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Commissioning of the ATLAS Tile Calorimeter

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TileCal is the barrel hadronic calorimeter for ATLAS at the LHC/CERN, made of iron and scintillating tiles and read out by wavelength-shifting fibers and photomultiplers. The commissioning of the detector in the ATLAS cavern started in 2005, and in September 2008, it participated successfully in the data taking with the LHC start-up single beam runs, with more than 98 % of the channels active. After the LHC shutdown, the TileCal commissioning activities focused on repairing additional channels, improving the detector calibrations and data quality procedures, and using the cosmic muon data to provide cross-checks on those calibrations an on the overall performance of the detector. This communication summarizes these aspects of the recent TileCal commissioning activities and provides a status of the detector readiness for pp collisions.

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1. Detector Description

TileCal[1] is the central region hadronic calorimeter of the ATLAS experiment[2] at the CERN Large Hadron Collider. TileCal is a sampling calorimeter using iron as absorber and tiles made of plastic scintillator as the active material. The tiles are oriented perpendicularly to the beam direction and staggered in radial depth. The light readout is done by wavelength-shifting optical fibers, that couple to photomultipliers (PMTs) located at the outer part of each module. Each of the TileCal barrels (a central, Long Barrel, and two Extended Barrels) are divided along phi in 64 modules ($\Delta\phi \sim 0.1$). The modules are divided in three radial layers, and cells with a $\Delta\eta$ of 0.1 (0.2 for the last layer).

Together with the central liquid argon(LAr) electromagnetic calorimeter, TileCal will measure the energy and direction of particle jets and, making use of a very good hermeticity, contribute to the determination of the event's missing transverse energy, in the region of $|\eta| < 1.7$. Performance studies carried out with test beams[3] show a very good resolution for pions, described by a stochastic term of $\frac{52.9\%}{\sqrt{E}}$ and a constant term of about 2.5% (measured in the 2004 ATLAS combined test beam), in good agreement with Monte Carlo simulations.

2. Detector Status and Performance of Calibration Systems

The TileCal electronics underwent a thorough program of repairs and refurbishing. During the last maintenance period (November 2008 - May 2009), this program was completed, in which 81 (32%) front-end electronics drawers were opened and repaired, and 11 (4.2%) low voltage power supplies (LVPS) were replaced or repaired. For future maintenance and repairs, 5% of spares for all components are available. After this maintenance program, 98.74% of the channels, or 99.07% of the cells, are operational. The data quality is continuously monitored to identify (and repair or mask) any malfunction (e.g. data corruption, high noise, LVPS failures). The cell noise level is between 30 MeV and 60 MeV (depending on the channels) and is very stable, with an overall variation within 1% over several months. A new description of the channel noise, based on a two gaussian model, was recently implemented, and contributed to a reduction in fake cell cluster seeds.

The response of TileCal is regularly monitored and corrected using a series of calibration systems that focus on each main detector component:

- The Charge Injection System (CIS) generates calibrated amplitude pulses, sent to each electronics channel. It allows the measurement of the number of ADC counts per picoCoulomb, with a measured stability below 0.1% over several months.

- The Laser system provides light pulses that are sent to all the PMTs with an optical fiber distribution system. It allows the measurement of the PMT gain stability, measured to be within 1%, and the synchronization of the channels.

- The Cesium calibration uses a hydraulic system to move a ^{137}Cs source through all the cells of TileCal. The detector response is measured with a charge integration system, and it allows the response of all cells to be equalized, by setting different PMT gains to compensate for non-uniformities in the optics part of the detection chain.

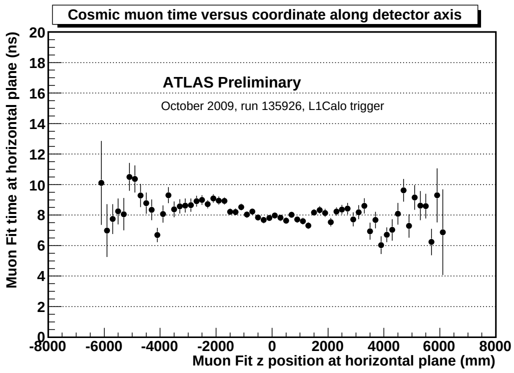

Figure 1: Time response for cosmic muons. The y axis shows the average over selected cells of the measured time, with a time-of-flight correction to the intersection point of the muon track with the horizontal plane. The x axis presents the coordinate along the beam axis of this intersection point.

3. Commissioning with the cosmic rays and LHC single beam

TileCal started taking cosmic muon data in 2005, with only a few modules. The full detector participated in the 2008 and 2009 combined ATLAS cosmic muon campaigns, and the data analysis is currently being finalized. In addition, the events from the first LHC single beam data have also proved to be quite useful in the performance analysis.

The energy response to muons from beam-collimator scraping allowed an estimation of the intercalibration of the 4 cylindrical sections of TileCal to better than 4%, which was the precision of this measurement. In terms of signal/noise ratio for cosmic muons (defined as the peak of the muon signa over the noise RMS) the measured value was quite high, about 36 (the value in test beam, from higher energy projective muons, was 44). Detailed studies of the energy response to cosmic muons are being finalized, and primarily use the ratio of deposited energy to crossed path length to assess the uniformity and validate the seting of the electromagnetic energy scale.

A good timing response, of about 2 ns, is necessary for the online energy reconstruction, and will also play a role in the rejection of background events not related to the LHC pp collisions, such as cosmic muons, transient noise and beam halo. The synchronization of the TileCal response is carried out with the laser system, and cross-checked with cosmic muon and single-beam data. This data also allowed some corrections to the laser calibration. Figure 1 shows the good uniformity (within 2 ns) of the TileCal time response measured with cosmic muons, after the final calibrations were applied, prior to the LHC collisions.

References

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