Direct Photons @ ATLAS

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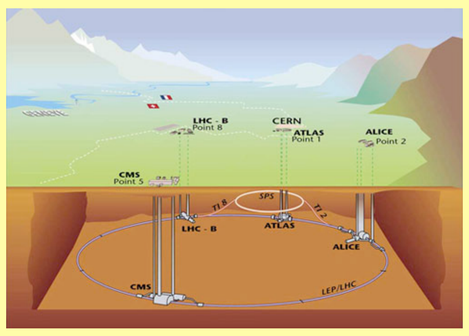
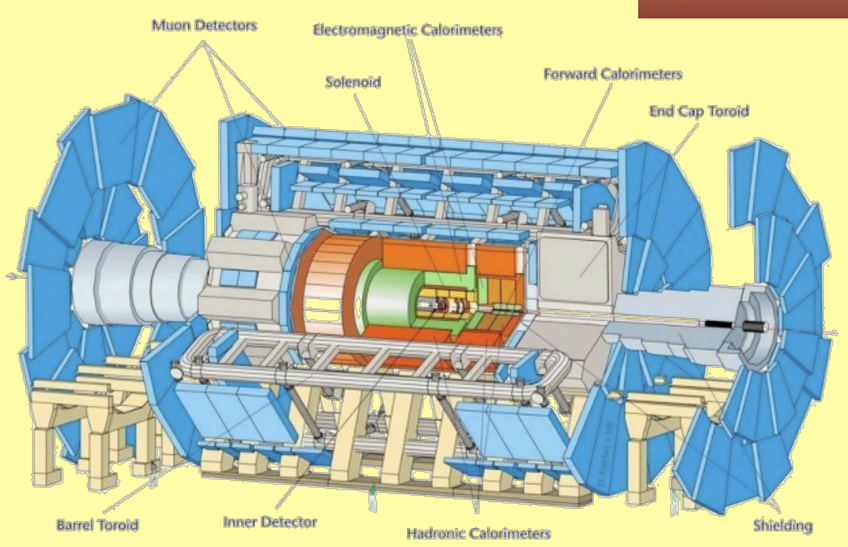
ATLAS: A Toroidal Lhc ApparatuS

The LHC:

- 14 TeV p-p collisions with a design luminosity of 10^{34} cm^{-2} s^{-1}
- 27 km circumference
- 9300 8T superconducting magnets at -271 °C





ATLAS experiment:

- 2T solenoid magnet
- three toroid magnets
- liquid argon electromagnetic and scintillator-tile hadronic calorimeters
- pixel, silicon strip, and transition radiation tracking detectors

- length 44 m
- height 25 m
- weight 7000 tons

Direct Photon Theory

Motivation

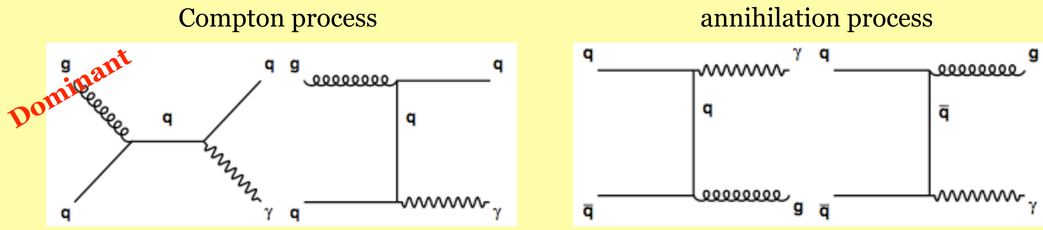
- *improve the precision of the high-x gluon PDF* (most interactions involve a gluon)
- *investigating parton densities evolution*
- *new physics* (deviation from theoretical predictions could bear evidence of many new processes like, for example, excited quarks or SUSY decay chains)
- *hadronic calibration* (from energy balance between the photon and the recoiling hadronic energy)

Leading order processes

Isolated photons

Compton process

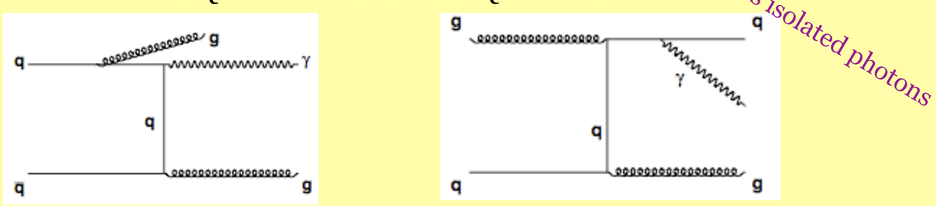
annihilation process



Next to leading order processes

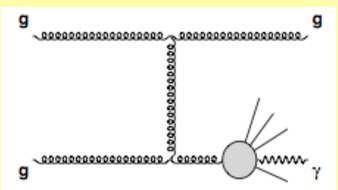
Initial QCD radiation and final QED radiation

Less isolated photons



Dominant background

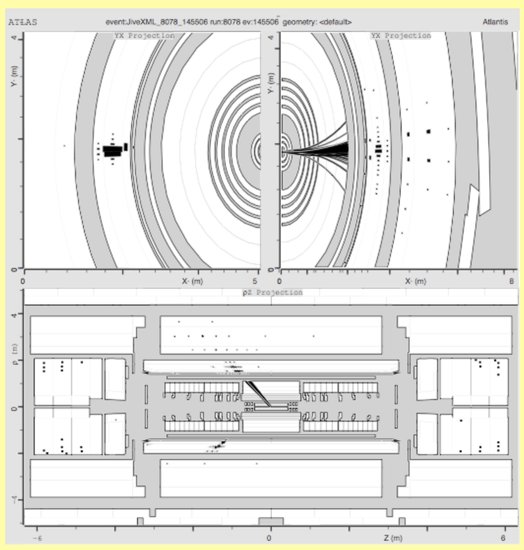
Di-jet events in which one jet fragments into light neutral mesons (e.g. π^0 and η decaying into two photons)



Detector Signature

Typical signature is one isolated photon and at least one jet opposite in the azimuthal direction

Good photon/jet separation is possible between the photon with no tracks and a slim shower and the jet having many tracks and a wider and deeper shower extending well into the hadronic calorimeter



Simulated direct photon event with a 786 GeV photon and a 722 GeV jet

Top left: photon shower
Top right: jet shower
Bottom: side view

Efficiencies

Fiducial acceptance: E_T > 20 GeV and | η | < 2.5

$$A = \frac{N_{gen}^{acc}}{N_{gen}}$$

Number of generated final state photons passing kinematic cuts divided by total number of generated photons

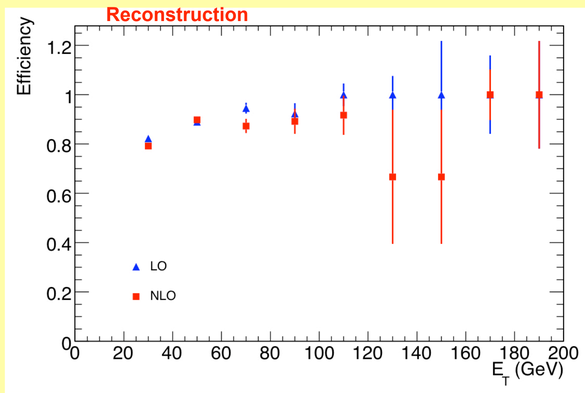
Overall acceptance for leading order (LO) photons with E_T > 20 GeV: ~93%

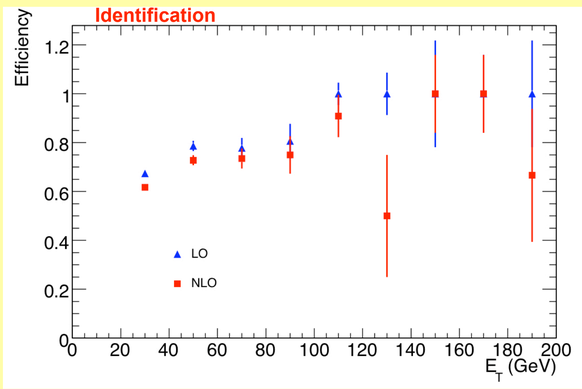
Reconstruction efficiency: number of generated final state accepted photons matching a fiducial photon requiring ΔR<0.2 divided by generated photons passing acceptance cuts

ΔR is defined as: $\Delta R = \sqrt{\Delta\eta^2 + \Delta\varphi^2}$

$$\varepsilon_{rec} = \frac{N_{gen}^{acc+rec}}{N_{gen}^{acc}}$$

Overall efficiency for LO: ~84%





Identification efficiency: number of photons passing identification criteria divided by number of matched photons

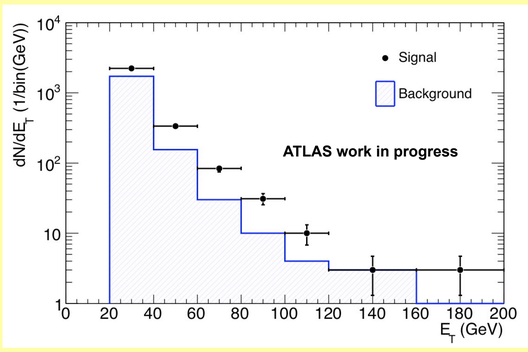
$$\varepsilon_{id} = \frac{N_{gen}^{acc+rec+id}}{N_{gen}^{acc+rec}}$$

Identification uses a cut-based method on discriminating variables based on calorimeter information (hadronic leakage, shower shapes, ...)

Overall efficiency for LO: ~71%

Background Estimation

The background estimation is Monte Carlo based. Candidates are classified after reconstruction, identification, trigger and an isolation requirement as signal or background according to a matching to a generated particle



The isolation requirement is based on a variable called Etcone20 corresponding to the total E_T inside a cone of R=0.2 in η-φ phase space around the reconstructed photon (excluding the photon energy). The isolation cut used is

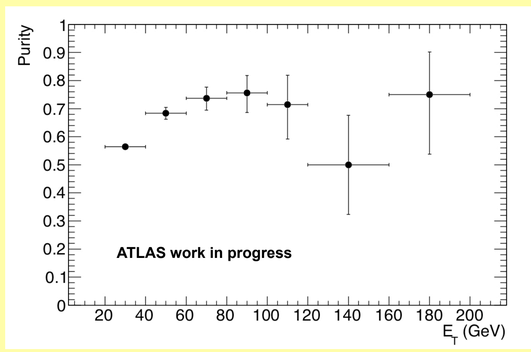
$$Etcone20 / p_T^{\gamma} < 0.1$$

The isolation cut suppresses events with photons collinear to the hadrons

The main contribution to the background (~77%) comes from π^0 and η

Assuming that the Monte Carlo describes the shower shapes and the level of the hadronic background accurately, one can estimate the signal purity as

$$P = \frac{N_{signal}}{N_{candidates}}$$



Cross Section

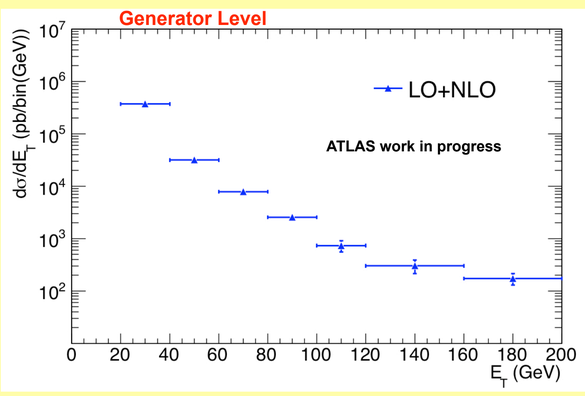
The cross section has been estimated at generator level selecting the highest p_T signal photon in each event

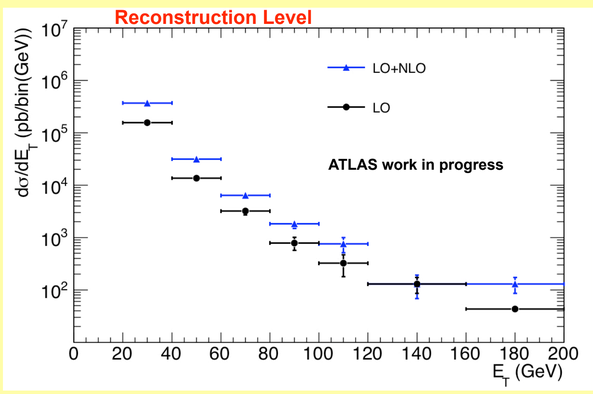
The cross section obtained is the estimated cross section for p_T > 20 GeV and all η

At generator level the cross section is given by:

$$\sigma = \frac{N_{signal}}{L}$$

The luminosity used is L = ~30 nb^{-1}





At reconstruction level the cross section has been estimated counting the number of highest p_T reconstructed photons after identification, trigger and isolation requirements

The cross section has been corrected for acceptance, reconstruction, identification, trigger and isolation efficiencies

$$\sigma = \frac{N_{signal}}{A \cdot \varepsilon \cdot L}$$

The results for the differential cross section at generator and reconstruction level are in good agreement