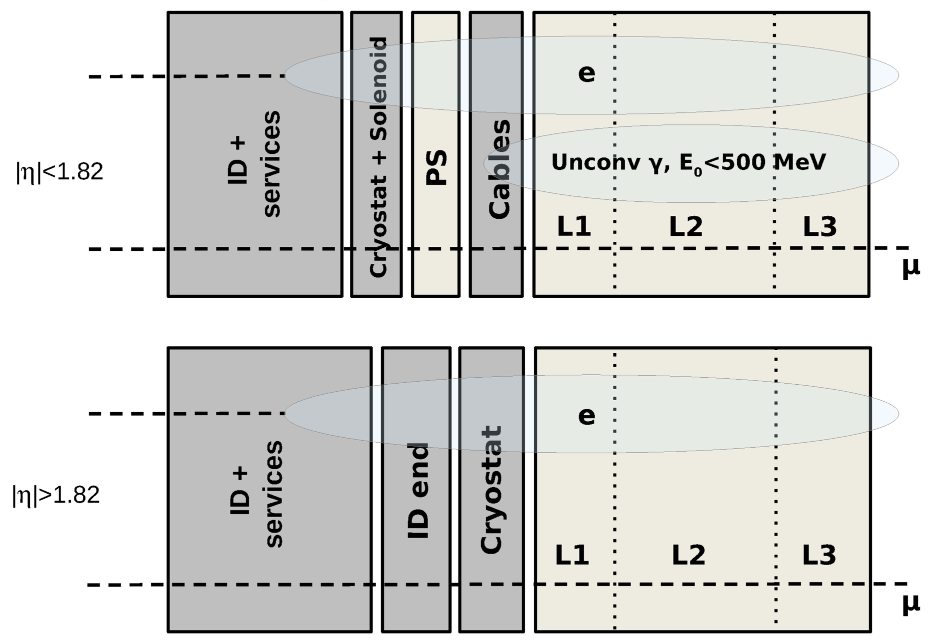
Electron and photon energy calibration with the ATLAS detector

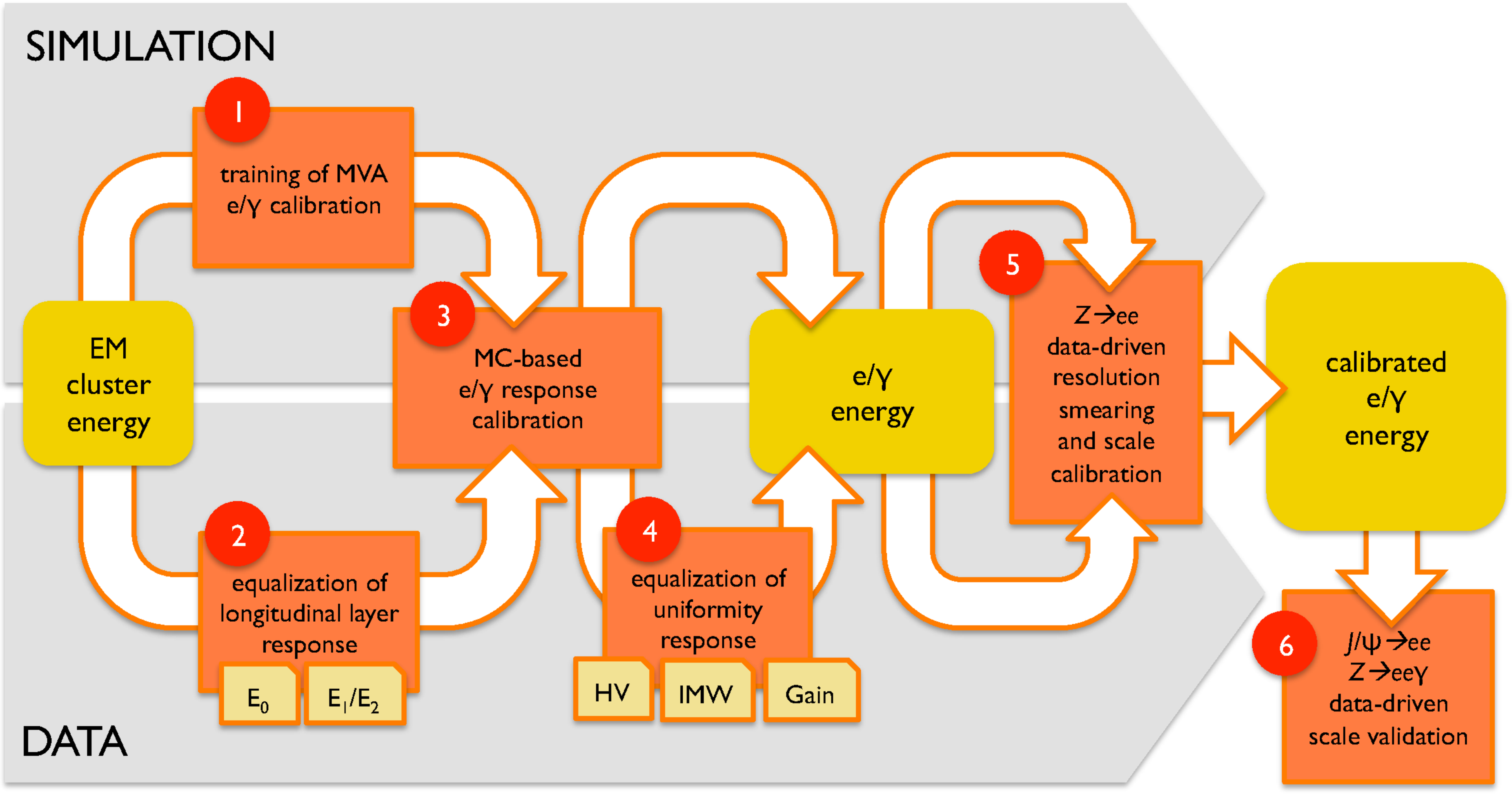
The energy of electron and photon candidates is measured from cell clusters in the EM calorimeter. They are calibrated following the same procedure.

Shower development in the electromagnetic calorimeter



Three main calibration steps:

- MVA based calibration (from MC) & layer inter-calibration (data)
- Detector non-uniformity correction (on data)
- Scales (data) and resolution (MC) from Z→ee events



MVA based calibration

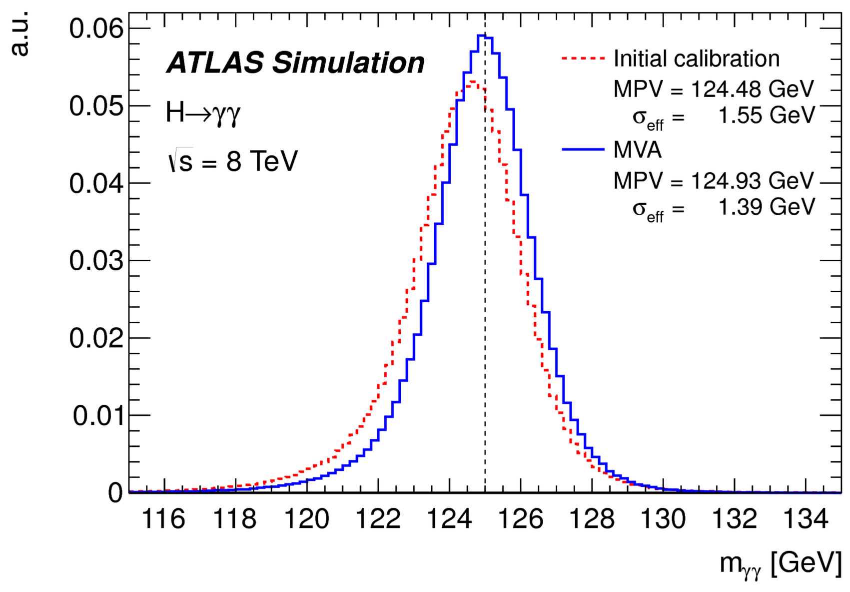
First step: calibration based on an MVA, trained on single electrons or photon MC.

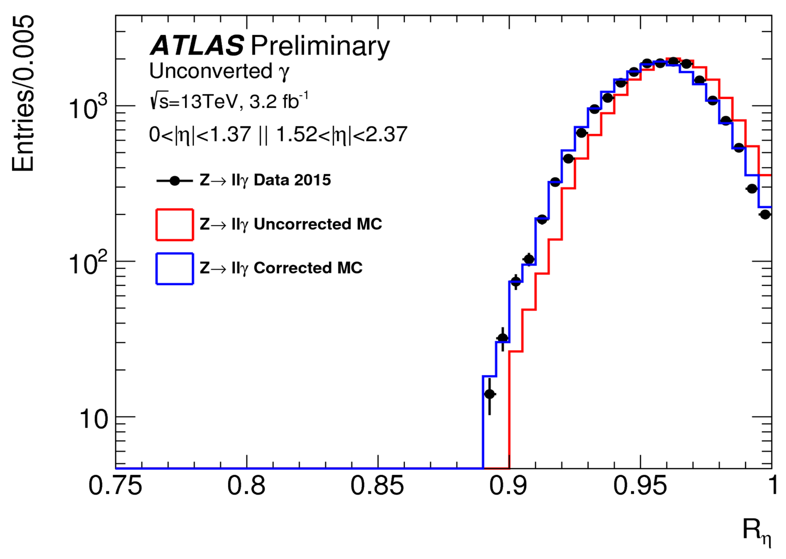
Categories of input variables:

- Total reconstructed cluster energy: absolute energy scale
- Ratio of energies in different layers: relative layer calibration
- (Relative) cluster position: detector non-uniformity, passive material, etc.
- (Properties of converted photons)

Improvements:

- include shower shape variables to reduce systematics and improve the resolution





In-situ scales from Z→ee

Residual miscalibration in data w.r.t. MC: η-dependent scales α_i:

$$E^{data} = E^{MC}(1+\alpha)$$

Good knowledge of Z mass used to calibrate electrons from Z→ee events.

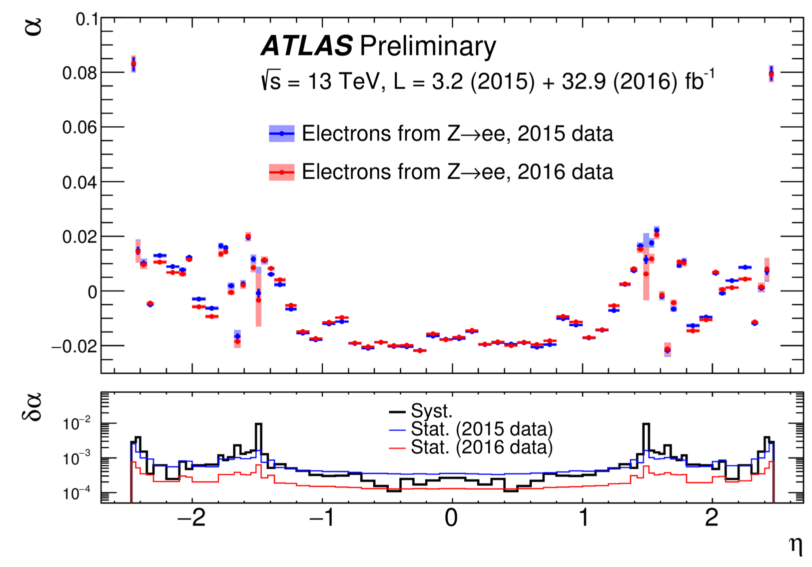
Energy dependence of energy resolution:

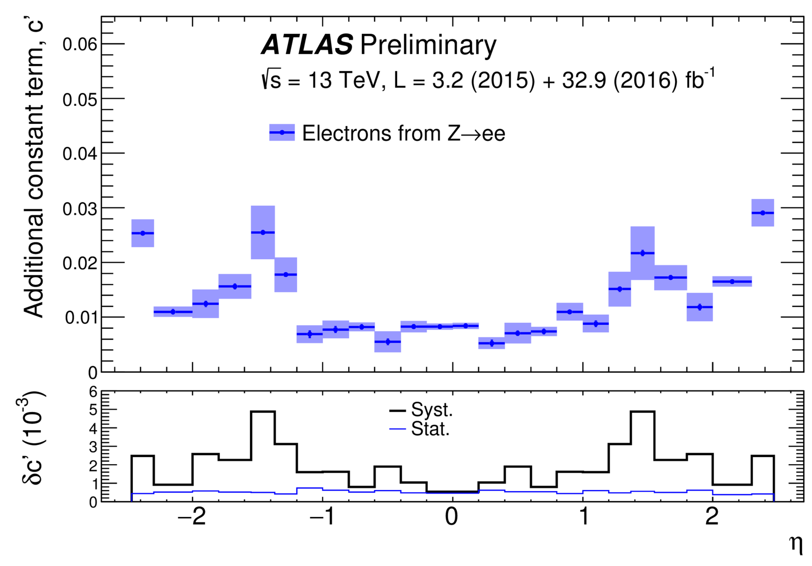
$$\frac{\sigma}{E} = \frac{a}{E} \oplus \frac{b}{\sqrt{(E)}} \oplus c$$

with sampling term a, noise term b, and constant term c.

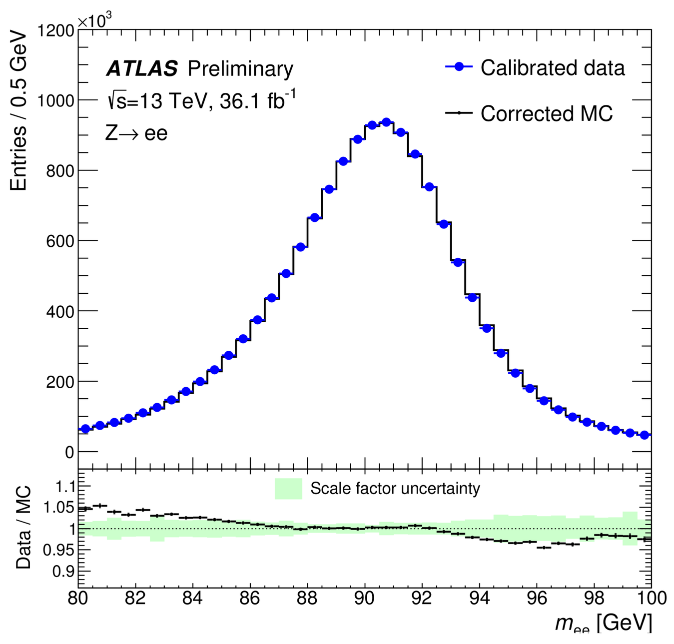
Smearing of the MC by additional constant term to account for the worse resolution in data:

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





Calibration closure on Z→ee lineshape



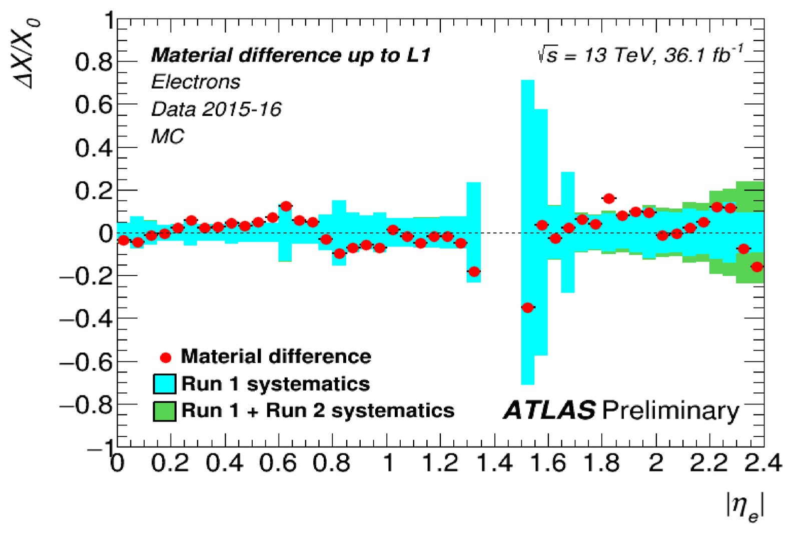
Good closure from of scale factors on Z→ee events (only small residual mismodelling.

Ideas for further improvement:

- scales as a function of additional kinematic variable (p_T or lateral shower shape)

Passive material in front of the EM calorimeter

- Passive material in front of calorimeter from longitudinal shower development (*E1/E2*) of electrons in data
- Method sensitivity estimated from MC with distorted geometries
- Systematics from run1 still valid, except for region with additional material at |η|>2

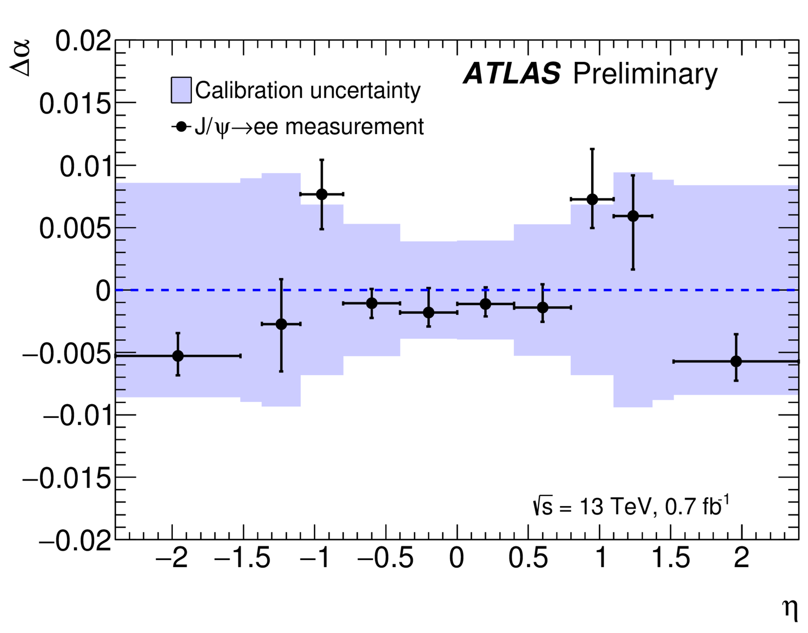


Calibration cross-checks

Extrapolation of systematics on scales from Z → ee to different energies and to photons. Tested by extracting residual scales from other reference processes.

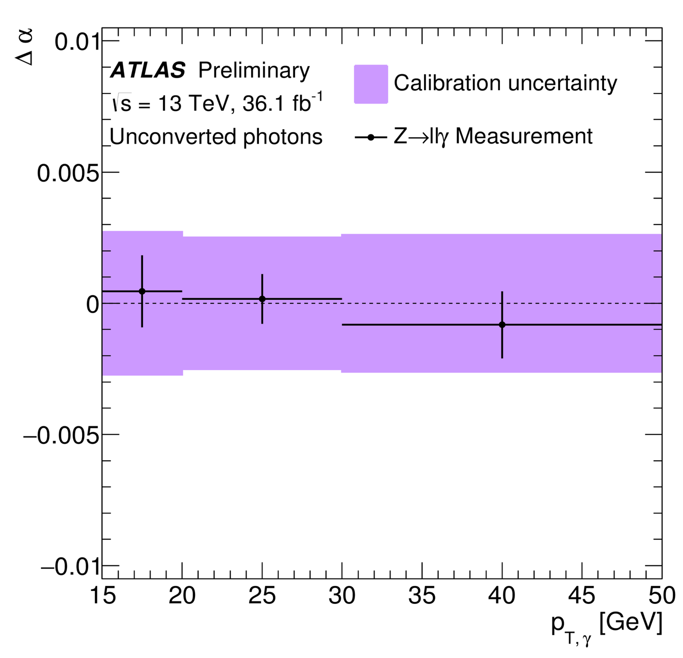
J/Ψ → ee: test low energy extrapolation

Overall miscalibration < 1%



Z → ℓℓγ: photon energy scale

Overall miscalibration ~0.3%



Impact on Higgs mass measurement from H→γγ events

Systematic	$\Delta m_H/m_H$
LAr cell non-linearity	0.16%
Layer calibration	0.15%
Other material (not ID)	0.10%
Lateral shower shape	0.09%
ID material	0.09%
Conversion reconstruction	0.04%
Z → ee calibration	0.04%
Background model	0.04%
Primary vertex selection	0.03%
Resolution	0.02%
Signal model	0.02%

Cell non-linearity:
related to calorimeter gain for shower reconstruction: computed from special run

Layer calibration:
relative calibration of different calorimeter layers using muons

Lateral shower shape:
leakage of reconstructed EM shower outside reconstructed window

References:

- ATLAS Collaboration, "Electron and photon energy calibration with the ATLAS detector using LHC Run 1 data ", July 2014, arXiv:1407.5063v2 [hep-ex]
- ATLAS Collaboration, "Photon identification in 2015 ATLAS data", ATL-PHYS-PUB-2016-014, Aug 2016
- ATLAS Collaboration, "Measurement of the Higgs boson mass in the H→ZZ*→4l and H→γγ channels with √s=13TeV pp collisions using the ATLAS detector", July 2017

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EPS Poster session - Venice, July 2017

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