THE LHCb RICH DETECTORS*

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LHCb, one of the experiments of the Large Hadron Collider at CERN, has been designed for high-precision measurements of the parameters of the CKM quark-mixing matrix, and for studies of rare B-hadron decays. An essential part of the experiment is an efficient system of particle identification, effective over a momentum range of 1–100 GeV/c. For this we use two ring imaging Cherenkov detectors with three Cherenkov radiators. Photons in the wavelength range 200–600 nm are detected by 484 pixel hybrid photon detectors.

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LHCb is one of the experiments of the Large Hadron Collider at CERN. It is a single forward arm spectrometer (see Fig. 1(a)), designed to study CP violation and rare decays of B mesons to high precision [1]. The physics aims of the experiment require accurate particle identification. In addition to the calorimeter and muon systems, two separate Ring Imaging Cherenkov (RICH) detectors will provide efficient discrimination between charged hadrons, in particular pions and kaons.

The first RICH detector (see Fig. 1(b)) is positioned immediately downstream of the vertex locator. Charged particles that are within the LHCb geometric acceptance first traverse an aerogel radiator, before passing through a volume of C_4F_{10} gas. These two radiators will distinguish between charged pions and kaons over a momentum range of 1–10 GeV/c and 10–60 GeV/c respectively. Cherenkov photons that are generated in the radiators are then reflected and focused by spherical carbon-fibre mirrors situated above and below the beam pipe, and then are reflected again off planar mirrors, to pass through a quartz window and reach the photon detector enclosure. Further downstream is RICH 2, equipped with a CF_4 radiator to cover momenta up to 100 GeV/c.

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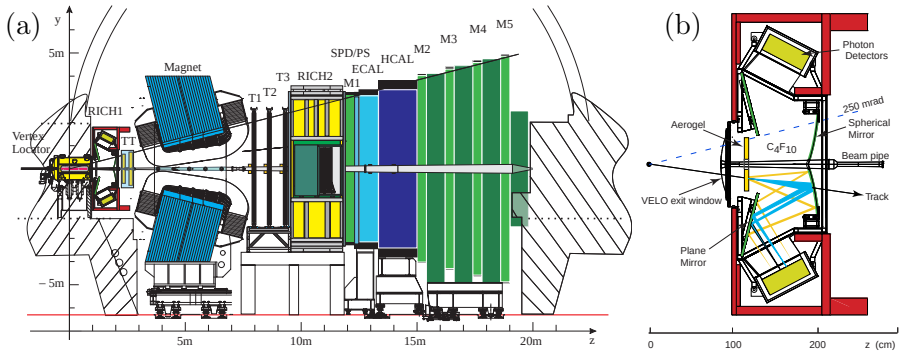

Fig. 1. (a) Schematic diagram of the LHCb detector [1]: to the left is the silicon vertex locator installed around the collision point, followed by the RICH 1 detector, a dipole magnet, tracking stations, the RICH 2 detector, electromagnetic and hadronic calorimeters and finally muon chambers. (b) In the RICH 1 sub-detector [1], Cherenkov photons, emitted by the passage of fast charged particles through the radiators, will be detected by planes of pixel HPDs.

Photons will be detected in both RICH detectors with pixel hybrid photon detectors (HPDs) [2] consisting of a quartz window on which is deposited a multialkali (S20) photocathode. A 20 kV potential is used to accelerate and cross-focus photoelectrons onto a silicon pixel anode at the base of the HPD. The sensor is segmented into an array of 32×32 pixels. Each pixel measures 0.5×0.5 mm and corresponds to a granularity of 2.5×2.5 mm on the photocathode. The two RICH detectors will require 484 HPDs in total.

A prototype version of the RICH has been tested extensively, with beams at Frascati and CERN [3]. Tests with a nitrogen radiator and Cherenkov rings fitting onto a single HPD photocathode enabled an analysis of the Cherenkov yield and angular resolution, with good agreement between the data and a detailed simulation. Further tests, still under analysis, have used a beam structure closer to that intended for the LHC, with bunch gaps of 25 ns, and have used a C_4F_{10} radiator, resulting in the rings spanning three or four HPDs.

RICH 2 is fully constructed and installed in the experimental area. As of September 2007, it has been fully powered and read out, through a slice of LHCb's triggering and data acquisition system. Further testing of the system is underway. RICH 1 is still under construction in the experimental area and commissioning is scheduled to start in December 2007.

REFERENCES

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