

Photons and Diphotos from the Tevatron

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Photon related measurements from the Tevatron W W eeee bbbb

Loosely organized around measurements that have some (perhaps remote) connection to structure functions and QCD

- 1) Methodology - how the measurements are made
- 2) Various Topics:
 - a) single photon cross section
 - b) photons plus jet(s)
 - c) single photons plus charm
 - d) diphotos
- 3) What to expect in the near future



Highly isolated (D0 2 GeV in an annulus dR .2 to .4
CDF 2 GeV in cone of .7 in $R = \sqrt{\Delta \eta^2 + \Delta \phi^2}$) neutral
electromagnetic clusters

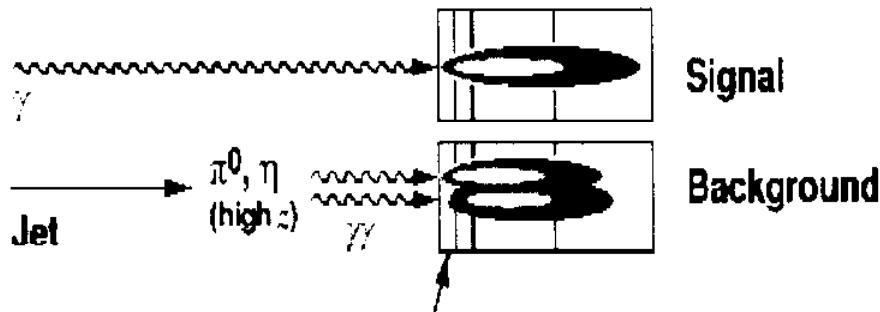
Background Estimation

Even after these cuts, significant background remains;
predominantly from QCD jets fragmenting to isolated π^0, η^0

$$\sigma_{jet} / \sigma_\gamma \sim 10^3$$

$$P(jet \rightarrow "y", z \approx 1) \sim 10^{-3}$$

Use longitudinal shower shape to estimate purity of sample:



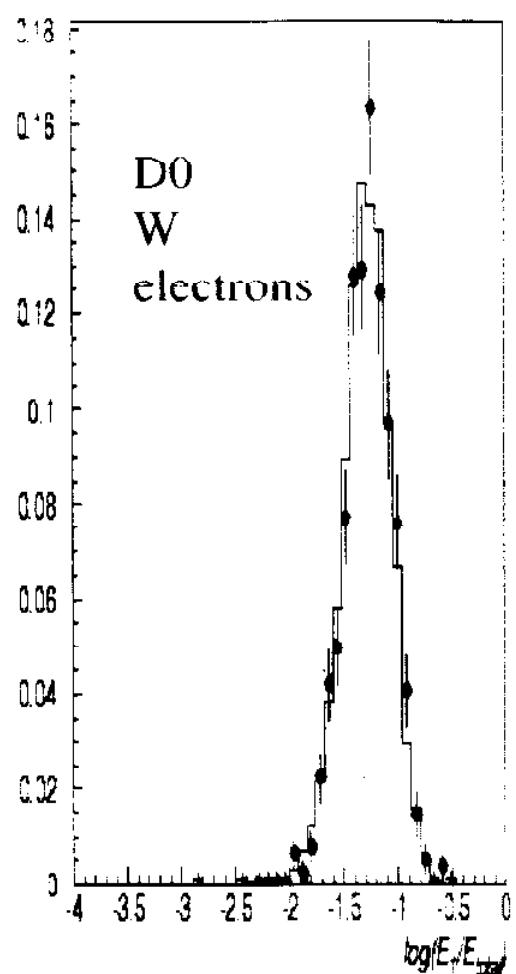
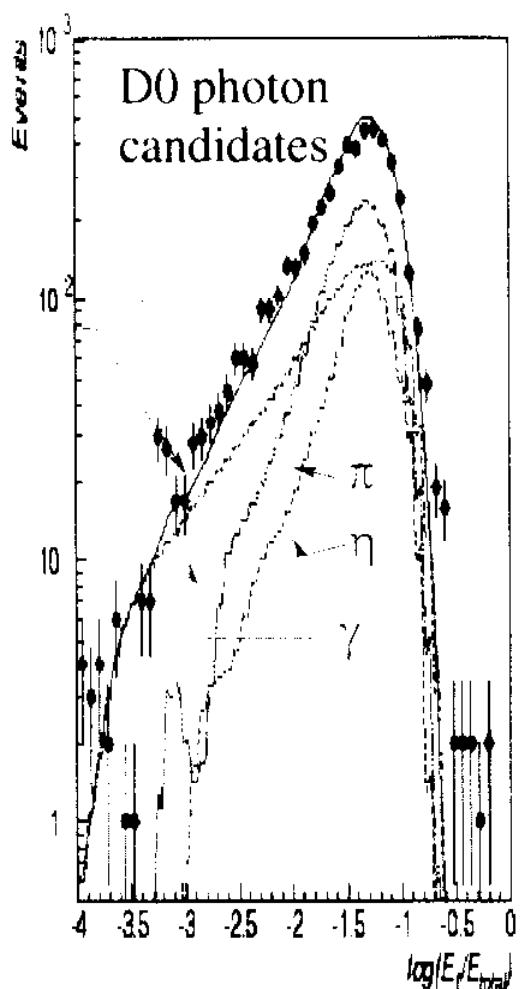
***Two photons → higher probability to convert
and deposit energy in first layer ($2X_0$)***

Other methods:

Shower shape used to discriminate between EM and hadronic electromagnetic shower

Counting conversions in a radiator in front of the calorimeter





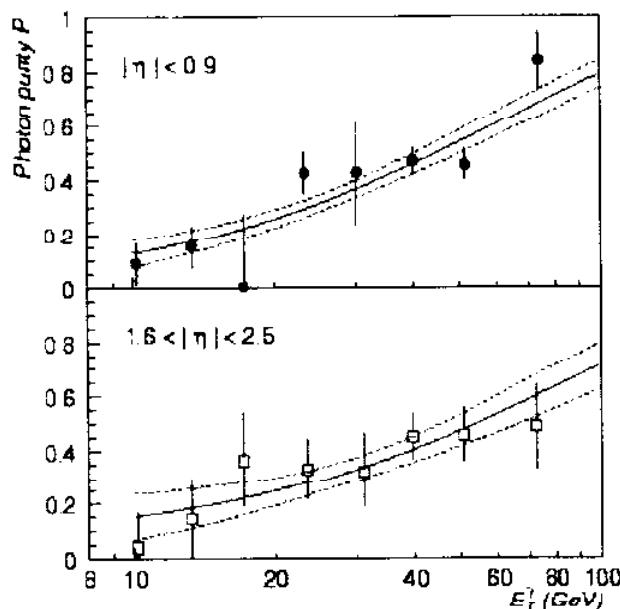
Purity determined in E_T bins then fit versus E_T

$$P = 1 - e^{-(a + bE_T)} = \text{Purity (photons/total)}$$

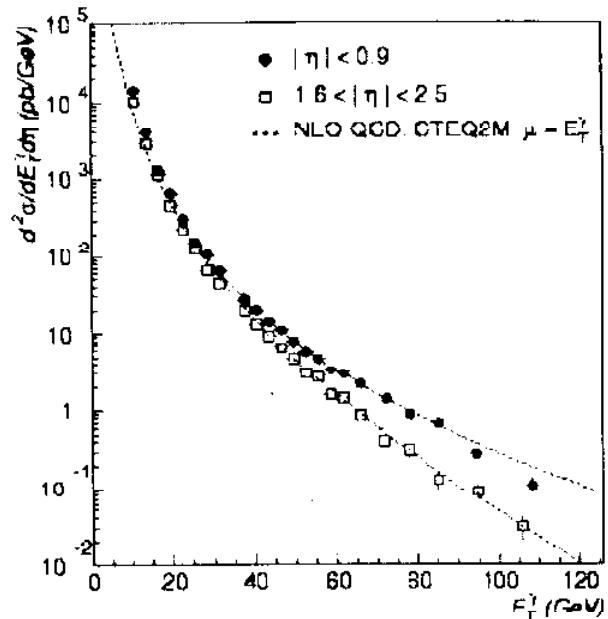


$\sim 15 \text{ pb}^{-1}$ each exp.

D0



Background curves used
to evaluate photon fraction

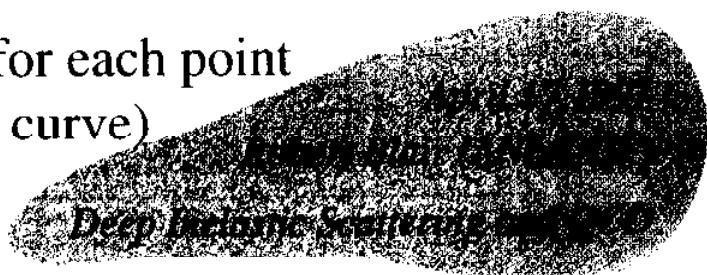


Cross section

CDF uses two methods:

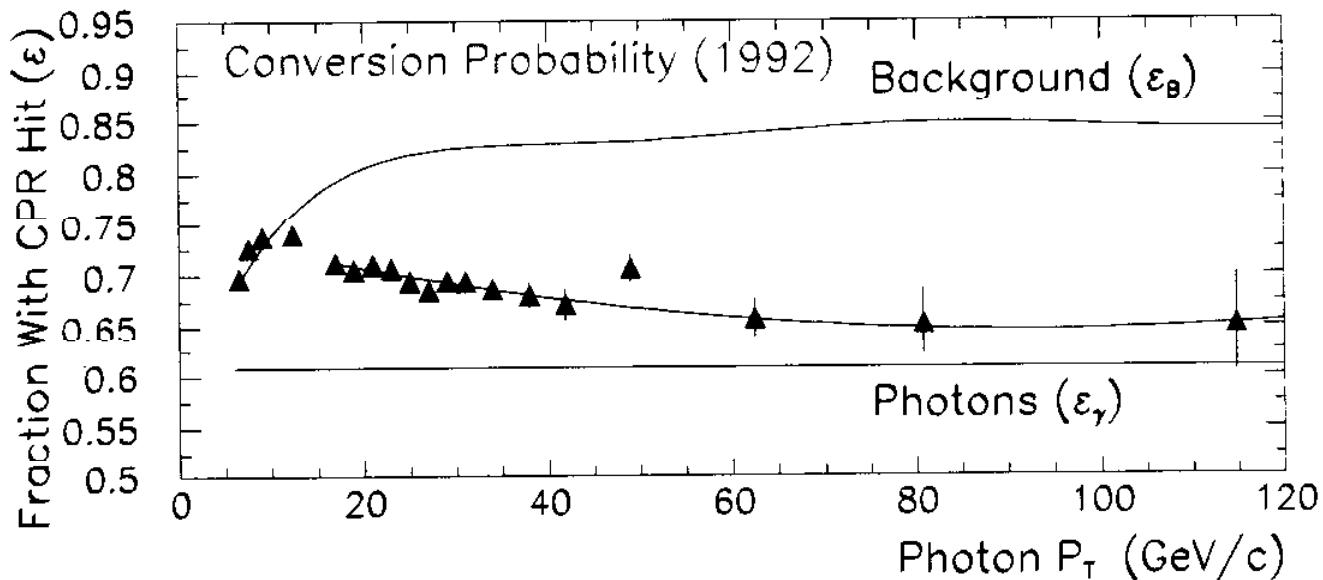
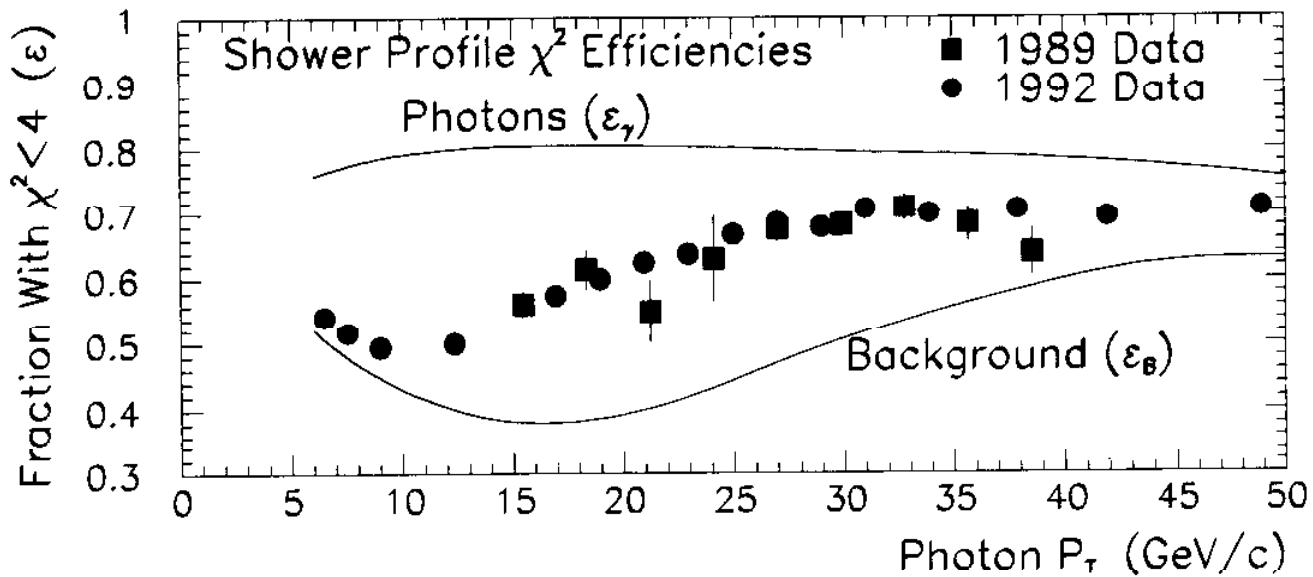
- lateral shower shape - good below 35 GeV in E_T
- conversion rate in traversing the coil

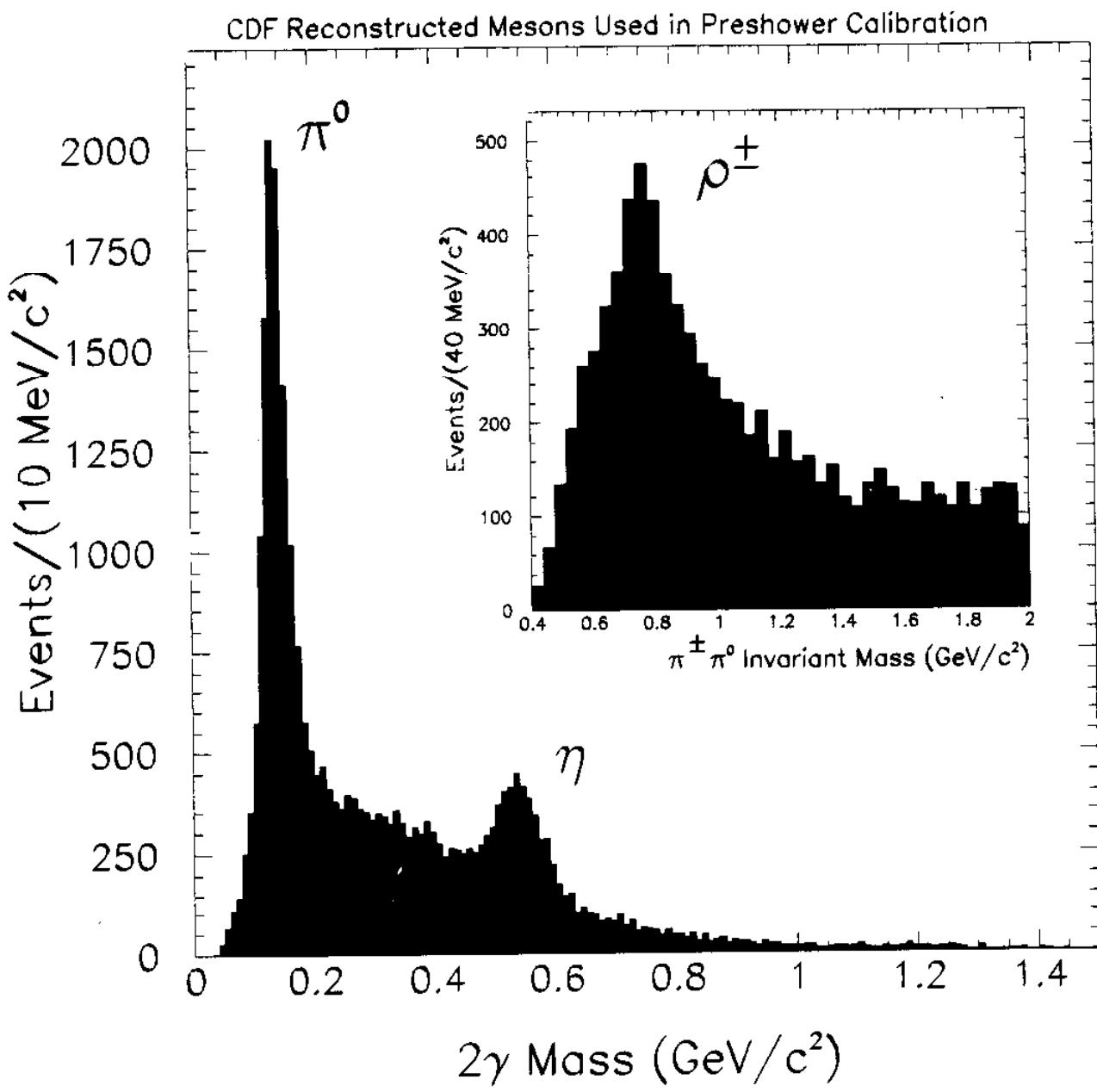
Background is evaluated for each point
plotted independently (no curve)

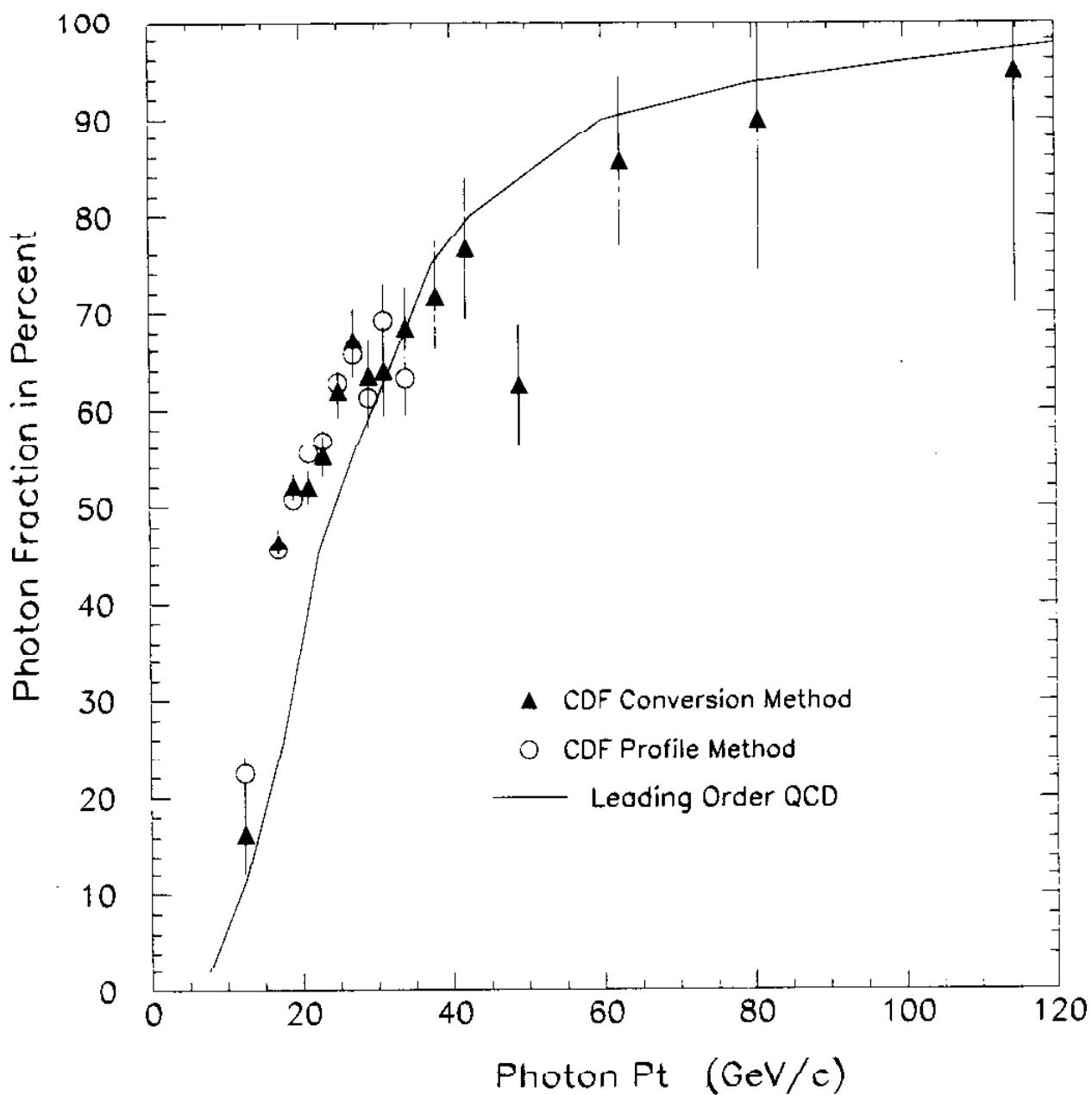


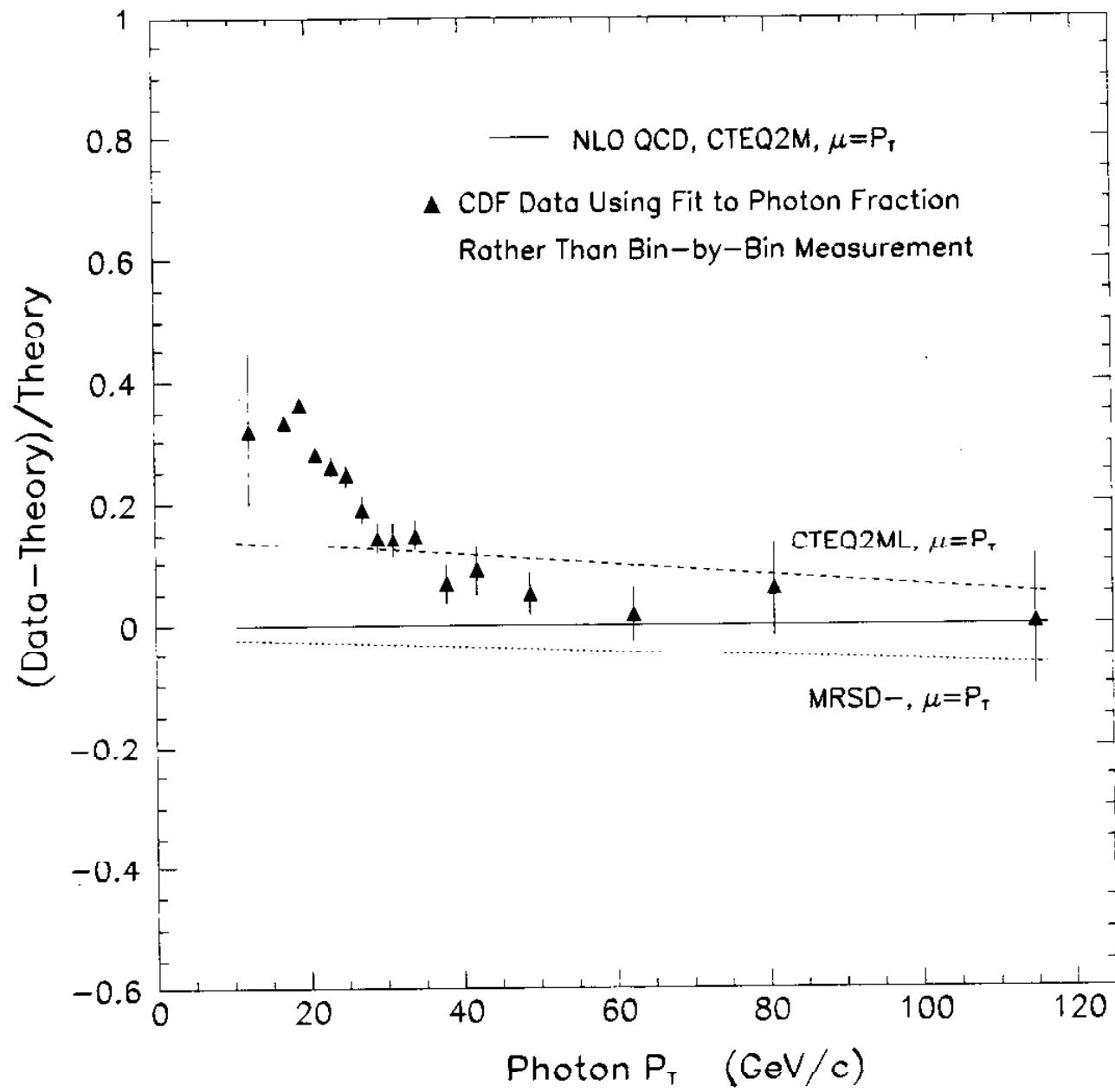
CDF Background Subtraction Methods

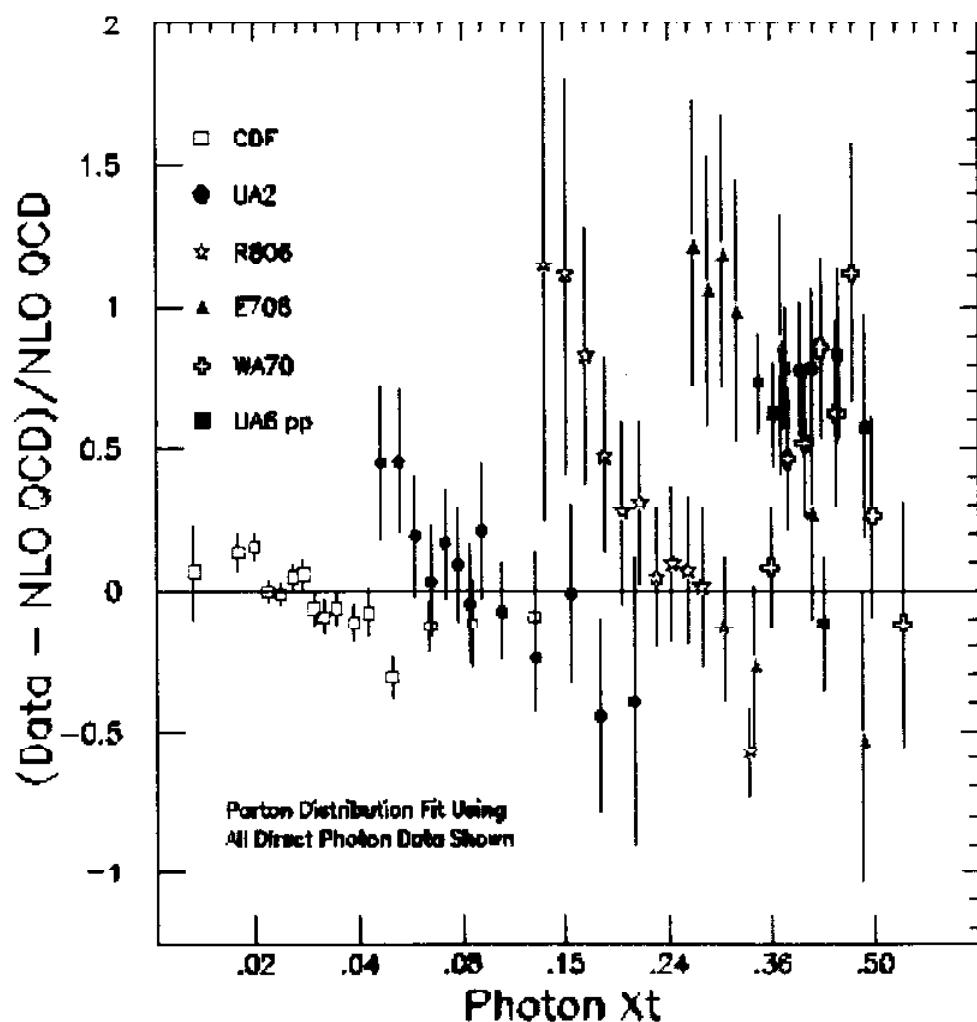
$$\text{Fraction of Photons} = (\varepsilon_B - \varepsilon) / (\varepsilon_B - \varepsilon_\gamma)$$



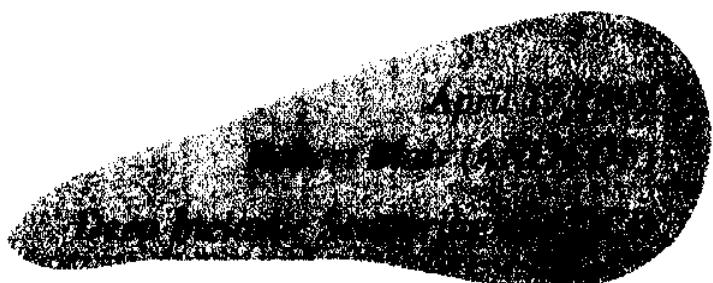


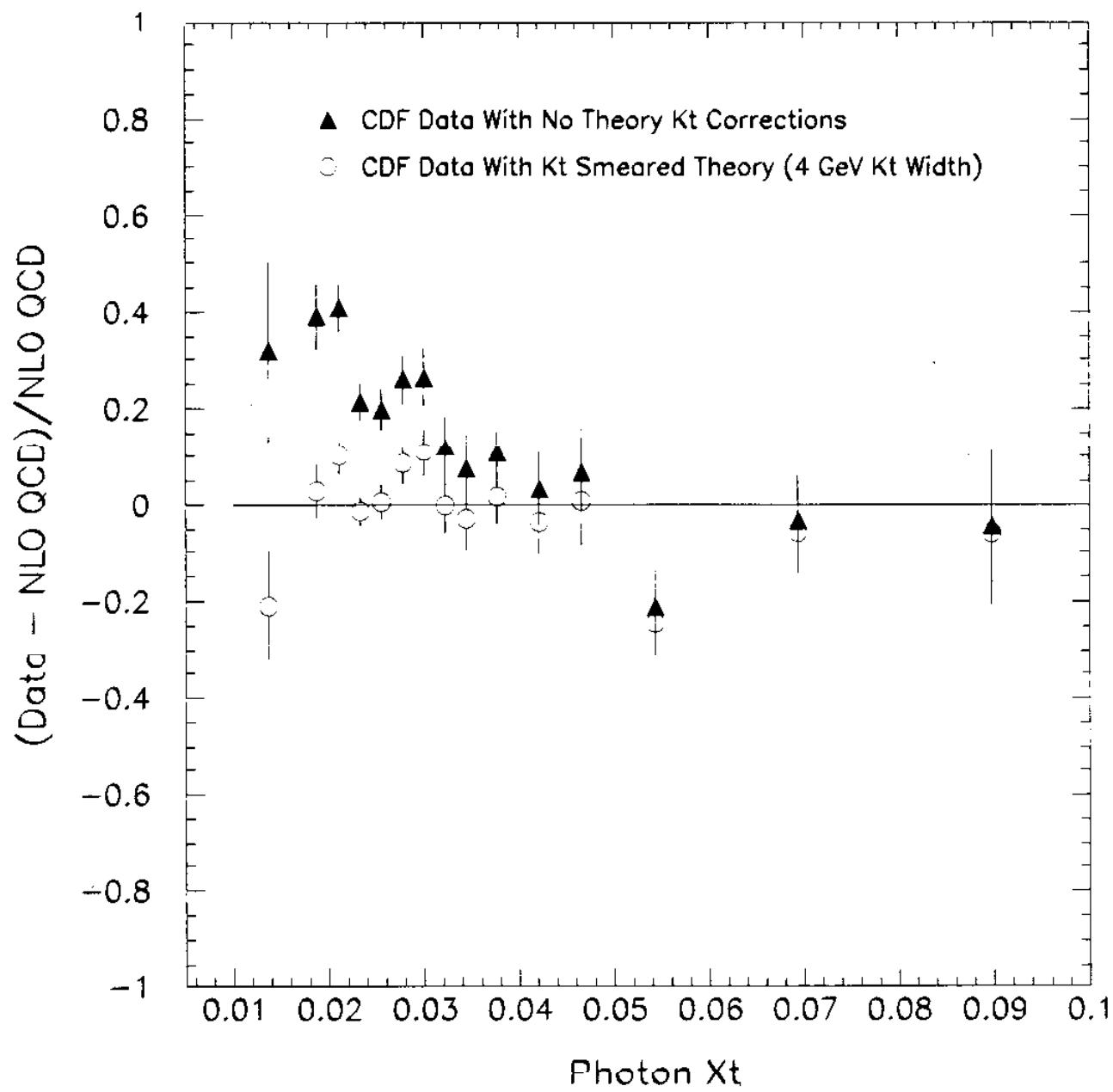


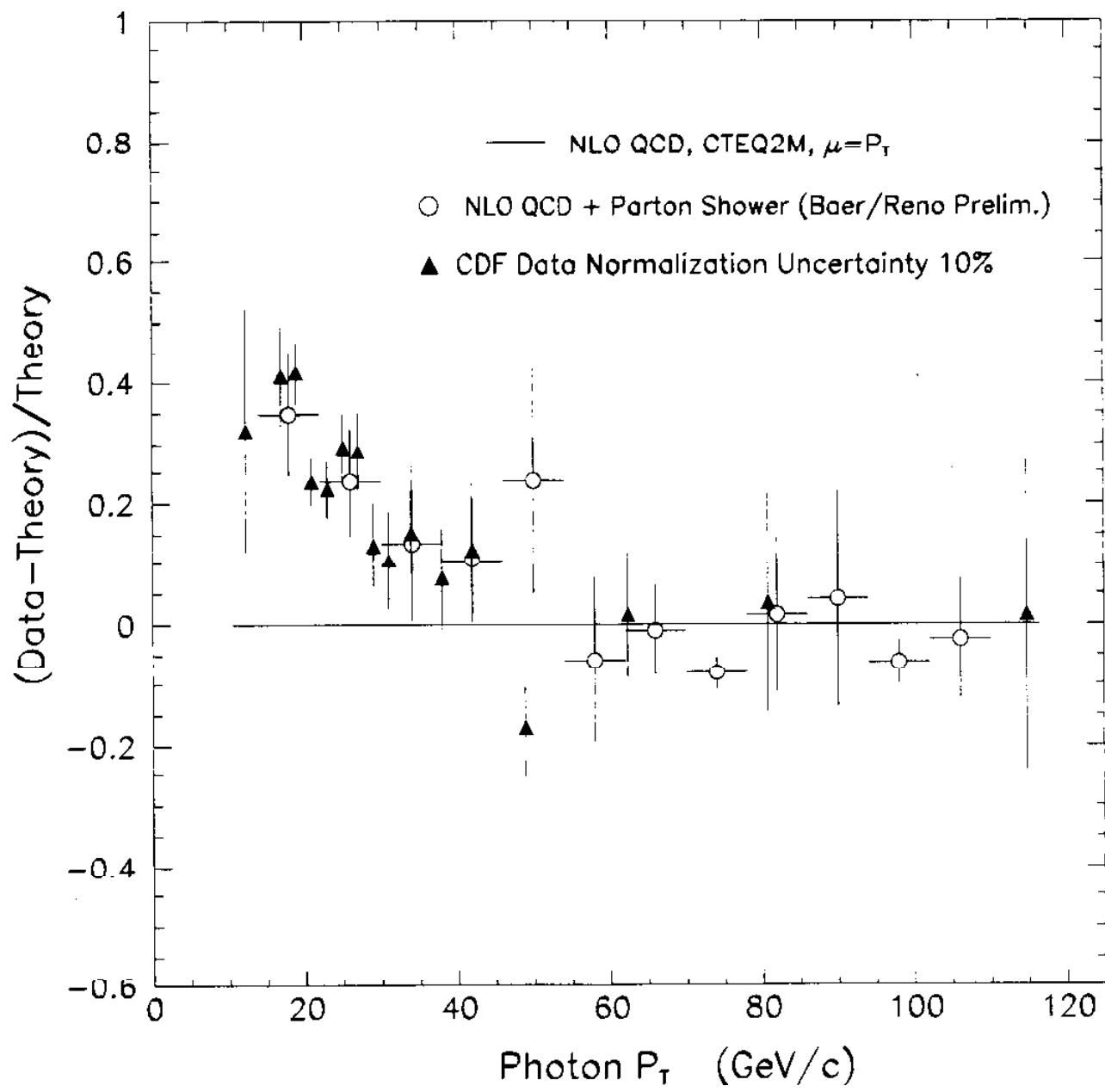


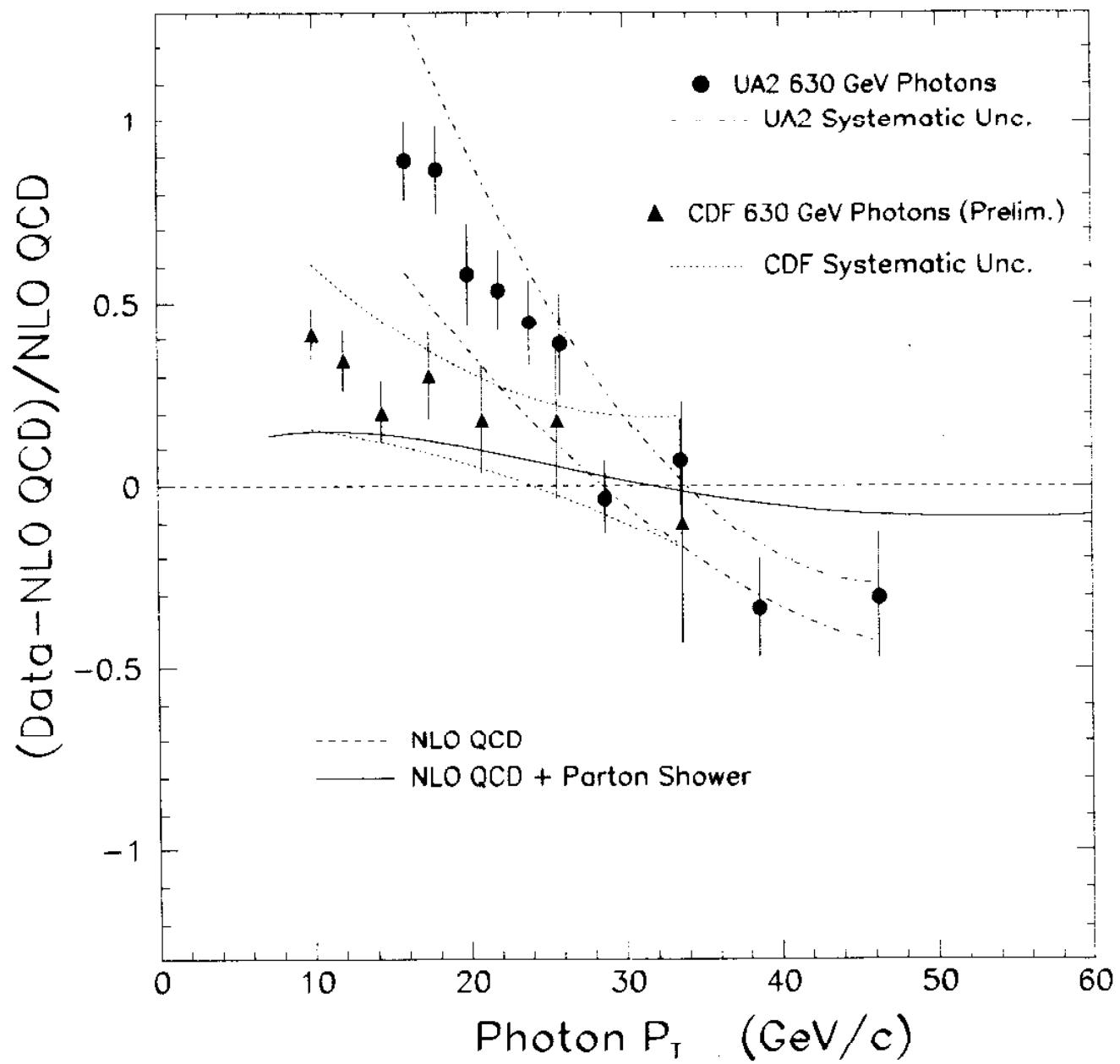


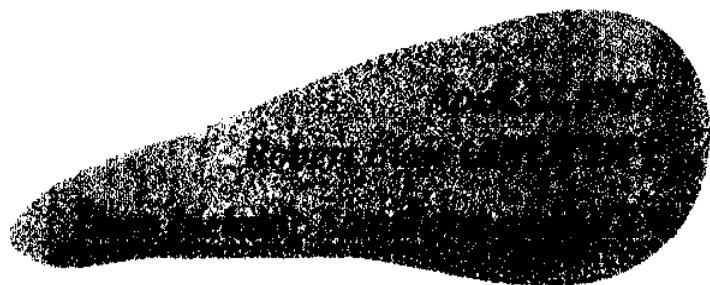
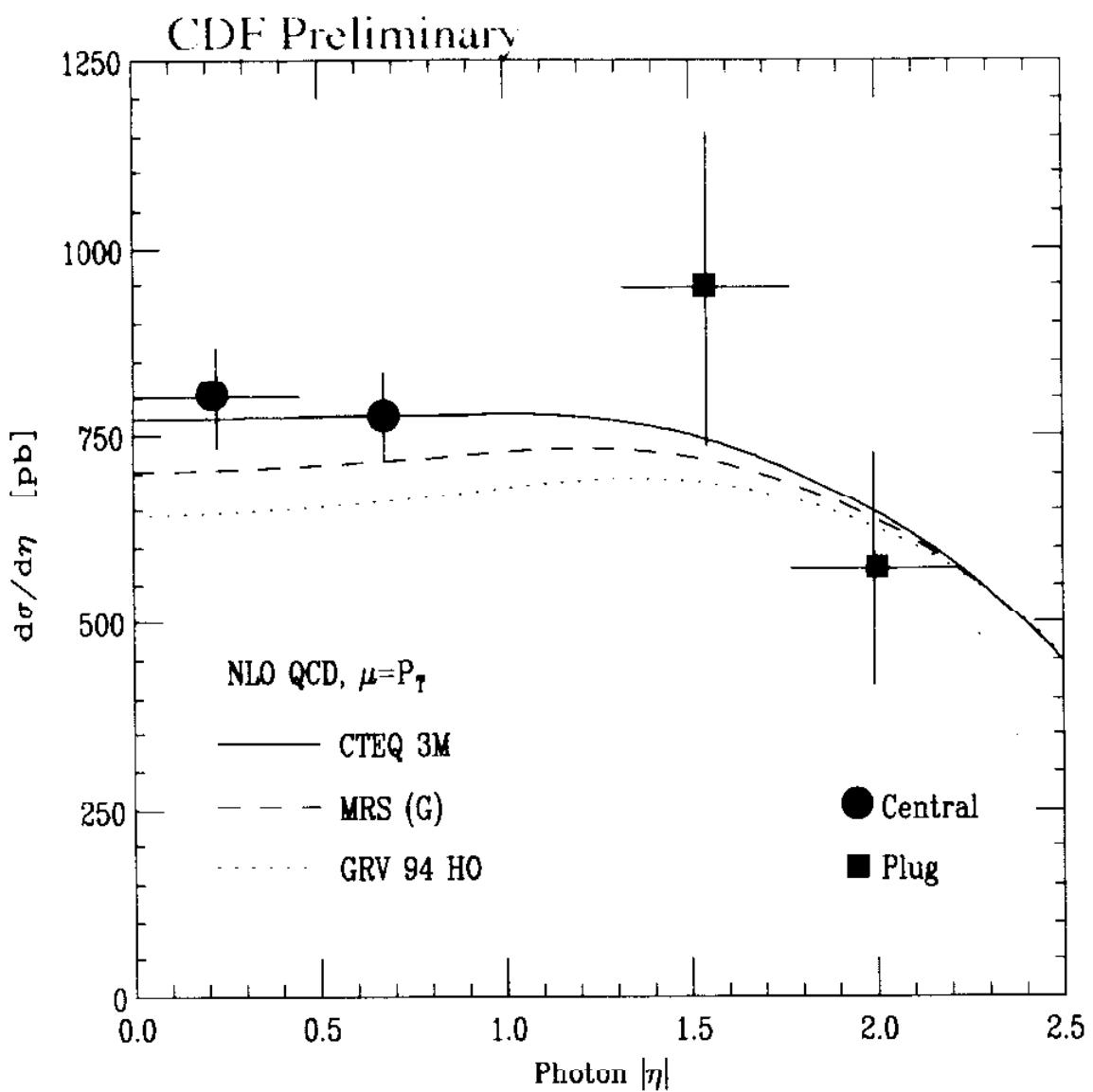
Deviations at low E_T not unusual
seen at low E_T NOT at low x !
The explanation appears to be soft multiple
gluon emmission and can be modeled by
adding shower MC's to standard NLO QCD.





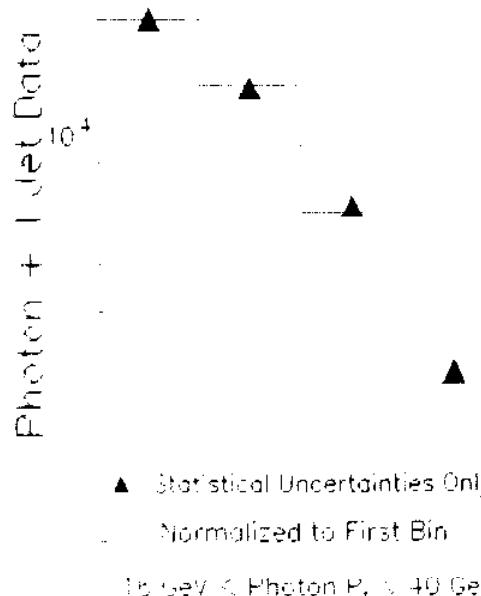






16 pb^{-1}
require jet 30° from back-to-back
with γ

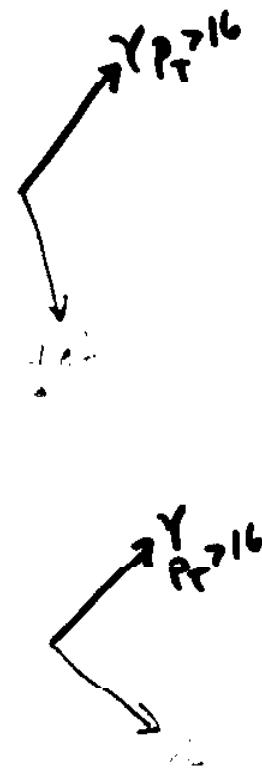
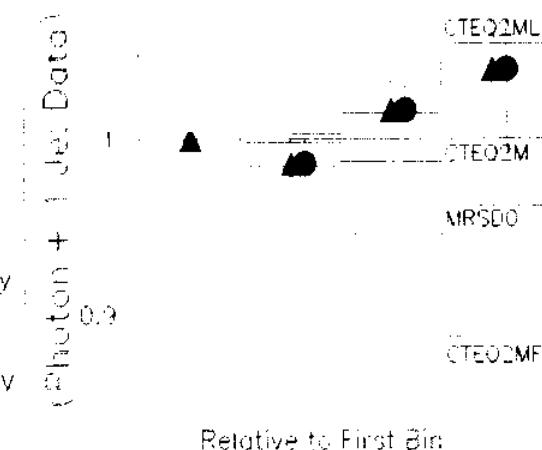
CDF Preliminary
Theory is NLO QCD
with CTEQ2M Parton Distributions



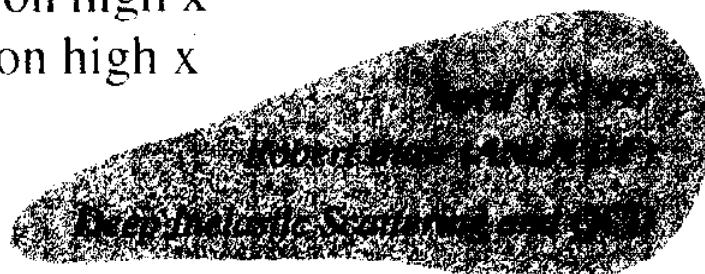
CDF Preliminary
Theory is NLO QCD
with CTEQ2M Parton Distributions

16 GeV < Photon P_T < 40 GeV

- ▲ Statistical Uncertainties
- Systematic Uncertainties



Central photon plus jet pseudorapidity picks out different x regions for initial partons.
central-forward is low x on high x
central-central is high x on high x



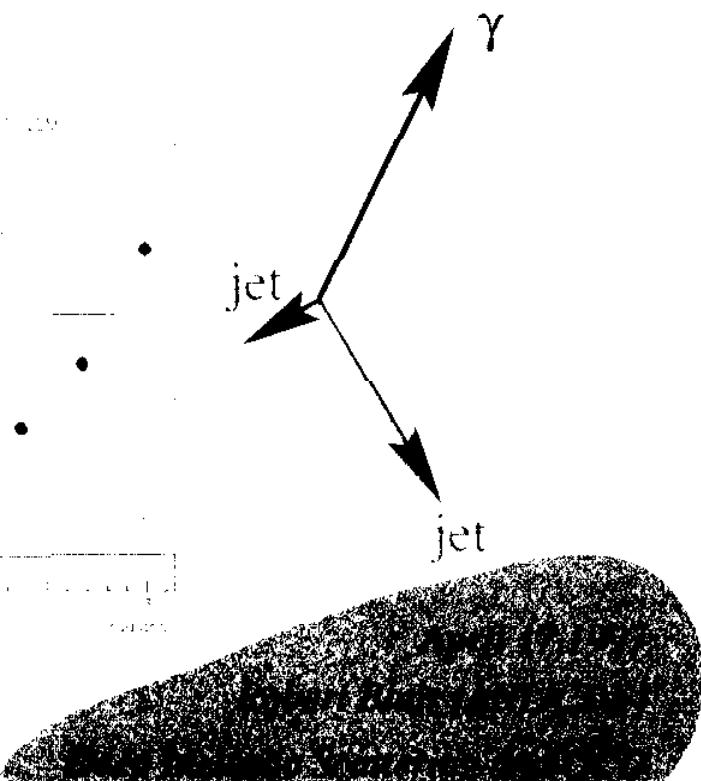
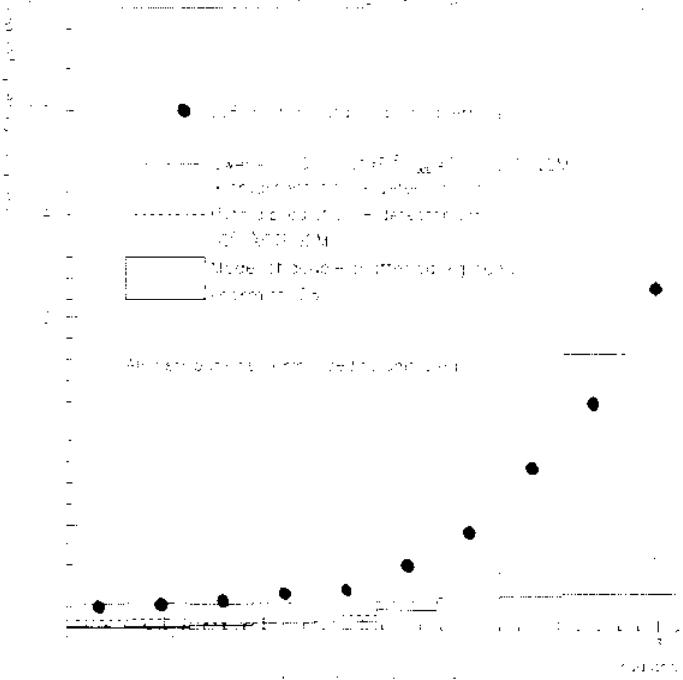
Run (1992-1993), $\sim 16 \text{ pb}^{-1}$

event selection

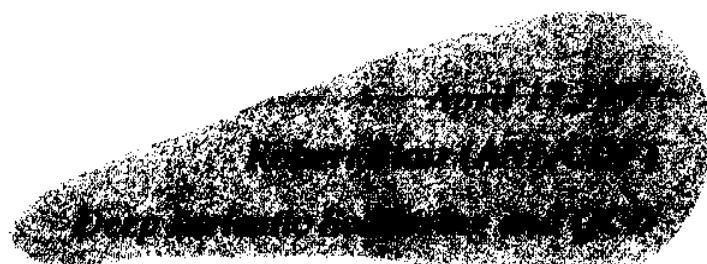
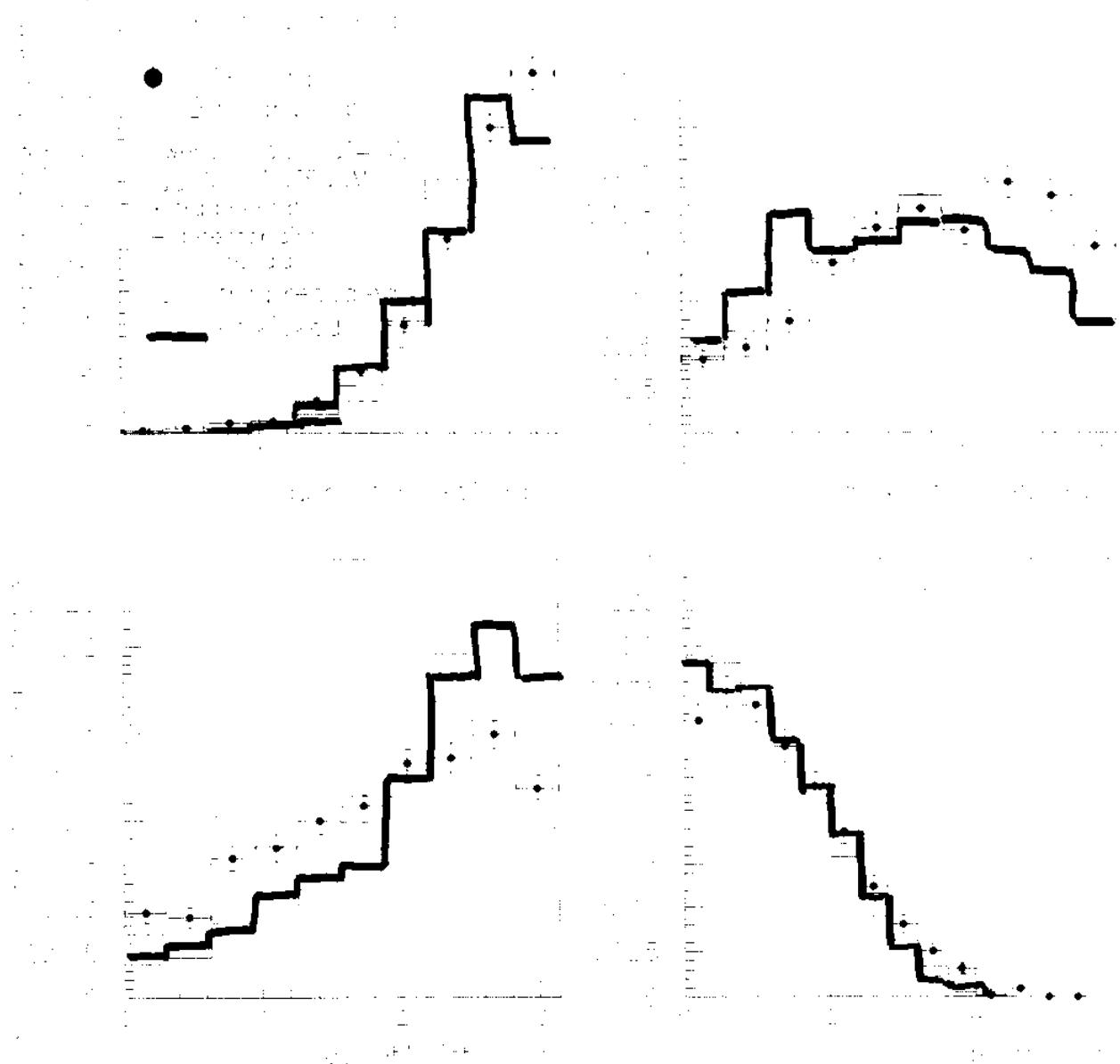
- chion:
 - central EM cluster: $|\eta_{\text{det}}| < 1.1, E_t > 16 \text{ GeV}$
 - isolation: extra transverse energy in $(\Delta\eta^2 + \Delta\Phi^2)^{1/2} = 0.7 \leq 4 \text{ GeV}$
 - no (3D) tracks: no 3D tracks pointing at preshower hit for $E_t \geq 35 \text{ GeV}$
 - transverse shower profile consistent with photon hypo. ($\chi^2 \leq 20$)
 - no extra clusters in shower_max chamber above 1 GeV
 - $|\eta_\gamma| \leq 0.9$
- $|z_{\text{vertex}}| \leq 60 \text{ cm}$
- jets:
 - 2 jets with $|\eta_{\text{jet}}| < 2.5, E_t > 8 \text{ GeV}$ ($R=0.7$ cone)
 - strong isolation requirement: $\Delta R_{\gamma,\text{jet}} \geq 0.8$

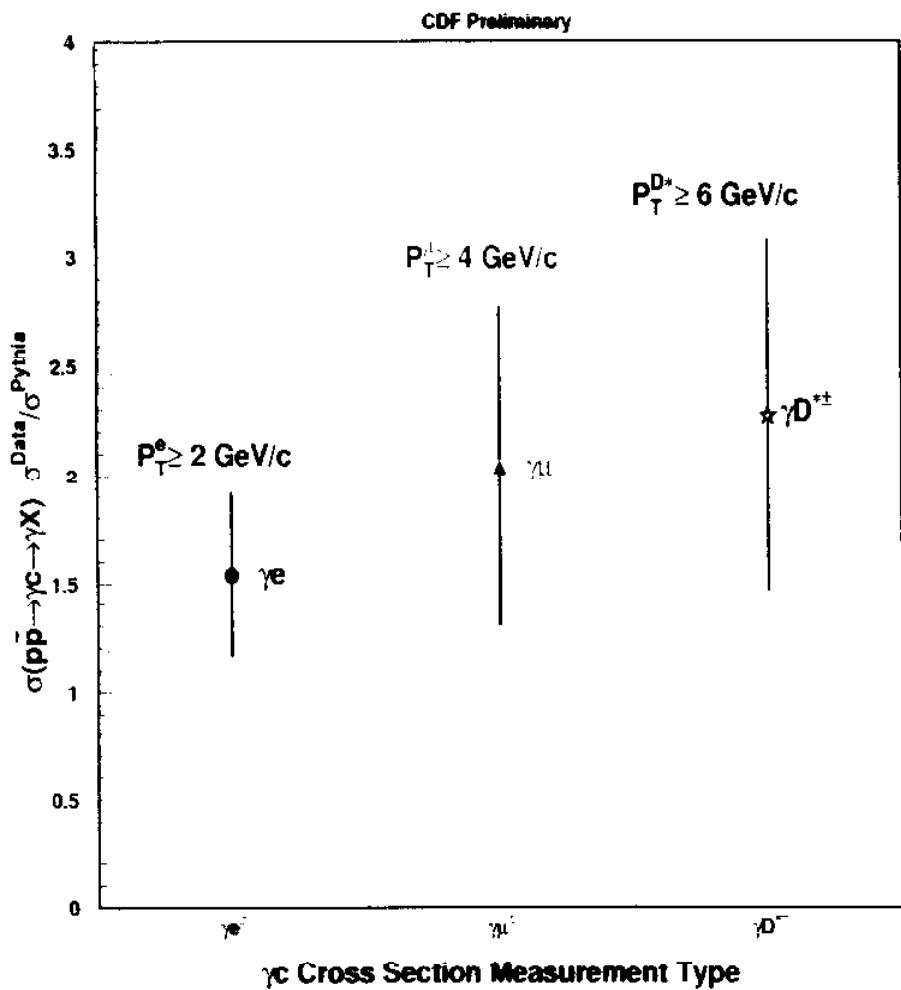
→ 34,116 photon + 2 jet - candidates

(average purity: 0.42)

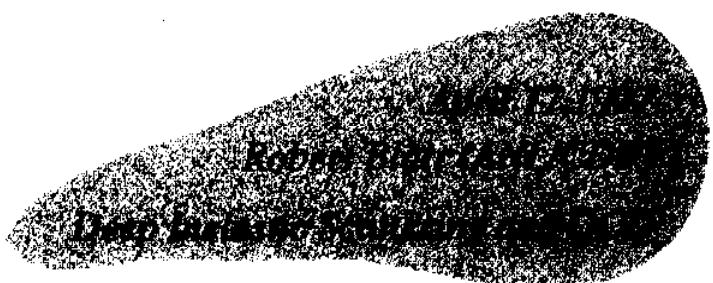


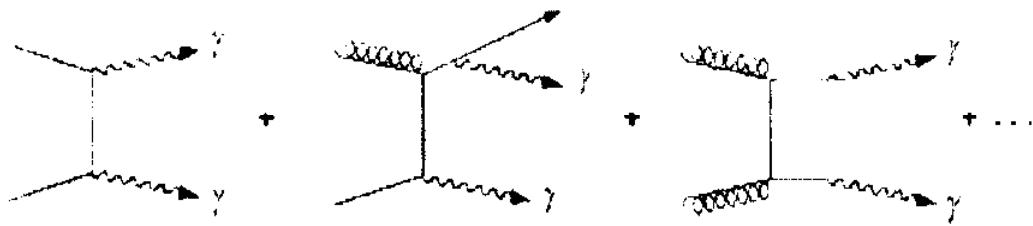
CDF Preliminary





CDF measurements of photon plus charm (sensitive to charm content of the proton). Run 1a only ~ 20 inverse picobarns of data, but much more photon muon data currently being analysed.





Born

DØ

NLO

Event Selection
80 pb⁻¹ Run 1B (1994-5)

Box

Software Trigger: 2 EM clusters, $E_T > 12$ GeV

Offline Selection: 2 candidates $|\eta| < 1.0$, $E_{T12} > 14, 13$ GeV
Isolation, shower shape, EM fraction,
Drift Chamber hits cut [reject $\ell \rightarrow ee$]

→ 418 $\gamma\gamma$ candidates

Acceptance × efficiency ~ 0.48 Purity (from EM_1/E_{total}):
 $E_{\gamma\gamma} < 20, E_{T12} < 20$ $P = 0.26 \pm 0.10$
 $E_{\gamma\gamma} > 20, E_{T12} < 20$ 0.30 ± 0.11
 $E_{\gamma\gamma} > 20, E_{T12} > 20$ 0.38 ± 0.22

D0 subtracts background by evaluating purity in four categories. CDF does point by point background evaluation and shows one bin background evaluation for comparison.



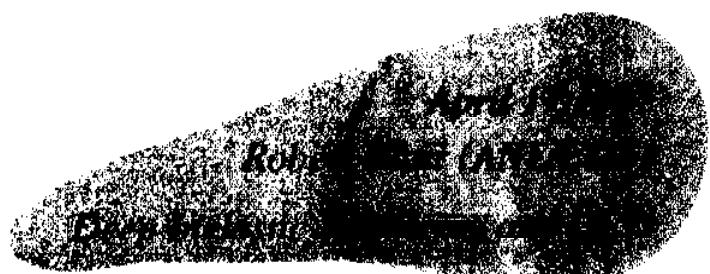
CDF Diphoton Sample

Run : (1992-1995), 84.0 pb^{-1}

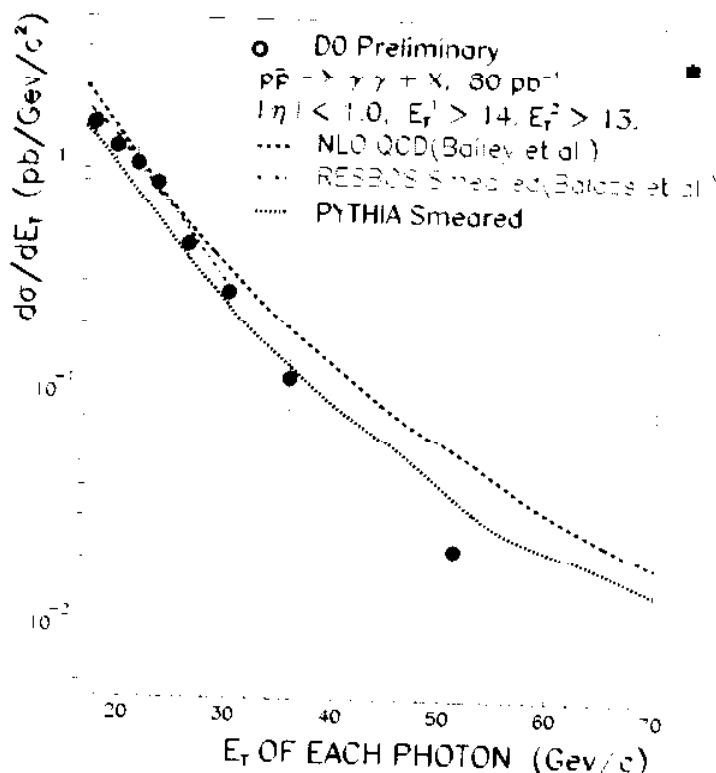
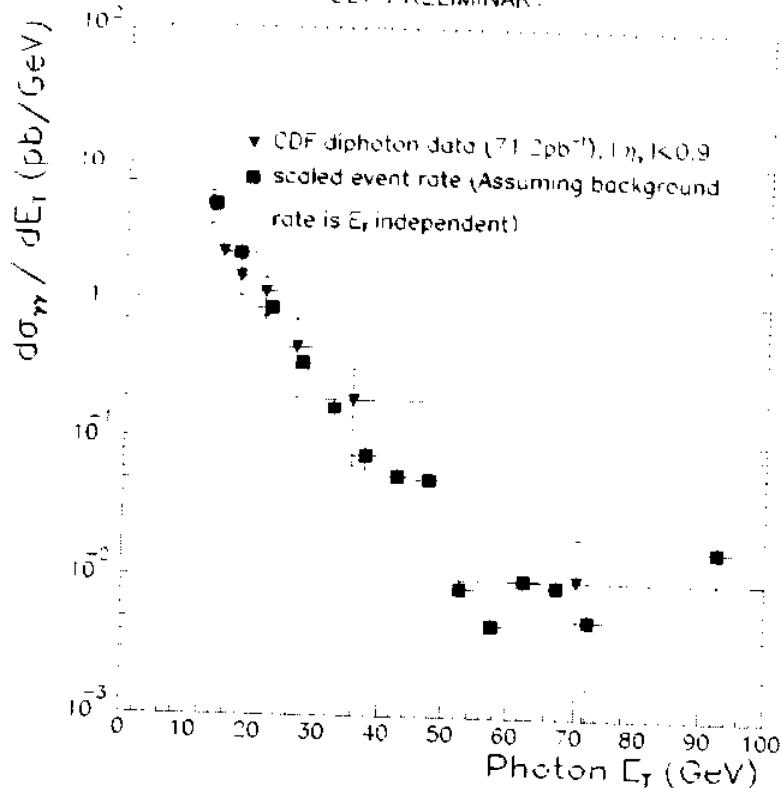
event selection:

- 2 central EM clusters: $|\eta_{\text{det}}| < 1.1, E_T > 12 \text{ GeV}$
- Level 2 diphoton trigger
- isolation: extra transverse energy in $(\Delta\eta^2 + \Delta\Phi^2)^{1/2} = 0.7 < 4 \text{ GeV}$
- no (3D) tracks; no 3D tracks pointing at preshower hit for $E_T > 35 \text{ GeV}$
- transverse shower profile consistent with photon hypo. ($\chi^2 \leq 20$)
- no extra clusters in shower_max chamber above 1 GeV
- $|z_{\text{vertex}}| \leq 60 \text{ cm}$
- $|\eta_\gamma| \leq 0.9$

⇒ 918 diphoton candidates



CDF PRELIMINARY

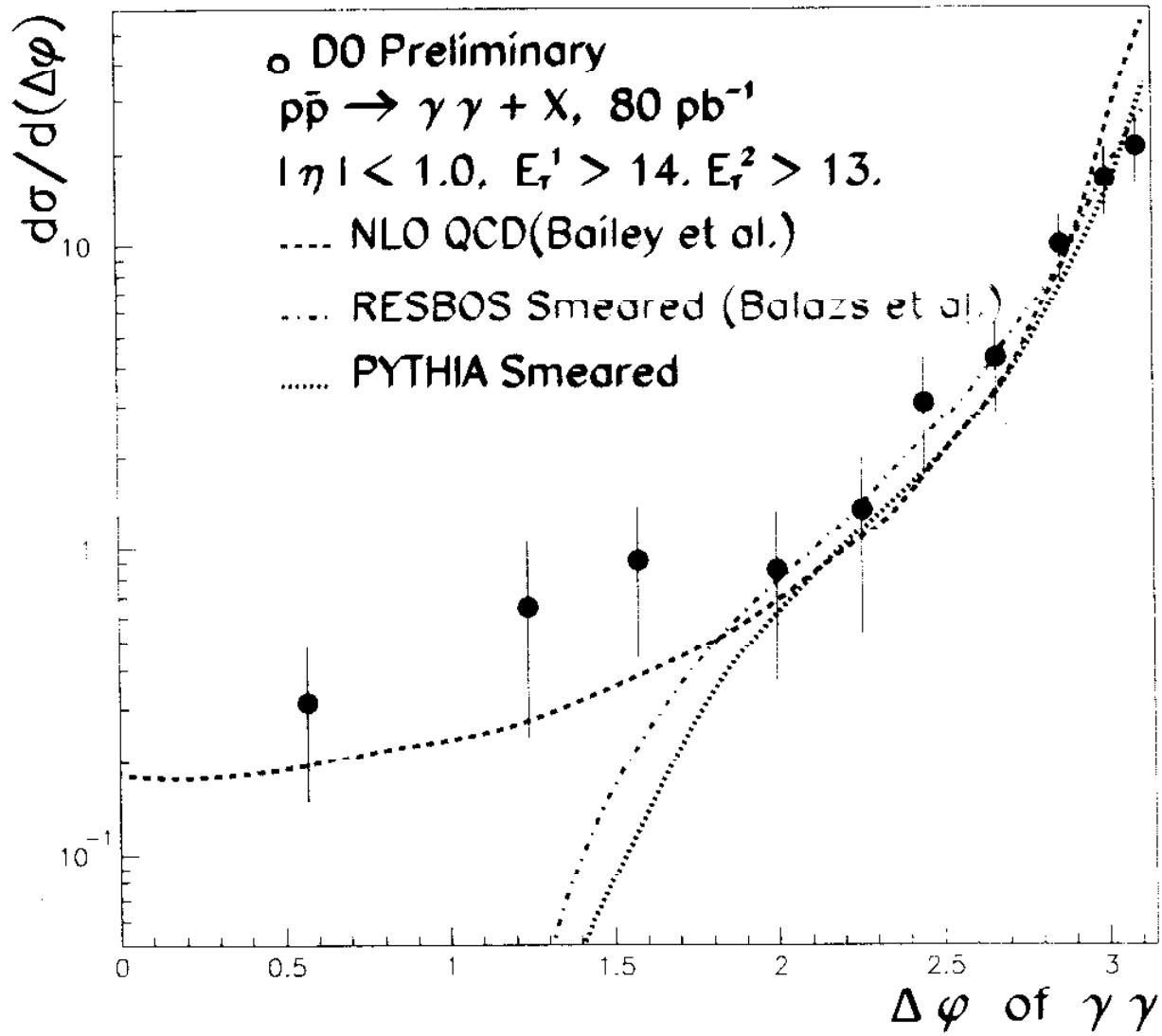


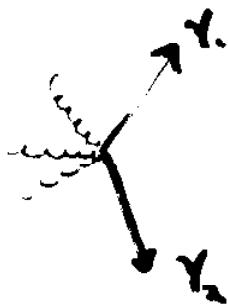
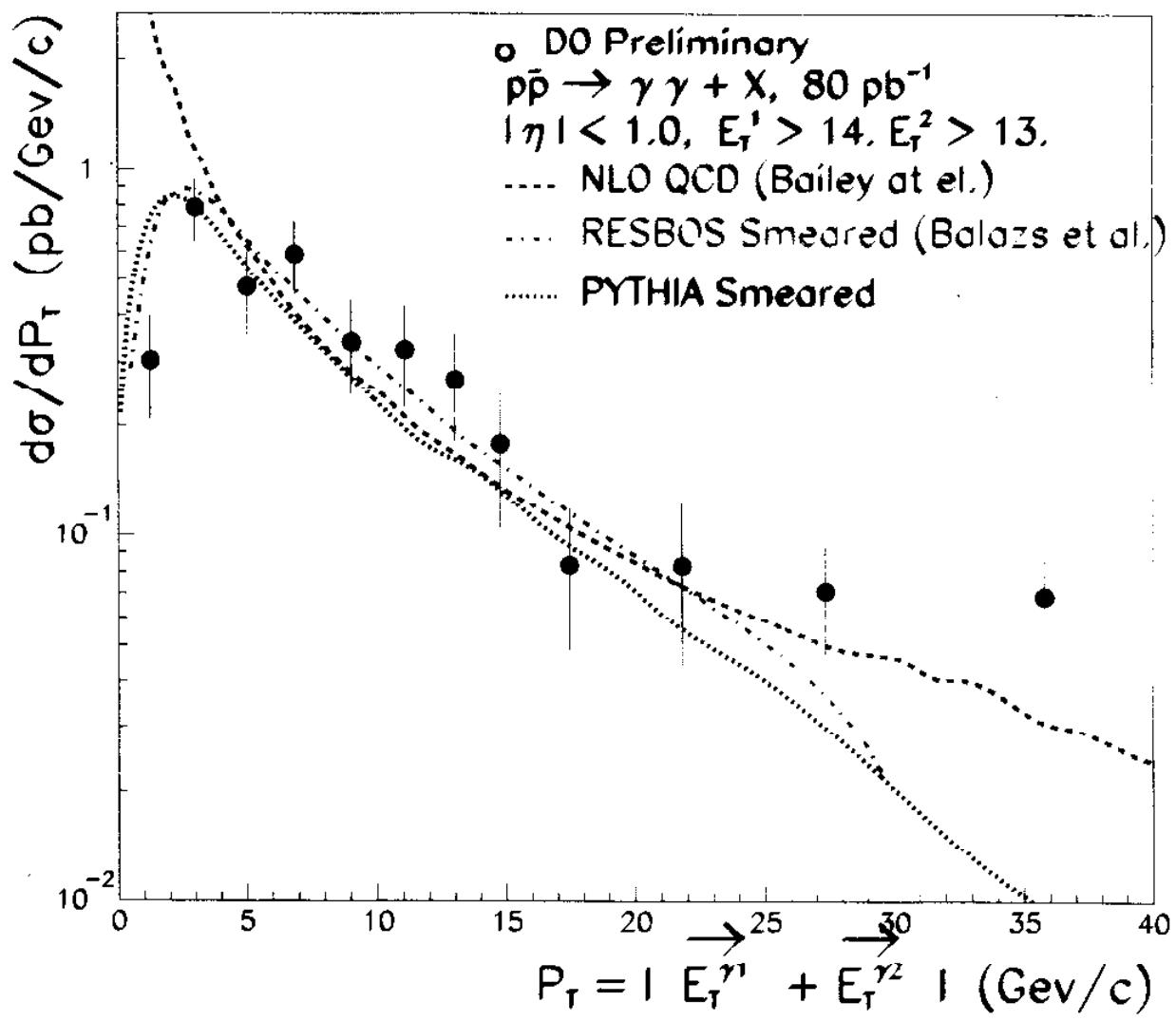
resummed NLO
model available:
RESBOS

Phys.Lett.B353,548-554,
1995, hep-ph/9505203.

resums multiple soft gluon
emission in the initial state;
originally for reproduction of
massive vector mesons







Conclusion

- Lots of photon measurements have helped tune our understanding of the limits of the perturbative calculations

For the Future

- New single photon cross section results for both D0 and CDF will be out soon.
- New photon plus muon results from CDF will follow.

