Prompt Photons in photoproduction at H1

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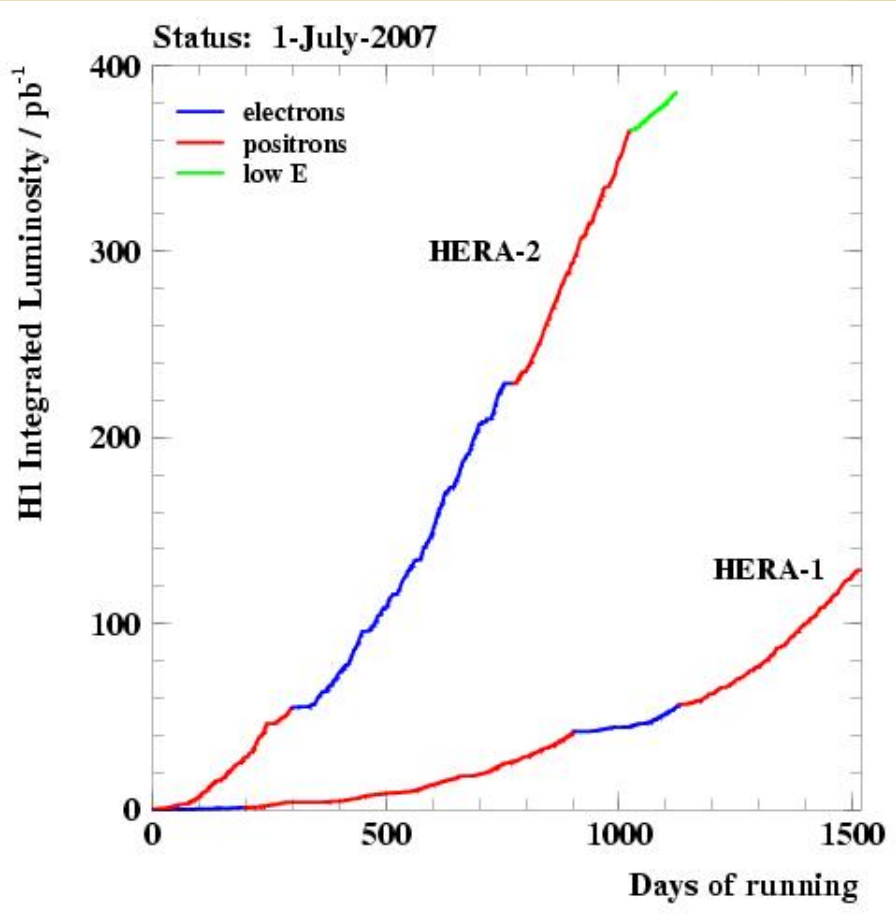
- HERA and H1 Introduction
- Prompt Photon Introduction
- Signal – Background discrimination
- Results
- Summary

HERA e-p collider

- Operating in Deutsches Elektronen-Synchrotron (DESY) in Hamburg, Germany
- 6.3 km accelerating ring
  - Beam energies:
    - proton: 920 GeV
    - electron: 27.6 GeV
  - Four experiments:

HERA e-p collider

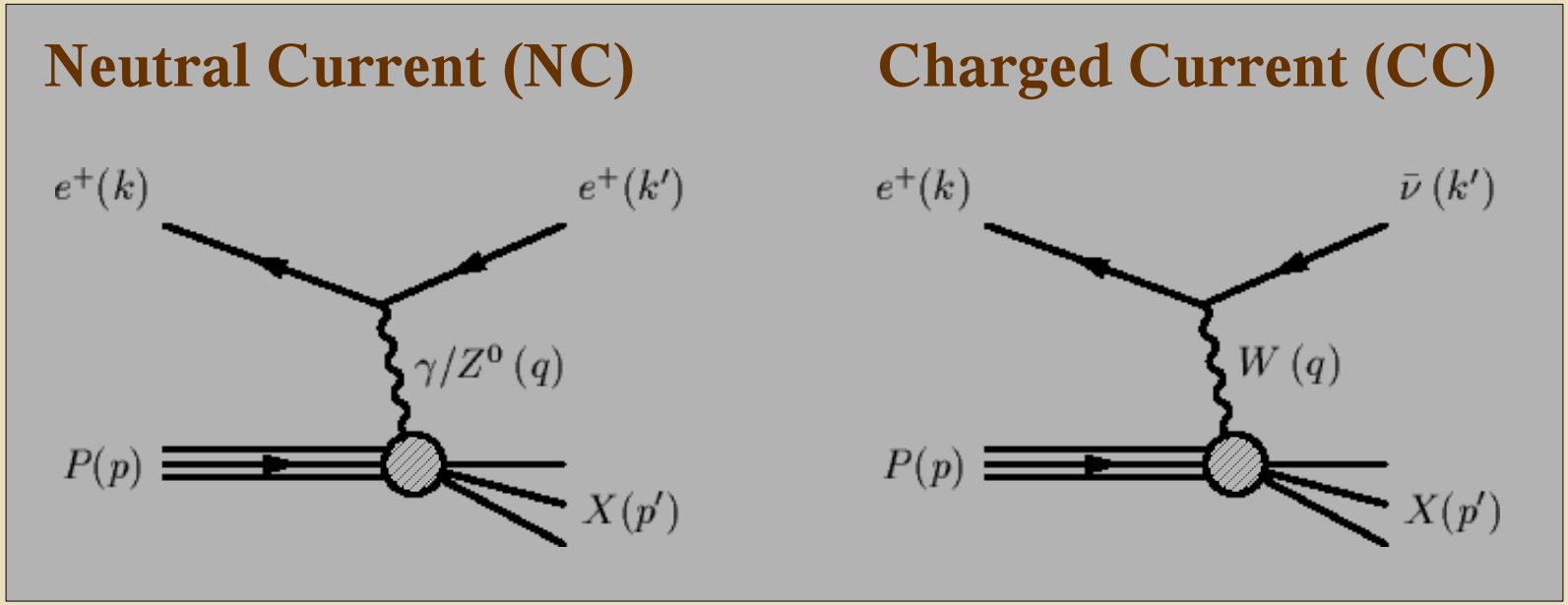
- 15 years of succesfull running
  - HERA I (1992 – 2000)
  - HERA II (2004 – 2007)



- Unique e-p collisions mainly used to probe QCD and content of proton

e-p collisions

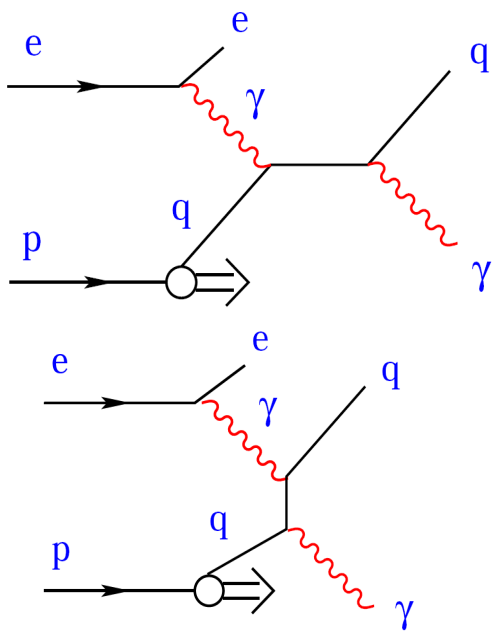
- e-p interaction via exchange of the...



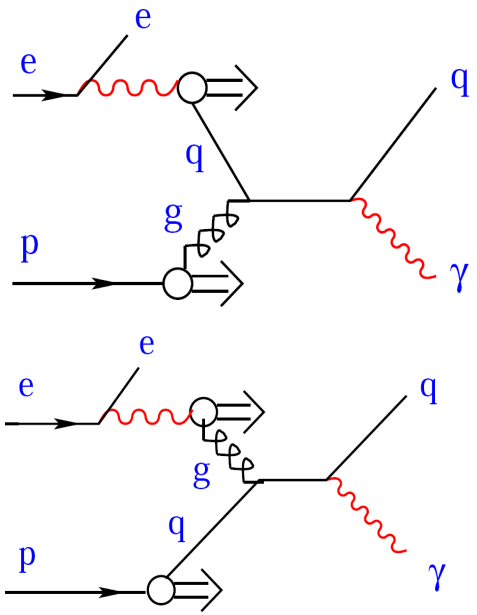
- Main observables:
  - Four momentum transfered square $\mathbf{Q^2}$
  - Momentum fraction of proton participating in hard interaction $\mathbf{x_p}$

Prompt photon study

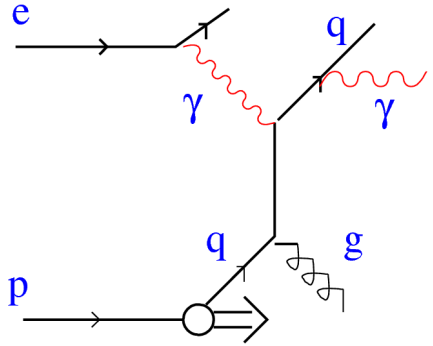
- Direct process
(γ interacts directly)



- Resolved process
(γ first resolves)



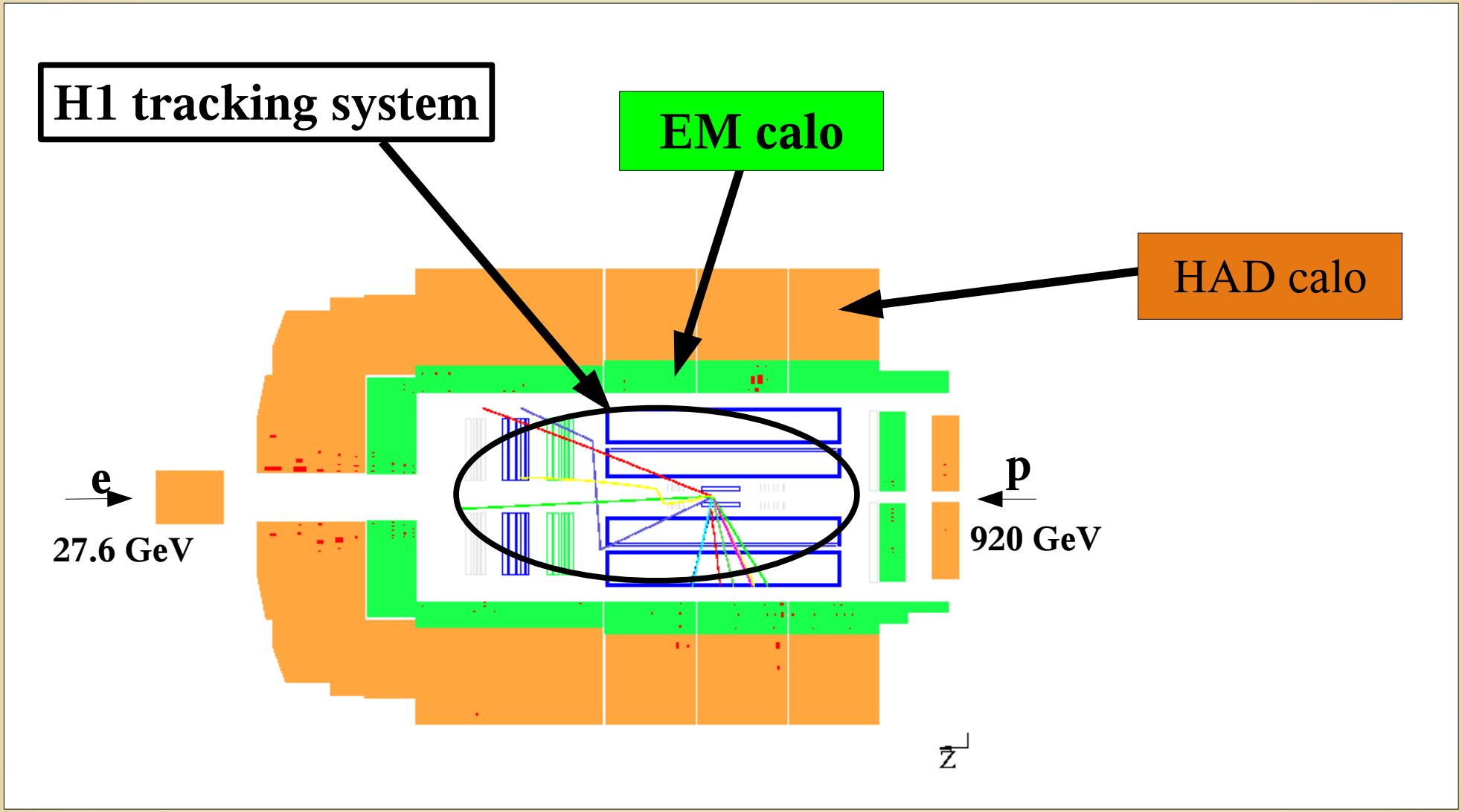
- Radiated
(initial or final state)



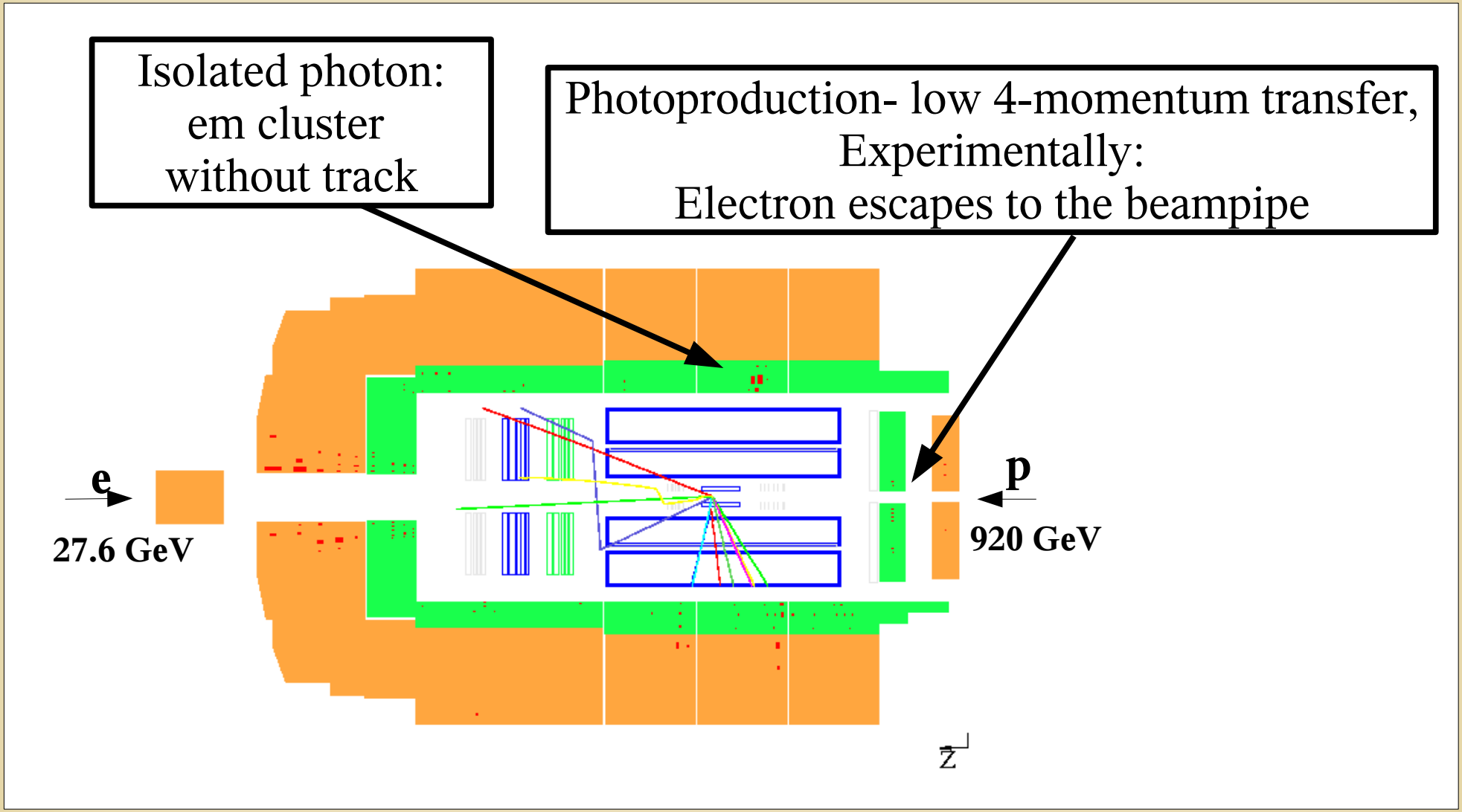
... and more

- Process sensitive to both proton and photon pdfs
- H → γ γ - important decay channel, background needs to be understood

H1 detector



H1 detector - prompt photon in photoproduction

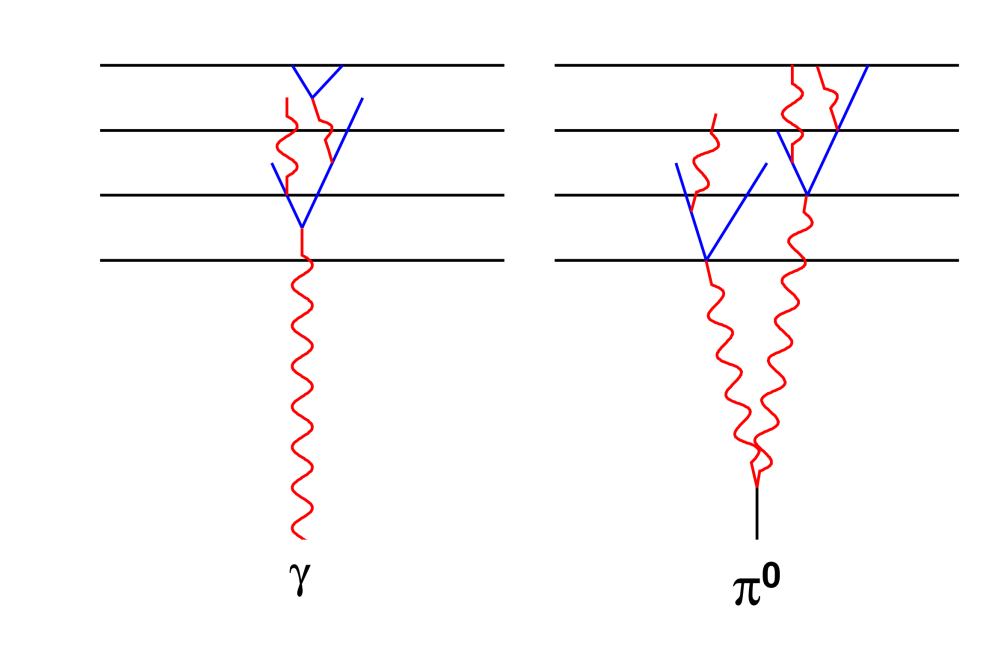


Background study multiphoton clusters

- Main background – neutral particles decaying into multiphoton final state

$$\pi^0 \rightarrow \gamma\ \gamma \qquad \eta \rightarrow \gamma\ \gamma \qquad \omega \rightarrow \pi^0\gamma \rightarrow \gamma\ \gamma\ \gamma$$

- Hadrons mostly in jets, but if by chance isolated... looking like Prompt Photon (em cluster without track)!

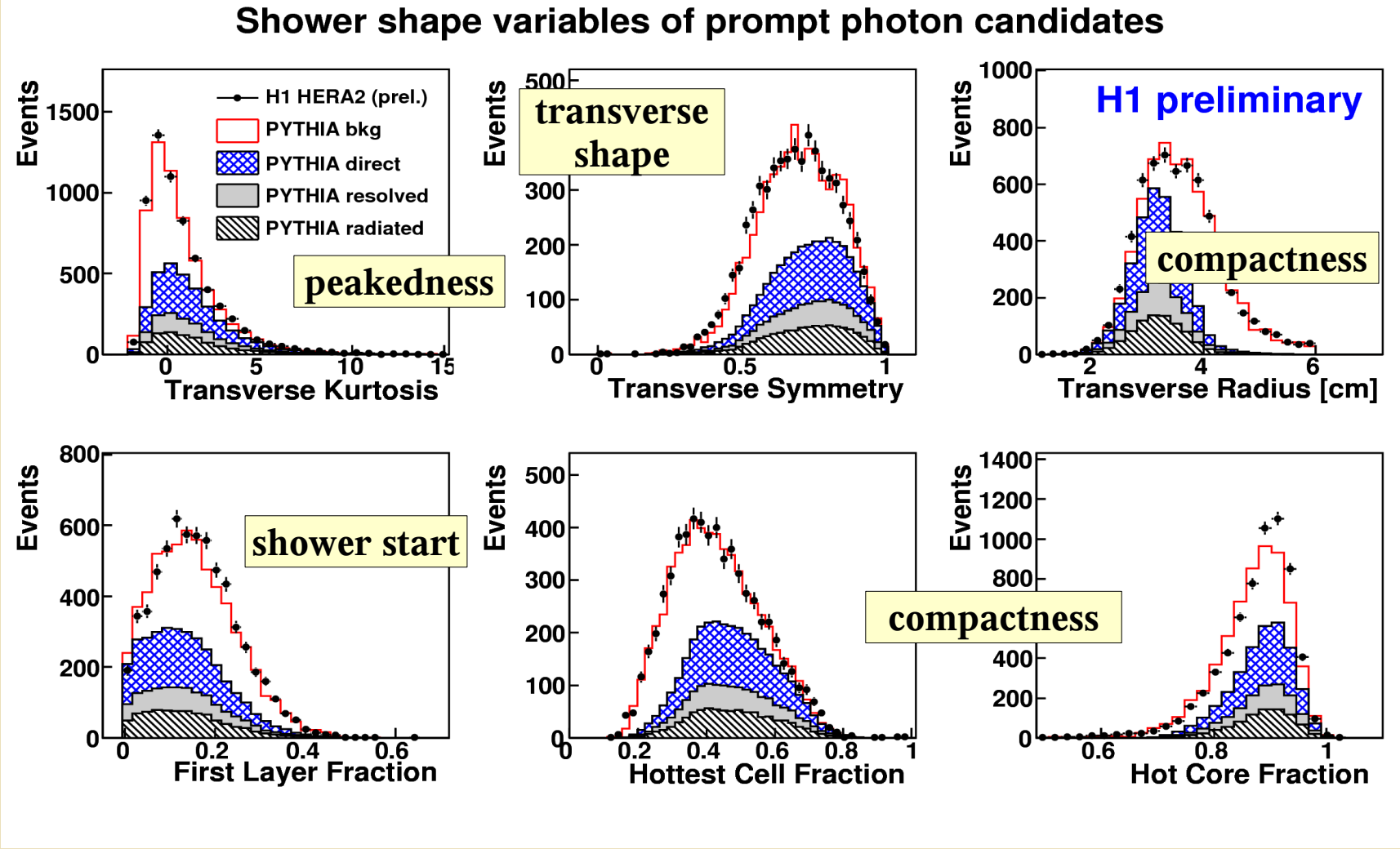


Shape of the cluster expected to be different

One could study

- Compactness
- Longitudinal shape
- Symmetry

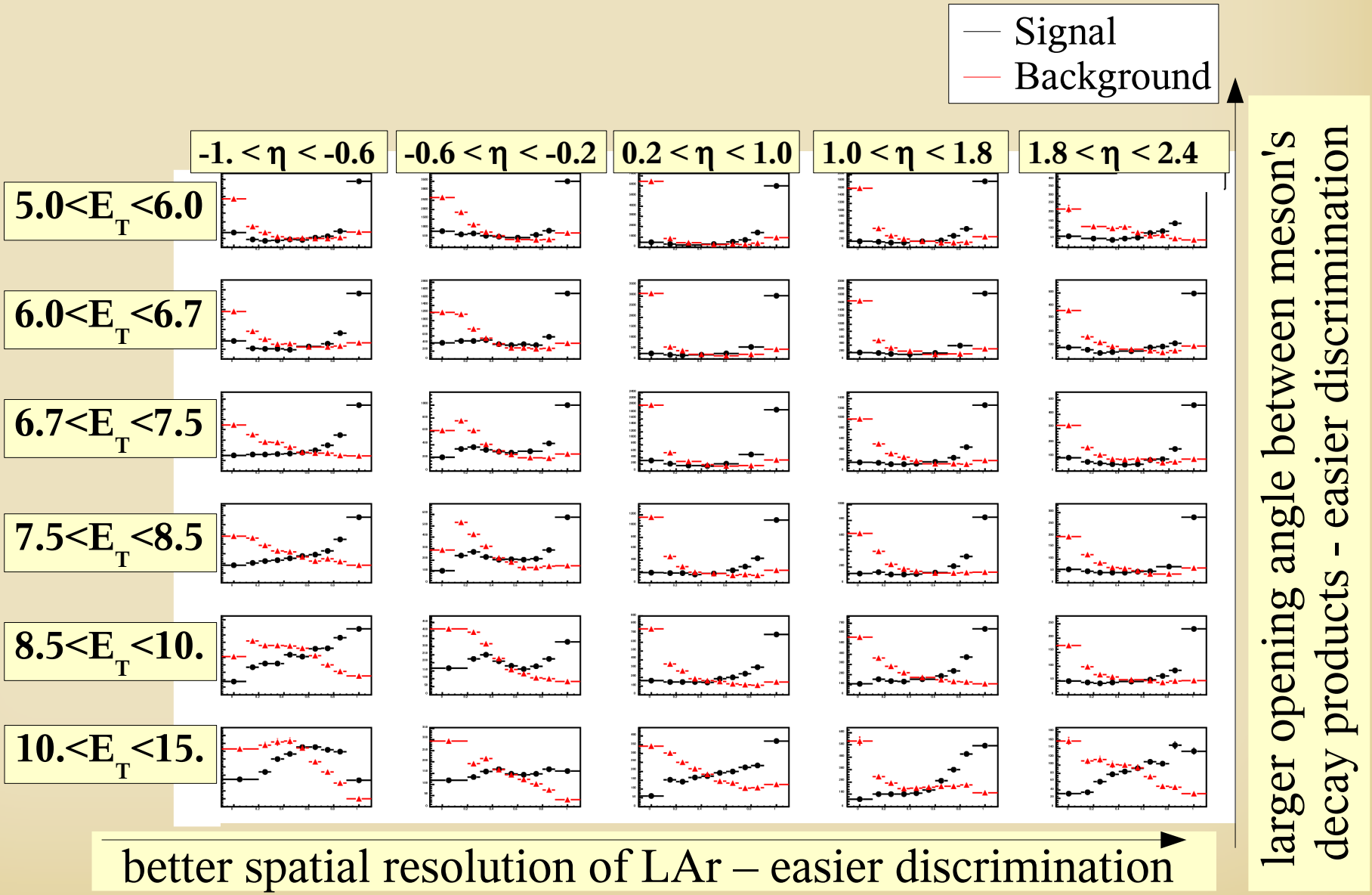
Cluster shape variables



- Combined with various multivariate methods (Likelihood, Neural Network, Decision Tree...)

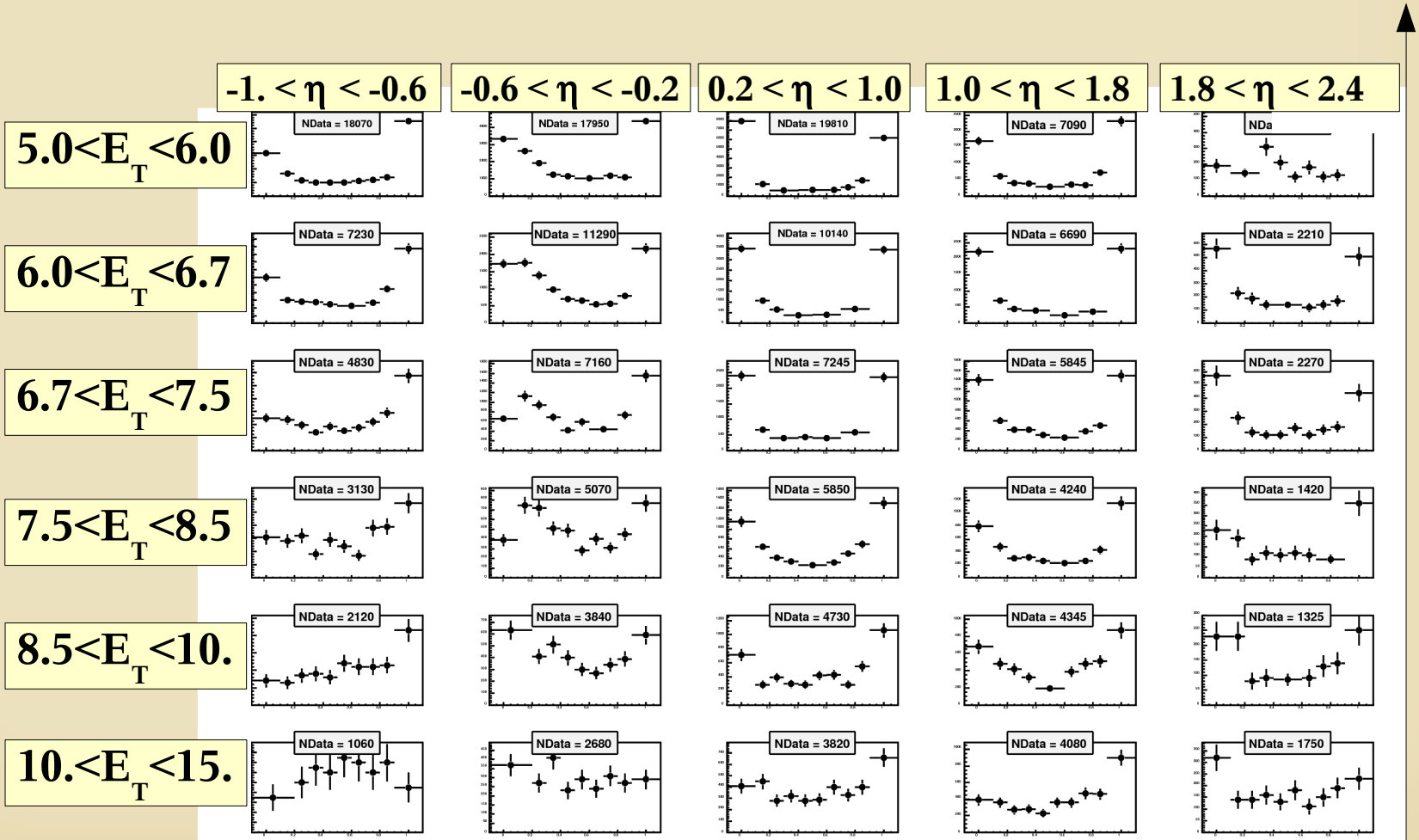
Signal extraction

- Discriminator maximizes the separation between Signal and Background



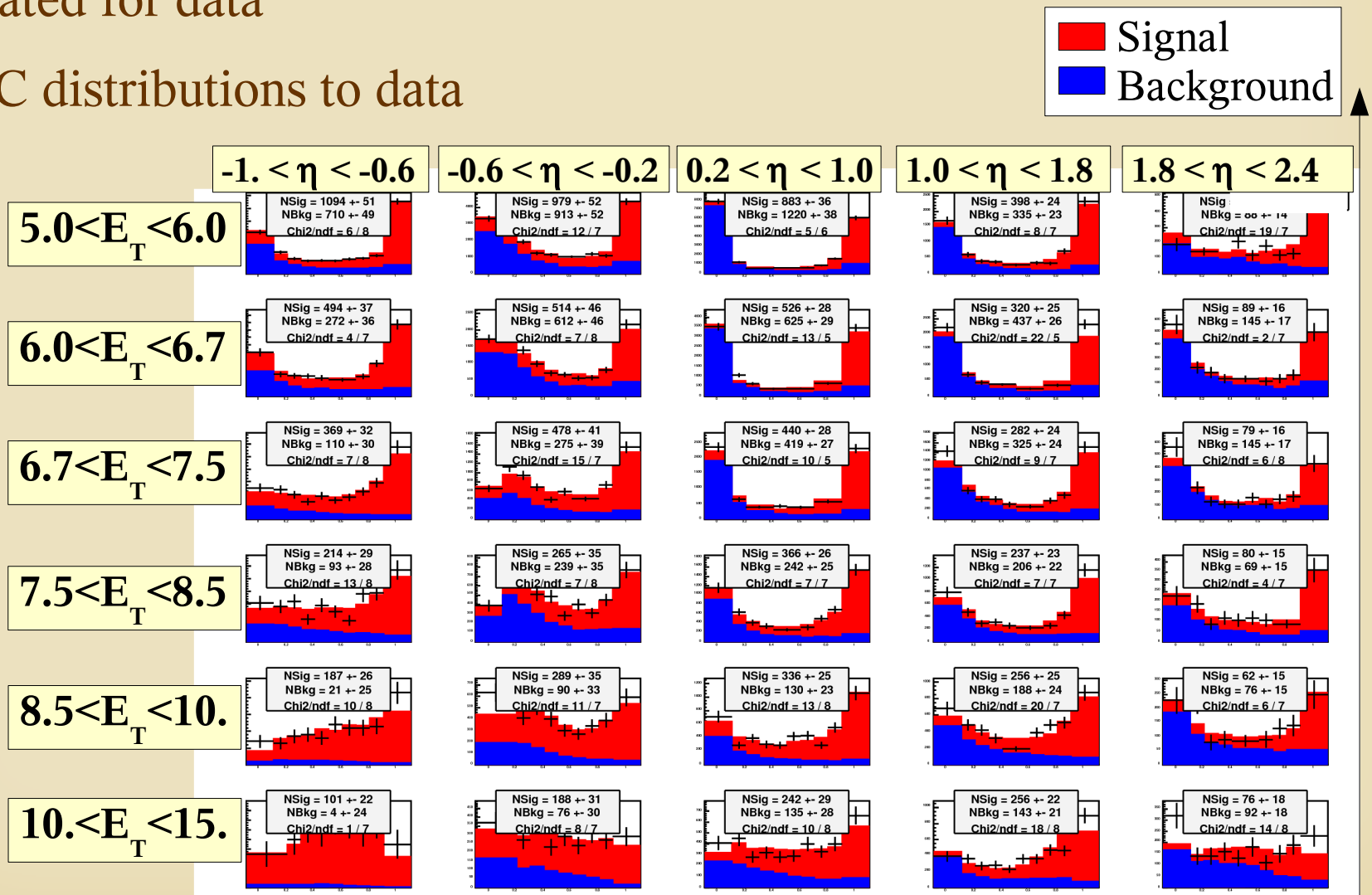
Signal extraction

- Discriminator maximizes the separation between Signal and Background
- Evaluated for data



Signal extraction

- Discriminator maximizes the separation between Signal and Background
- Evaluated for data
- Fit MC distributions to data



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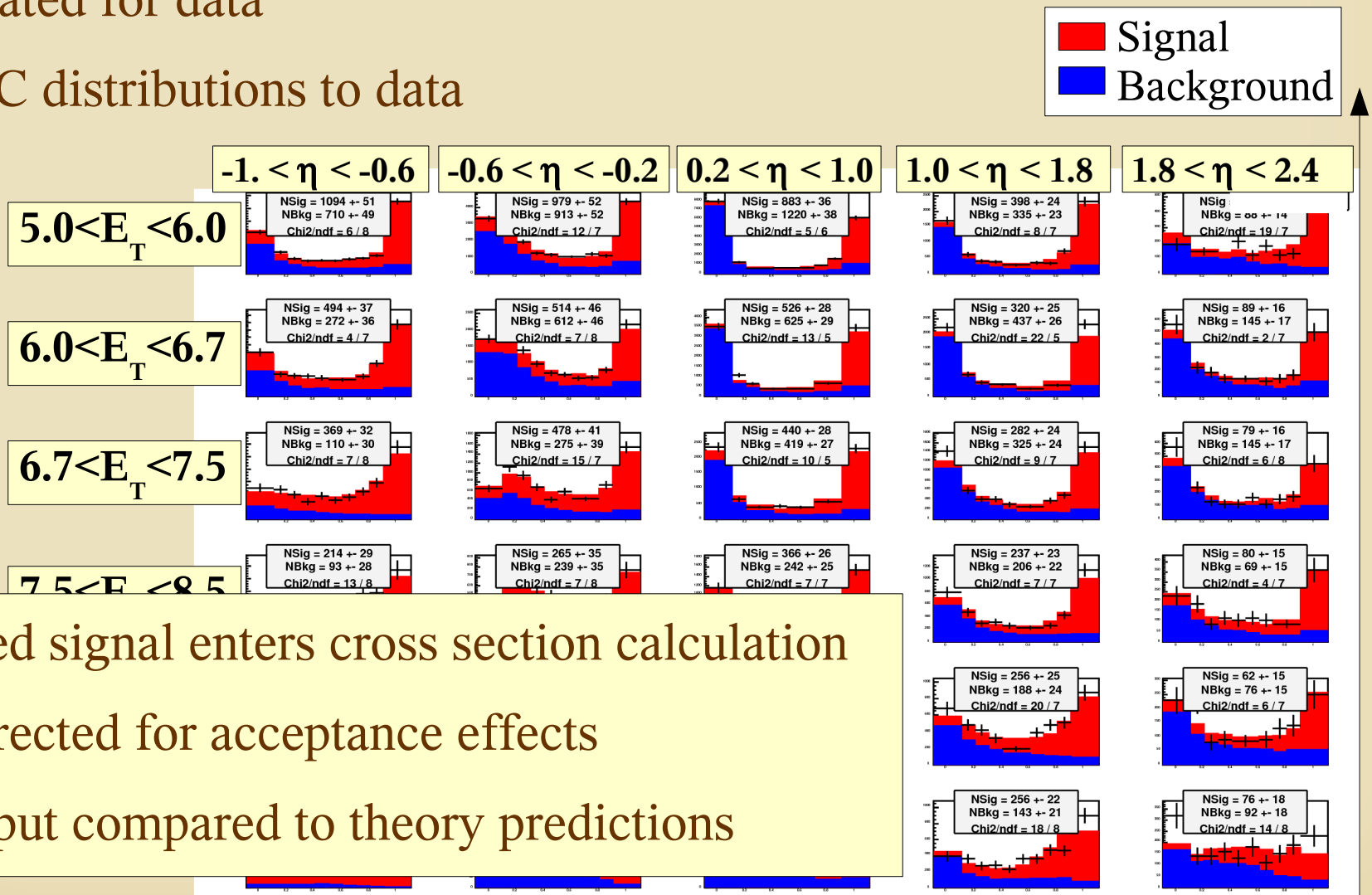
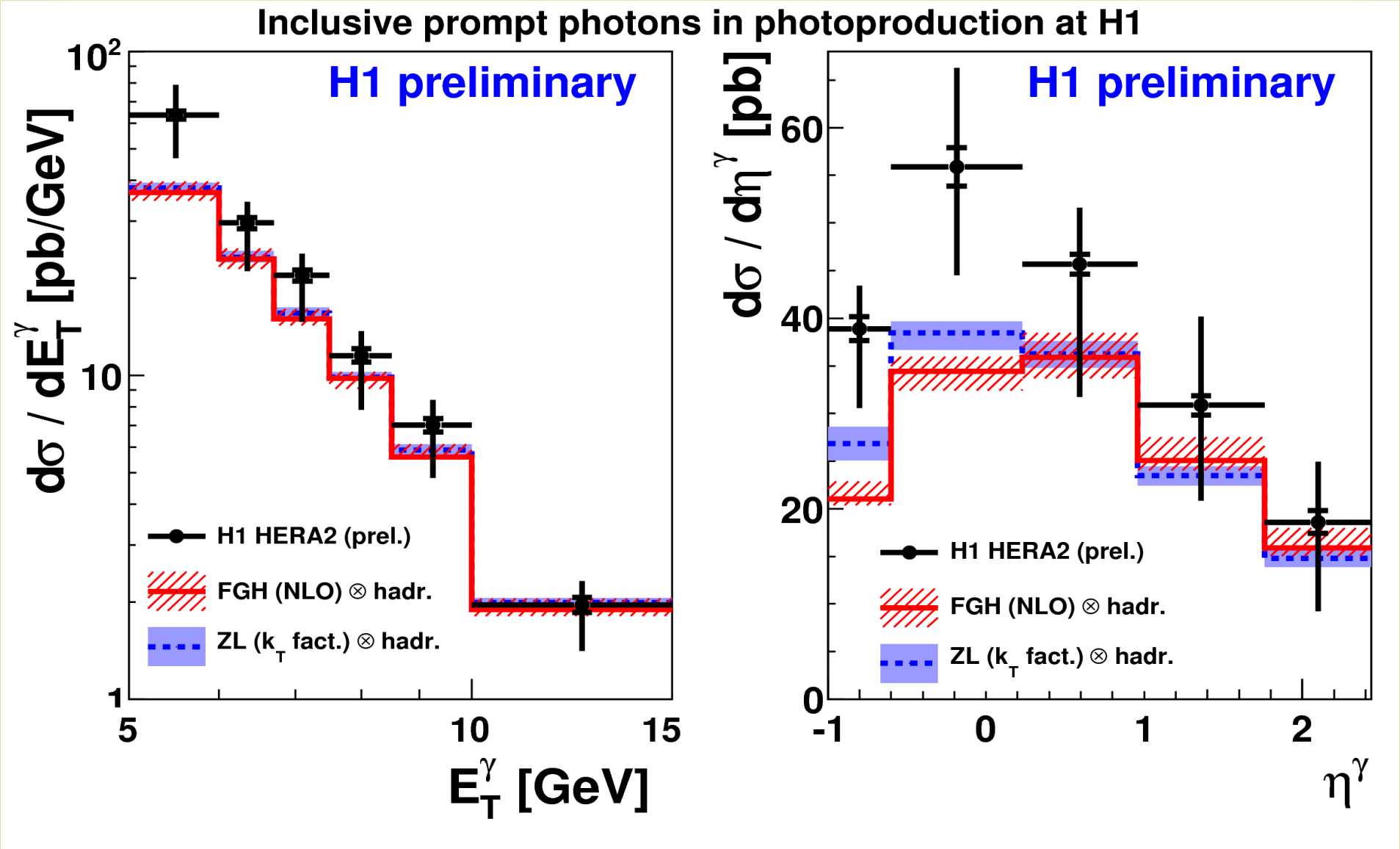
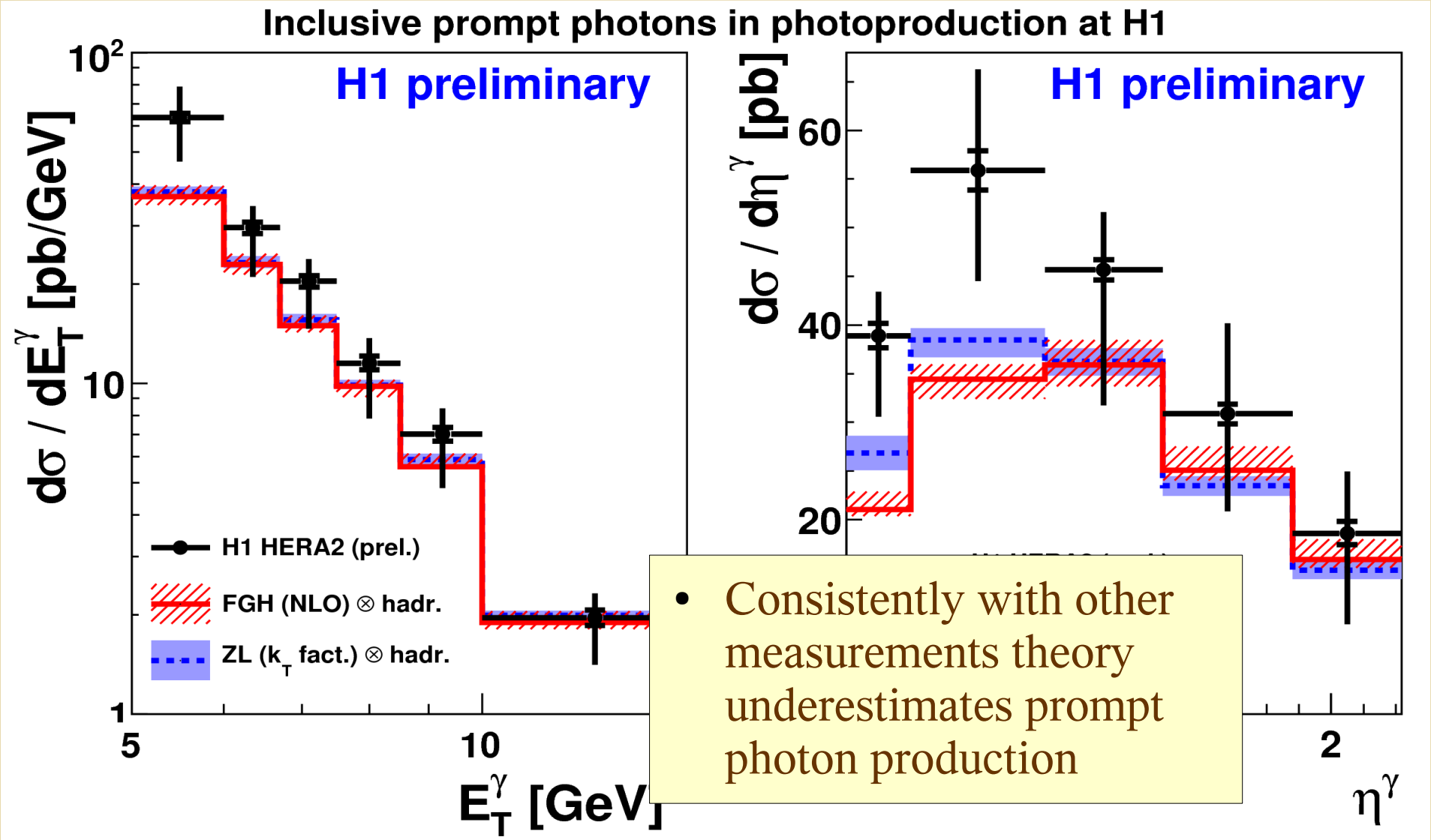


- Fitted signal enters cross section calculation
- Corrected for acceptance effects
- Output compared to theory predictions

Inclusive cross sections

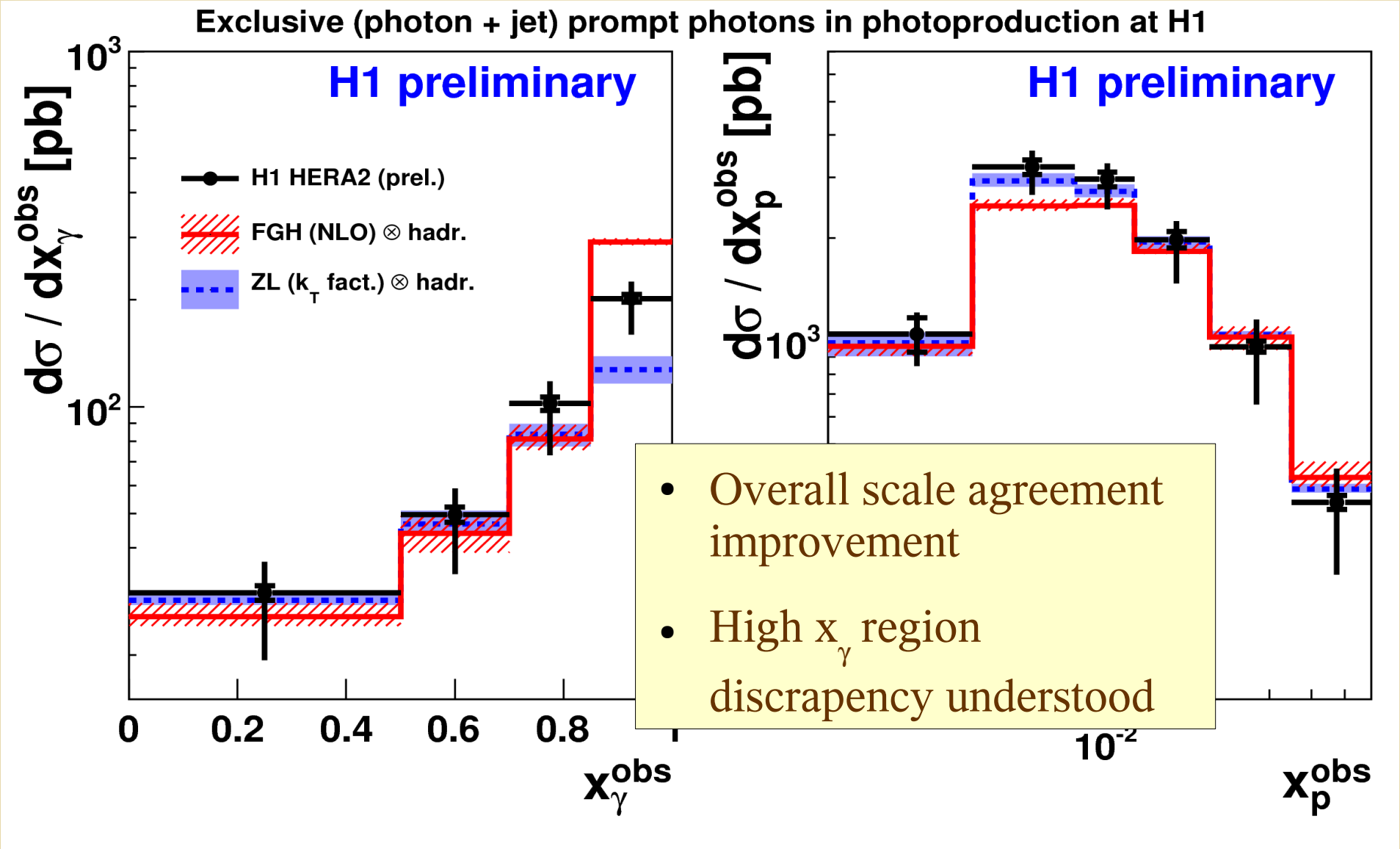


Inclusive cross sections



- Consistently with other measurements theory underestimates prompt photon production

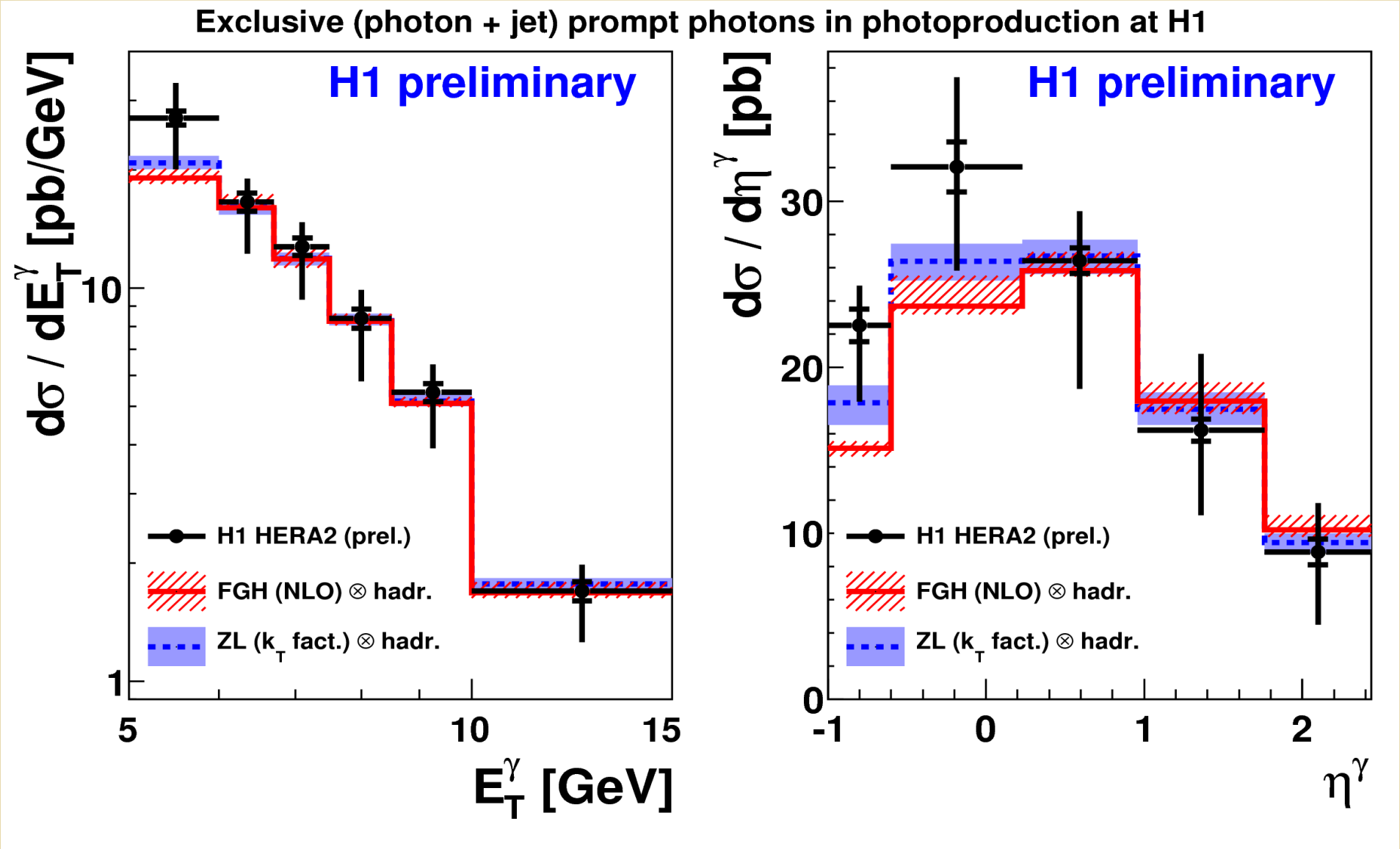
Exclusive cross sections



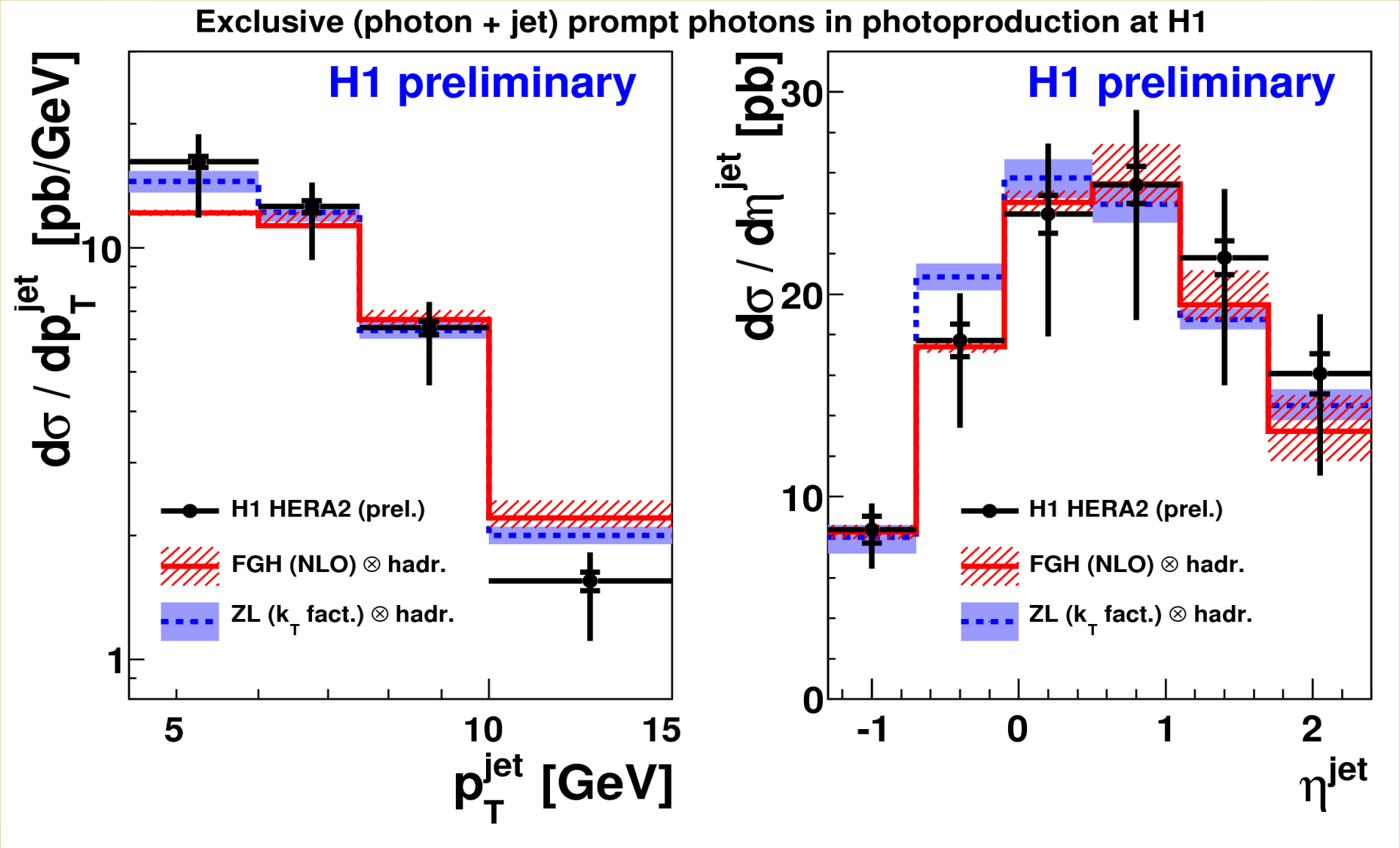
Summary

- Multivariate analysis used for discrimination photon signal and meson background (π^0)
  - Various methods have been studied and found to have low impact on final x-sections
- Both inclusive and exclusive Prompt Photon cross sections have been presented
  - Measurement compared to calculation results
  - Inclusive (photon) selection underestimated by both calculations and MC
  - Exclusive (photon + jet) selection described better

Exclusive cross sections

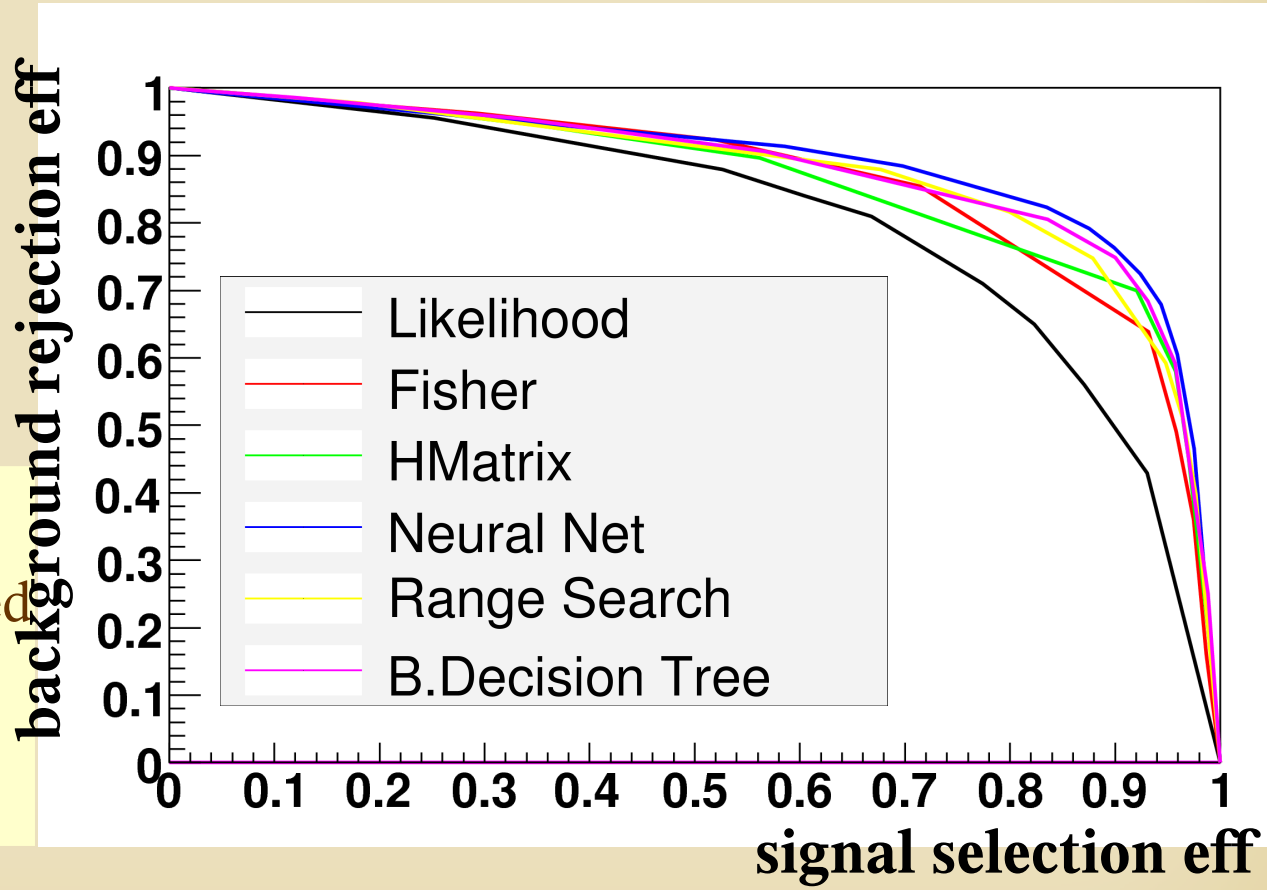


Exclusive cross sections



Multivariate methods 2

- Discrimination power of different methods
  - background rejection efficiency vs signal selection efficiency
- All methods comparative
- Here likelihood seems to be the weakest one



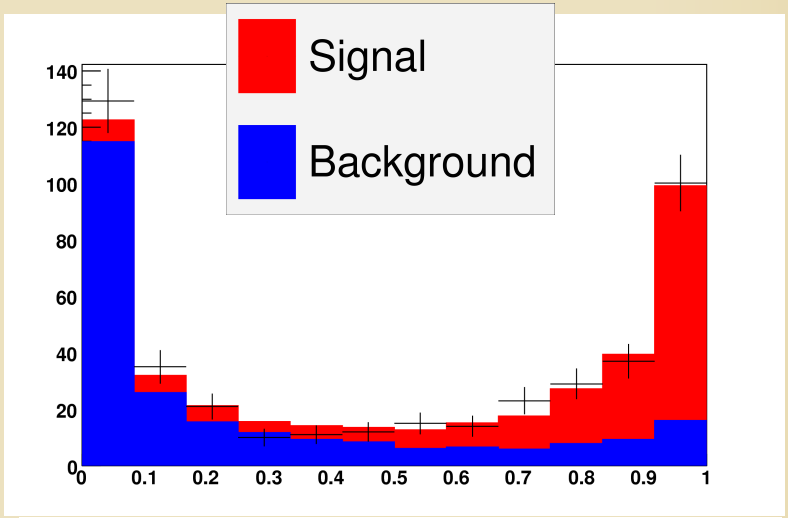
Remark:

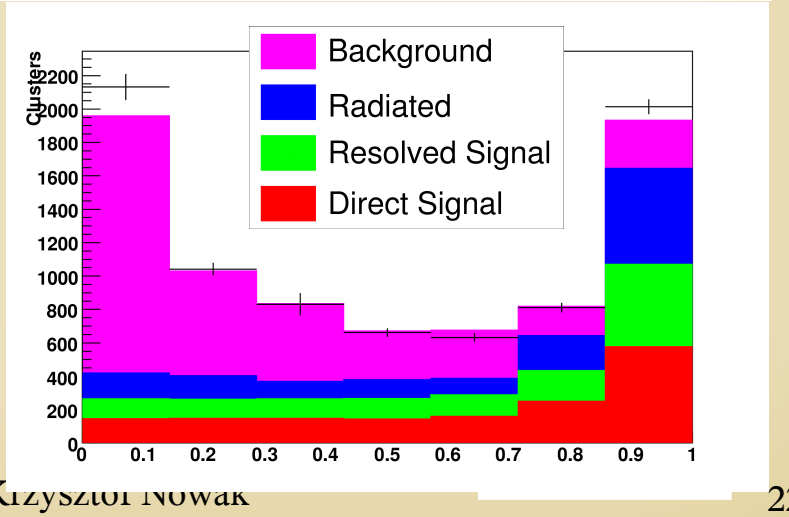
All the methods implemented in TMVA ROOT package

http://tmva.sourceforge.net

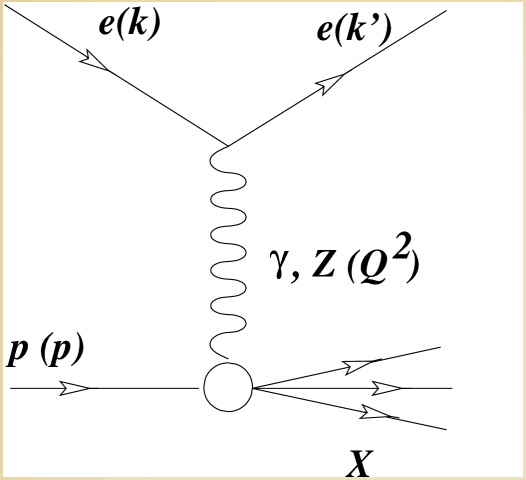
Multivariate methods 3

- Methods trained and evaluated with single particles MC (γ, π^0, η, ... 11 part. mixed acc. to MC)
  - motivation
    - only shape of isolated cluster needed
    - huge statistics possible





- Fit with Full MC (Pythia 6.2)
  - consistency check
  - derived global scaling



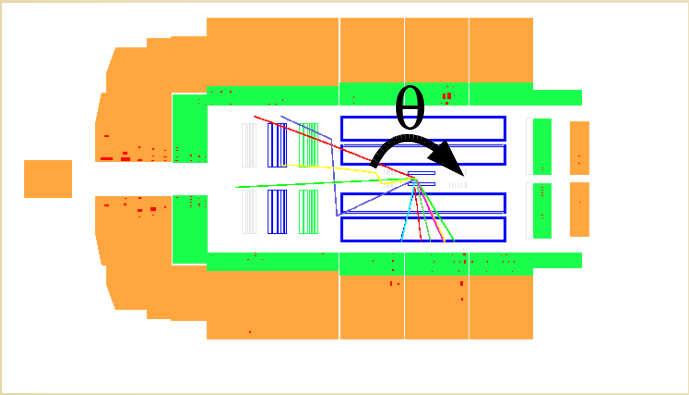
Phasespace

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

$$y = \frac{p \cdot q}{p \cdot k}$$

photoproduction

- $Q^2 < 1.\ \mathrm{GeV}^2$
- $0.1 < y < 0.7$



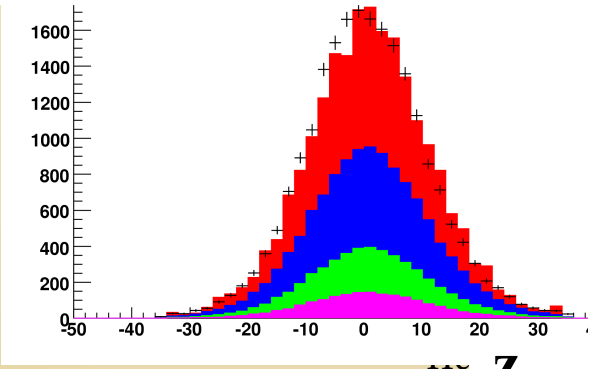
$$\eta = -\ln\left(\tan\left(\frac{\theta}{2}\right)\right)$$

photon

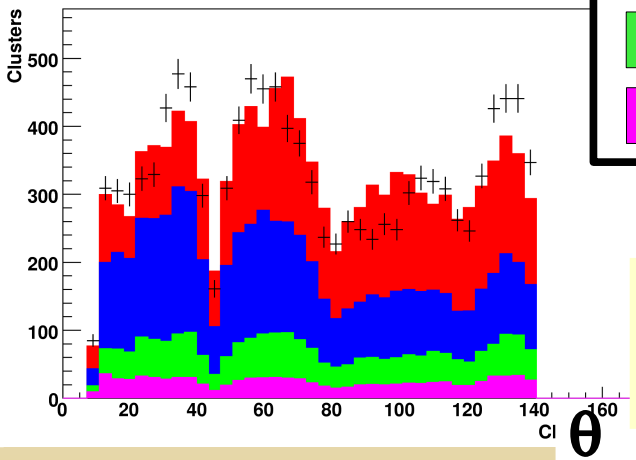
- $-1. < \eta^{\gamma} < 2.4$
  $[10° < \theta^{\gamma} < 140°]$
- $5. < E_T^{\gamma} < 15.$ [GeV]
- isolation

Background
Direct Signal
Resolved Signal
Radiated Signal

- Control plots



z_{vtx}



θ

Still about 50% of the background!