LHCC Poster Session –CERN, February 27th 2019

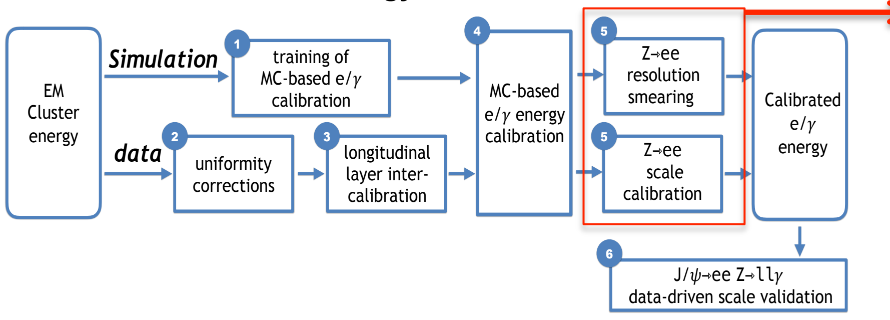
Energy scale calibration of the liquid argon electromagnetic calorimeter with Z→ee events

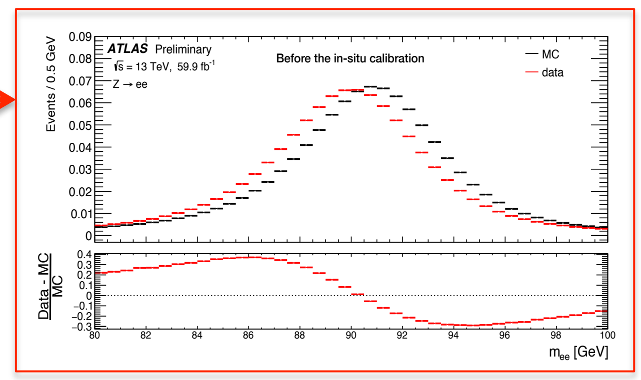
Motivation

- A precise calibration of the electron and photon energy is necessary for precision studies such as the Higgs, W and Z boson property measurements (mass, cross-sections ...).
- Electromagnetic particles (e,γ) are heavily used in precision measurements due to the high precision reachable by the electromagnetic (EM) calorimeter.

Overview of the calibration procedure for electrons and photons

The calibration procedure includes several steps, mainly consisting in a MVA-based calibration, uniformity corrections for the data, and derivation **of in-situ energy and resolution scale factors**:





<u>In the step</u> (5), two correction data/MC factors are extracted from the comparison between data and simulation, using the good knowledge of the Z boson mass:

Energy scales α: scale factor applied to data to match the energy response in simulation.

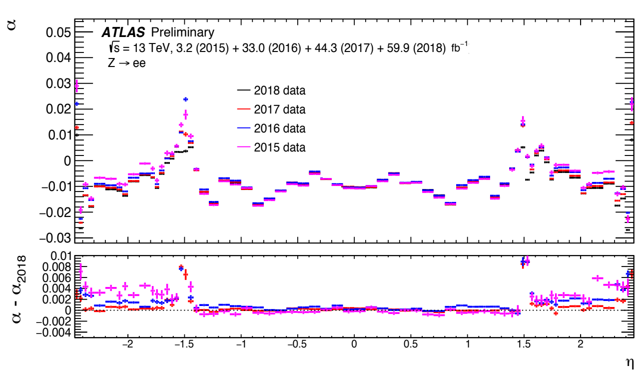
$$E_i^{\text{data}} = E_i^{\text{MC}}(1+\alpha_i)$$

Additional constant term c': smearing of the energy applied to simulation to match the energy resolution in data.

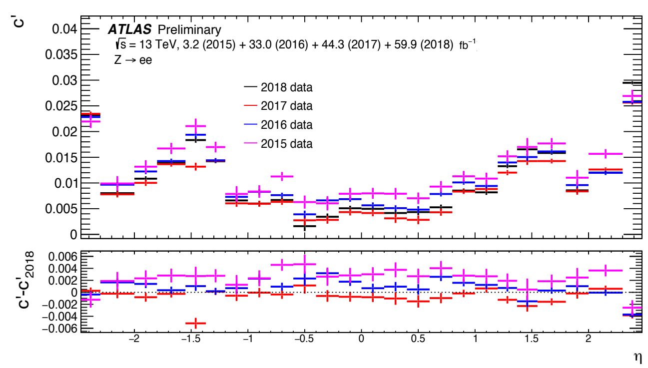
$$\left(\frac{\sigma(E)}{E}\right)_i^{\text{data}} = \left(\frac{\sigma(E)}{E}\right)_i^{\text{MC}} \oplus c_i'$$

In-situ calibration for standard runs

Electron scale factors α & additional constant term c'

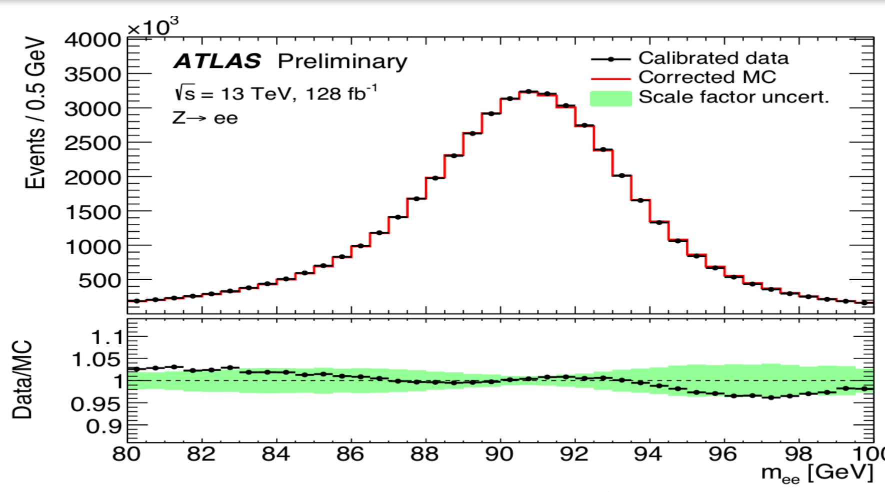


The energy scale factors α**:** results are compatible between different years in the barrel region, the observed effect in the end-cap is explained by the small luminosity dependence of the calorimeter response.



The additional constant term c': The constant c' depend on the pile-up : this effect is due to an overestimation of the pile-up noise is MC ⇒ the constant c' absorbs this mis-modeling.

Invariant mass distribution for standard runs

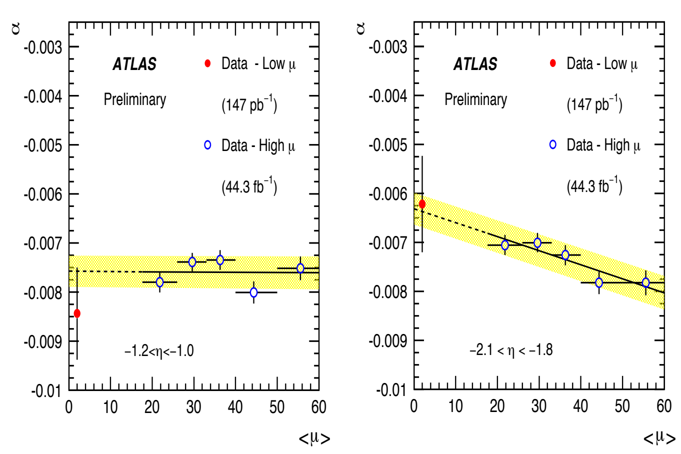


Inclusive di-electron invariant mass distribution from Z→ee decays in data compared to MC for the high-mu runs after applying the full calibration.

Electron scale factors for low pile-up runs (μ~2)

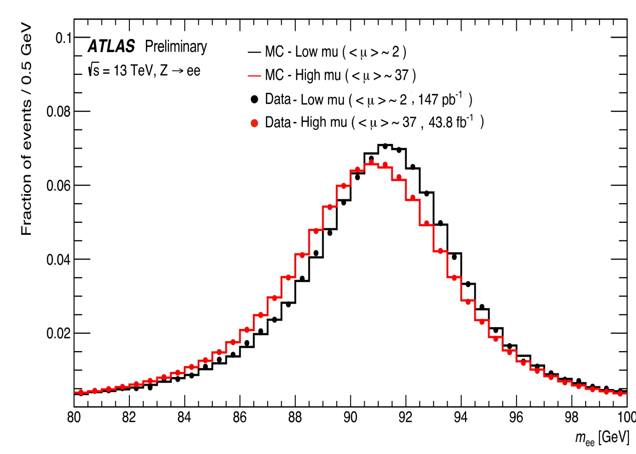
Extrapolation idea

- Extracting the correction scale factors with the same procedure as used for standard runs is limited by the low statistics of low pile-up runs.
- The complementary approach of extrapolation from high pile-up data:
  - ✓ Fit the pile-up dependence of the high pile-up data in 5 intervals.
  - ✓ Extrapolate to low pile-up.
  - ✓ Compare the extrapolation with the calibration of the low pile-up data.



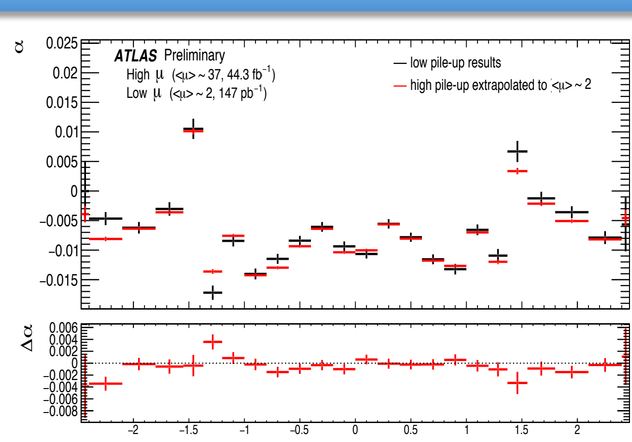
Difference of threshold between high/low pile-up runs

- For high and low pile-up runs, we use different topo-cluster noise thresholds for the energy reconstruction.
- For low pile-up dataset, the threshold for the energy reconstruction is lower and the reconstructed invariant mass is higher on average.
- The difference on the calibration has been taken into account in the extrapolation.



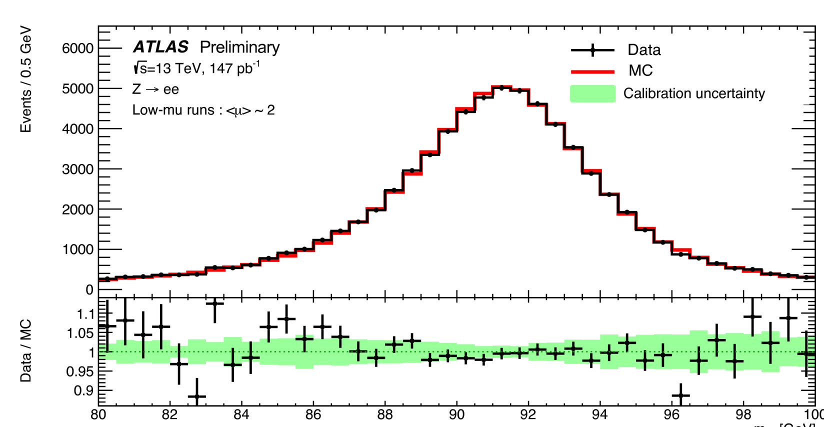
Comparison

- The extrapolated results are in good agreement with the calibration results using the low pile-up data.
- The statistical precision of the extrapolation is better than that of the low pile-up data.



Invariant mass distribution for low pile-up runs

- Distribution of the di-electron invariant mass for Z→ee candidates recorded in special low pile-up runs with √s=13 TeV. Data and MC are compared after applying the calibration derived from these special runs.



Conclusion

- The high pile-up energy scale factors are extracted using direct comparison between the invariant mass distribution of data and simulation using the good knowledge of Z bosons.
- To mitigate the large statistical uncertainty of the low-mu in-situ calibration, the results obtained using the standard (high pile-up) dataset can be extrapolated to low pile-up using a linear fit and taking into account another correction related to the difference of the topo-cluster noise threshold.

References

- Electron and photon energy calibration with the ATLAS detector using 2015-2016 LHC proton-proton collision data arXiv:1812.03848

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