

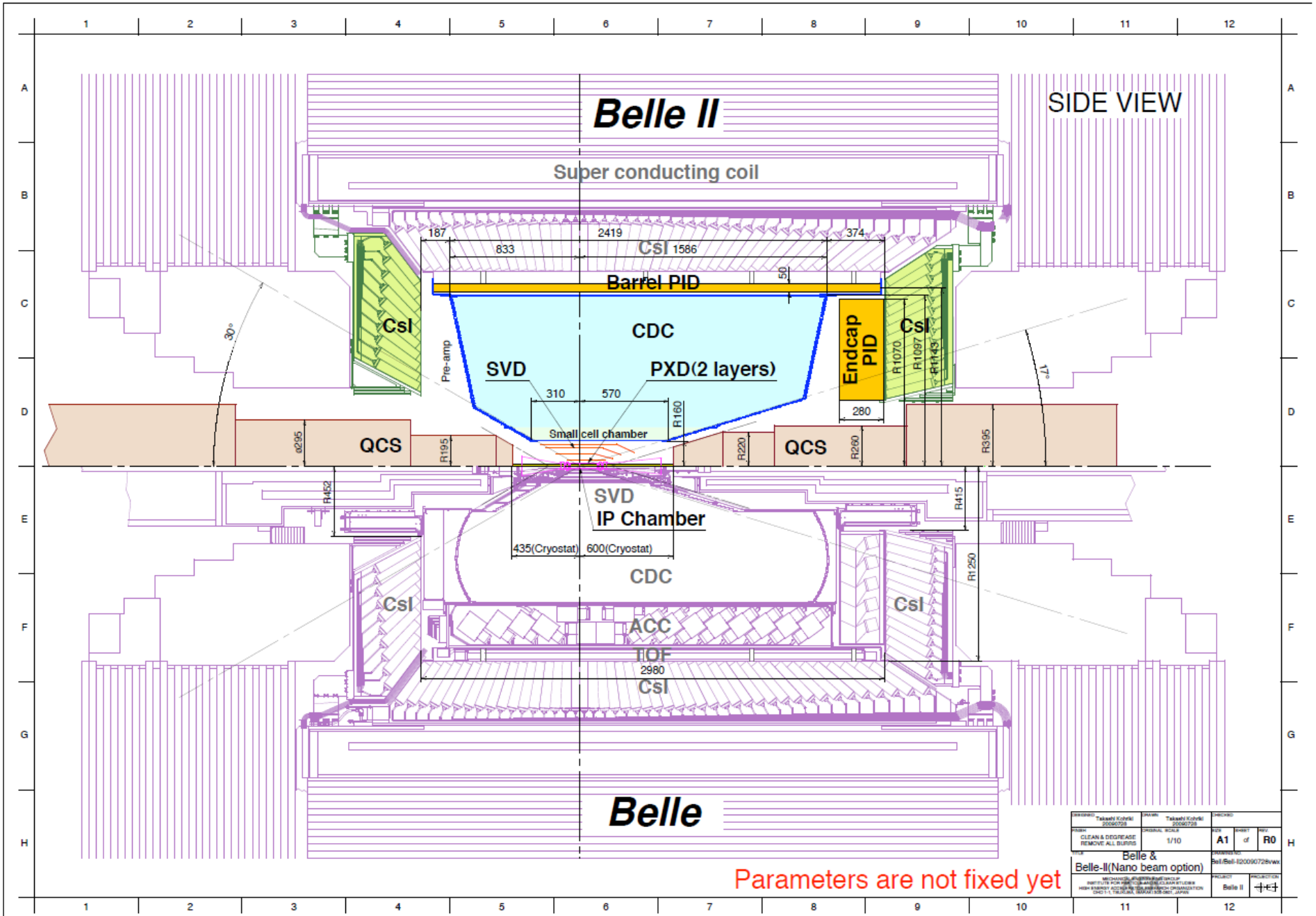
The BELLE II ARICH detector

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BELLE II detector



ARICH detector located in forward endcap (PID)

Target performance : K/pi separation at $> 4\sigma$ C.L. @ $0.5 < p < 4$ GeV/c.

ARICH

Detailed description of the detector :

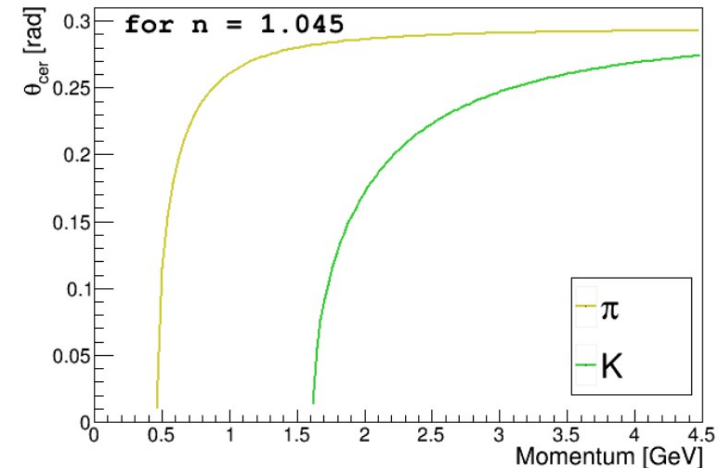
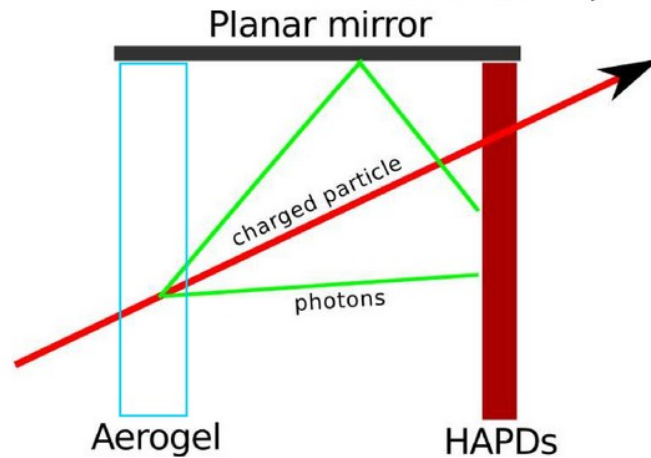
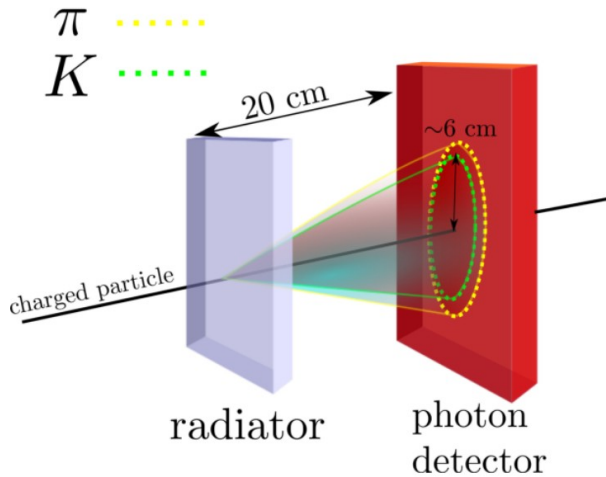
<https://confluence.desy.de/pages/viewpage.action?spaceKey=BI&title=ARICH+NutShell>

Need to have DDESY Belle2 account

- ➔ Proximity-Focusing **R**ing **I**maging **C**herenkov counter using Aerogel
- ➔ Particle mass is identified according to emission angle in aerogel radiator

$$m = \frac{p}{c} \sqrt{n^2 \cos^2 \theta_c - 1}$$

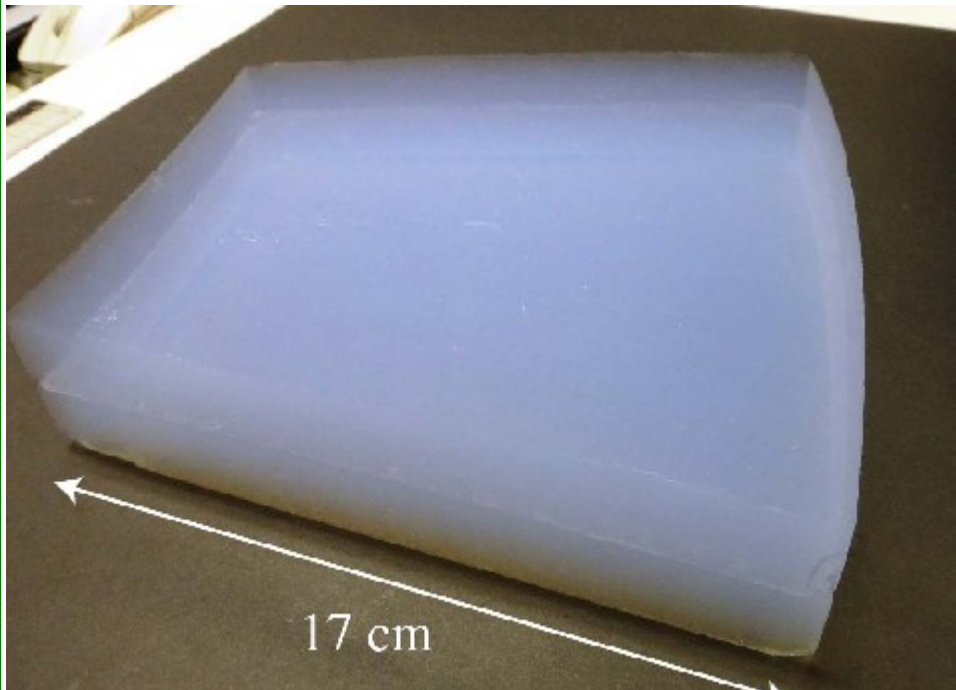
Particle mass ← m ← Particle Cherenkov angle θ_c ← Aerogel refractive index n



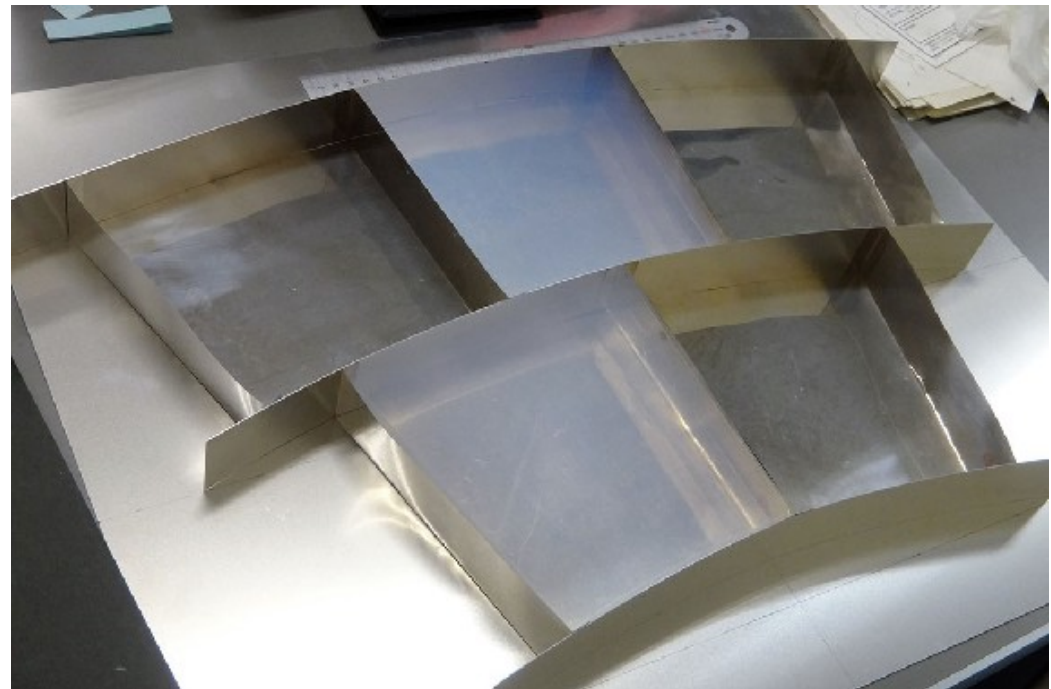
Silica Aerogel radiator

- ➔ As a radiator a silica aerogel is used. Aerogel is an amorphous, highly porous solid of fused silica (silicon dioxide – SiO_2). Refractive index can be adjusted.
- ➔ The size of the porous is smaller than $0.1 \mu\text{m}$ - this explain the bluish color due to Rayleigh scattering.
- ➔ For ARICH use two different Refractive indexes $n_1 = 1.045$ and $n_2 = 1.055$ for focusing purpose.
- ➔ Thickness of one layer is 20 mm (40 mm) in total.
- ➔ Light transmission length is 45 mm for first layer and 35 mm for second one.

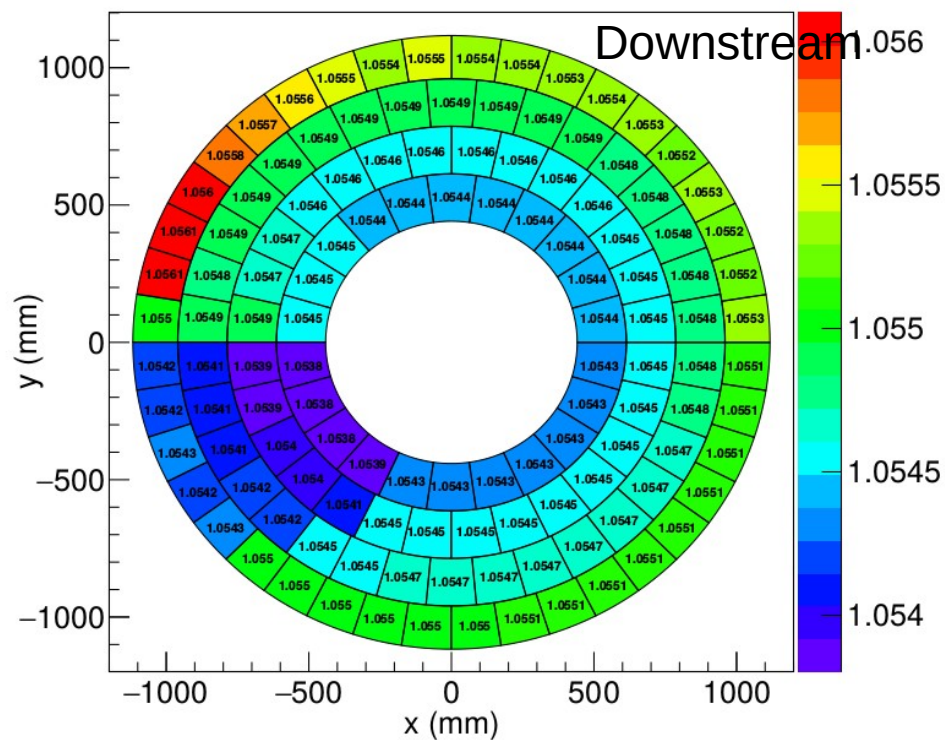
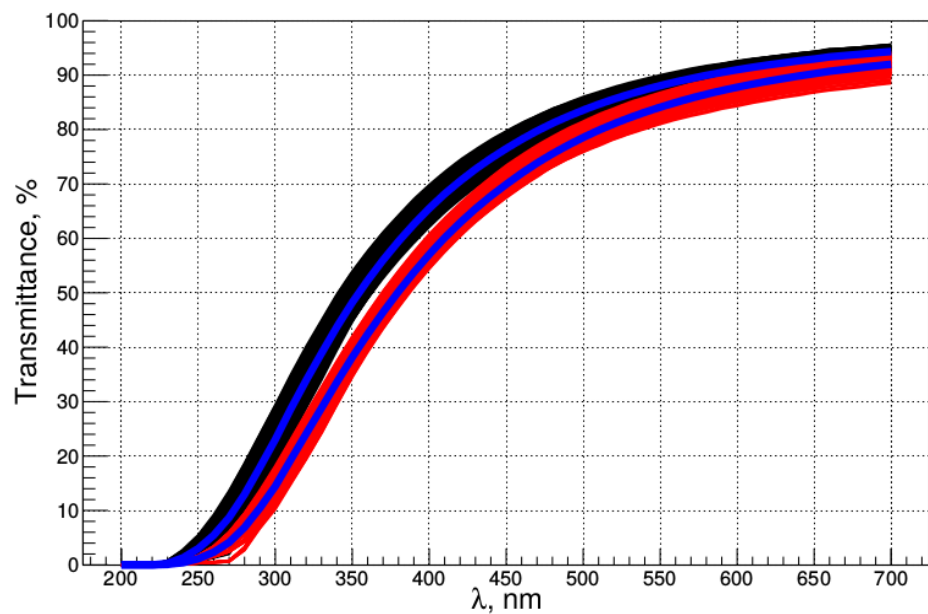
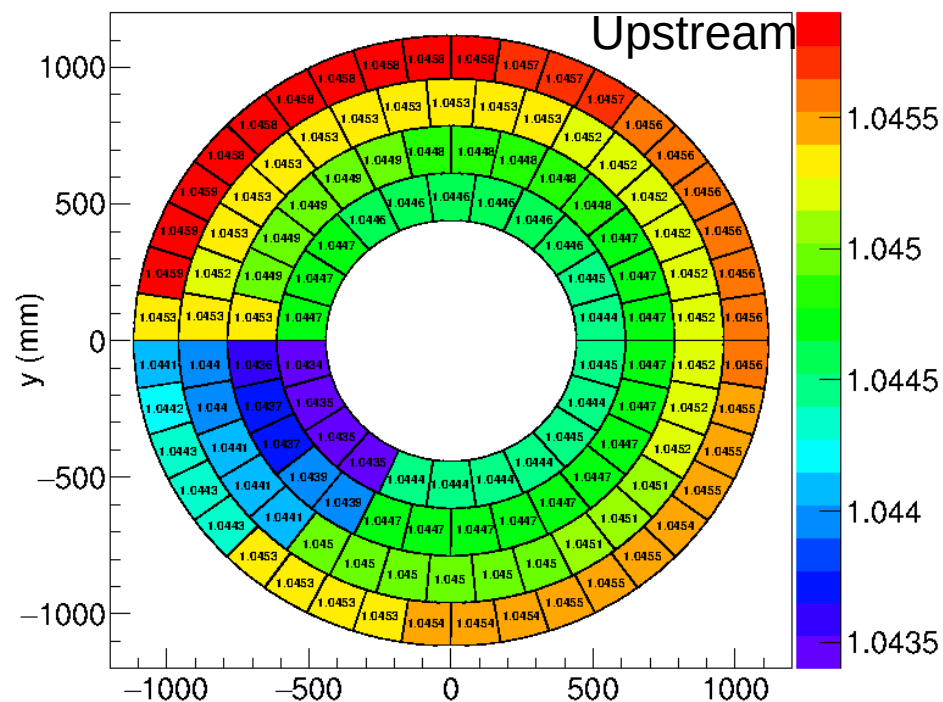
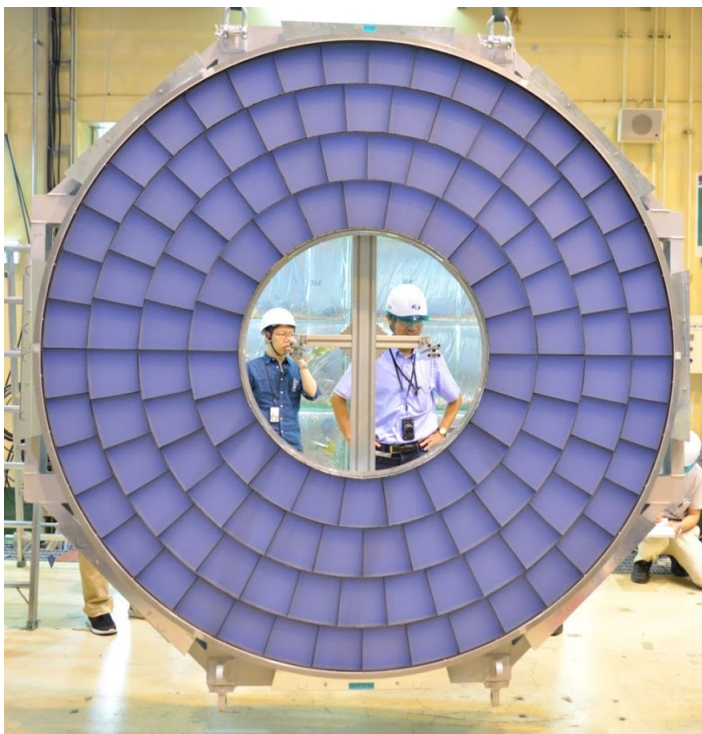
Two layers of wedge-shaped aerogel single tiles of size $17 \times 17 \times 4 \text{ cm}^3$



Aluminum support frame mockup for aerogel radiator



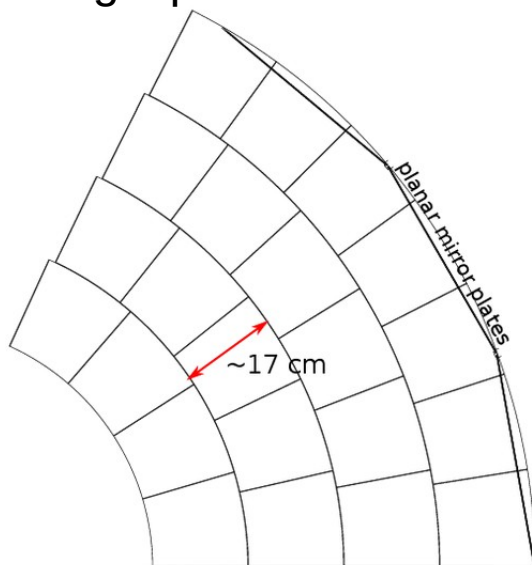
Silica Aerogel radiator



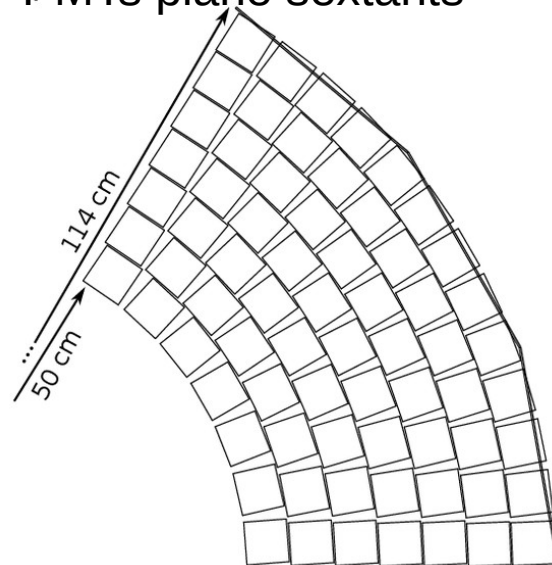
Overall ARICH detector

- Placed 2 m from I.P.
- $r_{in} = 56 \text{ cm}$, $r_{out} = 114 \text{ cm}$
- 3.5 m^2 coverage surface
- 6 sectors
- $2 \times 124 = 248$ aerogel tiles
- 420 HAPD modules with
- 60480 readout channels
- 18 planar mirror plates

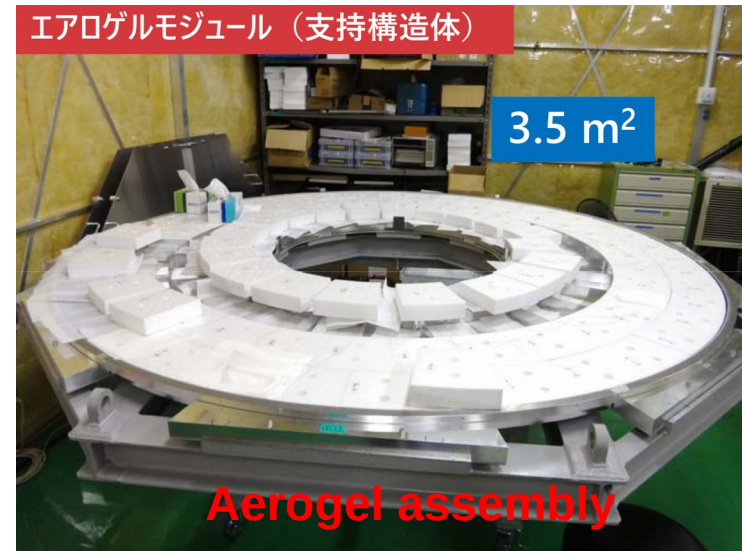
Aerogel plane sextants



PMTs plane sextants

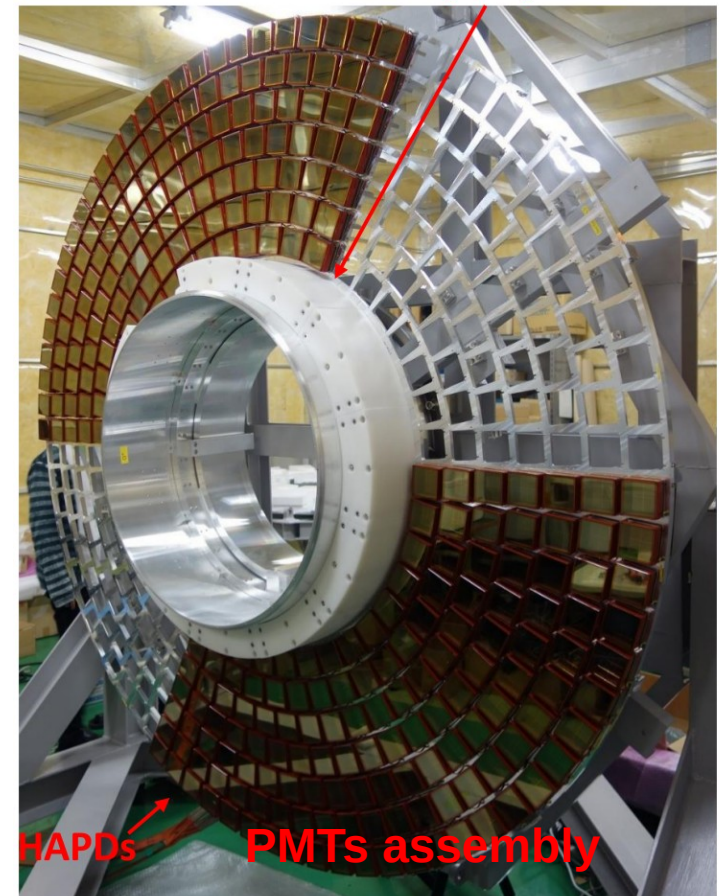


エアロゲルモジュール (支持構造体)



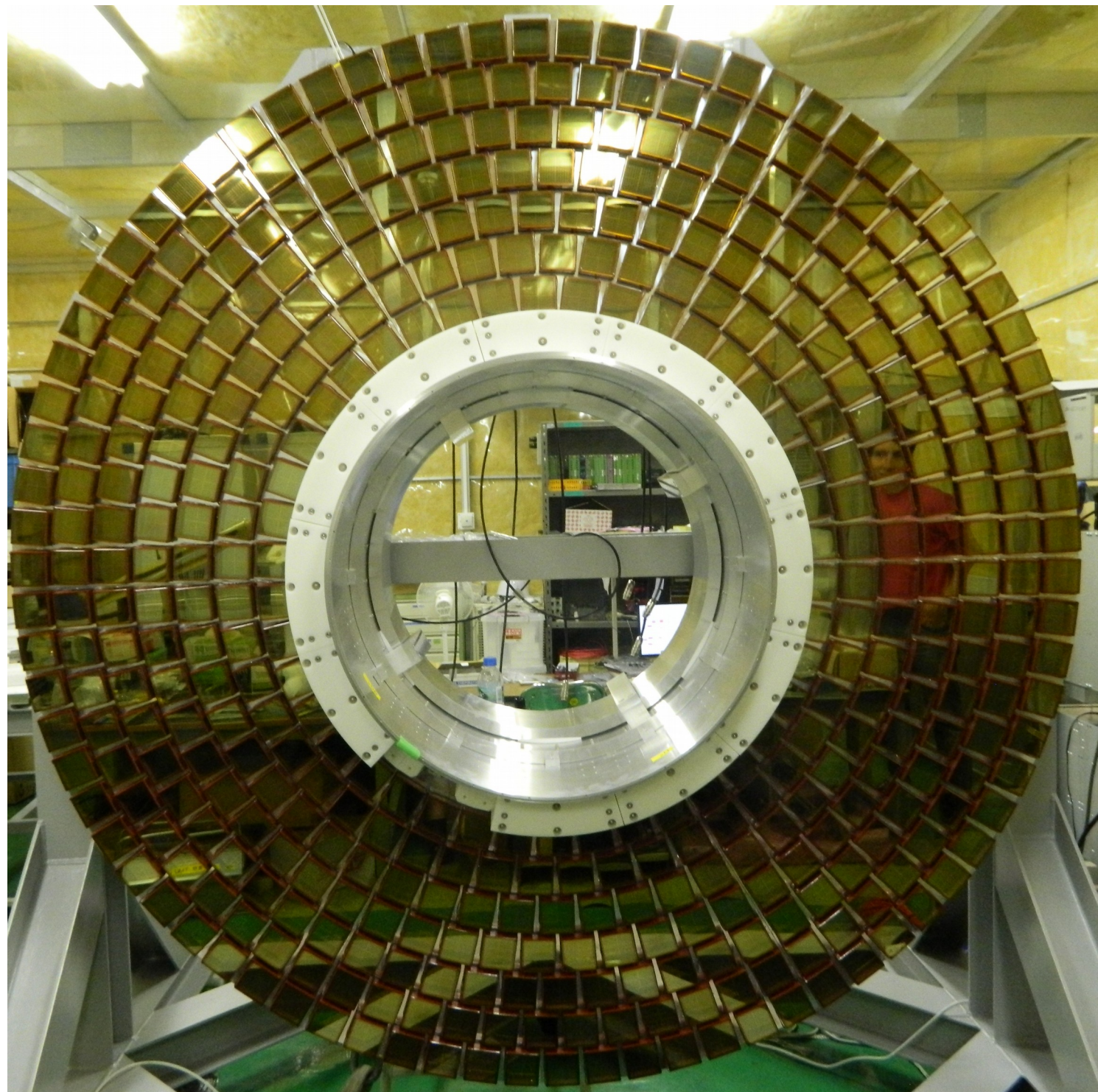
Aerogel assembly

Polyethylene shields

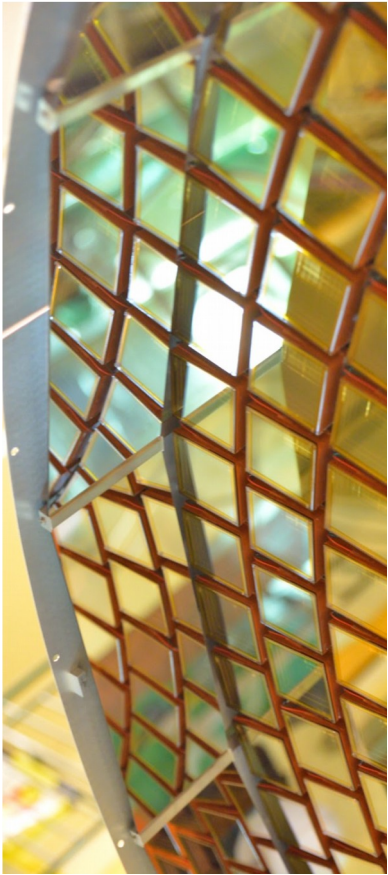


ARICH photon detector

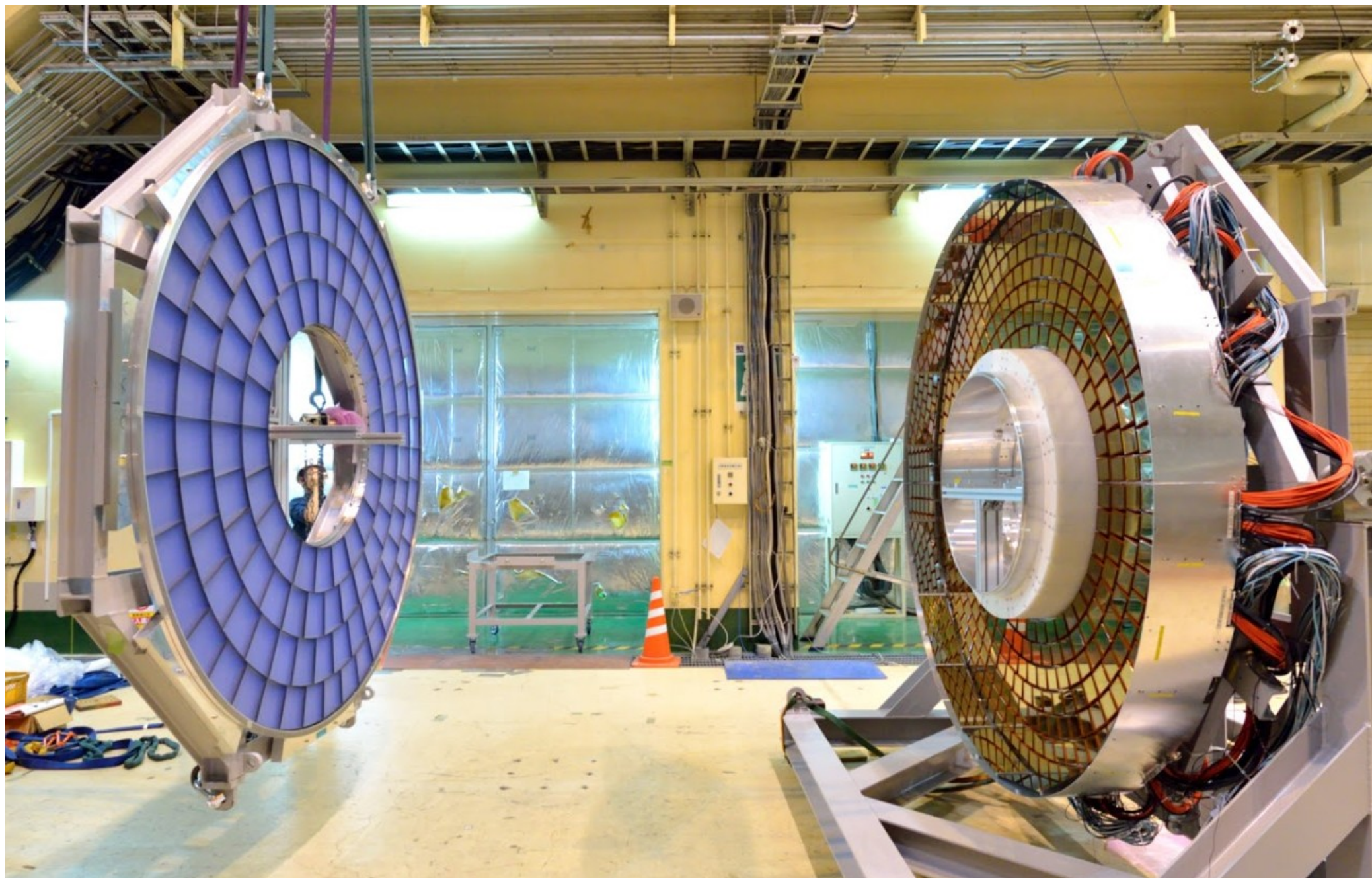
- 420 HAPD modules with
- 60480 readout channels
- 18 planar mirror plates



Mirrors from the edge

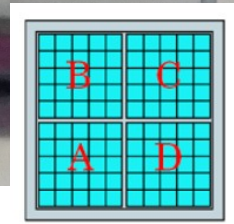
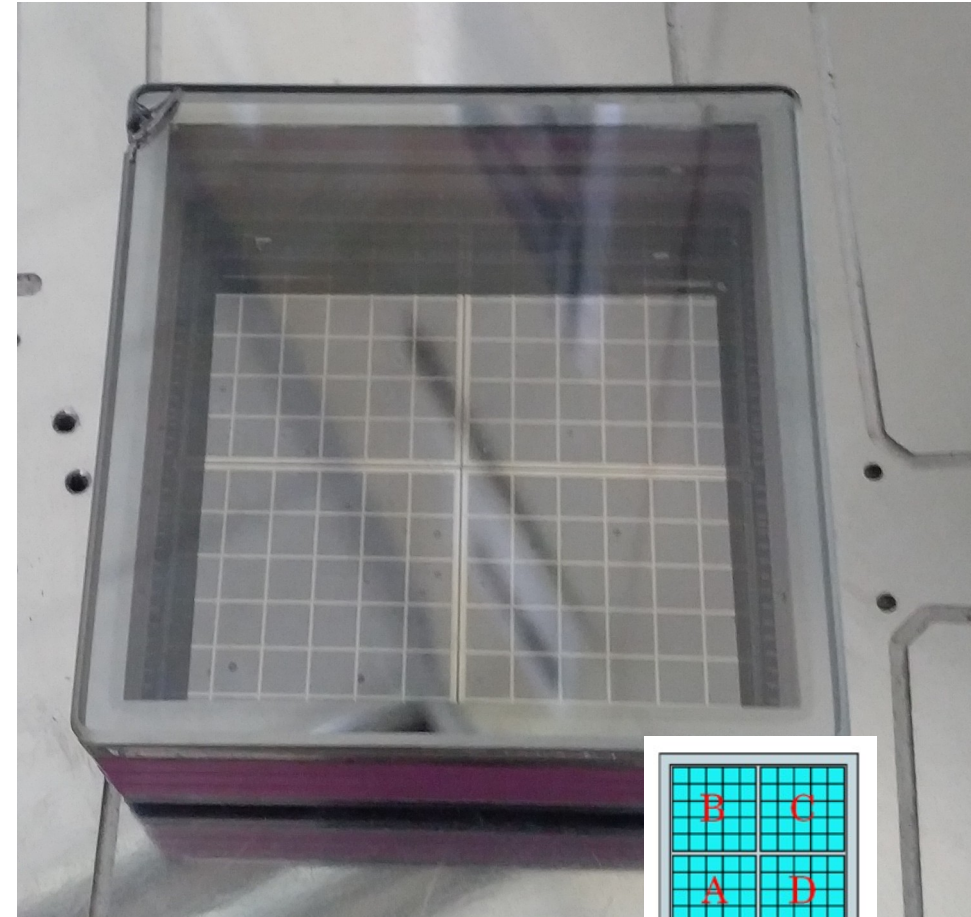
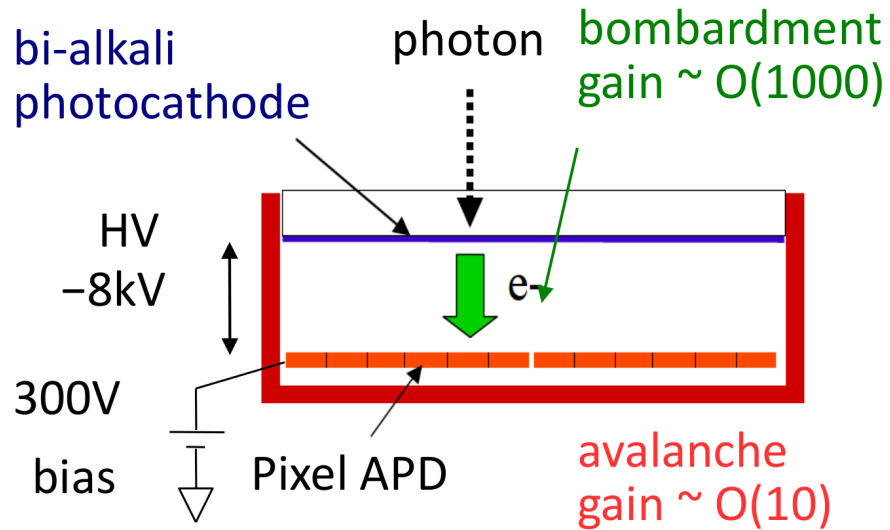


ARICH assembly – October 2017

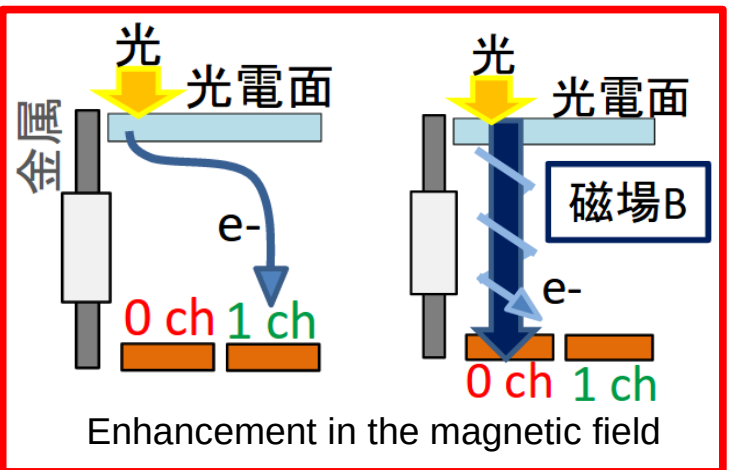


PMT

- ➔ Hybrid Avalanche Photo Detector (HAPD). Co-developed with Hamamatsu.
- ➔ 144 pixelated APDs : $5 \times 5 \text{ mm}^2$ position resolution. Effective area : $63 \text{ mm} \times 63 \text{ mm}$ in $73 \text{ mm} \times 73 \text{ mm}$.
- ➔ Signal gain $> 4 \times 10^4$ by Hybrid amplification process.
- ➔ Gamma / neutron tolerance for 10 years operation of Belle II.
- ➔ Operation in 1.5 T magnetic field.
- ➔ This detector have very poor time resolution ($\sim 100 \text{ ns}$) but this is not important for ring reconstruction.



□ 4.9 [mm]



RICH reconstruction. PID.

➔ “Simple” ring fit and Cherenkov angle reconstruction provide PID information but less precise than logarithm likelihood analysis.

➔ PID with ARICH detector based on logarithm likelihood analysis.

$$\ln L = -N + \sum_{\text{hit } i} n_i + \ln(1 - e^{-n_i})$$

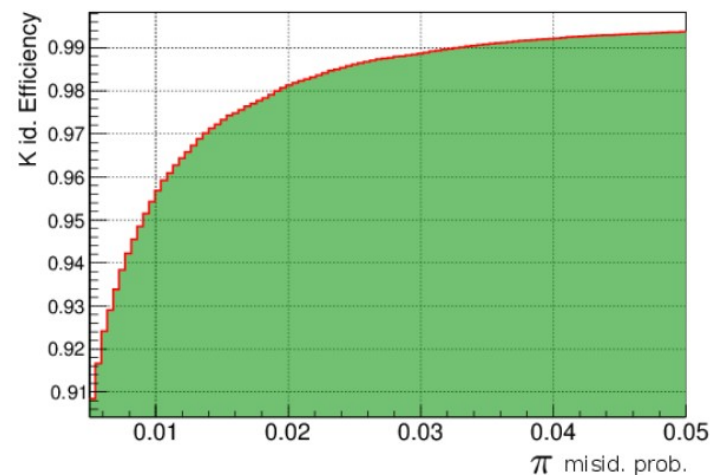
Expected number of detected photons

Number of detected photons

Probabilities for a HAPD pad to be hit.

PID with Cherenkov angle reconstruction

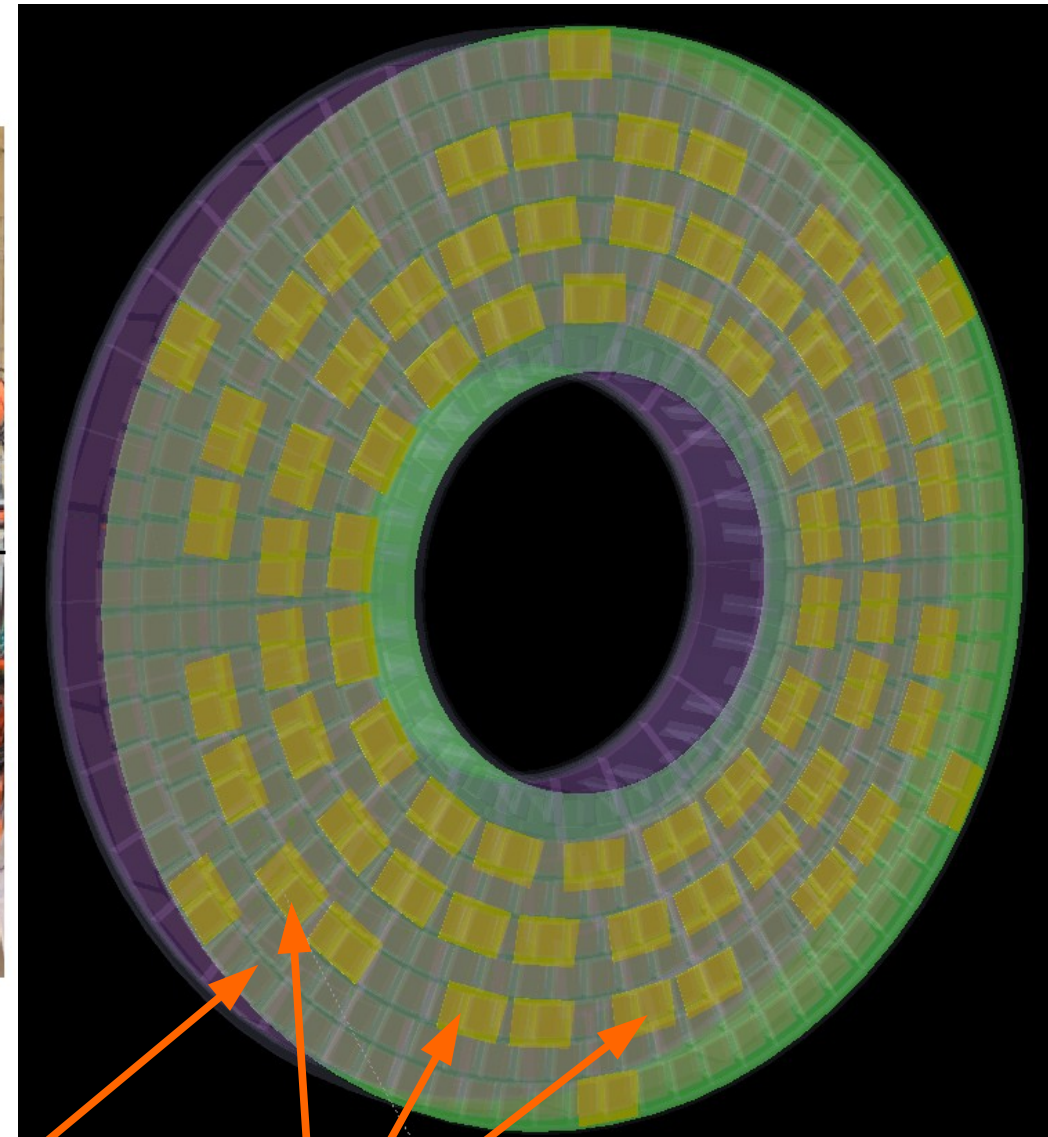
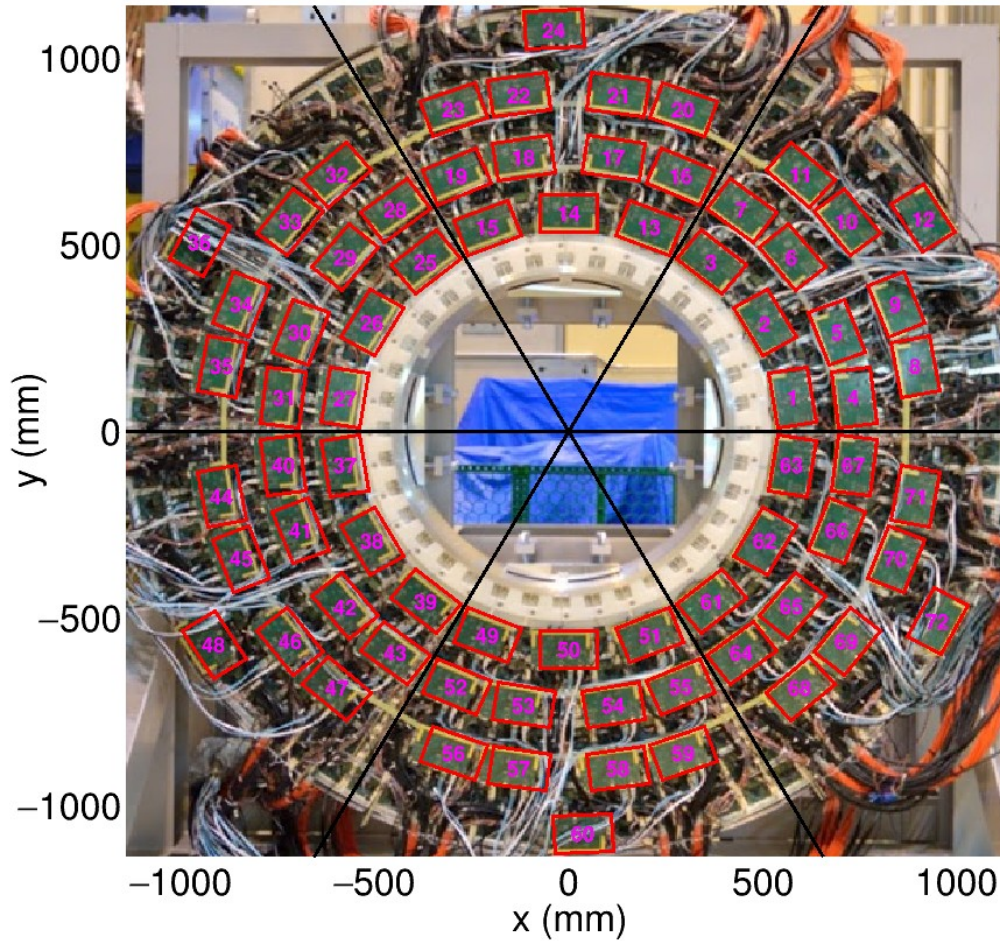
PID with likelihood analysis



Implementation of merger PCB, cables envelop and backward aluminum wall

Implementation

Checking of the positions



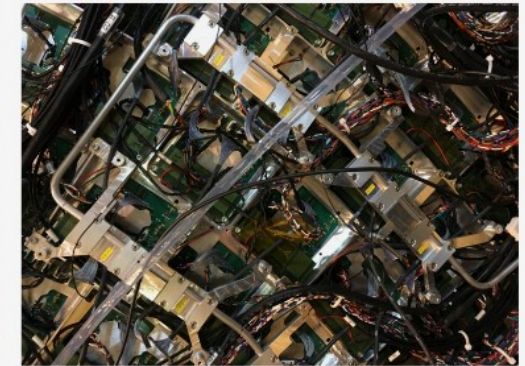
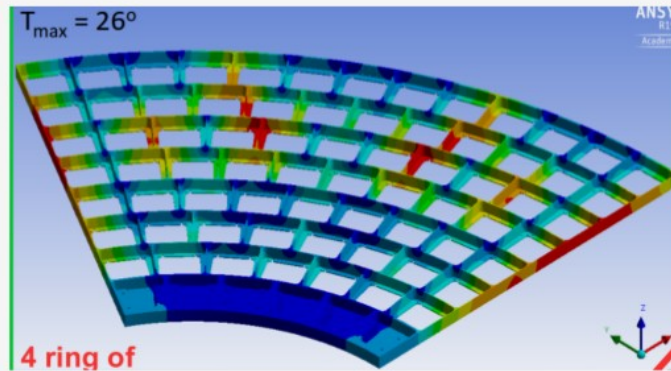
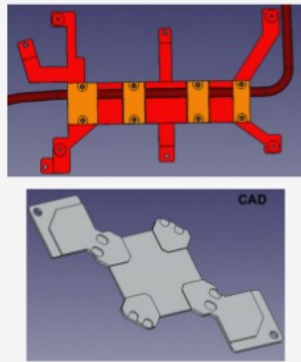
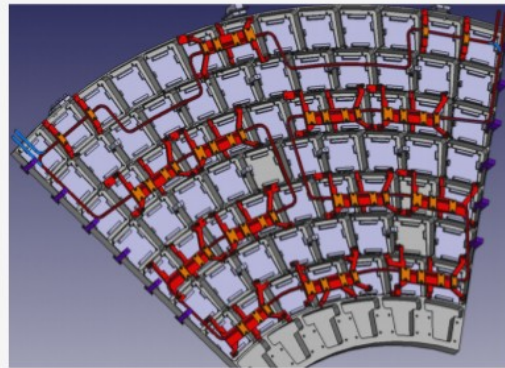
Cable envelop

Merger

ARICH cooling system upgrade

➔ Baseline cooling system* - was not sufficient to cool down the full detector.

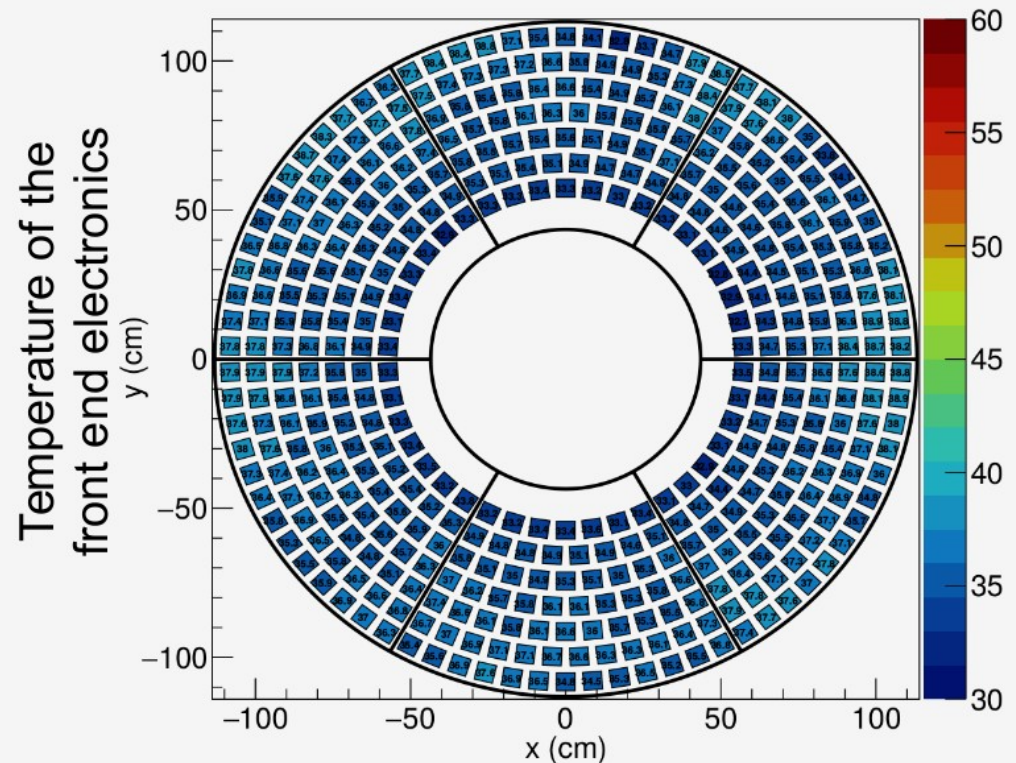
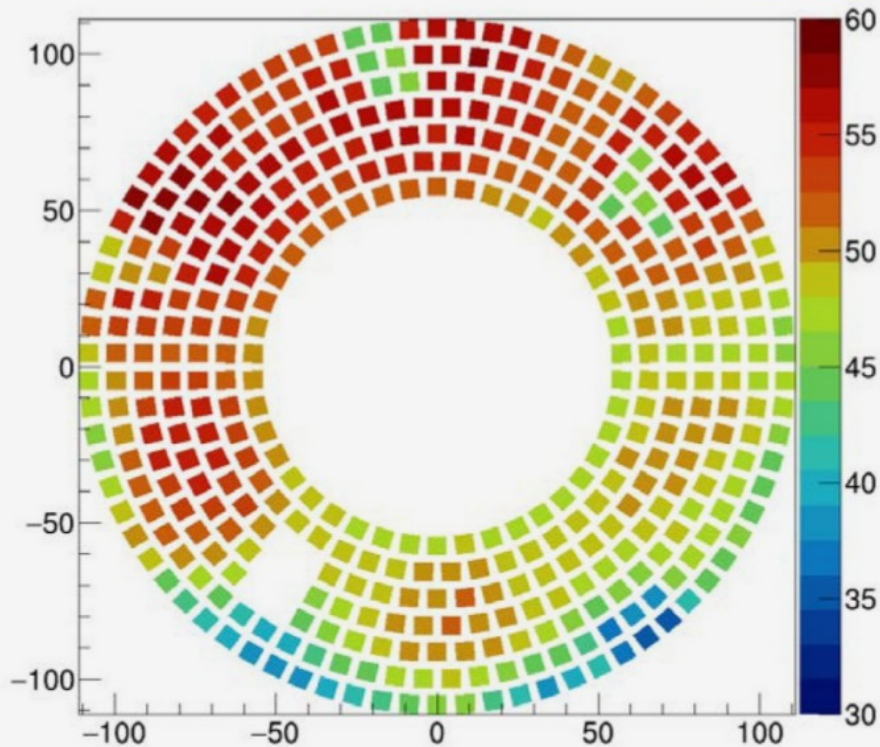
➔ New cooling system has been designed, simulated, fabricated, installed and tested after phase 2.



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Phase 2

feb_t1 2019.2.14 1:21:1 After phase 2



Designed and installed by the external company.

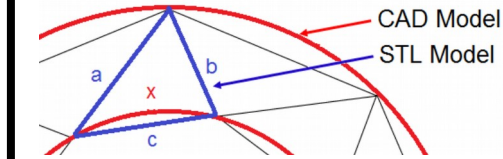
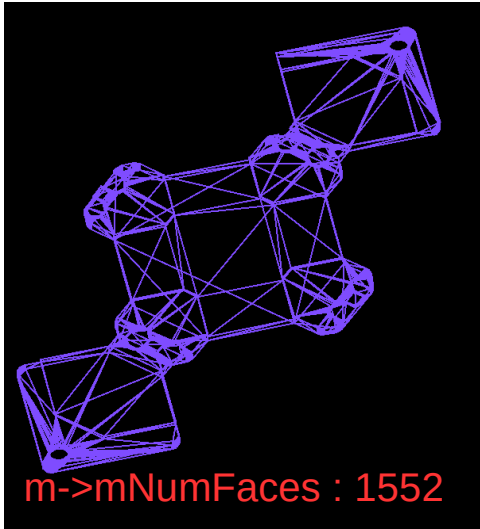
CAD (STEP file)

Implementation into BASF2

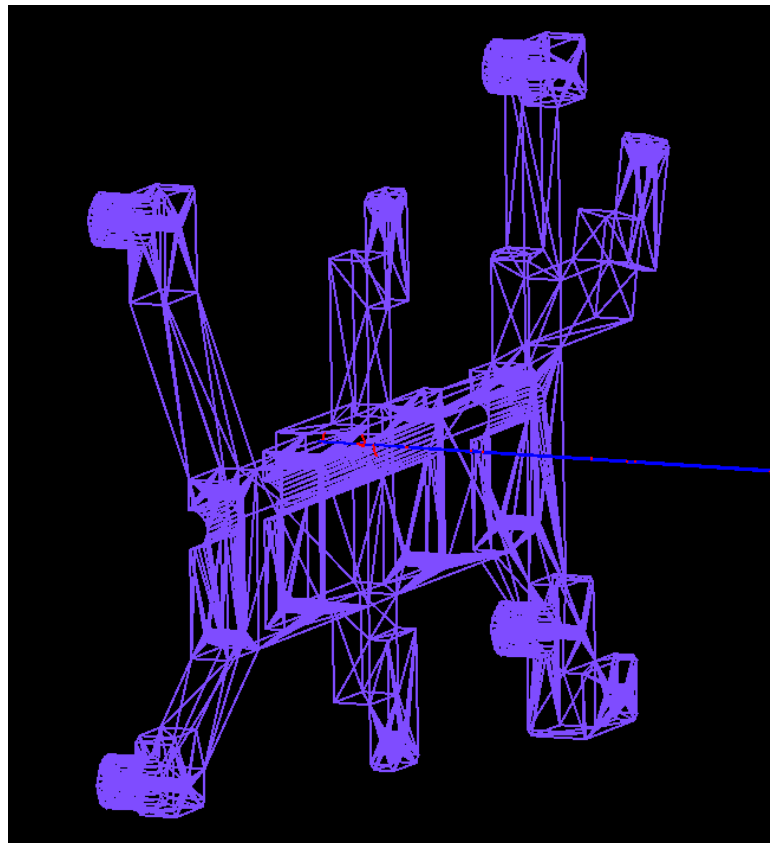
Free CAD
Mesh generation

Standalone
Geant4

BASF2



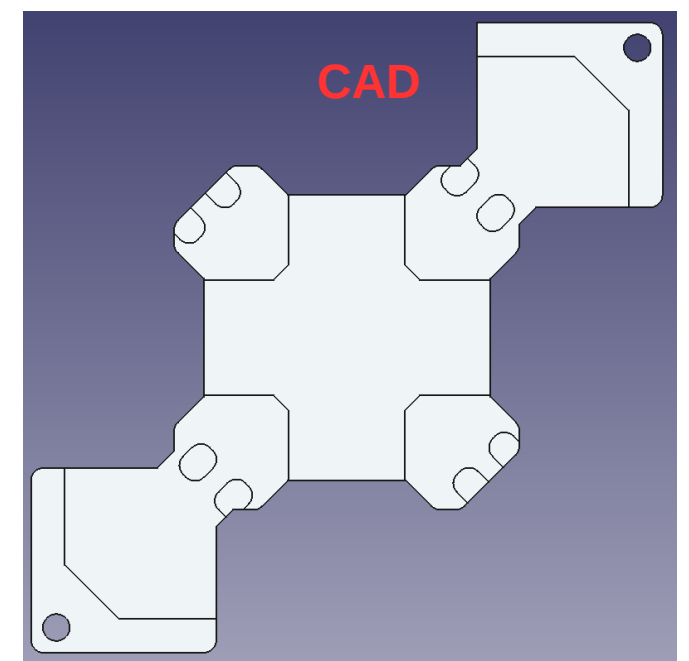
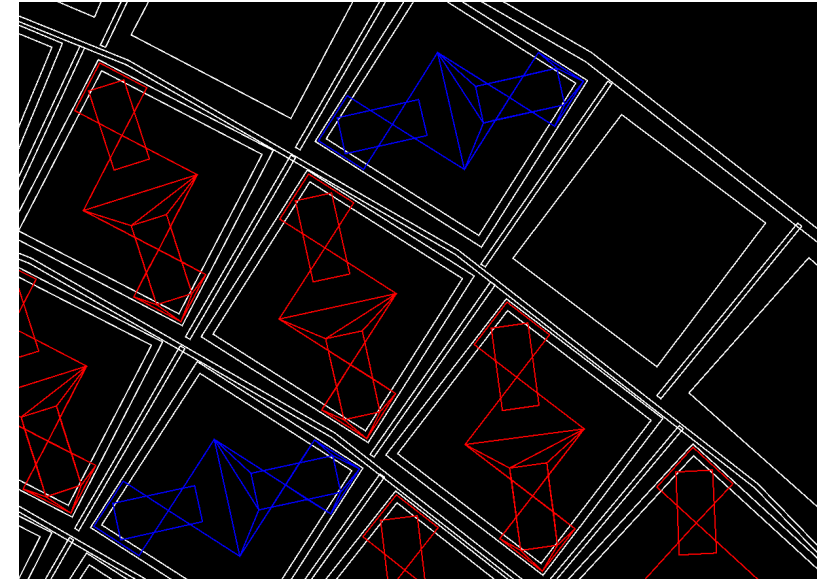
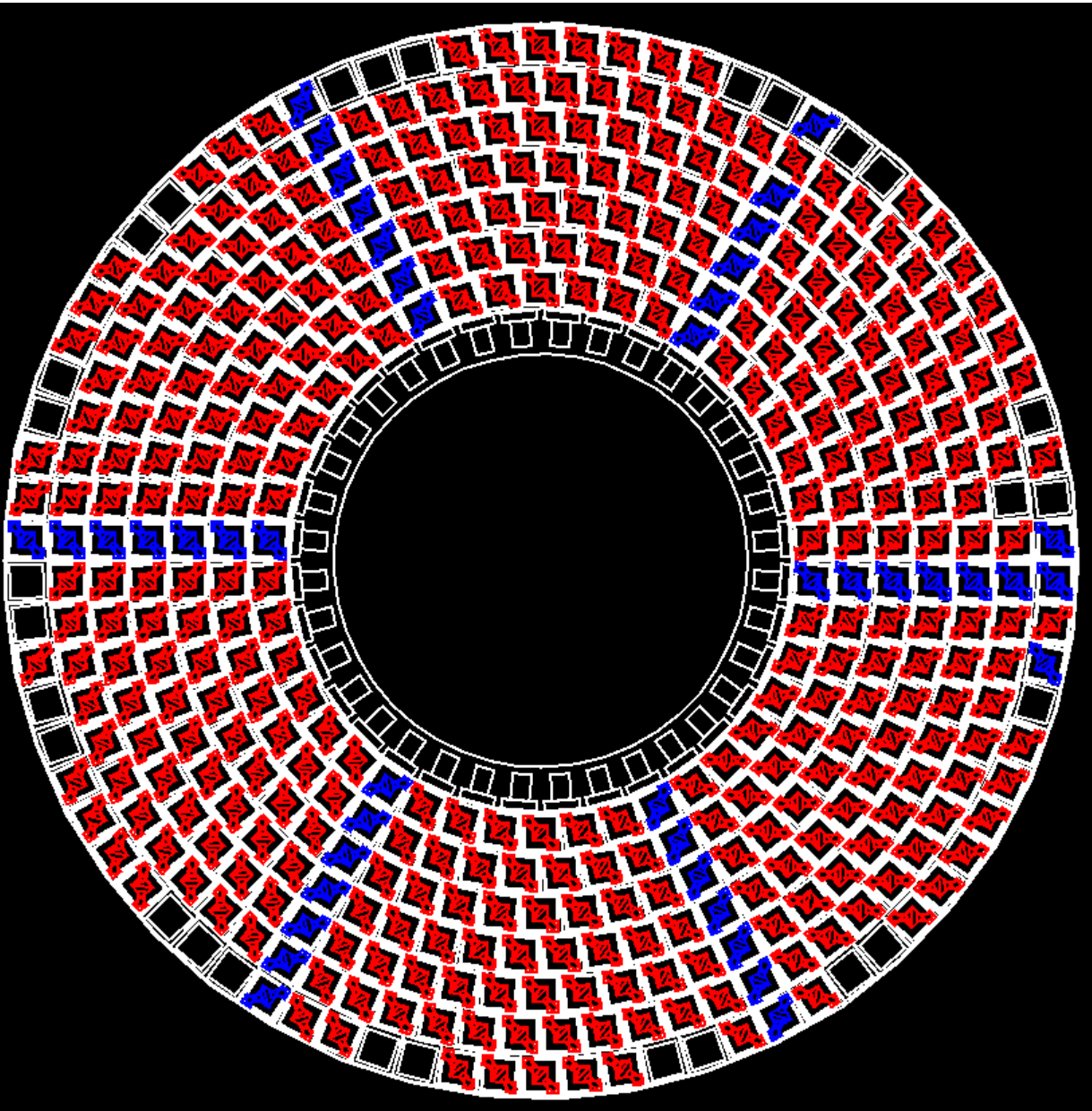
Geant4 with tessellated solid
constructed from the Mesh.



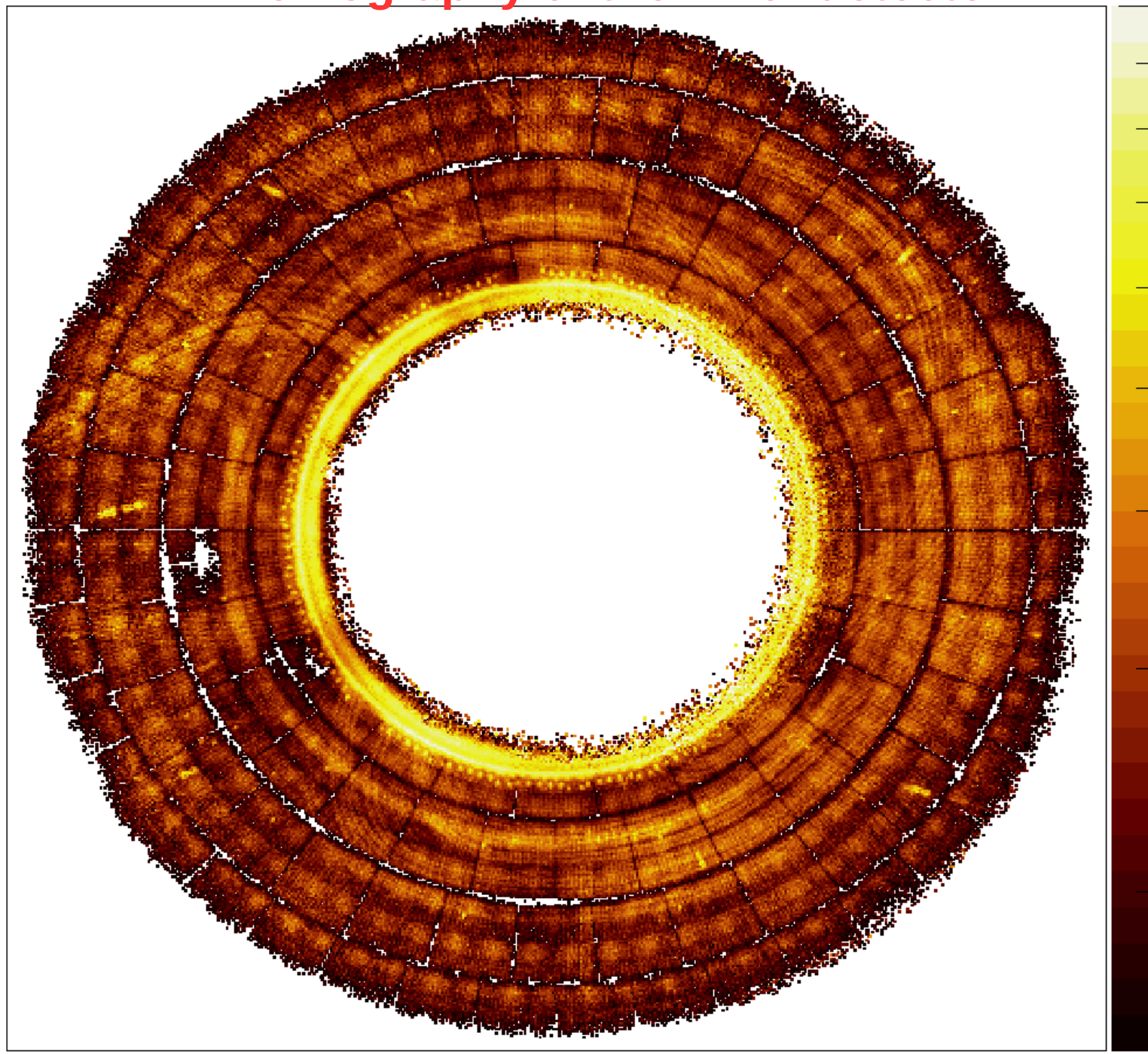
BASF2-first tests (tessellated volume)

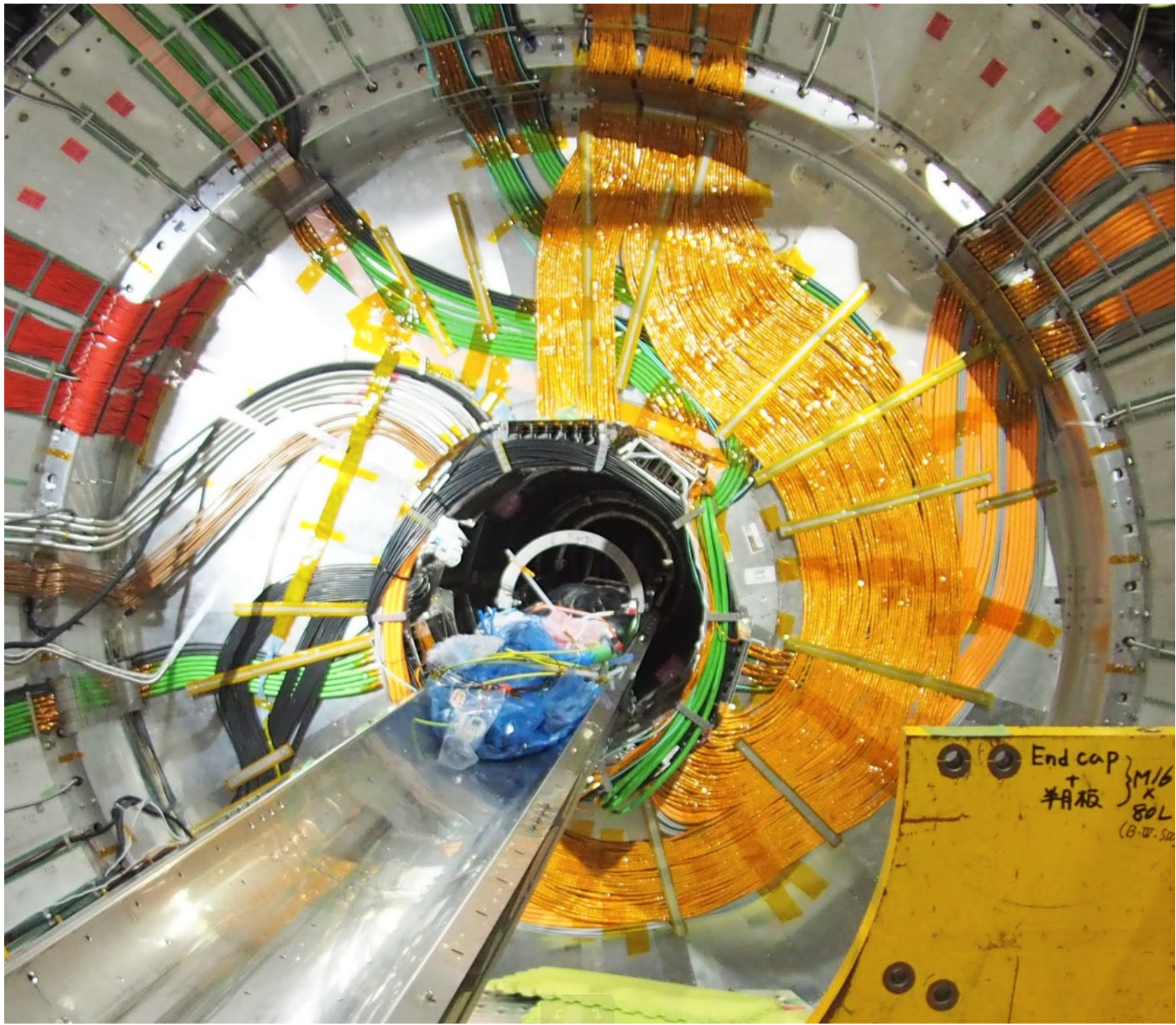
FEB cooling bodies

Simulation include : its approximate geometry, orientation (default and rotated), some of the FEB's does not have cooling body installed due to interface problem.

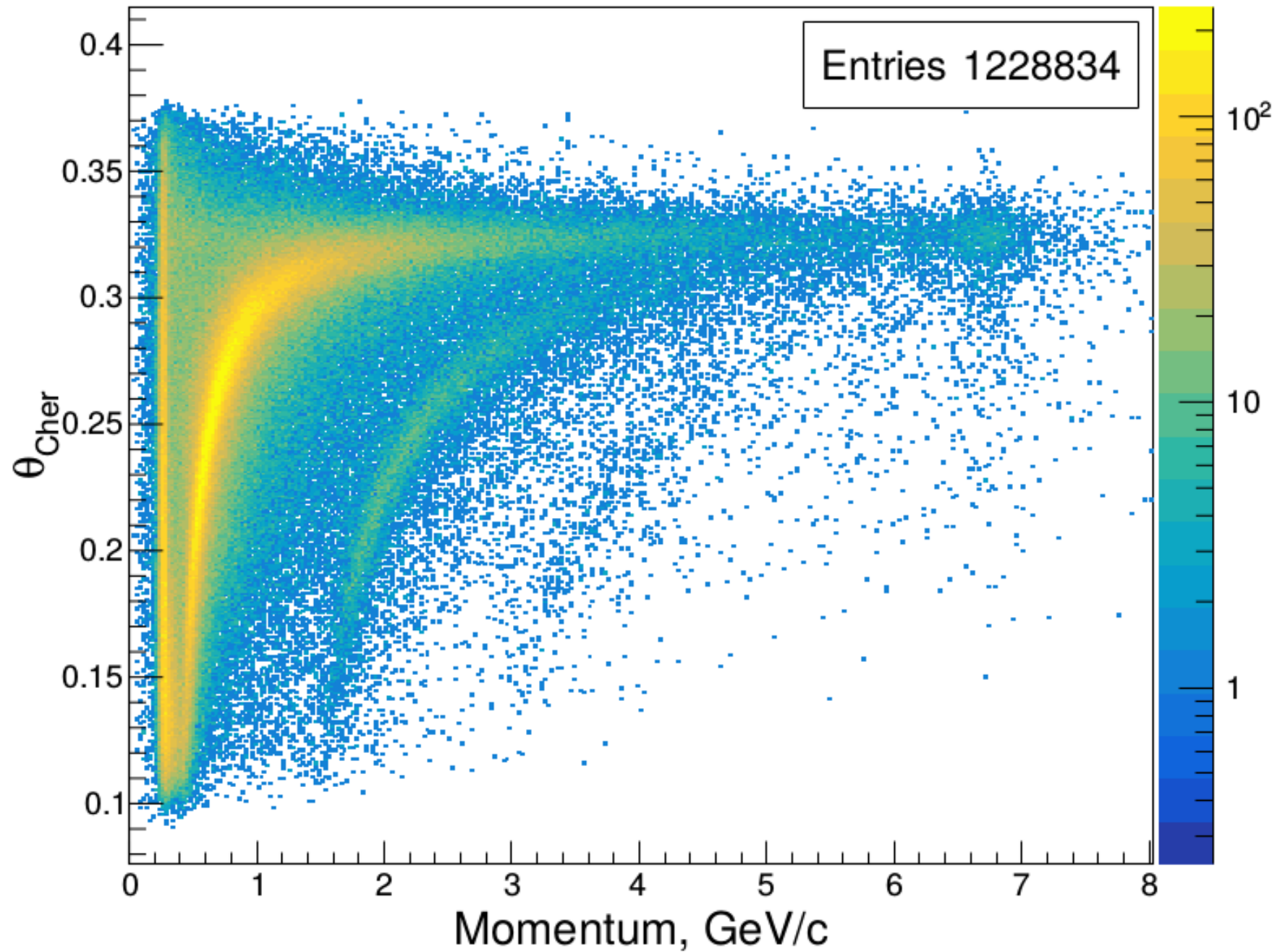


Tomography of the inner detector



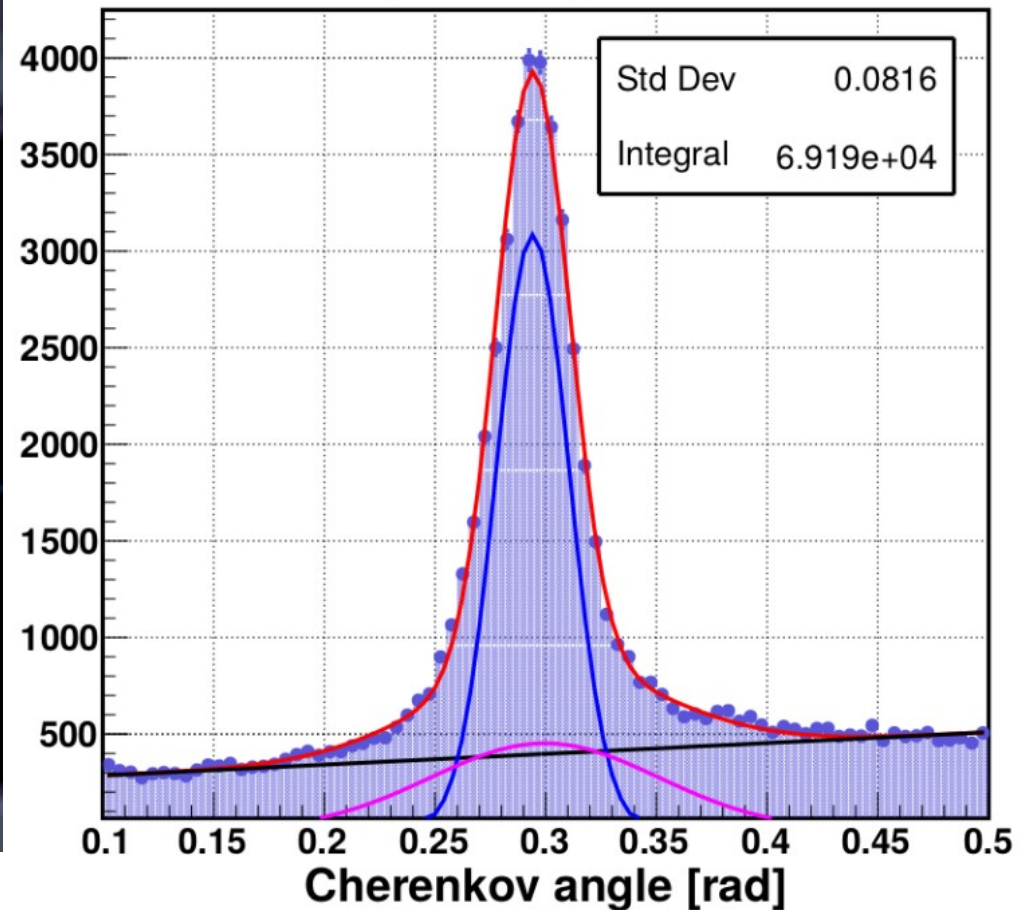
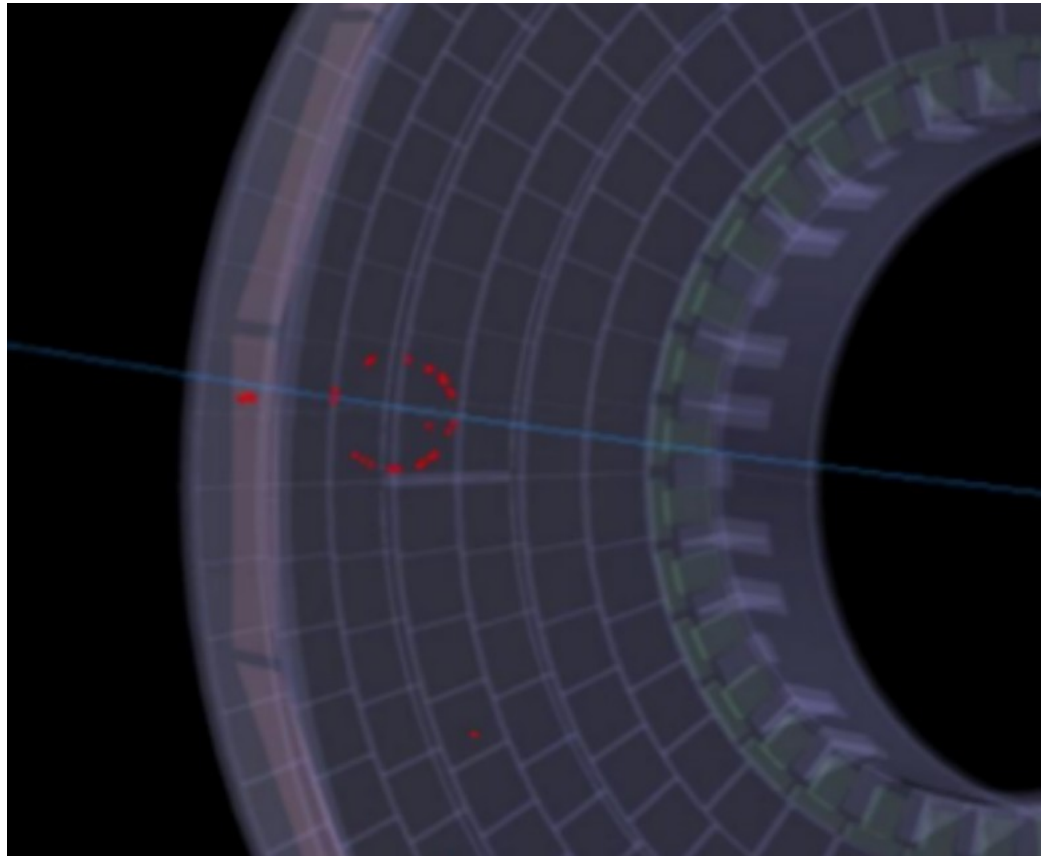


Cherenkov angle




Single Cherenkov photon angle resolution.

Reconstructed Cherenkov ring visualized with event display.



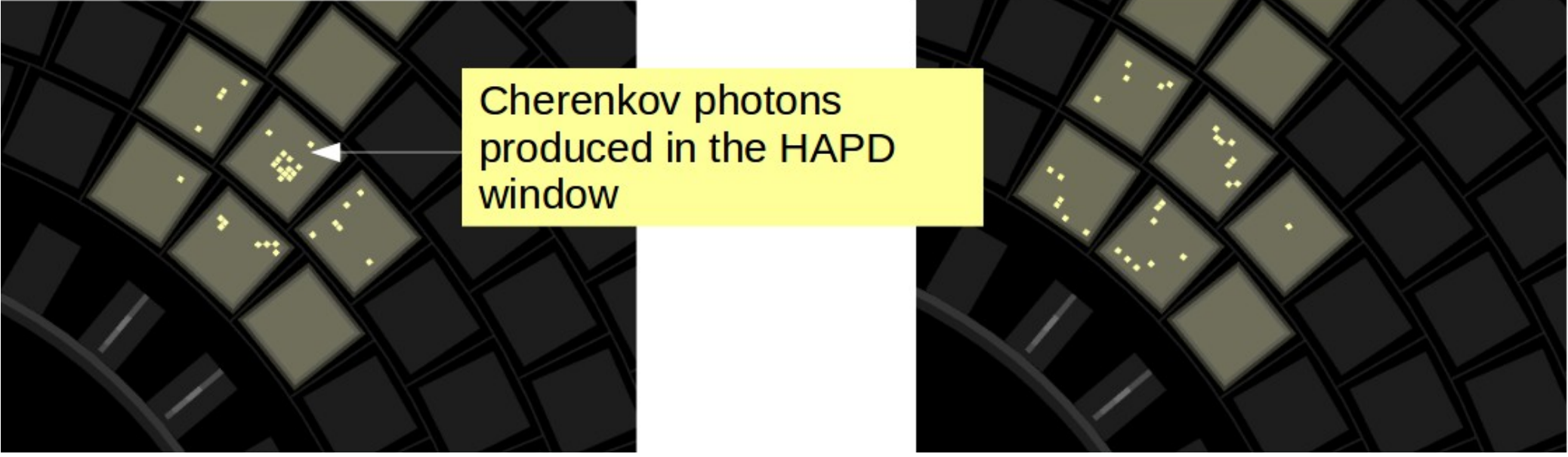
- Black line - non correlated background (electronics, beam background ...)
- Magenta line - correlated background (Rayleigh scattered photons, reflection from APD ...)
- Blue line – signal photons. Single photon resolution ~ 14 mrad.

BASF II – ARICH - Event Display



Clear isolated rings visible

The image shows a top-down view of the ARICH detector's segmented structure. It consists of a grid of rectangular segments arranged in a circular pattern. Several bright, yellowish-green spots are visible, forming distinct, isolated rings. A yellow text box at the top center contains the text 'Clear isolated rings visible'.



Cherenkov photons
produced in the HAPD
window

The image shows the same detector structure as above. A white arrow points from a yellow text box to a specific cluster of bright spots within one of the segments. The text box contains the text 'Cherenkov photons produced in the HAPD window'.