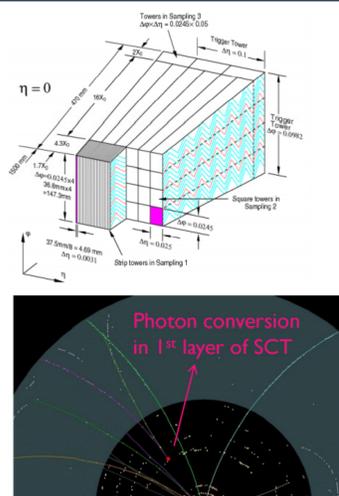


### Introduction to Photons in ATLAS

Several physics processes occurring in the proton-proton collisions at the Large Hadron Collider (LHC) produce final states with prompt photons. The main contributions originate from non-resonant production of photons in association with jets or of photon pairs, with cross sections of the order of tens of nanobarns or picobarns, respectively. The study of such final states, and the measurement of their production cross sections, are of great interest as a probe of perturbative QCD and can provide useful information on the parton distribution functions of the proton. Prompt photons are also produced in rarer events that are key to the LHC physics programme, such as di-photon decays of the Higgs boson with a mass near 125 GeV, occurring with a cross section of around 20 pb at  $\sqrt{s} = 8$  TeV. Finally, some of the typical expected signatures of physics beyond the Standard Model (SM) are characterized by the presence of prompt photons in the final state. They include for instance resonant photon pairs from graviton decays in models with extra spatial dimensions, pairs of photons accompanied by large missing transverse energy produced in the decays of pairs of supersymmetric particles, and events with highly energetic photons and jets from decays of excited quarks or more exotic scenarios.

### Photon Reconstruction

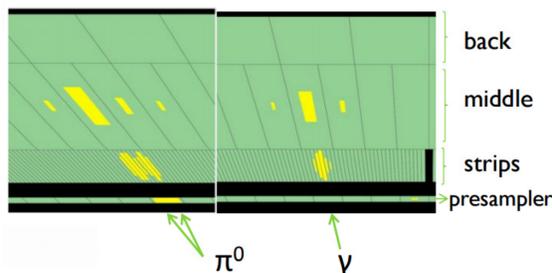
- **Use sliding window algorithm**
  - Find seed cluster with energy  $>2.5$  GeV
- **Form clusters  $\Delta\eta \times \Delta\phi$** 
  - Run1: converted photons used 3x7 clusters in the barrel, unconverted used 3x5 clusters in the barrel, all objects used 5x5 clusters in the endcap.
  - Run2: unconverted photons use 3x7 in the barrel.
- **Measure and calibrate cluster energy**
- **Match cluster to an ID track**
  - Electron – Photon separation
- **Match track to a secondary vertex**
  - Converted / unconverted photons separation



### Photon Identification

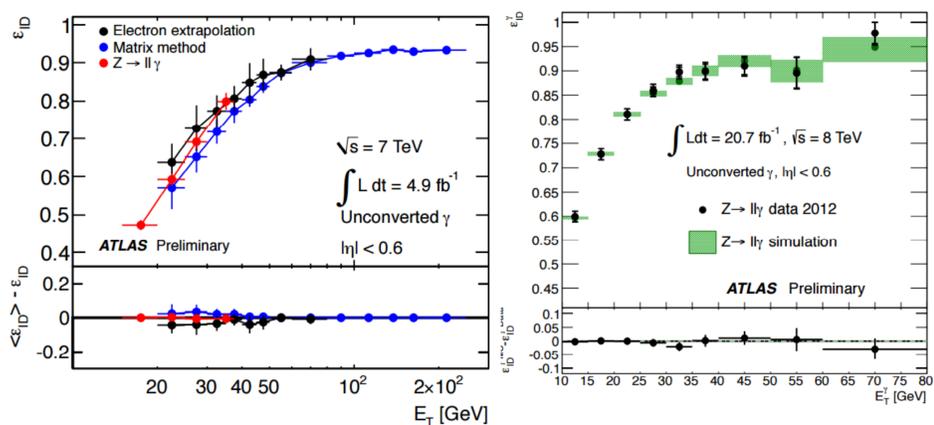
- Relies on variables that describe the shape of the electromagnetic shower in the calorimeter, as well as on the fraction of energy deposited in the hadronic calorimeter.
- 2 different sets of cuts with increasing background rejection used
  - loose, tight

**Example:** Due to the fine granularity of strips (EM), it is possible to distinguish between  $\gamma$  and  $\pi^0$  using strip variables. Strip granularity in  $\eta$ : 0.003 (barrel)



### Photon Identification Efficiency Measurements

- Measurement performed in bins of  $|\eta|$  separately for converted and unconverted photons.
- Three methods used: *photons from Z radiative decays, extrapolation from electrons from Z to ee decays, matrix method*
- Combination to reduce the uncertainties: ~5% to ~1-2% decreasing with  $E_T$ .
- Special treatment of correlations among photons to reduce the uncertainty on the event efficiency for multi-photon events:
  - Large impact on  $H \rightarrow \gamma\gamma$  signal strength evaluation



- For the data taken in 2012, at  $\sqrt{s} = 8$  TeV, the efficiency of cut-based photon identification algorithm increases from 45–50% (50–60%) for unconverted (converted) photons at  $E_T = 10$  GeV to 95–100% at  $E_T > 100$  GeV, and is larger than 90% for  $E_T > 40$  GeV.

### References

- Photon identification efficiencies (ATLAS-CONF-2012-123)
- <https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ElectronGammaPublicCollisionResults>

### The ATLAS Detector

**Forward calorimeter**

- LAr calorimeter
- Coverage:  $3.1 < |\eta| < 4.9$

**Inner Detector: 3 sub-detectors**

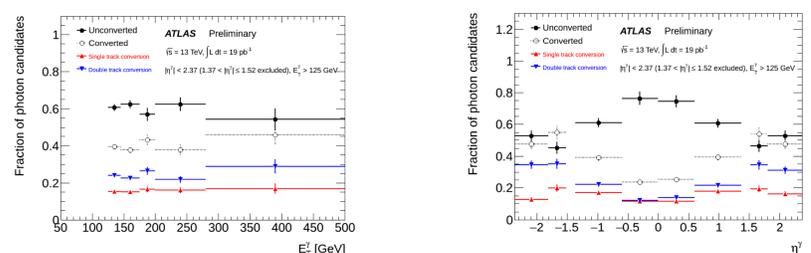
- Pixels: 3 layers,  $|\eta| < 2.5$
- Semiconductor Tracker: silicon micro-strip detector
- Transition Radiation Tracker: straw tubes,  $|\eta| < 2.0$

**EM calorimeter**

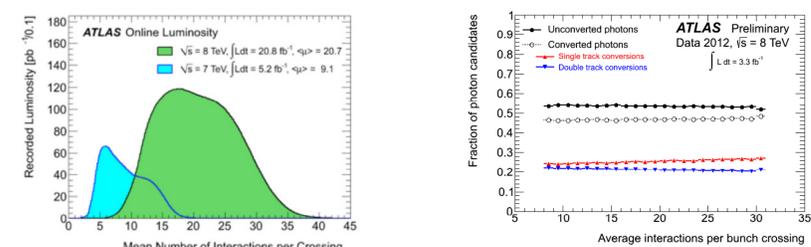
- LAr sampling calorimeter with accordion geometry
- Coverage: barrel  $|\eta| < 1.475$ , end-cap  $1.375 < |\eta| < 3.2$
- 3 longitudinal compartments with different granularity (strips, middle, back) + Presampler

Improvements for Run2 → A new pixel layer (Insertable Blayer, IBL) R=3.3cm

### Photon Conversion Reconstruction Performance



- Fraction of **tight** photon candidates reconstructed as unconverted or converted as a function of the  $E_T$  (left),  $\eta$  (right). The contamination of background photons from the decays of neutral hadrons in jets is estimated to be smaller than 5%.

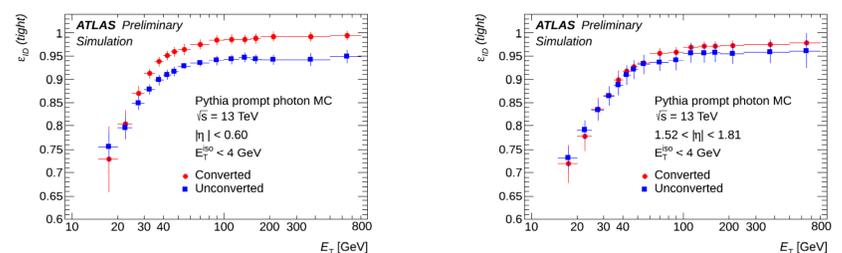


- Stable behavior of reconstruction of photon candidates as a function of  $\langle \mu \rangle$ . Without the changes, the number of conversions would have increased significantly at high pileup, indicating fake conversions.

### Conclusions and Outlook

#### Changes for 2015:

- Adaptation of conversion reconstruction to expected pileup conditions and to 25 ns bunch spacing
- Re-optimization of photon identification to improve pileup robustness



Photon identification efficiency as a function of transverse energy for converted and unconverted photons, corrections to the shower shapes derived from 8 TeV data are applied to improve the data-MC agreement.