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Experimental Research, H2020



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Aerogel Ring Imaging Cherenkov at the Belle II spectrometer

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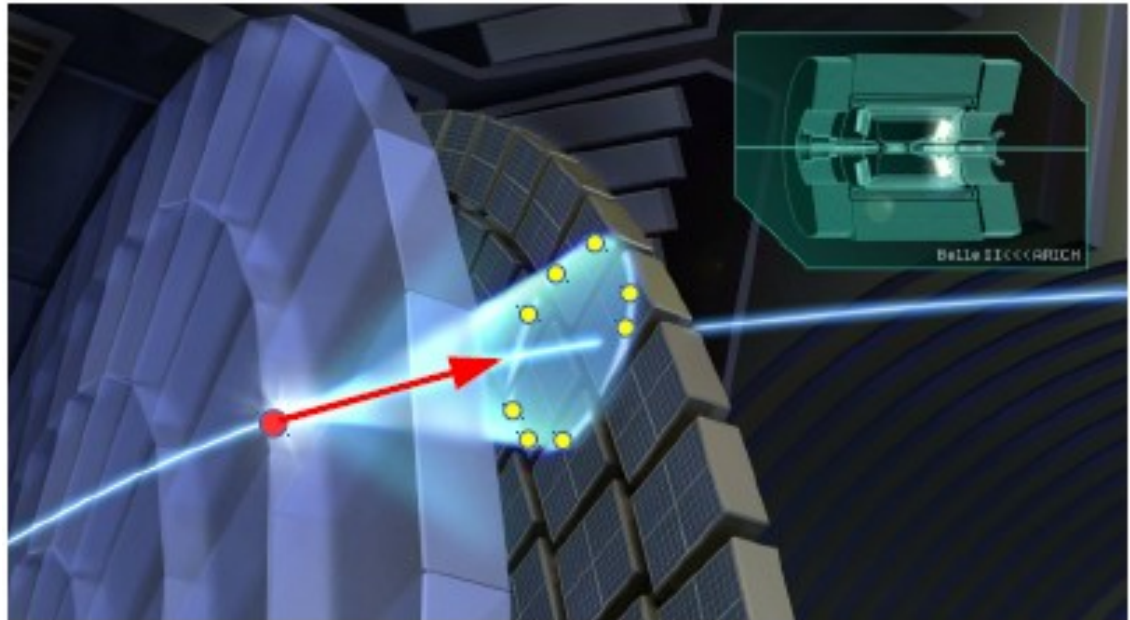
on behalf of the Belle2 ARICH group:

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Outline

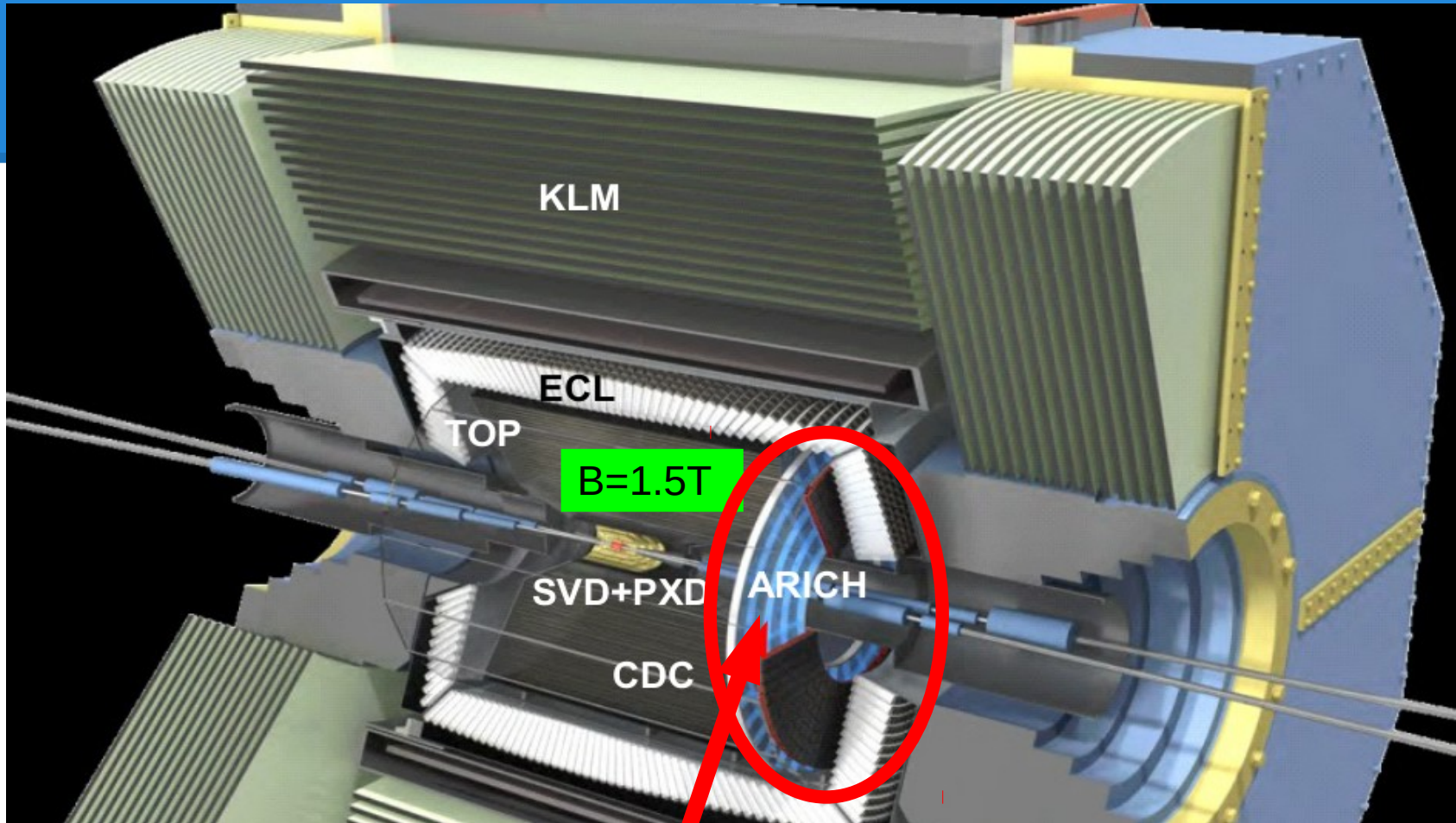
- Introduction
- Status of the project
- Achievements
- Schedule
- JENNIFER impact
- Summary



JENNIFER deliverables - ARICH part:

full commissioning and calibration → march 2018





Two dedicated particle ID devices -

both RICHes – designed to fit into available space:

- Barrel: imaging Time-Of-Propagation (TOP)

Talk by Tara Nanut

- End-cap: **Proximity focusing Aerogel RICH (ARICH)**

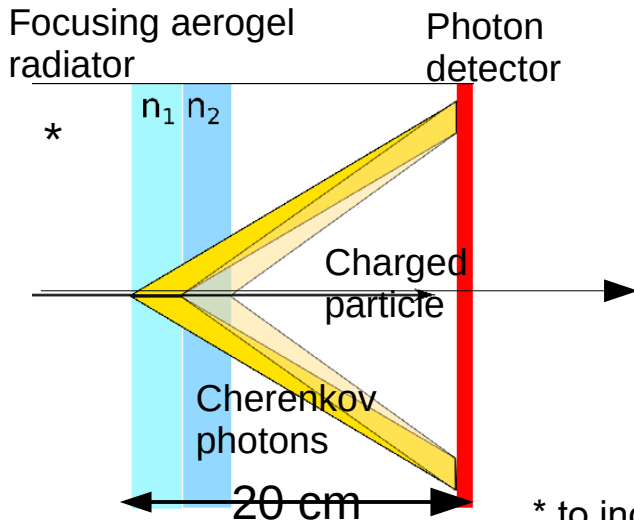
Introduction : Aerogel RICH

Goals and constraints:

- $> 4 \sigma$ K/ π separation @ 1-3.5 GeV/c
- operation in magnetic field 1.5T
- limited available space ~ 280 mm
- radiation tolerance (n, γ)

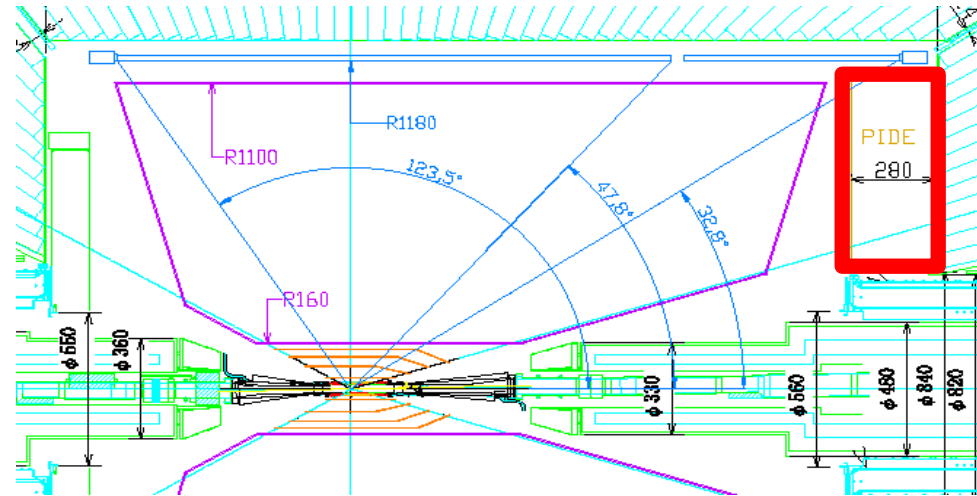
Selected type:

proximity focusing aerogel RICH



- $\langle n \rangle \sim 1.05$
- $\theta_c(\pi) \approx 307$ mrad @ 3.5 GeV/c
- $\theta_c(\pi) - \theta_c(K) = 30$ mrad @ 3.5 GeV/c
 - pion threshold 0.44 GeV/c,
 - kaon threshold 1.54 GeV/c
- neutron fluence: up to $\sim 10^{12}$ n/cm²
- radiation dose: up to ~ 1000 Gy

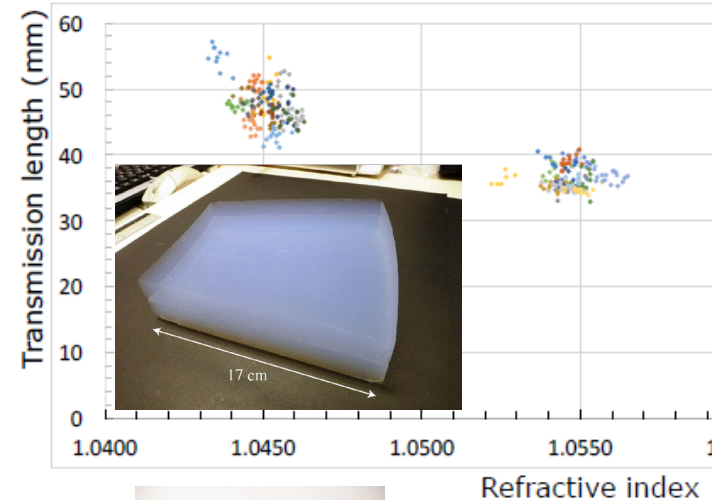
* to increase the number of photons without degrading the resolution



ARICH components

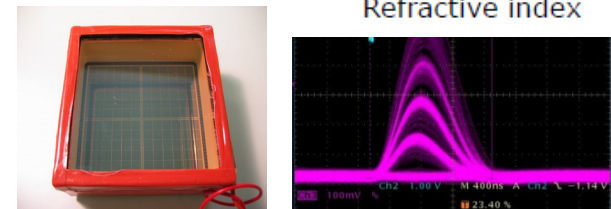
Aerogel radiator:

- Two 2cm thick layers $n_1 = 1.045$ $n_2 = 1.055$
- Optical transparency limited due to Rayleigh scattering
- large tiles $18 \times 18 \times 2 \text{ cm}^3$ to minimize photon losses at the edges



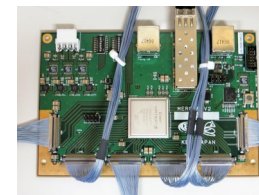
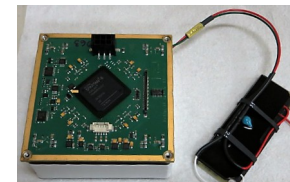
Hybrid Avalanche Photo Detector - HAPD

- 144 channels, total area 7cm x 7cm
- Excellent separation of single photoelectrons
- Works in a magnetic field of 1.5T



Readout Electronics: limited space behind the HAPD- 5cm

- Front-end board with 4 ASICs and Spartan6 FPGA
- Merger board prototype with Virtex5 FPGA:
JTAG, optical link, trigger in, front-end connector



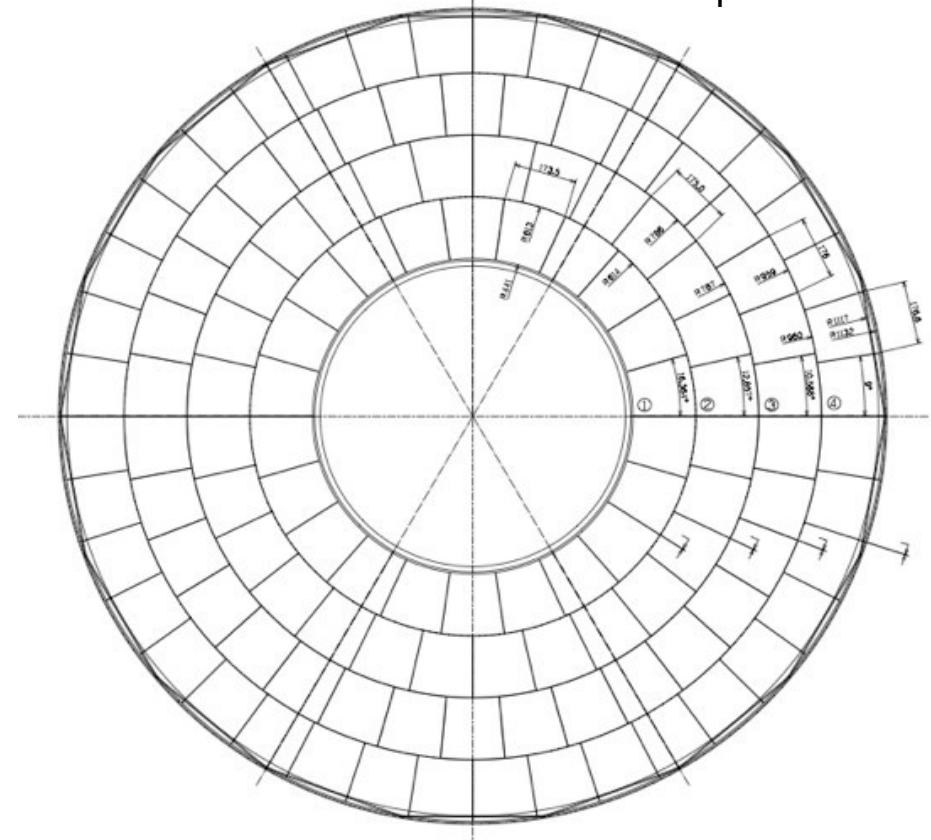
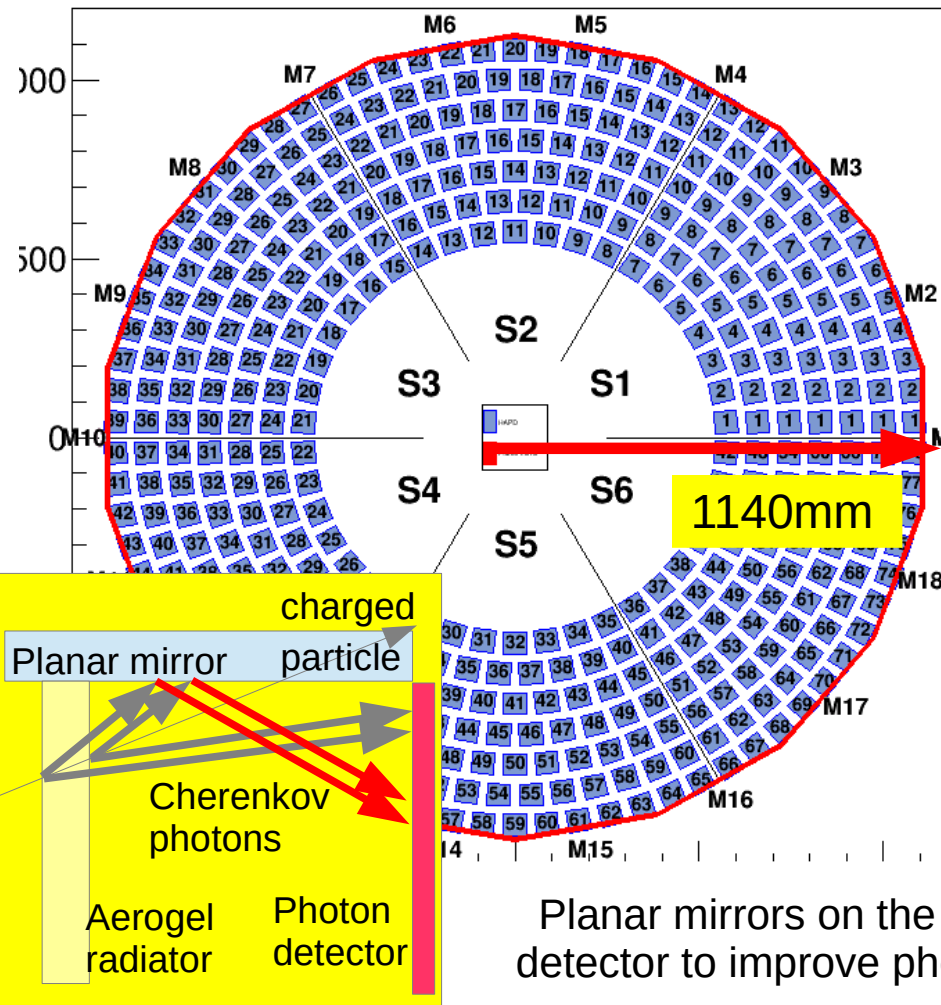


420 HAPD modules in 7 rings

Aerogel : 124x 2 layers

-wedge shape

strict mechanical tolerances to minimize photon loss

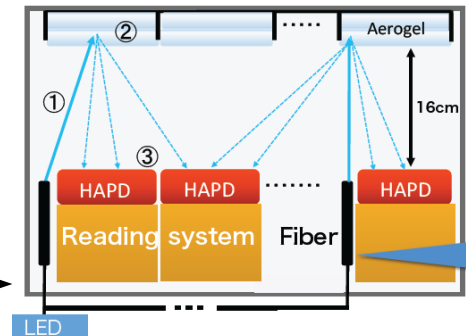
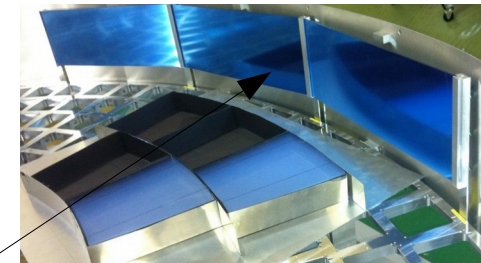
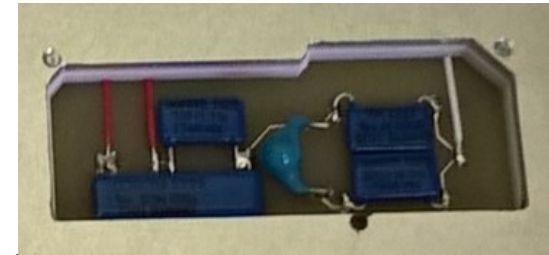


Planar mirrors on the edge of the detector to improve photon detection

Status of the ARICH project

Mass production of the components finished:

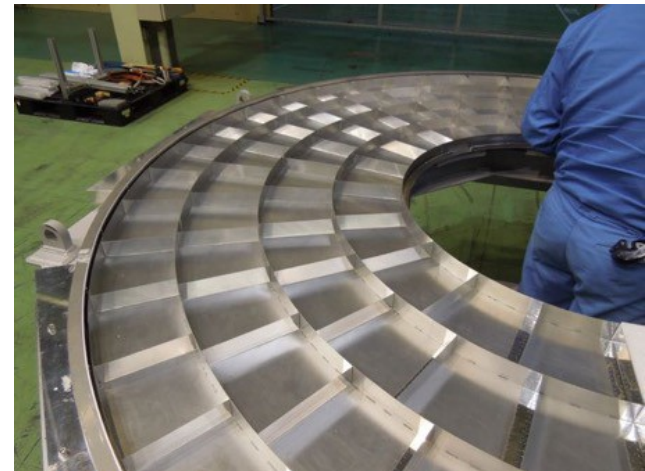
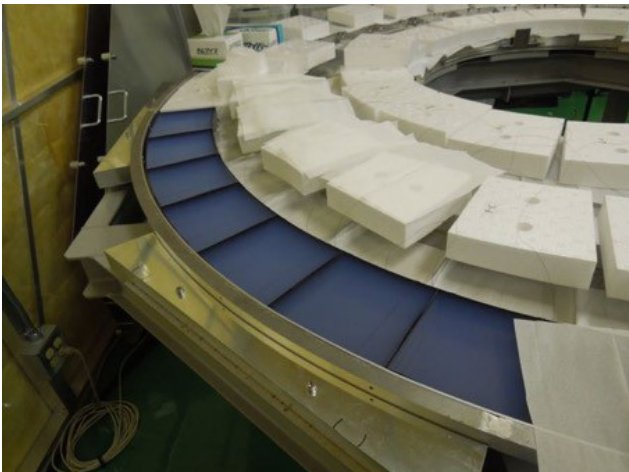
- Aerogel wedge tiles produced and cut to final shape
- 420 HAPDs (90% of the delivered samples operational, the remaining 10% were/will be replaced by the end of 2016)
- Readout Front End Boards: tested and delivered
- Merger boards
- HV divider boards to fix the metal ring potential
- Planar front surface mirrors
- LED Monitor system prepared: LED light reflected from the aerogel surface



Aerogel Tiles Installation



65 % aerogel tiles installed in the aerogel frame
will be finished by Oct. 2016





Status of the ARICH project

HAPD module: HAPD + FEB + HV divider

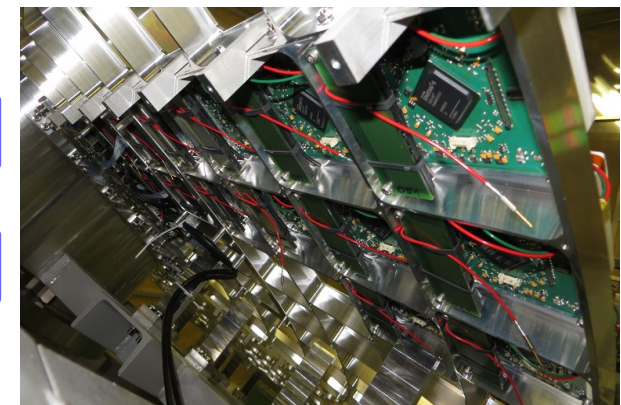
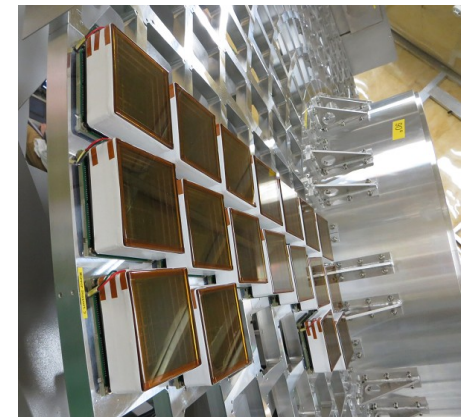
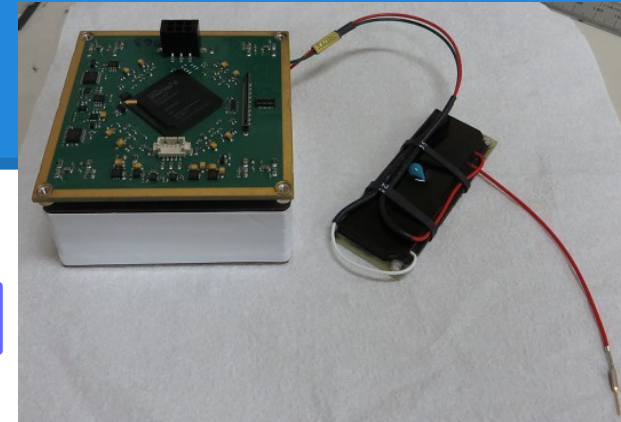
- assembly and tests almost finished → waiting for the getter reactivation



- Merger boards (1 fo 6 FEBs) will be installed after FEBs



- 1 already installed for cosmic ray tests
- LV power supplies delivered
- HV power supply system → now ordering → expected delivery Q1 2017
- polyethylene boron shield: 1/12 prototype t → delivery end of Oct. 2016
- DAQ chain through Belle2Link established
- Software and event display ready
- Databases populated and constantly updated



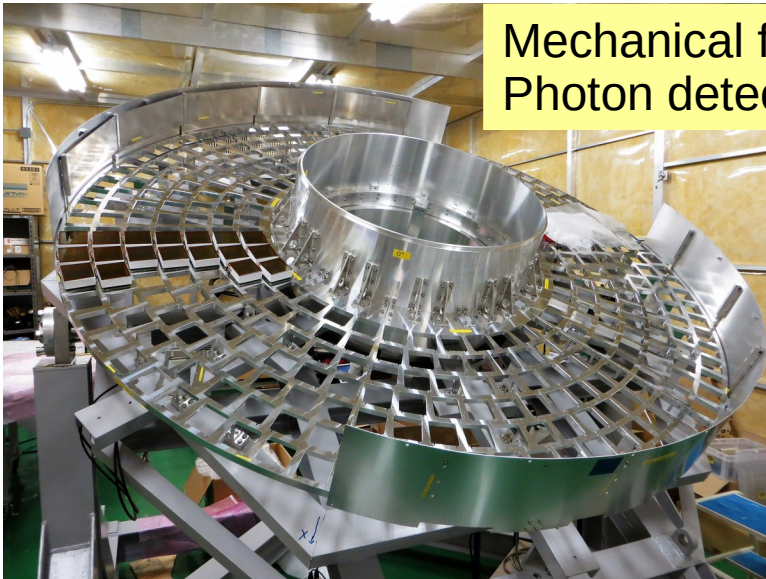


Photon detector installation

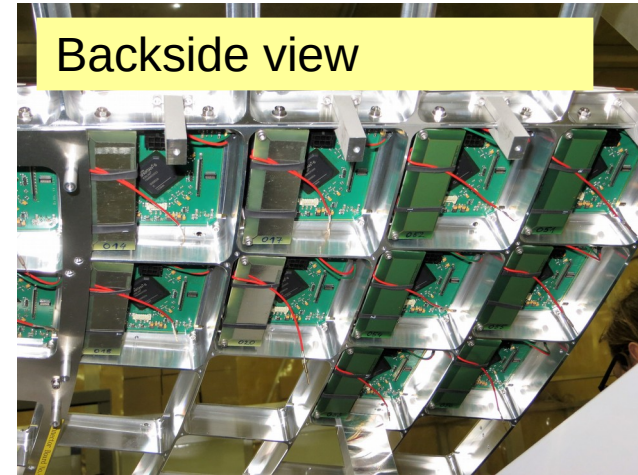
HAPD Modules are being installed to the structure



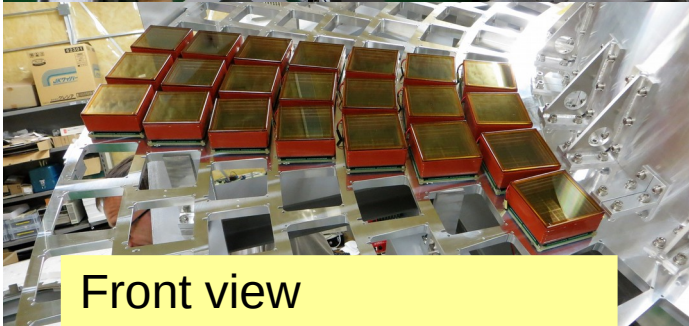
Mechanical frame -
Photon detector part



Backside view



Front view



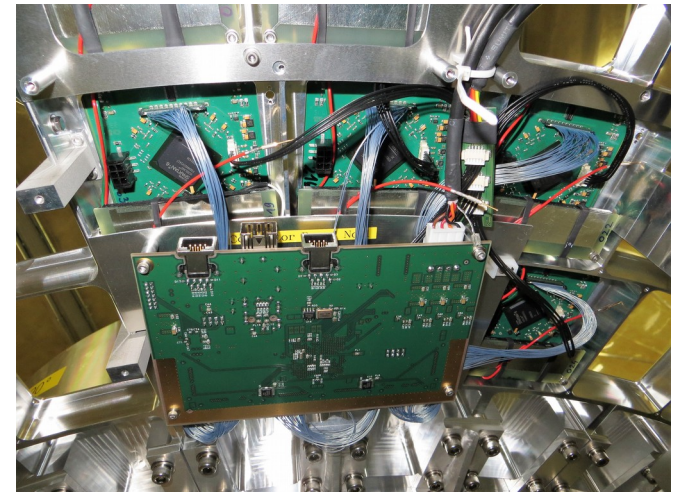
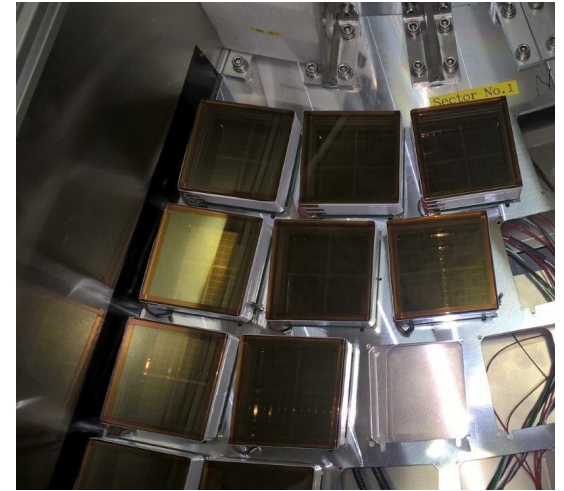
1/6 of the
detector
equipped



the rest will follow in the Q4 2016



Partially equipped photon detector
+
Aerogel tile
+
2 triggering scintillators



Achievements: First Cherenkov Rings with cosmic particles

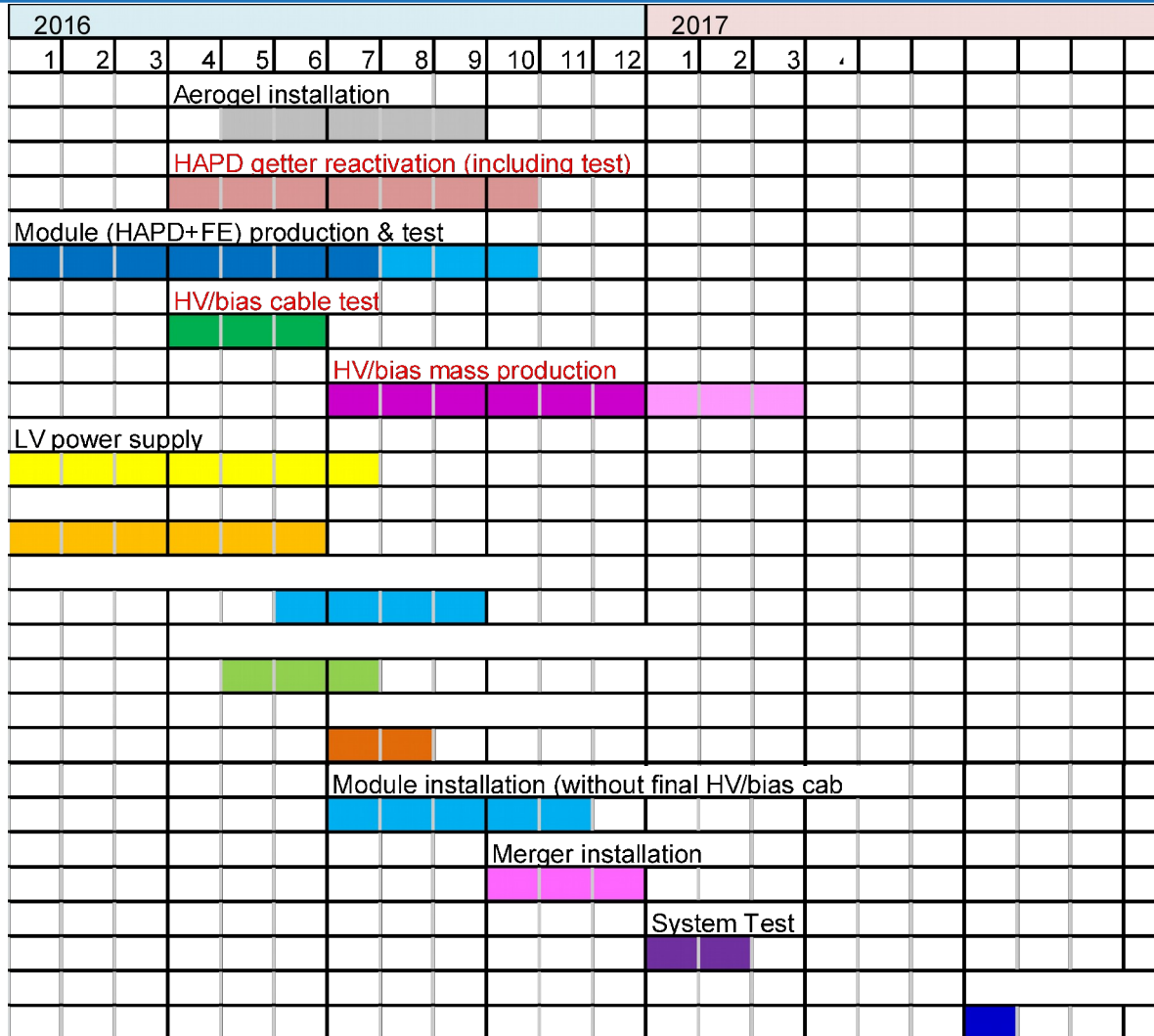


Clear isolated rings visible

Cherenkov photons
produced in the HAPD
window

Successful measurement of rings: 1st step toward the fully operational ARICH

ARICH schedule



Installation before roll-in
→ end of Feb 2017

Impact of the JENNIFER secondments

Direct impact:

Jennifer secondments enable

- crucial on-site presence during construction and commissioning of the ARICH,
- young researchers : extended stays now possible
- face-to-face cooperation with group members from other countries

Indirect impact:

Enable the European institution to be part of the leading groups in the particle identification instrumentation by Cherenkov radiation:

- Jožef Stefan Institute organized the most important conference in the area of Ring Imaging Cherenkov Detectors – RICH 2016, Sep. 4-9, Bled, Slovenia
- Samo Korpar → invited talk at the RICH 2016
- 12 contributions from the group on the RICH 2016

Summary

- Proximity focusing RICH with an aerogel as a radiator will be employed for efficient particle identification in the forward end-cap of the Belle2 spectrometer
 - The beamtest results and the detector simulations:
excellent kaon ID efficiency >95% for $p=0.5 \dots 3.5$ GeV/c @ low pion mis-ID prob. of 1%
 - Status
 - The mass production of the detector parts is finished.
 - Detector modules assembled → installation in the mechanical frame in progress
 - The installation in the Belle II spectrometer: 2017
 - Commissioning started
 - Achievements: The cosmic tests with partially equipped detector are under way. First rings have been recorded
- Installation of ARICH is progressing as planned
 - No delay is expected to finish the commissioning of the ARICH by the deadline
 - Jennifer enables to participate the researchers from European Institute (JSI) in R&D , the installation and the commissioning of the detector, and to share their expertise with the Japanese collaborators.