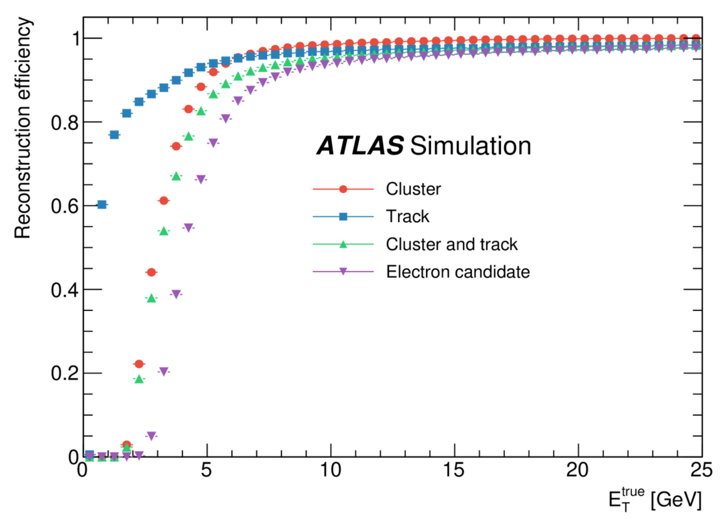
Performances of electron reconstruction + identification in Run 2 and preparation for Run 3

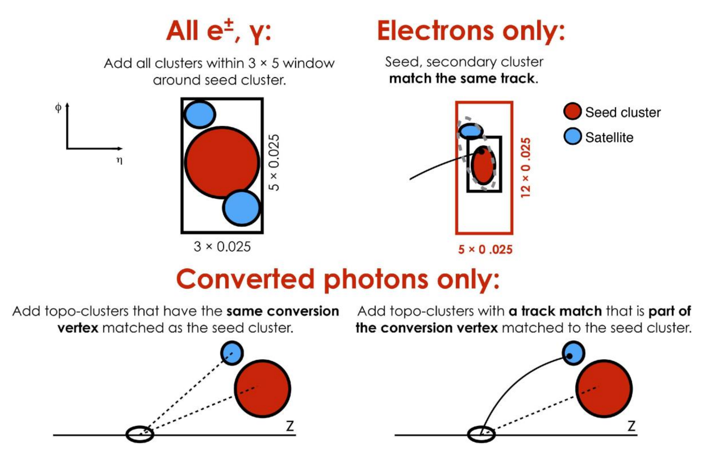
In the ATLAS detector, electrons and positrons, collectively referred to as electrons, leave characteristic signatures which allow them to be reconstructed and identified. The poster presents measurements of electron reconstruction and identification in $J/\psi \rightarrow ee$ and $Z \rightarrow ee$ events using Run2 data collected at centre-of-mass energy of 13 TeV in p-p collisions. The poster shows the development of a new identification algorithm based on a deep neural network targeting Run3.

Electron reconstruction

The reconstructed e^- candidates encompassed by EM calorimeter and the inner detector is based on three fundamental components characterizing the signature of electrons:

- localized **clusters of energy deposits** within EM calorimeter
- charged-particle **tracks** identified in the inner detector
- close **matching** in **η × ϕ** space of the tracks to the clusters to form the final electron candidates



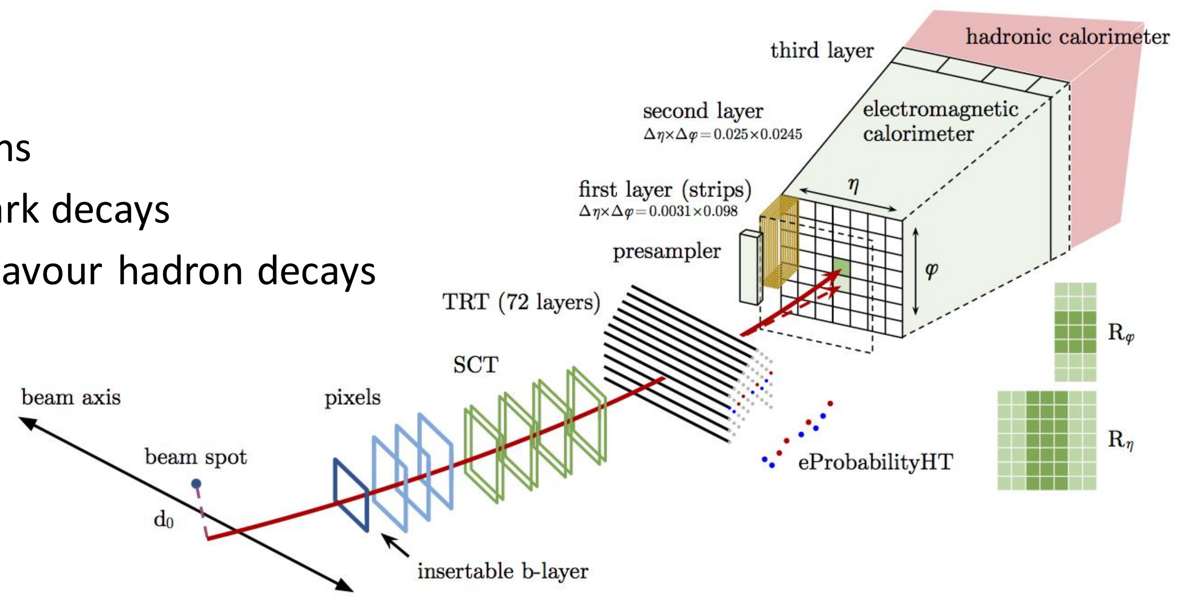


Electron identification

An electron passing through inner detector hits IBL pixel layer, 3 pixel layers, 4 double-sided silicon strips (SCT) and average of around 30 straw hits in the TRT.

Different identification criteria are used to discriminate electrons from background classes such as:

- hadronic jets
- electrons from photon conversions
- electrons from heavy-flavour quark decays
- electrons or photons from light-flavour hadron decays



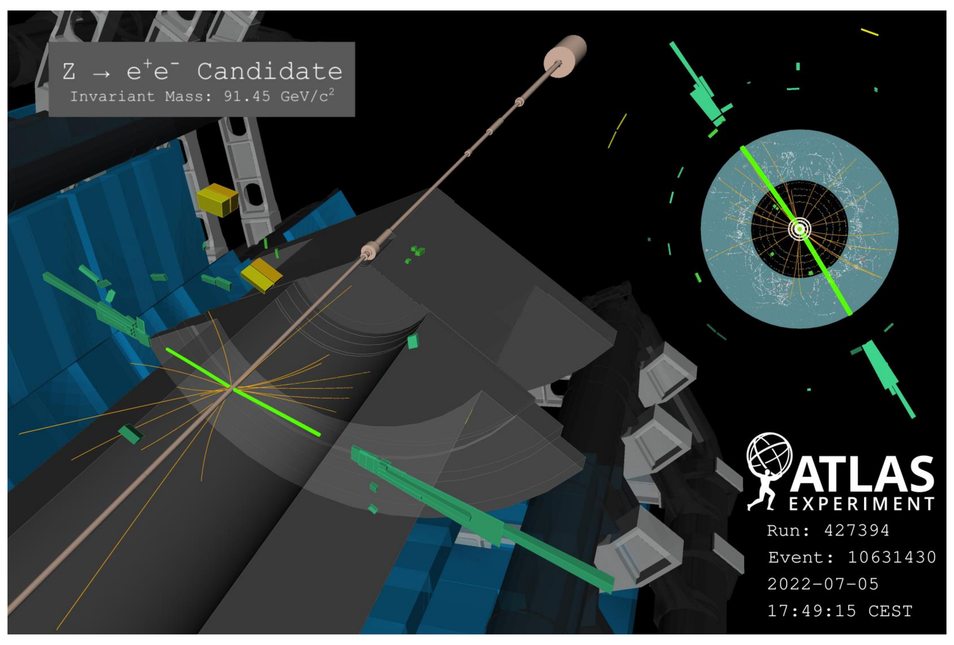
Three different **identification working points**: **loose**, **medium** and **tight** interpreted by a selection on a likelihood (LH) discriminant calculated from the calorimetric cluster shower shapes, track and **track-to-cluster** matching variables

Electron efficiency measurements → results

Electron efficiencies computed using the **Tag and Probe method**
Tag electron → strict selection criteria
Probe electron → unbiased & used for the efficiency measurements

The total efficiency ε_{total} being the product of the reconstruction ε_{reco}, identification ε_{id}, isolation ε_{iso} and trigger efficiencies ε_{trig}:

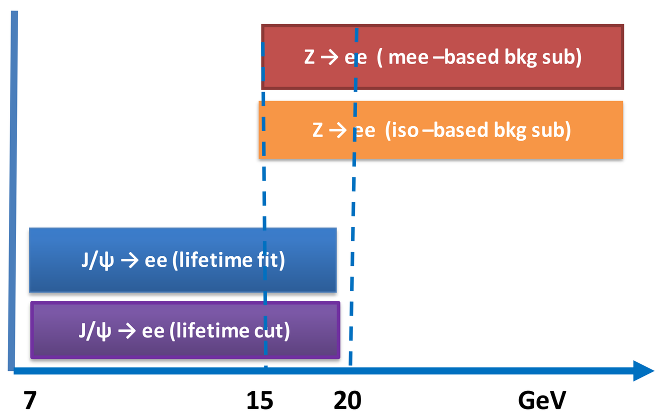
$$\varepsilon_{total} = \varepsilon_{reco} \times \varepsilon_{id} \times \varepsilon_{iso} \times \varepsilon_{trig}$$



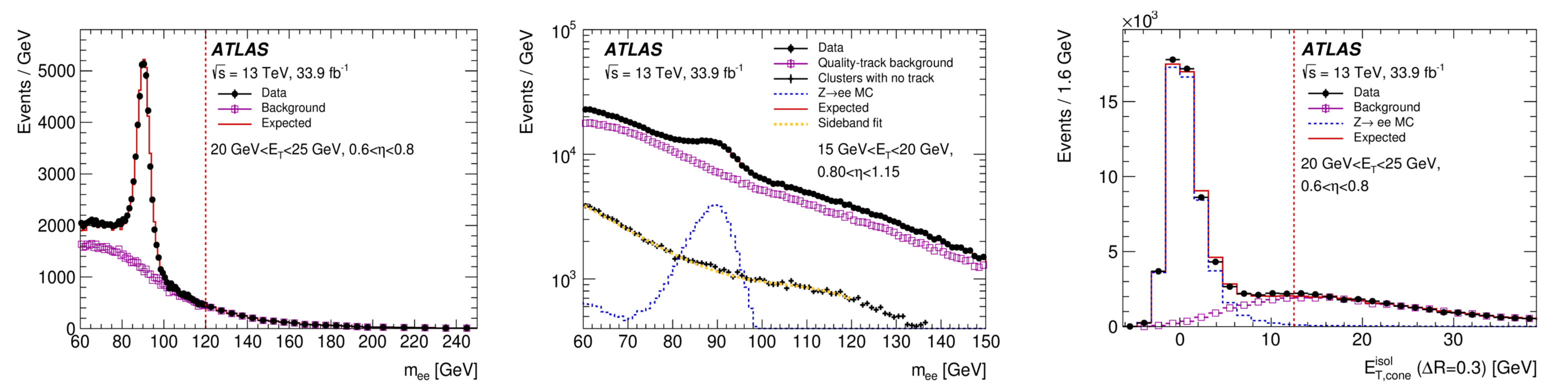
Two different resonances used for different energy range:

- $J/\psi \rightarrow ee$
- $Z \rightarrow ee$

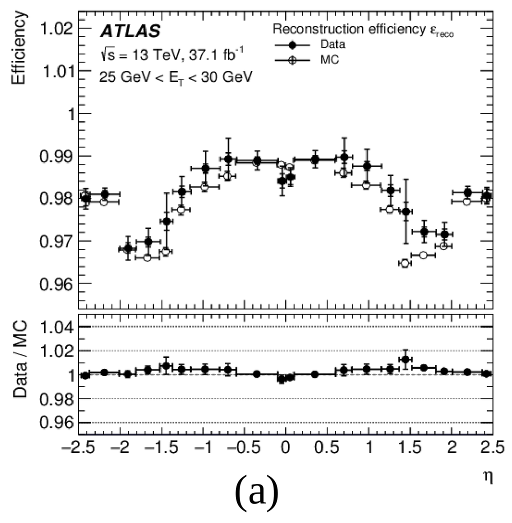
ε = N (probes pass criteria)/ N (total probes)



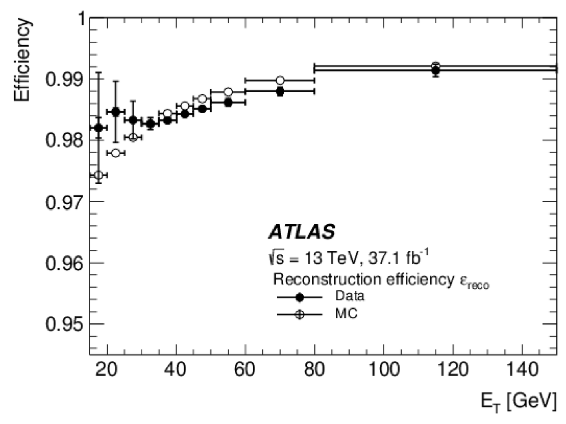
$Z \rightarrow ee$ (m_{ee}–based bkg subtraction) $Z \rightarrow ee$ (iso-based bkg subtraction)



Reconstruction efficiency (ε_{reco}) = Probes pass track quality / All EM clusters (e⁻ + γ)



(a)

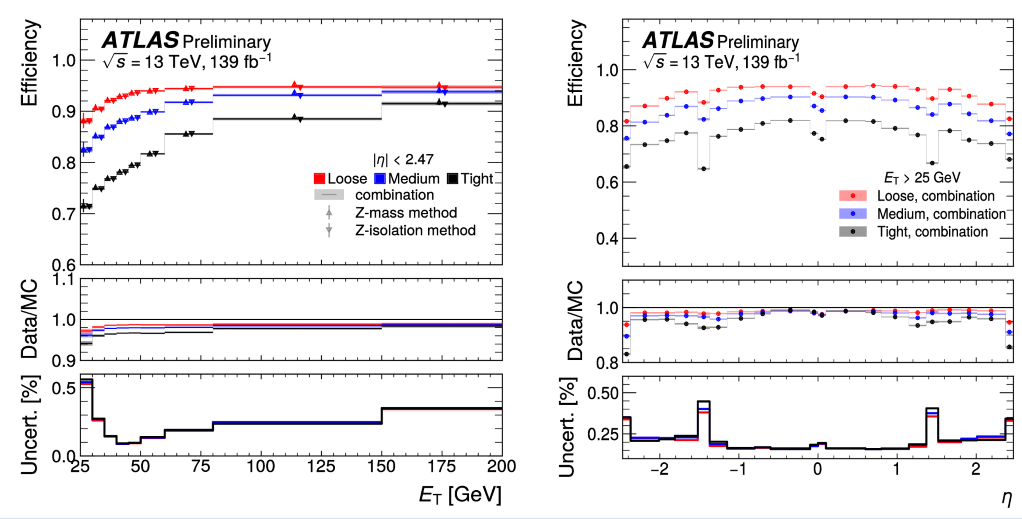


(b)

The reconstruction efficiencies as a function of E_T, η in bin 25 <E_T< 30 GeV (a) the total reconstruction efficiency (b)

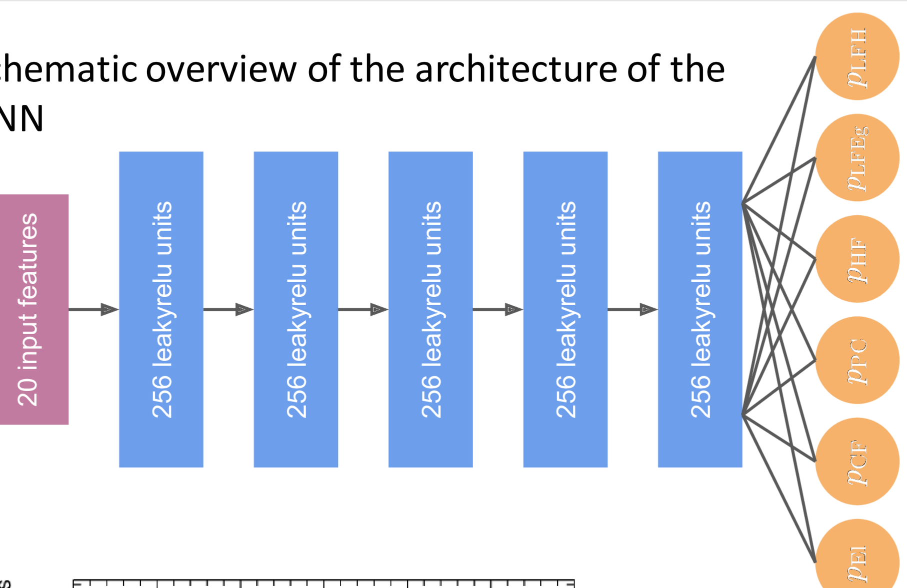
Identification efficiency (ε_{id}) = N (identified electrons) / N (reconstructed electrons)

The identification efficiency measurements as combination of Z-mass and the Z-isolation method (bottom left) Measured LH electron-identification efficiencies for the Loose, Medium, Tight operating points as a function of η (bottom right)



Development of DNN identification → Performance

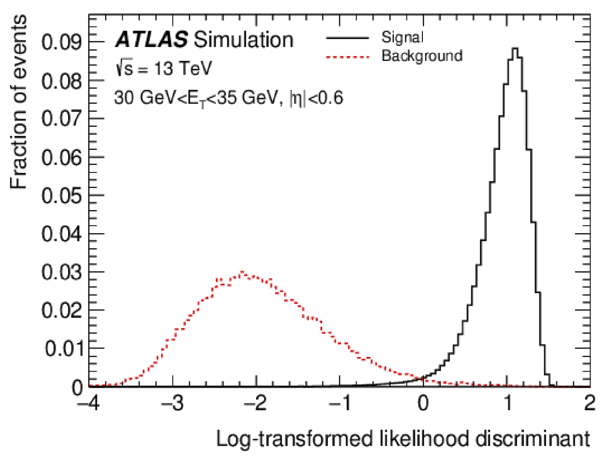
Schematic overview of the architecture of the DNN



For each electron candidate, a discriminant d_L is formed:

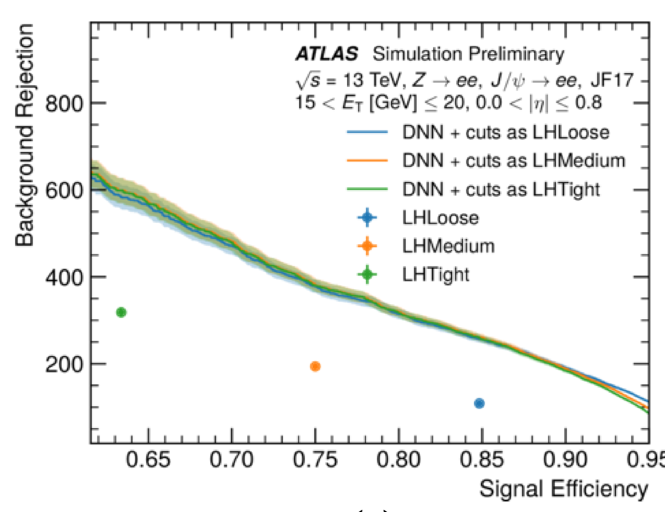
$$d_L = L_S / L_B$$

The electron LH identification is based on this discriminant. The discriminant d_L has a sharp peak at unity (zero) for signal (background)

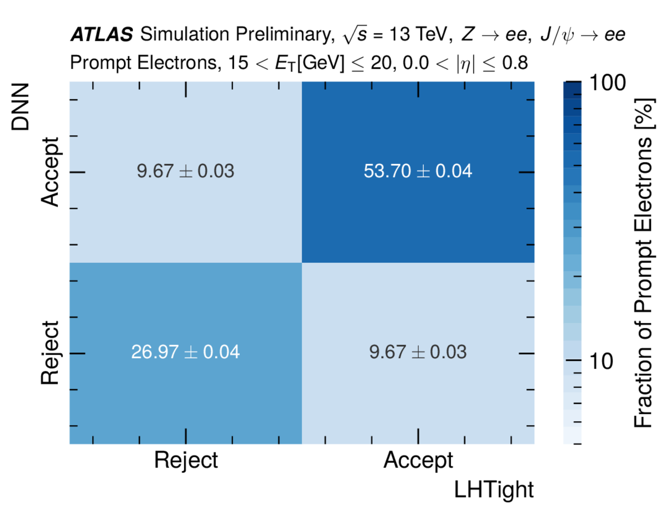


$$d'_L = -\tau^{-1} \ln(d_L - 1)$$

The distribution for transformed LH-based identification discriminant d'_L for reconstructed electron candidates with good quality tracks. For the prompt electrons and background, this distribution illustrates the effective separation between signal and background encapsulated in this single quantity.



(a)



(b)

ROC curves for the combined background for LHLoose, LHMedium, LHTight (a) Comparison of the selection of prompt electrons based on the DNN and the LH (b) shows a Tight working point.

[1] ATLAS Collaboration, JINST 14 (2019) P12006
[2] ATLAS Collaboration, EGAM-2022-01
[3] ATLAS Public Results, Event displays Run 3
[4] ATLAS Collaboration, PERF-2017-01

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