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Particle identification at the Belle II spectrometer

Rok Pestotnik

Jožef Stefan Institute, Ljubljana

on behalf of the Belle2 PID group

Outline:

- Introduction
- Status of the project
- Achievements
- Schedule
- JENNIFER impact
- Summary

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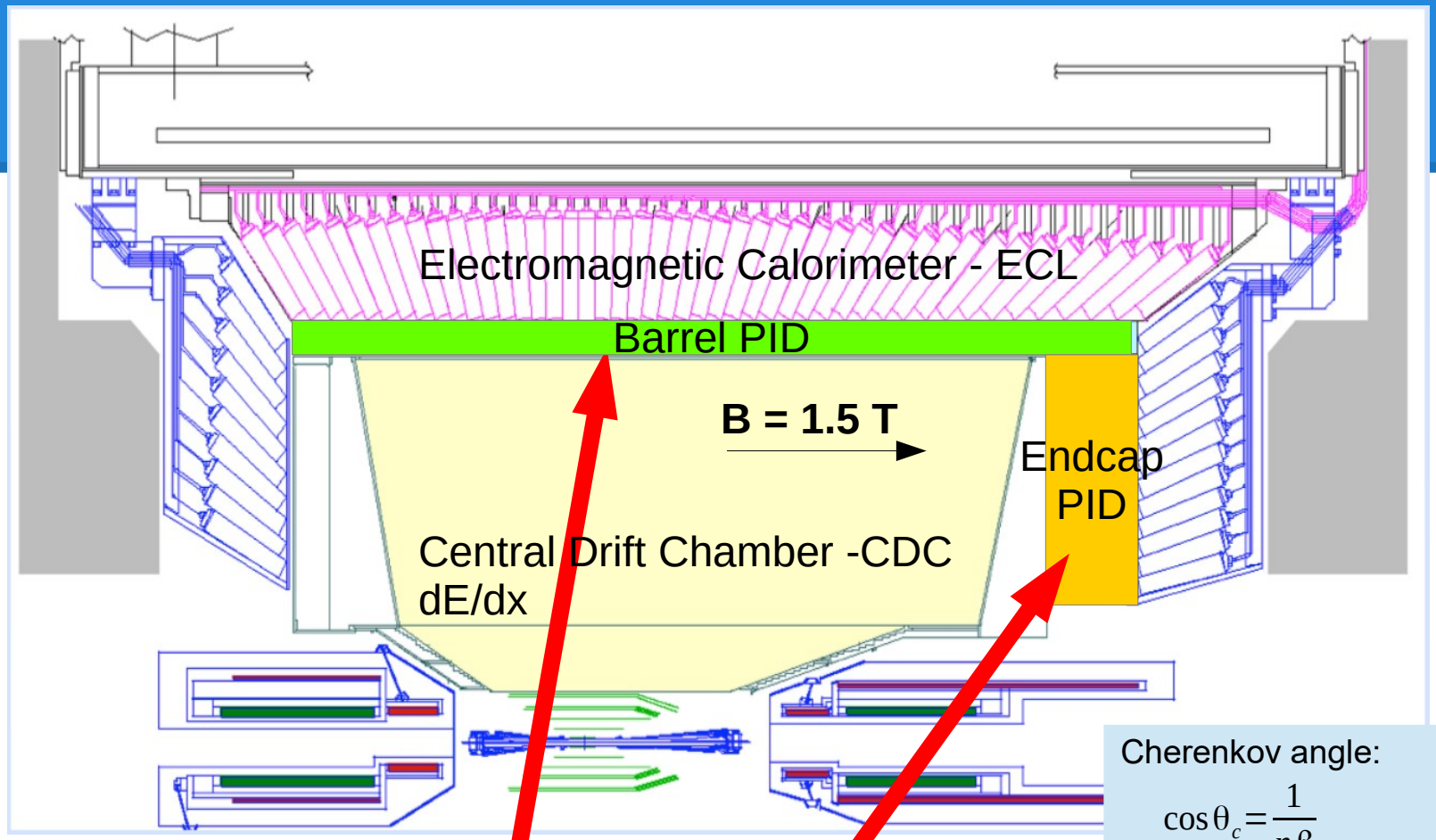
Particle identification in Belle II



Two dedicated particle ID devices: both RICHes

- Barrel: **Time-Of-Propagation (TOP)**
- End-cap: **Proximity focusing Aerogel RICH (ARICH)**

Photo detectors → operation in magnetic field 1.5T

Cherenkov angle:

$$\cos\theta_c = \frac{1}{n\beta}$$

Number of emitted photons:

$$\frac{dN}{dE} \propto L \sin^2\theta_c$$

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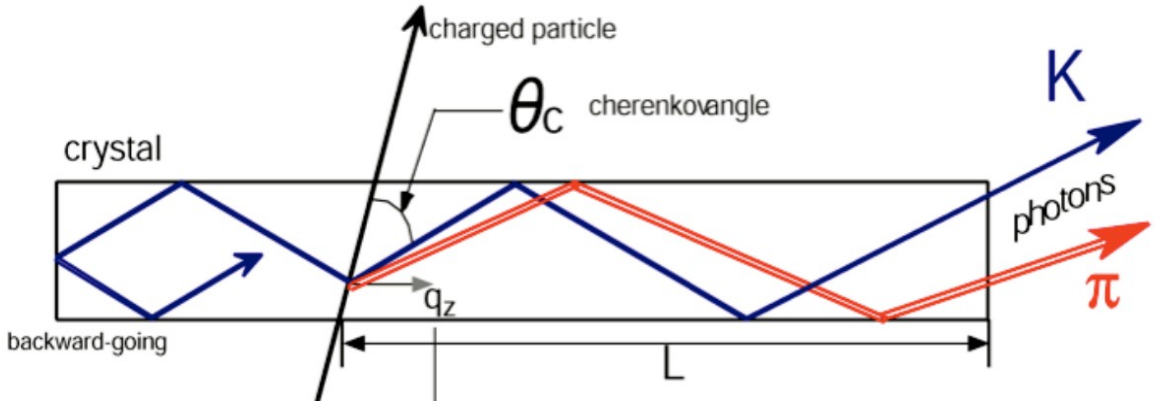
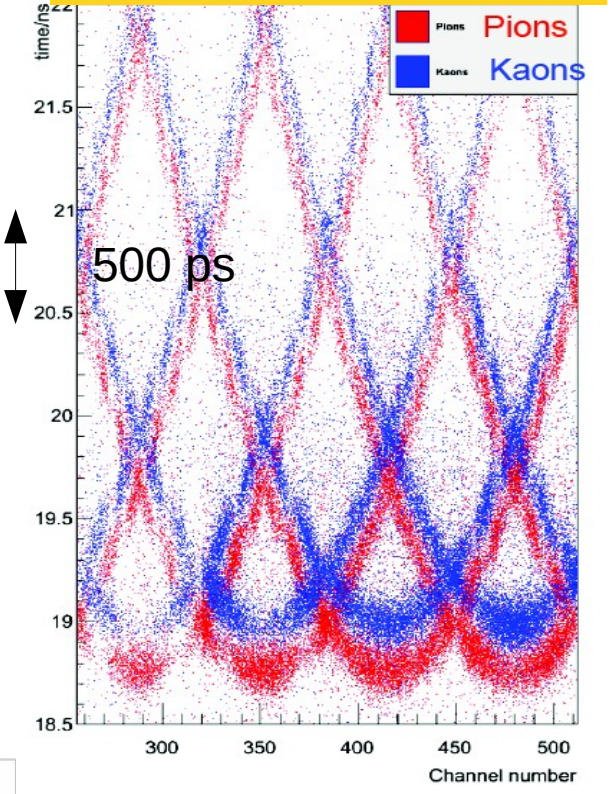
Barrel PID: Time of Propagation counter (TOP)

Cherenkov photons emitted in the quartz radiator → **internally reflected** → registered at the end of the bar by a fast position sensitive detector of single photons.



K/π → Different θ_c → Different path length → Different Time Of Propagation

Arrival time of photons vs position (ch. number)



θ_c reconstructed from:

hit position (x,y) and Time Of Propagation of photon.

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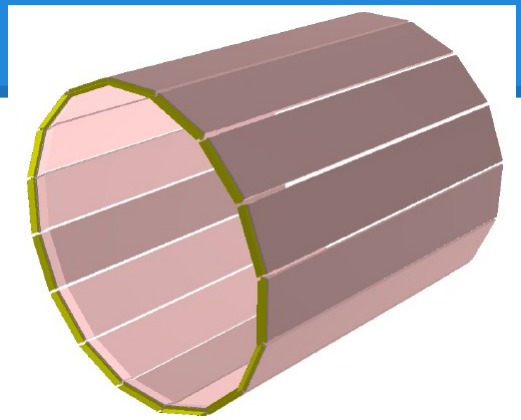
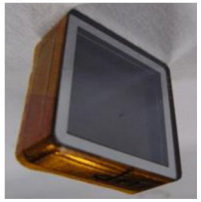
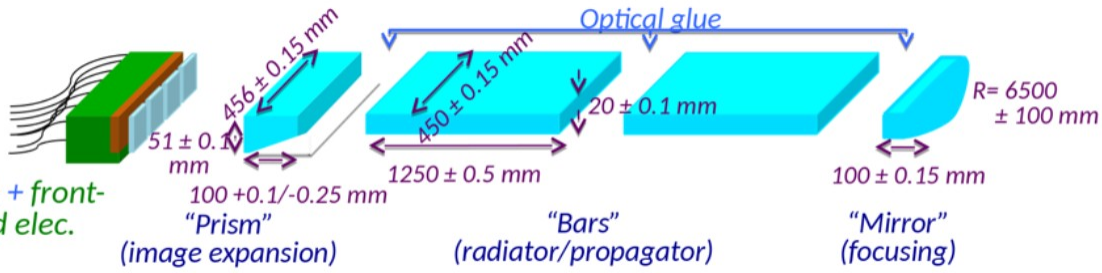
TOP geometry

16 modules at R=120cm

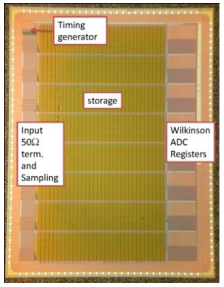


- quartz radiator
- focusing mirrors
- expansion prism
- photo detectors: MCP-PMTs
- read-out electronics

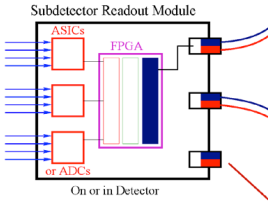


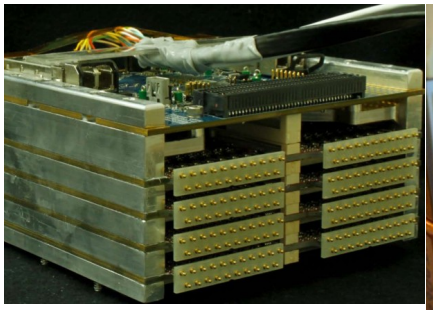


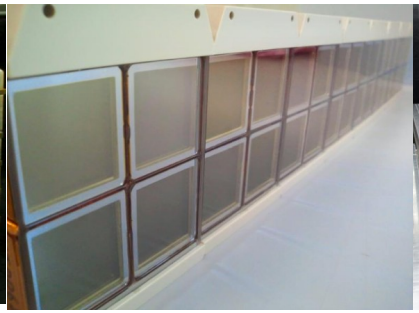
8k channel waveform sampling ASIC

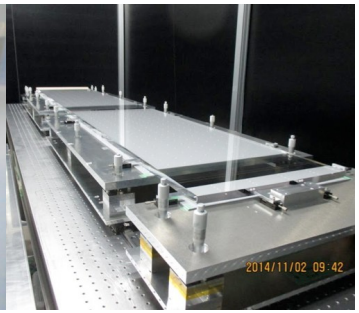


Carrier boards:
4 ASICS + Xilinx FPGA









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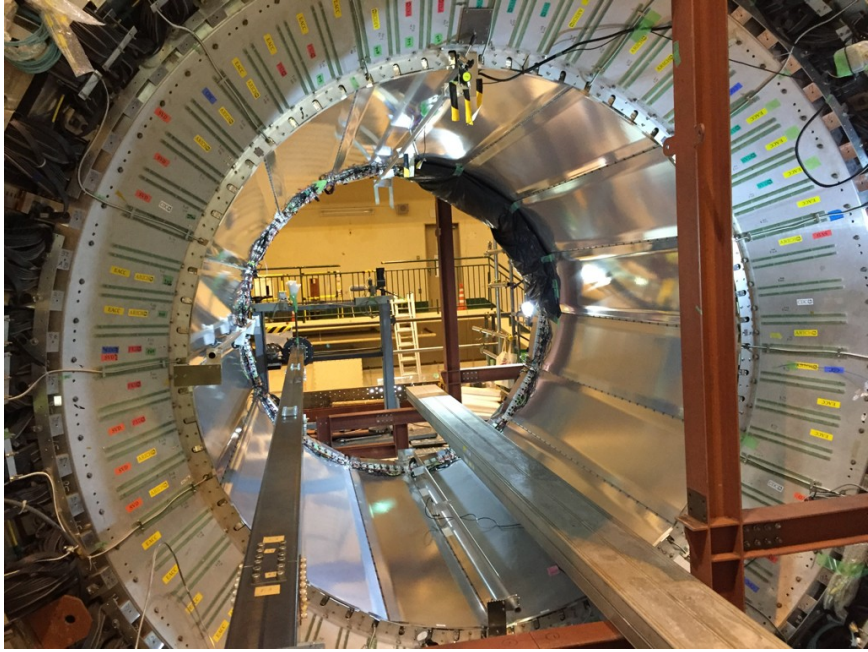
TOP Status



Assembly and installation

- 03/2015: Started module assembly
- 02/2016 1st module installation
- 04/2016 Module assembly completed, started continuous module installation
- 05/2016 Module installation completed

Top detector is being commissioned:

- First cosmic tests gave reasonable results
- Spring 2017: 3-month test with cosmic rays
- December 2017: expected first e+e- collisions
- Spring 2018: TOP counter expected to be fully commissioned

Progress according to schedule, no delay expected.

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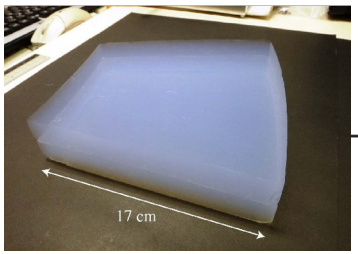
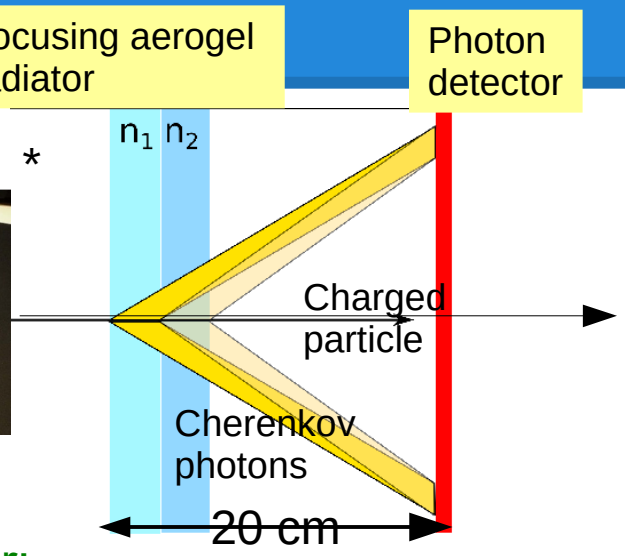
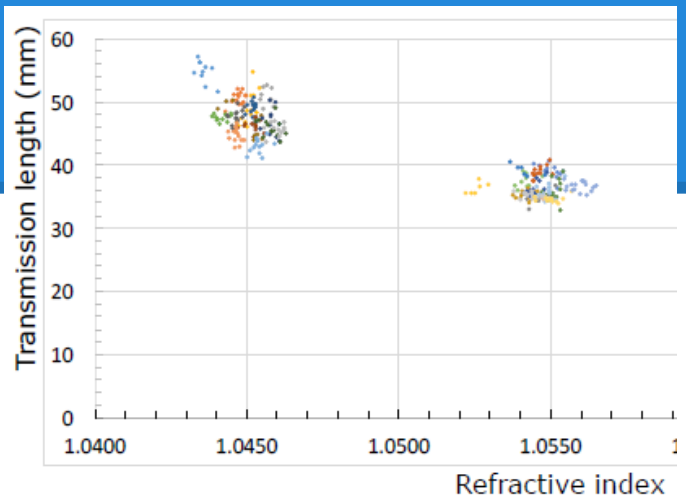
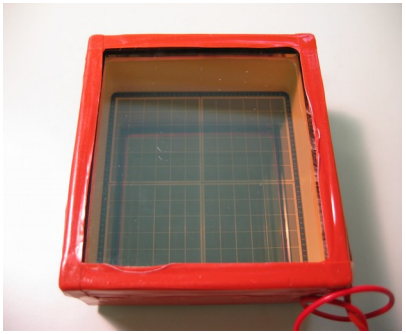
Endcap PID - Aerogel RICH







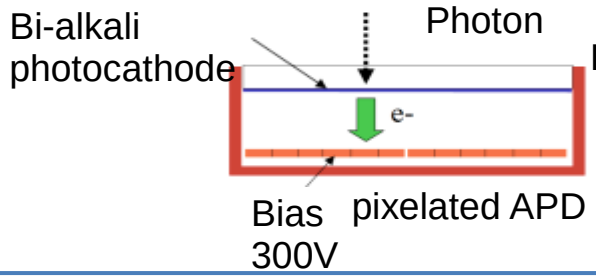


Aerogel radiator:

- Two 2cm thick layers n_1= 1.045 n_2= 1.055
- large tiles to minimize photon losses at the edges
- Optical transparency limited due to Rayleigh scattering

Hybrid Avalanche Photo Detector - HAPD

- 144 channels, total area 7cm x 7cm
- Excellent separation of single photo-electrons



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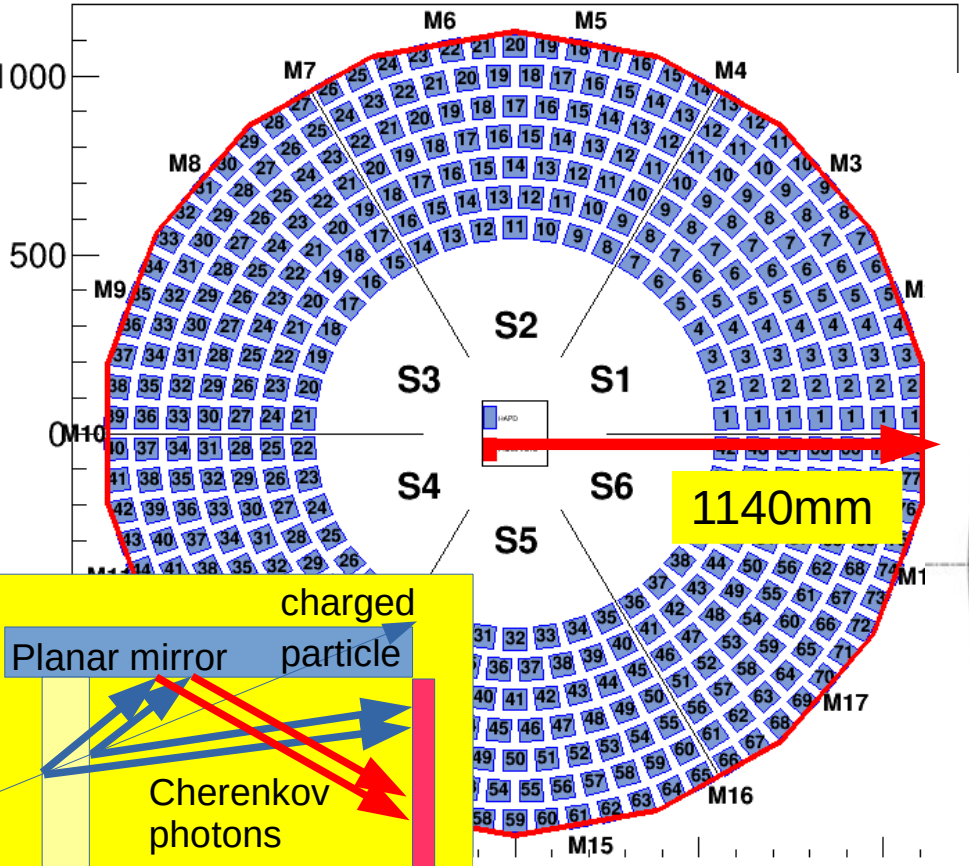
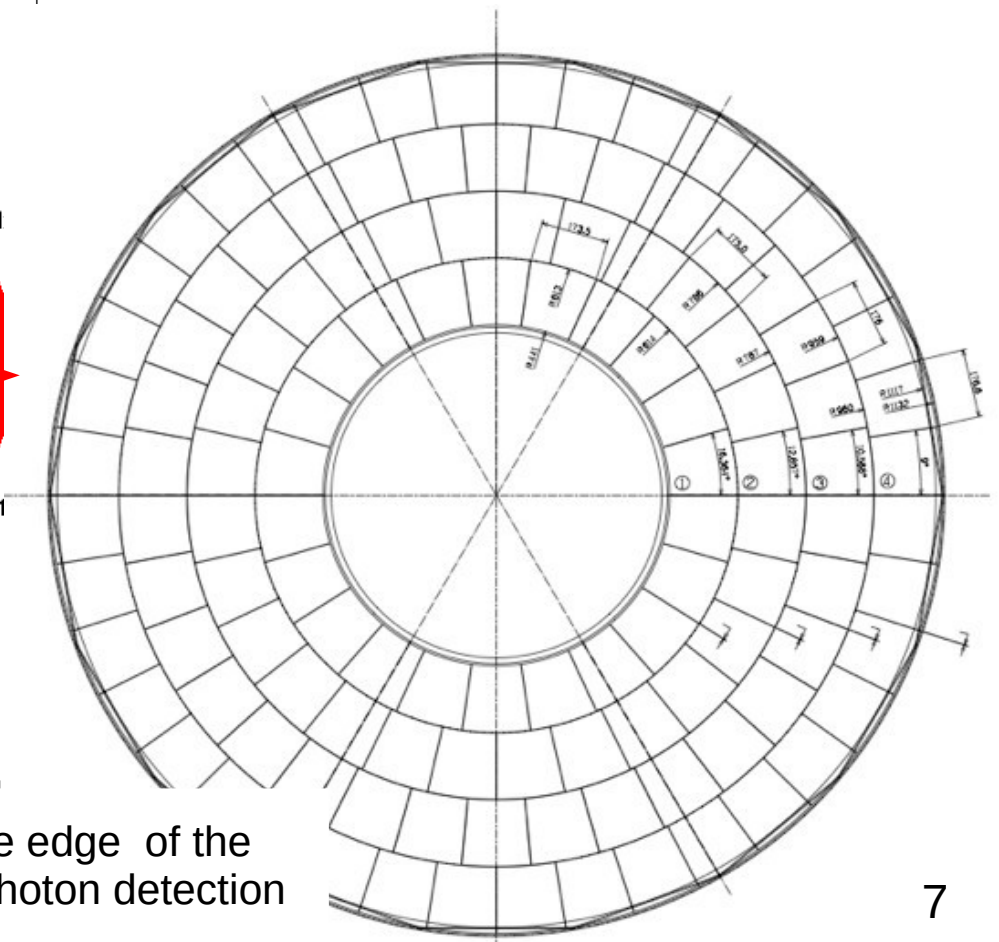
ARICH geometry

420 HAPD modules in 7 rings



Aerogel : 124x 2 layers
-wedge shape

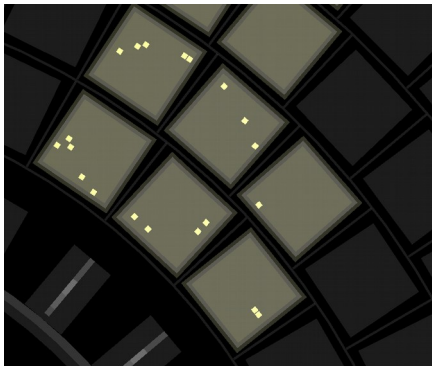


Planar mirrors on the edge of the detector to improve photon detection

ARICH Status

Assembly and installation

- 04/2016: HAPD module assembly + tests started
- 04/2016: aerogel installation started
- 07/2016 HV boards added to HAPD modules
- 07/2016 1st sextant HAPD module installation completed



- 10/2016 aerogel installation completed
- 12/2016 Photon detector installation completed

Read-out electronics is being commissioned

- 08/2016 First cosmic tests → clear isolated Cherenkov rings
- Q1 2017: System test and integration in the Belle II spectrometer
- Spring 2018: ARICH expected to be fully commissioned

Progress according to schedule, no delay expected

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JENNIFER impact

Belle II sub-groups in WP2 - 28 F.T.E. months
- **TOP** → **IJS + INFN** : 12 F.T.E. months
- **ARICH** → **IJS**: 16 F.T.E. months

JENNIFER secondment enables
- crucial on-site presence for installations and tests,
- face-to-face cooperation with group members from other countries

JENNIFER secondment especially valuable for early stage researchers:
- previously: approx. 1 month of on-site time in 2-3 years
- with JENNIFER support: approx. 1 month per year (factor 2-3x improvement)

This enables young scientists to take part in more front-page groups and activities, that demand also on-site presence - these were previously unreachable and it is a substantial improvement for their future careers.

JENNIFER secondments enable the European institutes to be part of the leading groups in the particle identification instrumentation by Cherenkov radiation → more then 20 contributions at the RICH 2016 conference- the most important conference for Ring Imaging Cherenkov Detectors

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Belle II PID Summary

For efficient particle identification at Belle II two RICH detectors will be installed

- TOP → Barrel PID and Aerogel RICH → Forward Endcap PID

All the key components of both detectors have been extensively tested.
Installation, assembly and commissioning is progressing as planned.

TOP:

- Detector successfully installed
- Commissioning is under way → will be finished on time - spring 2018

ARICH:

- 1/6 th of the detector installed
- Full detector installation by the end of 2016
- System test Q1 2017
- Integration the Belle II spectrometer Q1 2017
- Commissioning → acquired data with Cosmic rays – clear Cherenkov rings observed

No delay is expected to finish the commissioning by the deadline.

Jennifer enables the researchers from European Institute (JSI) in R&D to participate in the installation and the commissioning of the detector and share their expertise with the Japanese collaborators.

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