ATLAS Tile Calorimeter time calibration, monitoring and performance in Run 2

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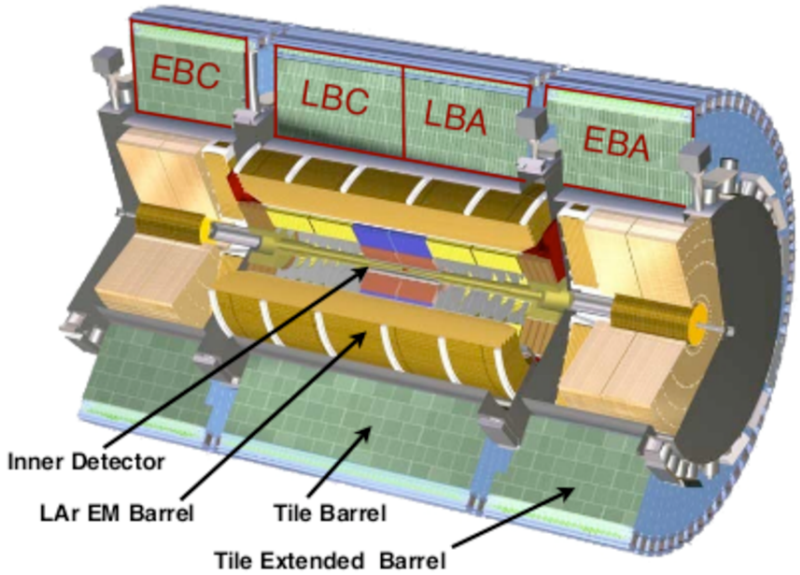
Tile Calorimeter

Hadronic calorimeter in ATLAS central region

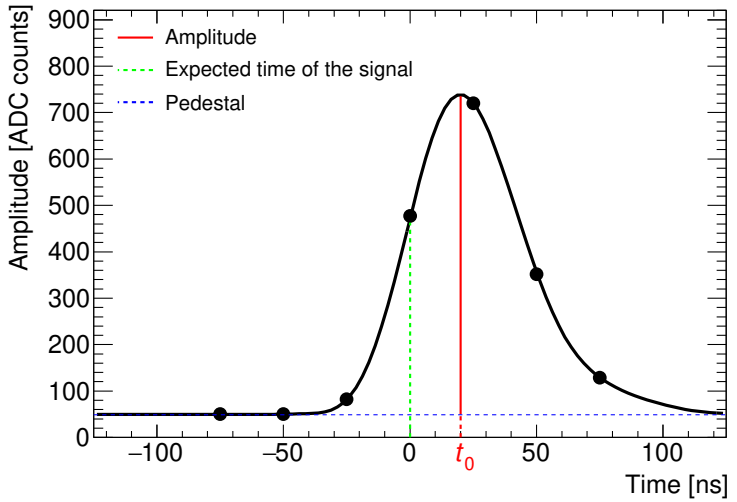
- Sampling steel/scintillator calorimeter
- 4 partitions: EBC, LBC, LBA, EBA
- Light from scintillating tiles collected by wavelength shifting fibers and routed to photomultiplier tubes (PMTs), usually 2 channels (PMTs) per readout cell



Signal reconstruction

- The analog signal from each PMT is shaped and split into two branches (high- and low-gain, ratio 64:1)
- Each pulse is then sampled every 25 ns and the signal amplitude (A) and time (t_0) are reconstructed (bottom plot)

$$A = \sum_{i=0}^{7} a_i S_i, \qquad t_0 = \frac{1}{A} \sum_{i=0}^{7} b_i S_i$$



- The amount of energy deposited by a particle traversing the cell is proportional to A
- Incorrect time calibration may lead to an inaccurate signal and energy reconstruction

Time calibration & monitoring overview

Time calibration

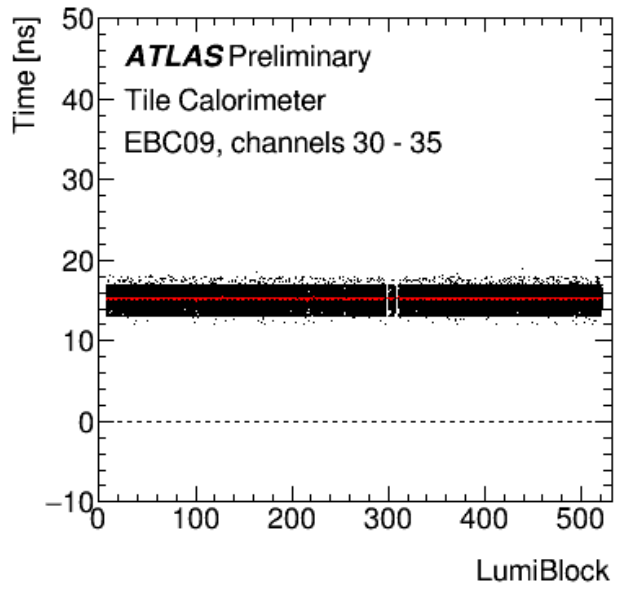
- Aims to set the channel time calibration constant so that a particle traveling from the interaction point at the speed of light gives a signal with $t_0 = 0$ ns
- Initial time constant settings is performed using laser pulses, beam splash events (if available) and later fine-tuned with collision data, exploiting jet events

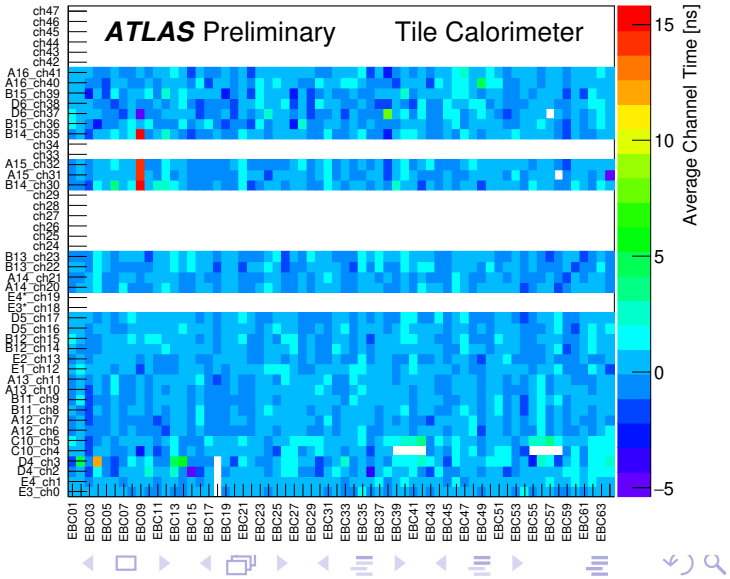
Time stability monitoring

- Allow for the time constants adjustment before the data are processed for physics analyses
- Using laser events shot during empty bunch-crossings (top plot)
- Using jets, similarly to the calibration based on collision data (bottom plot)

During Run-2, TileCal suffered from sudden changes of the time settings

- An example, module EBC09 channels 30-35, a time shift $\sim$ 15 ns lasted during the whole run





Time performance in Run-2

For the performance studies

- pp collision data at $\sqrt{s} = 13$ TeV are used
- All Tile Calorimeter cells belonging to reconstructed jets with $p_T > 20$ GeV are considered, after applying the usual event and jet cleaning procedures
- The region close to 22 GeV corresponds to the high-/low-gain channel readout transition

The mean cell time in jet events as a function of the energy deposited in cells (top plot)

- Slowly decreases with deposited energy due to neutrons/slow hadronic component of the hadronic showers.

The cell time resolution in jet events as a function of the cell energy (bottom plot)

- The closed circles correspond to Gaussian σ the open squares indicate the RMS of the underlying time distributions