Pile-up Noise Measurements in Tile Calorimeter of the ATLAS detector

Krystsina Petukhova

Center of High Energy and Particle Physics
The Institute for Nuclear Problems
Belarusian State University

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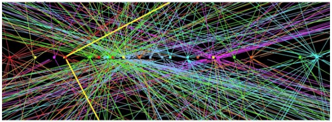
Outlook



Pile-up is multiple p-p interactions at the same bunch crossing.
They affects the measurement of jet kinematics.

$$< \mu >= \frac{\sigma_{inel}\mathcal{L}}{f_{LHC}\, n_{bunch}}$$

$\mathcal{L} = 10^{34} cm^{-2} s^{-1}$ $\sigma_{inel} = 80mb$
$f_{LHC} = 11245Hz$ $n_{bunch} = 2496$

Importance:

- jets reconstruction algorithm uses topological clusters as input
- topological cluster is made of energetically significant cells

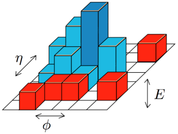
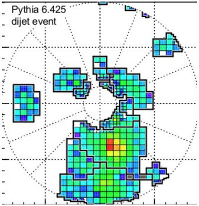


Illustration of a topological cluster:
dark blue seed cell
light blue selected adjoint and neighboring cells
red rejected cells



Purpose:

✗ measurement of pile-up noise constants in the Tile calorimeter cells

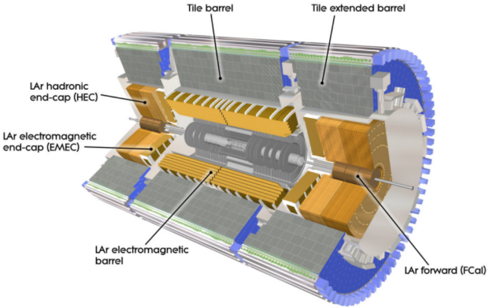
ATLAS Experiment

Goals:

- ✗ more precise measurements of Standard Model parameters
- ✗ search for new physics phenomena

Detectors:

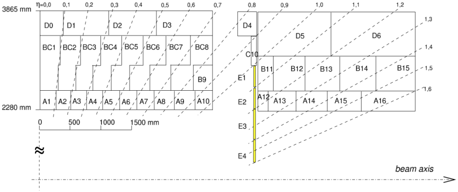
- inner tracking detector
- electromagnetic and hadron calorimeters: LAr, Tile
- muon spectrometer



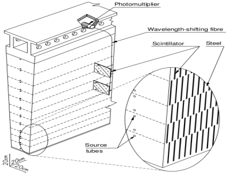
The ATLAS detector composition.

Tile Calorimeter

- a central *hadronic* calorimeter
- *sampling detector:* scintillating plastic "tiles" + layers of steel absorber
- *high-granularity* detector: 5182 cells, including special cells; 3 radial layers; 64 azimuthal modules; $|\eta| < 1.7$ coverage
- measures hadrons, jets kinematics, taus, missing E_T



The Tile calorimeter cells map.

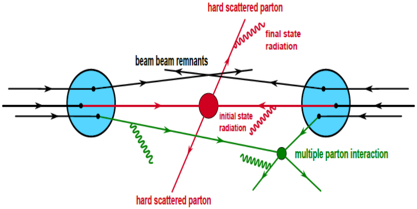


The TileCal module structure.

p-p Collisions and Pile-up Noise

p-p interactions:

- *hard*: deep inelastic high-p_t parton-parton scattering
- *soft*: inelastic parton-parton interaction at low-p_t range



pile-up affects measurements

In-time pile-up:

➪ simultaneous *p-p* collisions

Out-of-time pile-up:

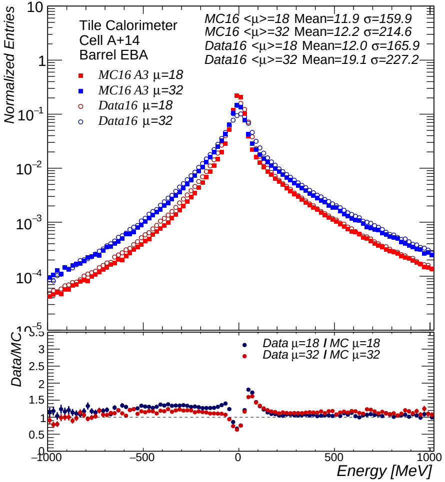
➪ impact of the past/future collisions on the signal shape in the current bunch-crossing

The Total Noise Measurement

- data 2016
- MC 2016

Measurement:

- the total noise σ_{tot} is the width of the cell energy distribution
- σ_{tot} has two components: electronics noise and pile-up noise
- σ_{elec} is measured with pedestal runs



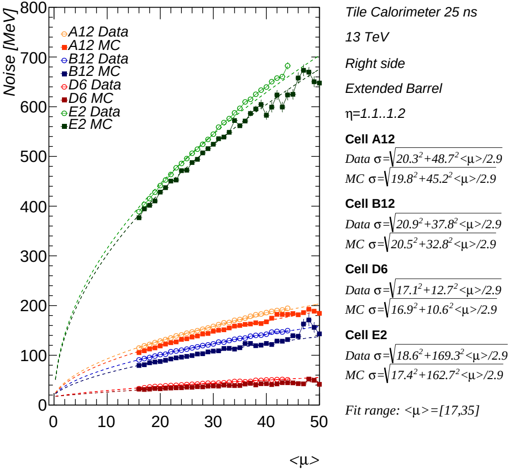
The energy distributions in A14 Tile Calorimeter cell in data ○ and MC ■ at $\mu = 18$ and $\mu = 32$.

Pile-up Noise Measurement

Total noise in a cell is a function of the average number of interactions $<\mu>$.

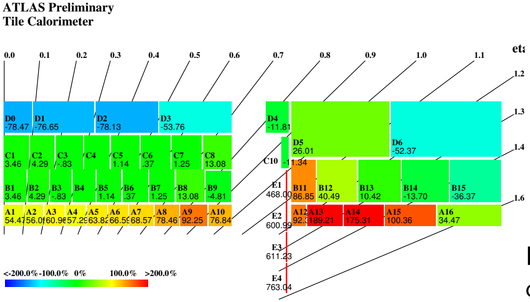
$$\sigma_{tot} = \sqrt{\sigma_{el}^2 + \sigma_{pile-up}^2 \frac{<\mu>}{k_{\mathcal{L}}}}$$

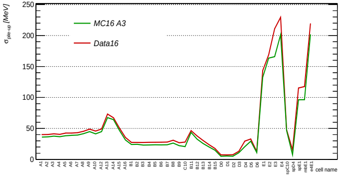
- applying fit to the "the total noise – $<\mu>$" with function, where $k_{\mathcal{L}}$ is a scaling factor
- extracting $\sigma_{pile-up}$



Pile-up dependence of the total noise in data ○ and MC ■.

Measured Pile-up Noise Constants





Pile-up noise coefficients for the cells in data — and MC —.

Cell	Data	MC
A1	40.05	36.03
B13	30.60	25.76
D5	32.99	29.39
E4	229.41	201.31

Pile-up noise activity in the Tile calorimeter cells.
The reference cell is the *BC4*.
The highest pile-up is for $A - cells$, the lowest one is for $D - cells$.

Summary

- ✓ The total noise in the Tile calorimeter cells is measured in *p*-*p* collision data at 13 TeV centre-of-mass energy collected in 2016, as well as in Monte Carlo.
- ✓ The pile-up noise depends on the cell position: the cells with highest pile-up level are in the $A-$layer and scintillator cells, the ones with low pile-up activity are in the $D-$layer.
- ✓ MC (`Pythia 8`) tuned to RUN-I well describes the soft component of the hard *p*-*p* collisions.
- ✓ The pile-up noise constants were calculated for all the Tile calorimeter cells and implemented into condition data base; they are used for by the collaboration throughout jet reconstruction in RUN-II.