Measurements of the Electron Reconstruction and Identification Efficiencies in ATLAS

Rencontres de Moriond EW 2014

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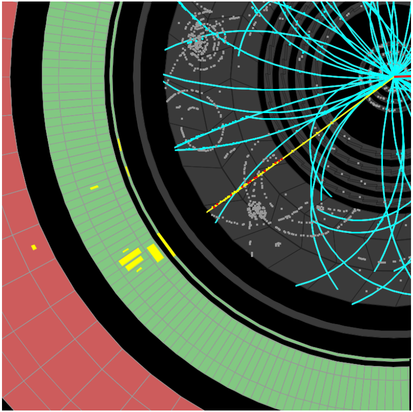
Electron Reconstruction and Identification

Motivation:

- Electrons are a vital part of ATLAS physics program, e.g. SM, Higgs, new physics searches
- precise knowledge of electron reconstruction and identification efficiency required

Reconstruction and Identification:

- electrons are reconstructed from *electromagnetic (EM) clusters* that are matched to a track,
  considering possible Bremsstrahlung
- several sets of *identification (ID) criteria* that differ in background rejection and signal efficiency
- cut-based and MVA-based criteria that rely on shower shape, track and track-to-cluster matching variables

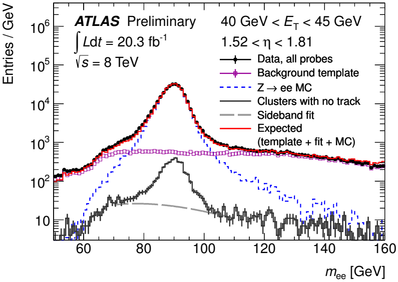


Electron Reconstruction Efficiencies

Ingredients to a Precise Measurement:

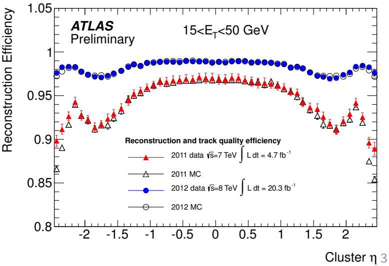
- a clean source of electrons, e.g. from $J/\psi \to ee$ and $Z \to ee$ decays
- a *tag-and-probe technique* is used to obtain a set of unbiased electrons (probes)

$$\epsilon = \frac{\text{\#probes passing ID - background}}{\text{\#all probes - background}}$$



Reconstruction Efficiencies:

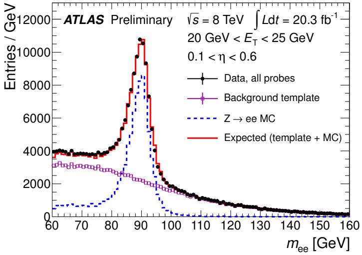
- cluster reconstruction efficiency > 99 % for electrons with $E_T > 15$ GeV (from MC)
- track reconstruction + track matching efficiency is measured in data
- background estimated in high M_{ee} side-band
- estimate electrons without a matched track from fit
- an improved reconstruction algorithm was deployed in 2012 yielding higher efficiencies compared to 2011



Electron Identification Efficiencies

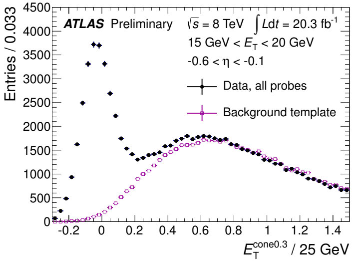
$Z \to ee$ T&P for electrons with $E_T > 15$ GeV:

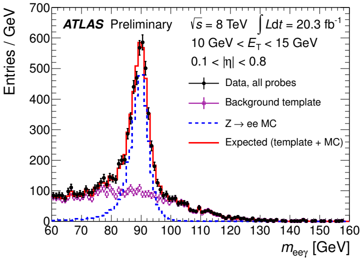
- two independent methods to subtract background:
  1. invariant mass of tag and probe M_{ee} (top right)
  2. the calorimeter isolation E_T^{cone} (bottom right)
- templates constructed from data



$Z \to ee\gamma$ T&P for electrons with $10 < E_T < 15$ GeV:

- use of radiative Z decays with hard QED FSR photons allows to probe electrons to lower energies
- the invariant mass is computed from three objects (bottom left)

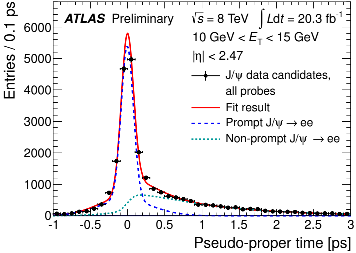


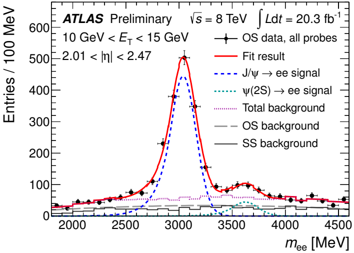


Electron Identification Efficiencies

$J/\psi \rightarrow ee$ T&P for electrons with $7 < E_T < 20$ GeV:

- $J/\psi \rightarrow ee$ have 'non-prompt component' from b hadron decays
- non-promt electrons are less isolated and have different efficiencies
- measured life-time τ used to differentiate between prompt and non-prompt decays
- two methods used:
  1. considering only short-τ events
  2. extracting the prompt-fraction by fitting τ



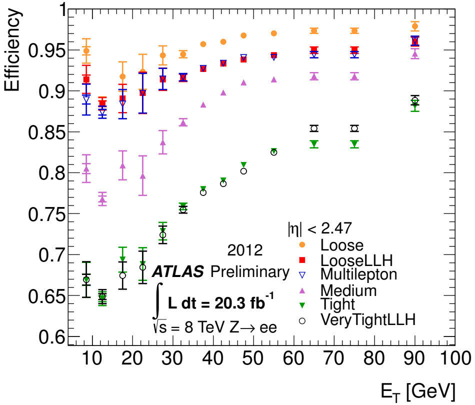


- background subtraction M_{ee} based, parametrizing J/ψ, $J/\psi(2s)$ and background

Combination and Results

Combination of Measurements:

- for a combination of measurements data/MC scale-factors are calculated for each of the methods
- a χ^2 minimisation is performed
- done for four sets of cut-based and three sets of MVA-based operating points



Results:

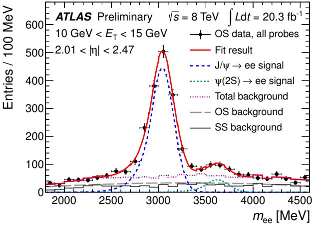
- the combination of independent measurements allows for a high precision
- the efficiency of the electron identification is known to a precision of $\frac{\Delta\epsilon}{\epsilon} < 5$ % for $7 < E_T < 30$ GeV and sub-percent precision for $E_T > 30$ GeV

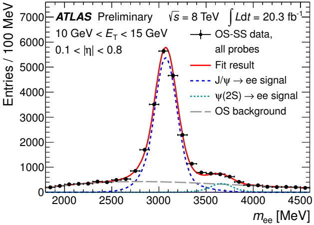
Backup

The pseudo-proper time for measurements with $J/\psi \rightarrow ee$ events is defined as:

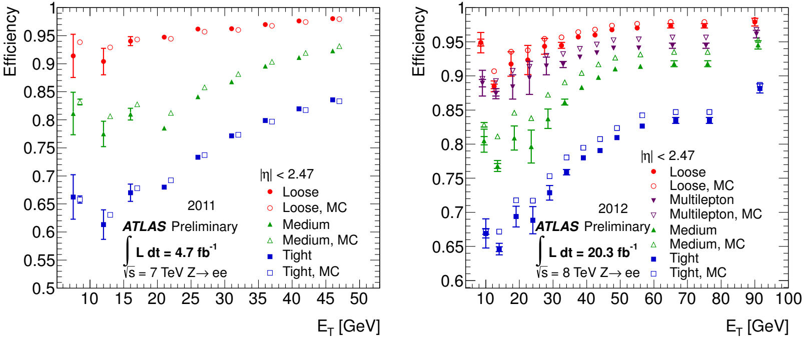
$$\tau = \frac{L_{xy} \cdot m^{J/\psi}}{p_{\mathrm{T}}^{J/\psi}}$$

with the displacement of the J/ψ vertex wrt. the primary vertex in the transverse plane L_{xy}, the J/ψ mass from PDG[1] and the reconstructed transverse momentum of the J/ψ candidate.





[1] K. Nakamura et al. (Particle Data Group), J. Phys. G 37, 075021 (2010)



electron ID efficiencies in 2011 (left) and 2012 (right)