# Photon identification efficiency measurements with the electron extrapolation method

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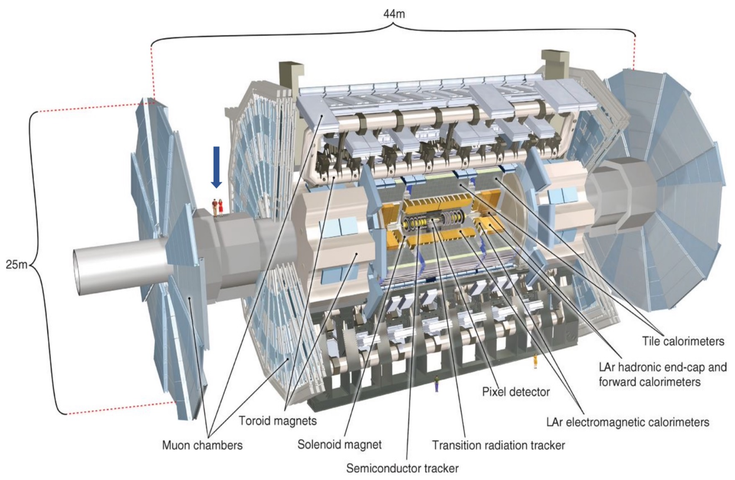
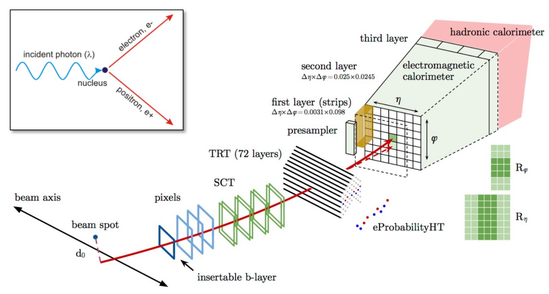
## Physics motivation

### ATLAS experiment




ATLAS is one of the main general-purpose detectors of the LHC.

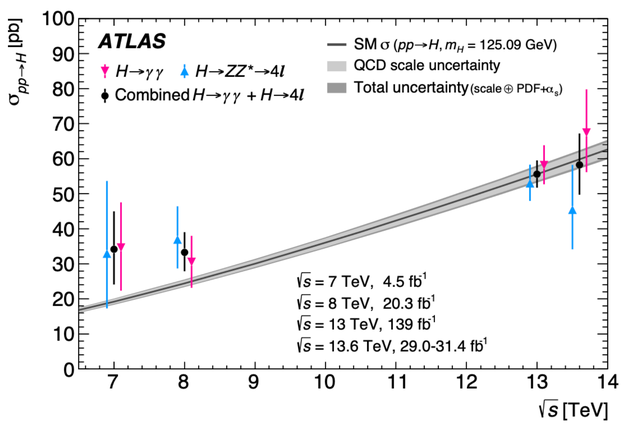
### Photons performance



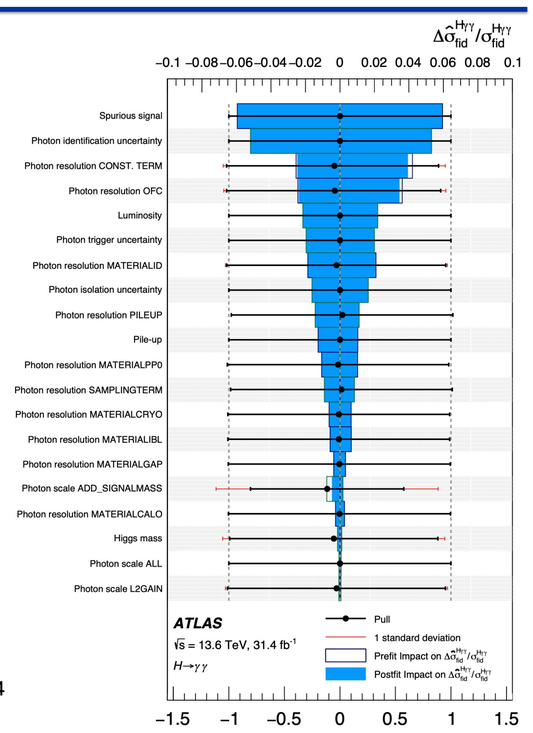

Photons (or converted to two electrons) without (with) track in internal detector, deposit energy in an electromagnetic calorimeter and then form a shower.

### Photons in physical analyses

Photons play a crucial role in many physical analyses. For example, in run3 H to $\gamma\gamma$ analysis, **photon identification uncertainty** is the second dominant uncertainty.



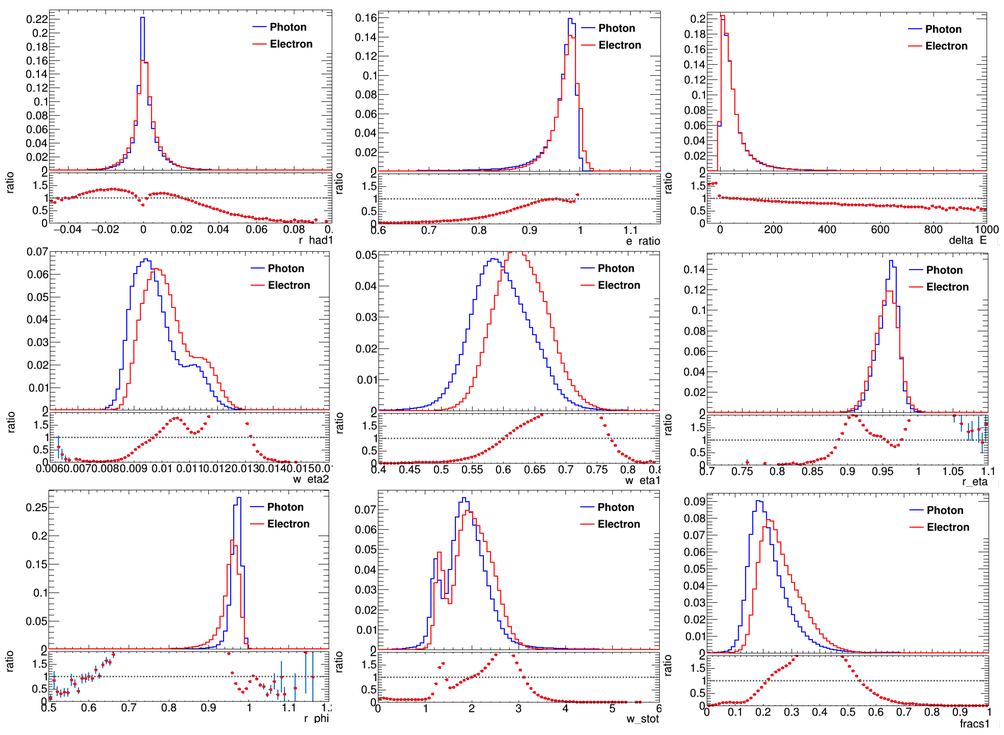

*ATLAS work in progress*




*ATLAS work in progress*

## Electron extrapolation method

### Photon identification variables




*ATLAS work in progress*

The identification of photons in ATLAS is achieved using a cut-based algorithm that applies a group discriminating variables.

### Electron extrapolation and Smirnov transformation

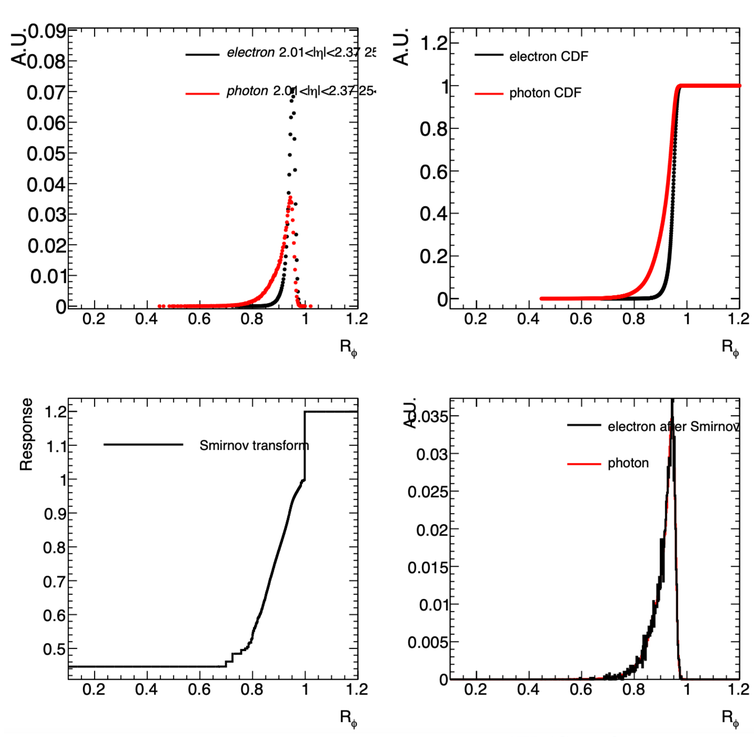
The definition of photon tight identification efficiency:

$$\varepsilon_i^{tight} = \frac{dN_i(tight, isolated)}{dN_i(loose, isolated)}$$

MC Electrons → **Calculate Smirnov** → MC Photons

Data Electrons → **Apply Smirnov** → Data Photons

Based on the similarity of electron and photon shower shapes distortion in calorimeter, transform the electron shower shapes into photon-like by Smirnov transformation. Then measure the photon ID efficiency by those photon-like sample.

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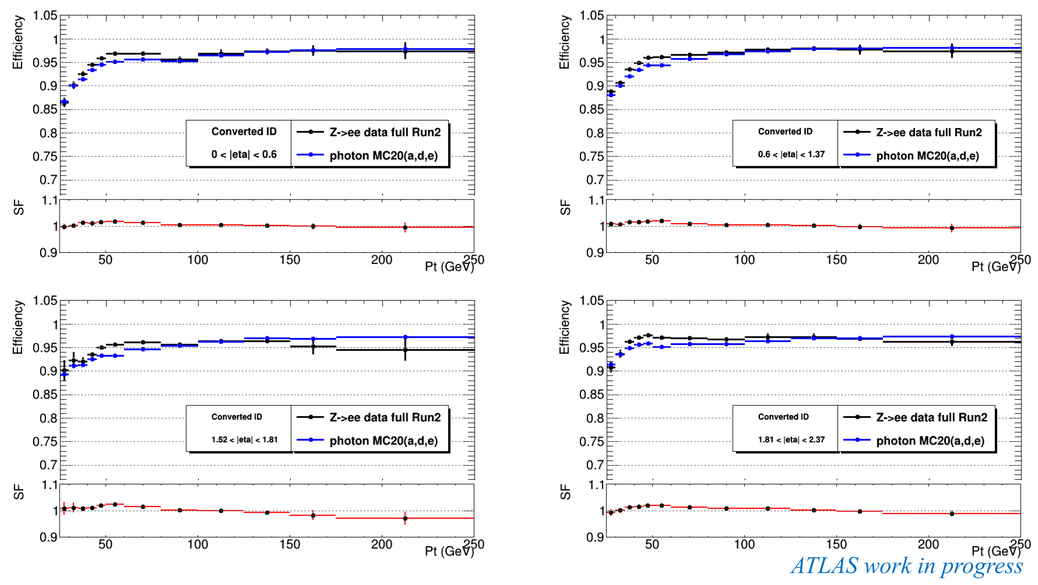
For two continuous one-dimensional distributions, Smirnov transformation provides a way to transform them into each other.

$$F(X) = \int_{-\infty}^{X} P(X')dX' \qquad x' = G^{-1}_{Photon}(F_{Electron}(x))$$

## Photon ID efficiency results for full Run 2 data

### Efficiency and scale factors for converted photon

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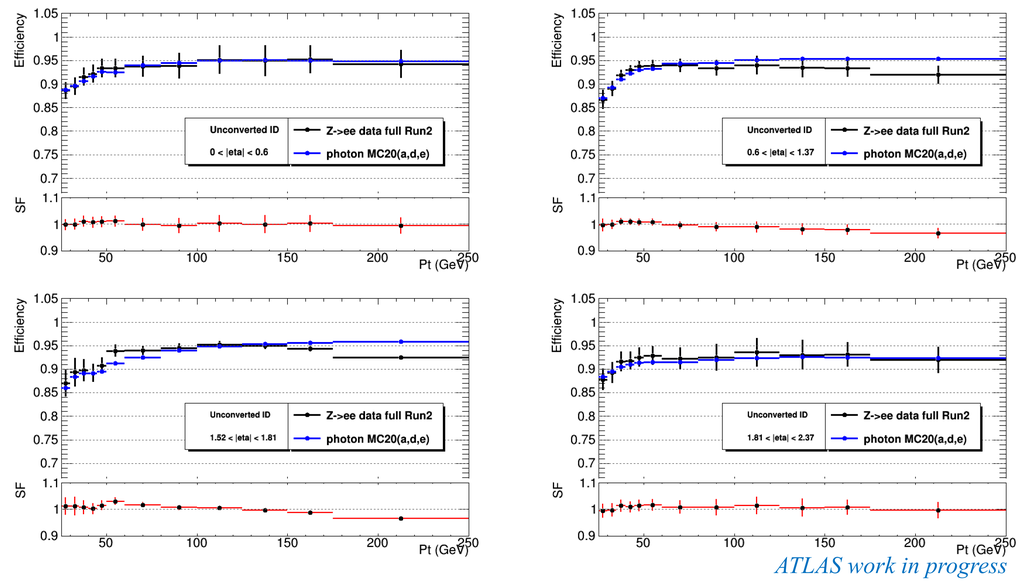
### Efficiency and scale factors for unconverted photon

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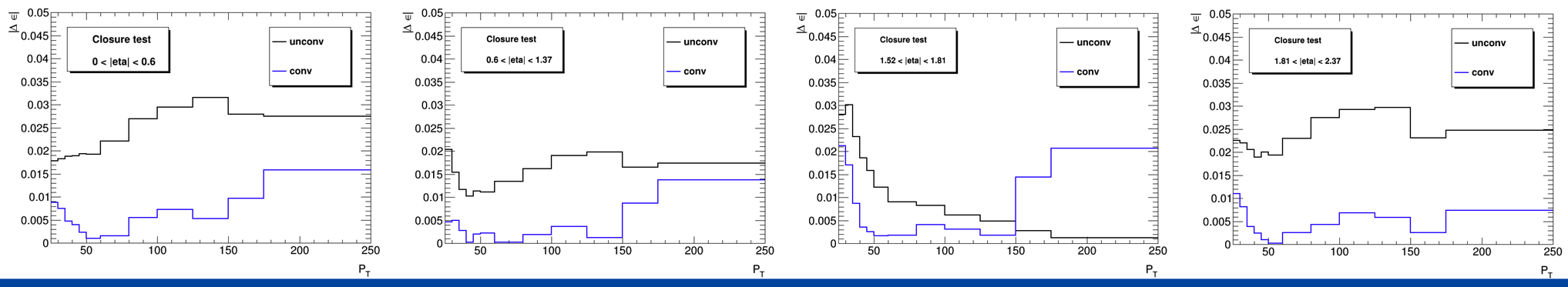
Scale factors are defined as ID efficiency of data divided by ID efficiency of MC. In most eta and $P_T$ bins, scale factors are close to 1.

### Systematic uncertainties of Closure test




Closure test evaluates Intrinsic uncertainty of Smirnov transformation, comes from not account for correlations between shower shapes. It is also the most dominant system uncertainty.

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**References: Photon identification efficiency measurements with the electron extrapolation method for the recommendations in release 22: Supporting documentation for the Photon identification in full Run2 ATLAS data, ATL-COM-PHYS-2023-866.**