A Data-Driven Method to extract the Photon Reconstruction Efficiency at ATLAS

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CERN Summer Student Program 2010,

Student Sessions.

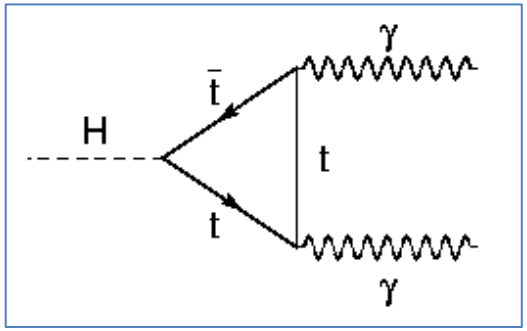
Detection of direct photon production at hadron colliders can be used for:

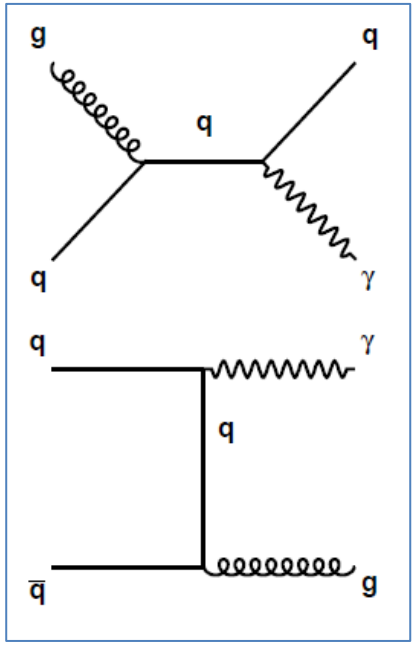
-Tests of QCD predictions.

- Constrain parton distribution functions.

- Higgs boson decay.

- Graviton decay.





- An excess of the number of photons is a possible signal of new physics.

- To compare the experimental data with the theoretical model, σ needs to be calculated from the data:

Number events that are seen.

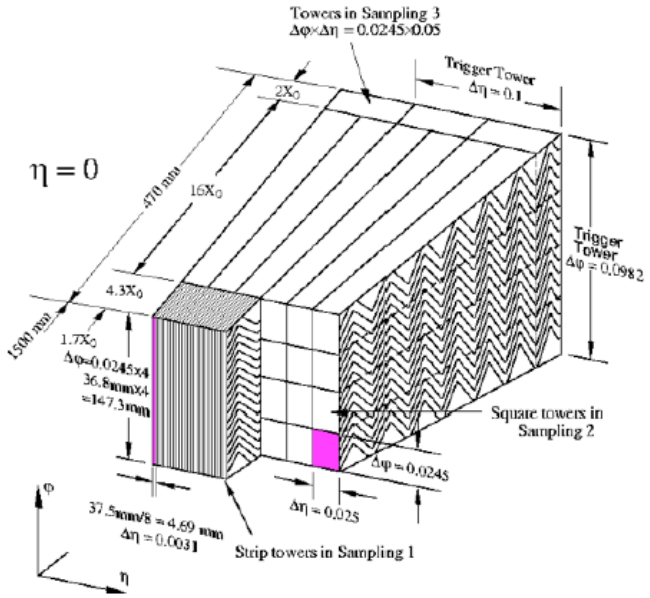
$$\sigma = \frac{N_{events} \cdot p}{\int L\,dt \cdot \varepsilon}$$

Purity: how many particles you have detected are really the particle you think.

Integrated luminosity (nb^{-1}): the amount of collected beam.

Efficiency (ε): how often a produced particle is reconstructed.

- Shower shape variables are the properties of the EM showers in the LAr detector. Photons shower shape variables exhibit an specific shape that allows us to identify them.



Among them:

- Reta=(E237/E277)
- Fside= (E+- 3 - E+-1)/(E+-1)

Measurement of the photon reconstruction efficiency

- To extract the efficiency we must know what the photon signal looks like in data and understand the discrepancies between Monte Carlo (MC) and data.

- For photons, it´s hard to estimate how well the signal is simulated because it is not easy to obtain a pure signal sample from data. This means that photon samples are always contaminated with background, therefore discrepancies between data and MC could come from a variety of sources (not necessary from the signal simulation).

- There is evidence of discrepancy between MC and data. For instance in the Reta shower shape variable.

Proposed alternative: measure the electron reconstruction efficiency and extrapolate it to photons!

- With electrons we have processes with high signal over background ratio (such as $W^{\pm} \rightarrow e^{\pm} \nu$ or $Z \rightarrow e^{+} e^{-}$). This allows to estimate the uncertainty of the efficiency from the comparison of the simulated signal v.s. the data signal.

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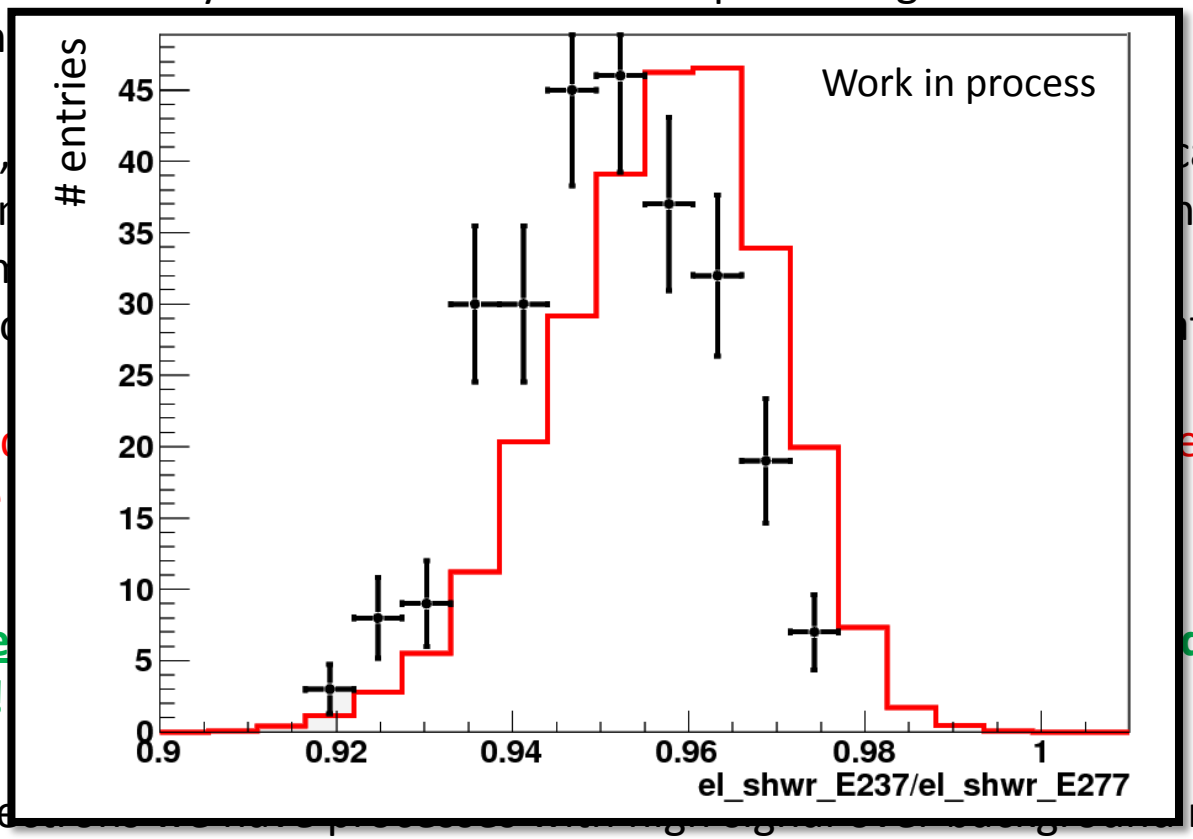

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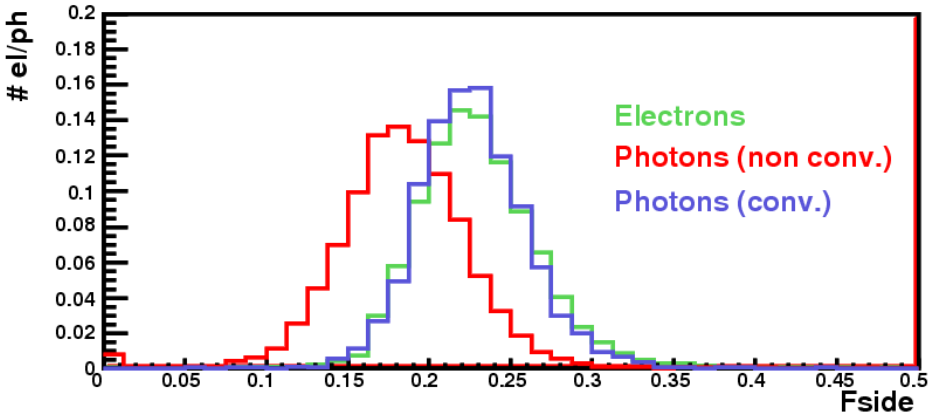
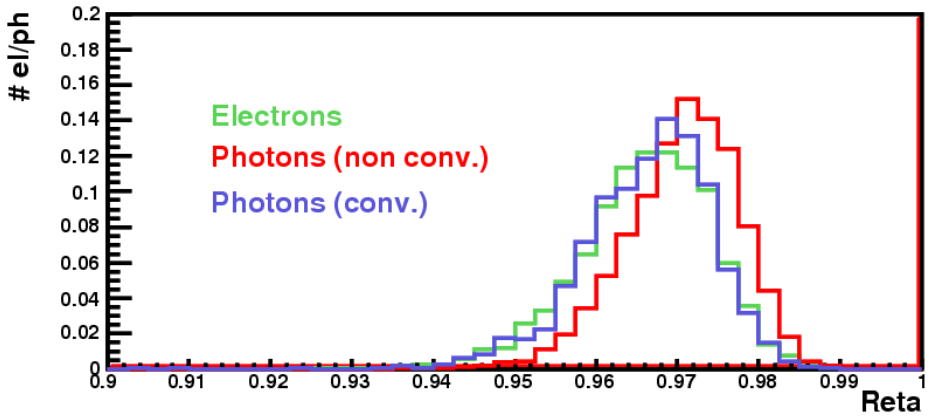
Electrons and photons produce an electromagnetic (EM) shower in the EM calorimeter. The proposed method is based on the fact that the physical processes of both EM showers are the same and hence the showers are equal for both electrons and photons.

- *Is this assumption true?* **NO! There are significant differences between the electron and the photon shower shape variables.**

Two examples of the discrepancy between the shower shape variables:



Number of entries for each value of Fside. Normalized to unity. η∈[0,0.6]

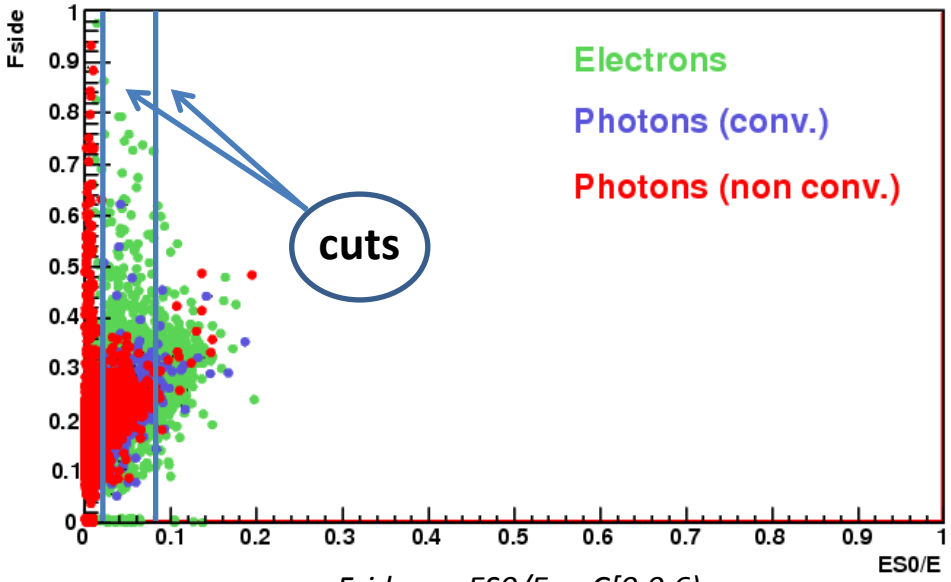


Number of entries for each value of R_{ETA}. Normalized to unity. η∈[0,0.6]

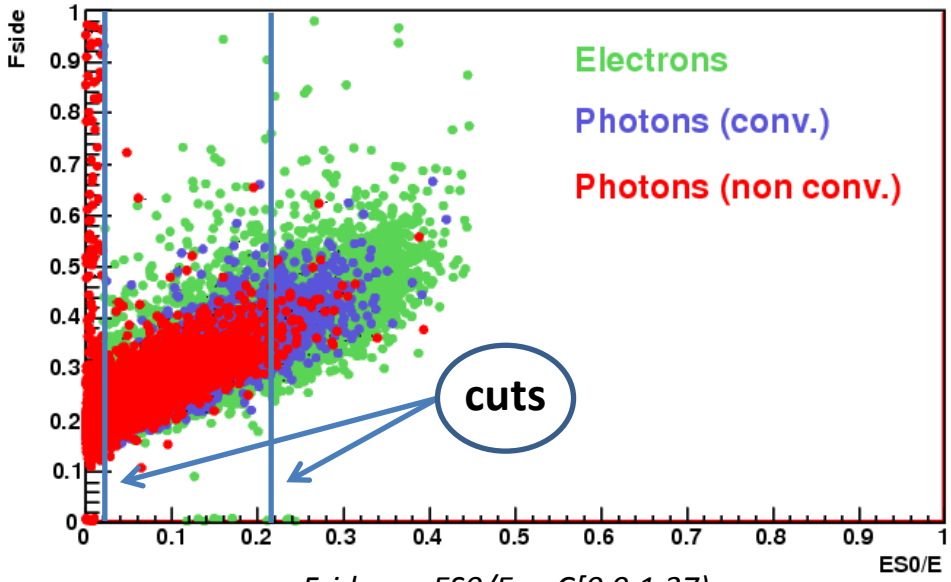
- *Why the assumption is not true?* **Because, the electrons radiate photons before entering in the calorimeter. Therefore, the EM shower starts earlier and its energy deposition is wider in the pre-sampler.** (demonstration in the next slide)

In order to legitimate the applicability of the described procedure to estimate the photon reconstruction efficiency and its error, we need to show that we can **select a subset of electrons that look like photons** (i.e., their shower shape variables are equal).

The electron showers are wider than the photon showers in the pre-sampler → we might look for **possible cuts in the fraction of energy deposition in the pre-sampler** (ES0/E).

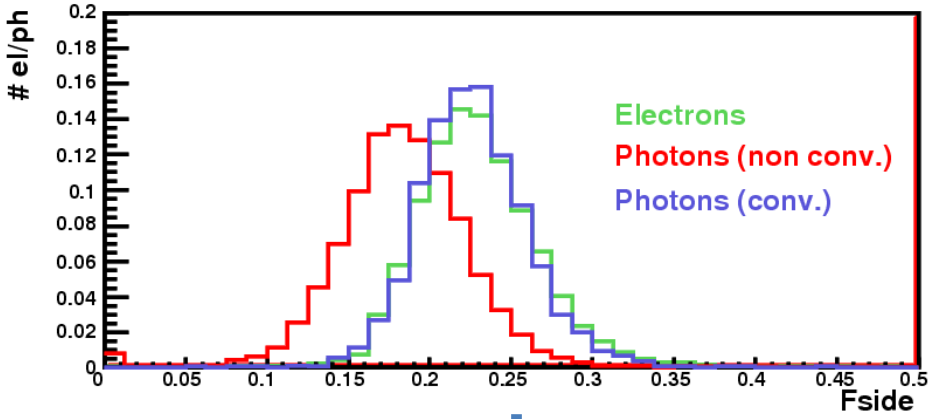


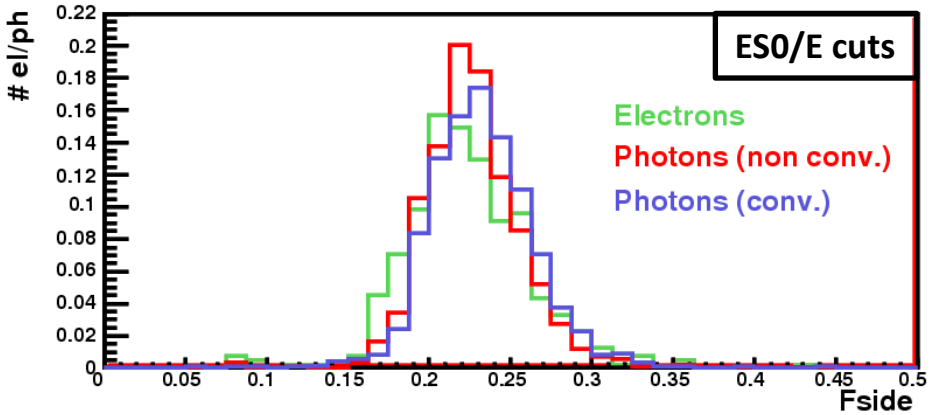
Fside v.s. ES0/E. η∈[0,0.6)



Fside v.s. ES0/E. η∈[0.9,1.37)

The electron deposits more energy in the pre-sampler and its shower is wider → **the electron showers start earlier than the photon showers.**





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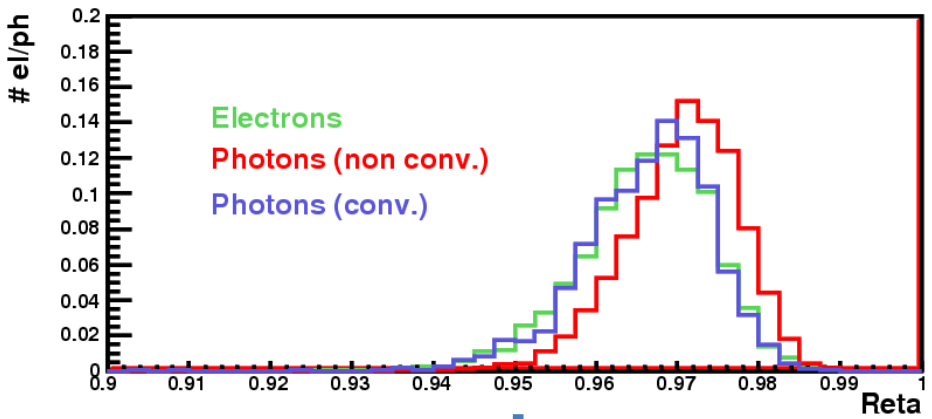

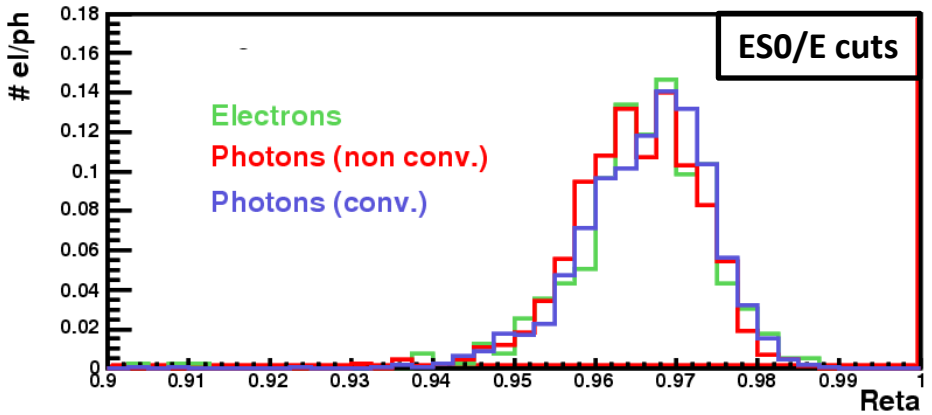

Number of entries for each value of R_{ETA}. Normalized to unity. ηЄ[0,0.6)

With the cuts in the pre-sampler, we are able to select a subset of photons and electrons that resemble each other.

This validates the applicability of the method.

Summary

- The difficulties in measuring the photon efficiency have been explained.
- An alternative data-driven method has been proposed.
- This method relies on the similarities of the electrons and photons showers in the EM calorimeter.
- A way to select a subset of electrons and photons that resemble each other has been shown. This validates the method.

Outlook

- Now we want to select an experimental data sample of electrons with high degree of purity.
- Once we have selected this sample, we can repeat the comparisons in order to select a subset of electrons that look like photons.
- Then, finding again the cuts in ES0/E, the efficiency and its uncertainty can be extracted and extrapolated to photons → and then measure the first cross section for direct photon processes at ATLAS!

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Thank you very much for your attention!