Tile calorimeter at work in the collision era

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1 Detector description

The Tile Calorimeter [1] is the central region hadronic calorimeter (Fig. 1 left) of the ATLAS experiment [2] at the CERN Large Hadron Collider.

The Tile Calorimeter is a sampling calorimeter using steel as absorber and scintillator plates as active medium. It is divided into a 5.8 m long central barrel and two 2.6 m long extended barrel cylinders, each having an inner radius 2.28 m and an outer radius of 4.25 m.

Each of the cylinders is composed of 64 azimuthal modules subtending $\Delta\phi = 0.1$. The Tile scintillator plates are placed perpendicular to the colliding beam axis, and are radially staggered in depth. The structure is periodic along the beam axis. Two sides of the scintillating tiles are read out by wave-length shifting (WLS) fibers into two separate photomultipliers (PMTs).

By the grouping of WLS fibers to specific PMTs, modules are segmented in pseudorapidity η and in radial depth. The resulting typical cell dimensions are $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$.

This segmentation defines a quasi-projective tower structure. Altogether, Tile Calorimeter comprises 4672 read-out cells, each equipped with two PMTs that receive light from opposite sides of the tiles.

The Tile Calorimeter together with the central liquid argon electromagnetic calorimeter will measure the energy of particle jets and contribute to the determination of the missing transverse energy of events in the pseudorapidity range $|\eta| < 1.7$.

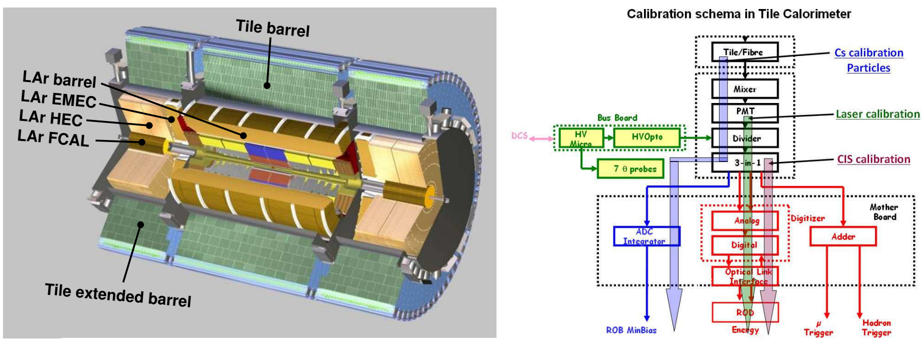

Figure 1: Left: View of the central part of ATLAS detector showing the tile calorimeter (tile barrel in center, tile extended barrels in side regions) surrounding the different segments of the liquid argon (LAr) calorimeter. Right: Calibration scheme in the tile calorimeter: Cs radioactive source, laser pulses, charge injection system.

2 Calibration

The Tile Calorimeter is equipped with a system that allows to monitor and to calibrate each stage of the read-out system exploiting different signal sources (Fig. 1 right).

The Charge Injection System sends charge pulses to each electronic channel. The system is designed to calibrate the read-out electronic system across all PMTs of the calorimeter at accuracy of 1 %. The Laser system provides light to all PMTs. It is designed to calibrate and monitor the response of the PMTs with a precision better than 0.5 %. The radioactive Cesium source ^{137}Cs moves through all Tile Calorimeter cells by a hydraulic system. The Cesium calibration system allows to obtain a uniformity of the cell response at the level of 0.3 %. [3]

3 Cosmic muons and splash events

The Tile Calorimeter response to cosmic and test-beam muons was used to measure the performance of the detector. The electromagnetic scale of the Tile Calorimeter modules was validated with the precision of 3 % using muons. Good agreement between data and Monte Carlo (MC) in test-beam and cavern muon data was observed.

The time offsets of the Tile Calorimeter cells were measured with cosmic muons and single beam data. The results agree within a precision of 1 ns.

In the splash events the LHC beam hits a completely closed collimator 140 m far from the center of the ATLAS and secondary particles penetrate all ATLAS detectors. The Tile Calorimeter cells timing after time-of-flight correction was validated (Fig. 2 left) and RMS = 0.45 ns was achieved for cells with proper time calibration.

4 Collisions

The distribution of the Tile Calorimeter cell response was compared with collision data at 7 TeV, 2.36 TeV, 900 GeV, minimum bias MC and randomly triggered events (Fig. 2 right). Good agreement between data and MC was observed.

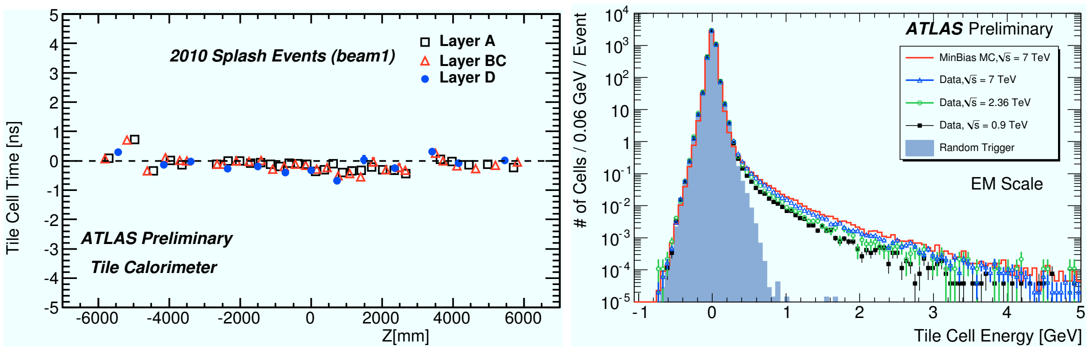

Figure 2: Left: The average cell time as a function of the cell Z (along beam axis) coordinate. Timing corrections based on the time of flight had been applied. Right: Energy of the tile calorimeter cells. The distributions from collision data at 7 TeV, 2.36 TeV, and 0.9 TeV are superimposed with Pythia minimum bias Monte Carlo and randomly triggered events.

The Tile Calorimeter cell response uniformity as a function of pseudorapidity η and azimuthal angle ϕ was compared between collision events at 7 TeV and non-diffractive minimum bias MC events (Fig. 3). A nice match between MC and data was seen.

The online signal reconstruction by the ROD/DSP Optimal Filtering Non Iterative reconstruction [4] was validated with the collision events as well as out of time events. It was shown that linearity of online algorithm is within a few percent in the significant time range $[-10, 10]$ ns.

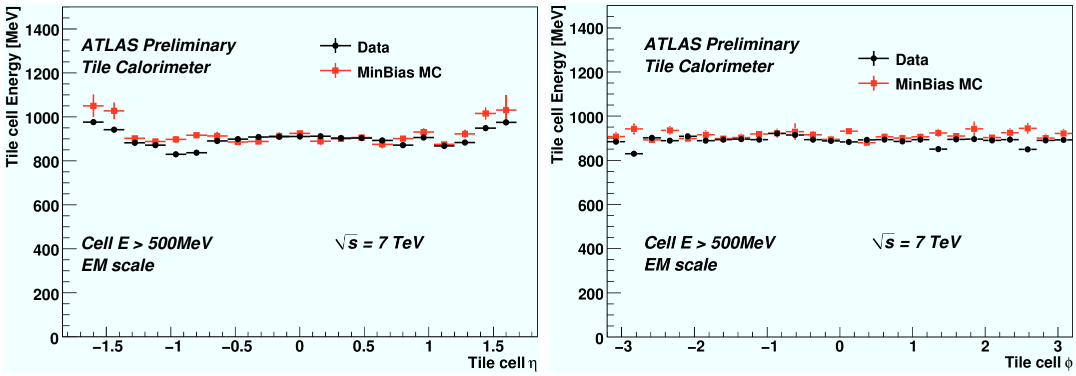

Figure 3: Tile calorimeter cell response uniformity as a function of pseudorapidity (left) and azimuthal angle (right) for 7 TeV collision and MC events.

5 Conclusion

The performance of the Tile Calorimeter has been measured and monitored using calibration data, random triggered data, cosmic muons, splash events and collision events.

The results of these studies give important information that assess the uniformity, the stability and the resolution of the energy measurements and, in general, the quality of the data description as given by the simulation of the Tile Calorimeter detector.

The performance and the quality of understanding the Tile Calorimeter is demonstrated. The detector is ready to detect hadrons, jets and to measure the missing transverse energy.

Acknowledgements

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References

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