Electrons in ATLAS: from Run1 to Run2

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Introduction

The performance of electron reconstruction, identification and calibration plays a critical role in several physics analysis with electrons in the final state, as for instance in Standard Model measurements, Higgs boson discovery and measurements, and the searches for new physics beyond the Standard Model. This poster will present Run 1 results and latest results from Run 2.

Reconstruction

In the central region of the ATLAS detector ($|\eta| < 2.47$) [1], the electron reconstruction is seeded from energy deposits (clusters) in the EM calorimeter, which are then associated to reconstructed tracks of charged particles in the inner detector. In 2012, the electron reconstruction consisted of the following steps:

- Electron seed-cluster reconstruction:
  a) building clusters by sliding-windows algorithm;
  b) duplicate removal algorithm.
- Electron-track candidate reconstruction:
  a) pattern recognition: standard pattern recognition using the pion hypothesis and modified pattern recognition algorithm, allowing larger energy loss to account for possible bremsstrahlung;
  b) track fit: track candidates are fitted with the same hypothesis as for pattern recognition using the global χ^2 fitter [3];
- Loose matching to cluster:
  a) tracks are extrapolated to the middle layer of EM calorimeter
  b) selection on the difference in φ (Δφ) between track and, cluster and if tracks have silicon hits, in Δη, and also after rescaling the track momentum to the measured cluster energy pass a tightened cut for Δφ variable;

Electron-track candidates previously defined are refitted using an optimized electron track fitter, the Gaussian Sum Filter (GSF).

- Electron-candidate reconstruction:
  a) track-cluster matching: GSF refitted tracks with tighter requirements on Δη and Δφ (more than one track can be associated with a cluster);
  b) choose the best match as primary track for the future analysis.

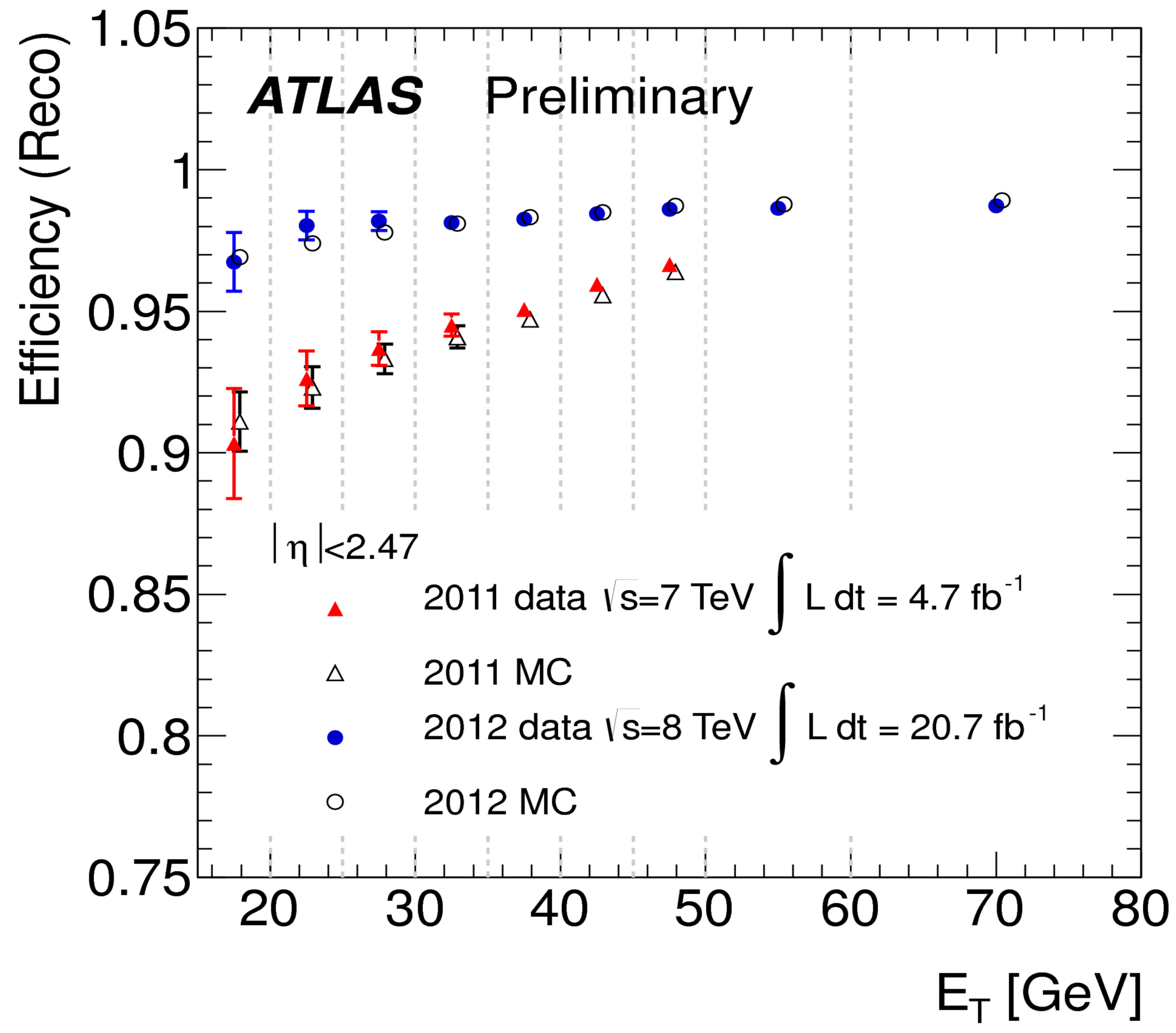

Figure 1: Run 1 reconstruction efficiencies measured using Tag&Probe method using Z→*ee* decay as a function of E_T integrated over the full pseudorapidity range. The difference between results in 2011 and 2012 is thanks to the improved pattern recognition and improved track-cluster matching introduced for 2012 data.

Identification

Objects built by electron reconstruction algorithms: signal electron and background objects including hadronic jets as well as background electrons from photon conversions, Dalitz decays and semi-leptonic heavy flavor hadron decays. To reject these backgrounds, electron identification is based on discriminating variables:

- longitudinal and transverse shapes of the electromagnetic showers in the calorimeter,
- properties of the tracks in the inner detector,
- matching between track and energy cluster

The cut-based selections contain few operation points: loose, multilepton, medium and tight (as shown in Fig.2) [2].

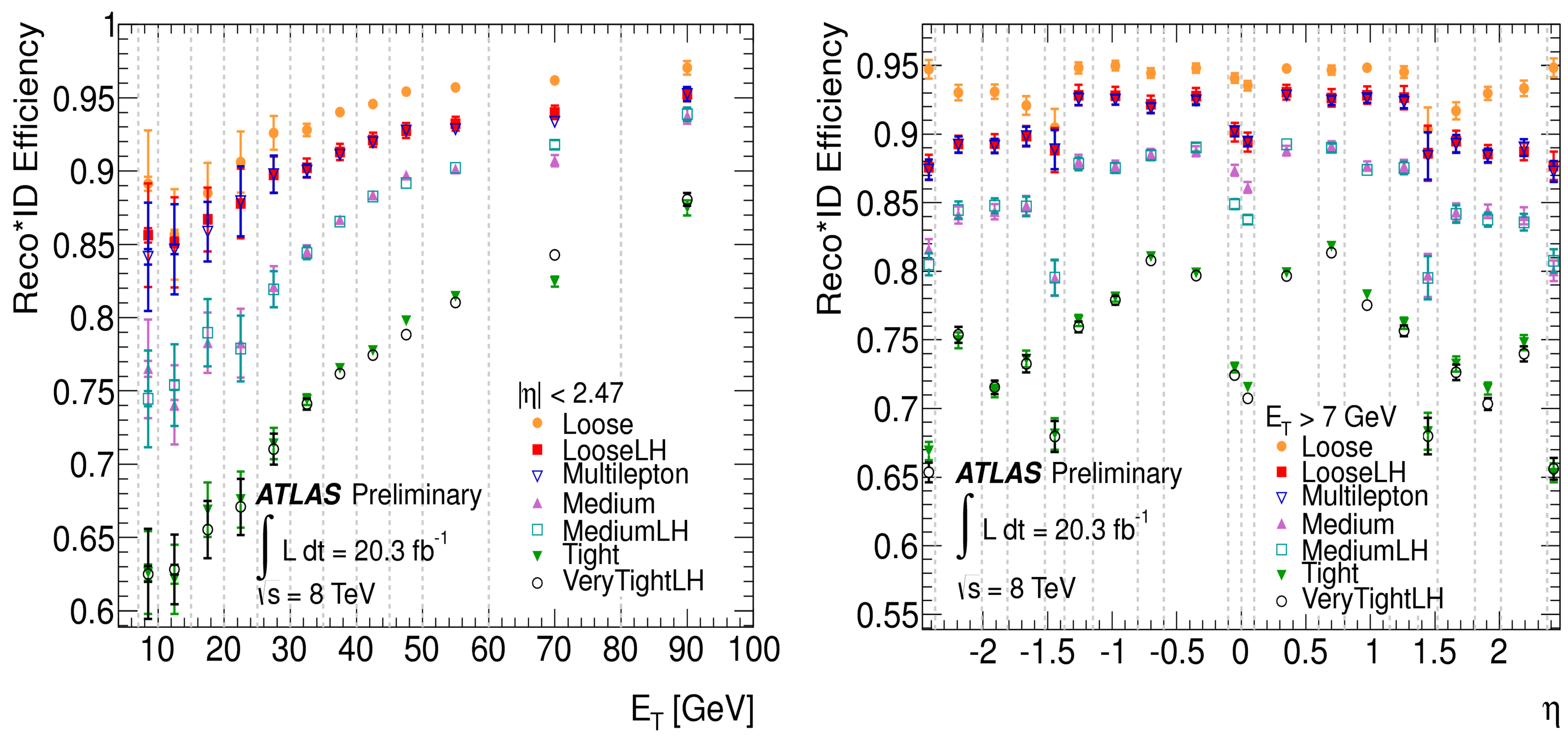

Figure 2: Measured combined reconstruction and identification efficiency for the various cut-based and likelihood selections as a function of E_T (left) and η (right) for electrons in Run 1 data.

Another technique used is likelihood (LH) identification:

- uses probability density functions (PDFs) of discriminating variables;
- overall probability is calculated for the object to be signal or background;
- for a given electron the probabilities are combined into a discriminant d_L on which a cut is applied: $dL = \frac{L_S}{L_S + LB}$, $L_S(\vec{x}) = \prod_{i=1}^{n} P_{s,i}(xi)$

For Run 2 the identification is adapted to changes in ATLAS detector: use Xe or Ar in different parts of the TRT, the new Pixel layer (IBL) and to have good pileup robustness with 25ns bunch spacing. Electron efficiency measurements using 2015 data (85 pb⁻¹) are presented in Fig.3 [4].

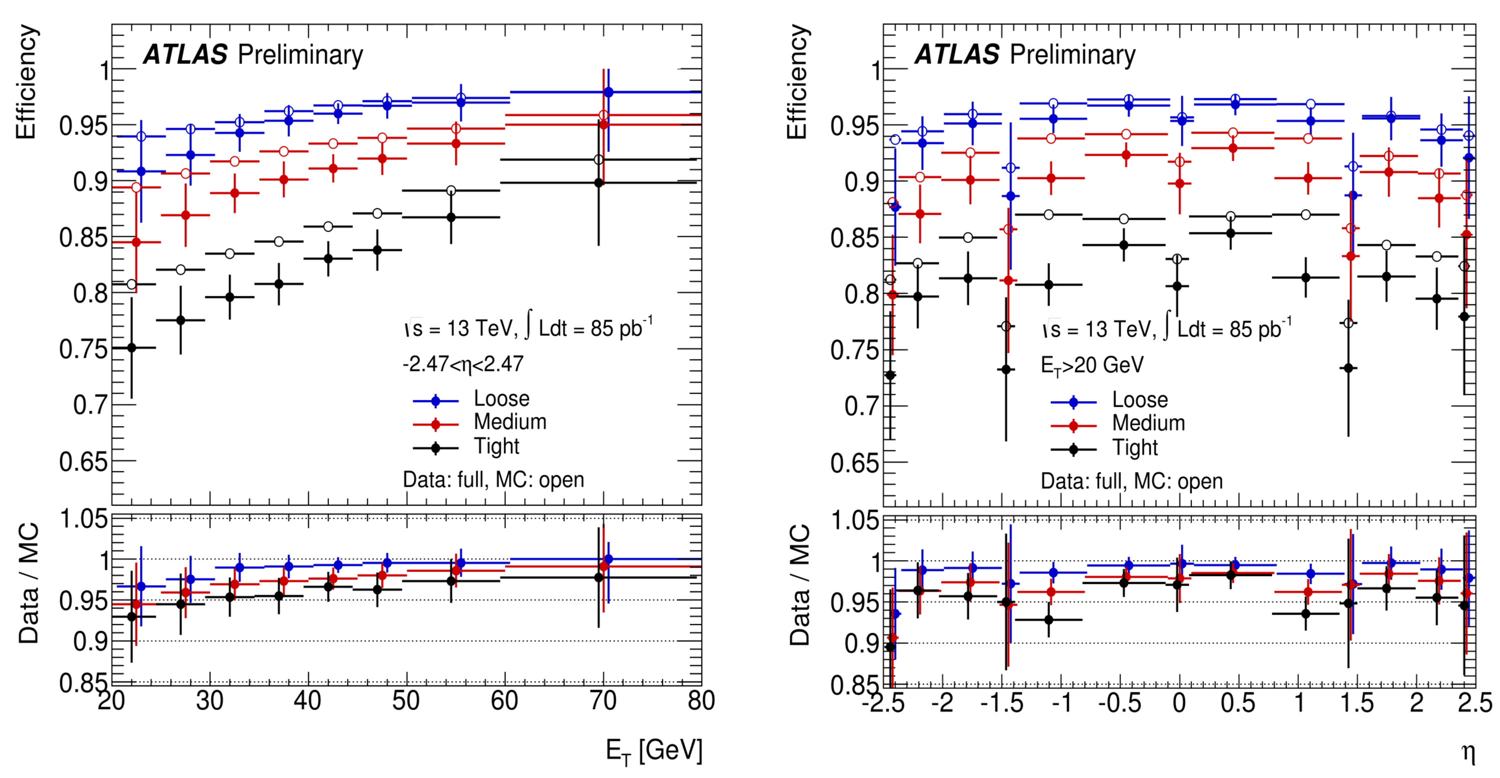

Figure 3: Electron identification efficiency in Z→ee events as a function of transverse energy E_T (left) and η (right). The efficiency is shown for three operating points that are based on a likelihood approach.

Calibration

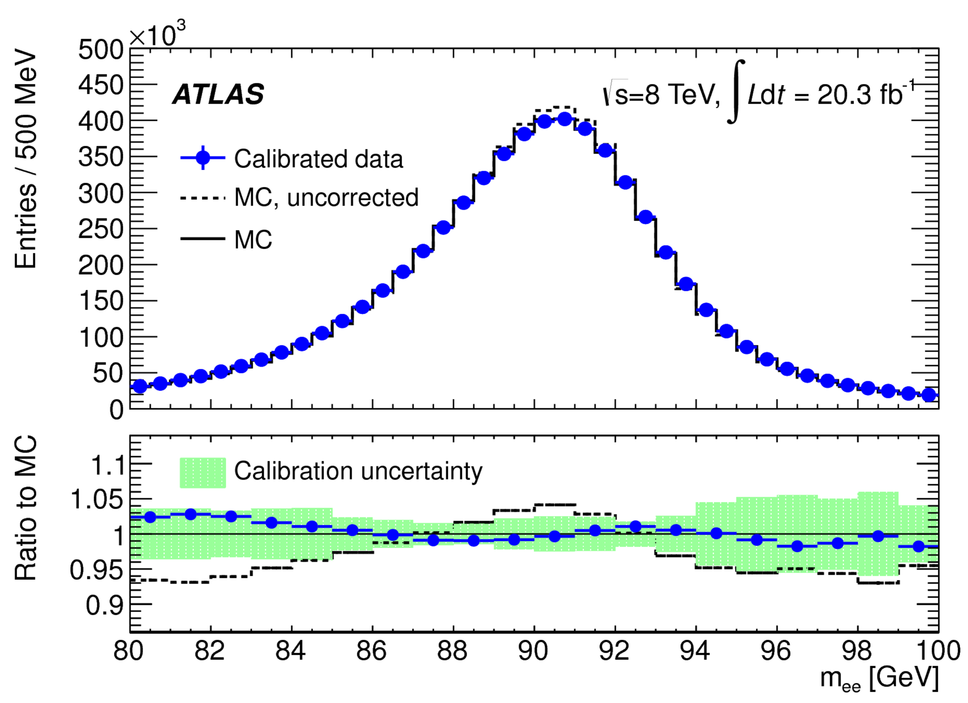

Figure 4: Dielectron mass distribution for the data corrected with the energy scale factors and the MC simulation with and without the resolution corrections [5].

References

[1] ATLAS Collaboration, The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) s08003

[2] ATLAS Collaboration, Electron efficiency measurements with the ATLAS detector using the 2012 LHC proton-proton collision data, ATLAS-CONF-2014-032

[3]T. Cornelissen et al, The global $\chi 2$ track fitter in ATLAS, J. Phys. Conf. Ser. 119 (2008) 032013.

[4] ATLAS Collaboration, Electron Efficiency Measurements in Early 2015 Data, https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/EGAM-2015-005/index.html

[5] ATLAS Collaboration, Electron and photon energy calibration with the ATLAS detector using LHC Run 1 data, arXiv:1407.5063,Eur.Phys.J. C74 (2014) 3071