Photon and electron identification with the ATLAS detector

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Abstract
Photon and electron identifications are a crucial input to many ATLAS physics analyses, including H → γγ, H → ℓℓ, SUSY and exotic searches.

For the 13 TeV running of the LHC, a number of improvements were made to the identification algorithms to improve the efficiency at high pileup conditions. Electron and photon efficiency measurements performed with pp collisions data at 13 TeV in 2015 corresponding to an integrated luminosity of 3.2 fb⁻¹ are presented in this document, as well as a first look at 2016 data.

The ATLAS detector
The ATLAS detector [1] is a multi-purpose apparatus with a forward-backward symmetric cylindrical geometry and nearly 4π solid angle coverage. It consists of the following detectors, with the inner detector (pixel, SCT and TRT) being inside a 2T magnetic field:

- Pixel and Silicon microstrip (SCT) trackers covering |η|<2.5.
- Lead-liquid argon electromagnetic (EM) calorimeter covering |η|<3.2; finely segmented in φ and η, and with three layers in depth for |η|<2.5.
- Hadronic and forward calorimeters, followed by the muon system.

Electron and Photon Identification

For Run-II, several changes to the input variables used for electron identification (ID) have been introduced [3].

- Taking advantage of the IBL, the number of hits in this innermost pixel layer is used for discriminating between electrons and converted photons.
- The change in the TRT gas led to modifications in the detector response and prompted the introduction of a new discriminating variable in the electron ID algorithms.

In Run-II, the electron ID is based on a likelihood discrimination combining calorimeter and track variables to separate isolated electron candidates from candidates originating from photon conversions, hadron misidentification and heavy flavour decays. In addition, isolation variables are used as further handles to separate signal and background.

The identification (ID) of prompt photons and the rejection of background coming mostly from photons from hadron decays relies on the high granularity of the ATLAS calorimeter [4]. There are two levels of ID:

- The loose ID exploits the discriminating variables (DV) only in the hadronic calorimeter and in the electromagnetic calorimeter second sampling layer, providing a highly efficient selection with back ground rejection, typically used for the trigger and background rejection.
- The tight ID level exploits the full granularity of the electromagnetic calorimeter and applies tighter requirements also on the DVs used by the loose ID.

In all cases, the requirements on the DVs are tuned separately for converted and unconverted photons.

The precision of the SF reaches a few percent at low E_T and is below 1% at high E_T.

The SF obtained for photons are closer to unity than the ones obtained for electrons because of the correction of the shower shape variables in simulation applied on photons to account for the average data-MC difference on these variables.

Photon ID efficiencies compared with the simulation

- The difference between the simulation and the data-driven measurements is taken into account by computing data-MC efficiency ratios, also referred to as scale factors (SF).
- The SF is computed separately for each method and then combined.
- Most SF values are close to unity.

This confirms that the simulation, with the applied corrections, provides a good description of the photon shower shapes in the collision data.

Conclusions

- Three independent analyses have been pursued to measure the photon ID efficiency:
  - Using photons from radiative Z → ℓℓ⁺⁻ decays
  - Extrapolating to photons the shower shapes observed for electrons from Z → ℓ⁺⁻ℓ⁻ decays
  - Directly measuring the efficiency on samples of reconstructed photons, after determining and subtracting the hadronic background with a technique based on track isolation.

The SF obtained for photons are closer to unity than the ones obtained for electrons because of the correction of the shower shape variables in simulation applied on photons to account for the average data-MC difference on these variables.

Identification efficiencies have been determined for prompt electrons produced in Z → ℓ⁺⁻ℓ⁻ and in Z → ℓ⁺⁺ℓ⁻ events in data and in simulated samples.

The precision of the SF reaches a few percent at low E_T and is below 1% at high E_T.

Discrepancies of around 5% between data and simulation are due to known mismodelling of the shower shapes and some of the track properties by the simulation. The efficiencies are found to be robust with respect to the number of primary vertices, in the range probed by the available data.

The ID algorithms based on a multivariate likelihood discriminator have been optimised such that only a small dependence on the pileup condition remains and will be investigated in the future.

References


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