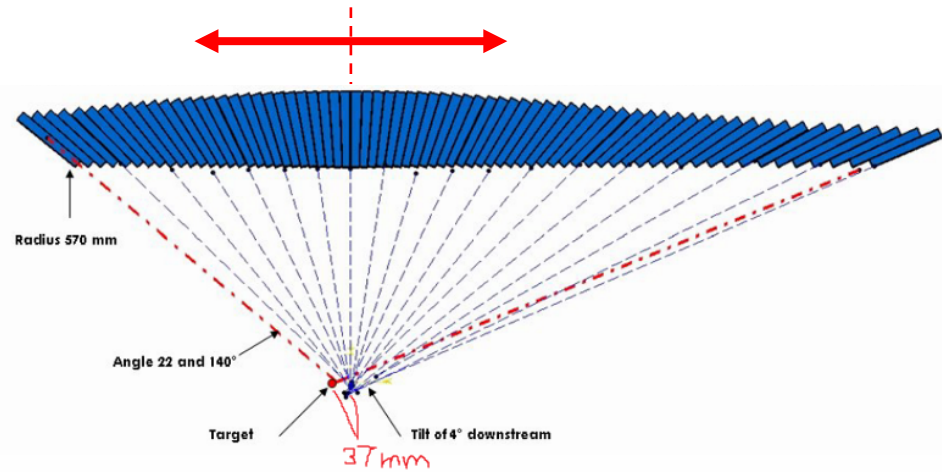
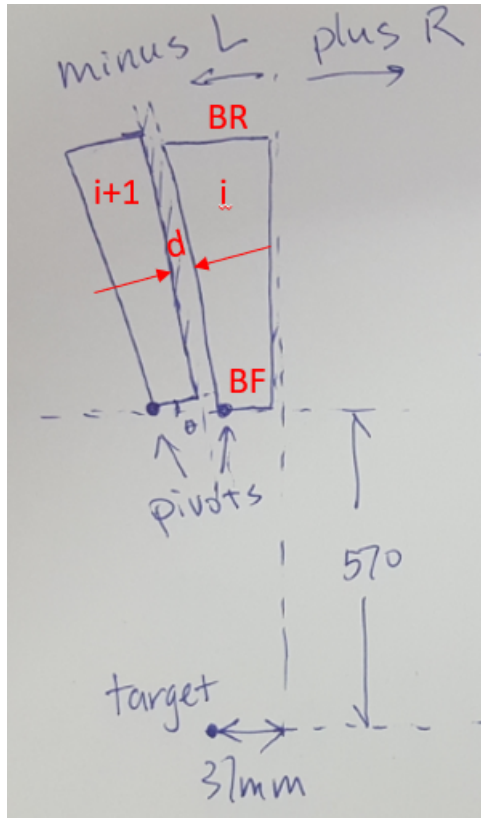
Longitudinal parameters (I)



- 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

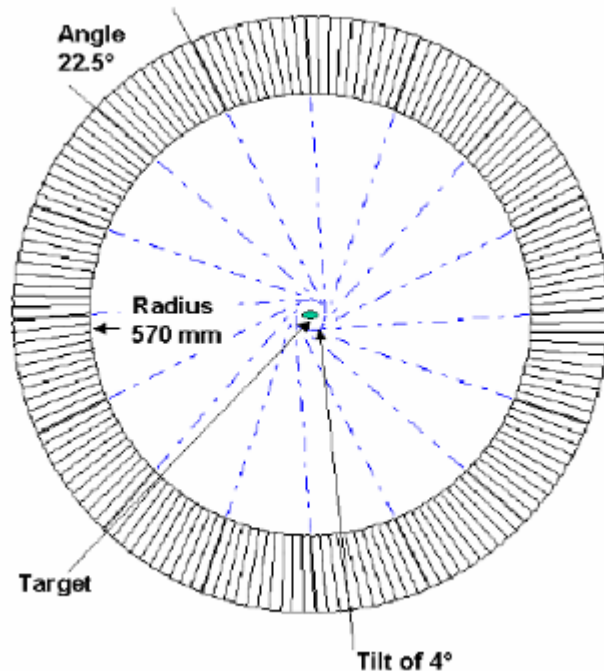


Longitudinal parameters (II)



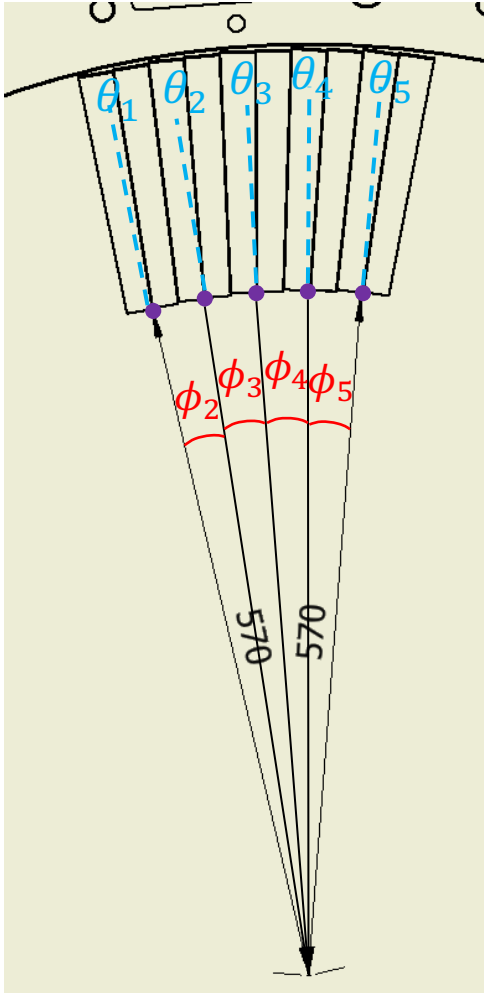
- ✓ z positions of the crystals are defined by the gap d and the crystal dimension
- ✓ For the $(i+1)^{\text{th}}$ crystal (minus)
 - ✓ $z_{i+1} = z_i - (BF + d)/\cos\theta_i$
 - ✓ where $\theta_{i+1} = \theta_i + \text{atan}\left(\frac{BR_i - BF_i}{L}\right)$
- ✓ Place the crystals from center to side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

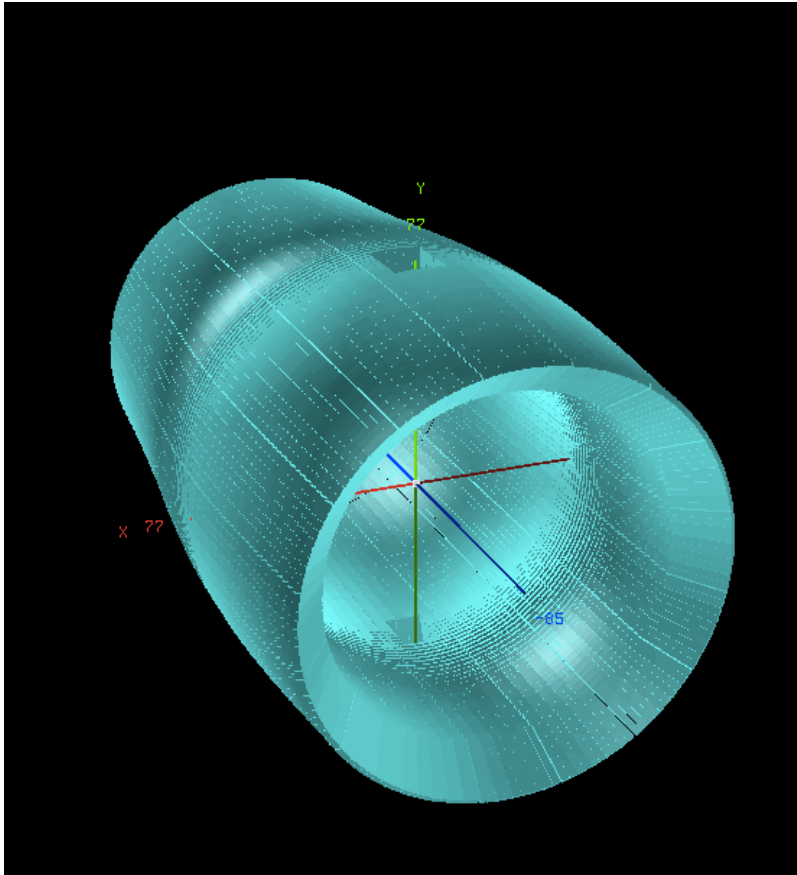
Circumferential parameters (II)



- ✓ Each 2 adjacent crystals form an alveole (5 alveoles for a slice)
- ✓ The positions of the alveoles are defined by the azimuthal angle Φ_i , the tilt angle θ_i and the inner radius of the barrel EMC
 - ✓ Φ_i : azimuthal angle w.r.t. the $(i-1)^{th}$ crystal pairs
 - ✓ θ_i : tilt angle w.r.t. the radial direction ($\sim 4\text{deg}$)
- ✓ Extract Φ_i s and θ_i s from the CAD
- ✓ Place the crystals one by one

	azimuthal: Φ_i (degree)	tilt: θ_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

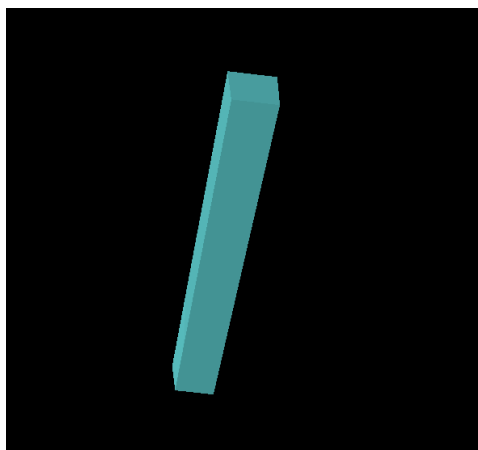
Constructing crystals in ROOT



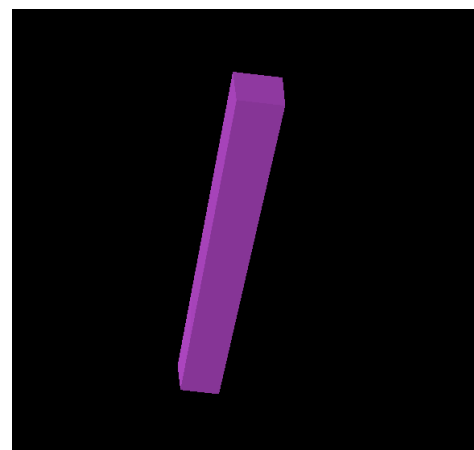
- ✓ Crystals:
 - ✓ Shape: TGeoTrap
 - ✓ Material: PbWO_4
- ✓ Modules:
 - ✓ Shape: TGeoVolumeAssembly
 - ✓ Made up of 4 (or 3)*10 crystals
- ✓ Super modules:
 - ✓ Shape: TGeoVolumeAssembly
 - ✓ Made up of up to 3 modules
- ✓ 16 slices
 - ✓ Shape: TGeoVolumeAssembly
 - ✓ Made up of 7 super modules
 - ✓ Slice 1/9: slice for target

Wrappings

Crystal w/o wrapping

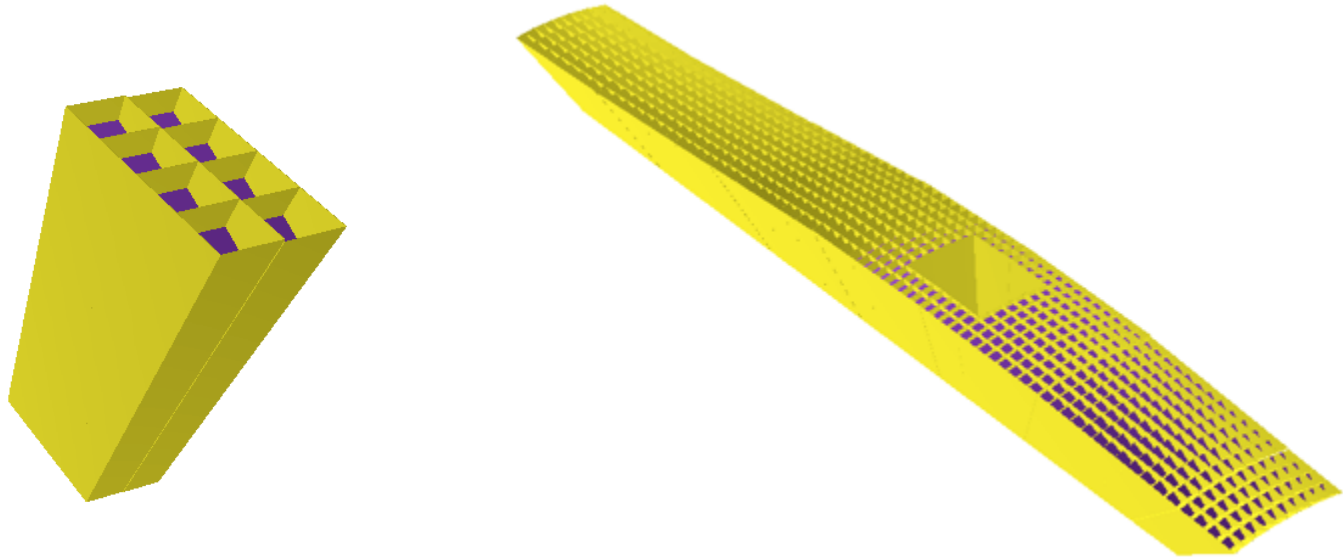


Crystal w/ wrapping



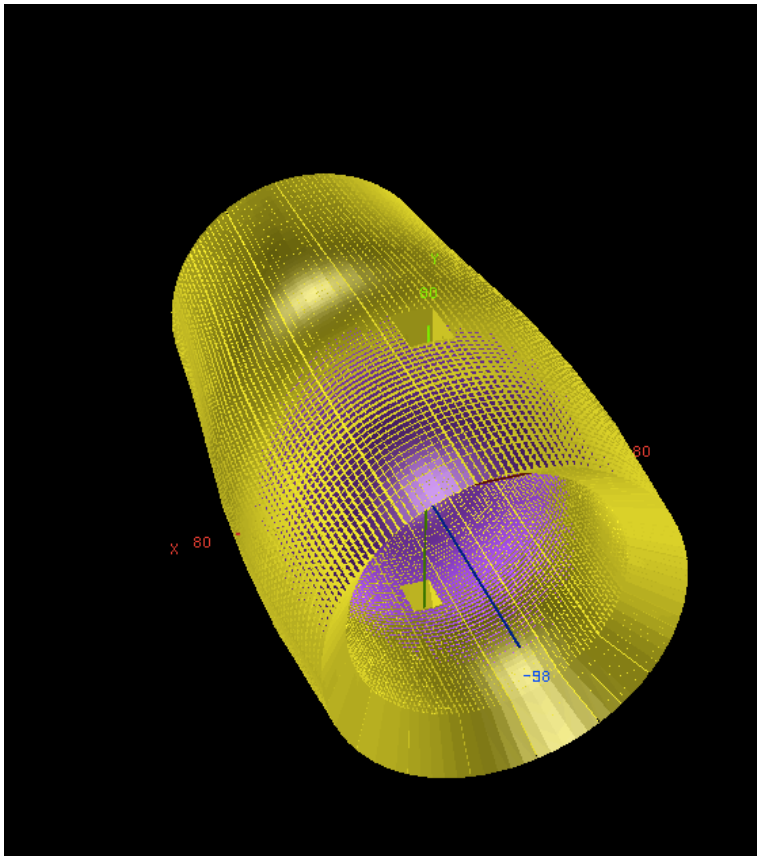
- ✓ Shape: TGeoTrap (outside the crystals)
- ✓ Material: Radiant Mirror Film ESR from 3M (VM2000)
 - ✓ Reflective material to
 - ✓ optimize light collection
 - ✓ reduce optical cross talk
- ✓ Thickness: 65 μm

Alveoles

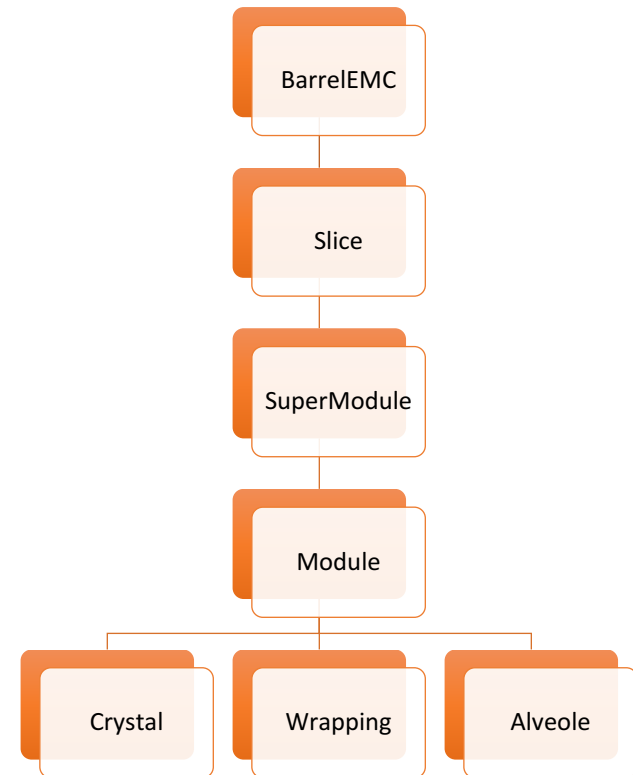


- ✓ Shape: TGeoTrap
- ✓ Material: Epoxy pre-impregnated carbon plain weave fabric
- ✓ Thickness: $200 \mu m$
- ✓ Gap to the crystal: $\sim 140 \mu m$

Putting everything together

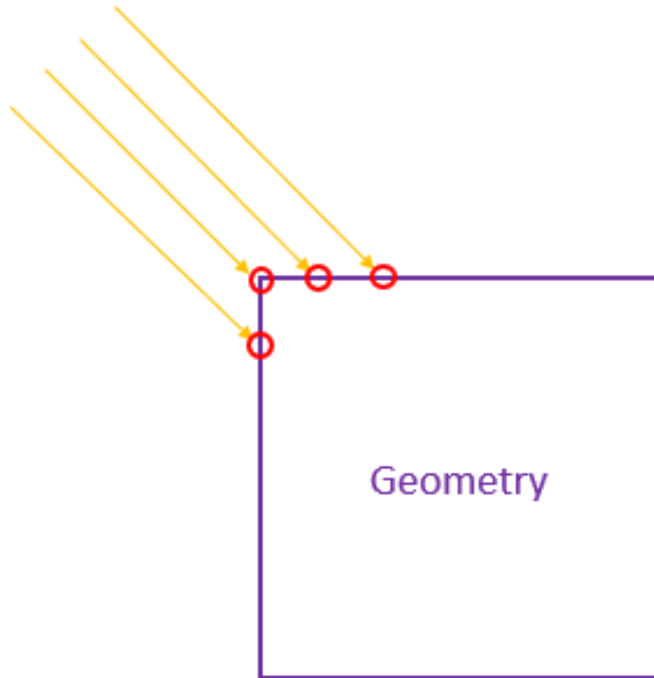


Volumes hierarchy



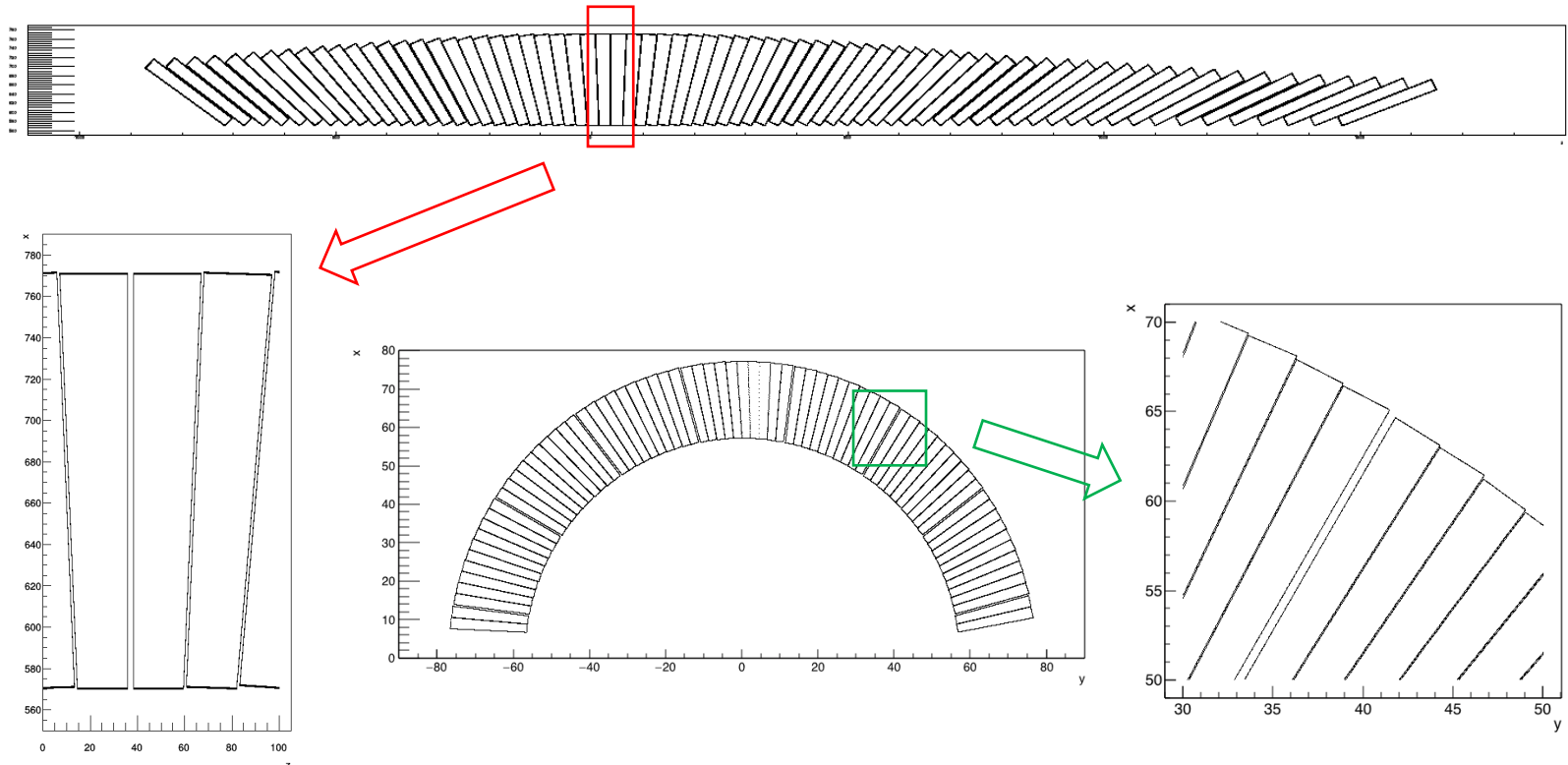
Modularized design - easy to plug-in and plug-out

Raytracing checks in ROOT



- ✓ 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													
		SM1		SM2		SM3		super modules			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											

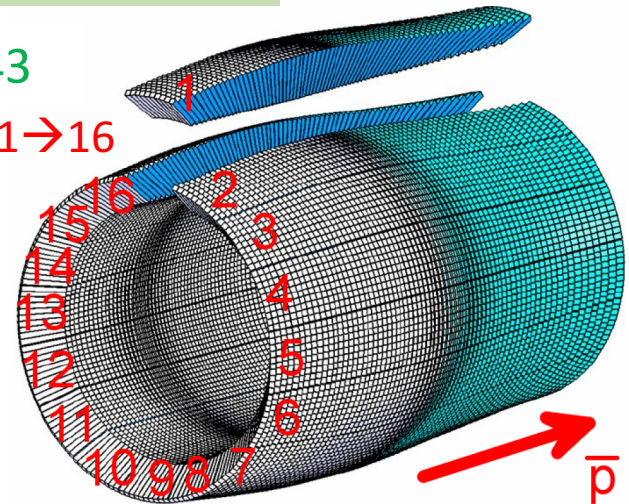
iCry: 10
↑
1

iRow: 28 ← 1

iRow: 1 → 43

iCopy: 1 → 16

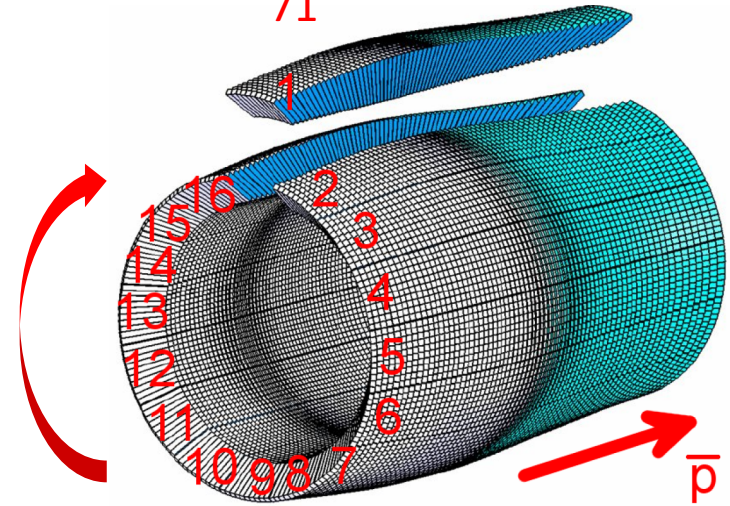
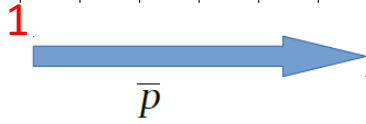
$$\text{detID} = \text{iMod} * 1\text{E}8 + \text{iRow} * 1\text{E}6 + \text{iCopy} * 1\text{E}4 + \text{iCry}$$



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

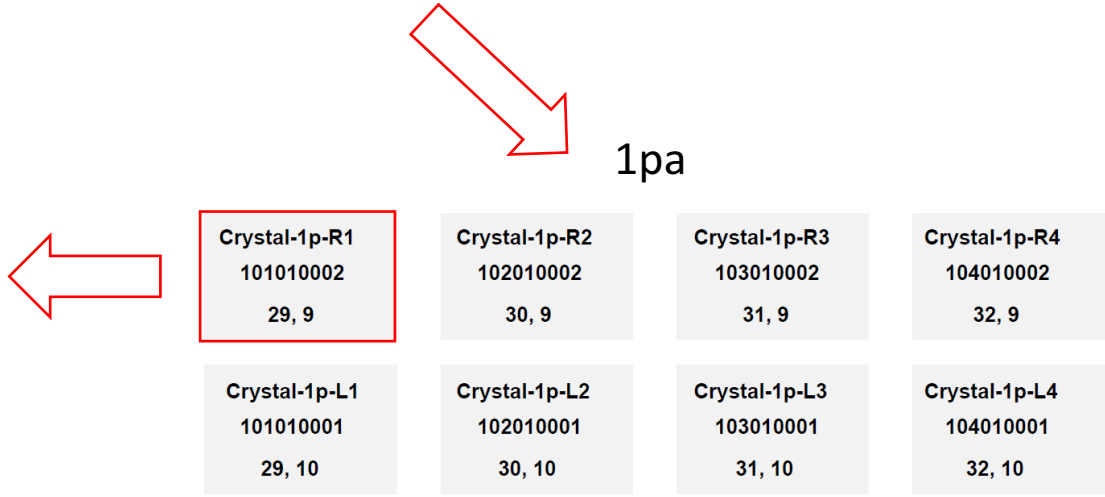
Crystal-1p-L1 101010001 29, 10	Crystal-1p-L2 102010001 30, 10	Crystal-1p-L3 103010001 31, 10	Crystal-1p-L4 104010001 32, 10	Crystal-1p-L1 101010002 29, 9	Crystal-1p-L2 102010002 30, 9	Crystal-1p-L3 103010002 31, 9	Crystal-1p-L4 104010002 32, 9	Crystal-1p-R1 101010002 29, 9	Crystal-1p-R2 102010002 30,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

DetID: 101010002

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

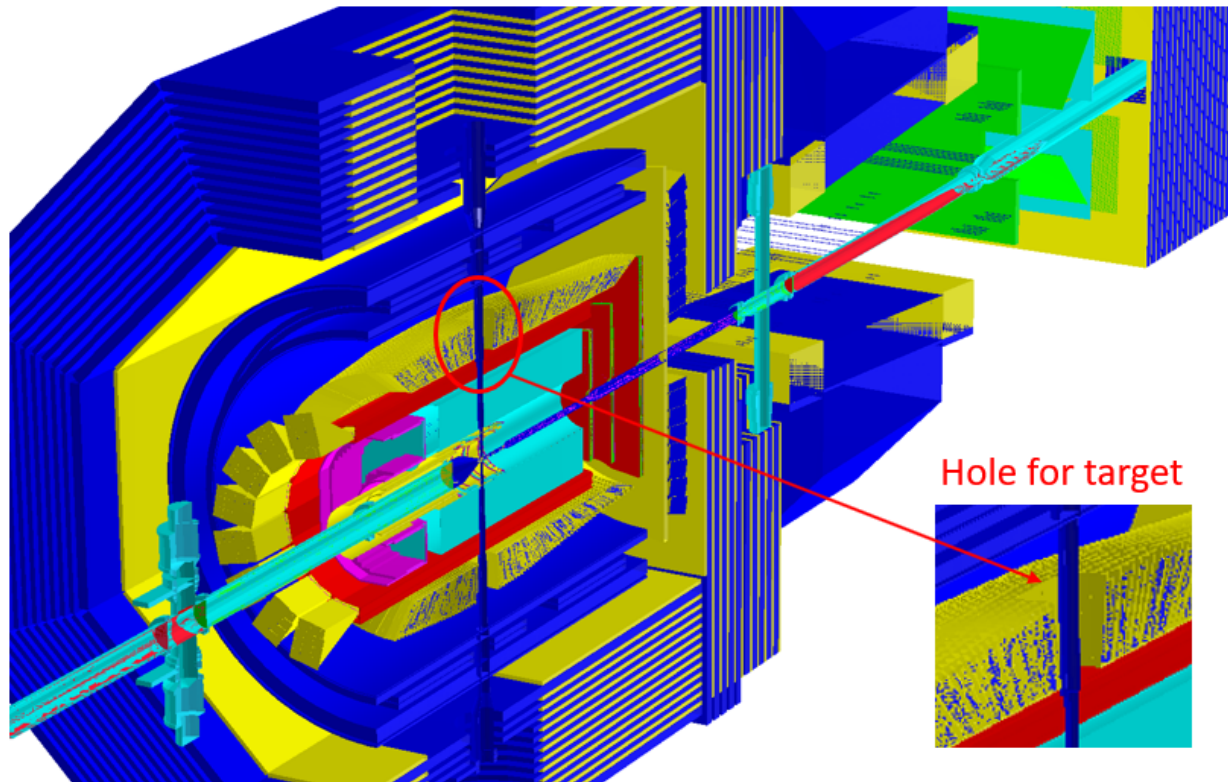
Two coordinate index

- ✓ iTheta = 29
- ✓ iPhi = 9



The detID to tci maps are correctly generated in pandaroot

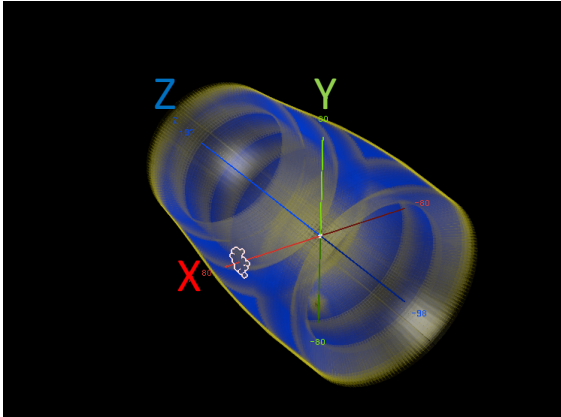
The new barrel geometry in pandaroot



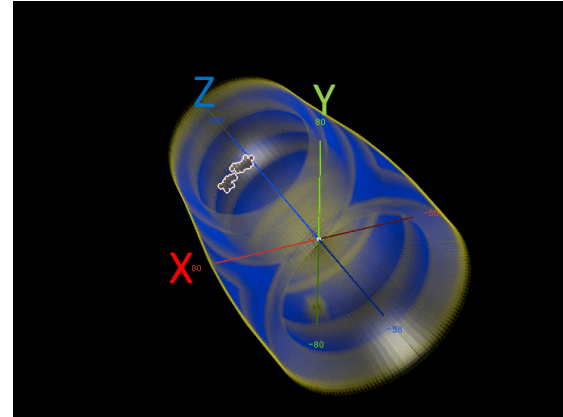
Cluster reconstruction tests

Single photon @ 2 GeV

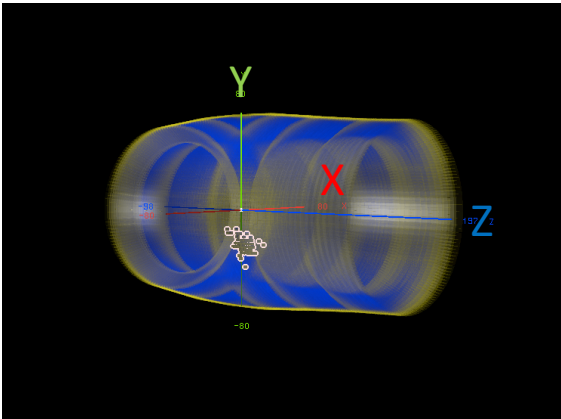
$\theta = 90^\circ, \phi = 0^\circ$



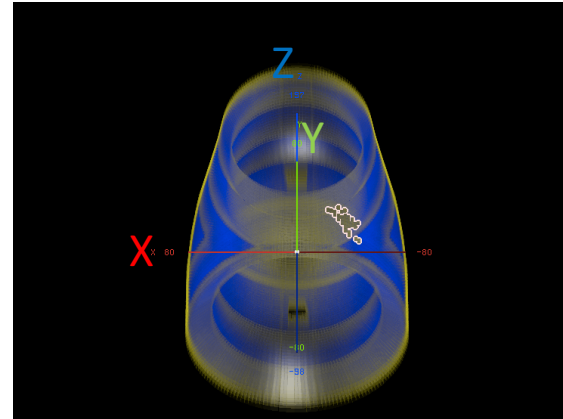
$\theta = 60^\circ, \phi = 45^\circ$



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



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



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**