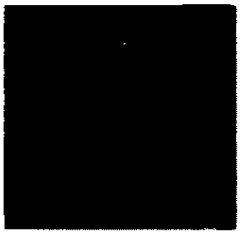
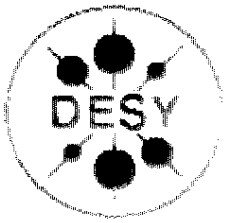




Prompt Photon Production
and
Deeply Virtual Compton Scattering

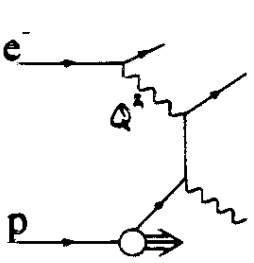
- **Introduction**
- **Prompt Photon Production**
- **Deeply Virtual Compton Scattering**
- **Summary**

Dr. Patrick R.B. Saull

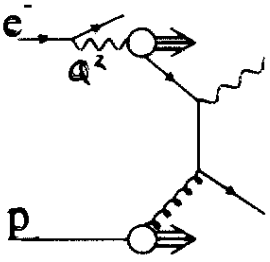
INTRODUCTION

Two types of photon production processes being studied at ZEUS

1. Prompt Photon Production:



Direct Prompt γp

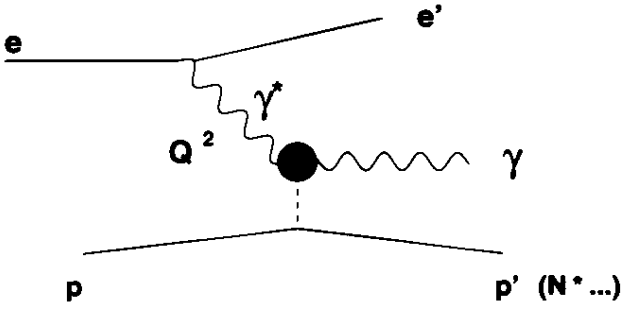


Resolved Prompt γp

$Q^2 \approx 0$

- ▷ Study parton density of photon
- ▷ Compare with NLO pQCD calculations

2. Deeply Virtual Compton Scattering:

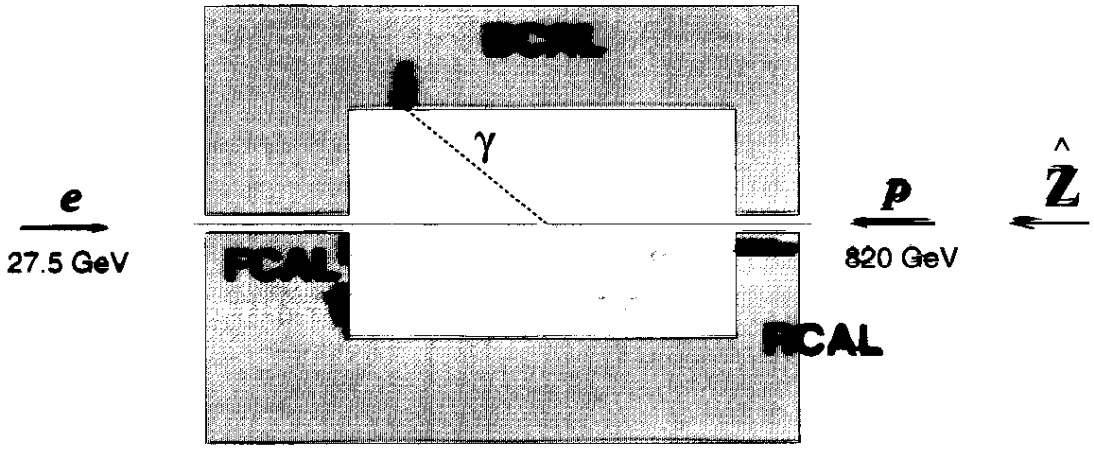


$Q^2 \geq 6$

- ▷ Skewed Parton Distributions
- ▷ $Re(A_{QCD})$ via interference with Compton

INTRODUCTION (CONT'D)

Look for *isolated* EM clusters in barrel part of ZEUS calorimeter with electron finder.



If photon candidate is in fact from $\pi^o, \eta, \cdots$ production, this should be reflected in the shower shape.

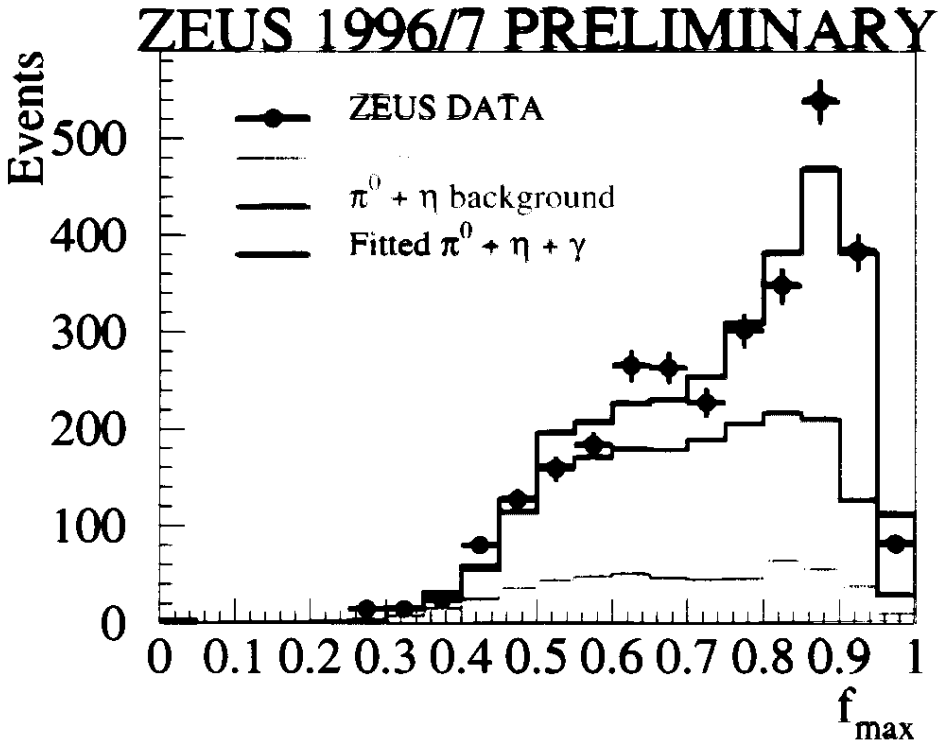
Two variables used to quantify photon candidate shower shape:

$$Z_{width} = \frac{\sum |Z_{cell} - \overline{Z}| \times E_{cell}}{\sum E_{cell}}$$

$$f_{max} = \frac{\text{Energy of most energetic cell in cluster}}{\text{Total energy in cluster}}$$

Prompt Photon Production

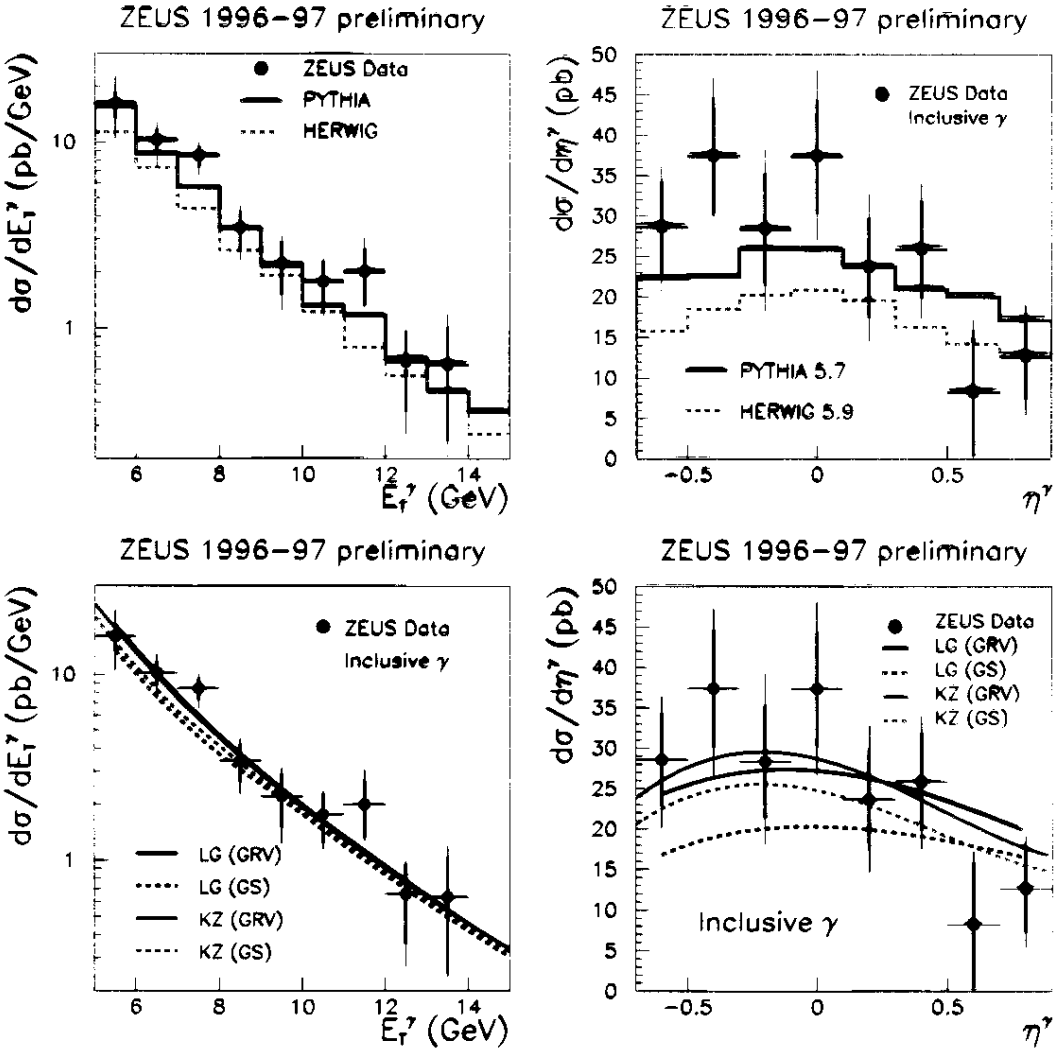
Fraction of energy in highest energy BCAL cell discriminates between γ and $\pi^0 + \eta$:



Prompt γ signal extracted by comparing numbers of events with $f_{max} > 0.75$ and $f_{max} < 0.75$

Prompt Photon Production

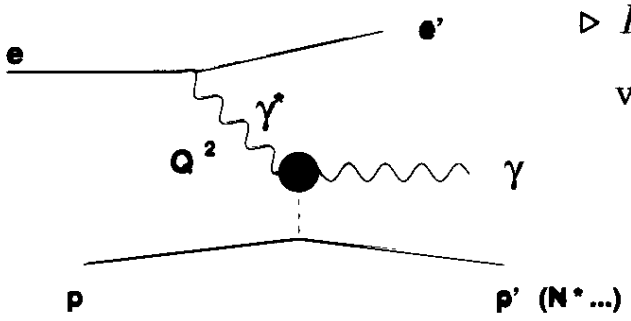
- $38pb^{-1}$ data
- $E_T^\gamma \geq 5$ GeV
- $-0.7 \leq \eta^\gamma \leq 0.9$
- No jet requirement on hadronic state balancing γ



- LO + parton-shower models roughly describe data
- Potential for sensitivity to photon structure but theoretical progress needed, and more data
- pQCD generally consistent with data

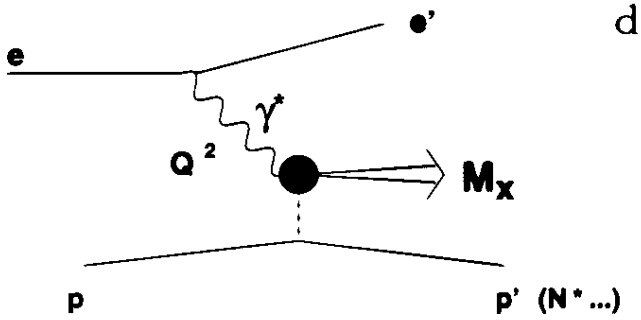
Deeply Virtual Compton Scattering

DVCS diagram:



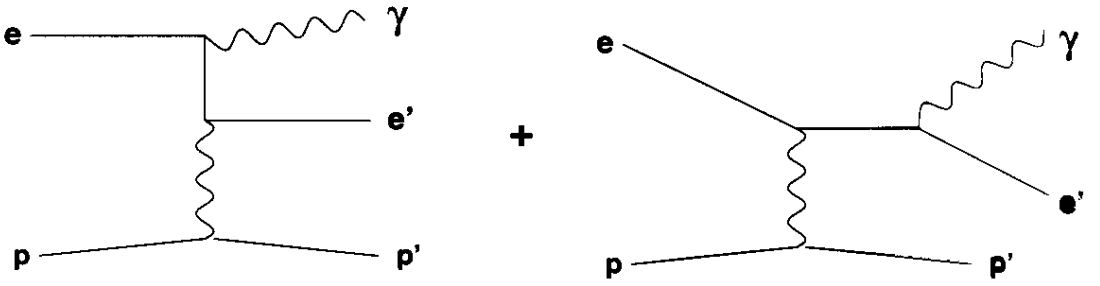
- ▷ Skewed Parton Distributions
- ▷ $Re(A_{QCD})$ via interference with Compton process

Compare:



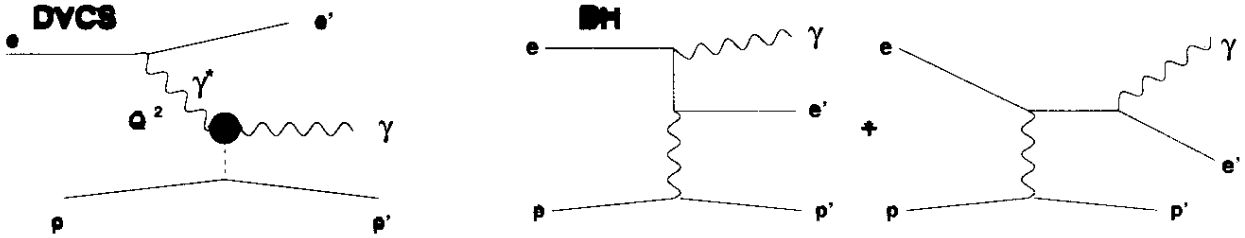
- ▷ More theoretical uncertainty due to hadronic final state

Competing process: (QED Compton)



DVCS - CROSS SECTIONS

L.L.Frankfurt, A.Freund and M.Strikman :
(Phys.Rev.D58 (1998) 114001)



$$\frac{d\sigma^{DVCS}}{dxdydtd\phi_r} = \frac{\pi\alpha^3 s}{4R^2Q^6}(1+(1-y)^2)e^{-B|t|}F_2^2(x,Q^2)(1+\eta^2)$$

$$\frac{d\sigma^{BH}}{dxdydtd\phi_r} = \frac{\alpha^3 s y^2[1+(1-y)^2]}{\pi|t|Q^4(1-y)} \frac{G_E^2(t) + \frac{|t|}{4m_p^2}G_M^2(t)}{1+\frac{|t|}{4m_p^2}}$$

$$\frac{d\sigma^{INT}}{dxdydtd\phi_r} = \frac{\pm.5\eta\alpha^3 sy[(1+(1-y)^2)]}{RQ^5\sqrt{|t|(1-y)}} F_2(x,Q^2)e^{-B|t|/2}$$

$$\times \frac{G_E(t) + \frac{|t|}{4m_p^2}G_M(t)}{1+\frac{|t|}{4m_p^2}} \cos\phi_r$$

$\cos\phi_r = \phi_e - \phi_p$

Use to write a MC generator → GenDVCS.

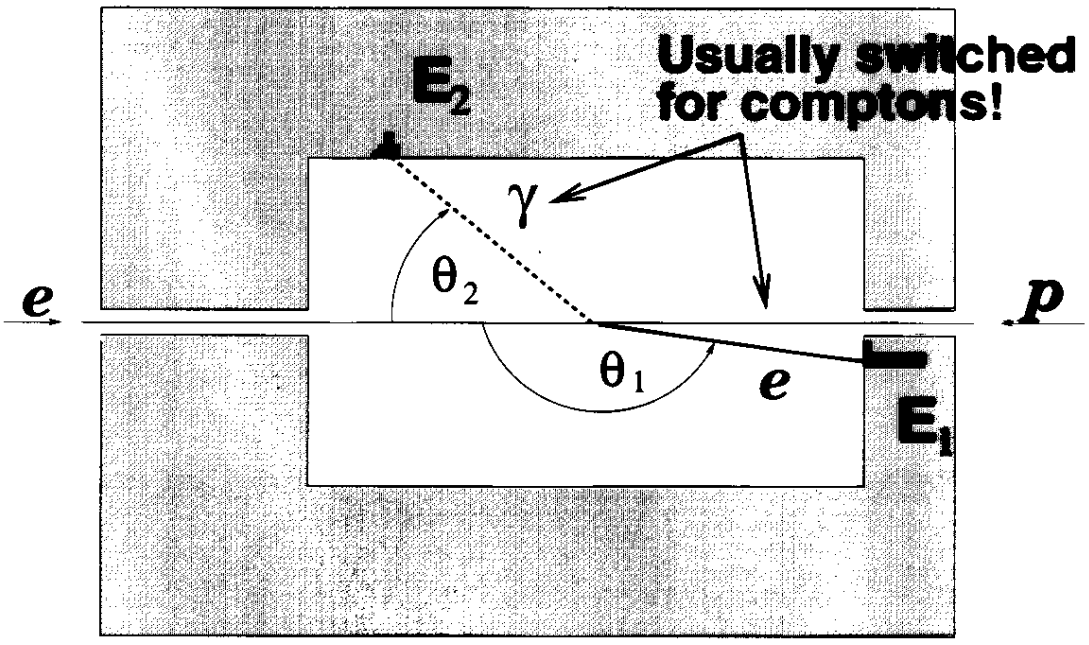
DVCS - Selection Criteria

Main selection requirements:

- 2 EM clusters in detector and nothing else
- 0 or 1 tracks; if 1, must be matched to cluster
- $\theta_1 > 2.8$rad (DVCS e^+ scatters at low angle)
- $\theta_2 < 2.4$rad (DVCS γ prominant at low y)
- $|\theta_1 - \theta_2| > 0.8$ rad (Compton suppression)
- $E_2 > 2$ GeV, $Q^2 > 6$ GeV^2, $M_{12} < 30$ GeV

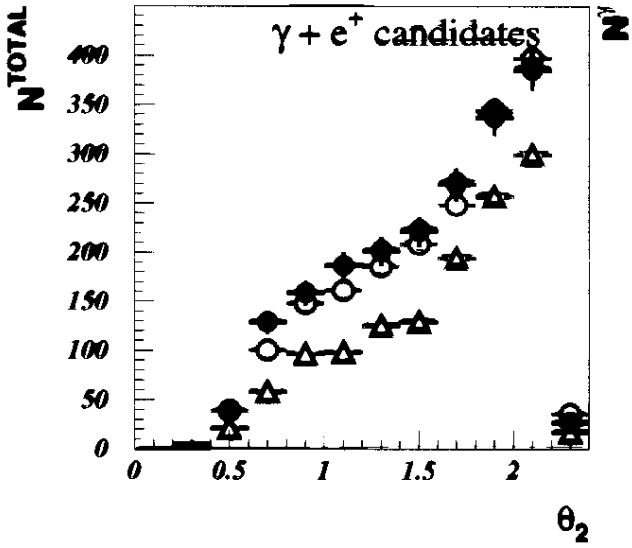
From 37pb^{-1} of ep data: 1954 events survive

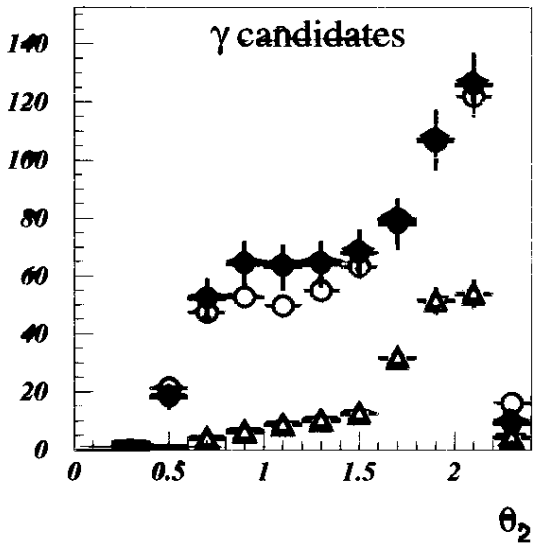
Typical DVCS topology in detector:

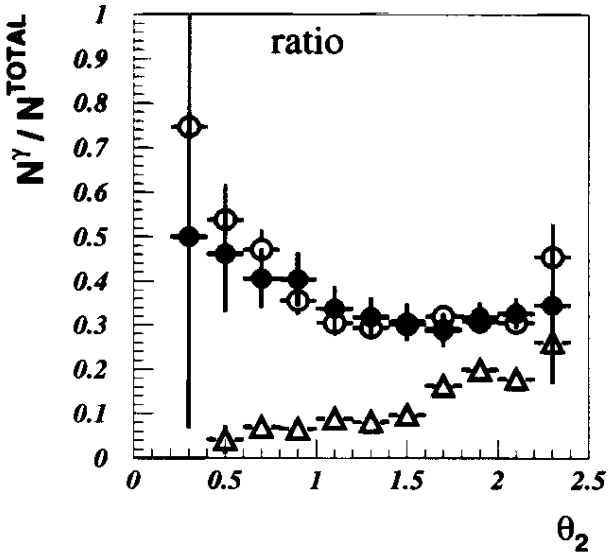


DVCS - θ_2 DISTRIBUTIONS

ZEUS 1996/97 Preliminary







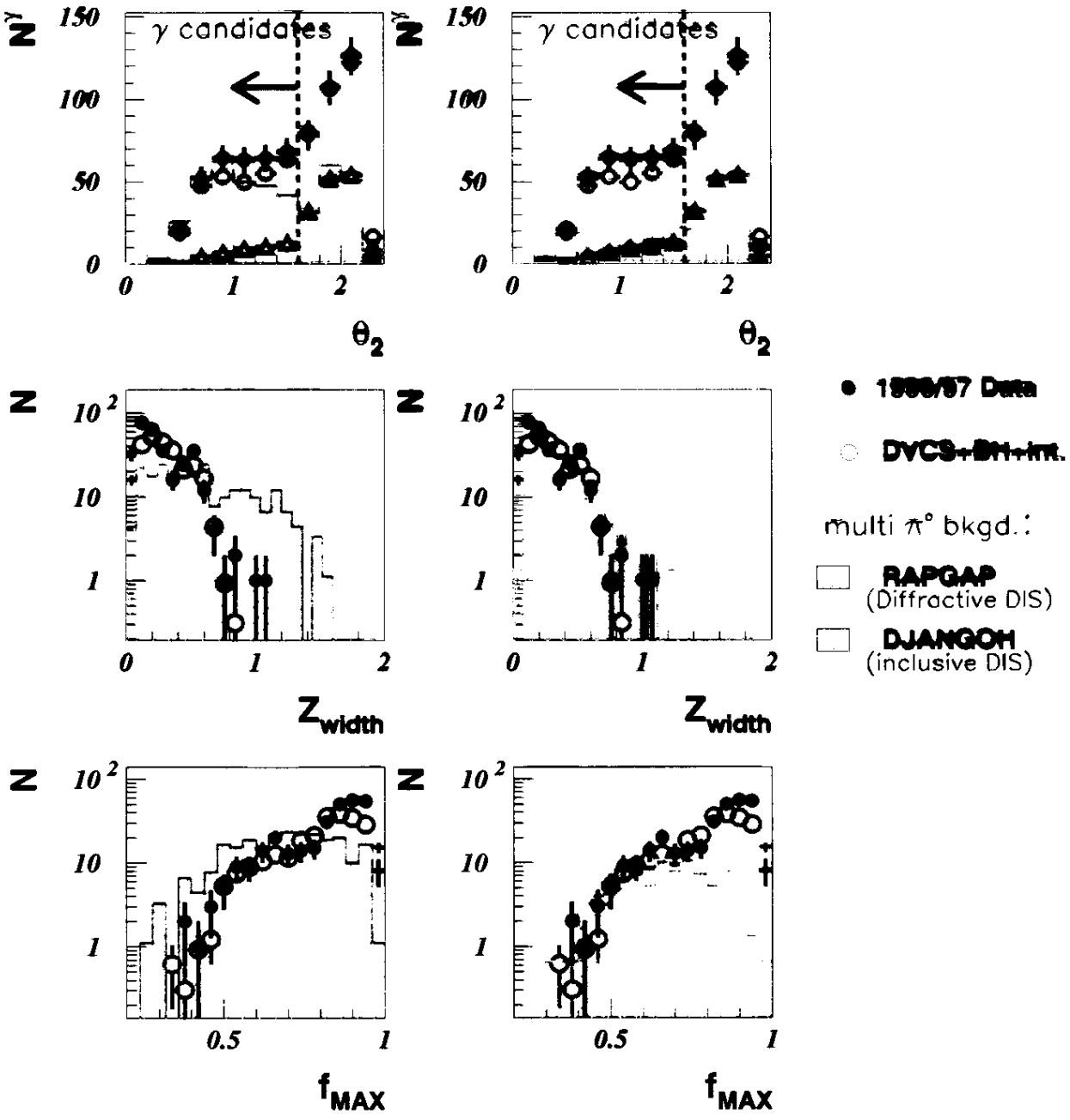
- ● **1996 - 1997 Data** (no acceptance correction)
- ○ **GenDVCS DVCS + BH + int.** (detector-level)
- △ **Compton2.0 el. only** (detector-level)

→ Appears to be clear signal for DVCS!

But, processes like $ep \to ep\pi^o$, $ep \to ep\pi^o\pi^o$, $ep \to ep\pi^o\eta$, ... potentially fake this signal.

DVCS - γ CAND. SHOWER SHAPES

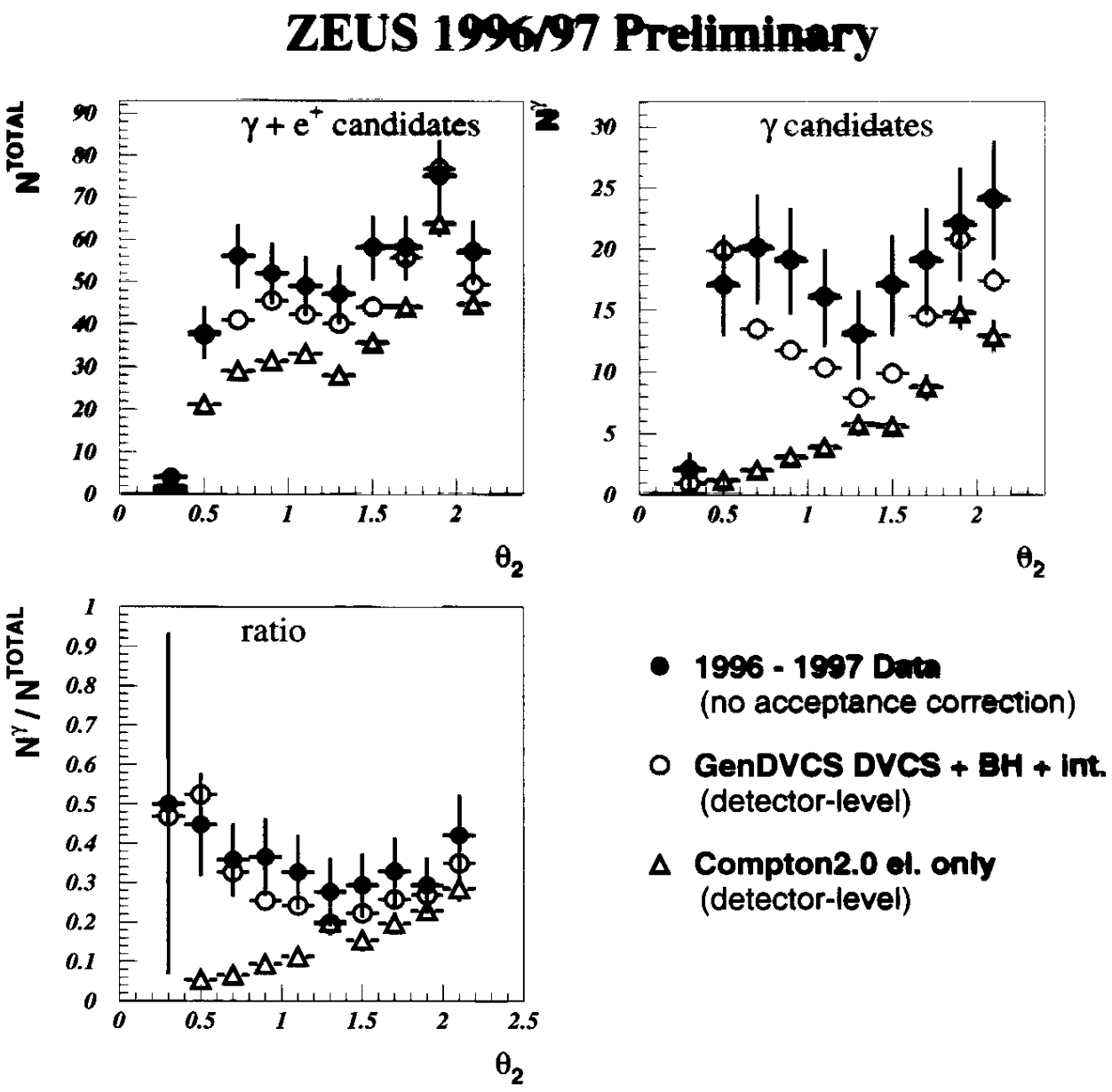
ZEUS 1996/97 Preliminary



$\rightarrow$ π^o / η hypothesis cannot account for shower shapes.

DVCS - θ_2 DISTRIBUTION ($E_2 > 5$ GEV)

Examine higher energy regime where hadronic background is expected to be small:



→ Signal persists for $E_2 > 5$ GeV.

Summary

ZEUS has measured the production of prompt photons in photoproduction as a function of E_T and rapidity:

- Results consistent with QCD predictions

ZEUS has found the first evidence for deeply virtual Compton scattering at HERA:

- Analysis of shower shapes of DVCS photon candidates indicates that potential background from hadron production is small, and cannot account for signal observed
- Data in reasonable agreement with LO prediction by L.L.Frankfurt, A.Freund, and M.Strikman
- Future work will focus on extracting measurements of **skewed parton distributions** through DVCS interference with QED Compton process