CERN/LHCC 2000-050
30 November 2000

Review of the LHCb RICH Technical Design Report

1 Introduction

This document describes the process and conclusions of the review of the LHCb Ring Imaging Cherenkov detector (RICH), designed to identify charged particles in the LHCb detector. The RICH system consists of two detectors, RICH1 covering the angular range $25 < \theta < 300$ mrad and providing K/π separation over the momentum range $1 < p < 50$ GeV/c, and RICH2 covering the angular range $15 < \theta < 120$ mrad and providing K/π separation over the momentum range $15 < p < 150$ GeV/c.

Examples of B decay modes where particle identification is necessary include $B_d^0 \to \pi^+\pi^-$, $B_s^0 \to D_s^{\mp}K^{\pm}$, $B_d^0 \to \overline{D}^0 K^{*0} \to (K^+\pi^-)(K^+\pi^-)$. Good K/π separation also enhances the efficiency for B tagging via kaon decay modes and the RICH counters can be used in conjunction with the calorimeter and muon detection systems for positive identification of electrons and muons.

The TDR was received on 7 September 2000 (CERN/LHCC 2000-037). On 2 October, the LHCb referees discussed the document with the collaboration. The open presentation was given to the LHCC session on 4 October. Following the LHCC meeting the LHCb group received a number of questions. The response to these questions and the discussion of milestones took place in the referees' meeting on 27 November. The referees were D. Cassel, Y. Karyotakis, A. Rostovtsev, and H. Schellman.

2 Detector Technology

The LHCb RICH system consists of 2 detectors, one (RICH1) mounted before the analyzing dipole magnet and the other (RICH2) mounted after the tracking system and in front of the electromagnetic calorimeter. The RICH1 system uses silica aerogel ($n \sim 1.03$) and C_4F_{10} gas as radiators while the RICH2 uses CF_4 gas. Cherenkov photons in both detectors are reflected by mirrors onto active sensor planes with areas of several square meters. Prototype readout electronics for Level-0 (on-detector) multiplexing and Level-1 (off-detector) signal processing are under development.

The photodetector of choice is a pixel HPD (hybrid photodiode) built in cooperation with DEP, which incorporates a modified version of the pixel readout chip developed in collaboration with ALICE. Conventional Multi Anode PMT's are also being considered as a backup technology. Each of the 430 HPD photodetectors is

83 mm in diameter and has 1024 pixels with digital readout. The prototype pixel chip was not available at the time that the TDR was submitted. At the time of this review, prototype chips with full functionality had become available for testing. The preliminary test results were promising but some essential specifications were not met. The most serious deficiency is that the maximum rate of the chip is apparently 20 MHz instead of the required 40 MHz. The currently available chip will be encapsulated in prototype HPDs in order to validate bump bonding and the encapsulation technique using the the final HPD tube design. This will occur in parallel with further chip testing and correction of the chip design if that proves to be necessary.

The detector layout has been optimized using a full simulation of LHC events with backgrounds, including particles passing through the photodetectors themselves. Test beam data were used to set many of the parameters in this simulation. The average number of photoelectrons detected per ring ranges from 6.6 for low momentum particles traversing the aerogel to 33 for higher momentum particles which traverse the C_4F_{10} in RICH1. The average number of photoelectrons/ring in RICH2 is expected to be 18. The kaon identification efficiency predicted by these simulations ranges between 70% at low momenta to 95% above 10 GeV/c with purities ranging from 40% at the lowest momenta to 85-100% at momenta above 10 GeV/c.

3 Comments

The LHCC finds the detector technology adopted for the RICH adequate to achieve the physics goals stated in the Technical Proposal, and **congratulates** the LHCb collaboration for the quality of work presented in the TDR.

Although there are no major concerns, the LHCC notes that:

- The development of the HPD is a critical item that requires milestones on the project leading to the technical choice between the HPD and Multi Anode PMT options.
- LHCb should keep the LHCC informed of progress toward this technical decision.

The LHCC recommends that LHCb follows the established practice of conducting an independent reviews of the engineering designs.

A list of agreed milestones to monitor and regulate the progress of the project is appended.

RICH Milestones

Mechanics and Optics	
finish optimizing engineering design	Mar 2002
10% of mirrors produced	Sep 2002
50% of mirrors produced	Jan 2003
finish mirror production	Jun 2003
begin RICH1 assembly in IP8	Jan 2004
begin RICH2 installation in IP8	Jul 2004
Photodetectors	
finish prototype HPD	Jun 2000
technical choice	Sep 2001
production readiness review	Nov 2001
place photodetector order	Mar 2002
10% of detectors produced	Dec 2002
50% of detectors produced	Jun 2003
finish detector production	Feb 2004
finish detector testing	Mar 2004
Readout Electronics	
finish prototype chain tests	May 2002
10% of Level-0 units produced	Jul 2002
50% of Level-0 units produced	Mar 2003
finish Level-0 unit production	Dec 2003
30% of Level-1 units produced	Dec 2002
60% of Level-1 units produced	Jun 2003
finish Level-1 unit production	Dec 2003
finish production and testing	Jan 2004
RICH Detectors	
ready for commissioning with beam	Jul 2005