The upgrade of the LHCb RICH detector
Matteo Bartolini

The LHCb experiment
- Single arm spectrometer dedicated to precision measurements of heavy quark physics probing indirectly new physics phenomena beyond the Standard Model in CP violation measurements, rare decays of $b$ and $c$ quarks and in the spectroscopy sector [1]

The RICH detectors
- The RICH detectors are able to identify charged hadrons in the final state using Cherenkov radiation
- Two RICHes provide PID in a wide momentum range
  - The emitted photons are focused by a system of reflecting mirrors into a photo-detector plane made of MaPMTs

The RICH detectors
- The experiment control system
  - The LHCb experiment
  - Used to configure the CLARO chips to the TELL40 boards. It is also PDMDB. It handles the data pack-
    - Every PDM is readout by the aPhotodetectorModule (PDM)
    - 4 ECs are grouped together to form a Photo Detector Module (PDM)
      - An R-type PDM is served by two PDMDBs whereas
      - an H-type PDM by only one PDMDB.
    - Every PDM is readout by the PDMDB. It handles the data packing and sends them via optical links to the TELL40 boards. It is also used to configure the CLARO chips

The upgraded photon-detection chain [2]
- The photodetecting unit consists of 8 x 8 pixel MaPMT produced by Hamamatsu Photonics with two different pixel sizes:
  - 2.8 x 2.8 mm² pixel size to cover the entire RICH1 and the central part of RICH2
  - 5.6 x 5.6 mm² pixel size to cover the outer part of RICH2.
- The analog signal produced by the MaPMTs is shaped, amplified and digitized by the CLARO chip:
  - 8-channel ASIC realized in 0.35 μm CMOS technology
  - Each channel is equipped with a 6-bit programmable threshold and a 2-bit programmable gain.
- The MaPMTs and the CLARO are assembled in Elementary Cells (ECs)
  - R-type EC, composed of four 2.8 x 2.8 mm² pixel size MaPMTs
  - H-type EC, composed of one 5.6 x 5.6 mm² pixel size MaPMTs
- 4 ECs are grouped together to form a Photo Detector Module (PDM)
  - An R-type PDM is served by two PDMDBs whereas
  - an H-type PDM by only one PDMDB.

The upgraded optical system [3]
- Keep the maximum detector occupancy < 30% at the new luminosity (x 5 increase)
  - The focal length of the spherical mirror is increased from 2710 mm to 3650 mm,
  - The photo detector plane is moved further away from the beam line
- Re-arrangement of the spherical mirror configuration allows to decrease the emission point uncertainty

Single channel calibration & time alignment
- Single photon detection efficiency is a crucial parameter of the RICH system
  - Each CLARO channel is calibrated by injecting a known charge
  - Thresholds are optimized channel by channel taking into account noise and gain
  - A time gate at the front-end (FE) electronics excludes out-of-time background photons selecting only prompt Cherenkov light (see Floris Keizer’s poster number 310) [4]

Performance
- The performance is evaluated using the LHCb simulation framework
  - The resolution of the Cherenkov angle $\sigma_C$ per track improved by a factor 2 for RICH1 and for RICH2
  - Improved PID capability

References