Performances of the signal reconstruction in the ATLAS Hadronic Tile Calorimeter

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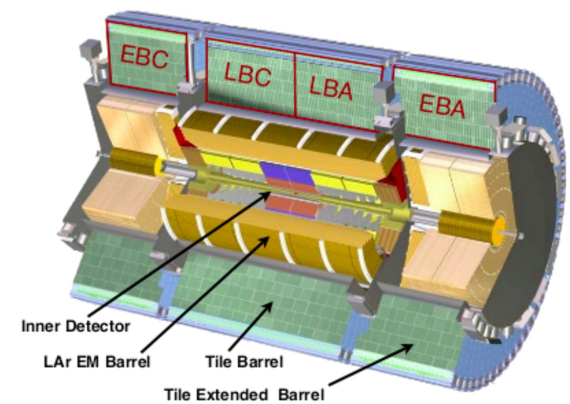
- The Tile Calorimeter (TileCal) is the central section of the hadronic calorimeter of the ATLAS detector.
It is a key detector for the reconstruction of hadrons, jets, taus and missing transverse energy.
Performance goals:
Resolution: $\frac{\sigma(E)}{E} = \frac{50\%}{\sqrt{E}} \oplus 3\%$. Jets Linearity: within 2% up to few TeV.
Technology: sampling calorimeter: steel/scintillating tiles coupled to wavelength shifting fibres read out by PMTs; composed of 3 radial layers with $\Delta\eta$ x $\Delta\varphi$=0.1x0.1 cells (0.2 x 0.1 outer layer).



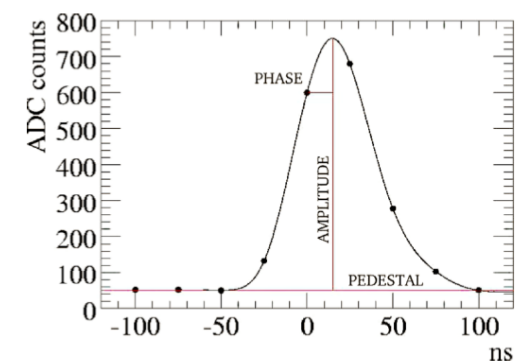
The online and offline signal reconstruction are performed using the Optimal Filtering Algorithm (OF)[1]:

-OF weights (a,b,c) are defined by pulse shape, noise and the expected signal phase.
- Two Implementations:
iterative method: for asynchronous signals (cosmic muons, laser calibration data, etc) assumes an arbitrary signal phase;
non iterative method: for synchronous signals (collision events) uses precise timing offset for every channel.

$$A = \sum_{i=1}^{n} a_i S_i$$

$$A\tau = \sum_{i=1}^{n} b_i S_i$$

$$p = \sum_{i=1}^{n} c_i S_i$$



The iterative method is slower and more sensitive to noise fluctuation and pileup. The non iterative method allows to cope with the acquisition high rate, it is the design method, employed in online and also in the offline. It is crucial demonstrate that these methods give similar performances under suitable conditions.

[1] Ref: W.E. Cleland and E.G.Stern, "Signal processing considerations for liquid ionization calorimeters in a high rate enviroment", NIM A, 338:467497, 1994.

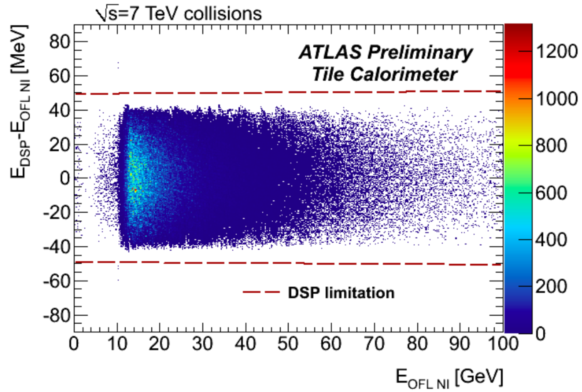
Comparisons of online and offline reconstruction

Small differences between online and offline OF expected:

-Parameters needed by reconstruction algorithm uploaded into ROS/DSP (fixed point arithmetic: constants and parameters described by 16 bits);

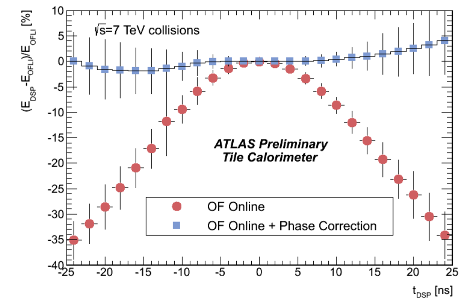
- Look-up Tables (LUT) used in DSP to evaluate the phase.

Online vs Offline Non Iterative



Precision ± 50 MeV at high energy for 99% of channels (± 1 MeV in the range 200 MeV-10 GeV). Values within the expectations.

Online vs Offline Iterative

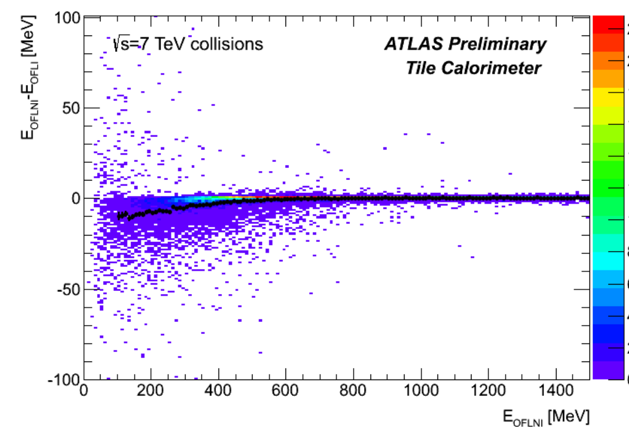


Variation in phase of pulses in the non iterative method causes an underestimation of amplitude. Deviation of the energy for small time variations within 1 bunch crossing can be corrected.

Comparisons for offline non iterative and iterative method at low signals

A clean sample of muons is selected requiring: pT >20 GeV, cell track path length > 100 mm and an azimuthal and longitudinal distance between the muon track extrapolated at the TileCal layer and the center of the cell of <0.048 $\Delta\eta$<0.048.

The most probable energy ranges from 400 MeV÷ 1 GeV depending on the cell size. For energy deposits >200 MeV the difference between the two methods is < 50 MeV for the majority of events, and the mean of the distribution < 10 MeV.



Conclusions

- The online reconstruction of the DSP has been validated with the LHC data using the offline reconstruction as reference. The precision of the online reconstruction is adequate and within the expectations. Currently the DSP reconstruction is used in the HLT.

-The performances of the offline non iterative and iterative Optimal Filtering methods are very close to each other up to very low energy ranges.