Noise dependence with pile-up in the ATLAS Tile calorimeter

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The Tile Calorimeter

- The Tile Calorimeter is the central hadronic calorimeter of the ATLAS detector.
- Composed of iron layers (as passive material) and scintillating plastic layers (as active material).
- Structure:
 - 4 partitions (LBA, LBC, EBA and EBC).
 - 4 layers (A, BC, D and special layers).
 - 16 towers (steps of 0.1 in η).
 - 64 modules (divisions in the azimuthal angle ϕ).

Pile-up in the ATLAS detector

- Tens of proton-proton interactions take place in a bunch crossing inside the ATLAS detector.
- Pile-up events also deposit energy in the TileCal cells which is hard to distinguish from the energy deposited by the interesting event.
- This is known as pile-up noise and is a component to the cell noise measured that increases as pile-up increases.

RMS as the noise estimator

- The RMS of the energy distribution can be used as a noise estimator:

$$\sqrt{\langle E^2 \rangle - \langle E \rangle^2}$$

- The noise measured increases with the mean number of interactions per bunch-crossing.
- The bunch-spacing also increases the cell noise.

Quantiles of the energy distribution as the noise estimator

- The quantiles of the energy distribution can be used to better characterise its shape.
- The energy ϵ is the k_{th} quantile of the energy distribution with Q quantiles if:

$$P(E \leq \epsilon) = k/Q.$$

- Non-gaussian behaviour with larger positive tails.

Conclusions

- The high rate at which the LHC produces proton-proton collisions implies a high amount of pile-up events taking place in the ATLAS detector.
- In the second operation phase of the LHC, with higher energy (13 TeV) and smaller bunch-spacing (25 ns), pile-up is expected to increase.
- To study the TileCal cell noise as a function of pile-up two estimators have been presented:
 - The RMS of the energy distribution.
 - The quantiles of the energy distribution.
- Using the quantiles estimator the shape of the energy distribution can be better characterised.