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LHCb calorimeter calibration

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The calorimeter system of LHCb consists of an electromagnetic and a hadronic calorimeter (ECAL and HCAL), as well as of a scintillator layer (SPD) and a pre-shower detector (PS) that contribute to the identification of hadrons, photons, pi0s and electrons. The calorimeter system plays a key role at the first level of the LHCb trigger, for which it provides high pT candidates and particle identification.
Because of the similarity of input signals and functionalities, common electronic system for the ECAL and HCAL is used, based on a dead-timeless and low pedestal integrator system using delay lines, followed by ADCs and pipeline buffers. They both control the PMT response with LED system.
Based on commissioning and very first data, the presented results will include the preliminary calibration, and a first evaluation of detector performances in terms of efficiency and trigger capabilities.
In particular emphasis will be put on calibration methods which differ for the different sub-detector systems:
- E-flow procedure for ECAL and HCAL
- The response to electrons, pi0 or minimum ionizing particle for the ECAL.
- monitoring the response to a Cesium source for the HCAL.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

Calibration of the LHCb calorimeters
LHCb calorimeter group

LHCb, one of the four particle physics experiments at the Large Hadron Collider at CERN, will perform studies of CP-symmetry violation and rare decays of B-hadrons. Its results will contribute to complete the understanding of quark flavor physics in the framework of the Standard Model, and may reveal sign of the physics beyond.

LHCb is a single arm spectrometer with a forward angular coverage from approximately 10 mrad to 300 mrad in the horizontal projection and 250 mrad in the vertical projection. The choice of the detector geometry is motivated by the fact that at high energies both quarks from the bb-pairs are predominantly produced at small angles to the beams, a feature exploited in the flavor tag. LHCb consists on a magnet, a Vertex Locator (VELO), four stages of tracking system, two ring imaging Cherenkov detectors, a calorimeter system and the muon system.

The main purpose of the calorimeter system is the selection and identification of hadrons, electrons and photons, and the measurement of their energies and directions, both at the first trigger level and at the offline event reconstruction. The reconstruction with good accuracy of pi0 and prompt photons is essential for event selection and for the study of B-meson decays and therefore is important for the LHCb physics program.
Four detectors are associated to perform such identification. In front of a classical structure of an electromagnetic calorimeter (ECAL) followed by a hadron calorimeter (HCAL), a double scintillation pad wall interlaid with a 2.5 radiation length lead wall allow to tag the charged particle (SPD) and to identify the electromagnetic nature of particles (PS) .

The PS/SPD, ECAL and HCAL adopt a variable lateral segmentation since the hit density varies by two orders of magnitude over the calorimeter surface. A segmentation into three different sections has been chosen for the ECAL and projectively for the SPD/PS. Given the dimensions of the hadronic showers, the HCAL is segmented into two zones only with larger cell sizes.
All calorimeters follow the same basic principle: scintillation light is transmitted to a photo-
multiplier (PMT) by wavelength-shifting (WLS) fibres. The single fibres for the SPD/PS cells are read out using multianode photomultiplier tubes (MAPMT), while the fibre bunches in the ECAL and HCAL modules require individual phototubes. In order to have a constant ET scale the gain in the ECAL and HCAL phototubes is set in proportion to their distance from the beampipe.

Because of the similarity of input signals and functionalities, common electronic system for the ECAL and HCAL is used , based on a dead-timeless and low pedestal integrator system using delay lines, followed by ADCs and pipeline buffers. In a similar way SPD/PS have common control electronics.
Performances of these detectors have been measured in test beams, and several calibration procedures have been exercised which differs for the different sub-detector systems:

- monitoring of the response to electrons, pi0 or minimum ionizing particle for the ECAL.
- monitoring the response to a Cesium source for the HCAL.
- monitoring the response to minimum ionising particle for PS and SPD

These procedures allow for both inter-cell and absolute energy calibration.

For each of the calorimeter sub-detectors a LED monitoring system illuminate each cell (or group of cells for PS/SPD) to monitor the PMT stability during data taking. The measured gain variation is used online to correct the energy calibration.

The foreseen contribution will cover, for the four sub-detectors, their design, calibration and monitoring, putting the emphasis on the coherence of the common choices and procedures to exploit and run the LHCb calorimeters.

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