Isolated photons in photoptoduction at HERA

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(on behalf of the ZEUS collaboration)

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HERA collider

E_e = 27.5 GeV
E_P = 920 GeV

$$\sqrt{s} = 318\ GeV$$

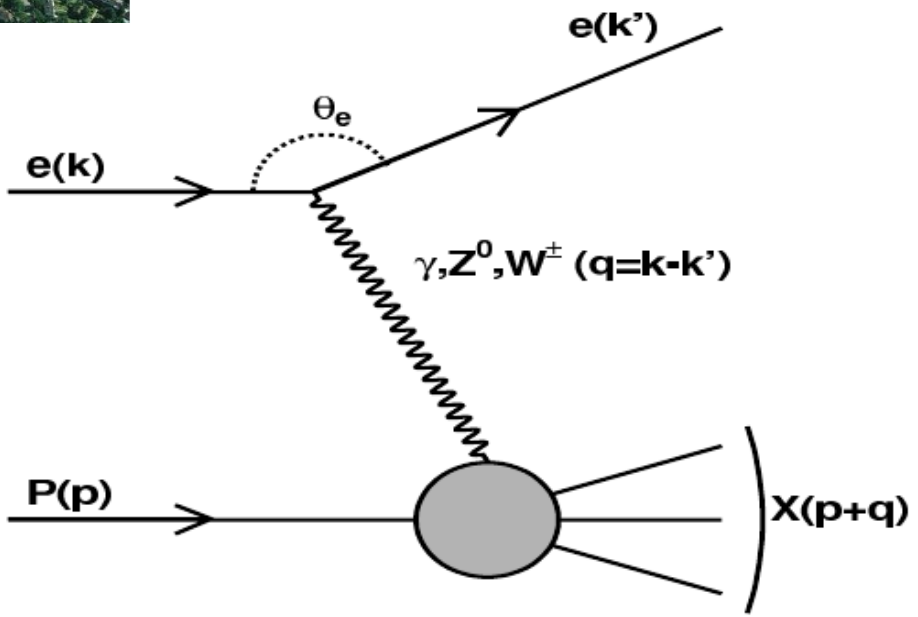
Kinematic variables

$$Q^2 = -q^2 = -(k - k')^2$$

$$x_{Bj} = \frac{Q^2}{2\,pq} \qquad y = \frac{pq}{pk}$$

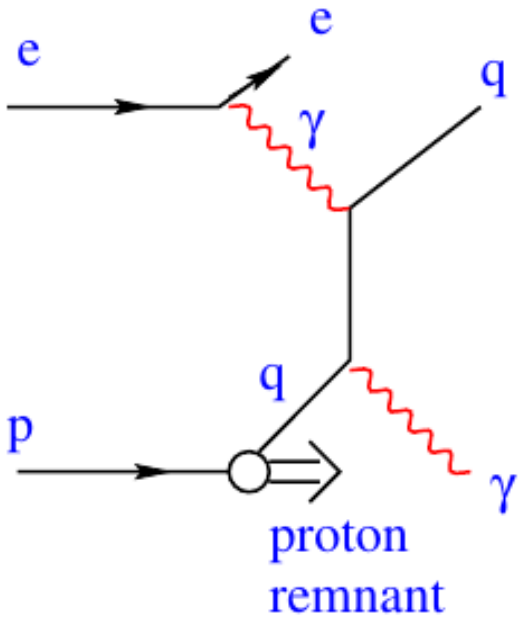
$$s = (p + k)^2 \qquad Q^2 = xys$$

$Q^2 \leq 1$ GeV^2: photoproduction
$Q^2 \geq 1$ GeV^2: DIS

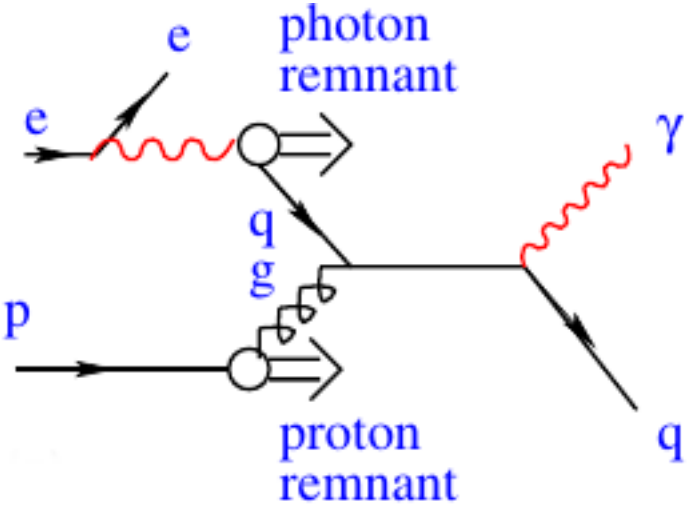


Isolated photons

Isolated (prompt) photons — photons with large E_T which emerge directly from hard scattering process.



Direct production



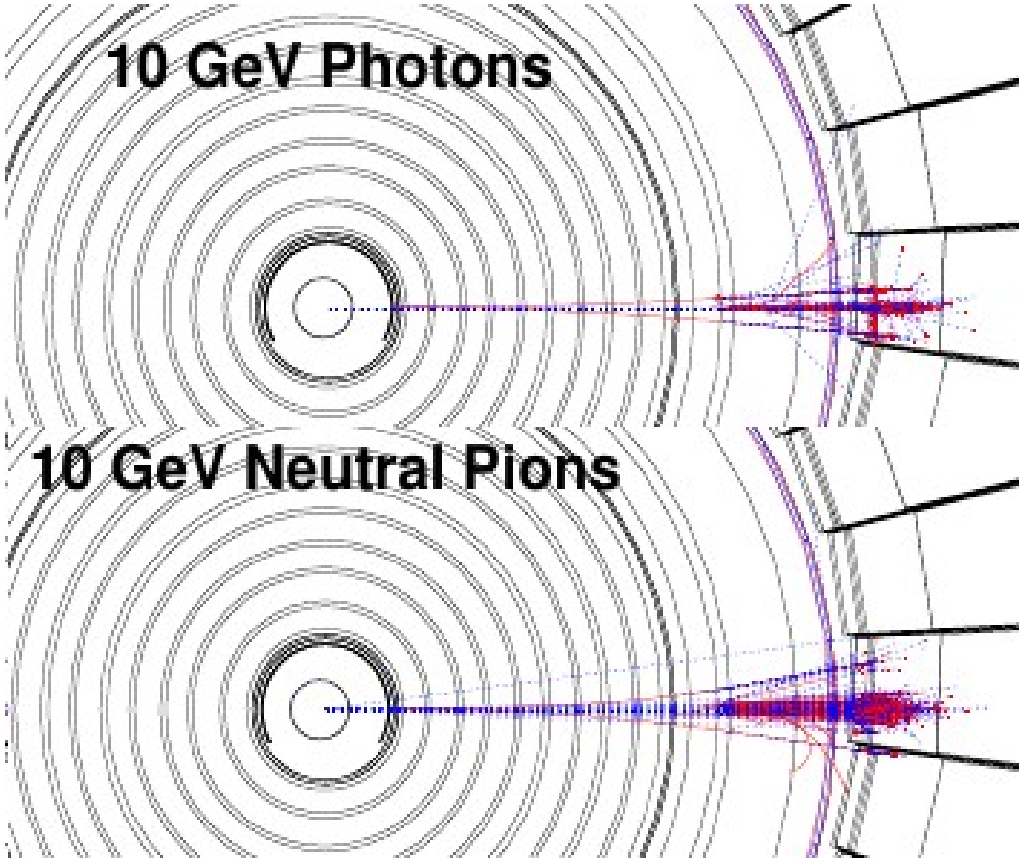
Resolved production

Isolated photons are not hadronisation products => give possibility of testing QCD model.

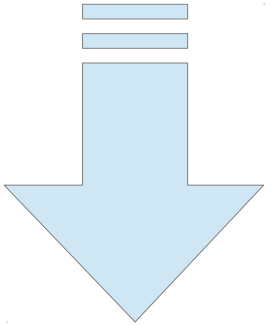
Backgroung process

The main source for the background is π^0 and η decays ($\pi^0 \rightarrow \gamma\gamma$, $\eta \rightarrow \gamma\gamma$, $\eta \rightarrow \pi^0\pi^0\pi^0$):

- little opening angle between decay products (photons);
- no track matched to an energy deposit;



The neutral meson energy deposit is significantly wider.



Backgroung can be suppressed using shower shape method

Event selection

Data: ZEUS HERA-II 2004-2007 (370 pb^{-1})

MC Signal: PYTHIA MC Background: PYTHIA (η and π^0 decays)

Kinematic region:

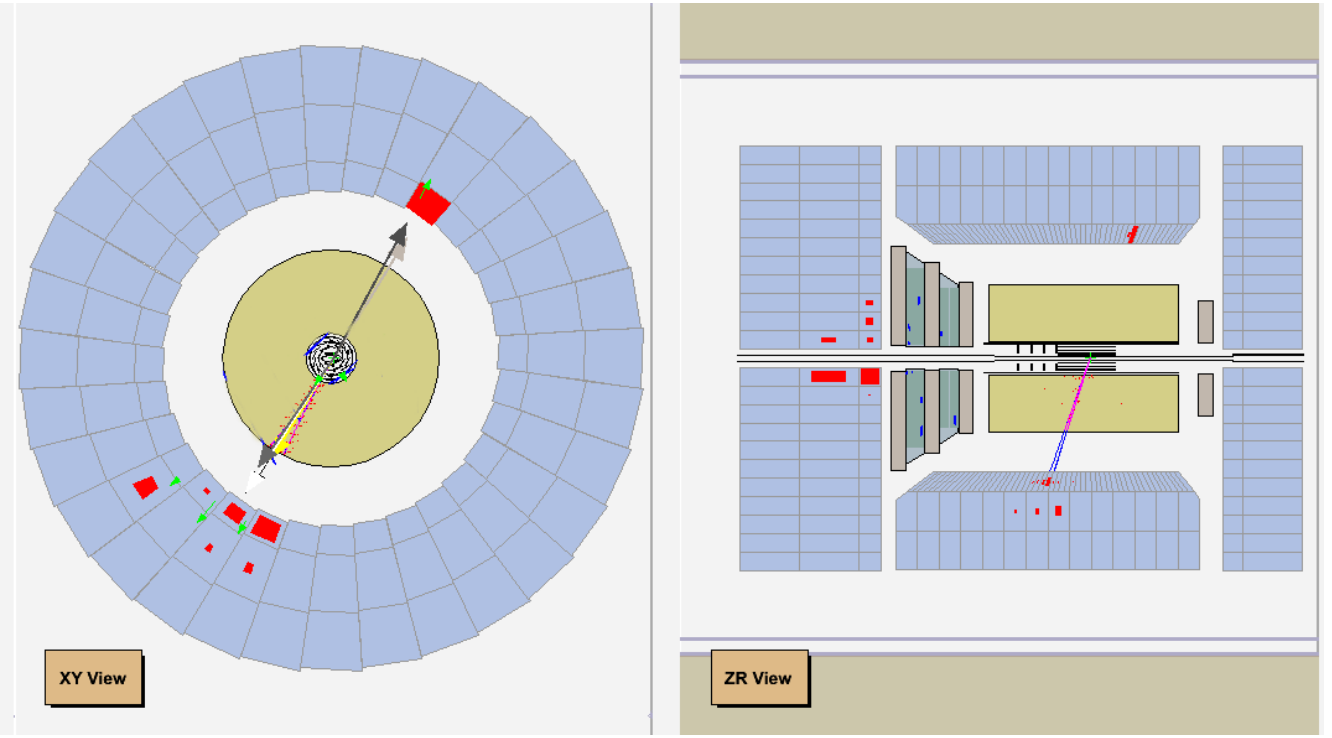
$Q^2 < 1\ GeV^2$

$6 < E_T^{\gamma} < 15\ GeV$

$-0.7 < \eta^{\gamma} < 0.9$

$4 < E_T^{Jet} < 35\ GeV$

$-1.5 < \eta^{Jet} < 1.8$



Isolation conditions for photon candidates

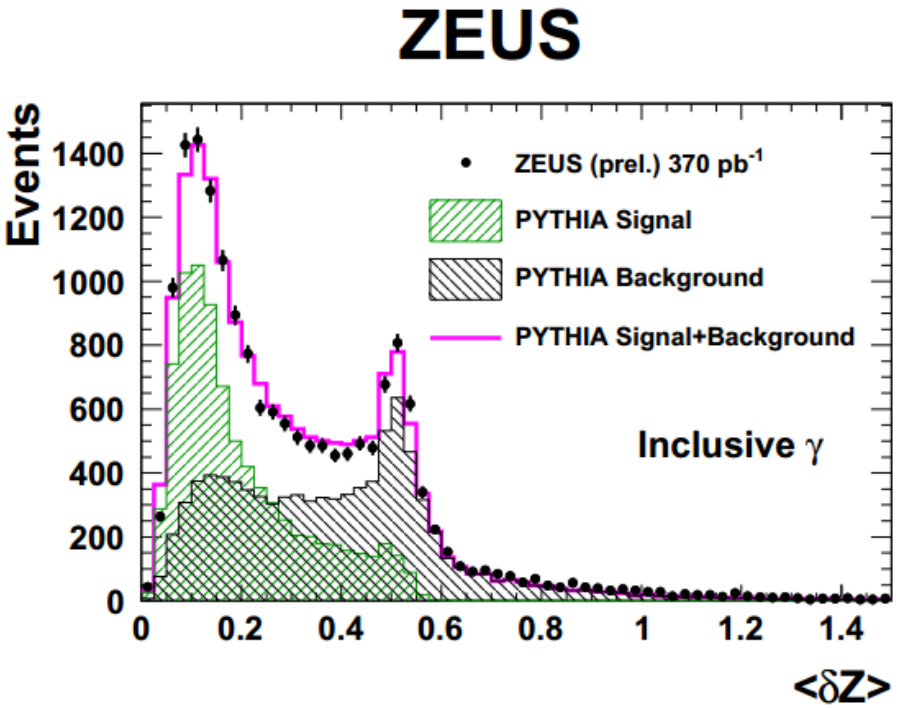
A photon candidate must have at least 90% of energy from jet-like object it belongs to ($\delta R = 0.2$).

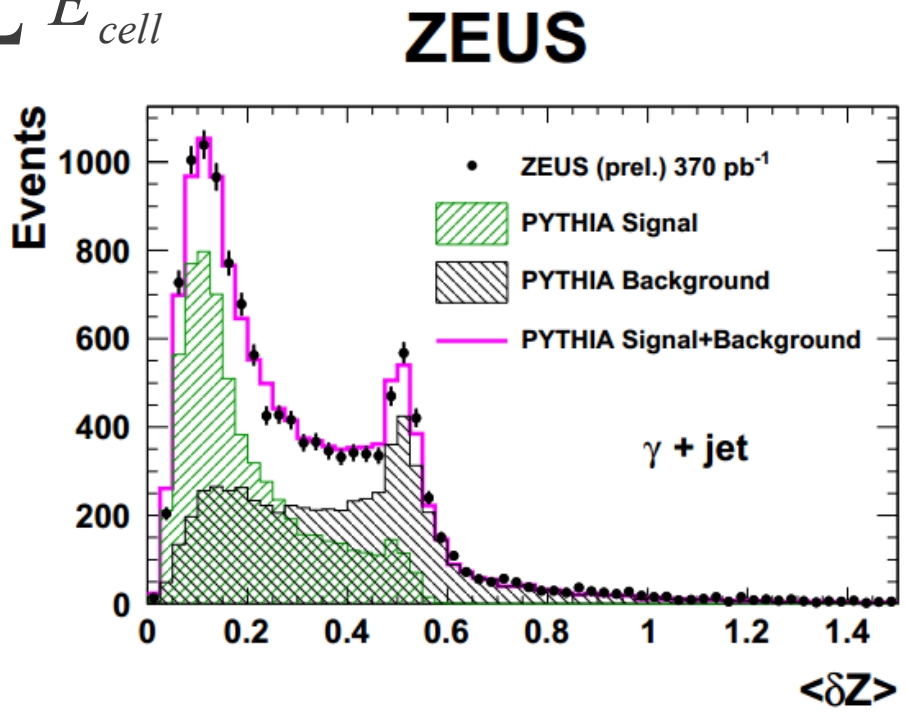
For isolated photon no tracks matched are required.

Signal extraction

Granularity of the ZEUS calorimeter provides a possibility to distinguish between signal and unsubtractable background

$$\langle \delta Z \rangle = \frac{\sum E_{cell} |Z_{cell} - \bar{Z}|}{\sum E_{cell}}$$

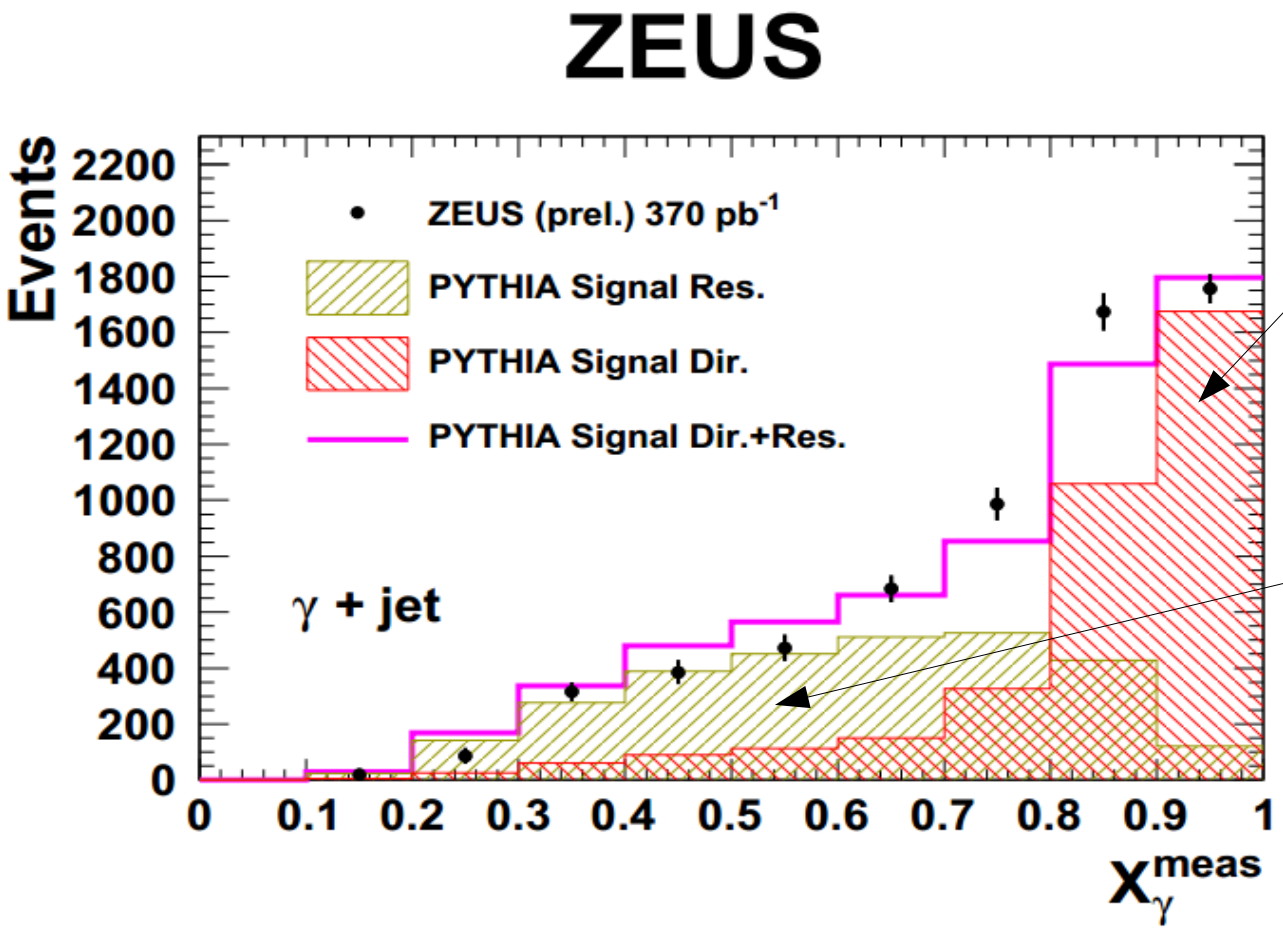


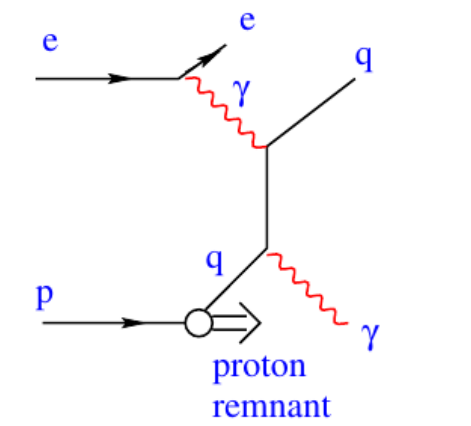


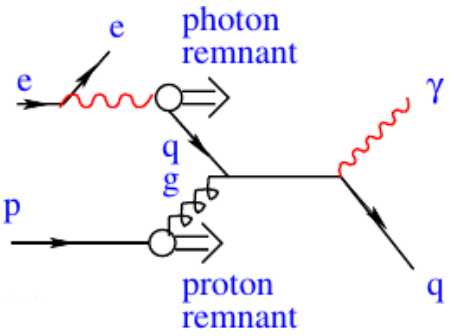
The energy weighted mean width <δZ> distribution can be fitted with separate sets of MC for signal and background

Direct/resolved signal mix

The fraction on direct and resolved prompt photon production is estimated using X_γ variable







$$X_\gamma^{meas} = \frac{E^\gamma + E^{Jet} - p_Z^\gamma - p_Z^{Jet}}{E^{all} - p_Z^{all}}$$

Extracted signal is fitted with MC distributions for direct and resolved processes

Theoretical predictions

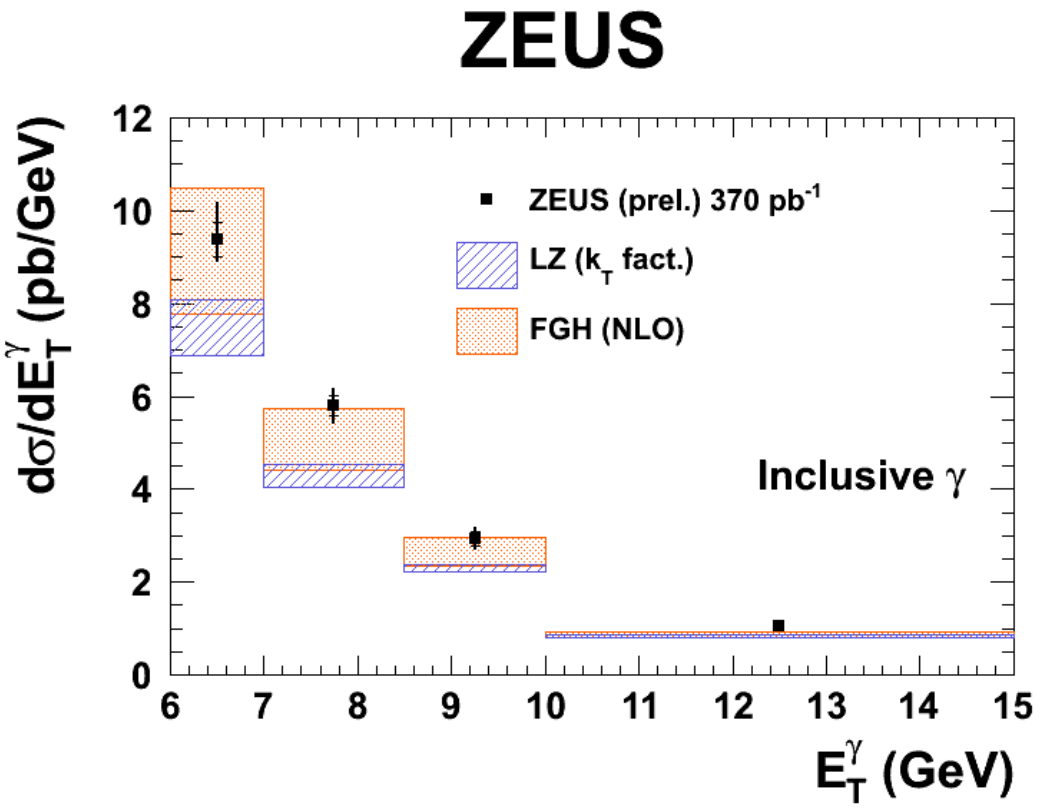
- **FGH** (M. Fontanaz, J.-P. Guillet, G. Heinrich)
Eur. Phys. J. C 21 (2001) 303

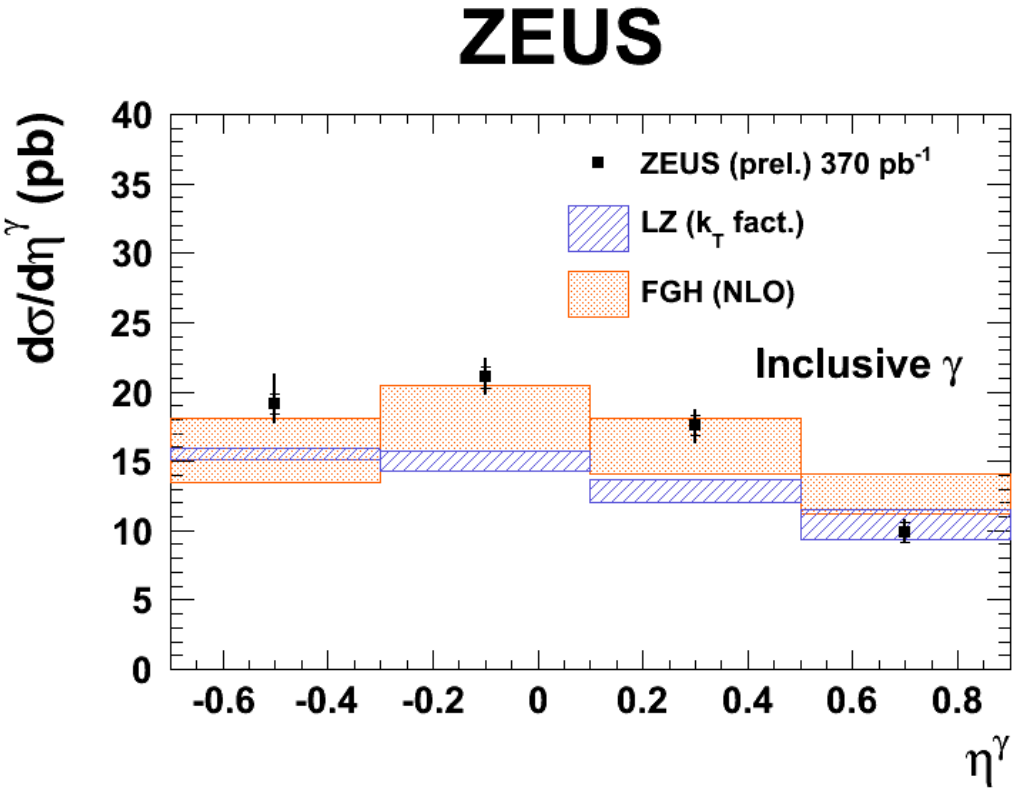
Full NLO calculation of direct and resolved processes, including **box diagrams and fragmentation component**. Uncertainty comes from **renormalisation scale**.

- **LZ** (A. Lipatov, N. Zotov)
Phys. Rev. D 81 (2010) 094027

The **k_T factorisation** method, **unintegrated proton and photon parton densities at LO** are used. Uncertainty comes from **renormalisation and factorisation scales** varied by factor 0.5 and 2 simultaneously.

Inclusive photon cross sections





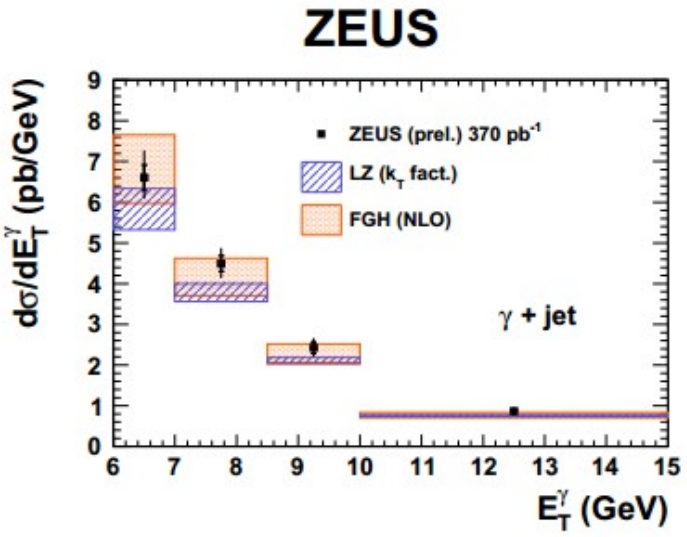
NLO predictions tend to describe data well within uncertainties.

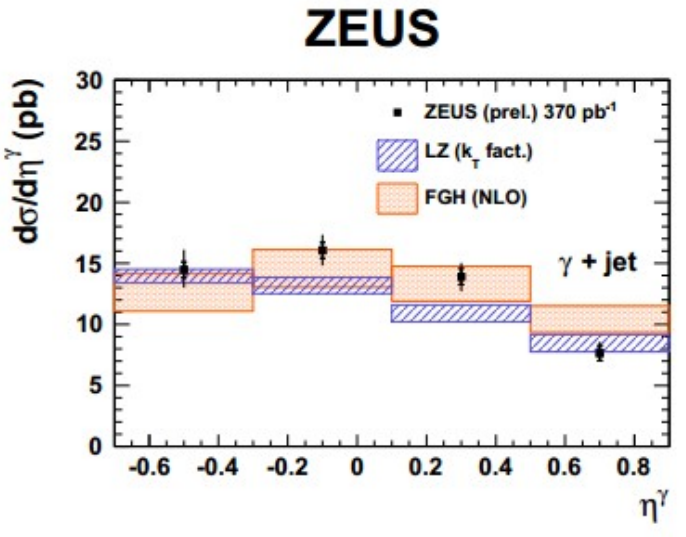
LZ underastimates data.

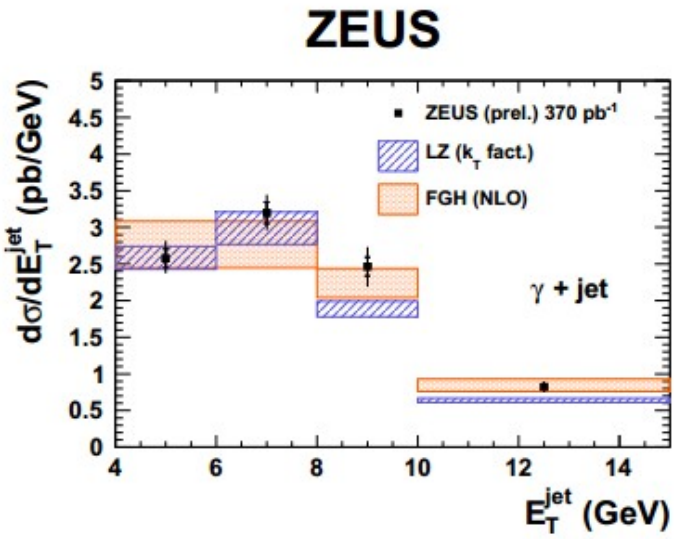
$Q^2 < 1$ GeV^2

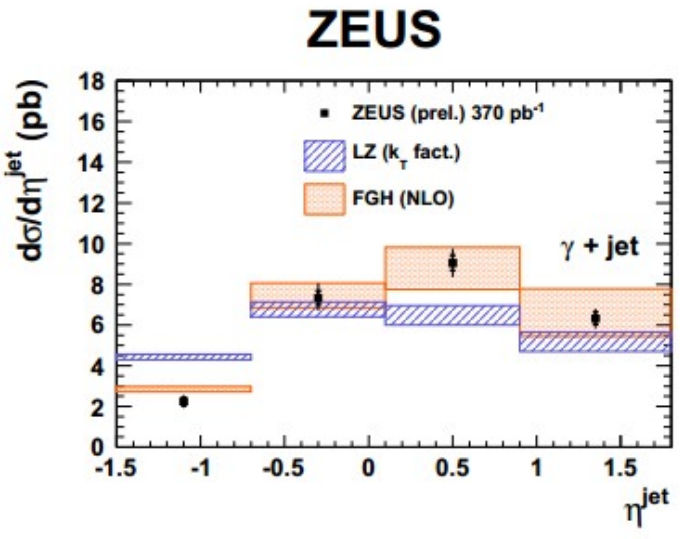
$6 < E_T^\gamma < 15$ GeV $-0.7 < \eta^\gamma < 0.9$

Cross sections for photon + jet









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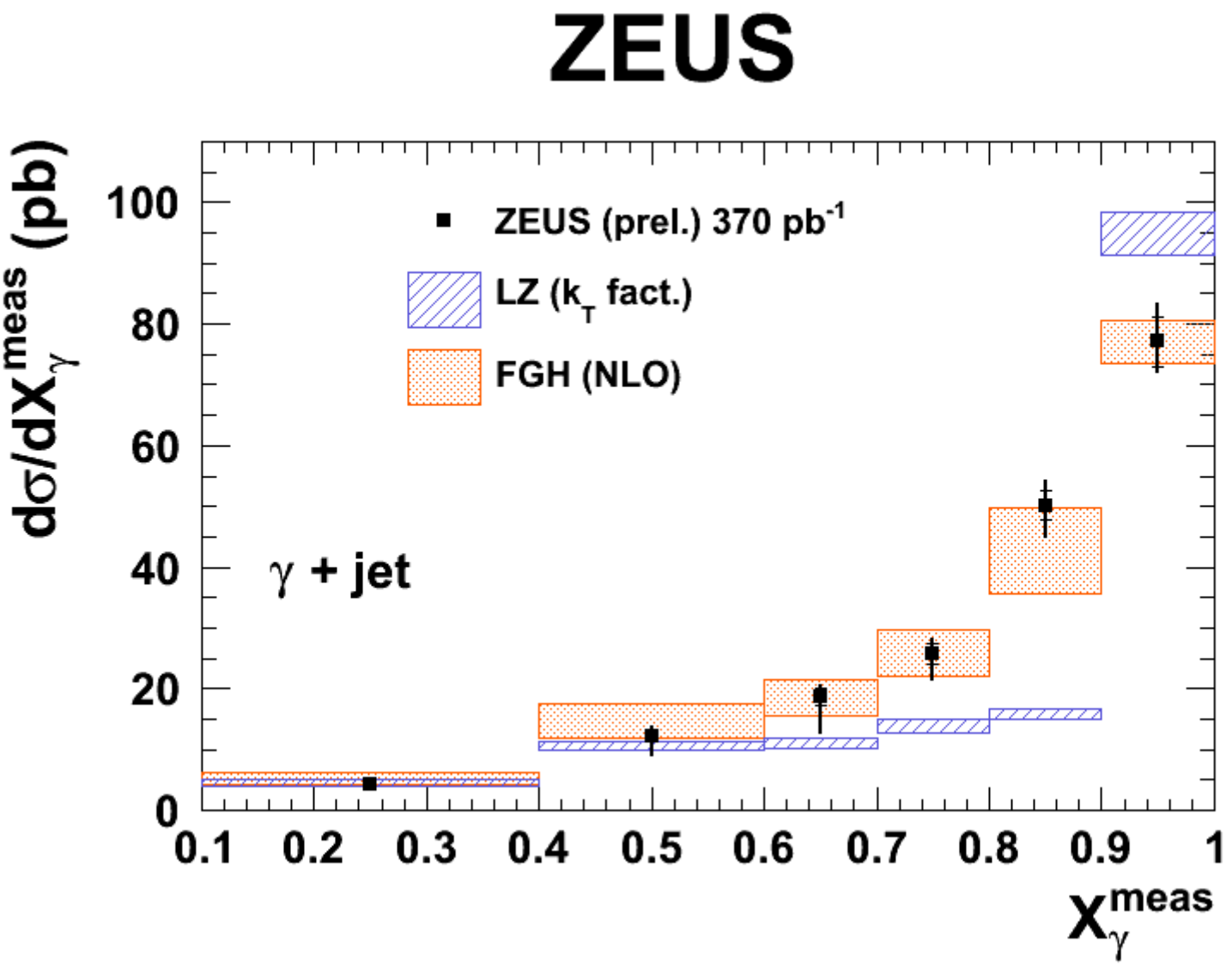
FGH demonstrates better agreement within uncertainties

Cross sections for photon + jet



Good description of the experimental data by FGH prediction

Summary

- Cross sections for isolated photons with and without jets were measured using at HERA-II data from ZEUS detector ($Q^2 < 1$GeV, PhP).

- The LZ method (k_T factorisation) describes data reasonably, although cross sections are underestimated (new values are coming).

- The NLO prediction by FGH describes data well within the uncertainty.