Electron identification efficiency measurements with the ATLAS detector & the impact of the pile-up

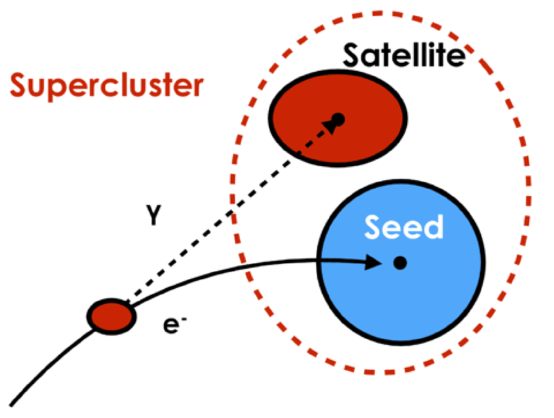
The capability to provide efficient electron identification over a wide range of energies is indispensable to the ATLAS physics program. For an optimal use in cross-section measurements and the search for new physics, it is of great importance that simulations model the electron identification accurately.

Precise efficiency measurement of both data and Monte Carlo across a wide energy range is therefore very important. Different analyses addressing different energy range, using two characteristic signatures, the Z boson and the J/ψ resonances, are used.

Electron reconstruction: from clusters to superclusters

By **combining clusters** originating from the primary electron with those from radiative interactions within the detector, we can

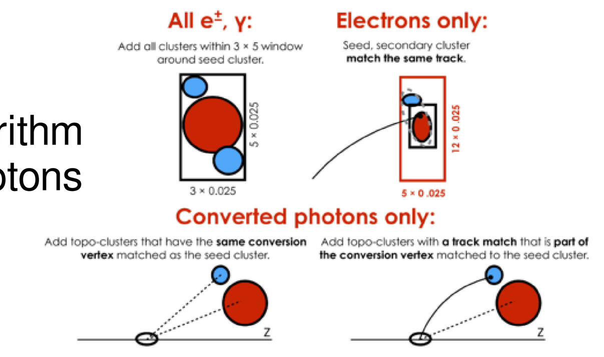
- **recover the energy** lost due to bremsstrahlung
- significantly **improve the energy resolution**
- naturally **develop an EM shower** in the calorimeter.

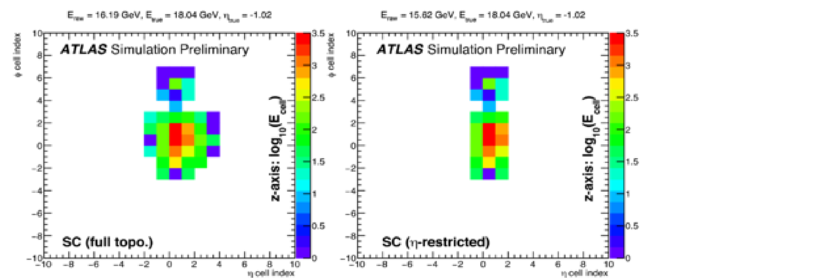


An electron that radiates away a bremsstrahlung photon due to interactions with the material of the inner detector.

Supercluster(SC): connect the primary cluster from the electron shower(**seed cluster**) with the nearby secondary cluster from the photon shower(**satellite cluster**).

Supercluster algorithm for electrons and photons





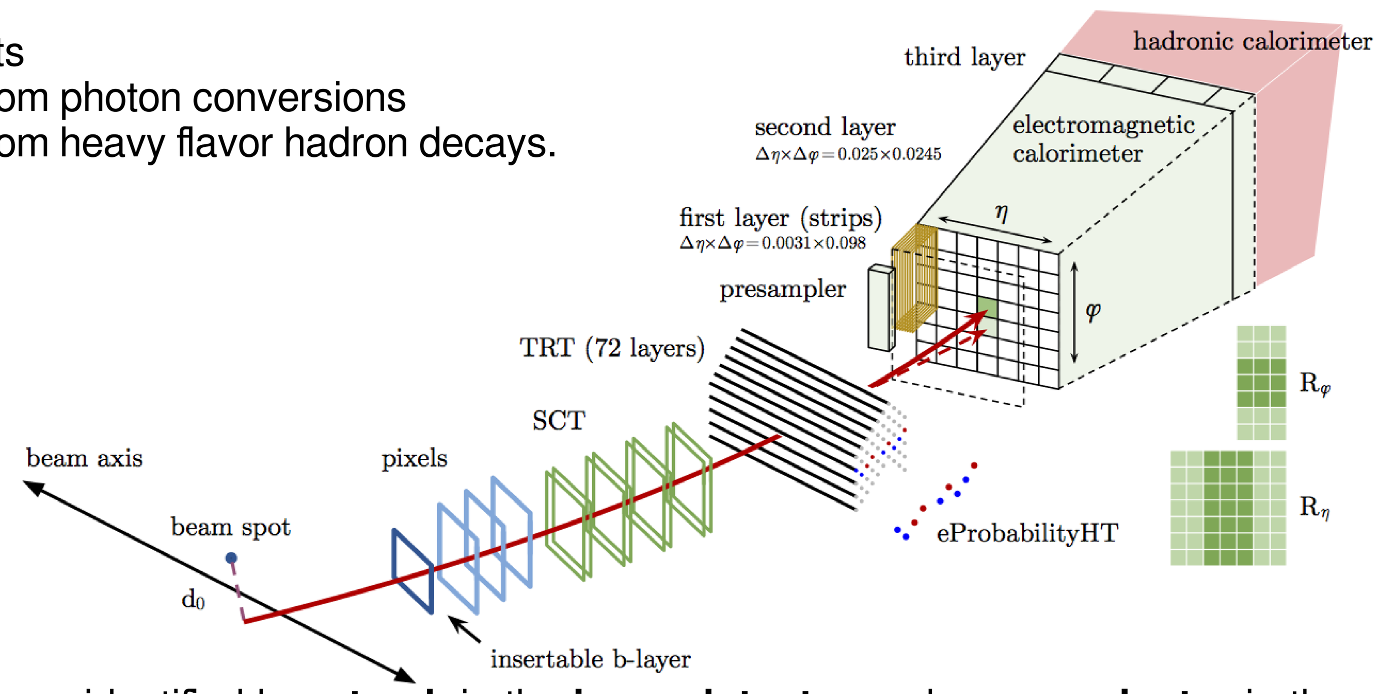
Effect of restricting cluster size in |η| on a sample of electron supercluster in the EM calorimeter.

*More details in **ATL-PHYS-PUB-2017-022**

Electron identification

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

- hadronic jets
- electrons from photon conversions
- electrons from heavy flavor hadron decays.



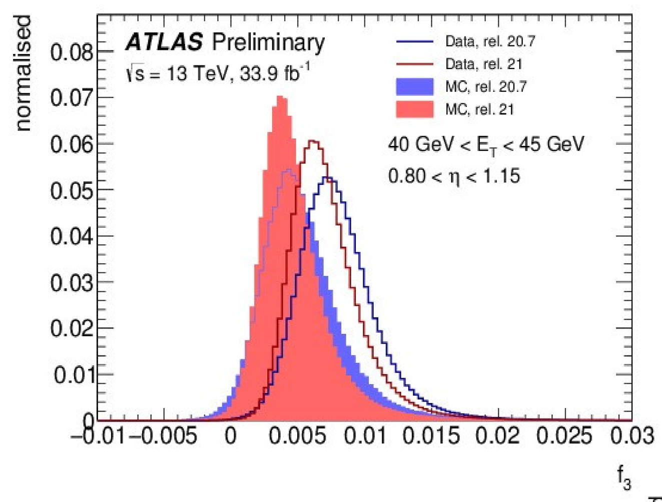
Electrons are identified by a **track** in the **inner detector** and a **supercluster** in the **electromagnetic calorimeter.**

Three different **identification criteria: loose**, **medium** and **tight**, defined by a selection on a likelihood(LH) discriminant computed from the calorimetric cluster shower shapes, track and **track-to-cluster matching** variables.

Electron discriminating variables

Probability density functions (PDFs) from data:

- used for the LH definition
- differ from different p_T and η bins.

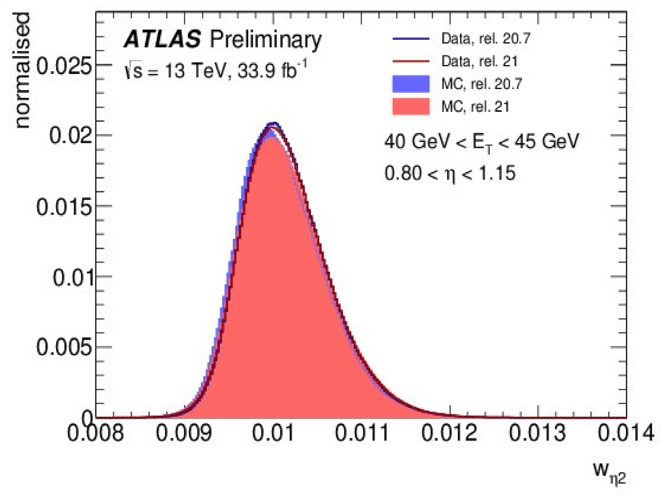


Back layer variable (change expected with the new SC reconstruction).

Ratio of the **energy** in the **back layer** to the **total energy** in the electromagnetic calorimeter

Middle layer variable (no change expected)

Lateral shower width



Electron efficiency measurements

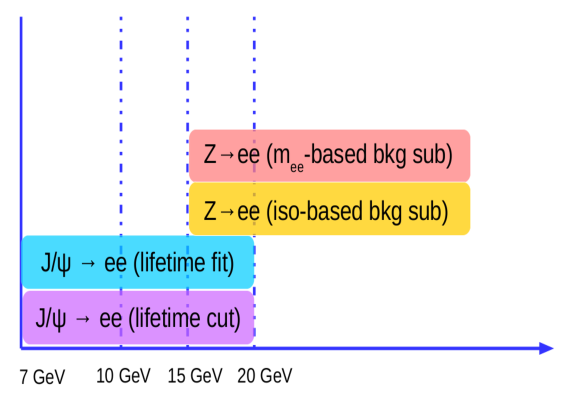
Electron identification efficiency measured using the **Tag and Probe method**.

Tag electron → strict selection criteria
Probe electron → unbiased & used for the efficiency measurements

Two different resonances used that address different energy range:

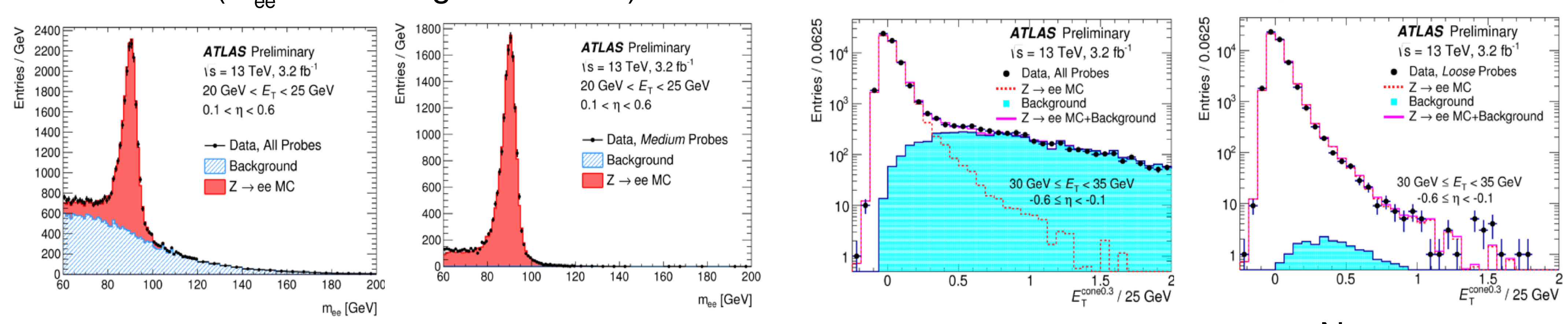
- J/ψ→ee
- Z→ ee

$$\epsilon = \frac{N_{probe\ pass\ the\ criteria}}{N_{total\ probes}}$$



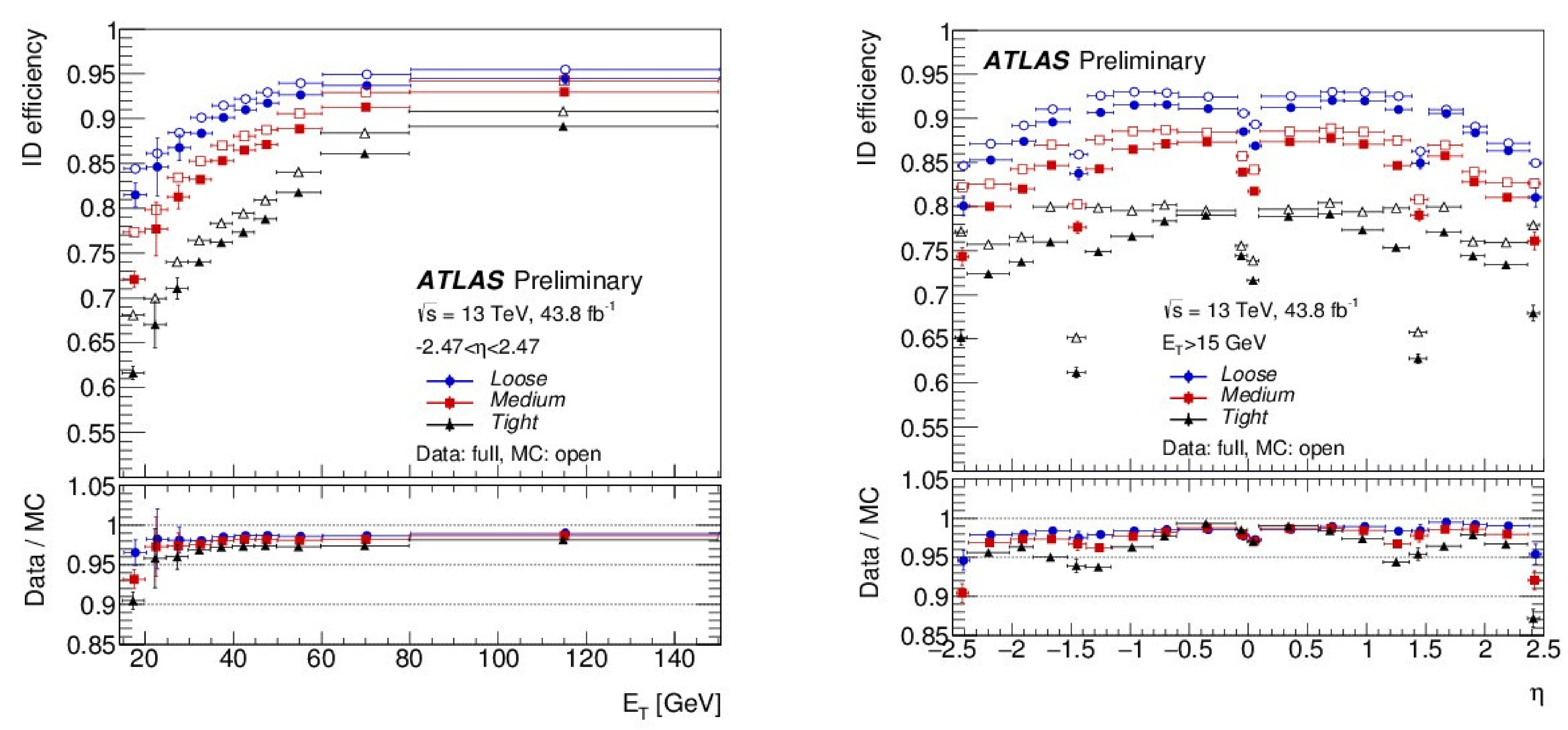
Double differential measurement in 240 bins using two alternative methods to estimate background in Z→ ee events:

Z→ee (m_{ee}–based bkg subtraction) Z→ee (iso-based bkg subtraction)



$N_{total\ probes}$ $N_{medium\ probes}$ $N_{total\ probes}$ $N_{loose\ probes}$

Electron efficiency measurements → results



Electron identification efficiencies of the Z→ ee events as a function of the transverse energy, and as a function of the pseudorapidity.

- For typical electroweak processes the **electron efficiency** is known with a **better precision than 1%**.
- **Correction factors** are used to match the efficiency in MC to the efficiency measured in data.

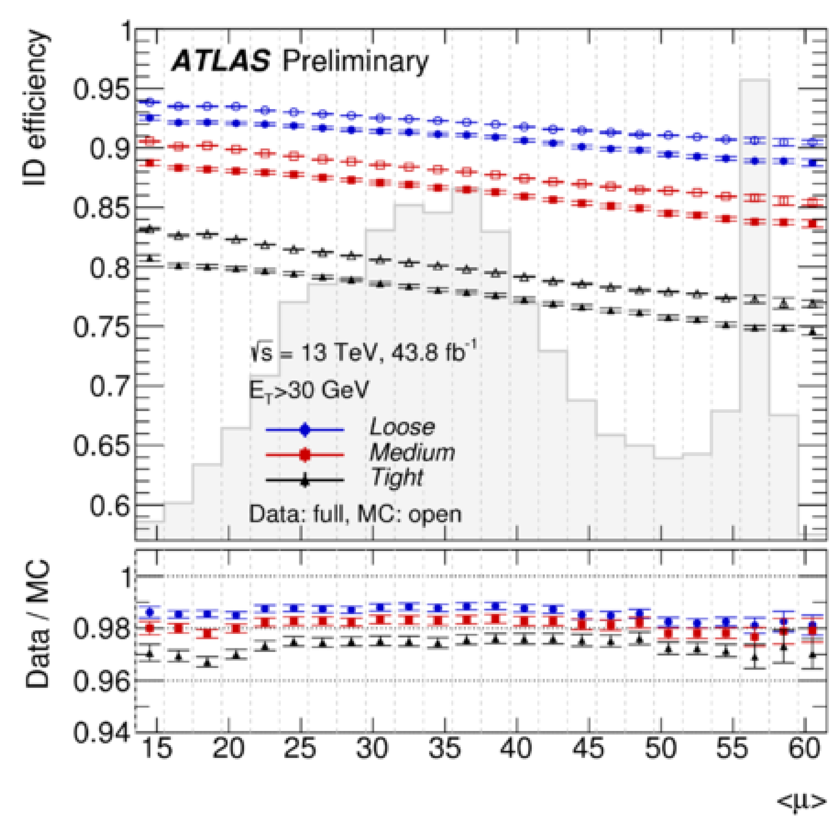
The impact of the pile-up

Pile-up effects vary proportionally to the average number of interaction per bunch crossing <μ>.

Increasing pile-up leads to

- **higher energy deposits in the calorimeter** → widens the shower shape variables
- **more tracks in the inner detector**

impact the electron reconstruction and identification



Identification efficiency for three different working points as a function of the <μ>.

Slope well modeled in MC.
Typical loss for <μ> ∈ [15,60]: ~ **4 %**

Reference: The efficiency measurements and the LH tuning are described in the **ATLAS-CONF-2016-024**

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