Journal Club
Measurement of the direct photon cross section with conversions

Alexander Koch

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Used Paper

Direct photon cross section with conversions at CDF

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Outline

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  - Collider Detector at Fermilab
- **Datasets and Analysis**
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  - systematic uncertainties
- **Results**
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What is measured

- motivation: measurment of the isolated direct photon cross section
  extract information about the parton distribution function (PDF)
- $p\bar{p}$ collisions @ $\sqrt{s} = 1.8\ TeV$ in $1994/1995$
- photons produced by
  - Compton scattering $g + q \rightarrow q + \gamma$
  - Annihilation $q + \bar{q} \rightarrow g + \gamma$
- pair production $\gamma \rightarrow e^+e^-$
- contamination of $\pi^0 \rightarrow \gamma\gamma$ and $\eta \rightarrow \gamma\gamma$ photons

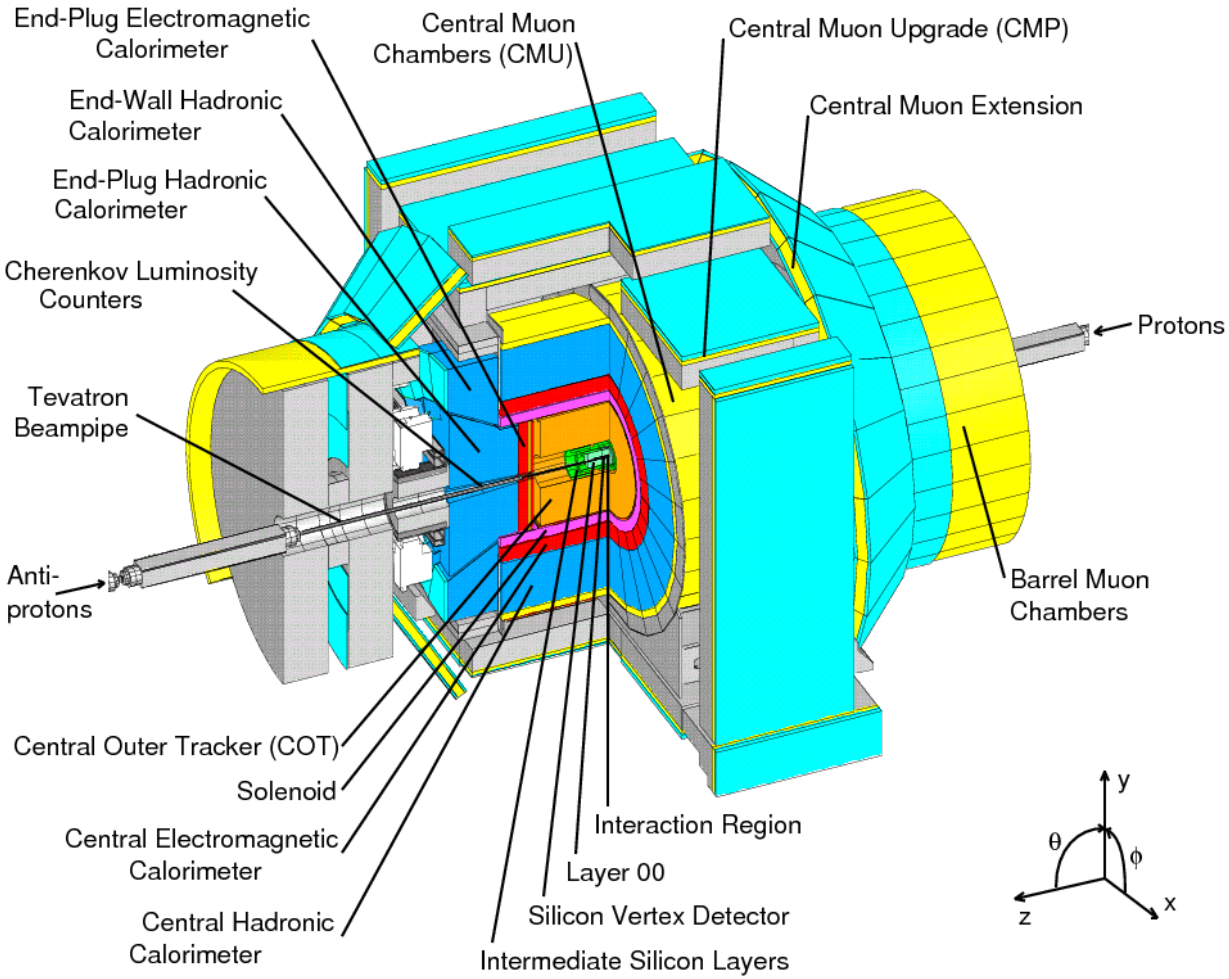
Collider Detector at Fermilab

Used Detectors

- Central Electromagnetic Calorimeter (CEM)
- Central EM Strip chamber (CES)
- Silicon vertex detector (SVX)
- Large central tracking chamber(CTC)

SVX and CTC are inside the 1.4T solenoid

CES is part of the CEM



Datasets

8 GeV electron data	**23 GeV photon data**
1 CEM cluster $>$ 8 GeV	1 CEM cluster $>$ 23 GeV
1 associated track with $p_T > 7.5$ GeV	no associated track
1 associated CES cluster	1 CES cluster > 0.5 GeV
EM shower energy spread over **several** CEM towers	neighboring calorimeter towers $E_T < 4$ GeV most energy is deposit in **one** CEM tower
several electron identification requirements	no electron identification requirements
integrated luminosity $73.6pb^{-1}$	integrated luminosity $83.7pb^{-1}$

Two types of events

1 tower event	**2 tower event**
measure summed E_T of both events in one CEM cluster	measure E_T of higher energy track and p_T of lower energy track

- 8 GeV electron data
  - require to be an 2 tower event
  - $|\eta| < 0.9 \quad |z_0| < 60$cm
  - cone energy cuts to suppress π^0 and η
  - missing energy $\tilde{E} < 25$ GeV to suppress $W \rightarrow e\nu$
- 23 GeV photon data
  - require to be an 1 tower event
  - $|\eta| < 0.9 \quad |z_0| < 60$cm
  - cone energy cuts to suppress π^0 and η
  - no missing energy $\tilde{E}$ cut
  - 28 GeV offline cut

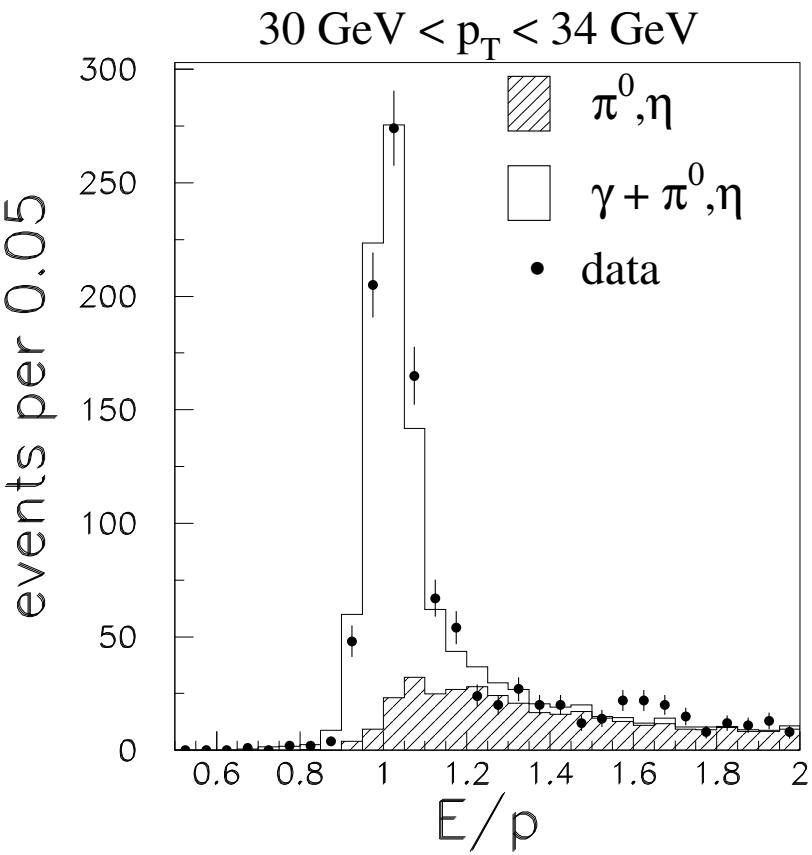
$\rightarrow$ both datasets have no events in common

π^0 and η background

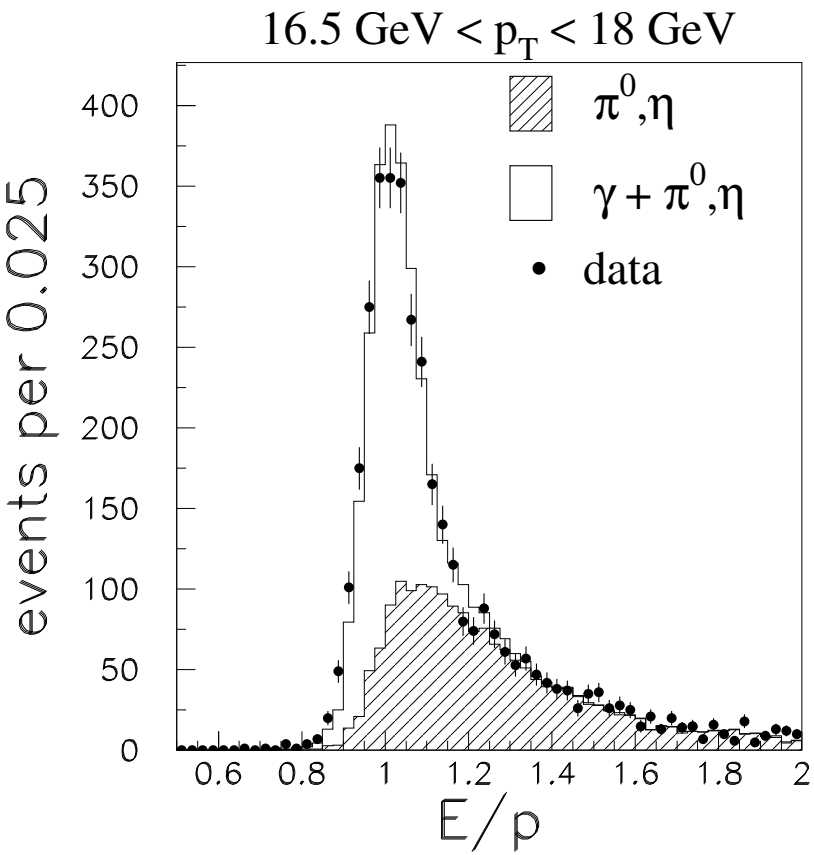
- Most π^0 and η are rejected by the previous cuts
- Build E_T/p_T ratio
  - 1-tower
    E_T is the two-tracked summed energy
    p_T is the sum of both track momenta
  - 2-tower
    E_T of the higher energy track
    p_T is the momenta of the associated single track
- γ peak expected at 1.0
- meson distribution is simulated by Monte Carlo simulation using a η/π^0 production rate of 0.69 ± 0.08

π^0 and η background

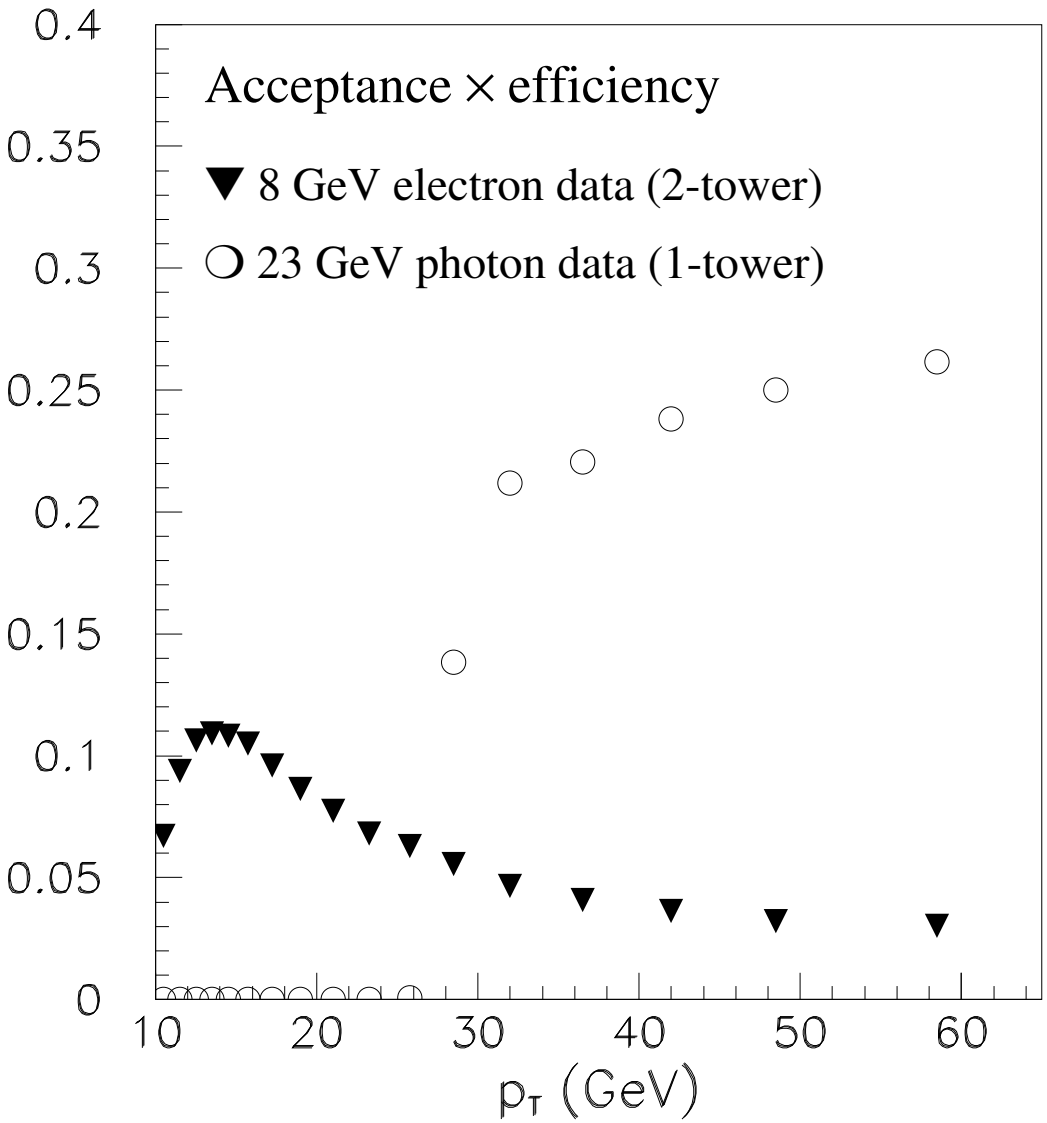
23 GeV photon data (1 tower)



8 GeV electron data (2 towers)



acceptance and efficency



Conversion probability

- total probability of the photon to convert in the CDF inner detector
- standard technique relies on a material map measured in the data
  gives conversion probability of $5.17 \pm 0.28\%$
- second technique compare Dalitz decays $\pi^0 \to e^+e^-\gamma$ to $\pi^0 \to \gamma\gamma$
  gives conversion probability of $8.02 \pm 0.73(stat.) \pm 0.73(sys)\%$
- several J/ψ measurments at CDF also gives evidence
  that the standard matarial scale is too small

$\to$ choose central value of $6.40 \pm 1.43\%$

Systematic uncertainties

- Monte Carlo E/p uncertainties
- background due to prompt electrons
- possible time dependence on the trigger efficency
- conversion identification efficency

$\rightarrow$ total p_T independent systematic uncertainty is $+28/-18\%$ for both datasets

Systematic uncertainties

p_T (GeV)	p_T dep. sys. err. (%)
8 GeV electron (2-tower) data:	
10-11	+10.6/-12.8
11-12	+9.3/-11.6
12-13	+9.4/-9.3
13-14	+8.5/-8.6
14-15	+6.7/-7.3
15-16.5	+6.7/-6.9
16.5-18	+5.7/-6.0
18-20	+7.6/-7.8
20-22	+7.0/-6.1
22-24.5	+4.3/-5.8
24.5-27	+5.1/-11.9
27-30	+5.7/-11.3
30-34	+4.1/- 11.1
34-39	+4.1/-11.0
39-45	+5.6/-11.5
45-52	+4.1/-10.8
52-65	+8.8/-13.3

p_T (GeV)	p_T dep. sys. err. (%)
23 GeV photon (1-tower) data:	
30-34	+2.3/-4.9
34-39	+2.8/-4.9
39-45	+3.9/-5.6
45-52	+5.0/-4.7
52-65	+4.7/-8.2

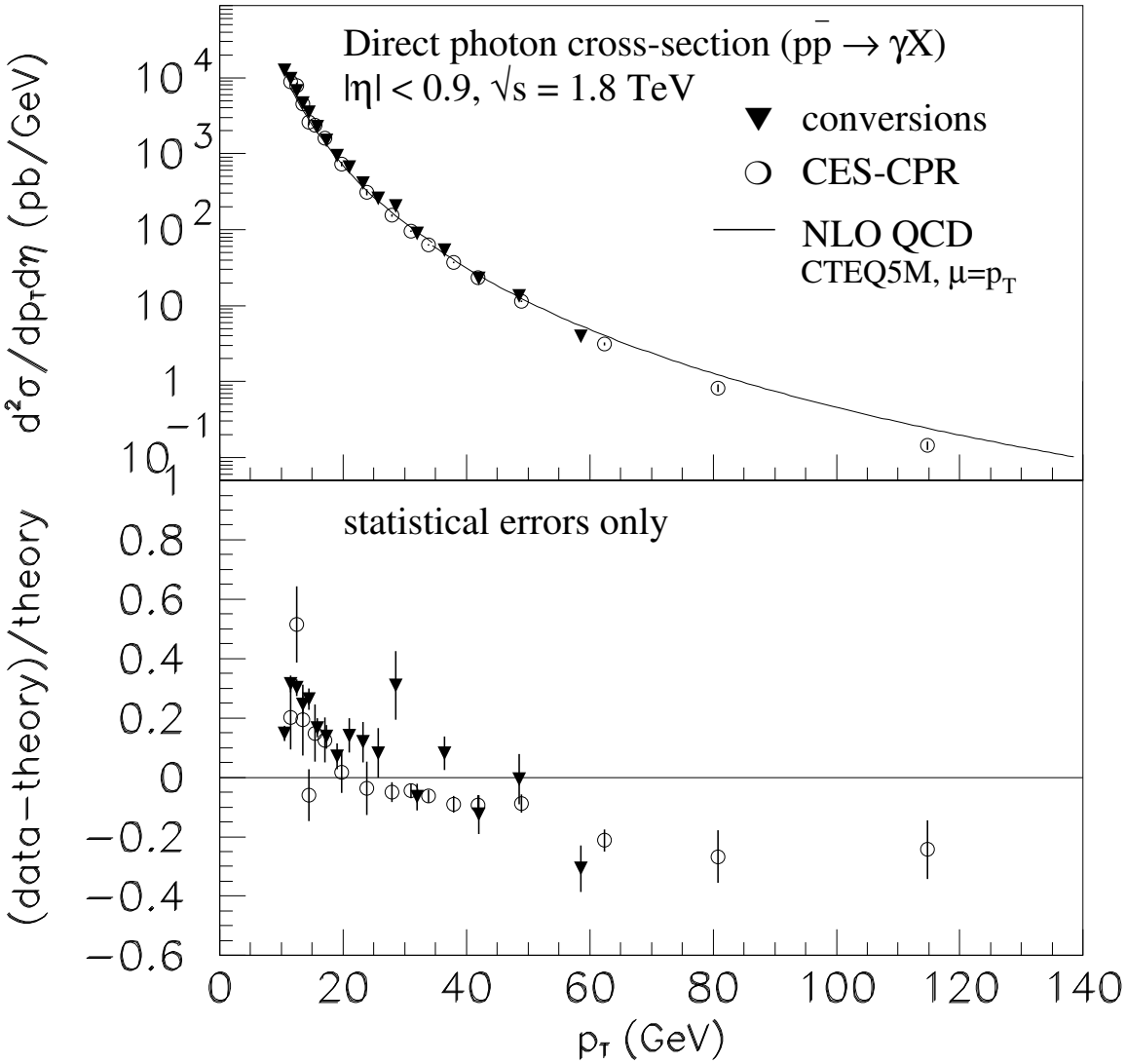
p_T dependence of the systematic uncertainties

Cross section calculation

$$\frac{d\sigma^2}{dp_T d\eta} = \frac{N_{signal}}{A \cdot \epsilon \cdot \Delta p_T \cdot \Delta\eta \cdot \int \mathcal{L}}$$

- $A \cdot \epsilon$ is acceptance times efficency corrected for the conversion probability
- $-0.9 < \eta < 0.9 \Rightarrow \Delta\eta = 1.8$
- Δp_T is the bin width
- $\int \mathcal{L}$ is the integrated luminosity
  - which is $73.6 pb^{-1}$ for the 8 GeV electron data
  - which is $83.7 pb^{-1}$ for the 23 GeV photon data

Results and comparison to theory



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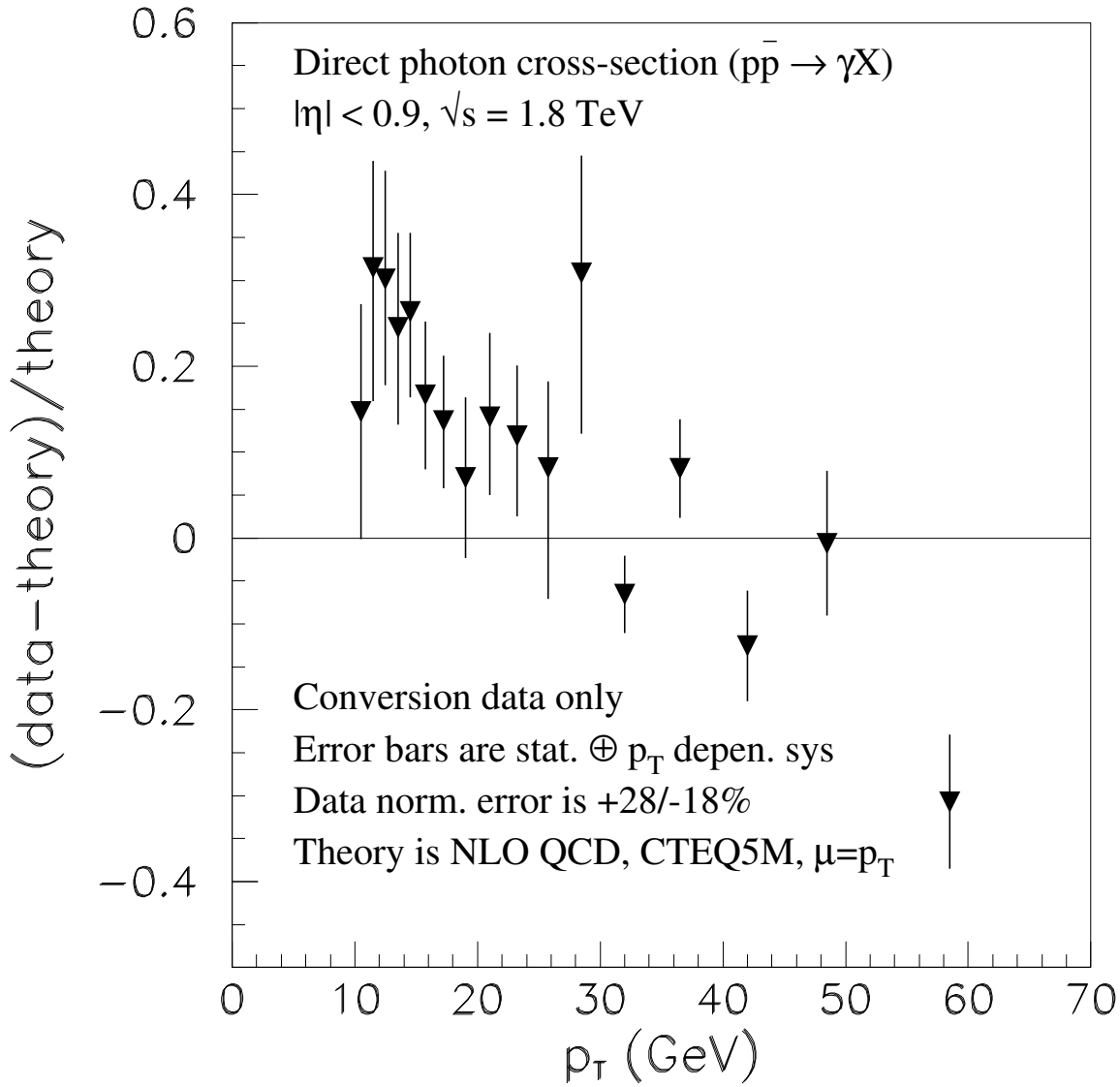

Conclusion

- the shape of the cross section is poorly described by next-to-leading-order (NLO) QCD calculations
- CES-CPR measurment agrees with that statement