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Review of the LHCb Inner Tracker Technical Design Report

1 Introduction

This document describes the process and conclusions of the review of the LHCb Inner Tracker Technical Design Report. The three tracking stations T1-T3, located between the magnet and the RICH2, consist of two different types of detectors. While the Outer Tracker is a Straw-Tube-Tracker, the Inner Tracker is equipped with silicon microstrip detectors.

The final states of many interesting B meson decay channels contain multiple charged particles. Therefore high single layer efficiency is required to achieve satisfactory overall reconstruction efficiency. For a low enough occupancy, to ensure high pattern recognition efficiency, the readout granularity of the detector has to match the requirements of particle fluxes as high as $5\times10^5\mathrm{cm}^2\mathrm{s}^{-1}$ while keeping the number of readout channels as low as possible to limit the costs. Excellent momentum resolution is required to obtain invariant mass resolutions of $\sim 10MeV/c^2$. Since multiple scattering dominates the momentum resolution special emphasis is put on minimising the material budget. Another key requirement for the design of the detector stems from the short time between the bunch crossings at the LHC, which demands a fast shaping time in the front-end electronics.

The TDR was received on 8 November 2002 (CERN/LHCC 2002-029). On 27 November 2002, the LHCb referees discussed the document with the collaboration. The open presentation was given to the LHCC session in November 2002. 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 LHCb Comprehensive Review at the 62nd LHCC meeting. The referees were K.Borras, F.Ferroni and Y. Karyotakis.

2 Detector Technology

The microstrip detectors chosen for the TDR use 320 μm thick single-sided p^+-on-n sensors with 384 strips per ladder and a strip pitch of 198μm. The 11 cm-long silicon sensors are mounted either alone or on 22 cm long ladders in case two sensors are chained. The geometrical layout is the result of an optimisation between the Outer Tracker occupancy and the Inner Tracker dimensions. It is made from four boxes upstream of the Outer Tracker layers. Each box contains four detector layers (x,u,v,x) with each layer built by seven staggered silicon ladders. In the top/bottom

boxes, one sensor ladder is used, while the two-sensor-ladders are mounted in the left/right boxes. A total surface of 4.2 m^2 is covered by 336 ladders.

The approximately 130k readout channels are connected to a readout hybrid and the front-end readout stores the detector signals with the LHC bunch crossing frequency of 40 MHz in an analog pipeline. A Beetle front-end chip, designed according to LHCb specifications and equipped with radiation-hard 0.25 μm CMOS, delivers the analog signal through $\sim$5m long copper cables to the service boxes for digitisation with 8-bit resolution. After the serialisation with a GOL chip the further data transmission to the Level-1 electronics is realized via $\sim$100m optical fibres for which commercial 12-fibre parallel VCSEL arrays were chosen. Finally the Level-1 electronics using the LHCb common readout board provides the interface to the data acquisition system and the Level-1 trigger.

3 Comments

The LHCC finds the detector technology adopted for the Inner Tracker 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 signal-to-noise ratio for the long ladders may become marginal. The collaboration should investigate all possibilities to improve it.
- Although the physics requirements for the region covered by this detector are fulfilled, the overall tracking performance has to be examined when the LHCb Detector Re-optimisation TDR will be submitted.

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.

Table 1: IT Milestones.

Milestone	Date
Project	
Final decision on production site(s)	06/2003
Engineering design finished	12/2003
First detector box in IP8, start of system commissioning	11/2005
Full system ready for global commissioning	09/2006
Silicon sensors	
Final order placed	03/2004
10% sensors delivered	09/2004
50% sensors delivered	01/2005
All sensors delivered	07/2005
L0 electronics	
BEETLE engineering run	03/2004
10% of hybrids assembled and tested	08/2004
BEETLE production run	12/2004
Readout link and service box	
Full prototype test of readout link	06/2003
L1 electronics	
Production of L1E boards started	03/2004
10% of L1E boards produced and tested	08/2004
50% of L1E boards produced and tested	04/2005
All L1E boards produced and tested	02/2006
Mechanics	
10% of ladder supports delivered	08/2004
Mechanics for first detector box ready	08/2004
Assembly	
Production sites ready	06/2004
Ladder assembly starts	09/2004
10% of ladders and first detector box assembled	01/2005
50% of ladders assembled	07/2005
All ladders and detector boxes assembled and tested	02/2006