Performance of the ATLAS Hadronic Tile Calorimeter

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The ATLAS Tile calorimeter

- The hadronic sampling calorimeter which uses steel as absorber and scintillating tiles as an active medium which are read out by wavelength shifting fibers
- Divided into long barrel (LB) and two extended barrels (EB) with overall dimensions of ~12 m length and 4.25 m (2.28 m) outer (inner) radius
- Granularity: 64 wedge-shaped modules (Δη/Δφ = 0.1)
- 5 radial layers: A (Δη/Δφ = 0.1), B (Δη/Δφ = 0.2)
- Each normal cell is read out by two photomultiplier tubes (PMT) to achieve uniform response; 5k cells, 10k PMTs
- Performance goals:
  - Energy resolution for μ (p) = 3% (5%)
  - Linear within 2% (4% Tavis gain)
  - Hermetic coverage for E^⊥ reconstruction

Detector signals Digitizer 3-in-1
ADC
ADC
PIPELINE    Σ
Analog 
trigger sums
Interface
OTx
GLINK
to ROD FORMAT
S
E
L
M
E
M

Energy reconstruction and calibration procedure

- Each of the Tile calibration systems tests a different part of the signal path — identification of the source of deviation
- The signal from the PMTs is shaped and amplified using two gains (1.04) and read out by 10-bits ADCs each 25 ns
- Amplitude and time are reconstructed using Optimal filtering algorithm

The cesium system

- 127I Cs γ-source is circulated through all the detector cells to equalize their respond
- In first scan calorimeter is equalized and in subsequent scans Cs is calculated as a ratio of measured to expected signals
- Cs system and associated constants are used to calibrate the scintillators, PMTs and to correct residual cell differences
- Precision of the measurement is better than 0.3% for each channel

The charge injection system (CIS)

- A known charge is injected in readout chain
- Calibration of the readout electronics
- Precision of the measurement is better than 0.1% for low and high gain ADCs connected to PMT

Combination of calibration systems

- Minimum Bias system
  - The system uses the integral reductor and measures the detector response to the minimum-bias events
  - It is used for monitoring of the instantaneous luminosity in ATLAS
  - The difference between Laser and Minimum Bias (or Csium) response gives the effect of the scintillators irradiation

Detector status

- Faulty channels are masked and not used for reconstruction
- The current number of masked channels is 0.36% and masked cells (both channels masked) is 0.06%
- Repairs performed during the maintenance period decreased the fraction of masked channels/cell
- The large maintenance period corresponds to the LHC long shutdown in 2015-2016

References

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/...
  - PublishedTileCalFigures
  - TileCalPublicResultsTiming
  - ApprovedPlotsTileEnergyCalibration
  - ApprovedPlotsTileSpatialShape
  - ApprovedPlotsTileStatus
  - ApprovedPlotsTileElectronics
  - ApprovedPlotsTileCalibration

Performance

Collision munus

- Collision events with muons produced in W → μν decays
- 2012 experimental data and Monte Carlo simulations (MC)

Cosmic munus

- Uniformity of the cell response to cosmic muons as a function of η for layer A, expressed in terms of normalized truncated mean (ΔE/Δη)
- The response is integrated over all cells in each η bin

Single hadrons

- Calorimeter response to single isolated charged hadrons, characterised by the mean of the energy-momentum-ratio (E/p) as a function of pseudorapidity

Time calibration

- The time calibration is important for the energy reconstruction; aims to set the phase in each channel so that a particle from the interaction point gives signal with measured time equal to zero
- The reconstructed time in all Tile calorimeter cells is monitored in physics runs with laser calibration events during empty beam crossings
- The plot on the left shows mean cell time in jet events as a function of the energy deposited in cells, each color corresponds to a different run
- The mean cell time decreases with deposited energy due to neutrino/slow hadronic components of the hadronic shower
- The plot on the right shows time resolution in jet events as a function of the energy deposited in cells, the closed circles correspond to Gaussian fit, the open squares indicate the RMS of the underlying time distributions
- Some channels suffer from sudden time changes due to configuration issues, which are seen in both physics and laser events
- Laser events are used to correct reconstructed time before processing of physics data
- The plots show reconstructed time in laser events in one channel (LBBC5 ch 28) before and after timing correction

References

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