Electron ID in ATLAS Run 2

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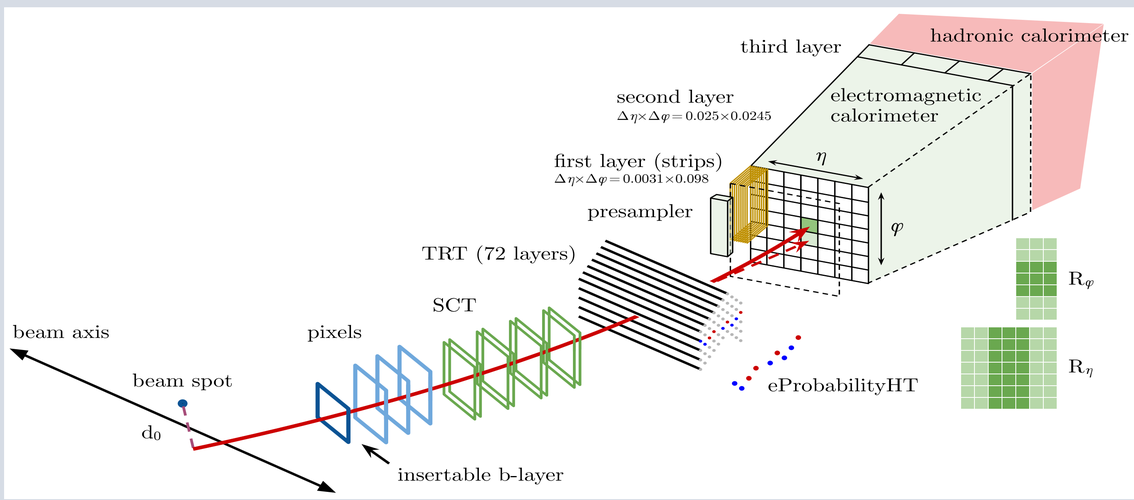
Introduction

Efficient and accurate electron identification (ID) is critical to measuring physics processes with leptons in the final states in the ATLAS detector

- Electron identification algorithm uses shower shape, track, and track-cluster matching information from inner detector and EM calorimeter as inputs
- Algorithm distinguishes prompt, isolated (separated from other physics objects) electrons from hadronic jets, converted photons, and heavy flavour decays (backgrounds)
- Algorithm is optimized for entire p_T (4.5 GeV - ~1 TeV) and central η (0-2.47) range
- Electron ID working group provides recommendation for 3 different operating points (OPs) with varying efficiencies for genuine electron and background processes selection to suit the needs of various ATLAS analyses

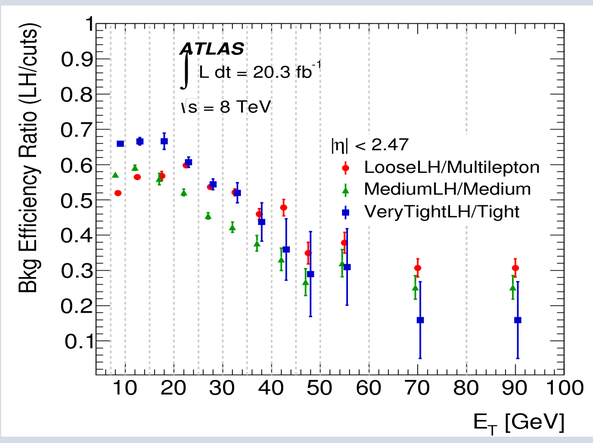


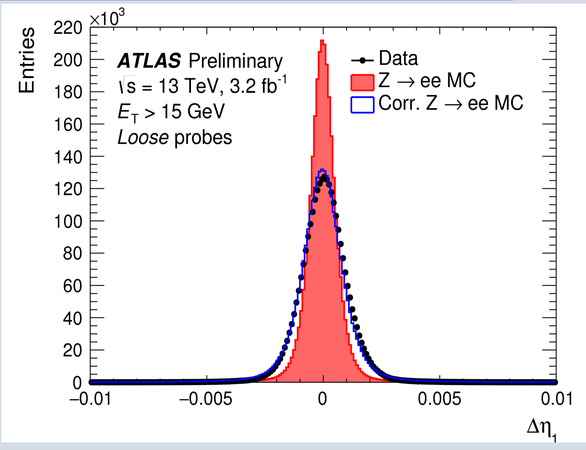
Electron Identification Method

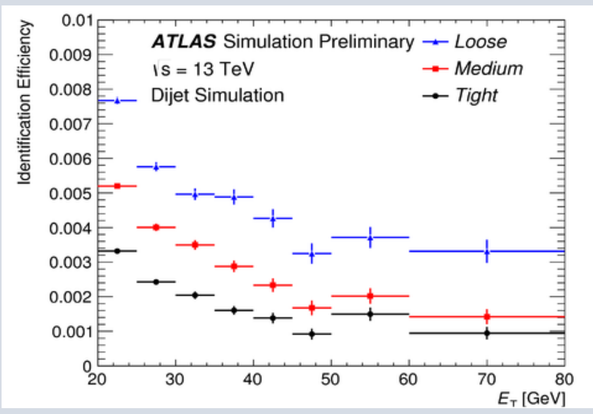
Electron ID uses a Likelihood Method:

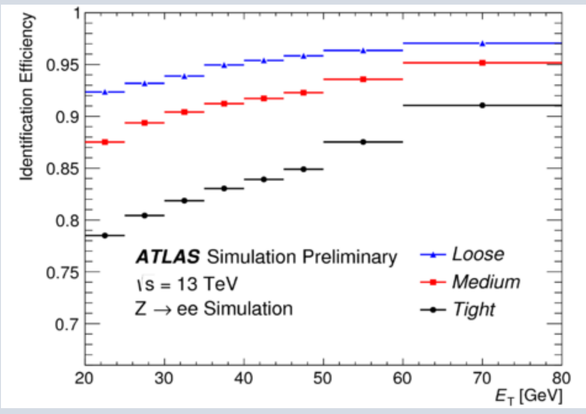
1. PDFs (Probability Density Functions) of discriminating variables for signal and background are formed from MC distributions (J/Ψ→ee for p_T≤15GeV and Z→ee for p_T≥20GeV)
2. PDFs are shifted and scaled (linearly) to match data to reduce known mis-modeling effects
3. PDFs are smoothed to minimize statistical fluctuations
4. LH discriminant calculated
5. Discriminant cut selected to match desired signal efficiency for specific Operating Points

Background rejection with LH ID is ~200% of previous cut-based ID



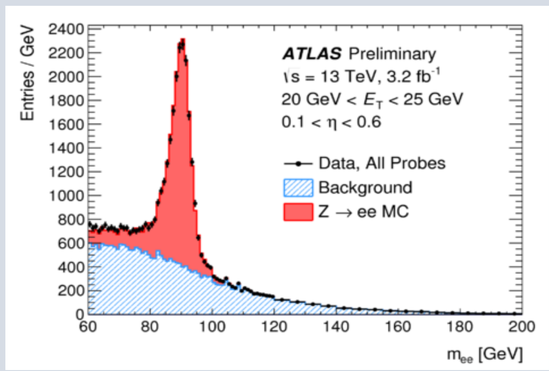


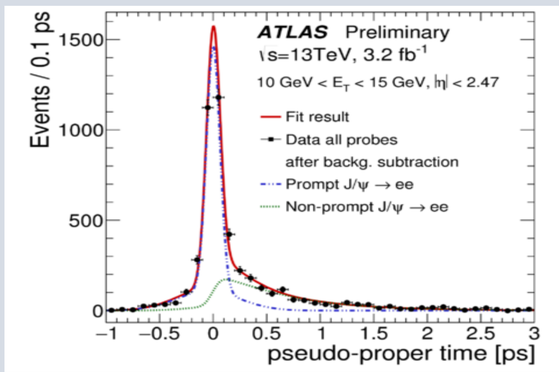


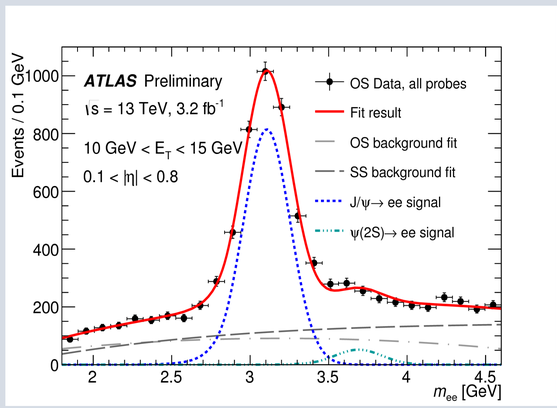


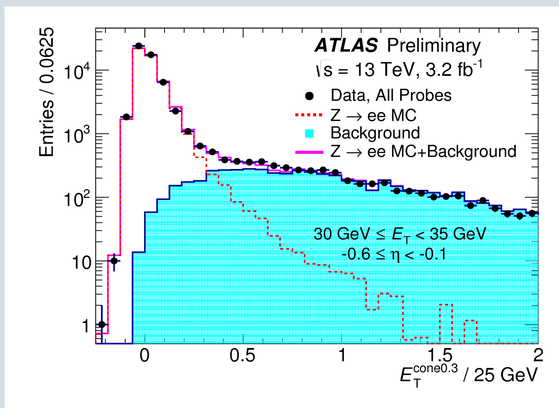
Tag and Probe Method

Tag-and-probe selects pairs of electrons from Z→ee or J/Ψ→ee decays by placing strict selection criteria on one electron (tag) and using the unbiased other electron (probe) for efficiency measurements or PDF calculations







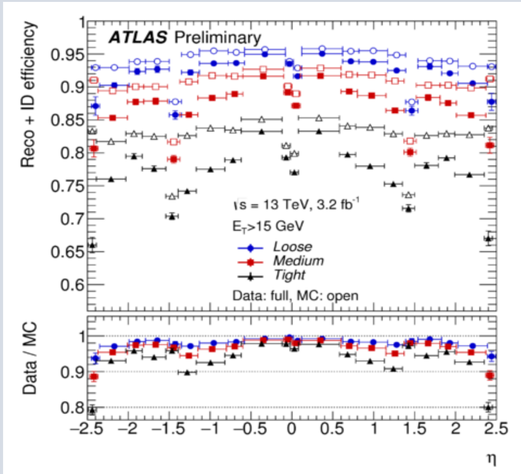


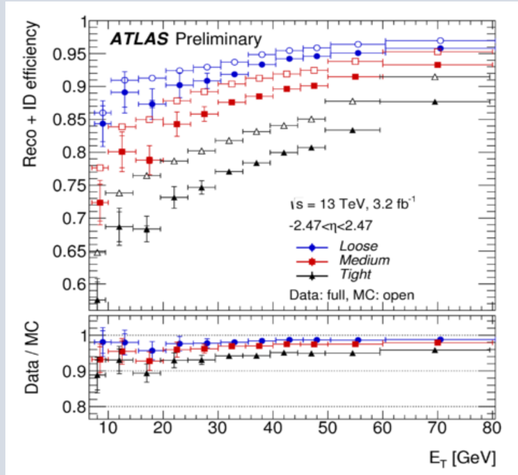
Sample Selection:

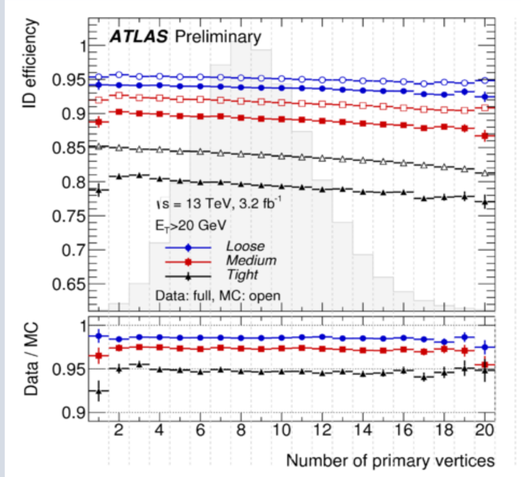
- **Signal MC**: truth matching to prompt, isolated electrons
- **Z→ee data**: cut on the combined electron mass or isolation + template background fit
- **J/Ψ→ee data**: isolation cuts and a cut (or fit) on the distance between the J/Ψ vertex and primary vertex (to select prompt J/Ψ)
- **Background** : all 2→2 QCD processes (can be misidentified as electrons)

ID Efficiency Measurements

- Measuring the electron ID efficiency and how it differs from data to MC is crucial to cross-section measurements and new physics searches.
- Efficiency=ε(tags passing criteria)/(all probes) is calculated using tag-and-probe methods for all Operating Points
- Efficiency ratios used to correct MC samples so $\varepsilon_{data} = \varepsilon_{MC}$ to ensure reliable physics results







Upcoming ID Improvements

- Will move to data driven PDFs for setting LH discriminant cut values for operating points now that sufficient 13TeV data has been collected: data driven ID was used during Run 1, but PDFs were only calculated from Z→ee events, Run 2 will use Z→ee and J/Ψ→ee
- Low p_T region (≤ 20GeV) is important for low mass SUSY searches and h→4l analyses. ID efficiency is significantly lower here, and this region is now being specifically studied for the first time
- Variables for low p_T region are being optimized using n-1 variable studies, new variables are being studied to increase efficiency in this difficult region
- New machine learning applications are being studied including convolutional neural network image processing using calorimeter cell information.

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References: ATLAS-CONF-2016-024, CERN-EP-2016-262