CERN/LHCC 2000-049
30 November 2000

Review of the LHCb Calorimeters Technical Design Report

1 Introduction

This document describes the process and conclusions of the review of the LHCb Calorimeters designed to identify electrons, hadrons and photons, and to measure their energies and positions. This information is used in the Level-0 trigger for B meson decays. The Calorimeter system consists of four detectors: Scintillator Pad Detector (SPD), Preshower (PS), Electromagnetic Calorimeter (ECAL), and Hadron Calorimeter (HCAL) covering the same angular acceptance as the charged particle spectrometers: 300 mrad horizontally, 250 mrad vertically, with a hole 30 mrad in both directions.

Good electron identification is required for the Level-0 trigger in order to provide high enrichment for B semileptonic and $B \to J/\psi X$ decay modes. The electron trigger has to achieve a 99% rejection of inelastic pp collisions while remaining efficient for B events. The ability to trigger on high p_T hadrons allows measurements of CP asymmetry in purely hadronic B decay channels like $B_d^0 \to \pi^+\pi^-$ and $B_s \to D_s^{\mp}K^{\pm}$. The reconstruction of π^0 allows measurements of B meson decay channels $B_d^0 \to \pi^+\pi^-\pi^0$ and $B_d^0 \to \overline{D}^0 K^{*0}$ with $\overline{D}^0 \to K^+\pi^-\pi^0$ to constrain the α and γ angles respectively. A photon trigger is useful for the study of specific physics channels like $B_d^0 \to K^{*0}\gamma$.

The TDR was received on 6 September 2000 (CERN/LHCC 2000-036). 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 design of LHCb calorimeters does not appear to have any major technological risk.

The SPD/PS system is made from a lead converter plate of two radiation lengths that is sandwiched between two layers of scintillator pads. The SPD is used in distinguishing between charged and neutral particles, while the PS separates electrons from pions. The lead thickness has been optimised to generate a sufficient number of secondary particles for an incident electron and minimise the energy loss in the absorber. Both detectors consist of scintillating pads readout by WLS fibers. fiber coils are located in a groove machined into a scintillator pad. Clear fibers coupled to the WLS fibers form bundles and are connected to a 64 anode PMT.

For the ECAL the shashlik technology has been chosen, satisfying the energy measurement requirement, $\sigma(E)/E = 10\%/\sqrt{E} \oplus 1.5\%$, where E is measured in GeV. It consists of blocks with a sampling structure of 2 mm of lead sheets interspersed with 4 mm thick scintillator plates. Light is collected by a number of wavelength shifting fibers read out by a single photomultiplier.

The HCAL is made out of steel and scintillating tiles, running parallel to the beam axis. WLS fibers running along the edges of the scintillator tiles staggered in depth, are grouped together to define cells, read out by one photomultiplier.

The Calorimeter system has a quasi projective geometry. The same lateral segmentation, 3 different cell size zones, is adopted for the SPD, PS and ECAL, while the HCAL is segmented in only 2 zones reducing the number of readout channels. The total number of channels in each of SPD, PS, and ECAL is 5952, while it is 1468 for the HCAL.

The front end electronics is designed to handle the data for the Level-0 trigger as quickly as possible and includes an integrator followed by an ADC and a digital pipeline buffer. For the SPD a simple discriminator is used instead of an ADC.

3 Comments

The LHCC finds the detector technology adopted for the Calorimeter 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 TDR does not include much information on the support system and integration. LHCb should provide more detailed information on these items as the engineering designs develop.
- LHCb test beam plans should include testing some modules with the final electronics. Procedures for (inter-)calibration and monitoring should be established.

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.

Calorimeter Detector Milestones

SPD/PS	
finish optimizing engineering design	Jul 2001
start serial production	Jul 2001
10% of modules produced	Jul 2002
50% of modules produced	Jul 2003
finish module production	Jul 2004
finish supermodule assembly	Dec 2004
finish installation	Mar 2005
ECAL	
finish optimizing engineering design	May 2001
start serial production	Jun 2001
10% of modules produced	Dec 2001
50% of modules produced	Jul 2003
finish module production	Aug 2004
finish module assembly	Nov 2004
finish installation	Feb 2005
HCAL	
finish optimizing engineering design	Jun 2001
start serial production	Oct 2001
10% of modules produced	Jul 2002
50% of modules produced	Jul 2003
finish module production	May 2004
finish optics assembly	Jun 2004
finish installation	Dec 2004
Calorimeter System	
ready for commissioning with beam	Jul 2005

Calorimeter Electronics Milestones

SPD	
finish optimizing engineering design	Dec 2002
start serial production	Mar 2003
10% of ASIC produced	May 2003
50% of ASIC produced	Sep 2003
finish acceptance tests	Sep 2004
finish installation	Apr 2005
PS	
finish chip engineering design	Jun 2002
start chip serial production	Jul 2002
finish optimizing engineering design	Dec 2002
10% of cards produced	Dec 2003
50% of cards produced	Jul 2004
finish acceptance tests	Nov 2004
finish installation	Apr 2005
ECAL/HCAL	
finish optimizing engineering design	Sep 2002
start serial card production	Oct 2003
5% of cards produced*	Nov 2003
50% of cards produced	Aug 2004
finish acceptance tests	Jan 2005
finish installation	Apr 2005

* preseries production