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Dynamics of isolated-photon and jet production at $\sqrt{s}$ = 7 TeV with the ATLAS detector

ATLAS-CONF-2013-023

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18/07/2013

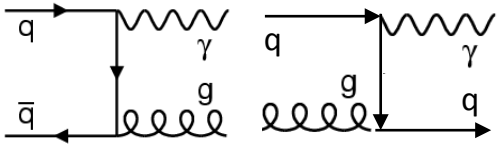
Introduction

Why this channel?

- ✓ test ground for perturbative QCD in a cleaner environment than jet production since the photon originates directly from the hard interaction
- ✓ help to constrain the gluon density in the proton
- ✓ one of the main backgrounds in searches for Higgs bosons decaying to a photon pair (useful to tune the description of this process in MC models)

$pp \rightarrow \gamma + jet + X$

DIRECT PHOTONS (DP)
originate from hard process



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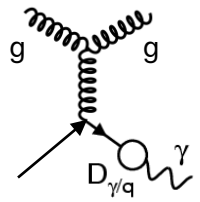
FRAGMENTATION PHOTONS (F)
arise from the frag. of a coloured high P_T parton



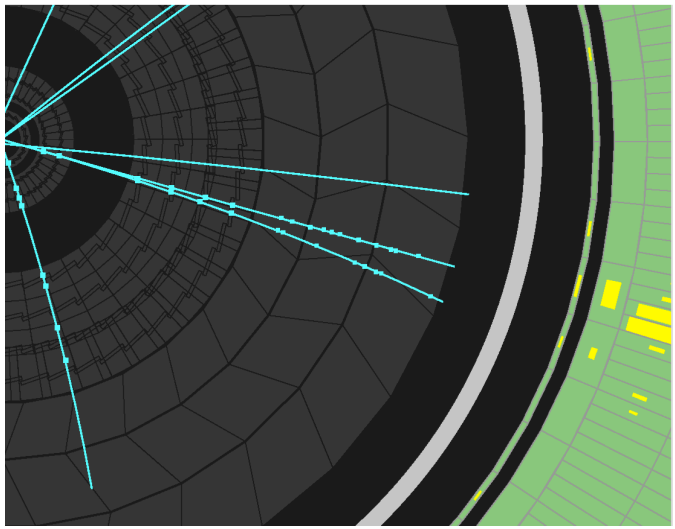
et al.

Distribution of $\cos\theta^{\gamma j} = \tanh(\Delta y/2)$ is sensitive to the spin of the exchanged particle (θ^* is the angle of scattering in the centre-of-mass frame)

- DP $\rightarrow (1-|\cos\theta^{\gamma j}|)^{-1}$ with $|\cos\theta^{\gamma j}| \rightarrow 1$
- F $\rightarrow (1-|\cos\theta^{\gamma j}|)^{-2}$ with $|\cos\theta^{\gamma j}| \rightarrow 1$

Photon selection

Only one trigger is used: $E_T^{\gamma} > 40$ GeV

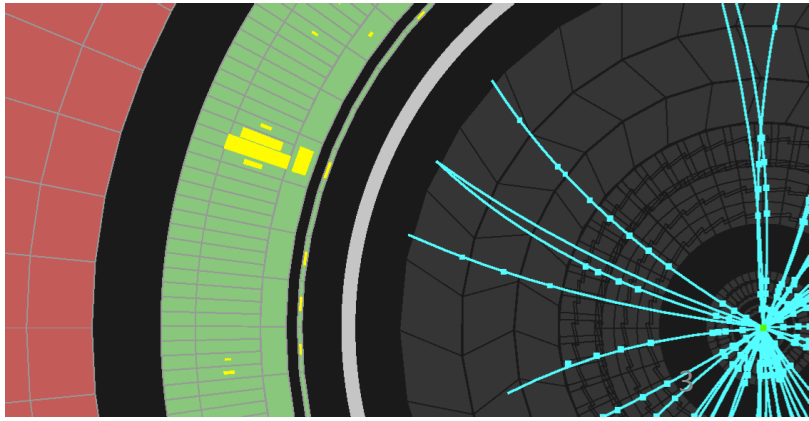


CONVERTED PHOTONs

Clusters matched with tracks, reconstructed in the inner detector and extrapolated to the calorimeter, were classified as electron candidates.

To recover photon conversions, clusters matched to pairs of tracks originating from reconstructed conversion vertices in the inner detector or to single tracks with no hit in the innermost layer of the pixel detector were classified as converted photon candidates

Reconstruction efficiency ($E_T^{\gamma} > 20$ GeV): 94.3 %



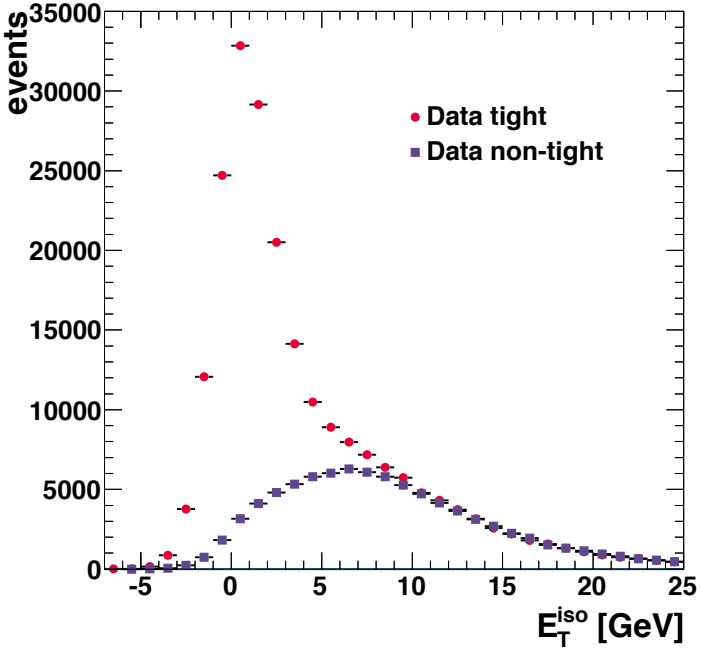
UNCONVERTED PHOTONs

Without matching tracks

Reconstruction efficiency ($E_T^{\gamma} > 20$ GeV): 99.8 %

Photon selection(II)

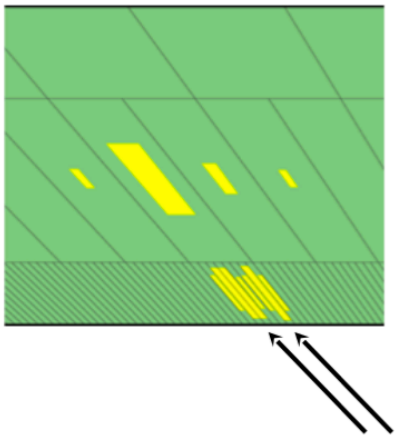
The **shower-shape** and **isolation** requirements independently for unconverted and converted γ



- γ "isolated", if $E^{iso}{}_T < 3$ GeV;
- γ "non-isolated", if $E^{iso}{}_T > 5$ GeV;
- γ "non-tight", if it failed at least one of the tight requirements on the shower-shape variables

suppress

main BG which consists of QCD ***multi-jet events*** where one jet contains a π^0 or η meson which carries most of the jet energy and is misidentified as an isolated photon because it decays into a photon pair.



$\pi^0 \rightarrow \gamma\gamma$

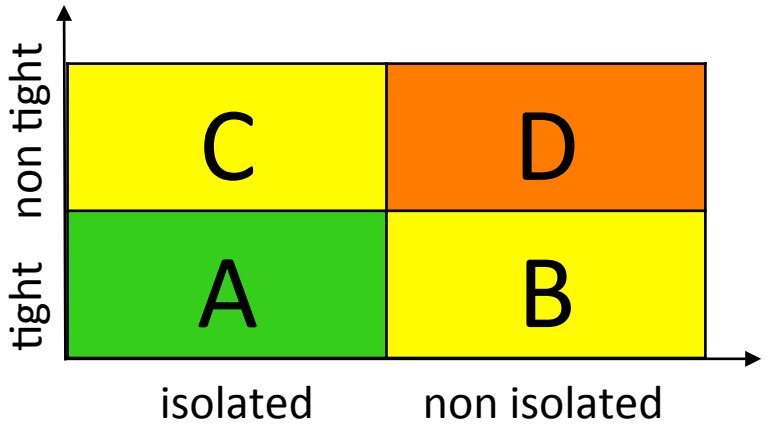
Jet selection

- anti-k_t algorithm is used
- Jets reconstructed from calorimeter signals not originating from a *pp* collision were rejected by applying jet-quality criteria
  - These criteria suppressed fake jets from calorimeter noise, cosmic rays and beam-related backgrounds
- Jets overlapping with the candidate photon or with an isolated electron were not considered
  - The requirement on the electrons suppresses contamination from *W/Z* plus jet events
- Jets were required to have calibrated transverse momenta greater than 40 GeV

In events with multiple jets satisfying the above requirements, the jet with highest P_T^{jet} (leading jet) was retained for further study

Signal extraction & efficiency

A BG subtraction method was devised, which does not rely on MC background samples and uses instead signal-depleted control regions to obtain a purer photon signal
The BG contamination in the selected sample was estimated using the 2D sideband technique



$$\frac{N_A^{BG}}{N_B^{BG}} = \frac{N_C^{BG}}{N_D^{BG}}$$ BG uncorrelated in this 2D plot

$$N_A^S = N_A - N_A^{BG}$$

$$N_i^S = \varepsilon_i N_A^{BG} \qquad i = B, C, D \quad \varepsilon_i \text{ estimated from MC}$$

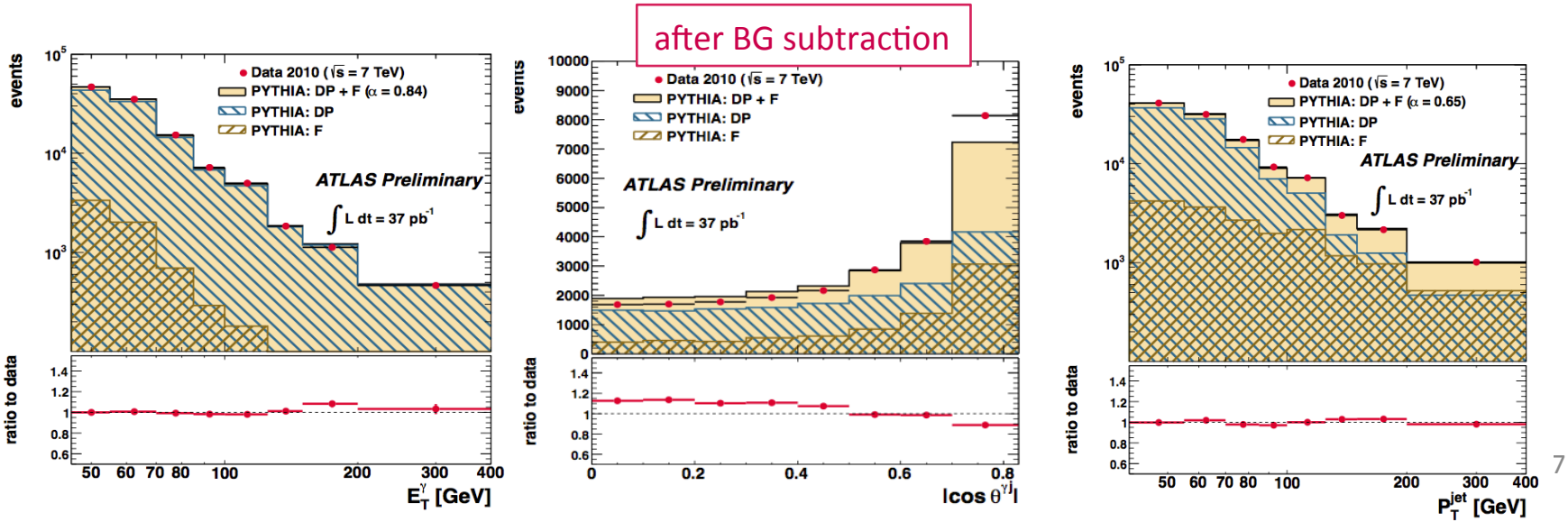
$$N_A^{\text{sig}} = N_A - R^{\text{bg}} \cdot (N_B - \epsilon_B N_A^{\text{sig}}) \cdot \frac{(N_C - \epsilon_C N_A^{\text{sig}})}{(N_D - \epsilon_D N_A^{\text{sig}})}$$

Observed distributions

Observed variables to check the MC :

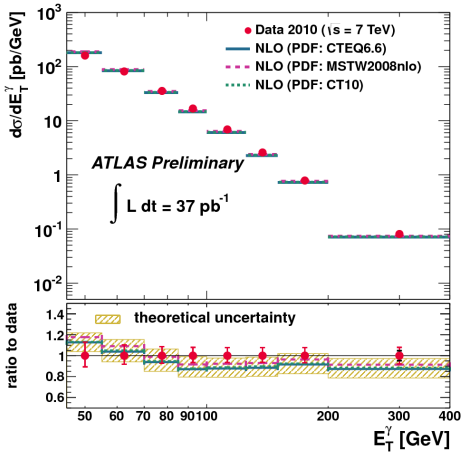
- E_T^{γ} photon transverse energy
- P_T^{jet} jet transverse momentum
- $|y^{jet}|$ jet rapidity
- $\Delta\phi^{\gamma j}$ difference in azimuthal angle between the photon and the jet
- $M^{\gamma j}$ photon-jet invariant mass
- $\cos\theta^{\gamma j}$

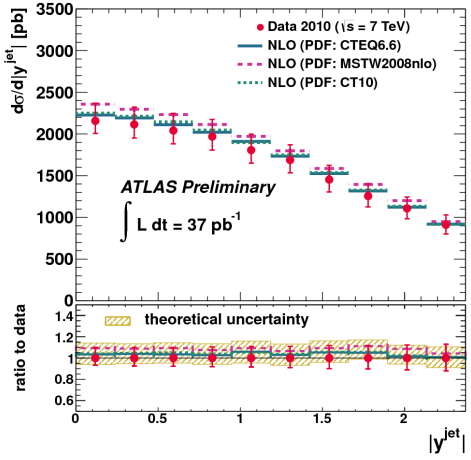
The data collected during 2010 at √s = 7 TeV is used to study the dynamic of isolated-photon plus jet production at relatively low E_t^{γ}, down to E_T^{γ} = 45 GeV.

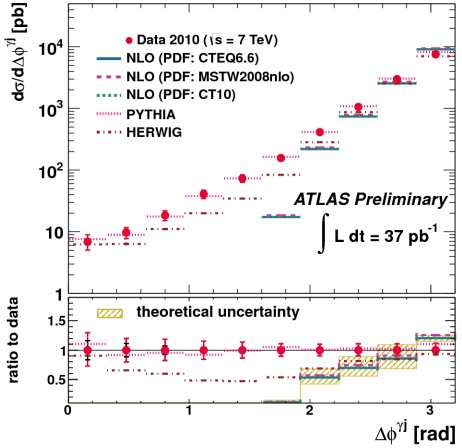


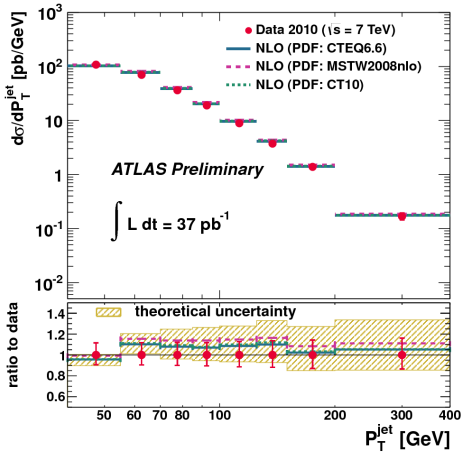
Results

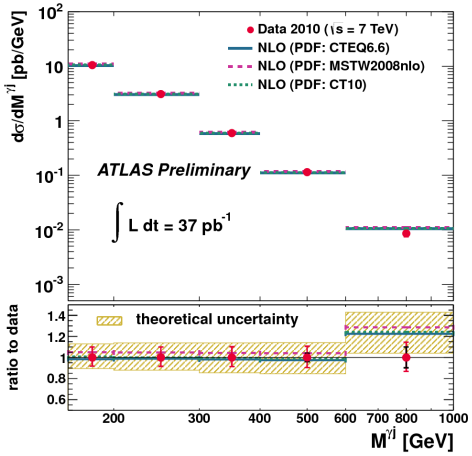
- γ + jet cross section measured for different variables
- Good agreement of data vs NLO QCD calculation for most plots in both shape and normalisation

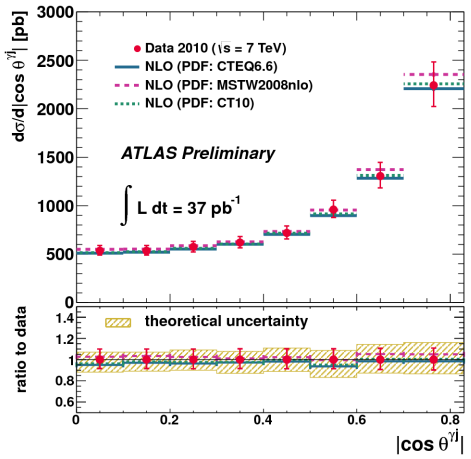






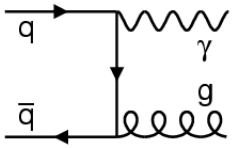




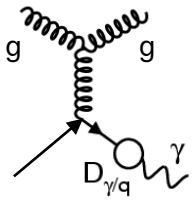


Results(II)

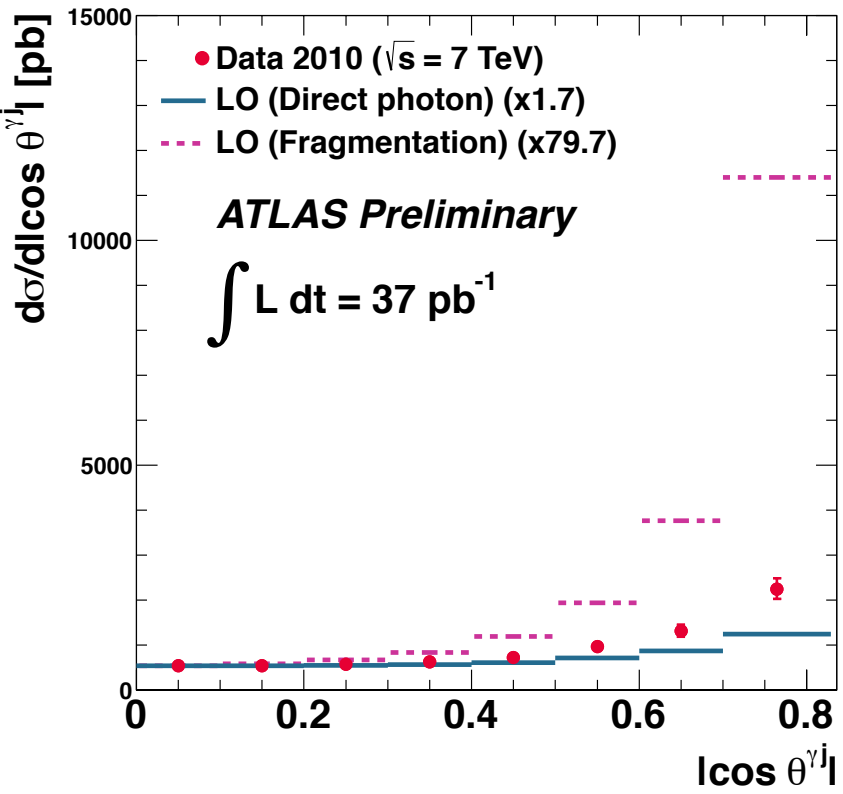
- $|\cos\theta^{\gamma j}|$ distribution sensitive to direct-photon vs. fragmentation ratio
- Leading order simulation gives an estimate on contribution of each DP and F process
- Fragmentation process becomes significant only for $|\cos\theta^{\gamma j}| \rightarrow 1$



$(1-|\cos\theta^{\gamma j}|)^{-1}$



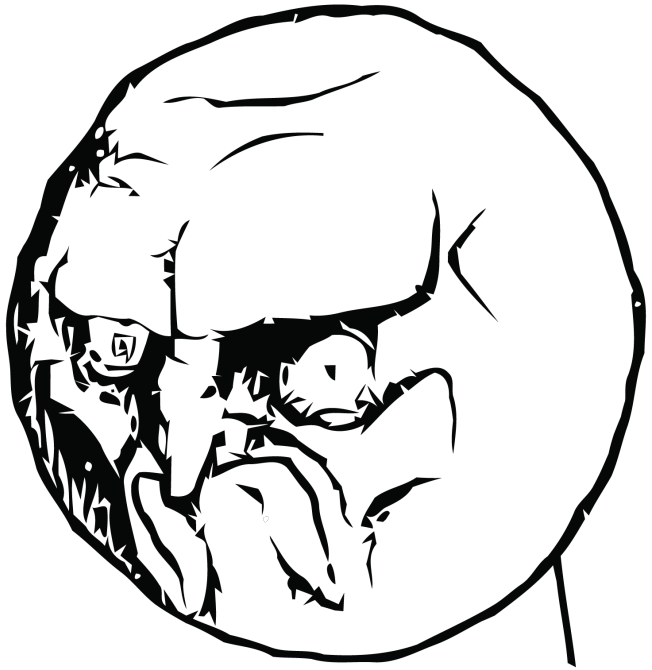
$(1-|\cos\theta^{\gamma j}|)^{-2}$



Conclusion

- Study of γ + *jet* important to test perturbative QCD
- γ + *jet* also presents background (2nd most important BG) in $H \rightarrow \gamma\gamma$ process
- For $E_T^{\gamma} > 45 GeV$ data are well described by next-to-leading order QCD calculation for different variables
- $\cos\theta^{\gamma j}$ distribution enables to conclude that direct-photon production through quark exchange is dominant.

Question or comments…?



NO.