# Updated Barrel EMC Geometry

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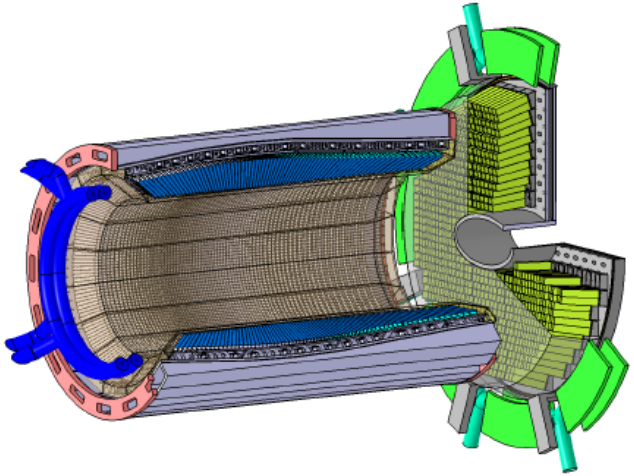


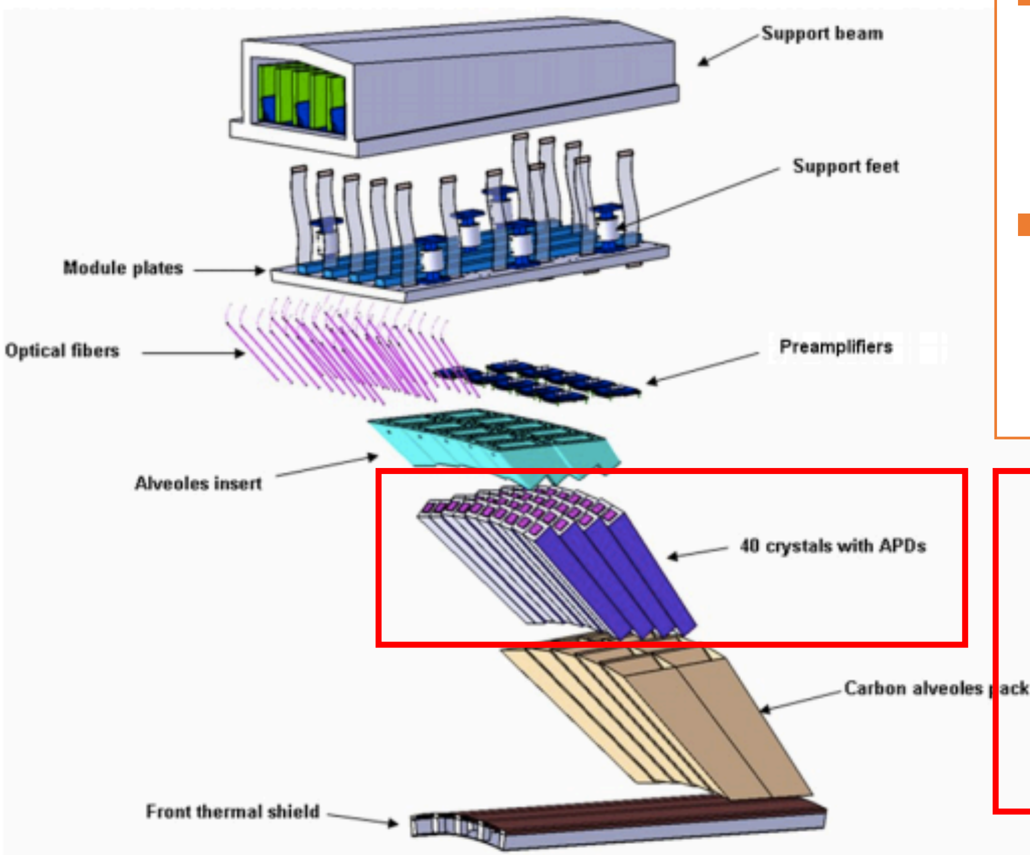
PANDA Collaboration Meeting 18/2
Jun 5th, 2018

Institute of High Energy Physics
Chinese Academy of Sciences

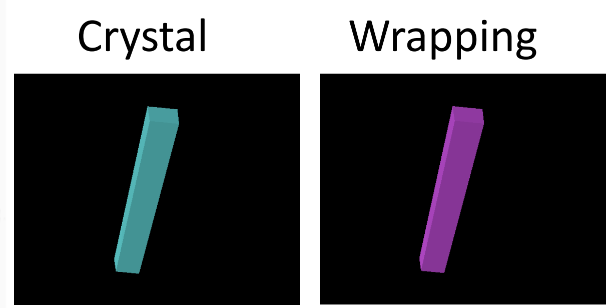
# Outline

- **Geometry description updates**
  - Crystal’s front end material updates
- **Some reconstruction checks**
  - Position/energy distributions for photons and charged particles

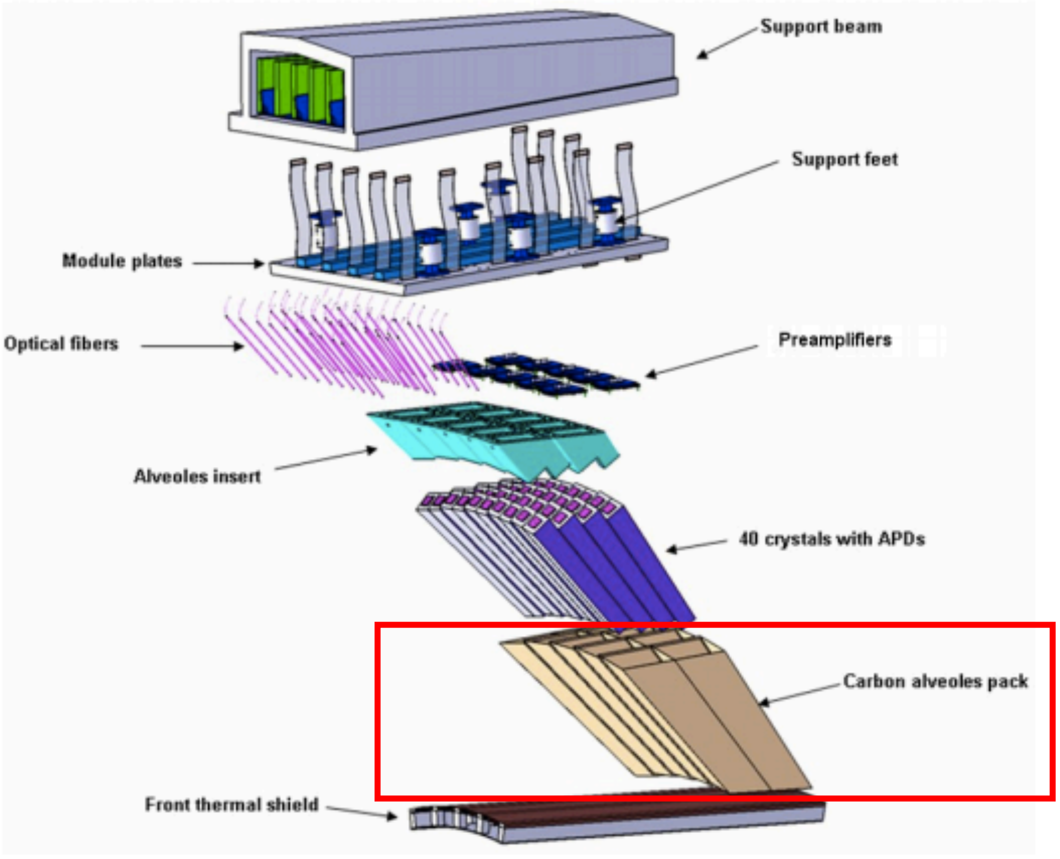
# Geometry updates



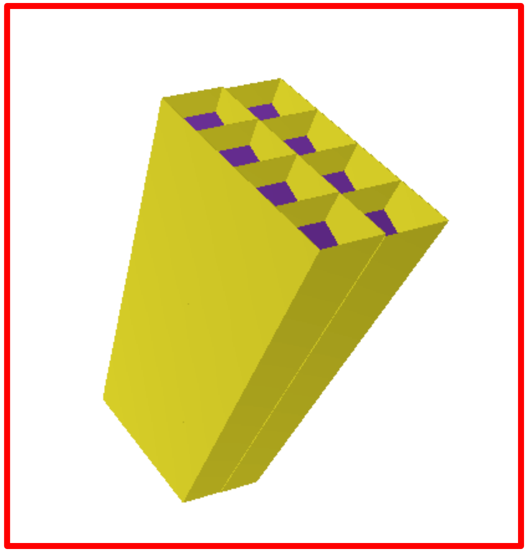

- The geometry updates were based on an old version of geometry in 2009 (only crystals).
- Until the last collaboration meeting, we have:
  - updated all crystals
  - newly added wrappings



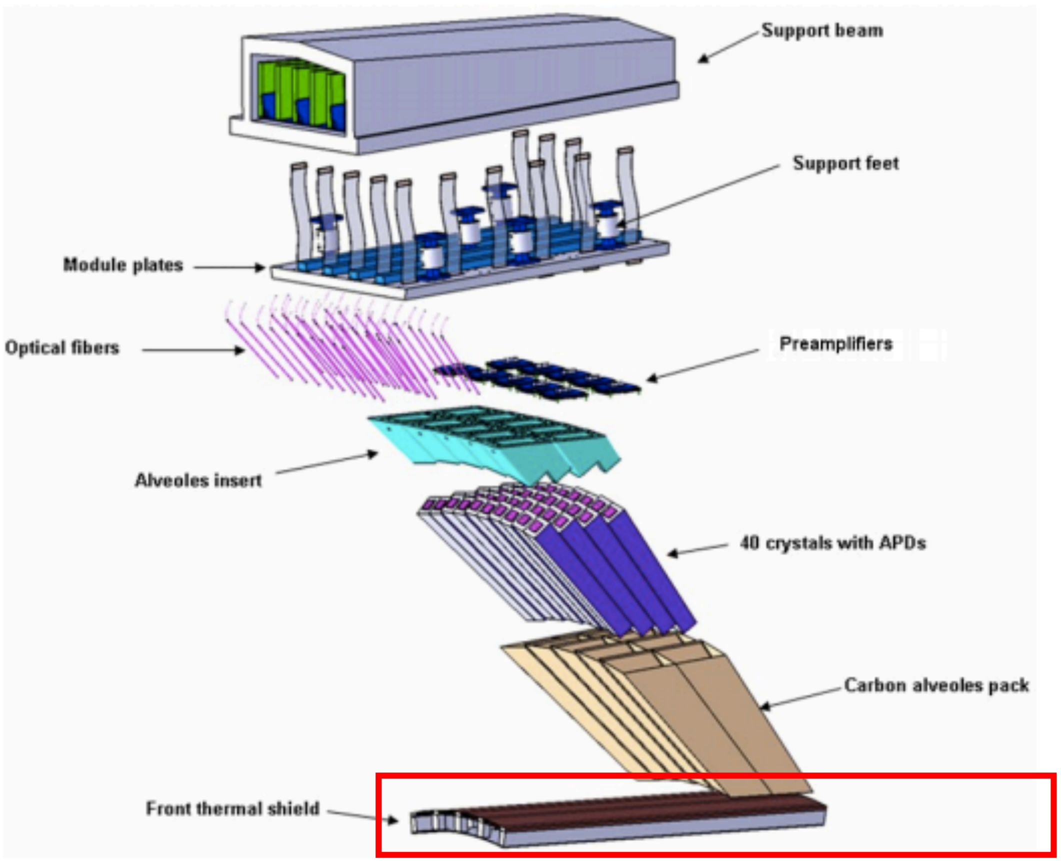
# Geometry updates




- We also have added:
  - Carbon alveoles

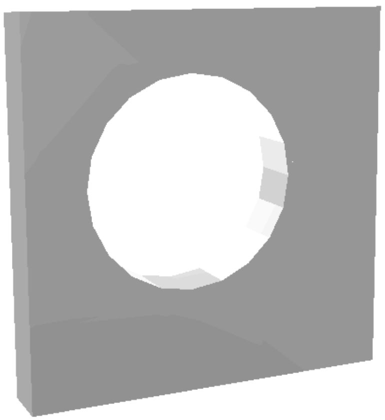


# Geometry updates

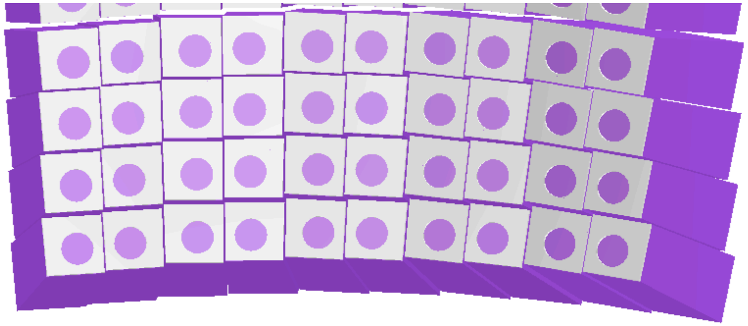


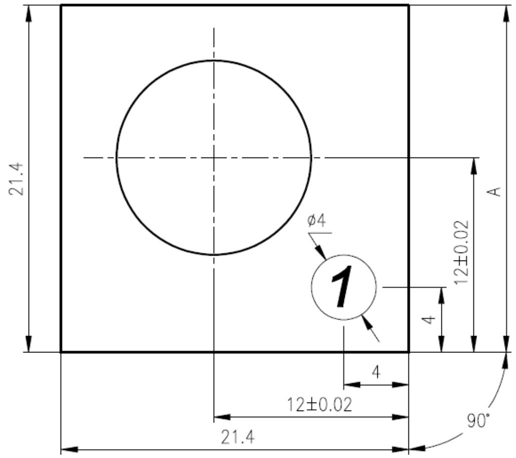

- In this work, we continue the geometry implementation for the front end materials, including:
  - Front insert
  - Temperature insulation
  - Aluminum plate

# Front insert



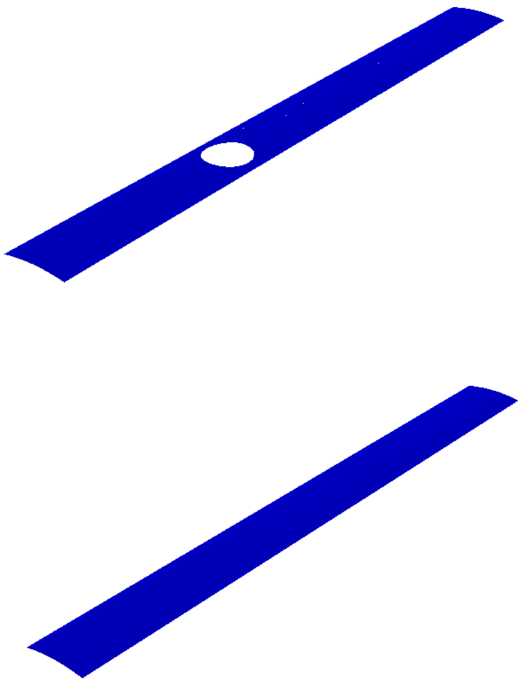
Front inserts are placed in front of the crystals





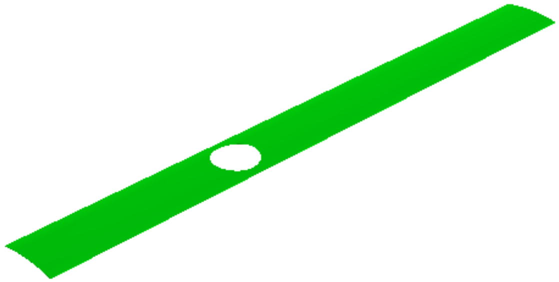

- ✓ Shape:
  - ✓ Cuboid with a hole
  - ✓ ~3 mm thickness in average
- ✓ Material: ABS plastic
  - ✓ Elements: C, H, N (molecule – 15:17:1)
  - ✓ Density: 1.07 g/cm$^3$

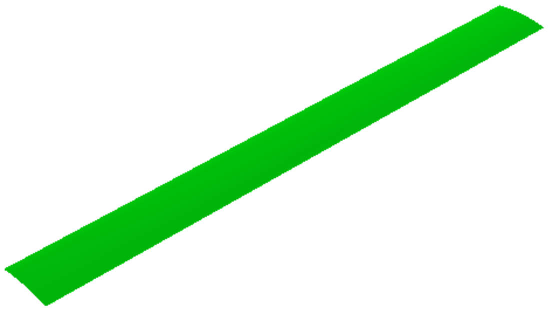
# Temperature insulation



- ✓ Shape:
  - ✓ Tube segment
  - ✓ Thickness: 1 mm
- ✓ Material: vakuVIP Heat 360 (Polyurethane)
  - ✓ Elements: C, H, N, O (molecule – 25: 42: 2 : 6)
  - ✓ Density: 0.225 $g/cm^3$

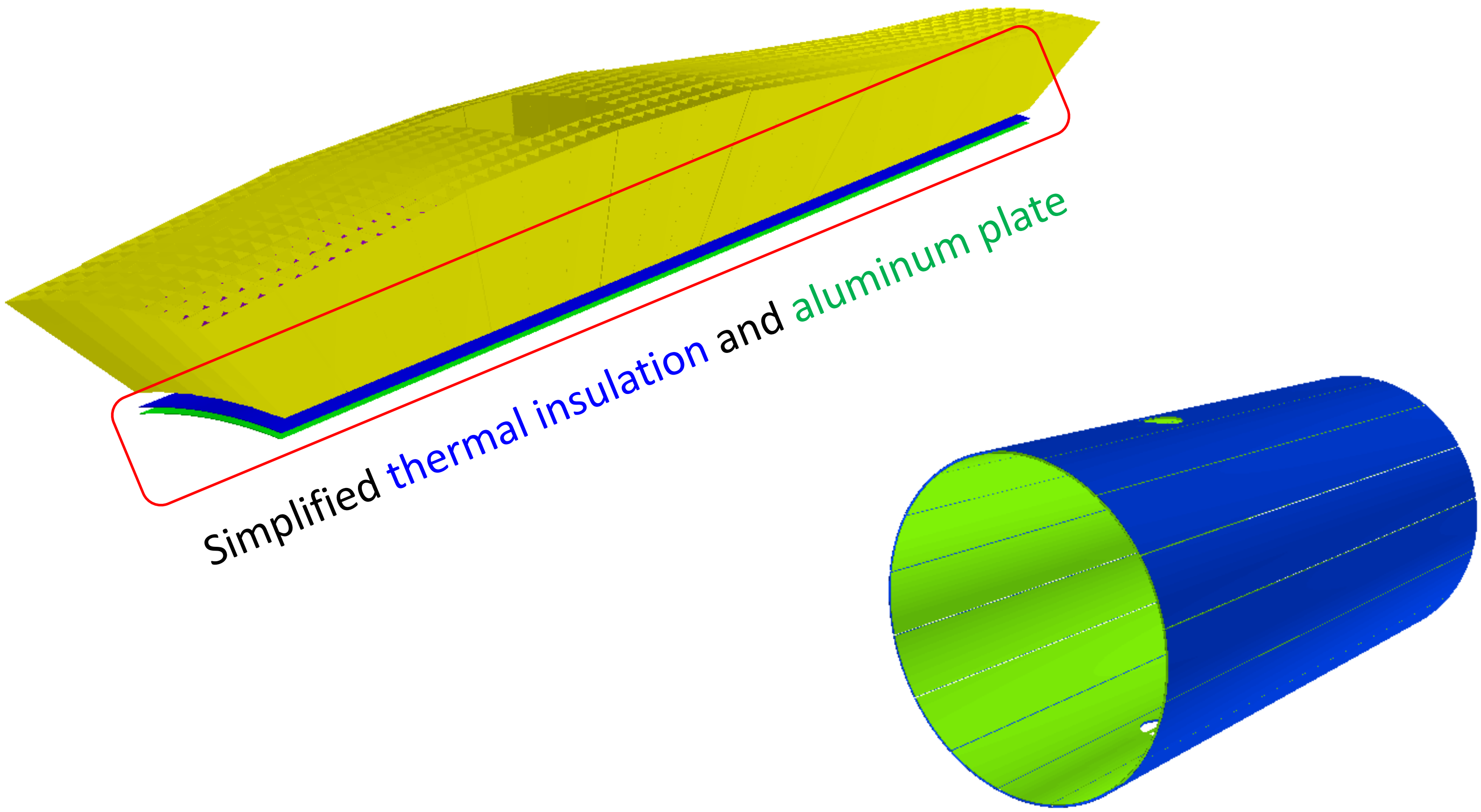
# Aluminum plate



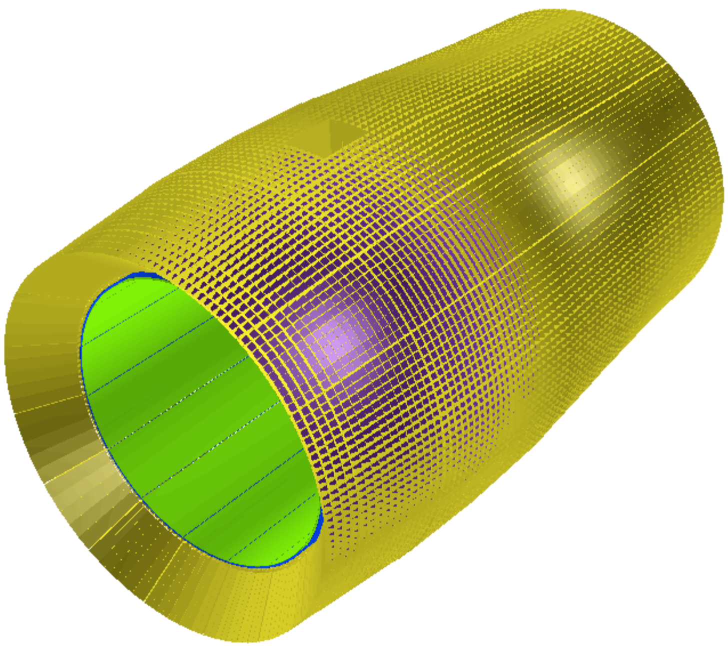


- ✓ Shape:
  - ✓ Tube segment
  - ✓ Thickness: 1 mm
- ✓ Material:
  - ✓ Element: aluminum
  - ✓ Density: 2.7 g/$cm^3$

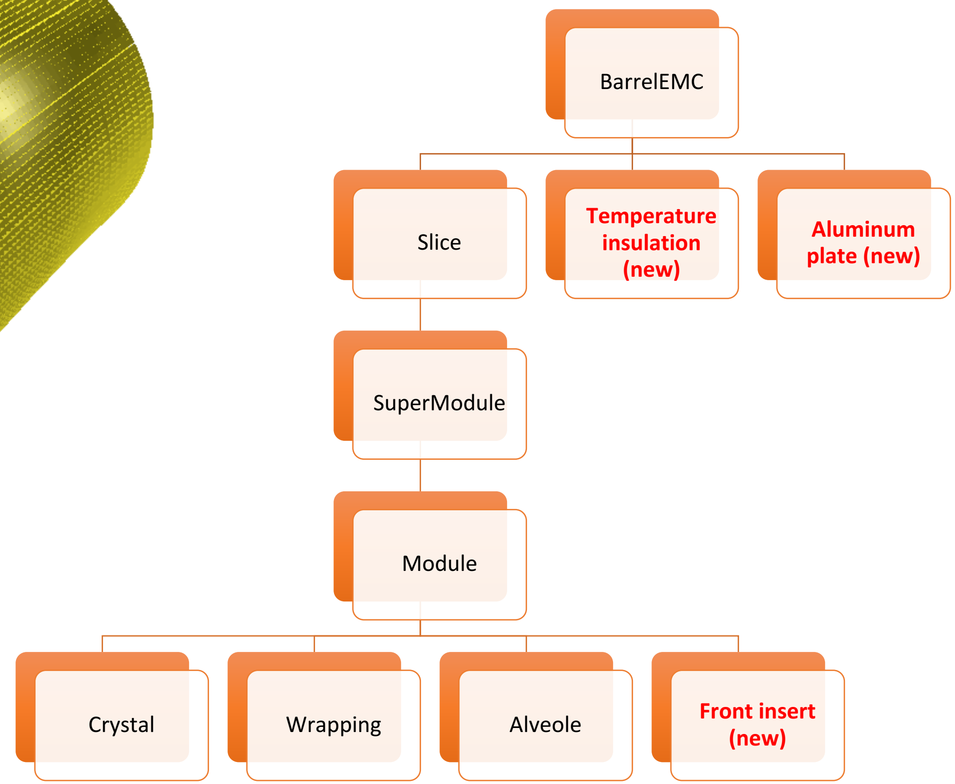
# Simplified vacuum insulation panel



# The updated geometry



Volumes hierarchy



# Material summary

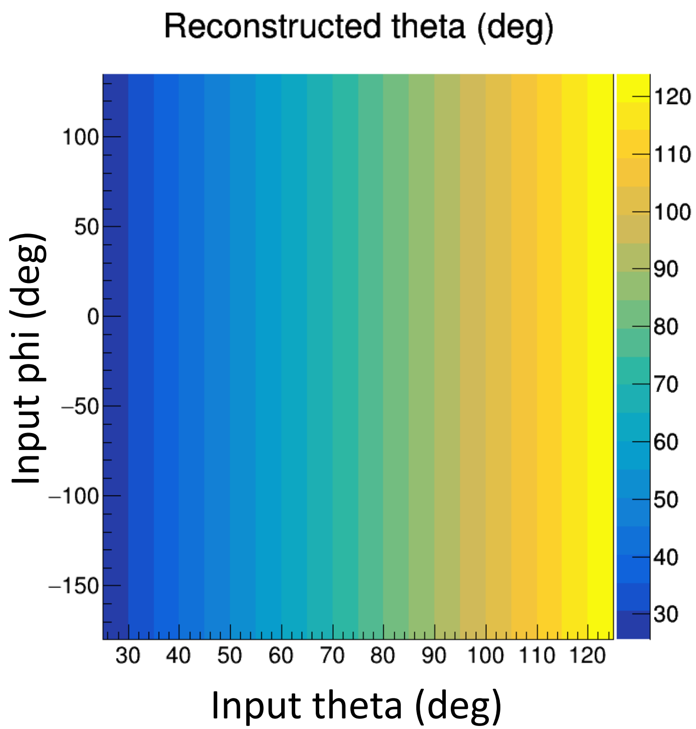
| Part | Material | Elements | Density ($g/cm^3$) |
|---|---|---|---|
| Crystal | PWO | Pb, W, O (molecule - 1:1:4) | 8.29 |
| Wrapping (new) | VM2000 | C, H (molecule - 2:4) | 0.9 |
| Alveole | Prepreg | C, H, Cl, O (frac. mass - 0.846:0.088:0.028:0.038) | 1.8 |
| Front insert (new) | ABS | C, H, N (molecule - 15:17:1) | 1.07 |
| Temperature insulation (new) | Polyurethane | C, H, N, O (molecule - 25: 42: 2 : 6) | 0.225 |
| Aluminum plate | Aluminum | Al | 2.7 |

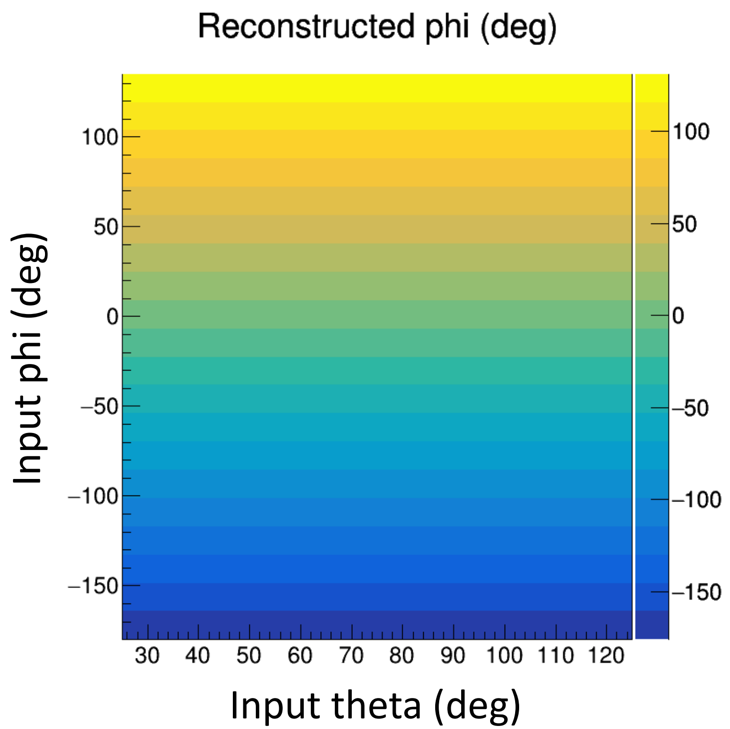
# Code update summary

- 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()
- Codes are ready to check into the pandaroot

# Check I – Photon position

- Generate 1 GeV photon with different input $\theta$s and $\phi$s, check the reconstructed directions.
- The plots show consistent input/output, which means the crystals' indices are correctly put in simulation



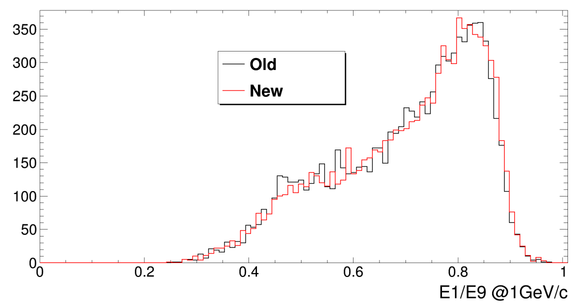



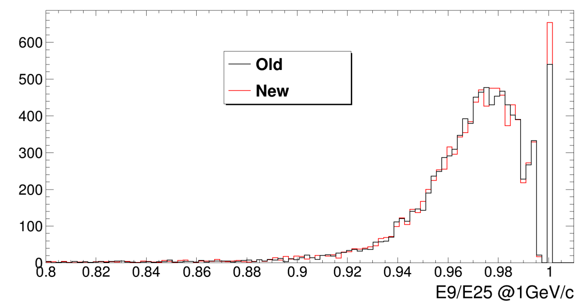
# Check II – Photon energy/moment

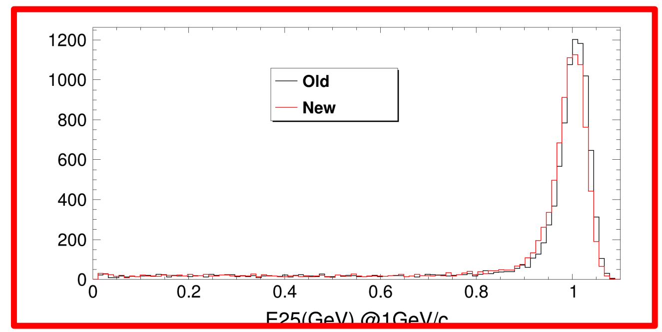
- **Some variables**
  - E1, E9, E25:
    - the energy deposited in the central crystal, the 3*3 crystal array, 5*5 crystal array containing the central crystal and the first innermost ring
  - Lateral moment:
    - $\frac{\Sigma_{i=3}^{n} E_i r_i^2}{\Sigma_{i=3}^{n} E_i r_i^2 + E_1 r_0^2 + E_2 r_0^2}$,
    - where n is the number of crystals associated to the shower, $E_i$ is the deposited energy in the i-th crystal with $E_1 \geq E_2 \geq \cdots \geq E_n$, $r_i$ is the lateral distance between the central and the i-th crystal, and $r_0$ is the average distance between two crystals.
  - Zernike moments $Z_{20}$, $Z_{53}$:
    - A set of Zernike moments which describe the energy distribution within a cluster by radial and angular dependent polynomials

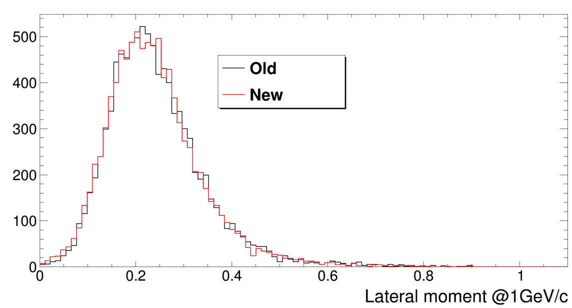
# Check II – Photon energy/moment

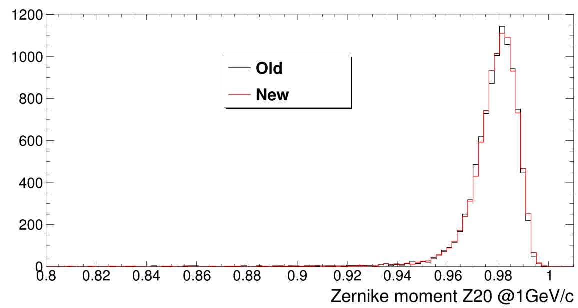
- ✓ Compare energy/moment distributions between the new and old geometries for 1 GeV photon
- ✓ Most distributions are similar, except for the E25. Mean value of E25 in the new geometry is slightly smaller than the old one. This is reasonable as in the new geometry more materials are imposed.

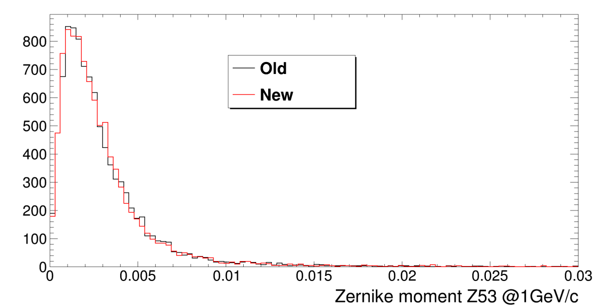


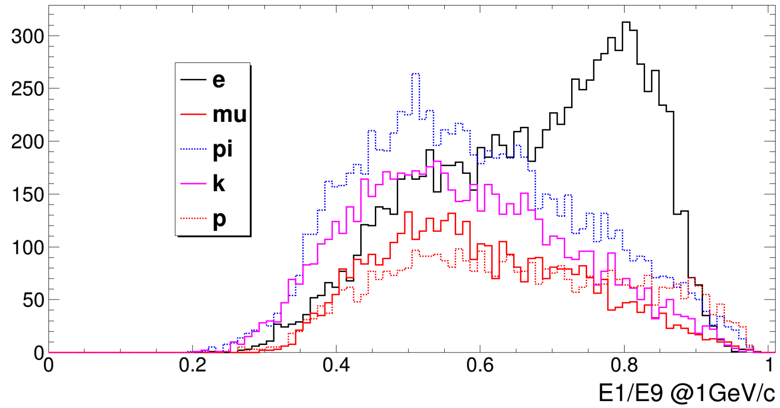



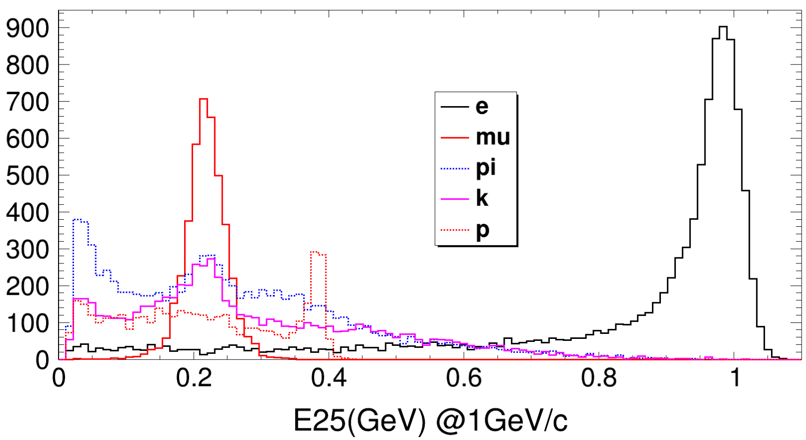



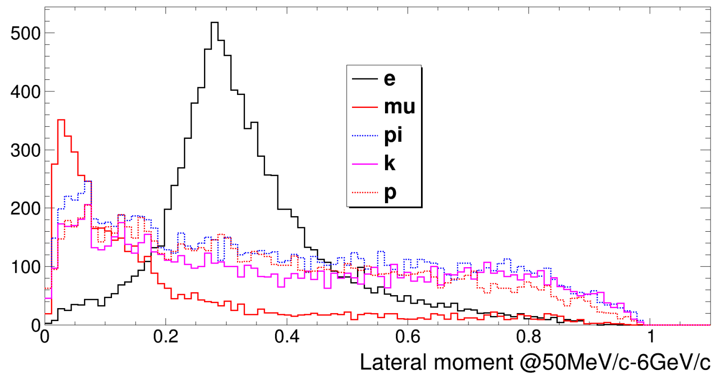
# Check III – Charged particles



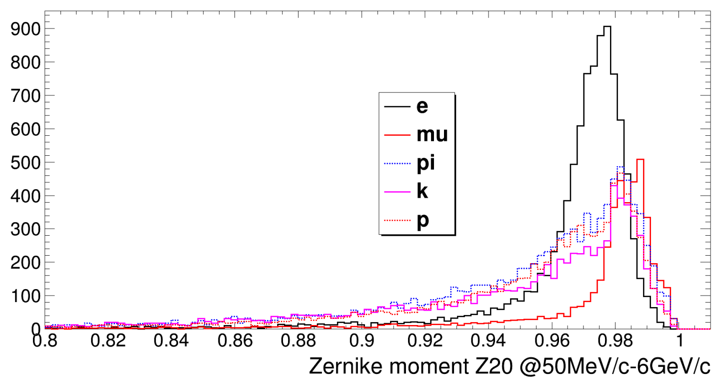



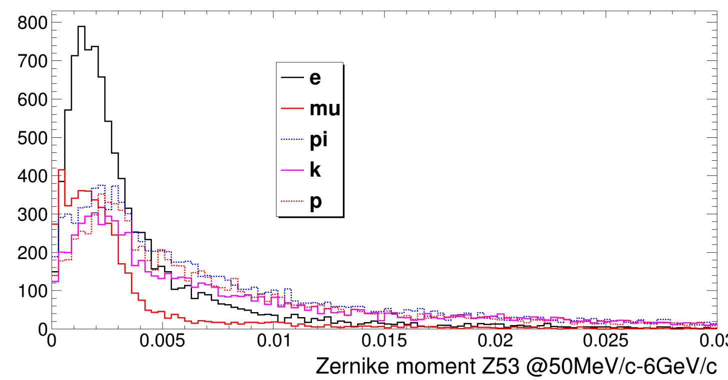

- ✓ Besides photon detection, EMC is also a powerful detector for electron identification.
- ✓ Generate e/mu/pi/K/p @ 1 GeV
- ✓ If we look at E25, for example, electrons can be well separated to other particles.

# Check III – Charged particles

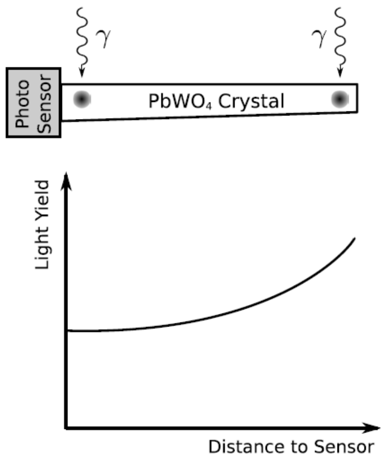



- ✓ Generate e/mu/pi/K/p within the momentum range of 0.05 – 6 GeV
- ✓ All distributions are reasonable



# Non-uniformity of light collection




For tapered parallelepipedal crystals, light yield at the rear end sensor distributed non-uniform due to the interplay of absorption and focusing effect.

From Bremer Daniel's thesis

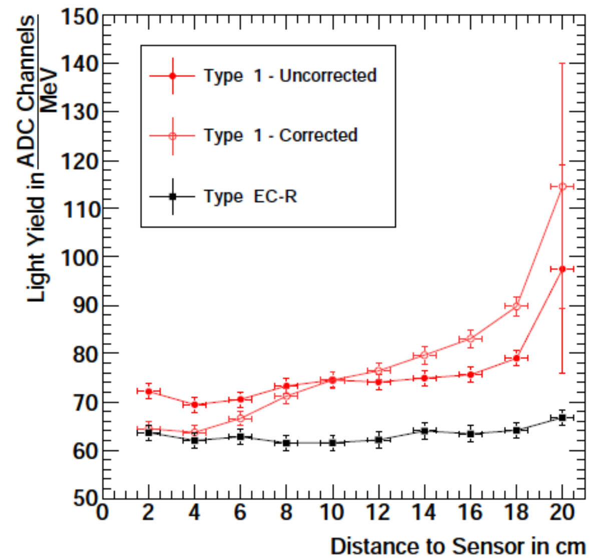
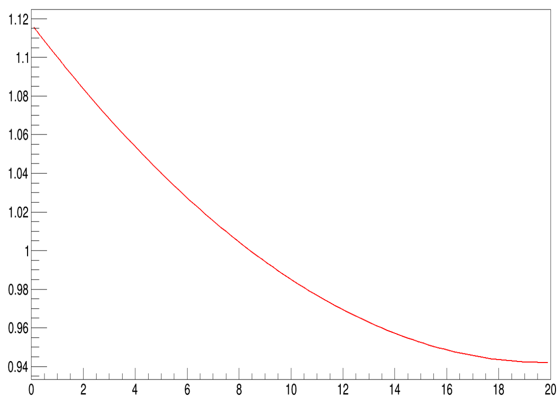



Figure 2.33: Position dependent response to minimum ionising cosmic muons at $-25\,^{\circ}$C for PWO-II crystals in type 1 and EC-R geometry. For the tapered shape, additionally the LY corrected for the most probable MIP energy deposition (see Tab. 1.3) for the corresponding pathlength $e(z)$ is shown.

# Non-uniformity of light collection (II)

Non-uniform function

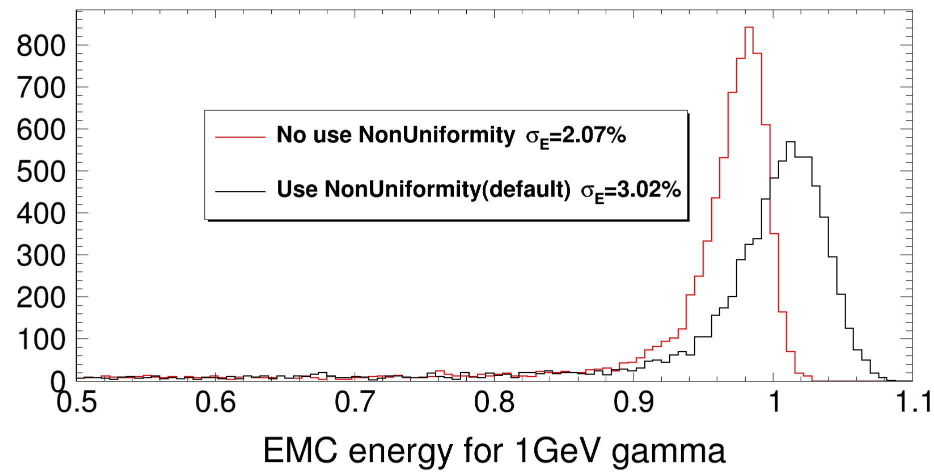



Distance to front end (cm)

Non-uniform function in pandaroot for a typical crystal:

$1.117356 + x\times(-0.01767657 + 4.456127\times10^{-4}x)$

- ✓ By enabling the non-uniformity correction, the reconstructed energy becomes larger
- ✓ Need to further study the reconstruction/calibration



# Summary

- Have Updated the front end geometries and materials for the barrel EMC
- The code is ready to check into the pandaroot
- Have looked at some of the position/energy distributions with the updated geometry. More detailed checks/studies will be done.
- To-do: Update the rear end materials. More information and suggestions are appreciated.

# Backup

The neural network inputs are the EMC cluster energy and the following six shower-shape variables:

- The lateral moment LAT of the shower energy deposition [14] defined as LAT $= \sum_{i=3}^{n} E_i r_i^2 / (E_1 r_0^2 + E_2 r_0^2 + \sum_{i=3}^{n} E_i r_i^2)$ where the $n$ crystals in the EMC cluster are ranked in order of deposited energy ($E_i$) , $r_0 = 5$ cm is the average distance between crystal centers, and $r_i$ is the radial distance of crystal $i$ from the cluster center.
- The second radial moment of the shower energy deposition, defined as $\sum_i E_i r_i^2$ where $r_i$ is the radial distance of crystal $i$ from the cluster center.
- The energy sum of a $3 \times 3$ block of crystals, centered on the single crystal with the most energy, divided by the larger $5 \times 5$ block, also centered in the same way.
- The energy of the most energetic crystal in the cluster divided by the energy sum of the $3 \times 3$ crystal block with the most energetic crystal in the center.
- The Zernike moments [15] $A_{2,0}$ and $A_{4,2}$ defined below.

The Zernike moment $A_{n,m}$ is defined as

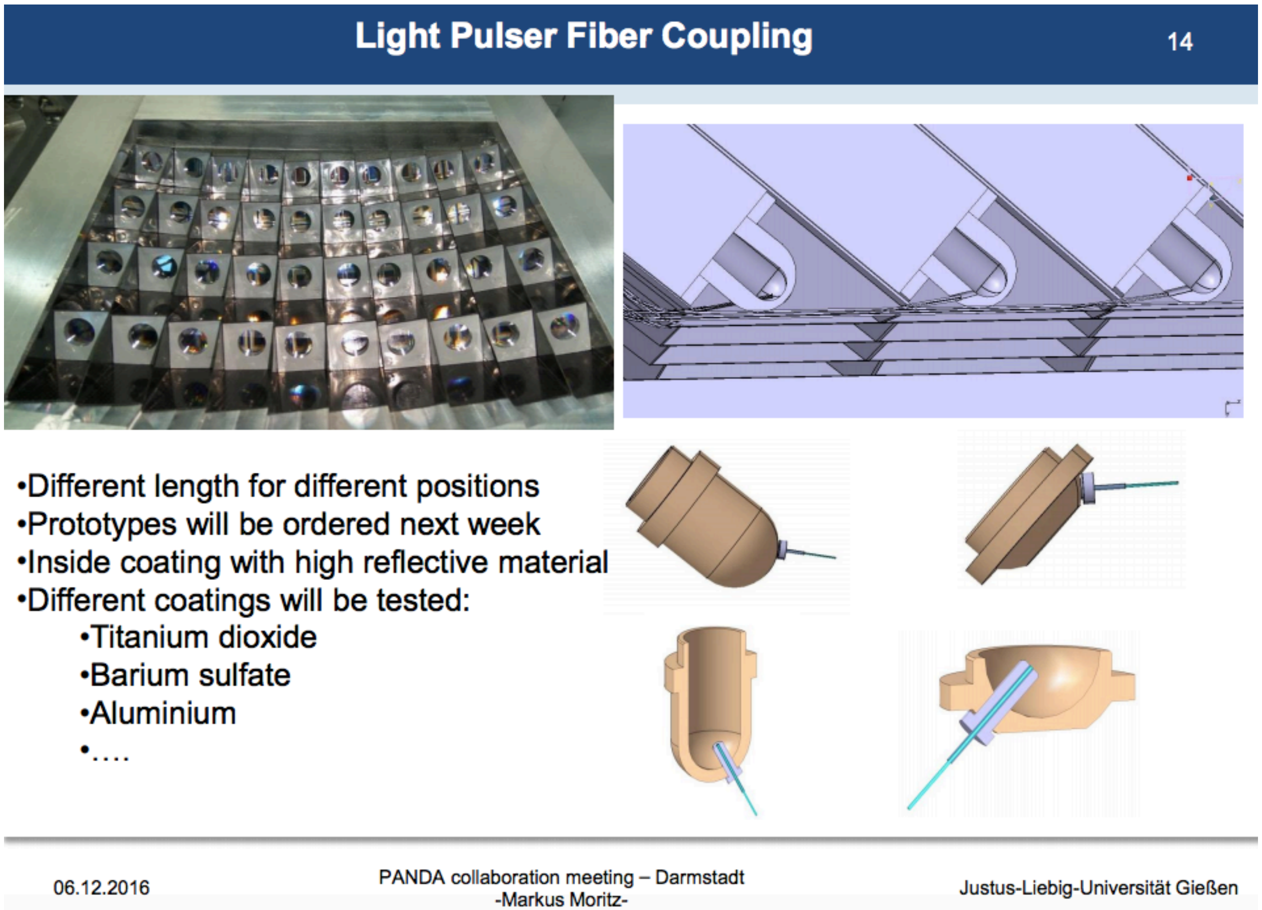
$$A_{n,m} = \left| \sum_i \frac{E_i}{E_{\text{tot}}} f_{n,m}(r_i/R_0)\, e^{im\phi_i} \right|$$

with

$$f_{2,0}(x) = 2x^2 - 1 \qquad \text{and} \qquad f_{4,2}(x) = 4x^4 - 3x^2$$

where $r_i$ and $\phi_i$ are the radial and angular separation of crystal $i$ with respect to the cluster center, $E_{\text{tot}}$ is the total cluster energy, and $R_0$ is a cutoff radius of 15 cm.

# Backup


Light Pulser Fiber Coupling
14
•Different length for different positions
•Prototypes will be ordered next week
•Inside coating with high reflective material
•Different coatings will be tested:
•Titanium dioxide
•Barium sulfate
•Aluminium
•….
06.12.2016
PANDA collaboration meeting – Darmstadt
-Markus Moritz-
Justus-Liebig-Universität Gießen