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Review of the Reoptimized Detector Design and Performance Technical Design Report

1 Introduction

This document describes the process and conclusions of the review of the Reoptimized Detector Design and Performance Technical Design Report. The LHCb detector has been reoptimized with respect to the Technical Proposal (TP) version, in order to reduce the material in the acceptance and improve the Level 1 trigger performance.

Precision measurements of the angles and sides of the unitarity triangle require the identification and reconstruction of many B meson decays with low branching fractions. Therefore, it is important to preserve a high trigger and reconstruction efficiency. The amount of material inside the acceptance region is directly related to the reconstruction efficiency. For the reoptimized detector, and taking into account the latest detector technologies ready to build, the radiation and interaction lengths X_0, λ_I in front of RICH2 are $\sim 40\%$, and $\sim 12\%$, respectively, which are comparable with the TP version. The introduction of a low magnetic field after the VELO detector and the trigger station (TT) allows an on-line transverse momentum measurement with a $\sim 20\%$ precision, used to improve the Level 1 rejection algorithm. The LHCb reoptimized detector maintains the physics capability as described in the TP.

The TDR was received on 9 September 2003 (CERN/LHCC 2003-030). On September 1 and 24 November 2003, the LHCb referees discussed the document with the collaboration. The open presentation was given to the LHCC session in September 2003. Following the LHCC meeting the LHCb group received a number of questions. The response to these questions and the discussion of milestones took place during the 67th LHCC meeting in November 2003. The referees were K.Borras, F.Ferroni and Y.Karyotakis.

2 Detector Technology

Most of the systems upstream of the RICH2 and across the LHCb acceptance have been affected by the effort to reduce the material budget.

- The number of VELO detector planes is reduced from 25 to 21. The thickness of the silicon sensors is reduced to $220\mu m$ and the RF foil was redesigned.

- The beam pipe consists of a 25 mrad, 1mm-thick Be cone, 1840 mm long, followed by a 25 mrad, AlBe one. Aluminum bellows are used to connect them.

- The RICH1 had to be redesigned. Two mirrors, a spherical one sitting inside the acceptance and a planar one located outside, focus the light on the photon-detector plane located on the top and bottom of the detector. Lightweight material is considered for the spherical mirrors. The photon-detectors have to be shielded against the magnetic field.

- The Trigger Tracker (TT) downstream of RICH1 consists of 4 detection layers (x,u,v,x) covering $143.5cm \times 118.5cm$. Layers (x,u) and (v,x) are separated by $30cm$. The detector is based on silicon wafers of $11cm$ long and $7.8cm$ wide with a read out strip pitch of 198 μm. It is located in the stray field of the LHCb magnet and provides transverse momentum information for the Level 1 trigger, while it improves the long-lived particle reconstruction efficiency. The overall detector design is well advanced.

- The number of tracking stations is reduced to three, all located downstream of the magnet.

The collaboration has performed a full simulation, including realistic detector performance and reconstruction. The robustness of the design has been checked by assuming conservative detector performances, lower efficiencies, higher noise, etc. and higher track multiplicities. Tracking efficiency, ghost rates and particle identification performances are adequate for the physics programme. For few key channels, ex: $B^0 \rightarrow J/\psi\varphi$, $B_s^0 \rightarrow D_s^- h^+$, a full analysis has been performed to check the sensitivity of the experiment to important CP violating parameters. The physics expectations of the reoptimized detector will allow a precision measurement of the CP parameters, and a coherent test of the Standard Model.

3 Comments

The LHCC finds the detector reoptimization, 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:

- Magnetic field mapping in the RICH1 photon-detector region, including the magnetic shielding, has to be performed soon after the magnet installation.

- Studies on the physics capability of the experiment for the measurement of the CP parameters and the experiment's discovery potential should continue and the results should be documented.

Table 1: Milestones for the RICH 1 detector.

Milestone	**Date**
Mechanics and optics	
Engineering Design Review	June 2004
Production drawings completed	September 2004
Order for mirrors and structure placed	November 2004
Begin assembly at CERN	September 2005
Mirrors produced and tested	September 2005
Installation and commissioning	
RICH 1 begin installation in IP8	December 2005
System commissioned with $> 50\%$ photon detectors	September 2006

The LHCC recommends that LHCb follows the established practice of conducting independent reviews of the engineering designs. A list of agreed milestones to monitor and regulate the progress of the project is appended.

The LHCC **recommends** general approval of the LHCb Reoptimized Detector Design and Performance Technical Design Report.

Table 2: Milestones for the TT station.

Milestone	Date
Project	
Engineering design finished	October 2004
Full system ready for global commissioning	September 2006
Silicon sensors	
Final order placed	October 2004
10% sensors delivered	April 2005
All sensors delivered	October 2005
L0 electronics	
10% hybrids assembled and tested	April 2005
All hybrids assembled and tested	October 2005
Mechanics	
Detector station box ready for mounting ladders	August 2005

Table 3: Milestones for the beam pipe.

Milestone	Date
UX85/1 qualification prototype delivered	December 2003
Engineering Design Review	December 2003
Be beam pipe order placed	June 2004
Be beam pipe delivered	June 2005
Beam pipe installed	July 2006