

Prompt Photon Production in Photoproduction at HERA

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on behalf of the H1 Collaboration*

OUTLINE

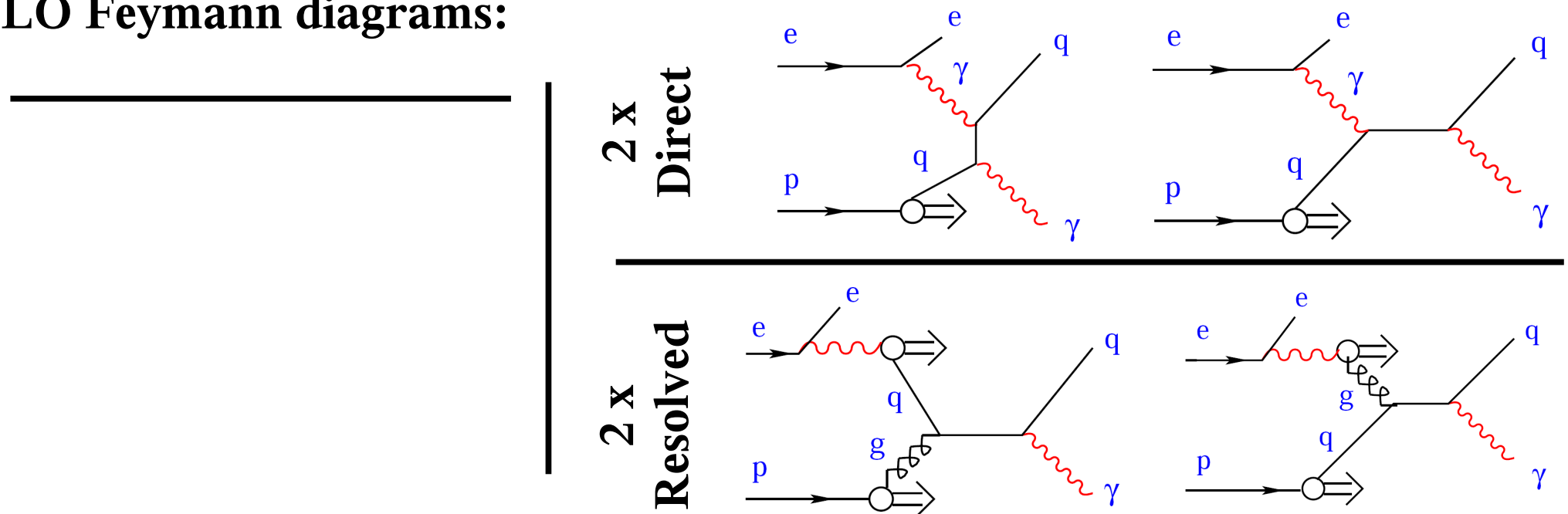
- Prompt Photons at HERA
- Analysis Strategy
- Preliminary Results
- Summary



Prompt photons at HERA

- Sensitivity to quark and gluon pdfs of photon and proton
- Generally lower hadronization correction than for di-jet events
- Prompt photons as background for Higgs discovery
- Several calculations available (NLO, k_T -factorization)

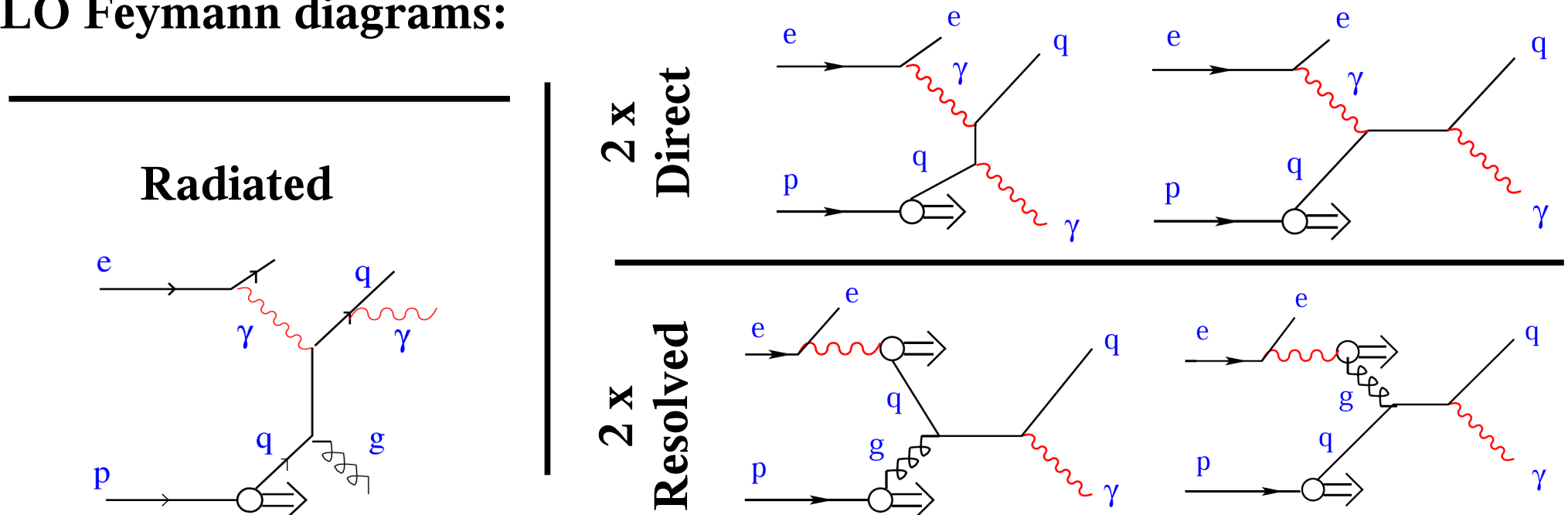
LO Feymann diagrams:



Prompt photons at HERA

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LO Feymann diagrams:



Prompt photon in the H1 detector

HERA collider:

electrons (27.6 GeV)

protons (920 GeV)

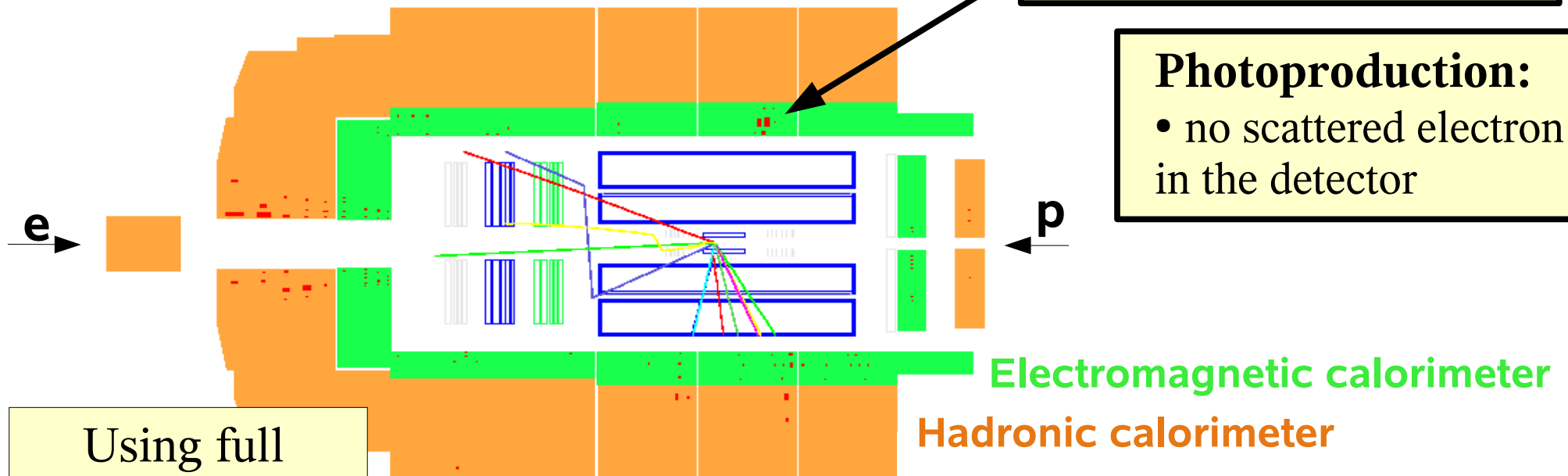
CM: 318 GeV

Photon candidate:

- cluster in em calorimeter
- not associated to track
- isolated

Photoproduction:

- no scattered electron in the detector



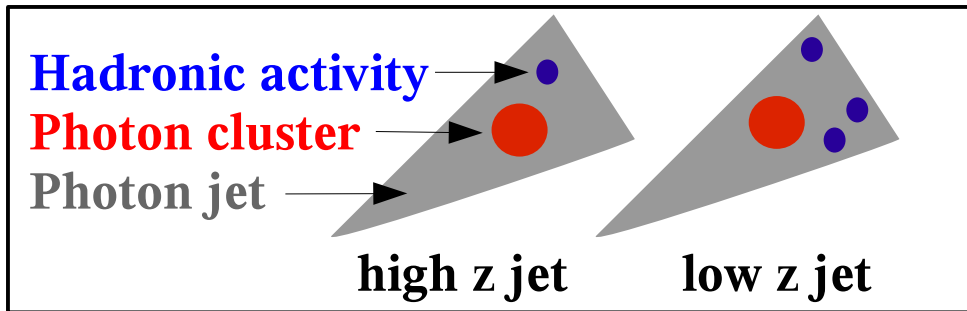
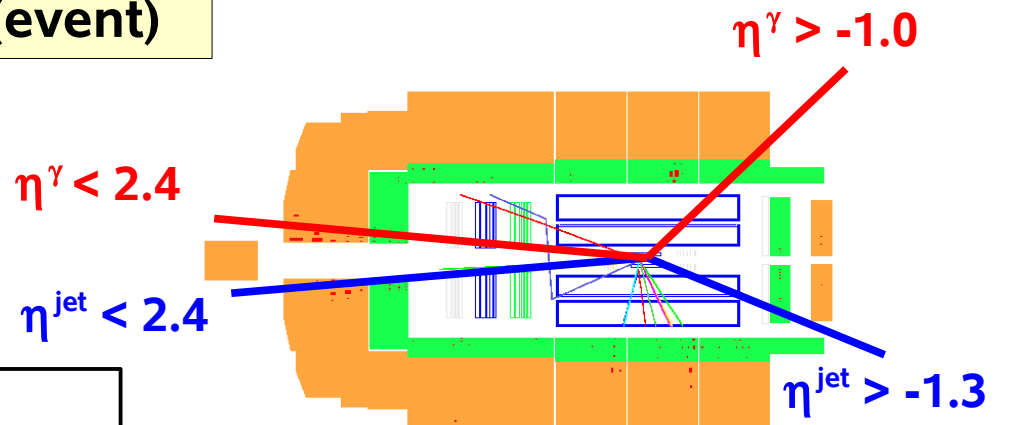
Using full
HERA II data:
340 pb⁻¹

Phase space definition

- Inclusive measurement

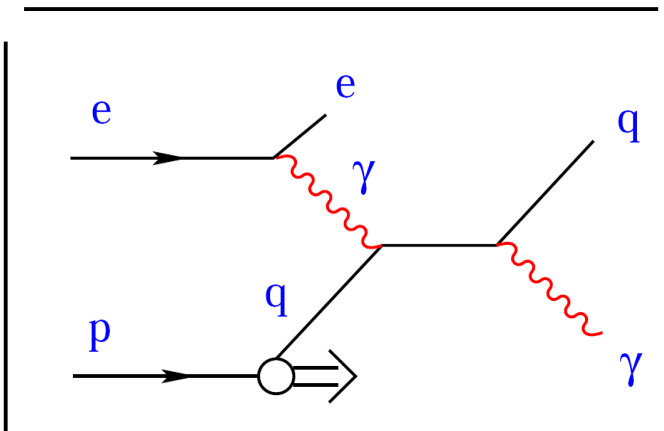
- $Q^2 < 1 \text{ GeV}^2$ • $0.1 < y < 0.7$ (event)

- $5 \text{ GeV} < E_T^\gamma < 15 \text{ GeV}$ (photon)
- $-1.0 < \eta^\gamma < 2.4$
- $z = E_T^\gamma / E_T^{\text{photon-jet}} > 0.9$



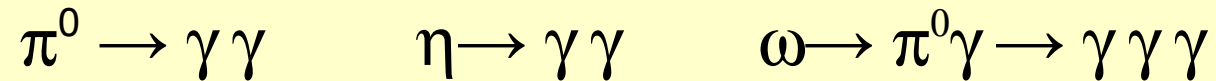
- Exclusive (photon + jet) measurement

- $p_T^{\text{jet}} > 4.5 \text{ GeV}$ (jet)
- $-1.3 < \eta^{\text{jet}} < 2.4$
- k_T jet algorithm used



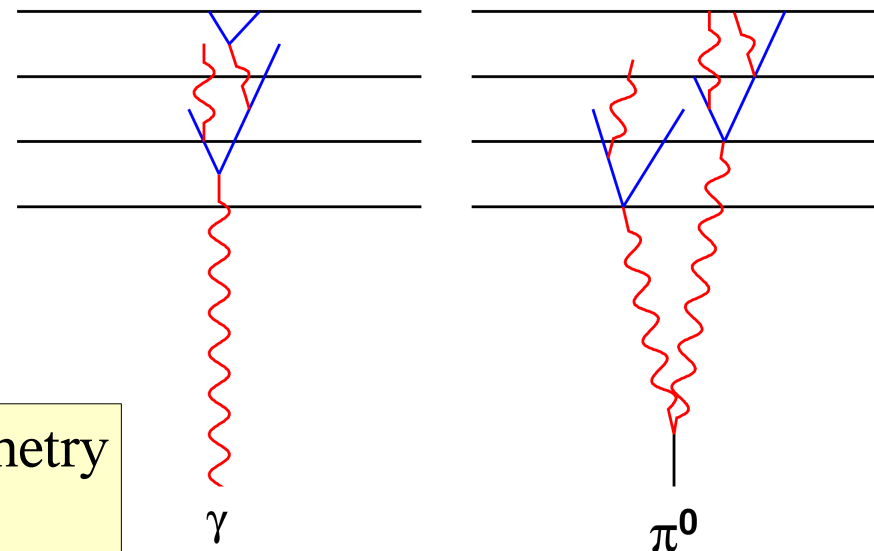
Background from multi-photon clusters

- Hadrons decaying into multi-photon final state



- Cluster shapes used to statistically discriminate between signal and background
- Multi-photon clusters

- less compact
- more asymmetric
- showering earlier

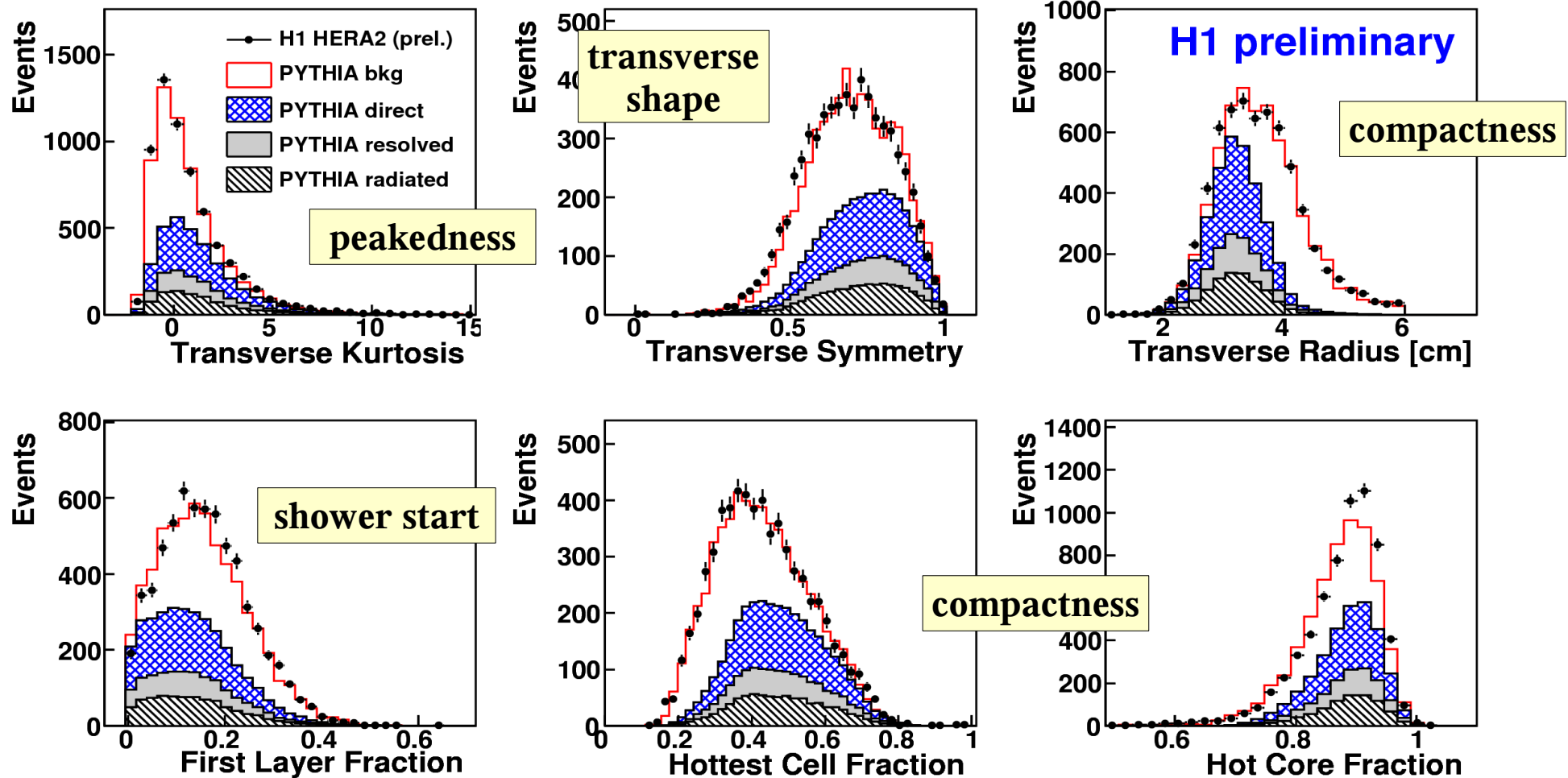


Remark: decay kinematics, detector geometry
- variables highly dependent on E_T , η

Variables used in multivariate analysis

Shower shape variables of prompt photon candidates

(full E_T , η range)



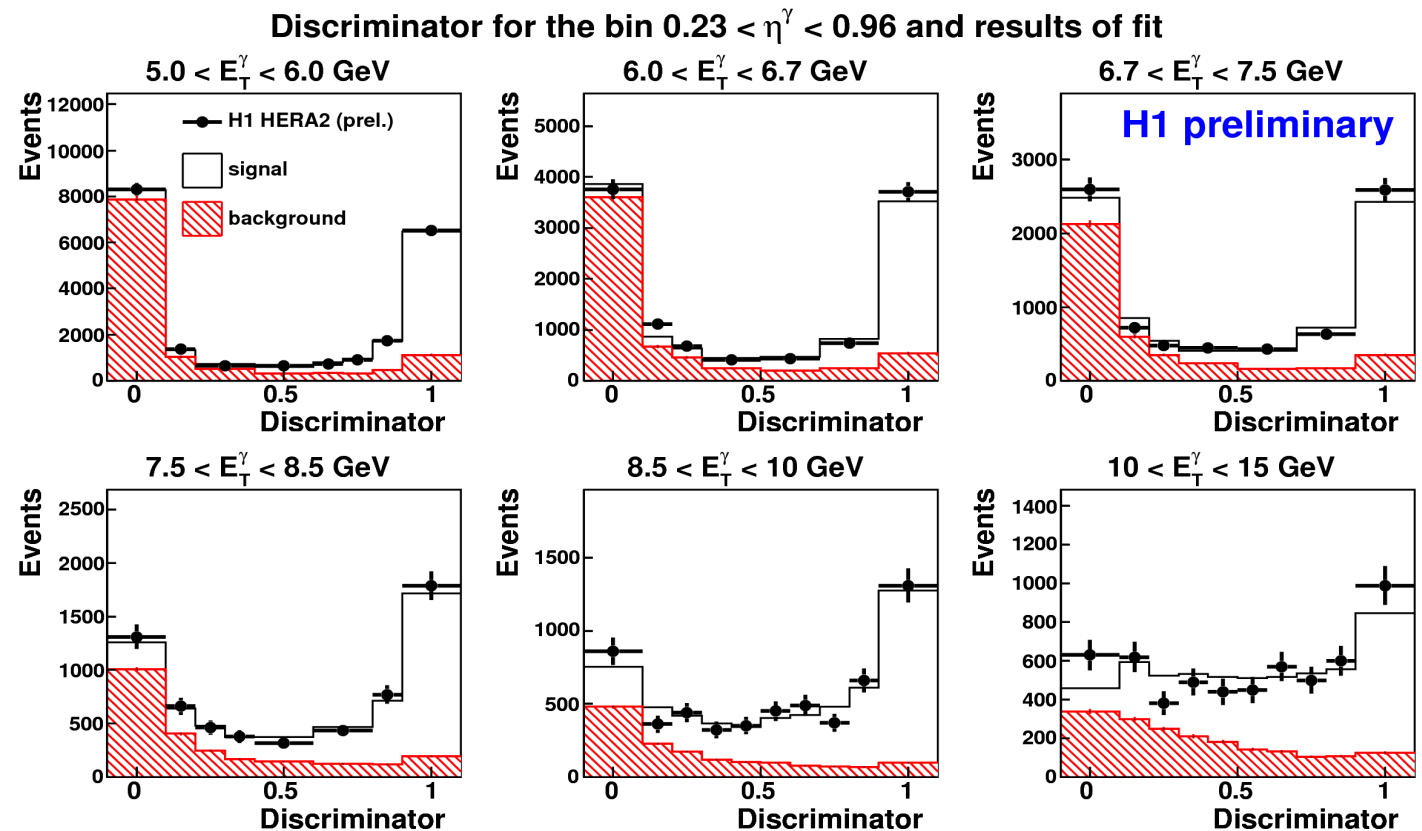
- Cluster shapes described well in MC (scaled to meas. cross sections)

Signal extraction

- Number of photons determined in each analysis bin by discriminator fit (likelihood method used)

- Single particles (γ , π^0 , η , ...) MC used for training and evaluation

- Decrease of discriminating power with rise of cluster's energy



Calculations

- Fontannaz-Guillet-Heinrich (FGH)

- collinear approach (NLO)
- includes quark-to-photon fragmentation
- box diagram $\gamma g \rightarrow \gamma g$

- Zotov-Lipatov (ZL)

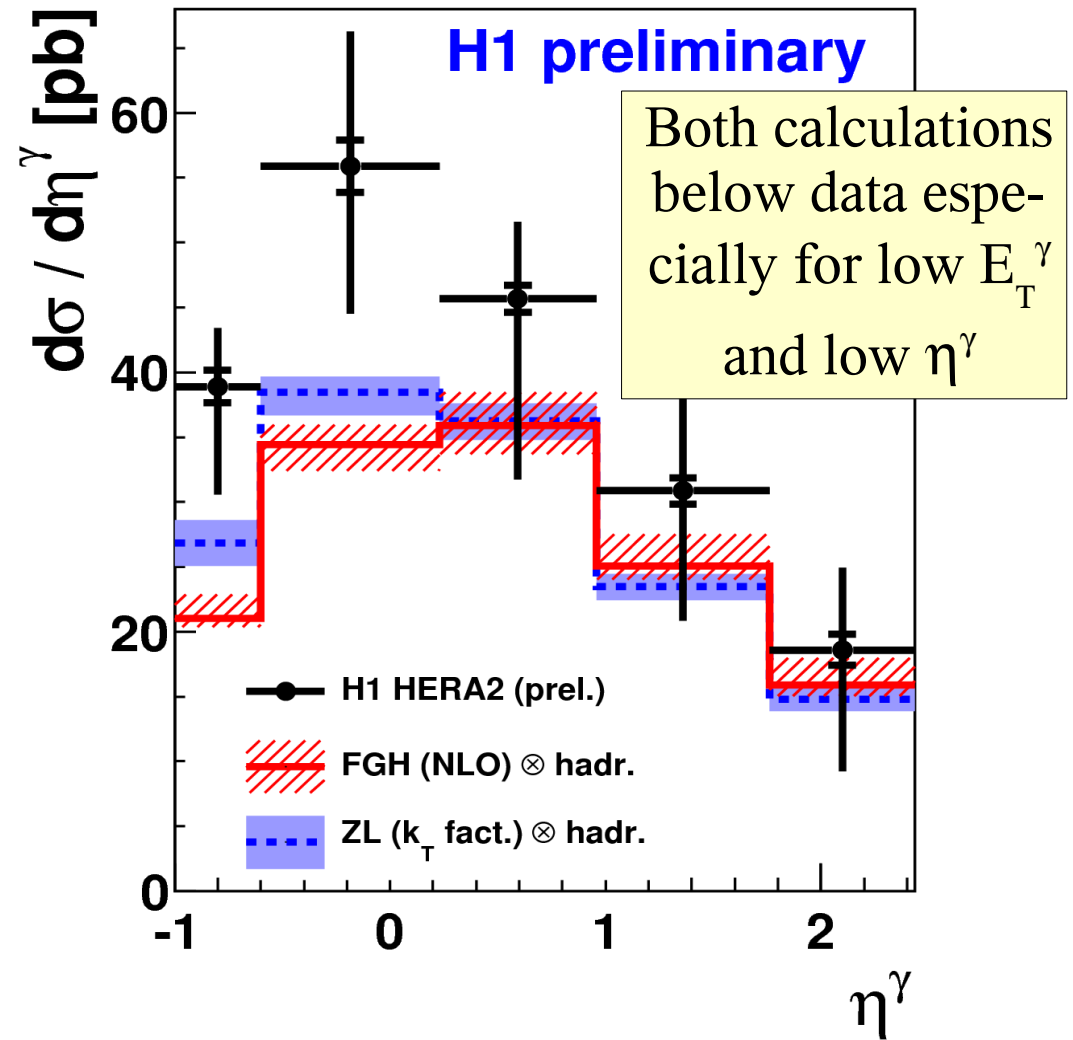
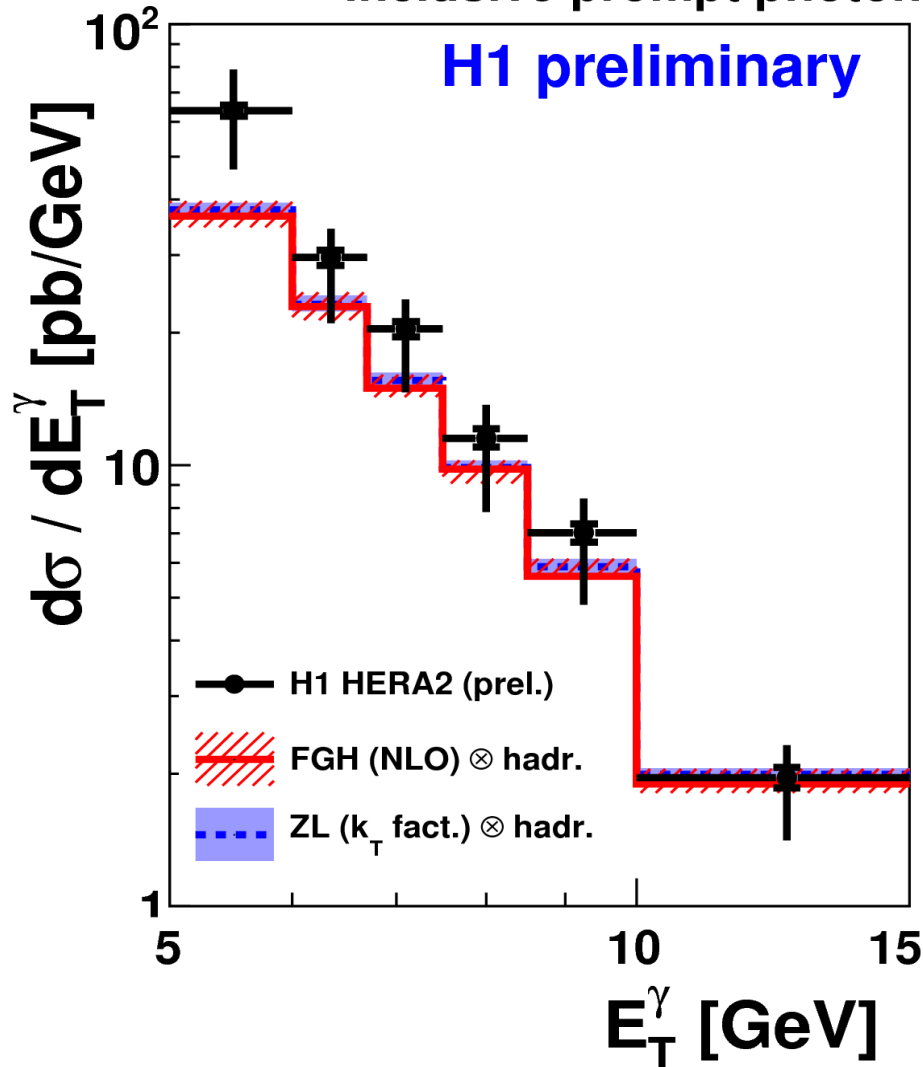
- k_T -factorization approach (unintegrated pdfs used)
- using Kimber-Martin-Ryskin prescription for updf

Error estimation: simultaneous variation of fragmentation and renormalization scale (E_T^γ) by factor 2.0 and 0.5

Corrected for hadronisation and multi-parton interaction effects and compared to measured cross sections

Inclusive prompt photons

Inclusive prompt photons in photoproduction at H1



Exclusive prompt photons + jet

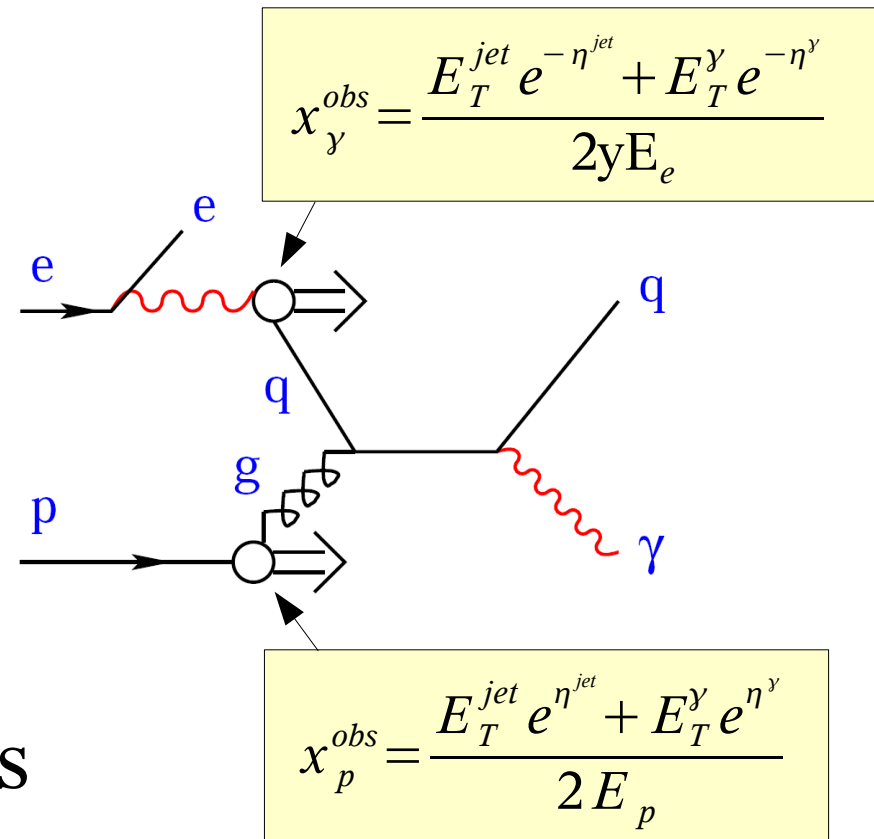
- Phase space

as inclusive photon

- $Q^2 < 1 \text{ GeV}^2$
- $0.1 < y < 0.7$
- $5 \text{ GeV} < E_T^\gamma < 15 \text{ GeV}$
- $-1.0 < \eta^\gamma < 2.4$
- $z = E_T^\gamma / E_T^{\text{photon-jet}} > 0.9$

+ jet

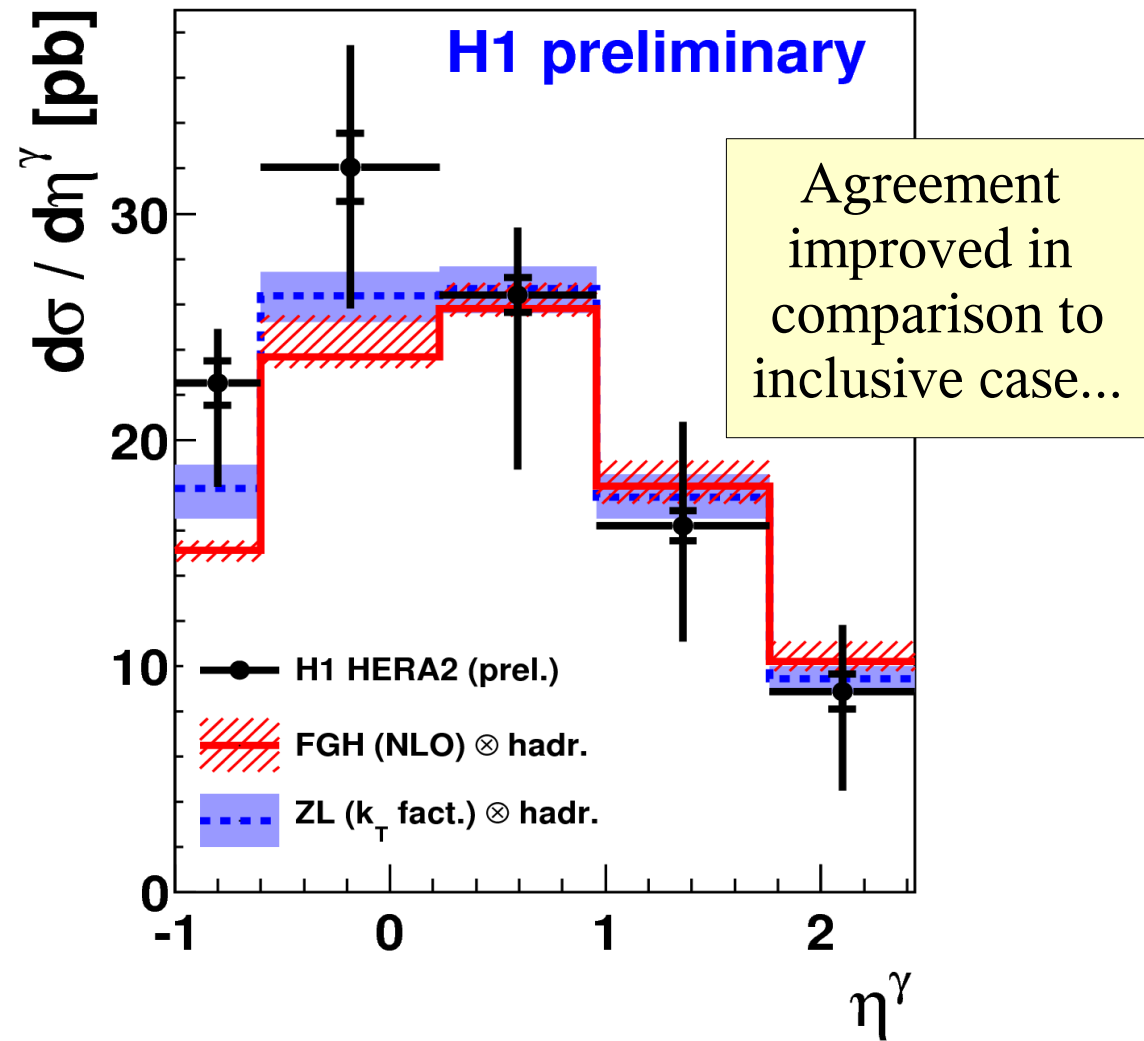
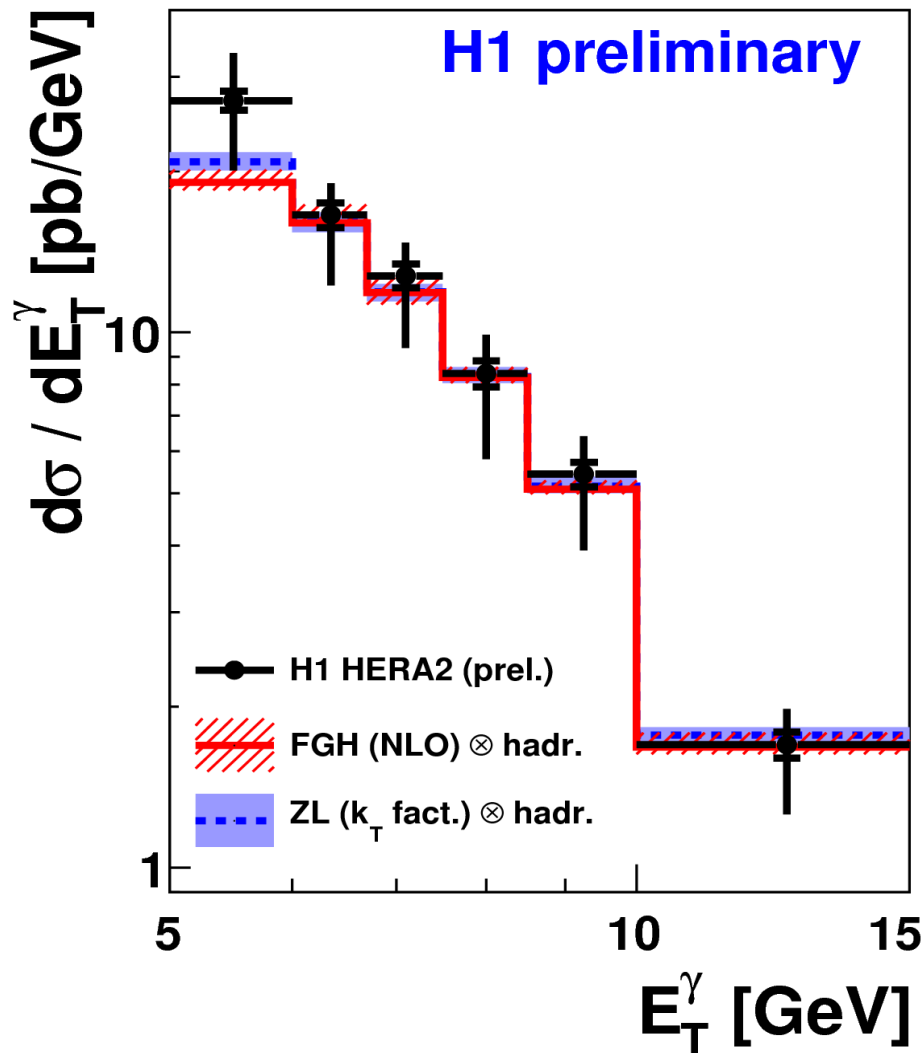
- $p_T^{\text{jet}} > 4.5 \text{ GeV}$
- $-1.3 < \eta^{\text{jet}} < 2.4$



- $x_{\gamma(p)}^{obs}$ variables interpreted as momentum fraction of photon (proton) entering the hard interaction

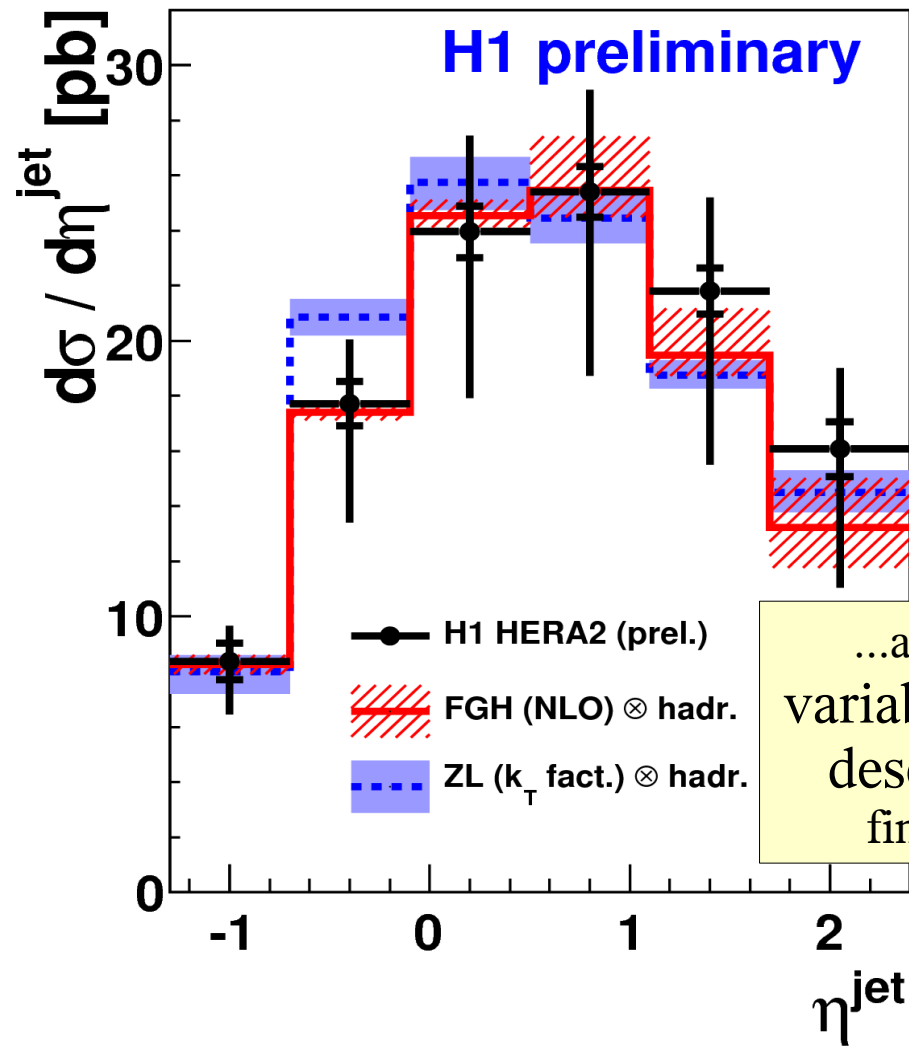
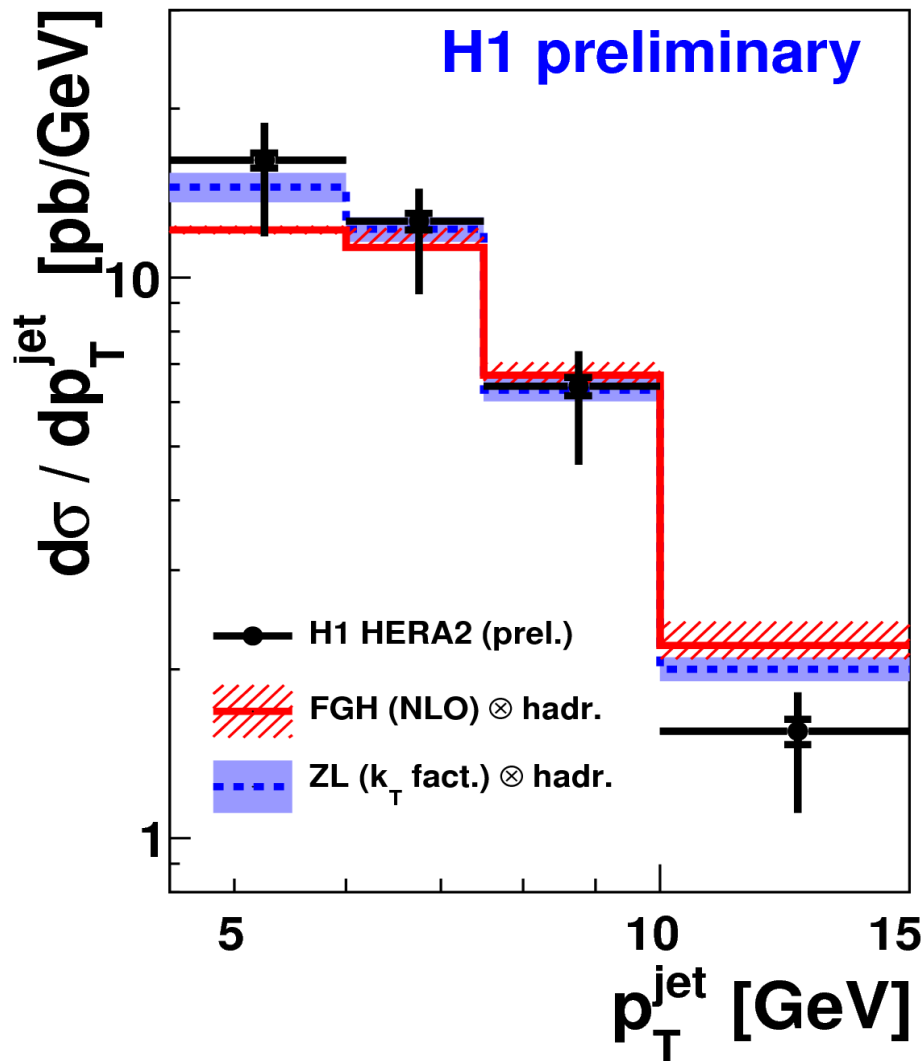
Exclusive prompt photons + jet

Exclusive (photon + jet) prompt photons in photoproduction at H1



Exclusive prompt photons + jet

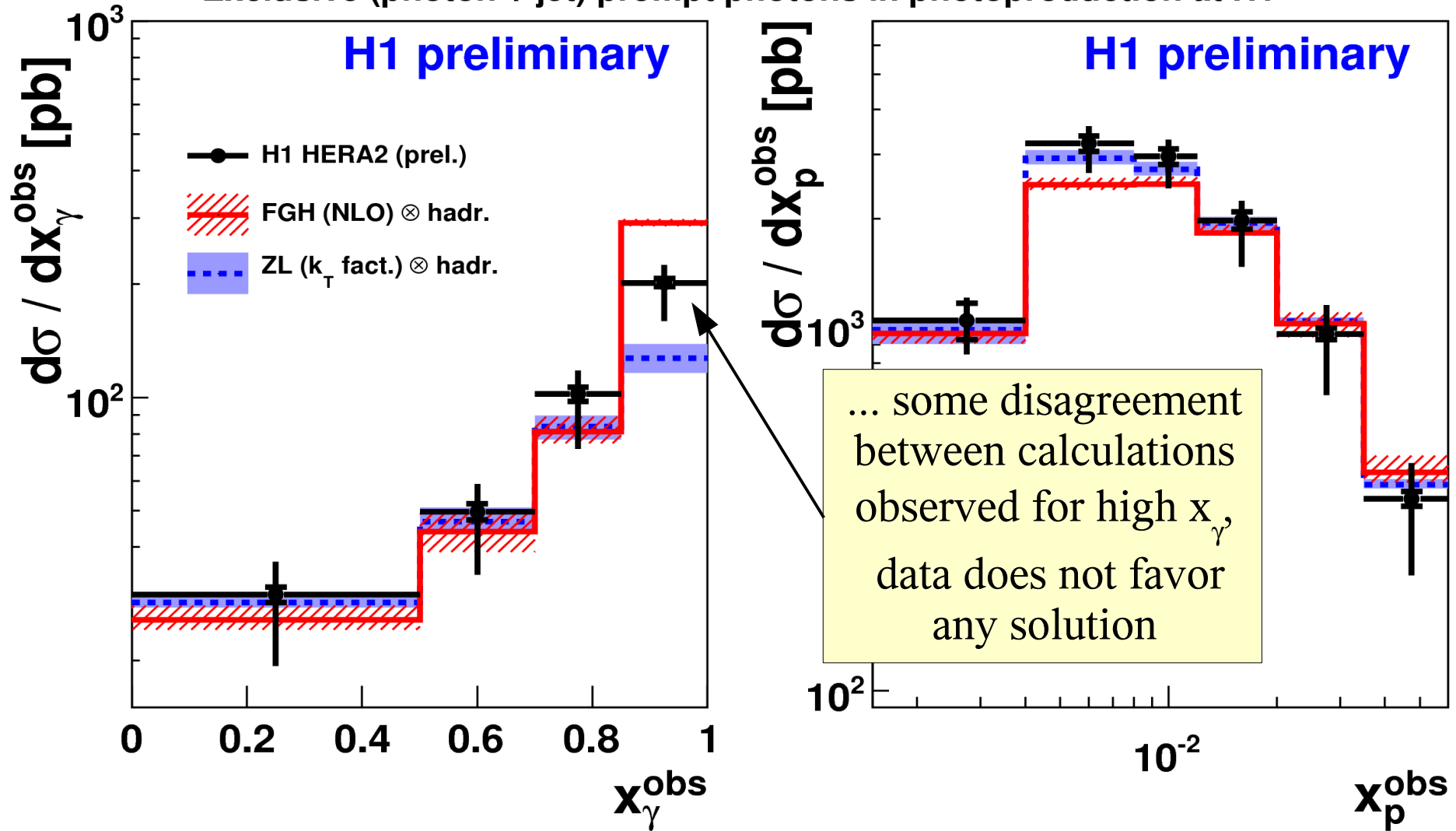
Exclusive (photon + jet) prompt photons in photoproduction at H1



...also jet variables well described, finally...

Exclusive prompt photons + jet

Exclusive (photon + jet) prompt photons in photoproduction at H1



Isolated photons in DIS at HERA

- Parallel measurement in DIS recently published by H1 (*0711.4578 [hep-ex]*)

- Phase space

• $4 < Q^2 < 150$ [GeV²] **Event**

• $y > 0.05$

• $W_x > 50$ GeV

• $E_e > 10$ GeV **Scattered electron**

• $153^\circ < \theta_e < 177^\circ$

• $3 < E_T^\gamma < 10$ [GeV] **Photon**

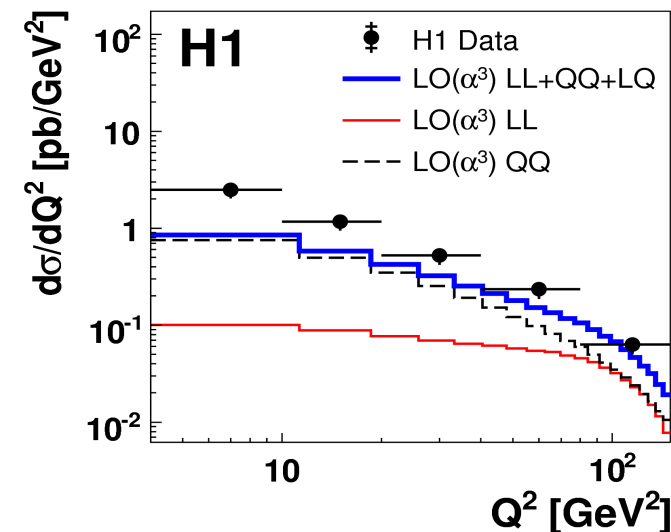
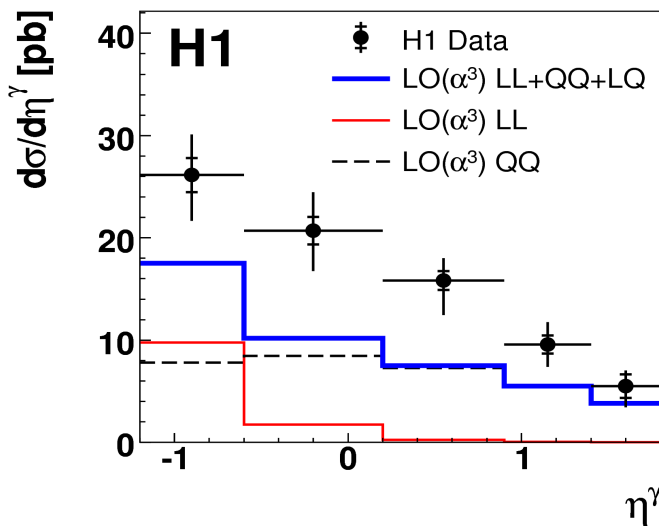
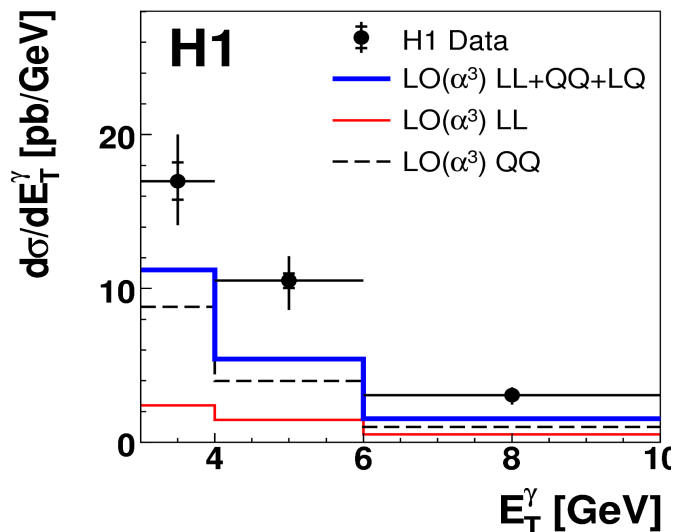
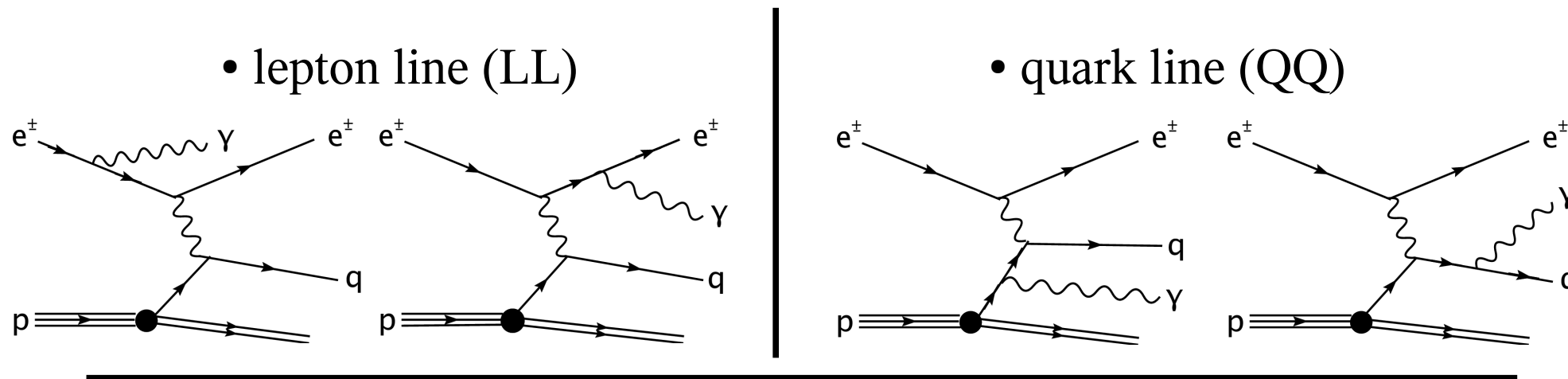
• $-1.2 < \eta^\gamma < 1.8$

• $z = E_T^\gamma / E_T^{\text{photon-jet}} > 0.9$

- LO collinear calculation available for photon and photon plus jet production, NLO only for exclusive photon plus jet

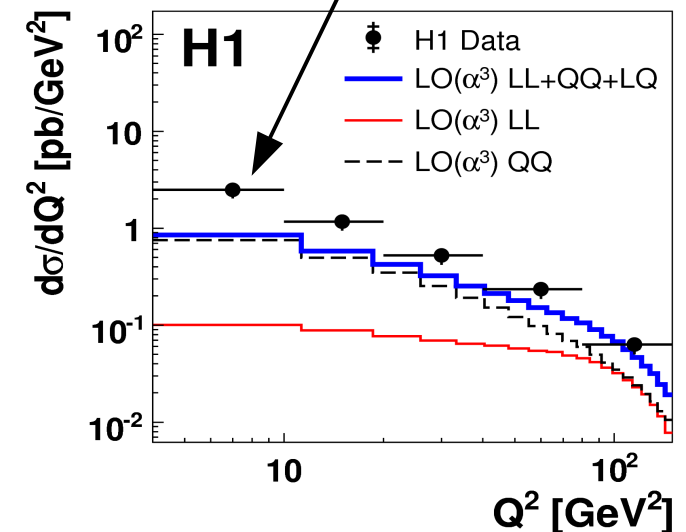
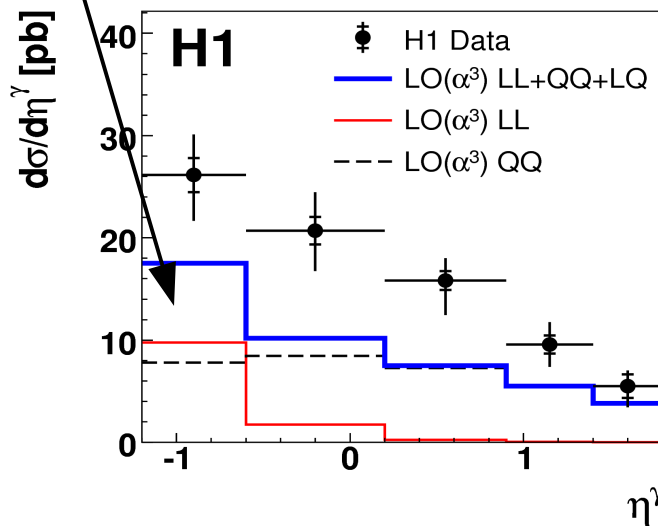
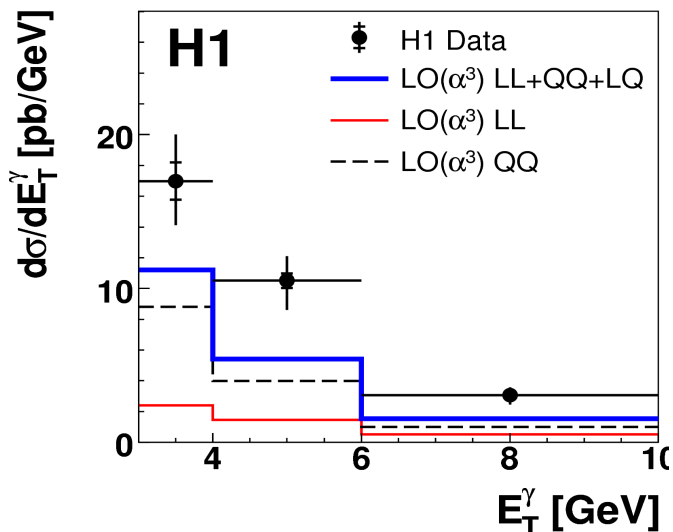
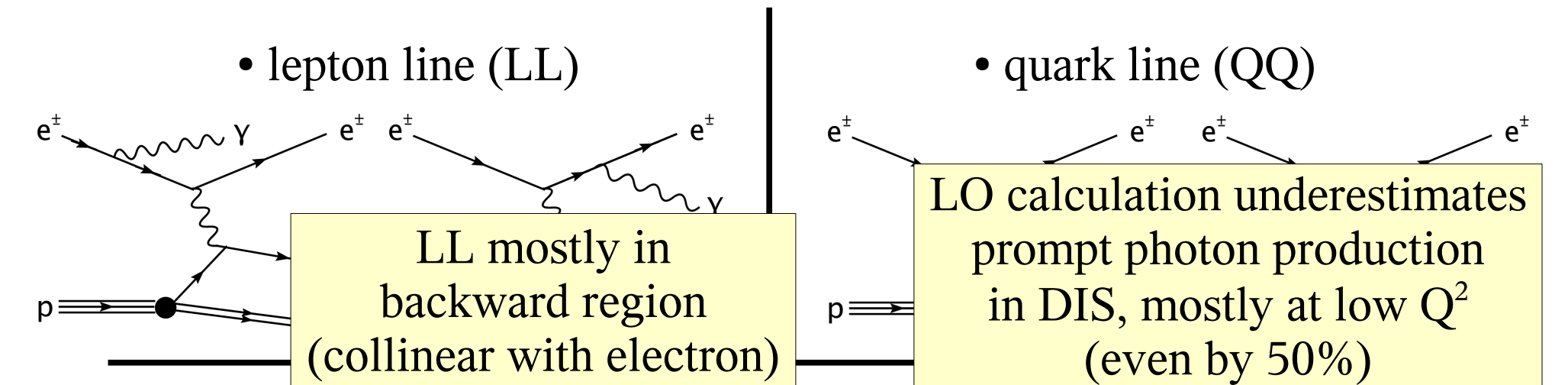
Inclusive isolated photons in DIS at HERA

- Contribution from photons radiated from



Inclusive isolated photons in DIS at HERA

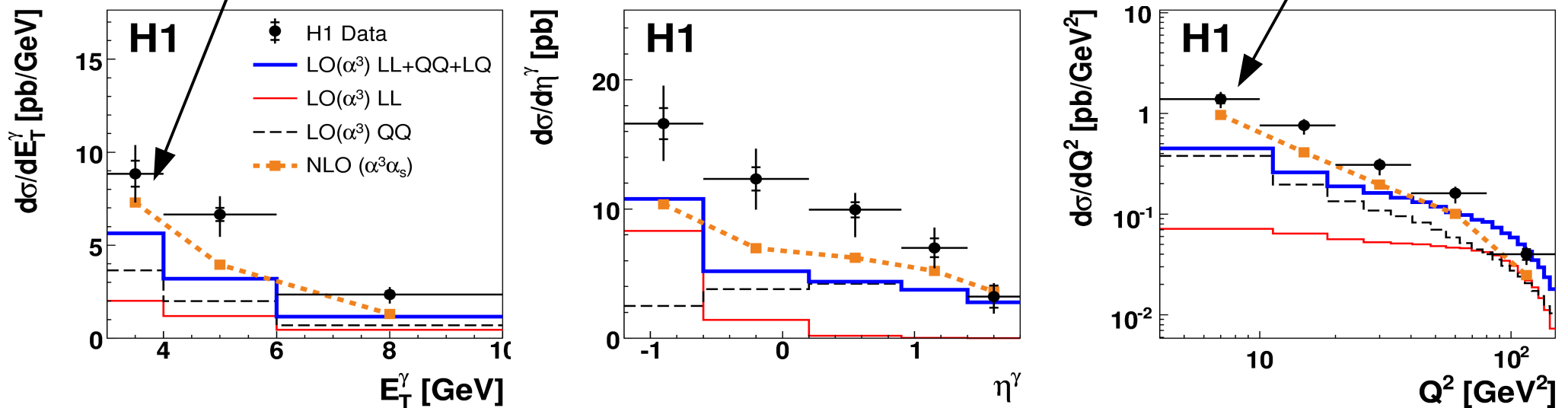
- Contribution from photons radiated from



Exclusive isolated photons in DIS at HERA

- LO exclusive (photon+ jet) calculation underestimates the cross section by the same factor as in inclusive case
- NLO correction helps to describe the shape

NLO most significant improvement at low E_T^γ and low Q^2



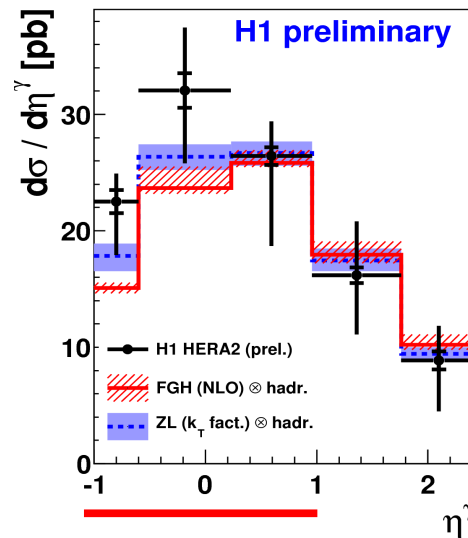
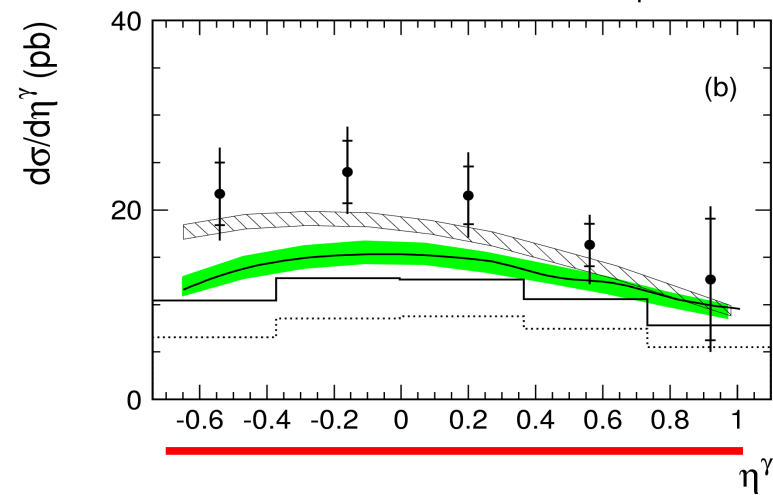
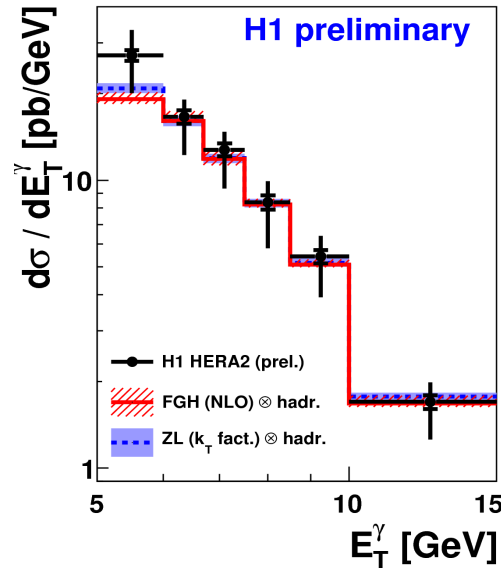
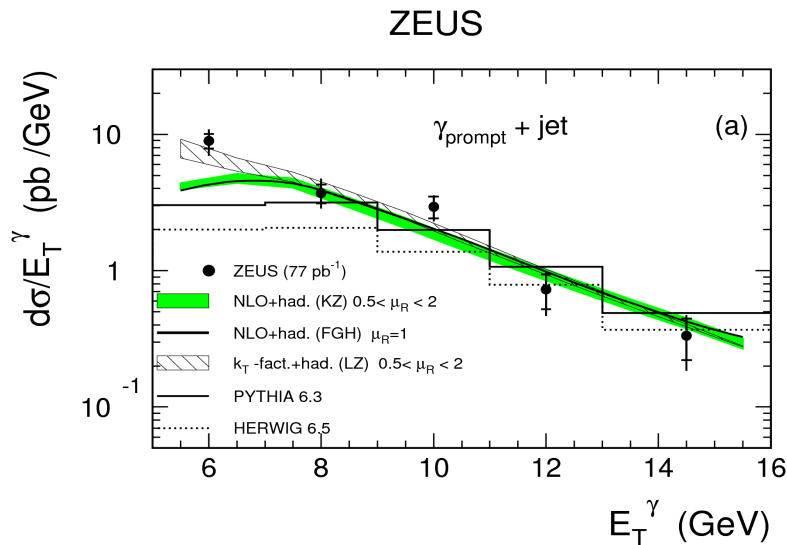
Summary

- New H1 results on prompt photon production presented
- With HERA II data statistical error eliminated, systematic error dominant
- Measurement compared to calculation predictions
 - Inclusive prompt photon production underestimated by calculations (especially at low E_T^γ)
 - Exclusive prompt photon production found to be nicely described by calculations (except high x_γ region)
- Similar observation derived from H1 measurement in DIS
 - LO significantly underestimates data at low Q^2 and low E_T^γ
 - For photon plus jet NLO 30% below data, shape described

Systematic error summary

- Cluster shower shapes description in MC – high dependence of final results on small changes - up to 30%
- Trigger correction + Energy uncertainty - 5% (20% at low E_T^γ)
- Description of conversion rate in the detector - 15% in the most forward η^γ bin
- Single particle usage impact – 15% in the most forward η^γ bin
- HERWIG-PYTHIA acceptance correction difference – 10% in the most forward η^γ bin

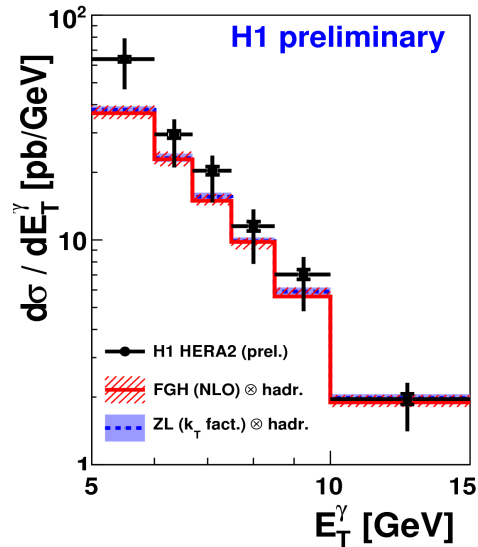
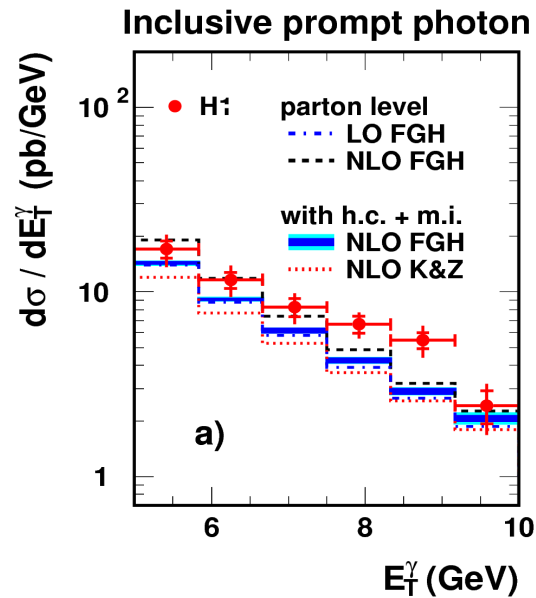
Other measurements – Exclusive ZEUS



- ZEUS HERA I data (hep-ex/0608028)
- Phase space differences:

	ZEUS	H1
y	(0.2, 0.8)	(0.1, 0.7)
η^γ	(-0.74, 1.1)	(-1.0, 2.4)
η^{jet}	(-1.6, 2.4)	(-1.3, 2.4)
p_T^{jet}	> 6 GeV	> 4.5 GeV

Other measurements – Inclusive H1



- H1 HERA I data (hep-ex/0407018)
- Phase space definition differences:

	H1 HERA I	H1 HERA II
y	(0.2, 0.7)	(0.1, 0.7)
E_T^γ	(5, 10) [GeV]	(5, 15) [GeV]

