Photoproduction of isolated photons with a jet at HERA. Status report

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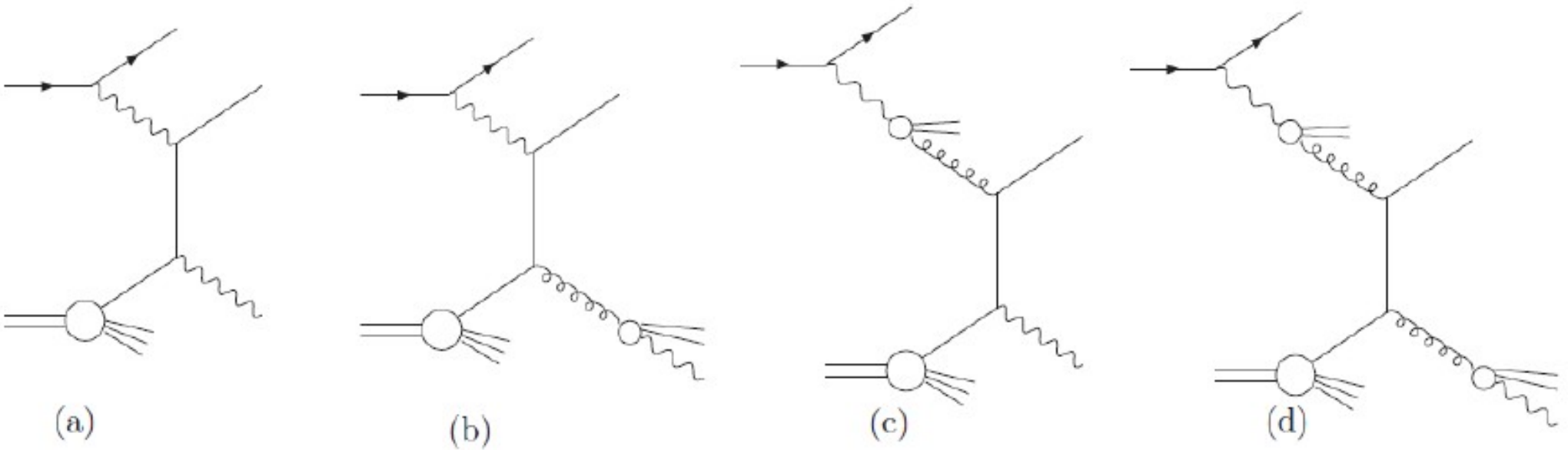
Introduction



A prompt photon is one that emerges directly from a perturbative QCD process. LO diagrams are illustrated above:
(a) direct, in which the entire incoming photon interacts,
(c) resolved, in which a parton from the photon interacts.

Higher order pQCD processes occur and also "fragmentation" processes (b, d).

Motivation

- Prompt (isolated, high p_T) photons are a useful tool to study and test QCD.

- Their measurements are more precise than hadronic jets.

- Prompt photons can be used to measure and constrain the pdfs of proton and photon.

- Looking at two new variables:
  - x_p – measures longitudinal momentum transfer from proton – sensitive to PDF and modelling of parton in proton – interesting to see LMZ description of this with k_T-factorisation.
  - $\Delta\Phi$ – the azimuthal difference between the photon and the jet, sensitive to higher order processes.
- Study of two regions of x_γ – longitudinal momentum transfer from photon, resolved- and direct-enhanced:

$$x_\gamma < 0.7 \text{ and } x_\gamma > 0.8$$

Data Samples

Data: HERA II 04p, 04/05e, 06e, 06p, 07p (Common Ntuples v06d) 374 pb^{-1}

MC Signal: 04p, 05e, 06e, 06p, 07p (CN v06b PYTHIA) Direct, Resolved

MC Background: 04p, 04/05e, 06e, 06p, 07p (CN v06b PYTHIA - Heavy Flavour Group, Jet – Sebastian's + Filtered) Direct, Resolved

Cuts

Event Selection

Trigger HPP16 on

$0.2 < y_{JB} < 0.7$

$|$ Zvtx $|<40$ cm

$|$BCAL time$|<10$ ns

Cal $p_T<10$ GeV

No SINISTRA electron with Prob > 0.9 and Yel < 0.7

Prompt Photon Selection

Tufo[0] =31

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

$6<E_T{}^{zufo}<15$ GeV

$E^{zufo}/E^{jet}>0.9$

ZufoEemc/ZufoEcal>0.9

track isolation in cone 0.2

$x_\gamma < 0.7$ or $x_\gamma > 0.8$

Jet Selection

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

$4<E_T{}^{jet}<35$ GeV

Truth level selection

$Q^2<1$ GeV^2

$0.2<y_{JB}<0.7$

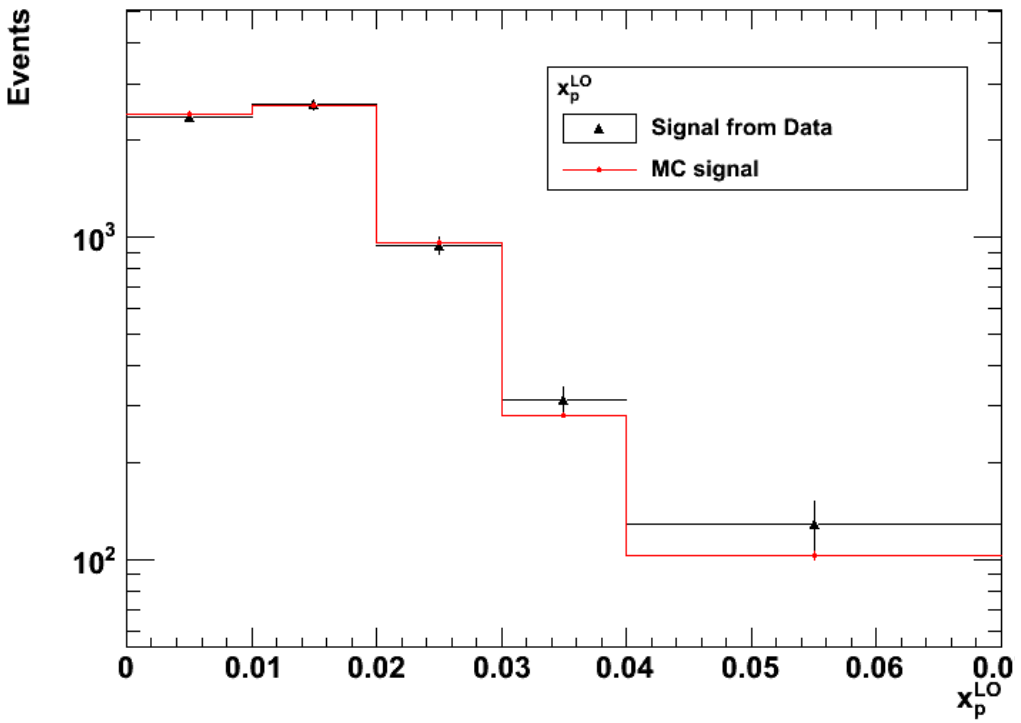
Particle type 29

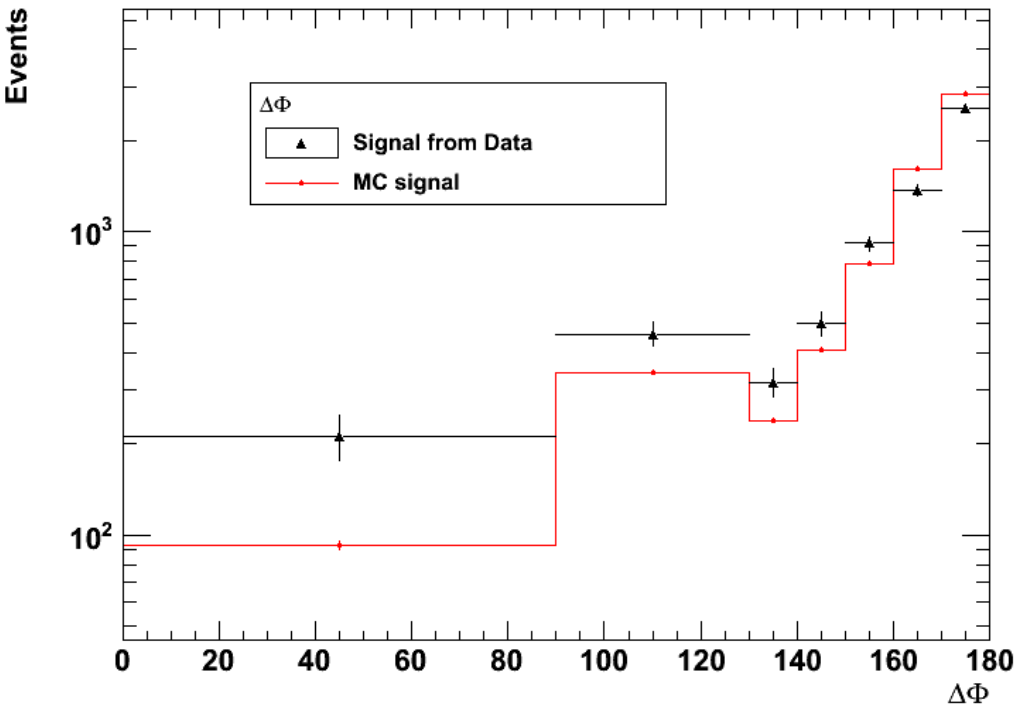
$-0.7<\eta^{particle}<0.9$

$6<E_T{}^{particle}<15$ GeV

$E^{particle}/E^{jet}>0.9$

Control plots. All x_γ



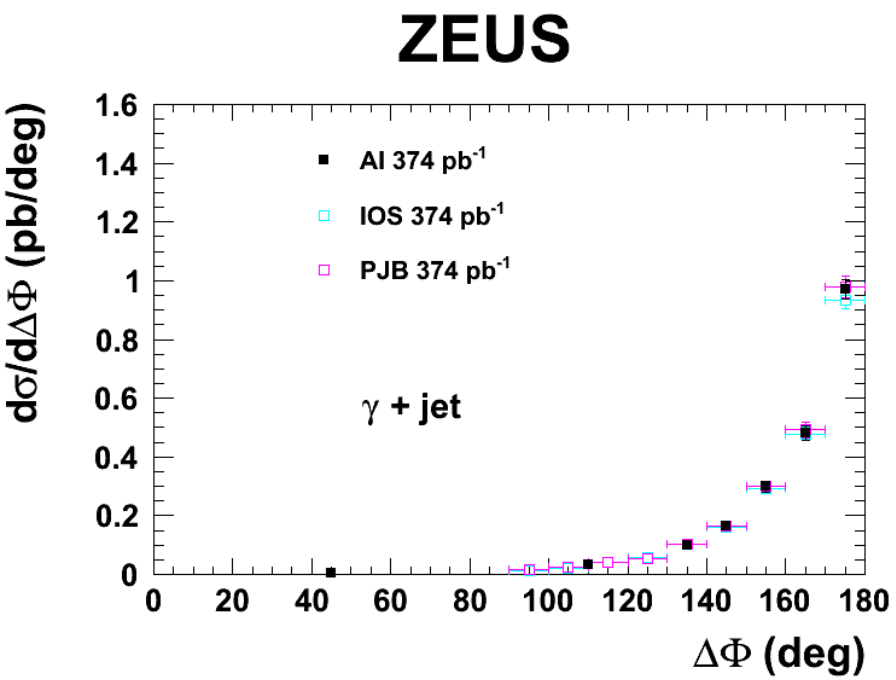


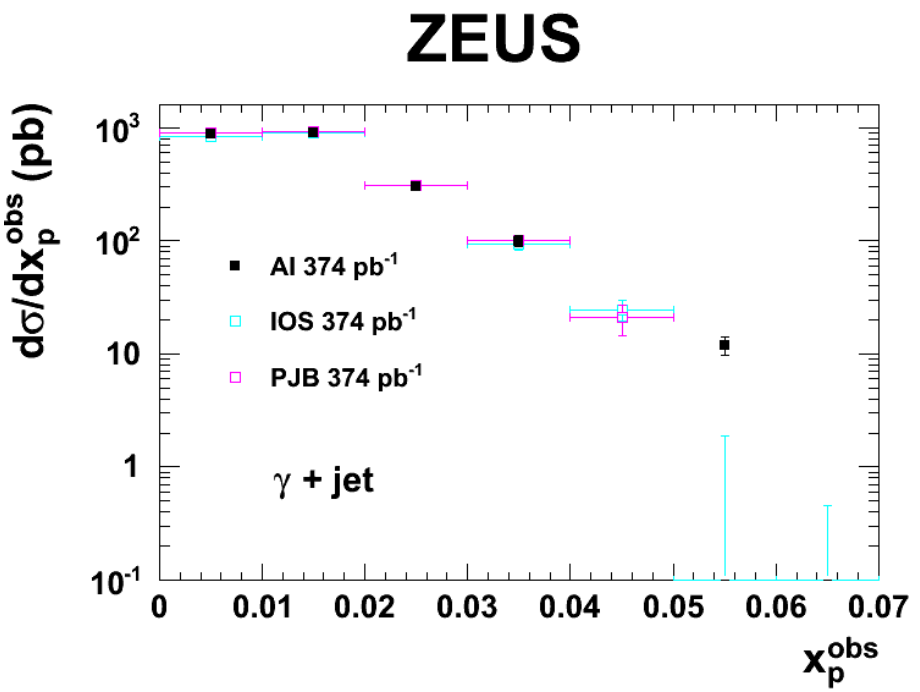
$x_p = (E_T^\gamma * \exp(\eta^\gamma) + E_T^{jet} * \exp(\eta^{jet})) / (2*E_p)$

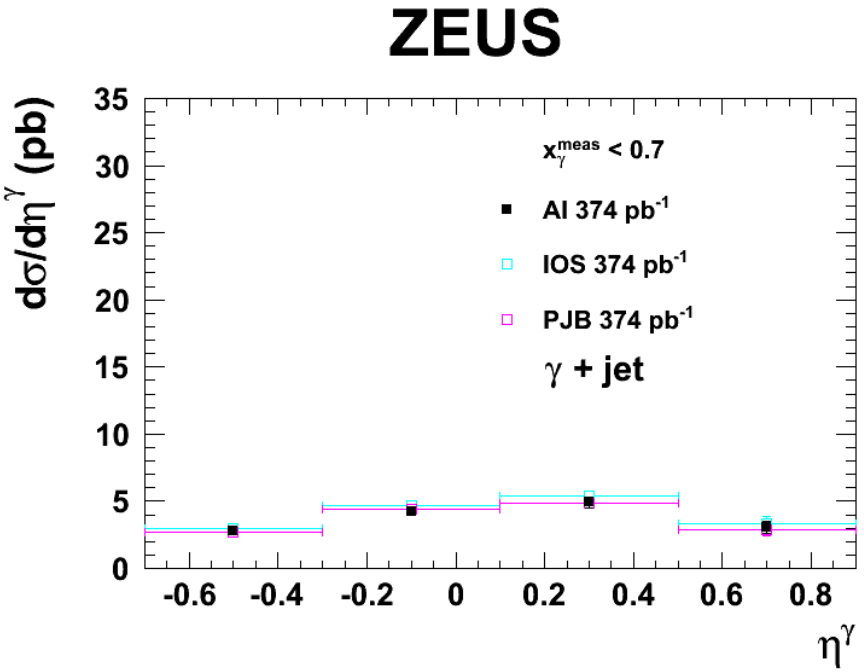
$\Delta\Phi = (\Phi_\gamma - \Phi_{jet}) * 180 / \pi$

Control plots use the number of fitted photons (Signal from Data) and compare them with signal MC.

Comparison between analyses







Good agreement between three analyses.

Differences can be attributed to different approaches to acceptance calculation, selection, spline for photon definition and use of corrections.

Theory

FGH (Fontannaz, Guillet and Heinrich) - the LO and NLO diagrams and the box-diagram term are calculated explicitly. Fragmentation processes calculated in terms of fragmentation function.

LMZ (Lipatov, Malyshev and Zotov) - k_T-factorisation method makes use of unintegrated parton densities in the proton. Fragmentation terms are not included. The box diagram is included together with $2 \rightarrow 3$ subprocesses:

$\gamma(k_1) + q(k_2) \rightarrow \gamma(p_1) + g(p_2) + q(p_3)$

$\gamma(k_1) + g^*(k_2) \rightarrow \gamma(p_1) + q(p_2) + \mathrm{qbar}(p_3)$

$\gamma(k_1) + g(k_2) \rightarrow \gamma(p_1) + g(p_2)$.

A case with $gq \rightarrow \gamma q$ process included is examined (denoted as GQ).

Cross sections. $x_\gamma < 0.8$

Motivation: check that sum x_γ [0.;.8] + [.8;1.]= [0;1]

Theory shown is for $x_\gamma < 0.7$

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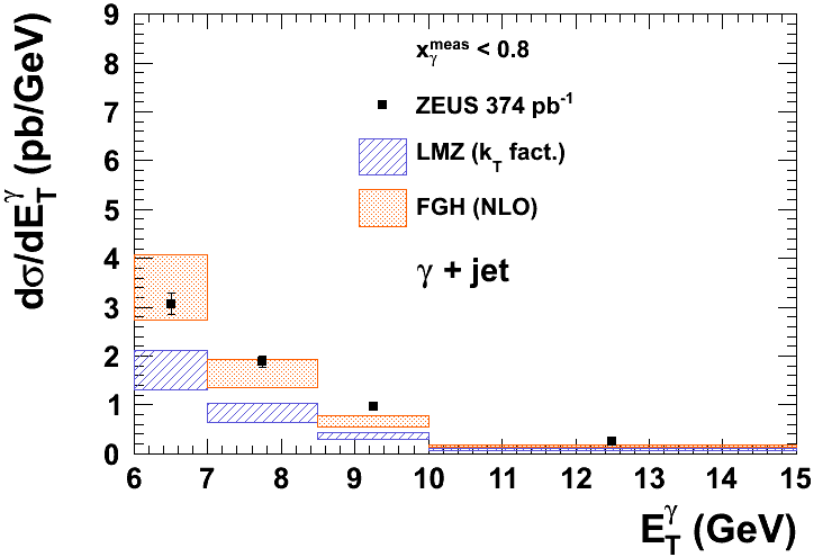

Data cross section:
8.55 + 12.97 = 21.52 vs 22.02

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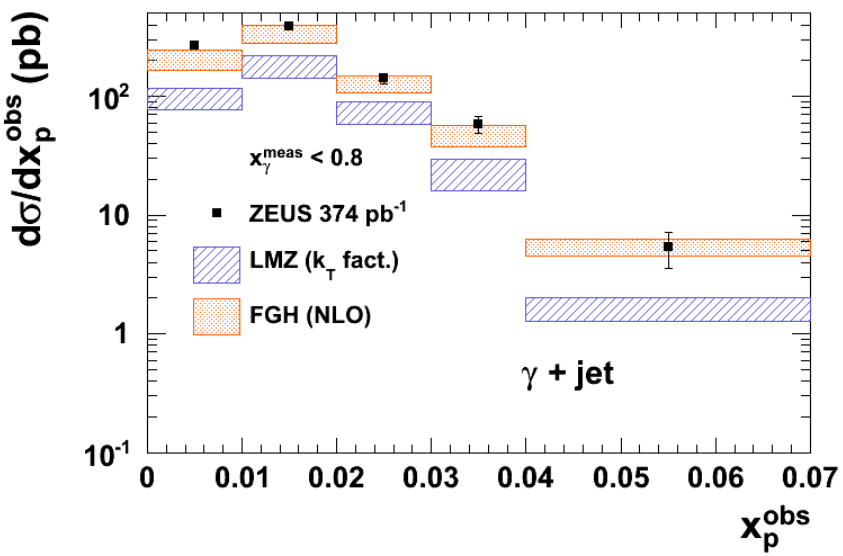
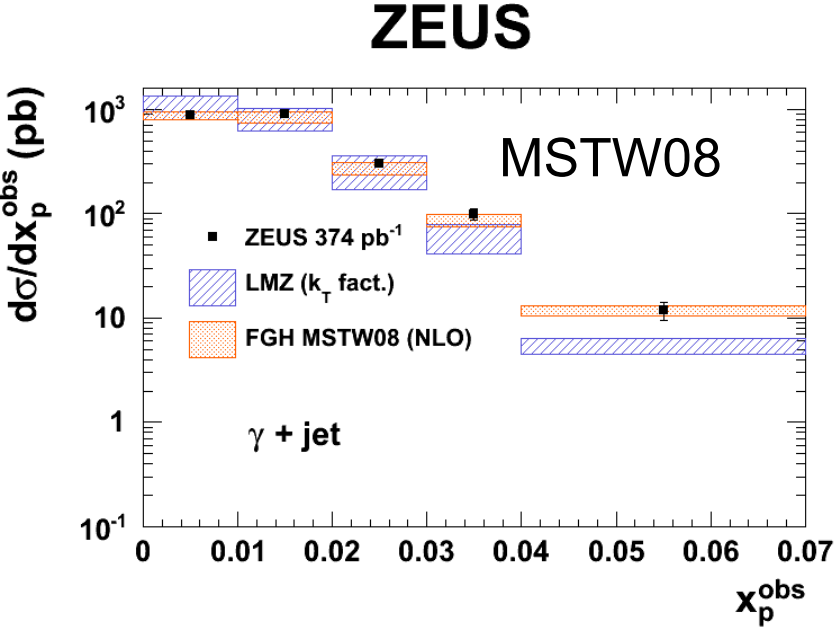
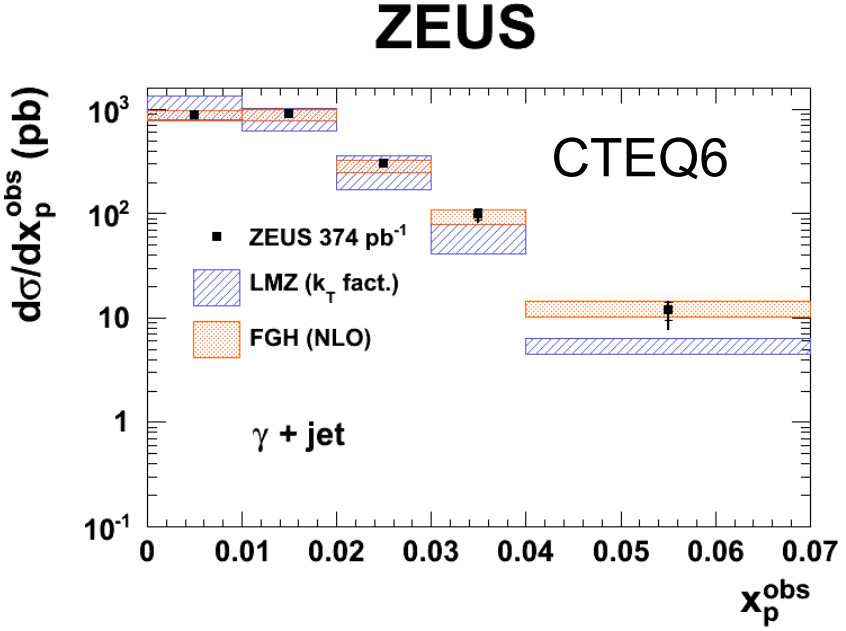


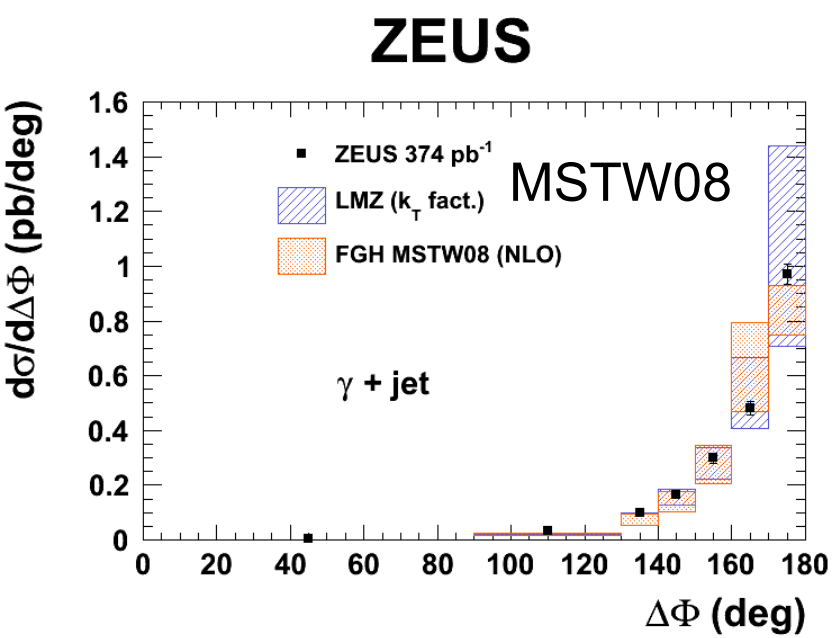
Data cross section:
8.71 + 12.82 = 21.53 vs 22.34

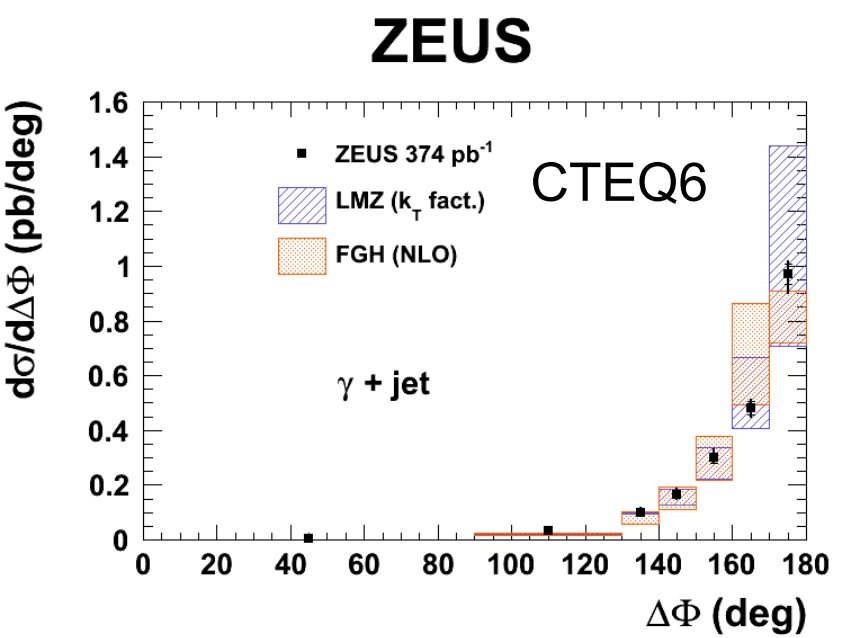
Difference between cross section in all x-gamma and the sum of $x_\gamma < 0.8$ and $x_\gamma > 0.8$ is within errors.

Different PDF for proton in FGH calculation





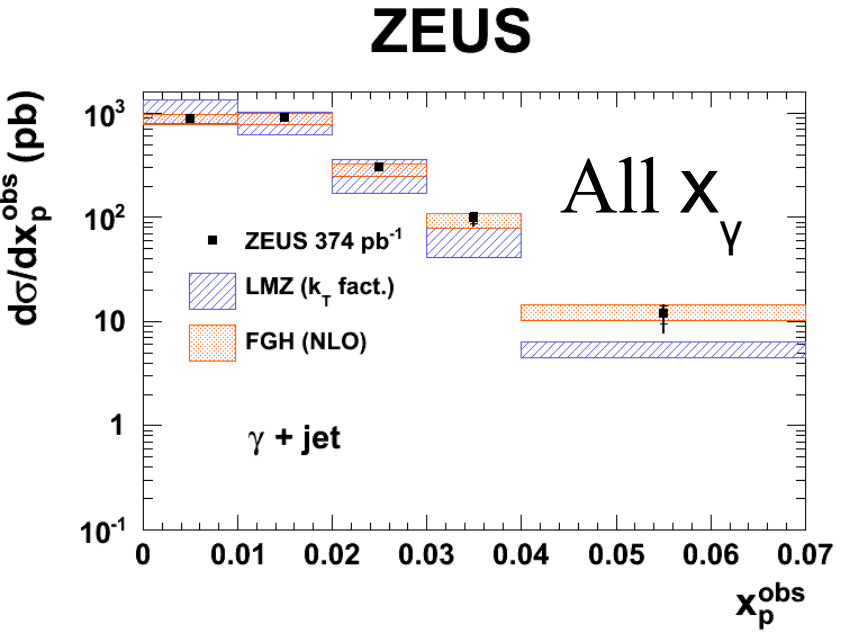




For proton PDF in FGH code MSTW2008 is used instead of CTEQ6.

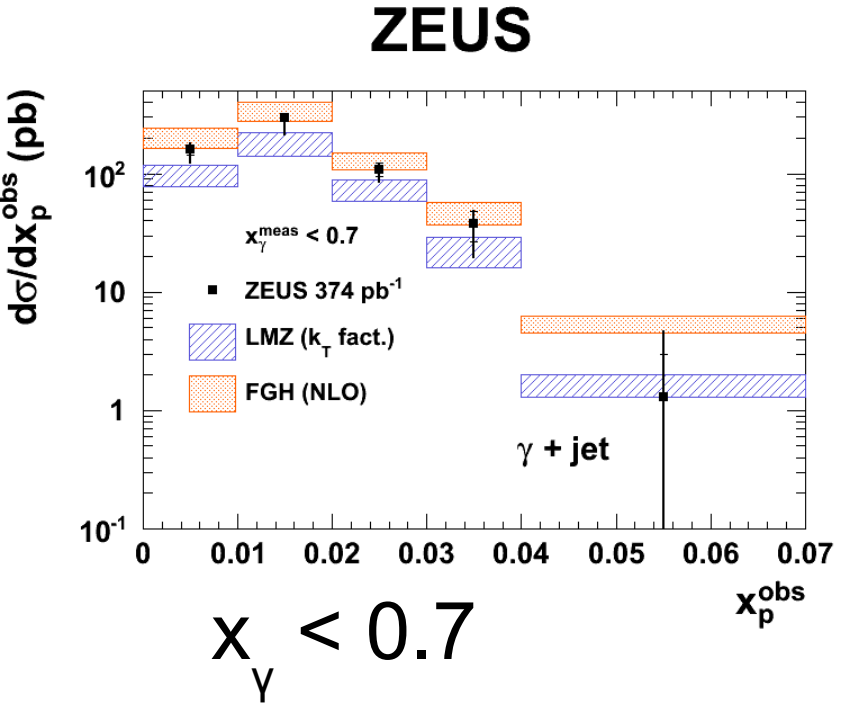
Results look similar to CTEQ6.

Cross sections. x_p

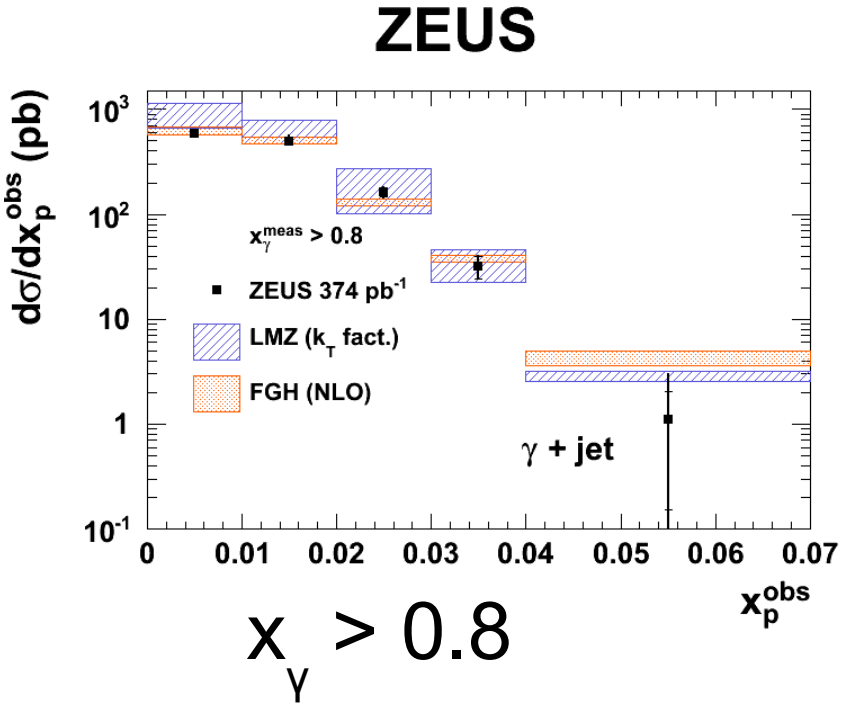


Reasonable description of data by predictions in all x_γ regions.

Here and on following plots:
- hadronisation corrections are applied to theory.
- inner and outer error bars – statistical uncertainties and statistical and systematic in quadrature.

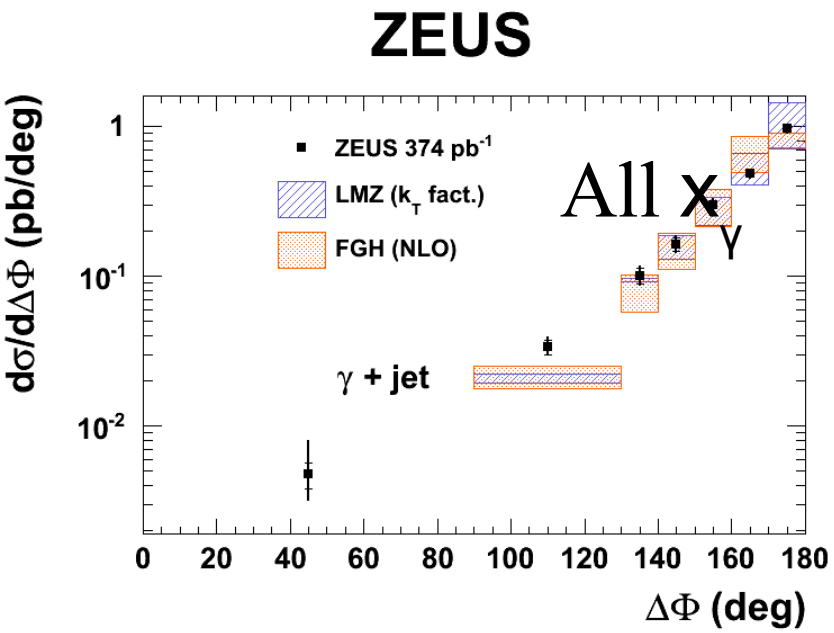


$x_\gamma < 0.7$

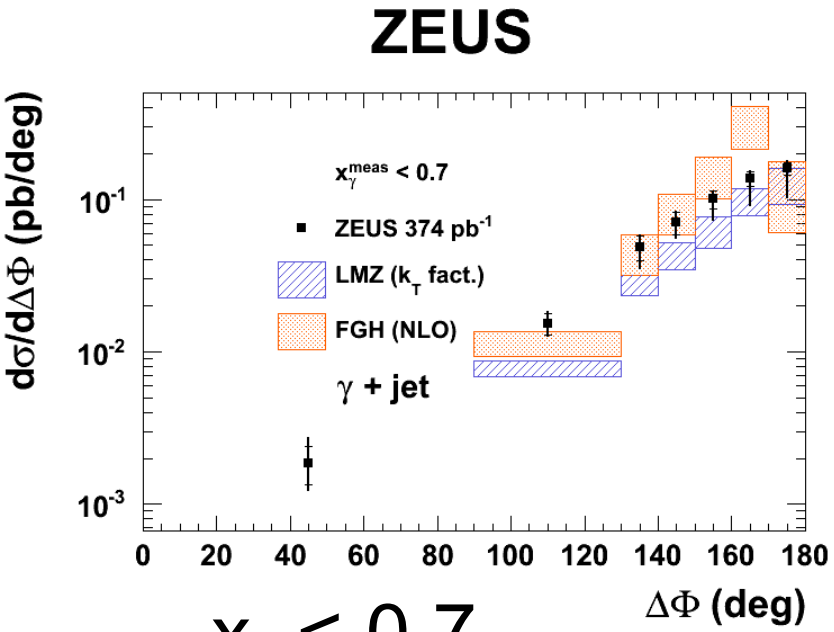


$x_\gamma > 0.8$

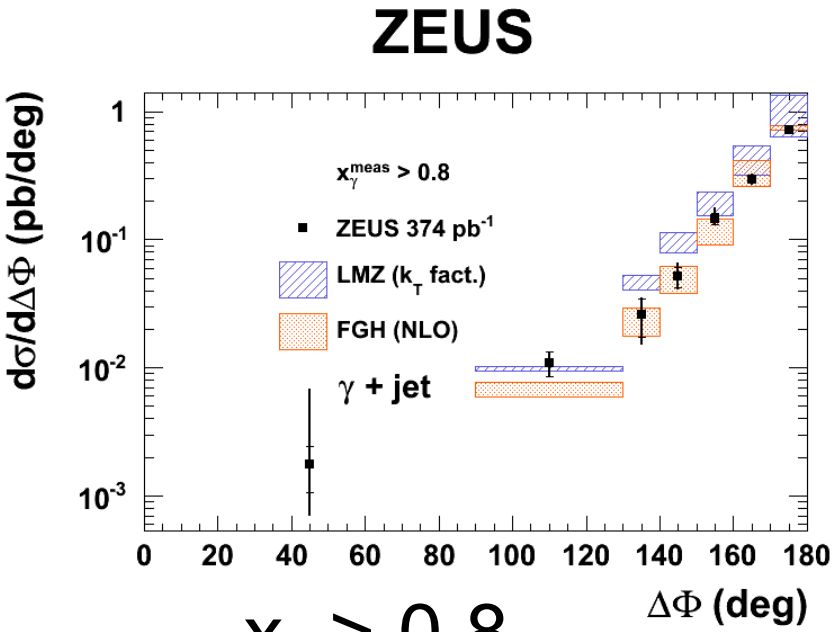
Cross sections. ΔΦ



Reasonable description by FGH, however there is an overestimation in the next-to-last bin for $x_\gamma < 0.7$.



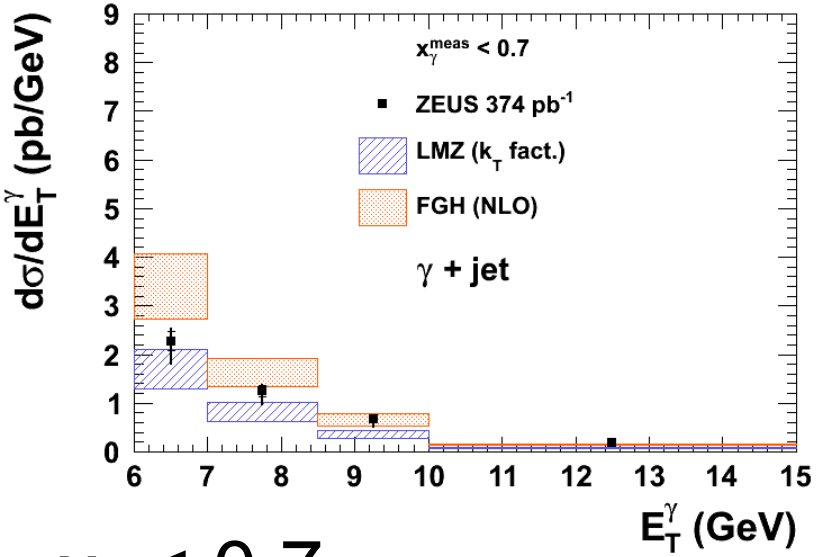
$x_\gamma < 0.7$



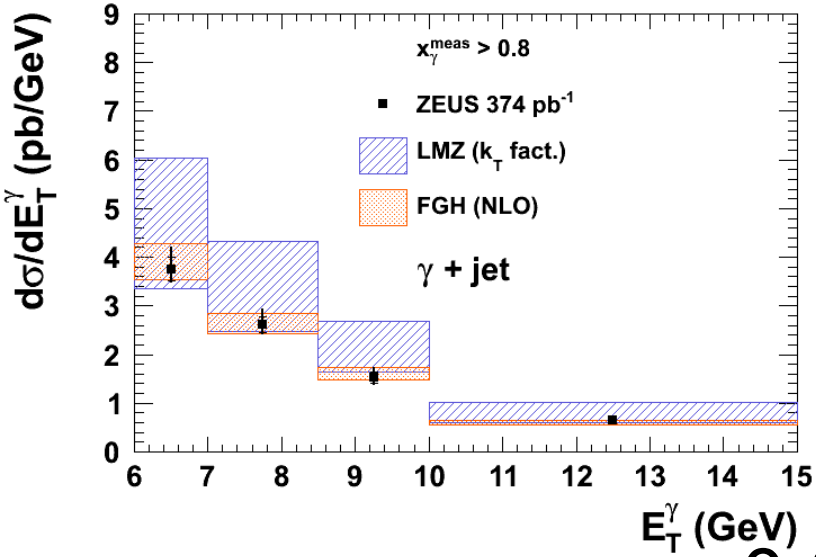
$x_\gamma > 0.8$

Cross sections. E_T^γ and η^γ

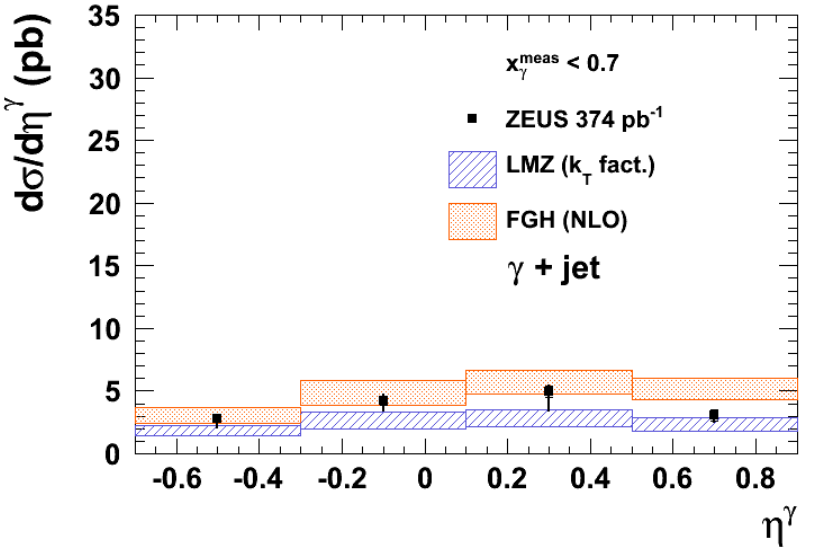
$x_\gamma < 0.7$ ZEUS



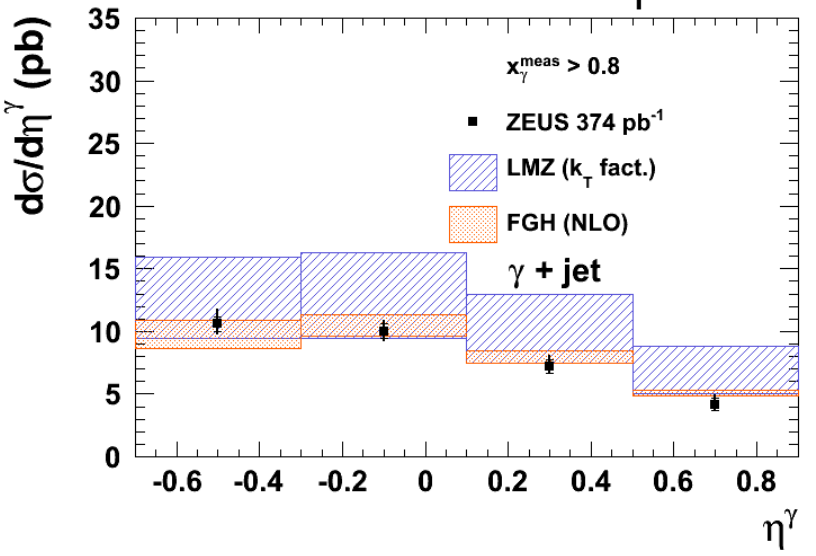
ZEUS $x_\gamma > 0.8$



$x_\gamma < 0.7$ ZEUS

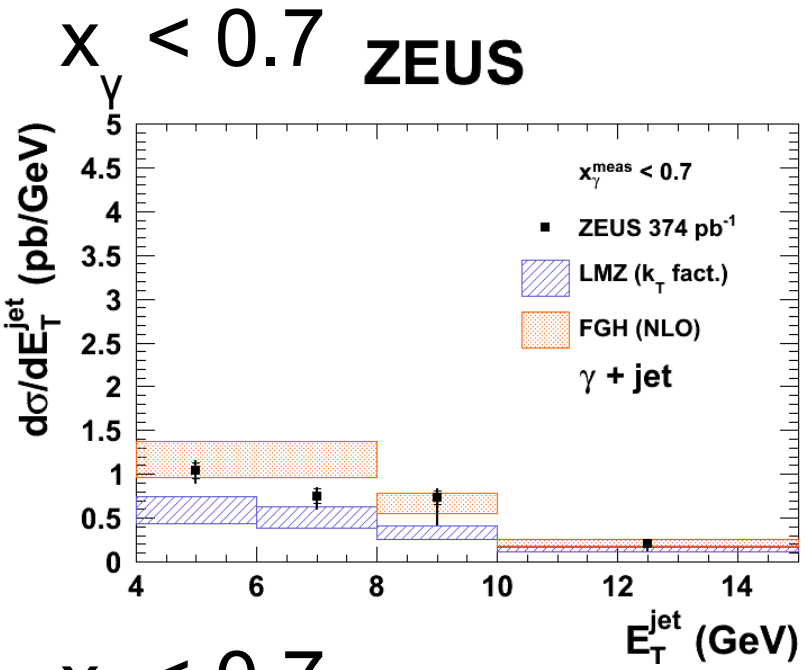


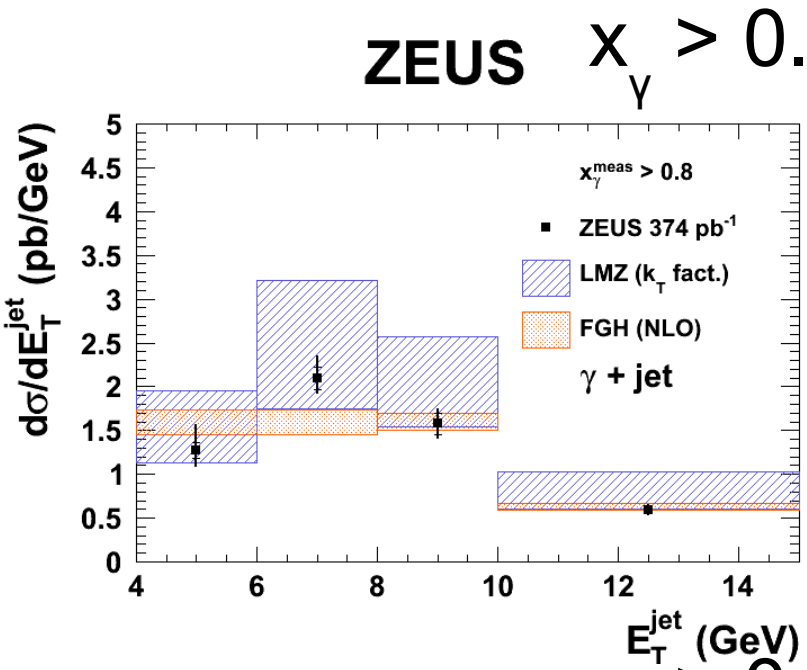
ZEUS $x_\gamma > 0.8$

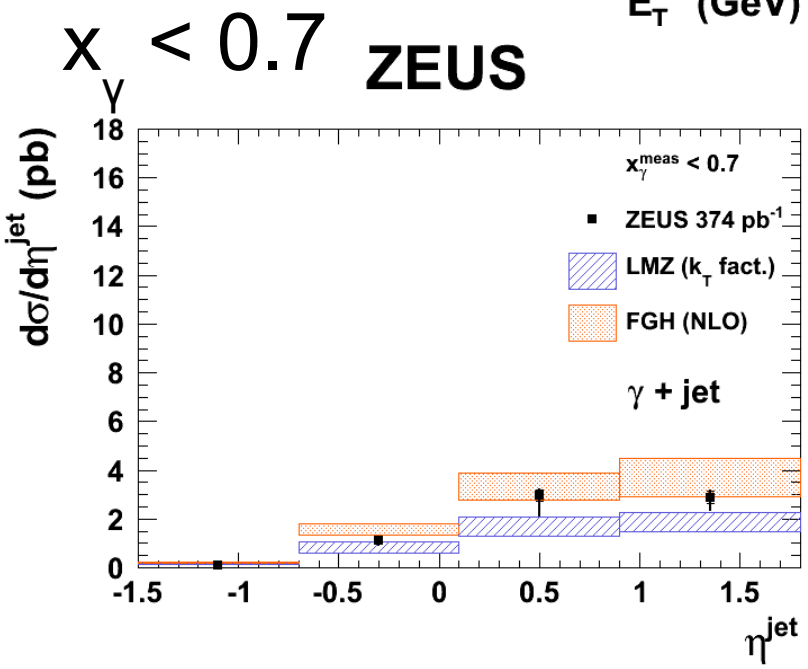


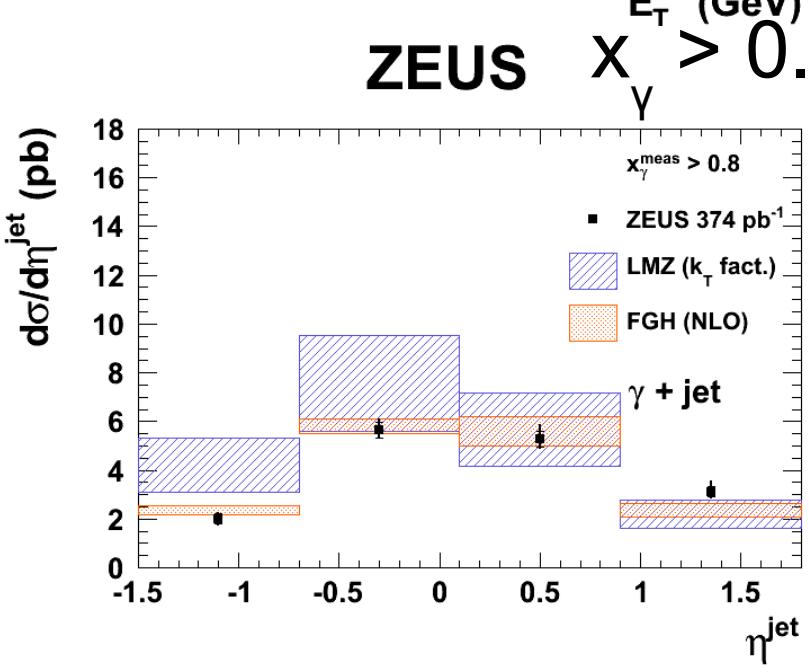
FGH tends to overestimate and LMZ underestimate $x_\gamma < 0.7$ region.

Cross sections. E_T^{jet} and η^{jet}







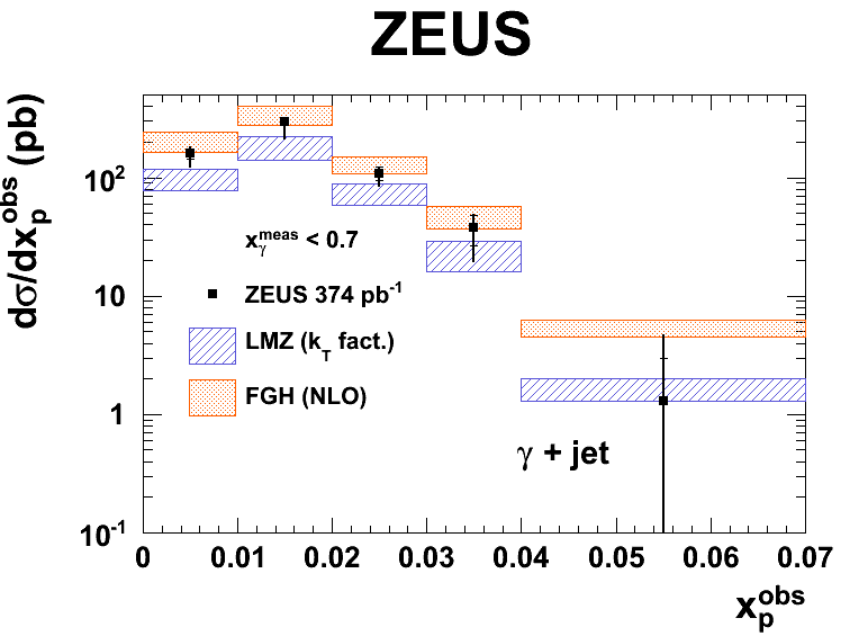


First two FGH E_T^{jet} (4-6 and 6-8 GeV) bins are combined due to singularity.

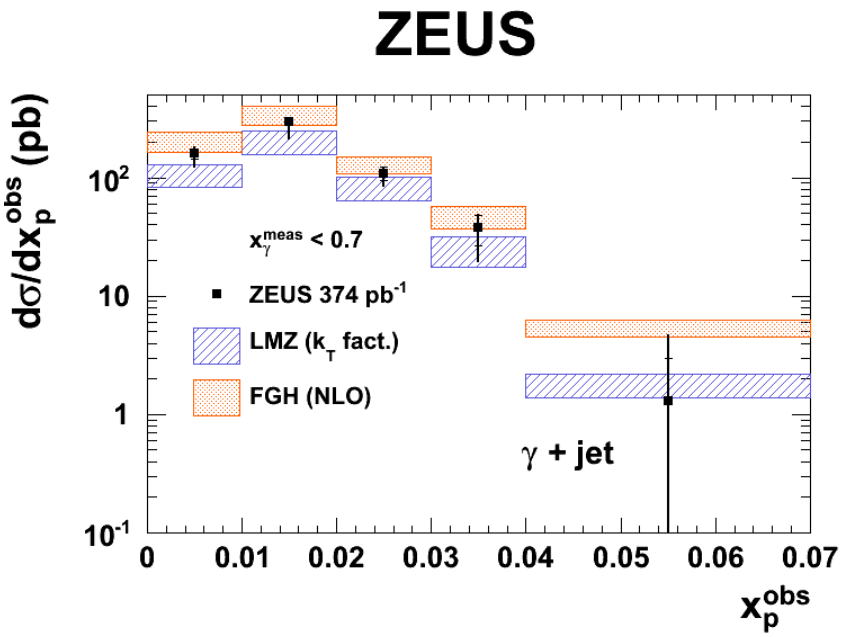
FGH tends to overestimate and LMZ underestimate x_γ < 0.7 region.

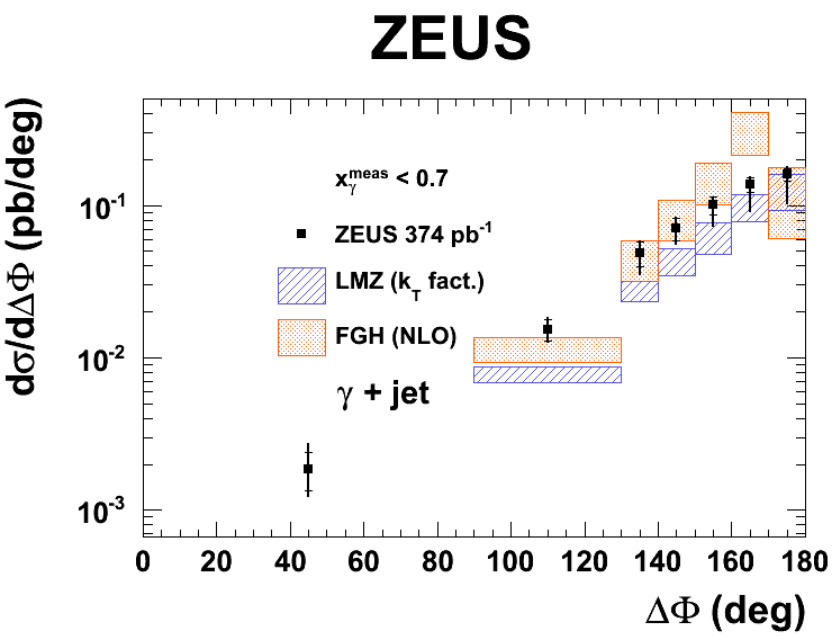
Cross sections. LMZ GQ added. $x_\gamma < 0.7$

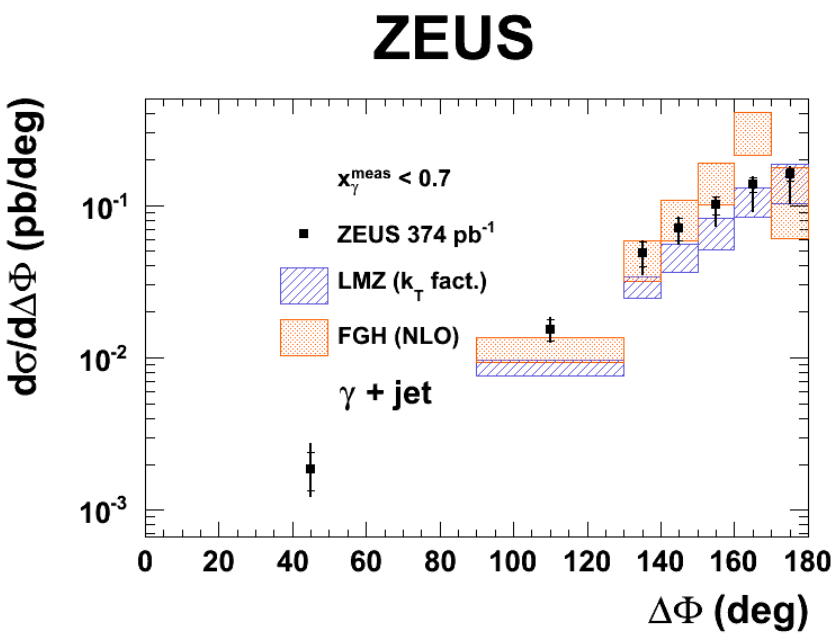
LMZ without GQ



LMZ with GQ



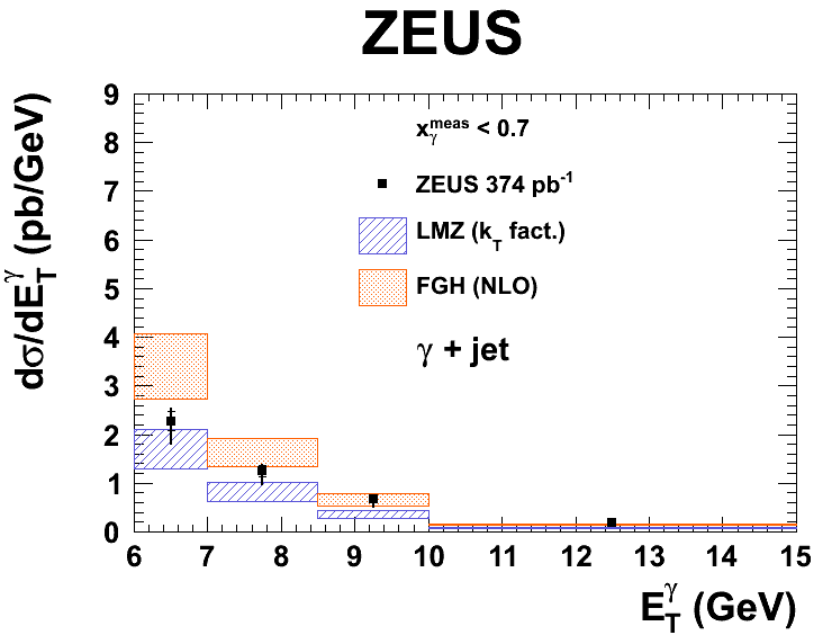




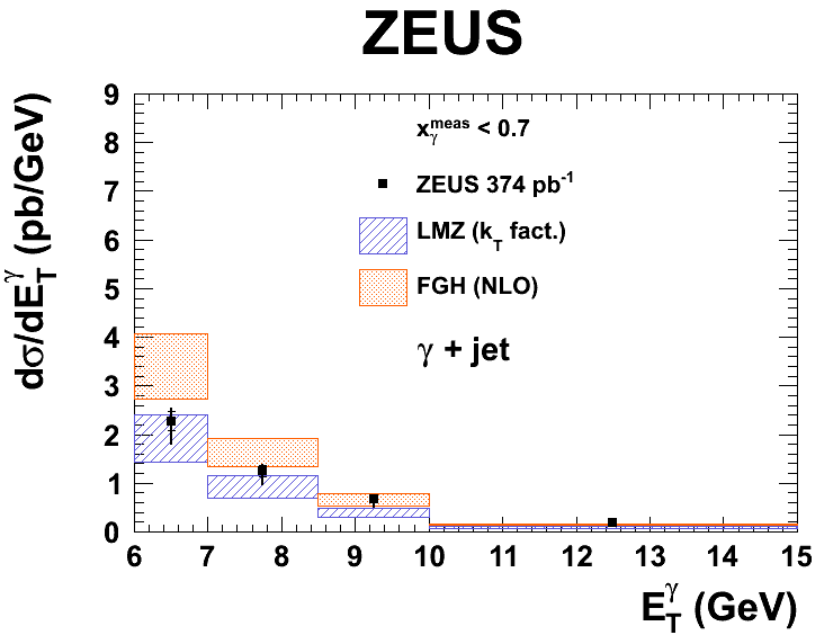
gq → γq process added. LMZ underestimation is reduced.

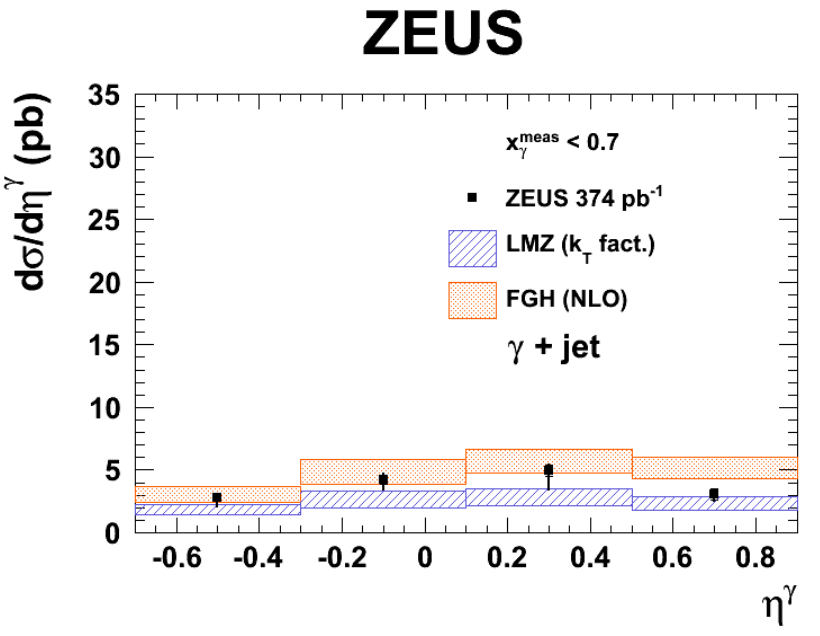
Cross sections. LMZ GQ added. $x_\gamma < 0.7$

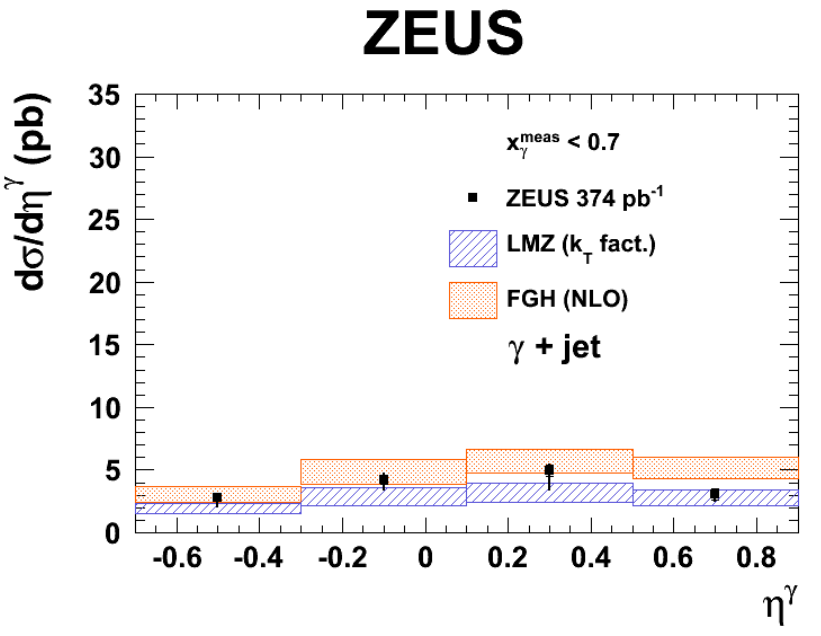
LMZ without GQ



LMZ with GQ



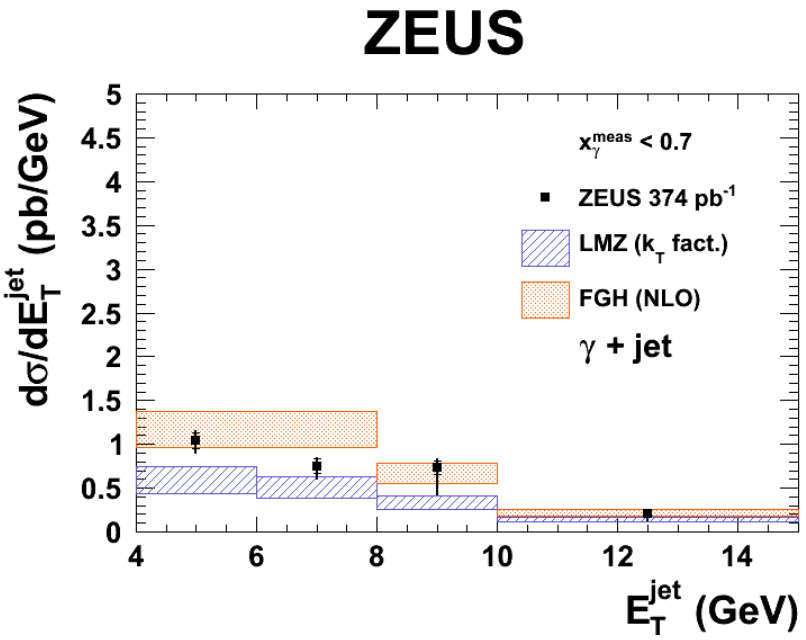




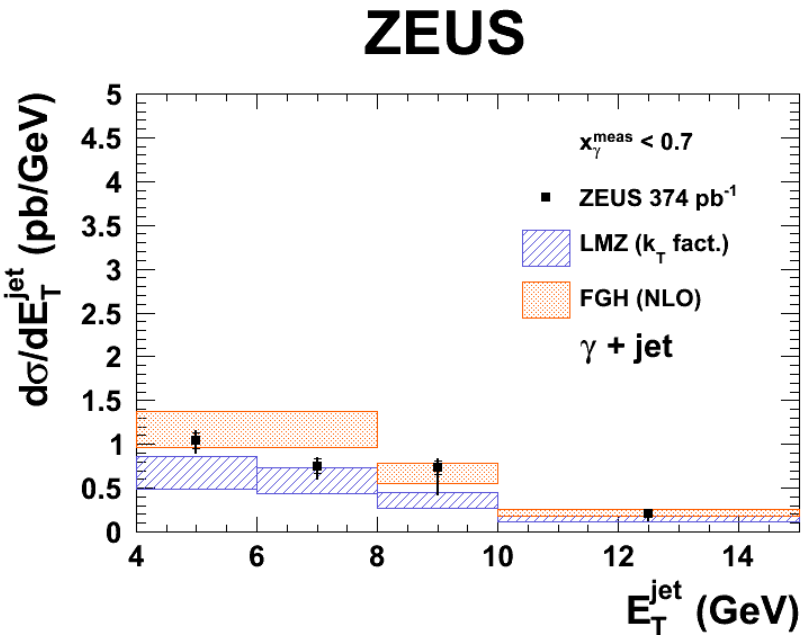
gq → γq process added. LMZ underestimation is reduced.

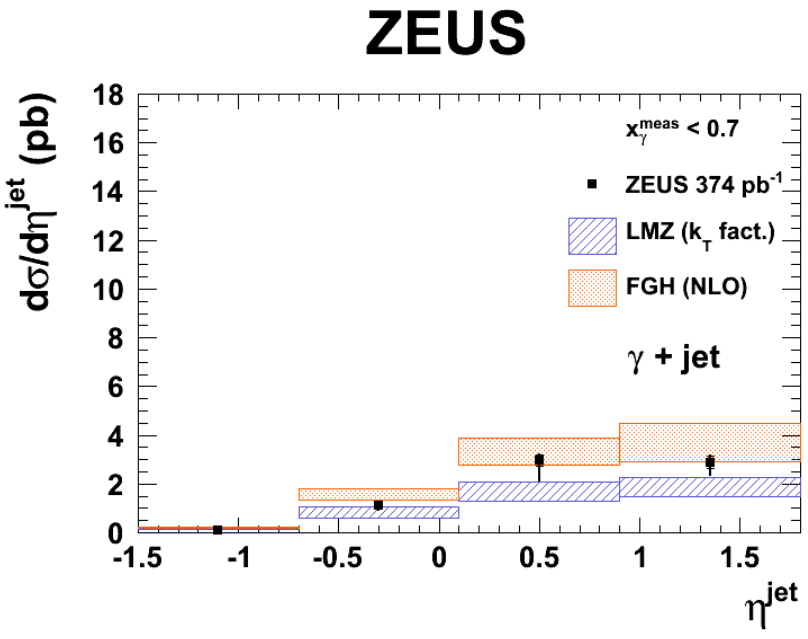
Cross sections. LMZ GQ added. $x_\gamma < 0.7$

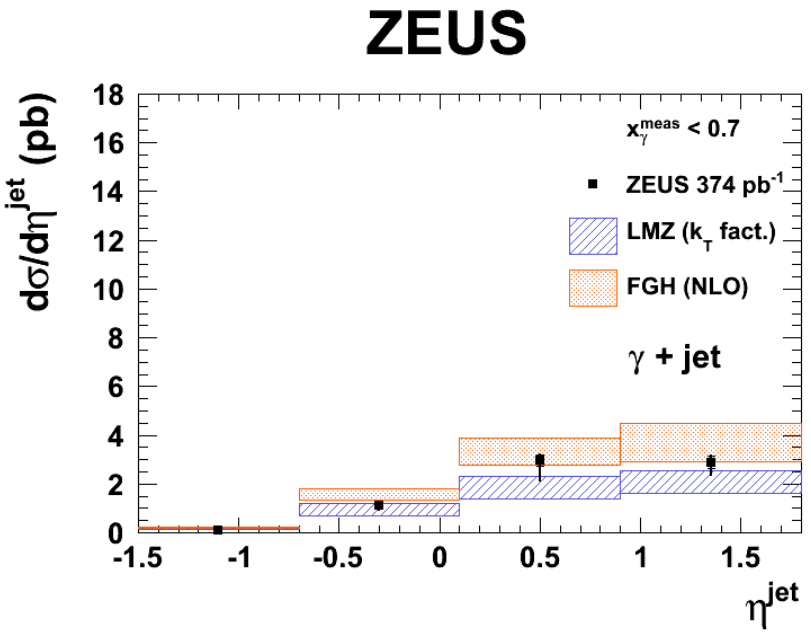
LMZ without GQ



LMZ with GQ







gq → γq process added. LMZ underestimation is reduced.

Conclusion

Control plots using number of fitted photons and compare them with signal MC presented.

Data cross sections in $x_\gamma < 0.8$, FGH MSTW08 checked, LMZ predictions added.

Both models describe the direct region well.
FGH (LMZ) overestimates (underestimates) the resolved region cross section.

Future plans

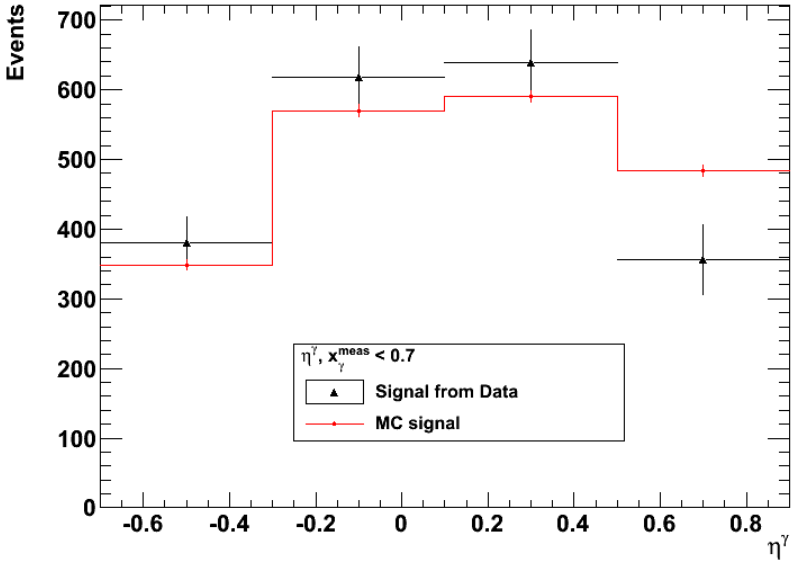
Reach agreement on corrections.

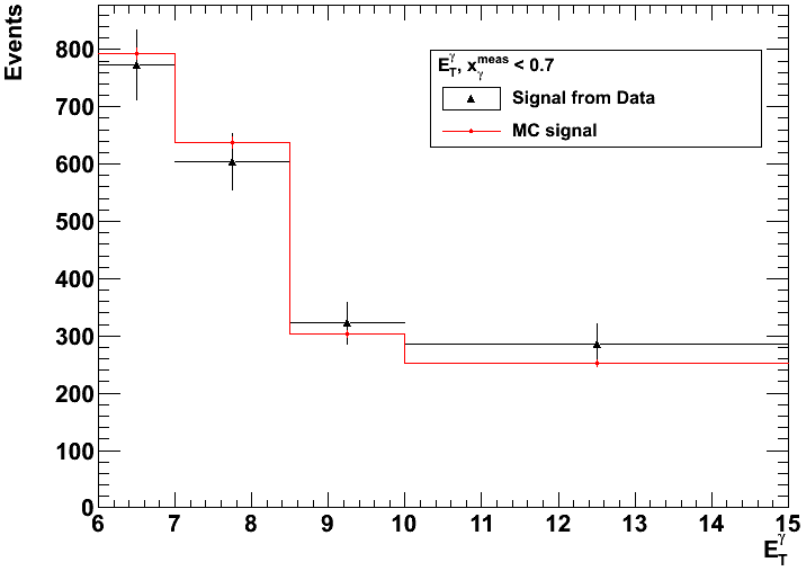
Finish studying HERWIG systematic.

Trigger study, DIS contamination.

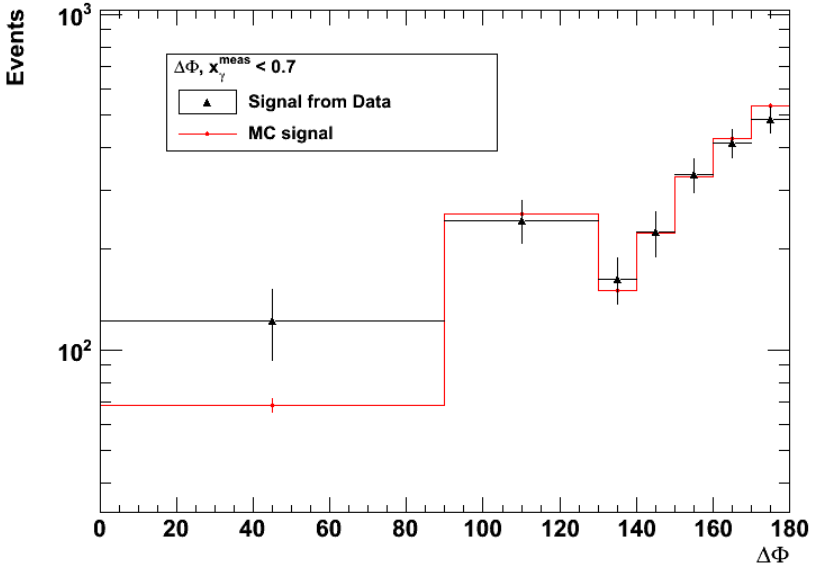
Backup slides

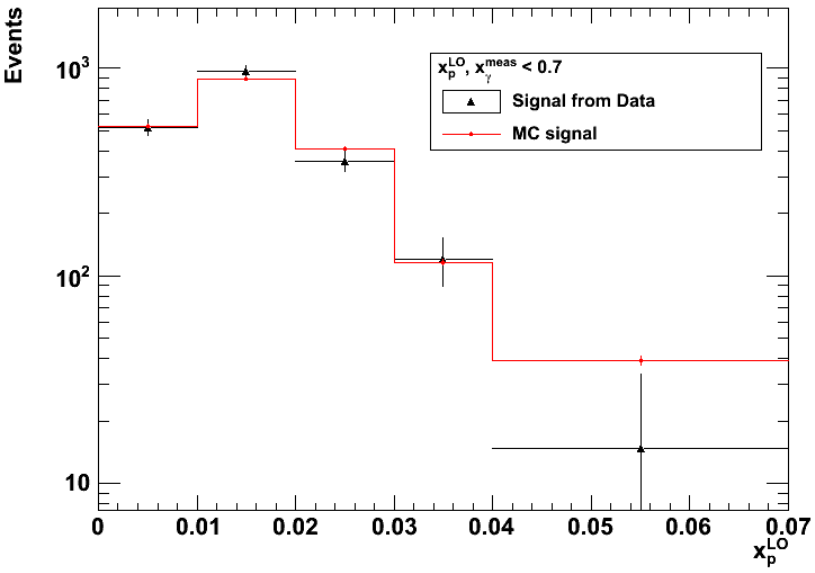
Control plots. $X_\gamma < 0.7$

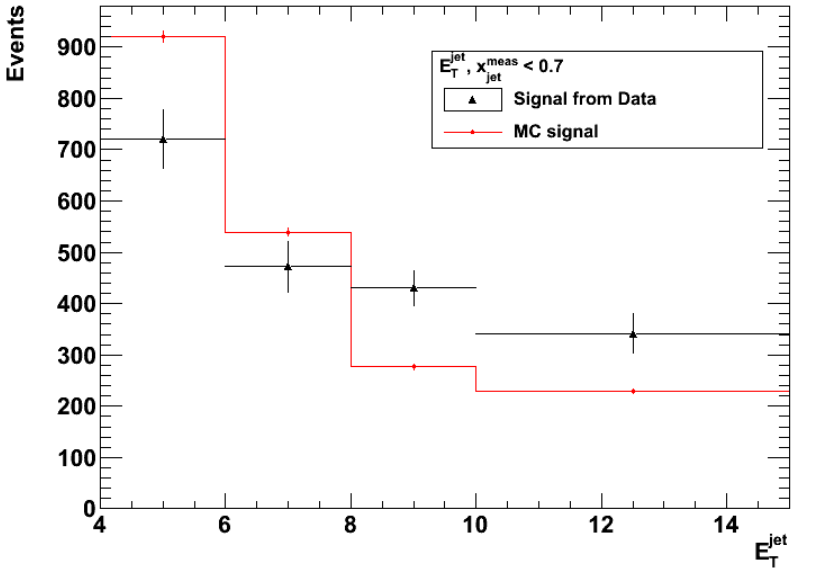


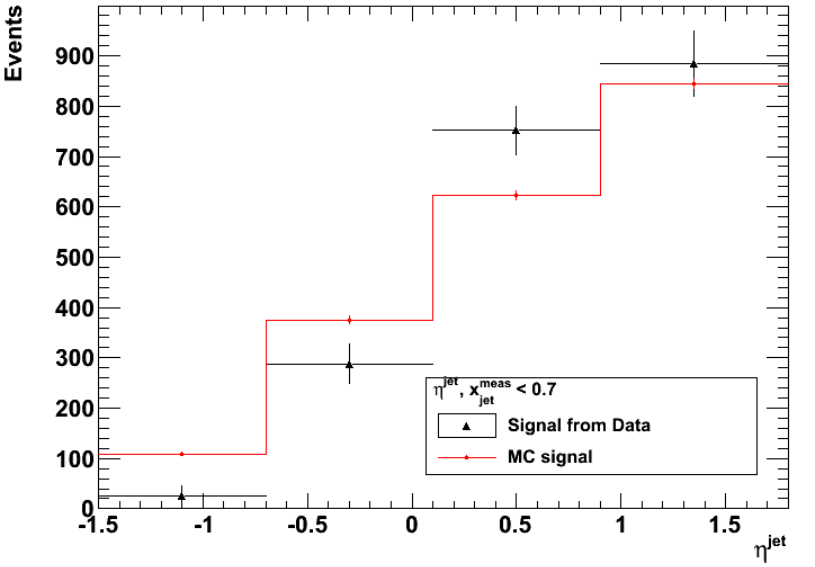


Control plots. $X_\gamma < 0.7$

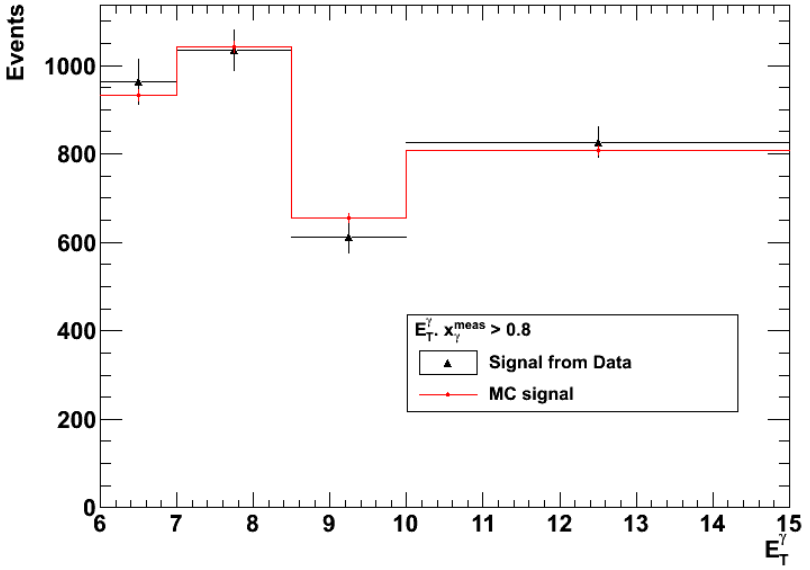


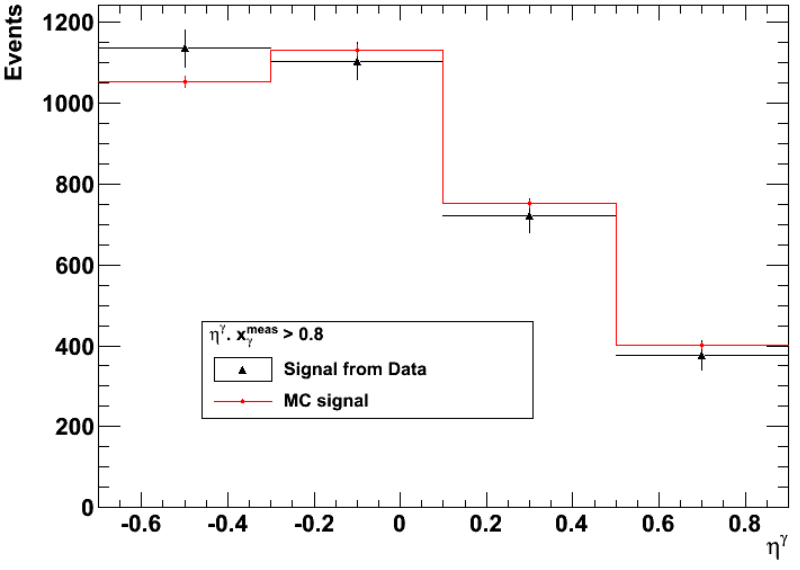




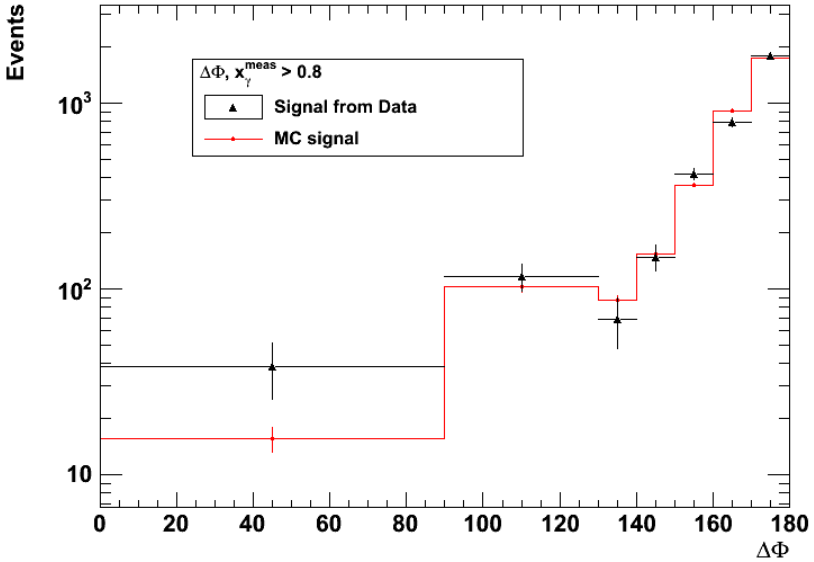


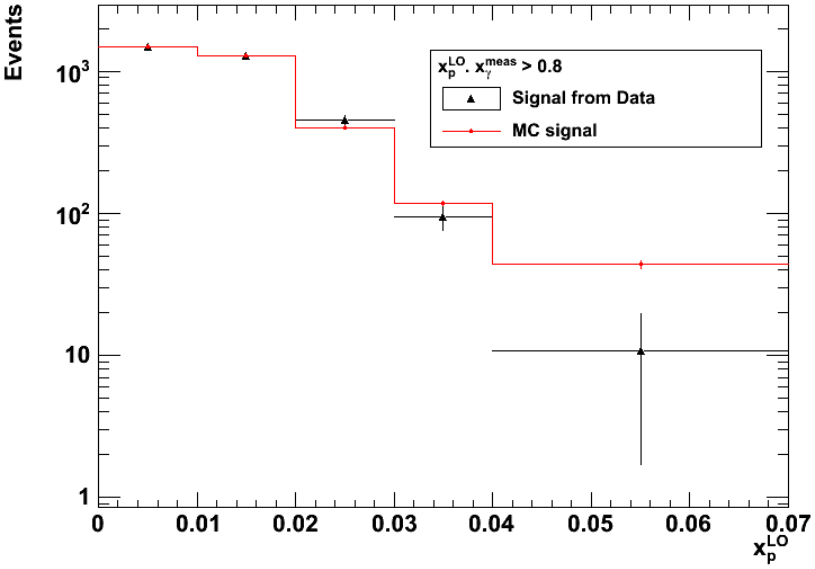
Control plots. $X_\gamma > 0.8$

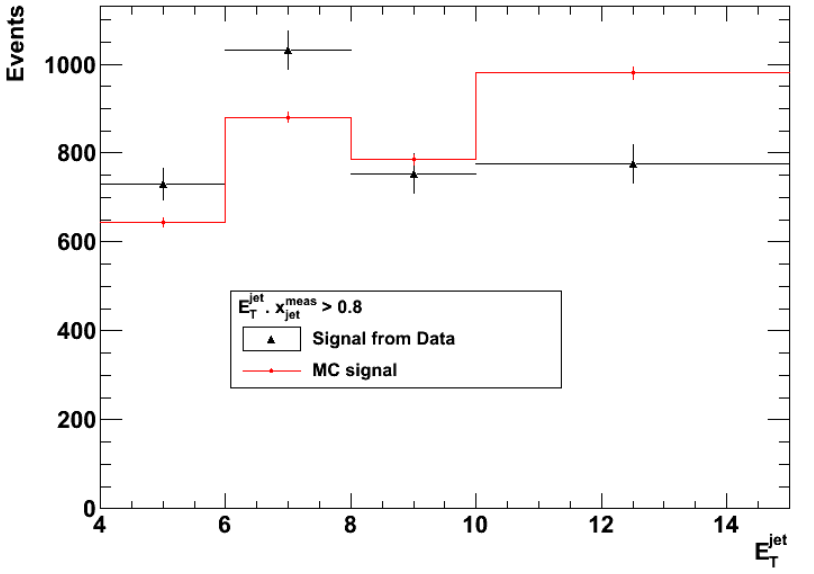


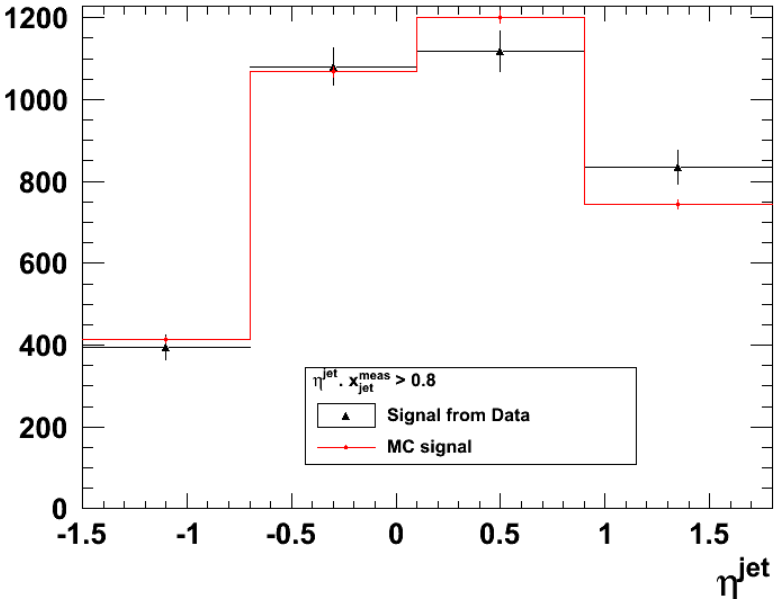


Control plots. $X_\gamma > 0.8$

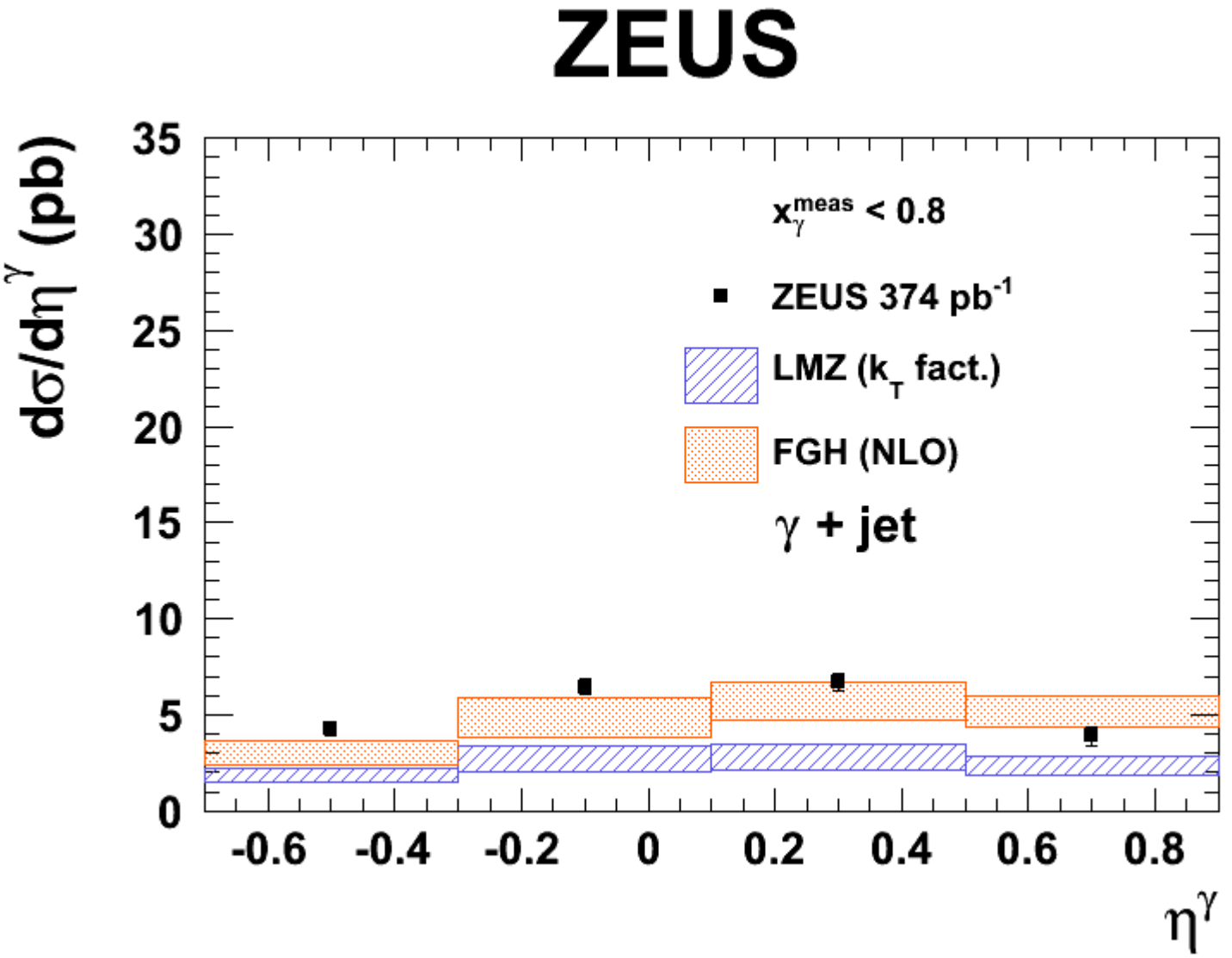








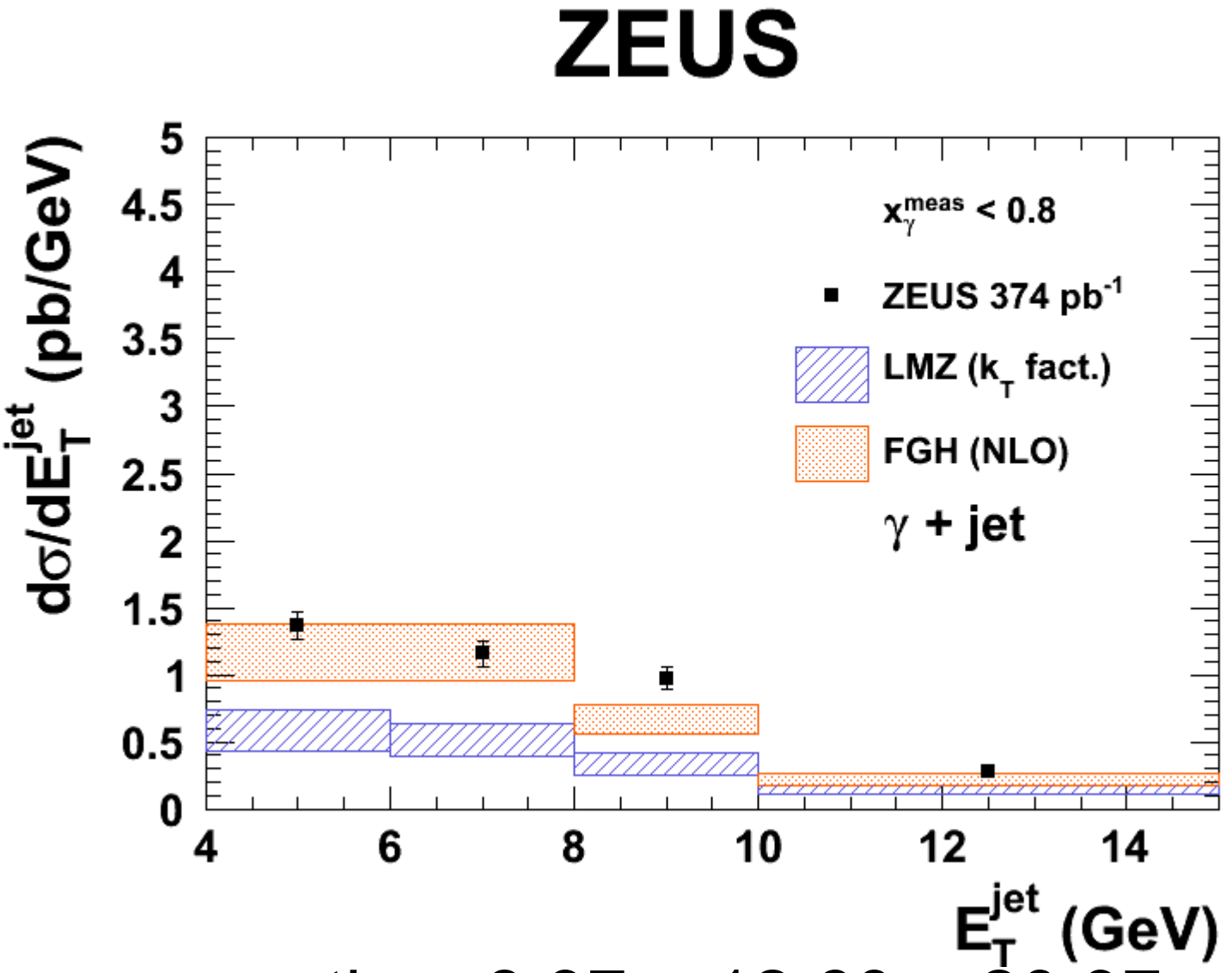
Cross sections. $x_\gamma < 0.8$



Data cross section: 8.53 + 12.79 = 21.32 vs 21.97

Theory is for $x_\gamma < 0.7$.

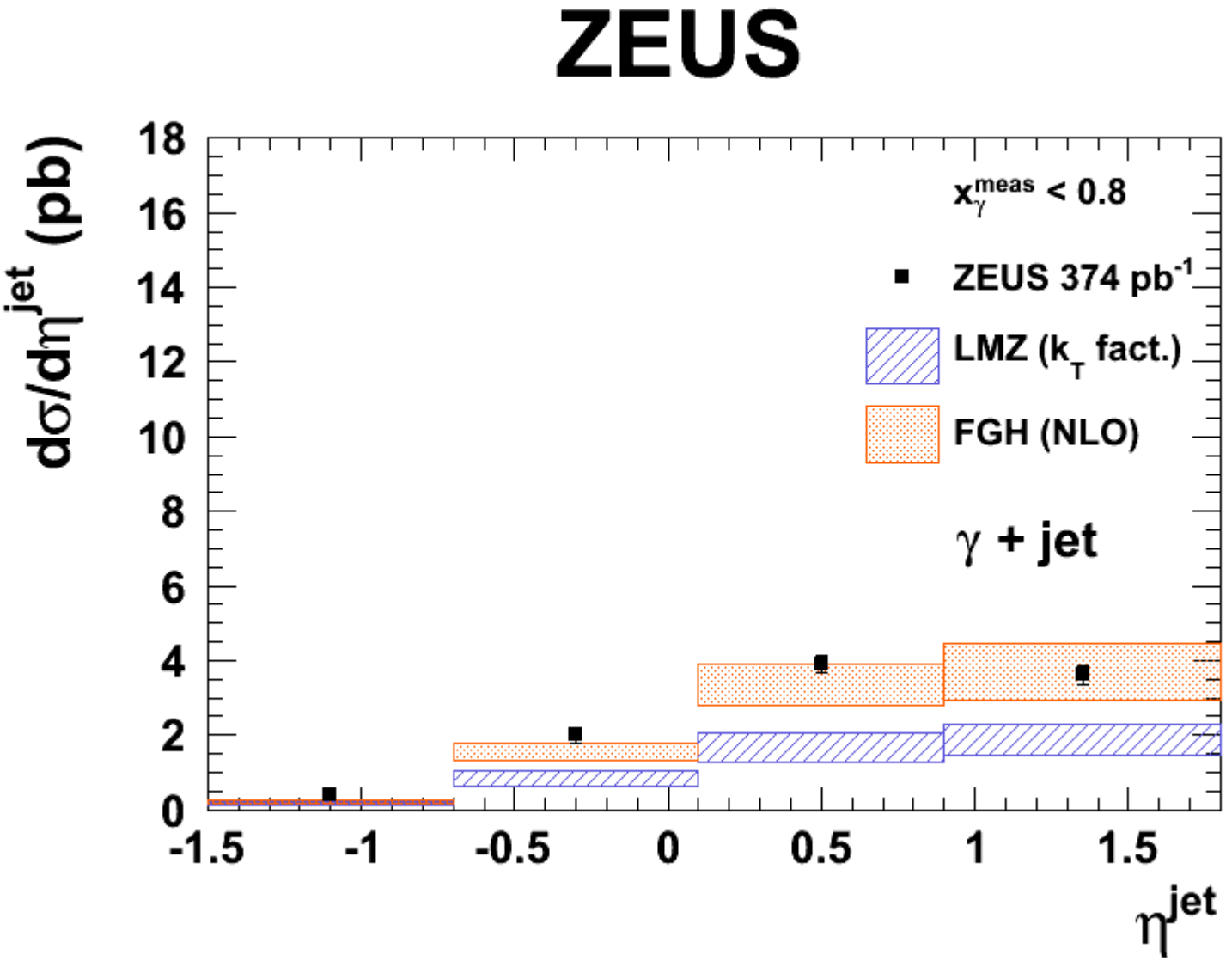
Cross sections. $x_\gamma < 0.8$



Data cross section: 8.37 + 12.60 = 20.97 vs 21.36

Theory is for $x_\gamma < 0.7$.

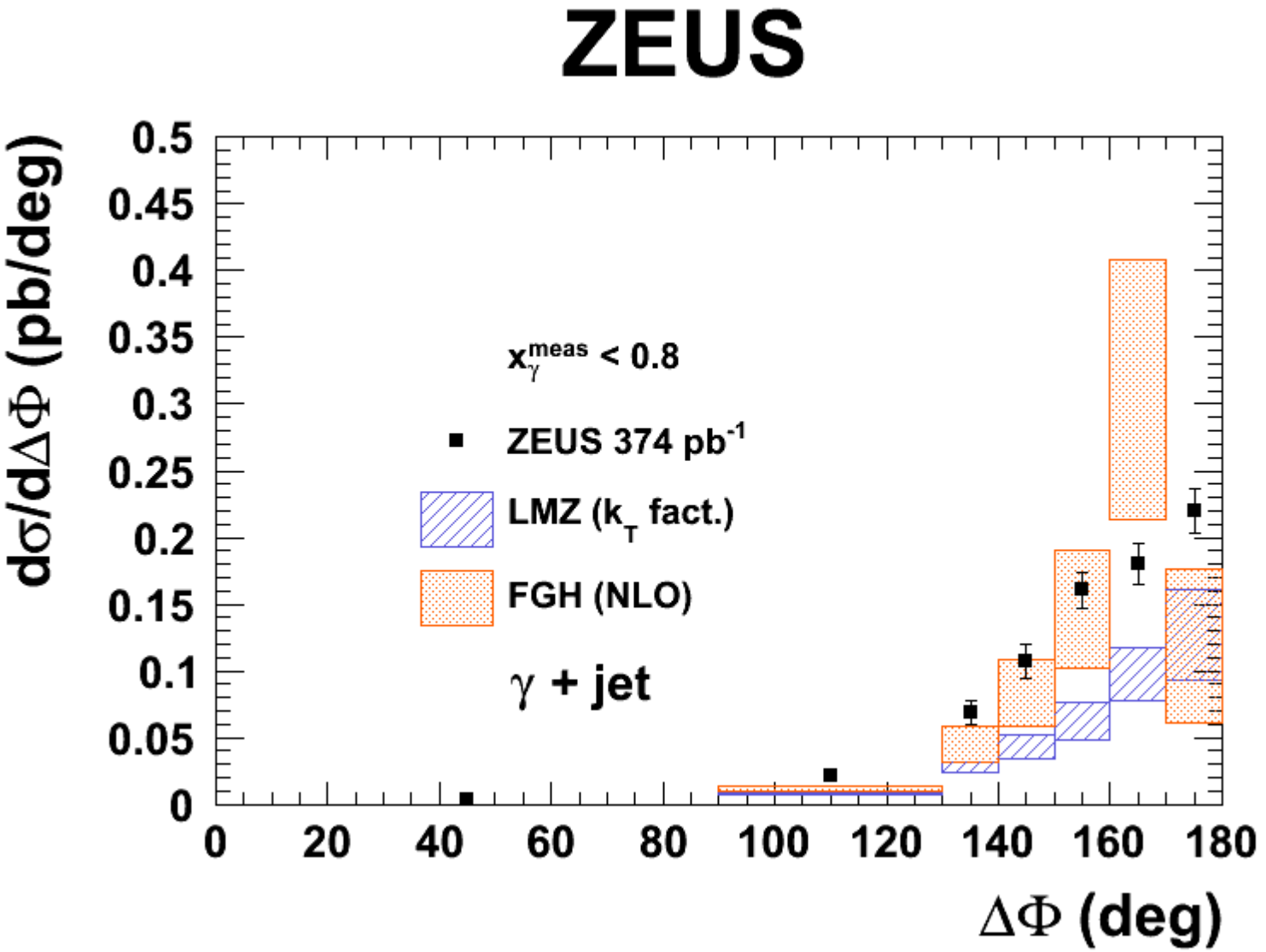
Cross sections. $x_\gamma < 0.8$



Data cross section: 7.42 + 13.12 = 20.54 vs 22.47

Theory is for $x_\gamma < 0.7$.

Cross sections. $x_\gamma < 0.8$



Data cross section: 8.50 + 12.96 = 21.46 vs 21.95

Theory is for $x_\gamma < 0.7$.