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

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

*Talk by Tara Nanut*
Introduction : Aerogel RICH

Goals and constraints:

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

Selected type:

proximity focusing aerogel RICH

- $<n> \sim 1.05$
- $\theta_c(\pi) \approx 307 \text{ mrad } @ 3.5 \text{ GeV/c}$
- $\theta_c(\pi) - \theta_c(K) = 30 \text{ mrad } @ 3.5 \text{ GeV/c}$
- pion threshold 0.44 GeV/c,
- kaon threshold 1.54 GeV/c
- neutron fluence: up to $\sim 10^{12} \text{ n/cm}^2$
- radiation dose: up to $\sim 1000 \text{ Gy}$

* to increase the number of photons without degrading the resolution

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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 $7\text{cm} \times 7\text{cm}$
- 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

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ARICH geometry design

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
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 light 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
- DAQ chain through Belle2Link established
- Software and event display ready
- Databases populated and constantly updated
HAPD Modules are being installed to the structure

Mechanical frame - Photon detector part

1/6 of the detector equipped

the rest will follow in the Q4 2016
Commissioning: Cosmic Ray tests

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: 1\textsuperscript{st} step toward the fully operational ARICH
### ARICH schedule

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- **Aerogel installation**
- **HAPD getter reactivation (including test)**
- **Module (HAPD+FE) production & test**
- **HV/bias cable test**
- **HV/bias mass production**
- **LV power supply**
- **Module installation (without final HV/bias cab)**
- **Merger installation**
- **System Test**

**Installation before roll-in**

→ end of Feb 2017

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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 ..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.