The upgraded LHCb RICH detector: status and perspectives

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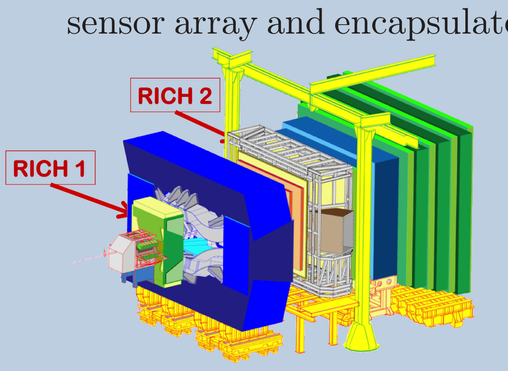
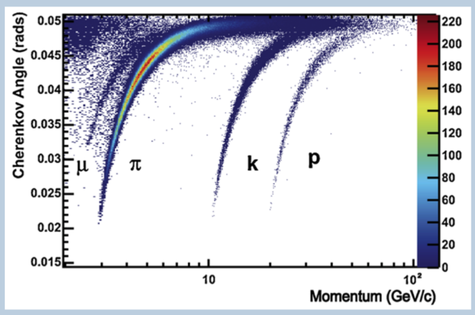
The LHCb experiment and its RICH detectors

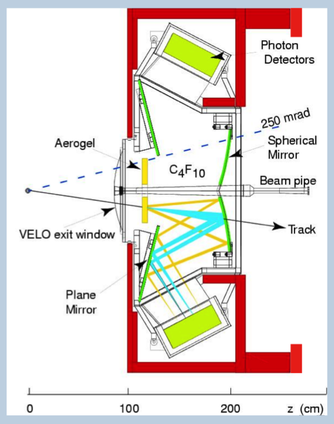
- The LHCb experiment at LHC is dedicated to probe New Physics in CP violation and rare decays of b and c quarks [1]
- An excellent particle identification (PID) is fundamental
- RICH detectors are able to identify charged hadrons in a momentum range $1.5 \div 100\,\mathrm{GeV}/c$ using two detectors (RICH-1 and RICH-2) and 3 radiators [2]
- Photon detectors: Hybrid Photon Detector (HPD) with pixel sensor array and encapsulated electronics (1 MHz maximum rate)



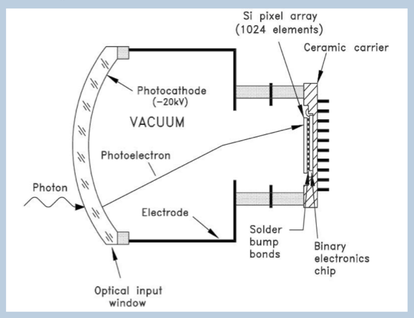
Layout of the current LHCb detector



Reconstructed Cherenkov angle



Layout of the current RICH-1 detector

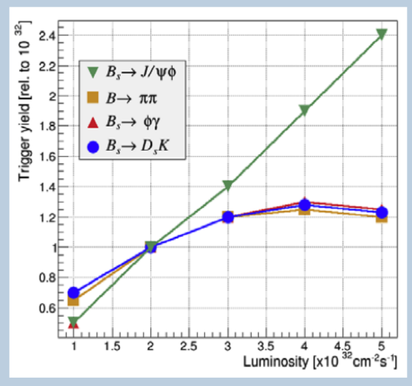


A schematic picture of the Pixel HPD

The LHCb Upgrade

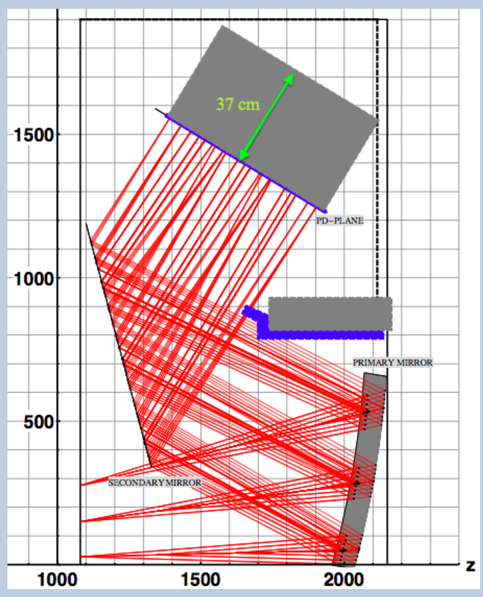
Plan for the LHCb upgrade in 2018 during the second long shutdown (LS2) in order to fully exploit LHC flavour physics potential [3]

- Goal: collect $50\,\mathrm{fb}^{-1}$
- Running @ $\mathcal{L} = 2 \cdot 10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Remove trigger limitations and readout detector @ 40 MHz



Upgrade of the RICH-1 optical system [4]

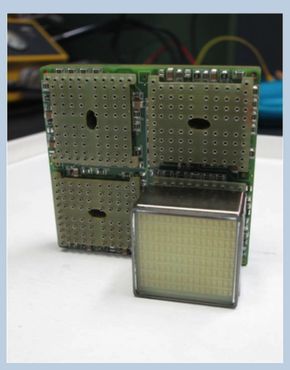
- RICH-1 optical layout has to be modified to be able to handle higher detector occupancies: the prohibitively large occupancy ($\sim 35\%$) in the upgrade environment would decrease the PID performance
- Increased focal length of the RICH-1 spherical mirror and optical layout modified taking into account mechanical constraints
  - Reduced peak occupancy
  - Photon yield increased
  - Improved resolution on the Cherenkov angle and on PID performance



RICH-1 upgrade optical layout optimised using a ray tracing software

Final mechanical design is almost completed

Replace RICH photodetectors [4]



Hamamatsu MaPMT R11265

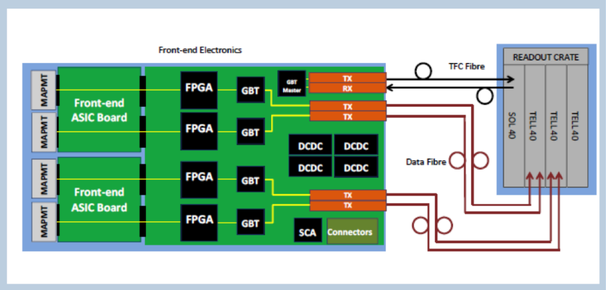
- 64 (8×8) pixels in $23 \times 23\,\mathrm{mm}^2$

Hamamatsu MaPMT H12700 to be installed in the outer regions of RICH-2 where the occupancy is smaller

- 64 (8×8) pixels in $48.5 \times 48.5\,\mathrm{mm}^2$

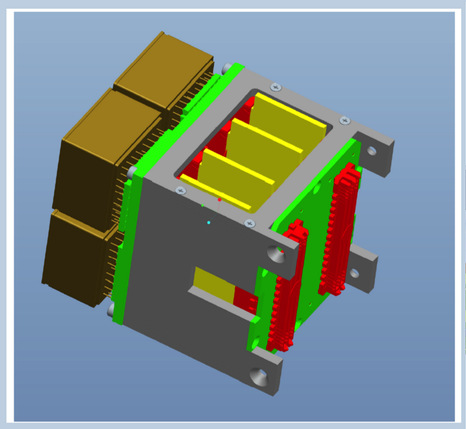
External front-end electronics (custom CLARO chip) and digital board [see P. Carniti's poster: "ALDO: a radiation-tolerant, low-noise, adjustable low dropout linear regulator"]

- Adjustable channel gain and discriminator threshold
- Fast electronics
- Low power consumption
- Radiation tolerance verified in irradiation tests

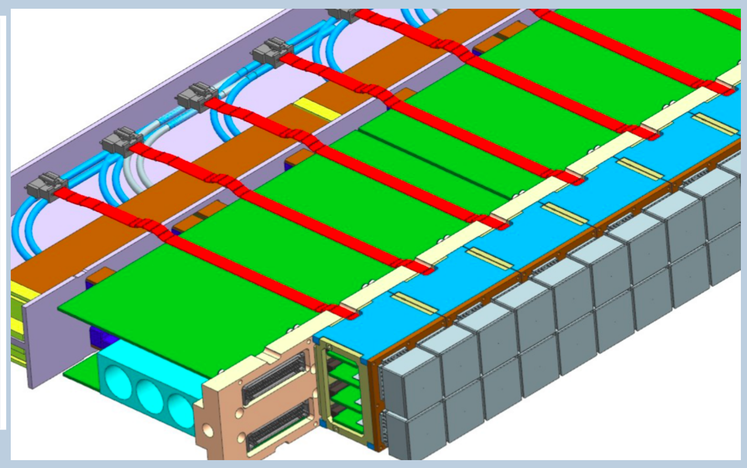


Mechanical structure: MaPMT modules

- To provide heat dissipation into the cooling system
- To provide also structural stability, ease of access, modularity

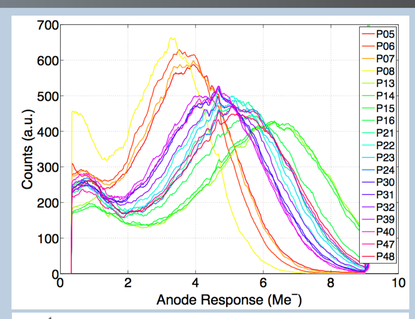


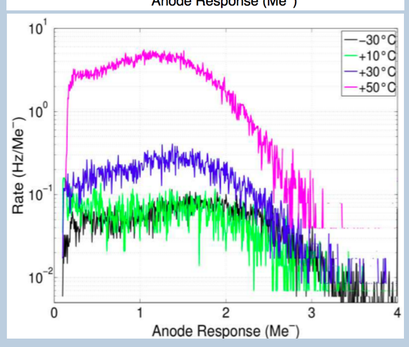
Basic unit: Elementary Cell



Characterization of MaPMT in laboratory

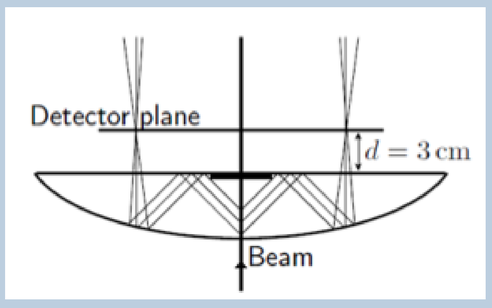
- Single photon gain and uniformity ($2 \div 3$)
- Dark current rate ($< 5\,\mathrm{Hz}$) per pixel
- Cross-talk ($< 1\%$)
- Behaviour vs Temperature
- Tolerance to magnetic fields and shielding [see S. Gambetta's poster "Behaviour of multi-anode photomultipliers in magnetic fields for the LHCb RICH upgrade"]
- Aging



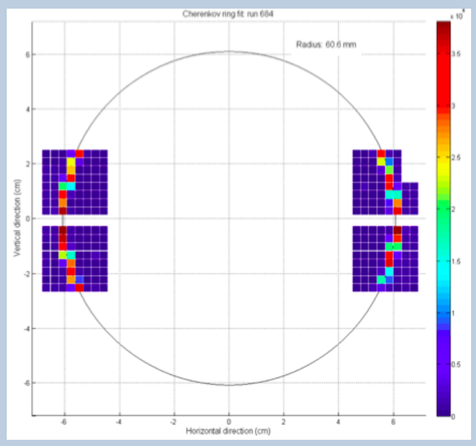


Testbeam with the full opto-electronics chain @ SPS North Area at CERN

- Test and qualify MaPMT, prototype housing and FE assemblies
- Using solid radiator with focusing geometry (lens)



Recorded Cherenkov rings with the full readout chain!



- Next testbeam in July to test several ECs with the new version of the readout electronics and with a mechanical structure prototype

References

[1] LHCb Collaboration, JINST **3** (2008) S08005.

[2] LHCb RICH Collaboration, Nucl. Instrum. Meth. A **766** (2014) 245.

[3] CERN-LHCC-2011-001, "Letter of Intent for the LHCb Upgrade"

[4] CERN-LHCC-2013-022, LHCB-TDR-014