Standard Model di-photon production at ATLAS

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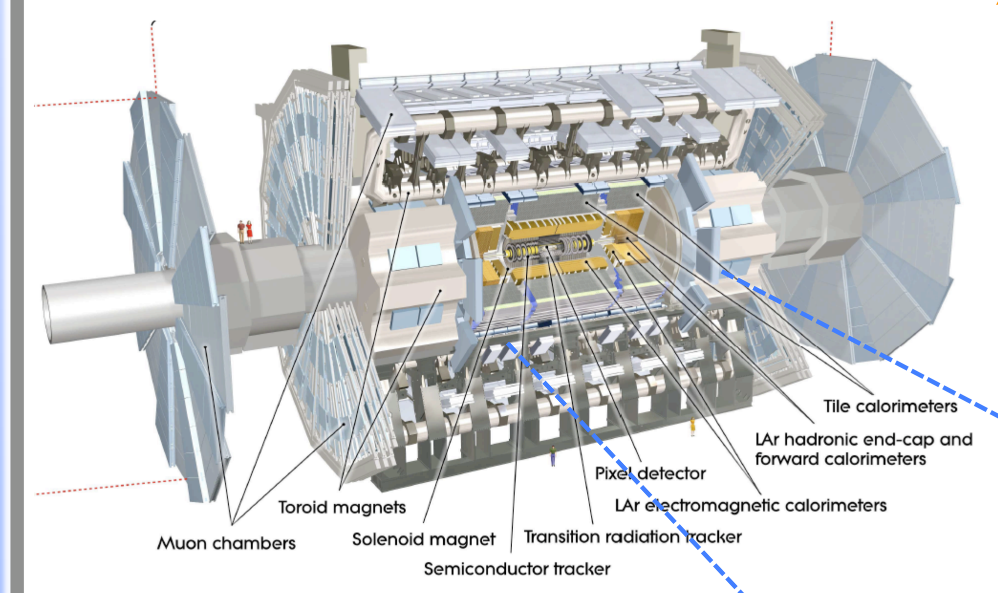
Motivations

A SM di-photon production measurement @ LHC could:

- *increase understanding of pQCD*: primary source of direct photons
- *determine background to yet undiscovered physics*: H→γγ, R.S. graviton (any deviation from expected behaviour can be the hint for new processes)

The ATLAS experiment

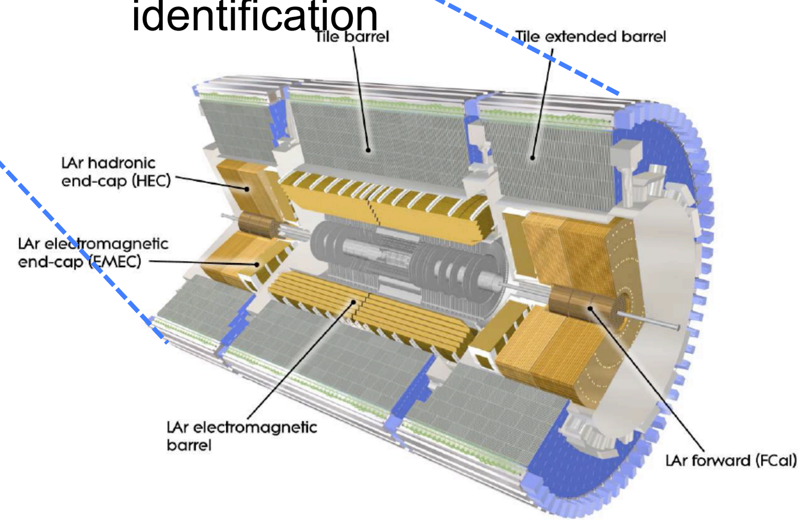


A multipurpose detector:

- high granularity to cope with LHC luminosity
- good p_T resolution for charged-particle in the inner tracker
- **highly segmented e.m. calorimeter for electron/photon reconstruction**
- full coverage hadronic calorimeter
- separate toroidal field for muon identification

Liquid Argon e.m. calorimeter:

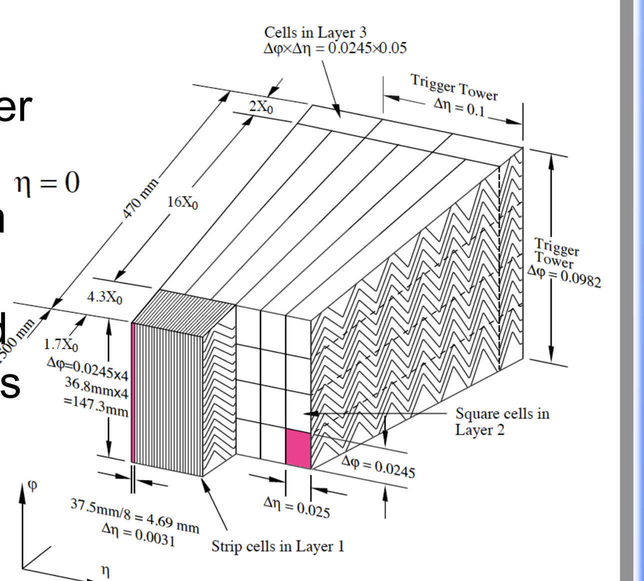
- coverage |η|<3.2 (precision strips <2.5)
- 3 layer longitudinal segmentation
- total thickness: >25 X_0
- 170 K channels
- presampler layer for |η|<1.8



Photon reconstruction and identification

Reconstruction:

- sliding window *ΔηxΔφ = 5x5* cells in the middle layer to find a local maximum
- track/vertex matching to *disentangle* electrons from unconverted and converted photons
- re-build the cluster: *ΔηxΔφ= 3x7* cells for converted photons, *ΔηxΔφ= 3x7* cells for unconverted photons
- weighting cells and energy position + position dependent corrections



Identification: photon/jets discrimination based on their characteristic features

- Photons: narrow objects well contained in the e.m. calorimeter
- Jets: broader profile with significant energy deposition in hadronic calorimeter

Present implementation: *cut-based identification method* relying on:

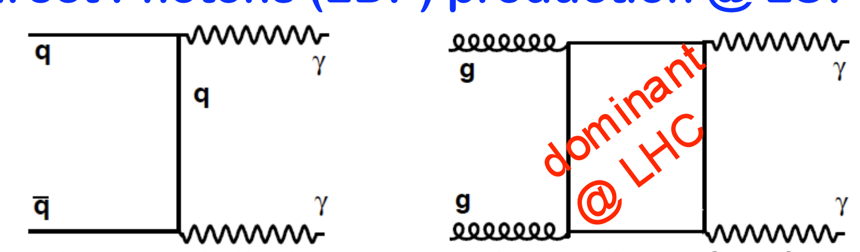
- energy deposition in first layer of hadronic calorimeter
- longitudinal and lateral shower shape in the e.m. calorimeter
- high granularity of strips to reject π^0 background (to distinguish between showers from 2 photons vs. single photon)

Di-photon theory

Photons classification:

- *Direct Photons*: from primary parton-parton interaction, well isolated
- *Fragmentation Photons*: ISR and FSR from quarks, less (or not) isolated
- *Background Photons*: from hadron decays (π^0,η) in jets

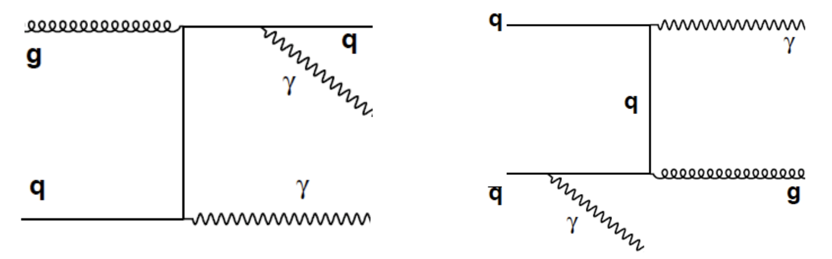
- 2 Direct Photons (2DP) production @ LO:



qqbar annihilation gluon-gluon {box}

cross section (*): (47.5 ± 0.2) pb

- Direct + Fragmentation photons (DP+Frag) production @ LO:



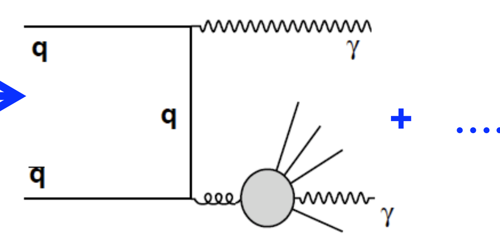
cross section (*): (37.2 ± 0.9) pb

(*) computed with PYTHIA requiring both photons with E_T>20GeV, |η|<2.5

- Background processes: at least one of the 2 photons is a background photon (γ+jet and di-jet events where one or two jets fragment into light neutral mesons)

3 possible combinations:

- ***Direct photon + background photon*** (**DP+Bkgd**)
- ***Frag. photon + background photon*** (**Frag+Bkgd**)
- ***2 background photons*** (**2Bkgd**)



- 2 Fragmentation photons (2 Frag) production @ LO: not yet addressed

Signal selection & efficiency

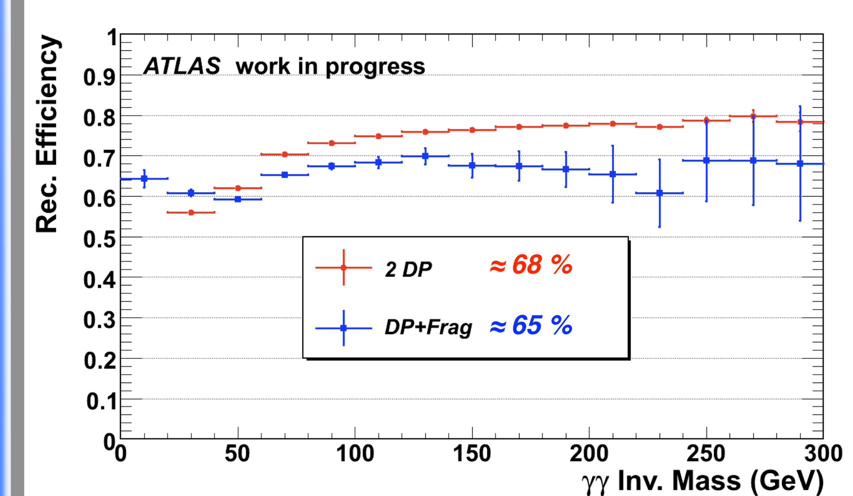
Fiducial Cuts: both photons with E_T>20 GeV, |η|<2.5

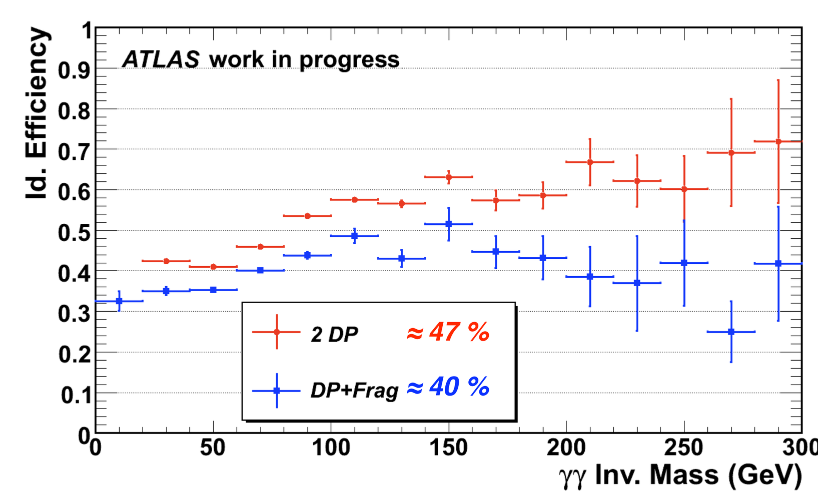
Identification Cuts: ATLAS standard photon identification + *calorimetric isolation* (sum of energy in the e.m. calorimeter in a cone around the object defined by ΔR<0.2)

Trigger: g20 (at least one photon with E_T>20GeV, |η|<2.5)

Efficiency evaluation is MC based:

- ***reconstruction efficiency:*** a reconstructed photon passing fiducial cuts needs to have a distance ΔR<0.2 to the truth photons, with ΔR defined by: $\sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$
- ***identification efficiency:*** require both matched reconstructed objects to pass identification cuts
- ***trigger efficiency:*** *g20* trigger ≈100% efficient w.r.t. offline selection for the signal



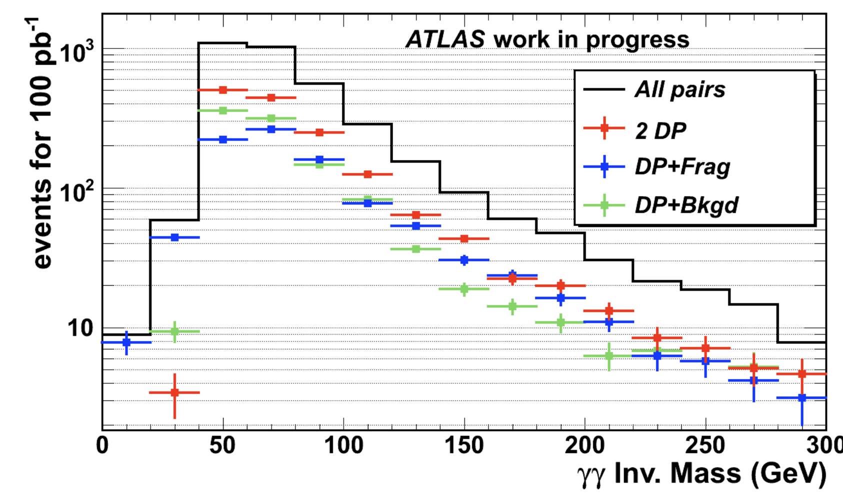


Different performance is expected for the two types of photon signal.

Background and purity

The background estimation is MC-based. Events passing selection criteria are classified as one of the two types of signal or background according to a matching (ΔR<0.2) to a truth generated particle (when more than two photons are passing selection, classification is based on the two highest E_T photons).

	events for L=100 pb^{-1}
2 DP	1502 ± 39
DP+Frag	923 ± 30
DP+bkgd	1032 ± 32



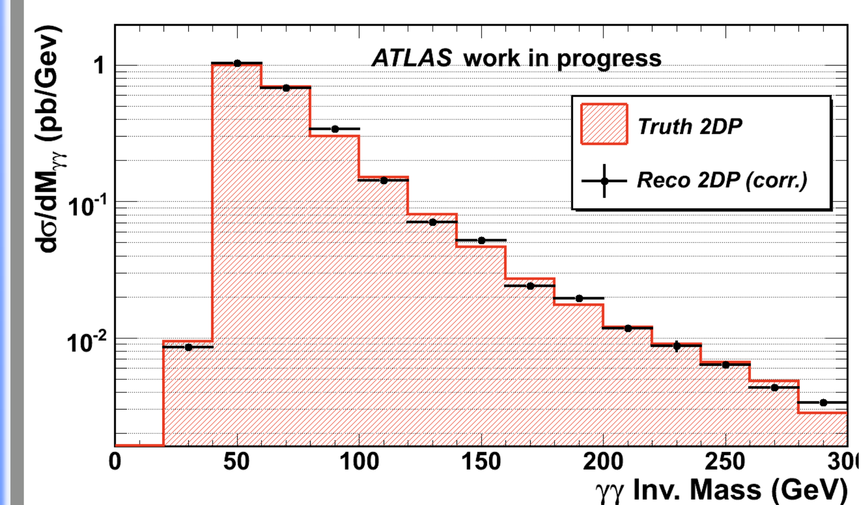
Due to the small probability for a jet to fake a photon in the detector (≈10^{-3}), the di-jet contribution to the invariant mass spectrum *has not yet been estimated*. If we estimate the probability from the γ+jet events and apply it to di-jet events we obtain the same order of magnitude for the DP+bkgd, Frag+bkgd and 2 bkgd events.

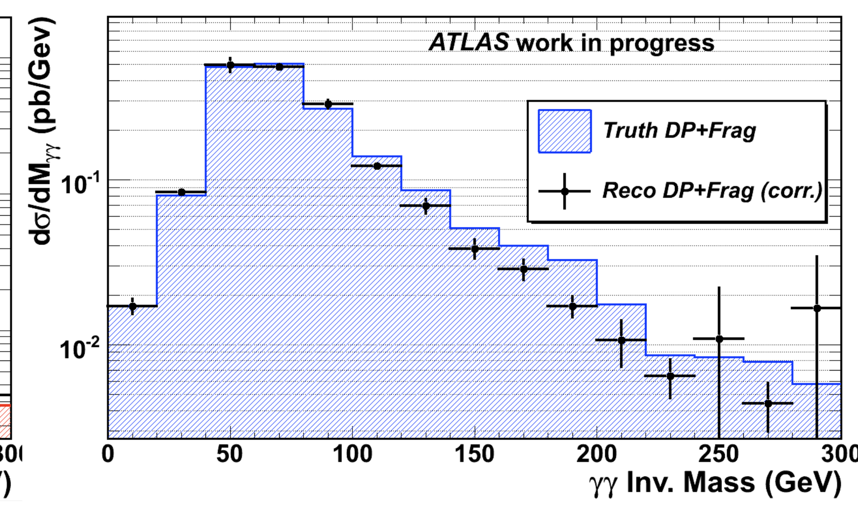
Proposed selection leads to a *sample purity of ≈ 45 %* (more work is needed to better estimate the 2Bkgd and Frag+Bkgd events).

Cross Section

To retrieve generator (truth) level cross section need to correct the reconstruction level results for detector effects (reconstruction and id. efficiencies).

The method: compute the weight of each event by multiplying the efficiency of each of the two photons. Single photon efficiency info is stored in a 2-dimensional η vs. E_T matrix evaluated from independent samples.





2DP cross section: (48.1 ± 0.8) pb

DP+Frag cross section: (35.6 ± 1.2) pb

The results for the differential cross section at generator and reconstruction level are in fair agreement (few % differences).

Conclusions

A MC-based study aiming at determining ATLAS detector performance in measuring SM di-photon cross section is in progress. Need to evaluate di-jet background contribution and move towards data-driven techniques.