Fermi National Accelerator Laboratory

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CDF

Direct Photons at CDF

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FOR THE CDF COLLABORATION

Direct Photon measurements from the CDF experiment will be described. These include the inclusive photon pt spectrum, photon+jet angular distributions, diphoton production, photon+2jet production, and photon+charm production. Comparisons to QCD predictions will be made.

1 Introduction

The Tevatron Collider has produced collisions of antiprotons and protons at a center of mass energy of 1800 GeV. The Collider Detector at Fermilab (CDF) is a general purpose magnetic detector, used by a collaboration of $\sim$ 450 physicists, to study these collisions. In 1988/89 CDF recorded $4pb^{-1}$ of data, denoted "Run 0." In 1992/93 we recorded $20pb^{-1}$, denoted "Run 1a," and in 1994/95 we recorded $90pb^{-1}$, denoted "Run 1b." A further small sample from 1995/96 is denoted "Run 1c" which notably includes a $0.5pb^{-1}$ sample at center of mass energy 630 GeV.

The study of the production of direct isolated photons is good way to confront predictions of QCD; prompt photon production should be dominated by the Compton process ($gq \rightarrow \gamma q$) which should be sensitive to the gluon distribution.[1] Calculations at next-to-leading order (NLO) should make predictions reasonably accurate.[2] The lower E_T may be influenced by initial state showering or k_T kick[3] as is implemented in PYTHIA.[4] Also, the observed spectra may be distorted by fragmentation photons not removed by the isolation requirement.[5]

Direct photons are identified statistically in CDF by, in addition to isolation, the shower maximum transverse profile in the electromagnetic calorimeter and by conversion probability in preshower detectors. Standard samples of photons from η^0 decay and π^0's from $\rho^{\pm}$ decay allow a systematically clean statistical (rather than event by event) separation.

2 Inclusive Photon Production

Direct isolated photon production was measured using 1a data.[6] The E_T spectrum is compared to predictions in Fig. 1. The agreement with NLO QCD predictions at high E_T is quite good but the excess at the low end seems to require internal k_T as may be provided by using shower Monte Carlo techniques.

Most photon measurements are for the central detector, photon pseudorapidity $|\eta| < 1$. In the E_T range $27 < E_T < 40$ GeV the measurement has been extended

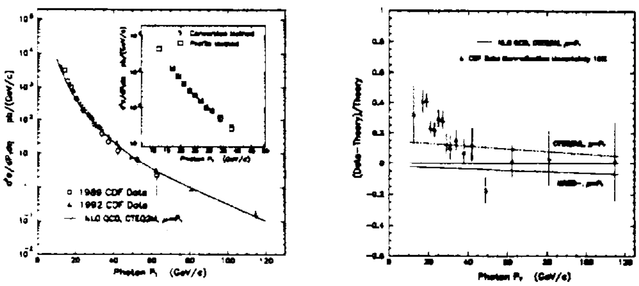

Figure 1: CDF inclusive isolated photon production as a function of photon E_T for central photons at 1800 GeV (left) on a log scale comparing the two photon identification methods and (right) the linear theory difference showing the low E_T excess which implies k_T smearing.

to the plug detector so that rapidity comparison can be made. The result is compared to predictions in Fig. 2.

The recent 630 data has allowed a further comparison with predictions as well as UA2 results.[7] The results, shown in Fig. 3, are in systematic disagreement with the UA2 measurement but agree well with predictions compatible to those which describe the 1800 data.

3 Photon plus Jet

The angular distribution of photon in the photon plus jet center of mass should be different than the equivalent dijet angular distribution due to the different mix of spin of the t channel exchange. Dijets,[8] photon plus jet,[9] and W production[10] are compared in Fig. 4 (left). The distributions are fairly well described and the residual discrepancy in the photon distribution can be explained if the isolation requirement does not completely remove fragmentation as opposed to Compton photons, as seen in Fig. 4 (right).

4 Photon plus Two Jets

The study of photons produced with two jets can confront the QCD ability to predict additional soft radia-

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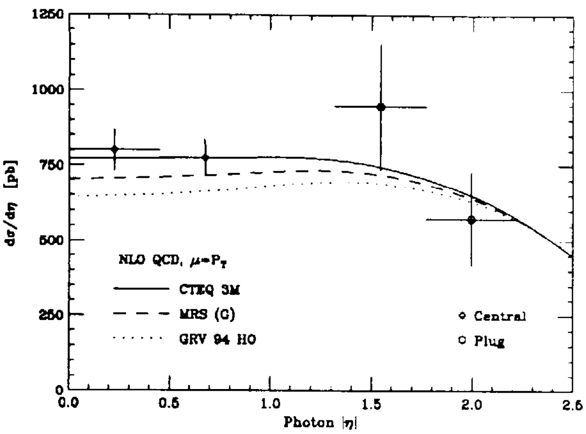

Figure 2: CDF preliminary photon $|\eta|$ distribution for E_T between 27and 40 GeV.

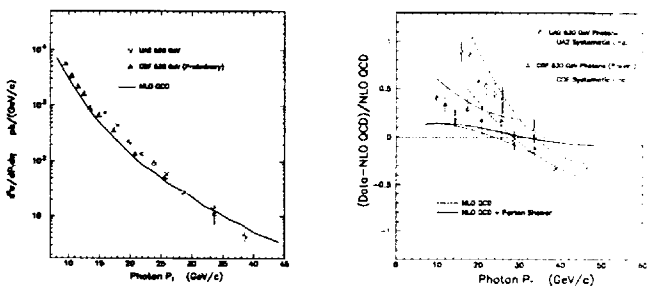

Figure 3: CDF preliminary inclusive isolated photon production as a function of photon E_T for central photons at 630 GeV compared to UA2 left on a log scale and right the linear theory difference showing the low E_T excess which implies k_T smearing.

tion. One complication is that double interactions need to be accounted, but this can be done by looking at relative azimuth of the softer jet which would be essentially flat if it came from and uncorrelated interaction. These are observed as well as a signal reasonably well predicted by NLO QCD in Fig. 5. Other energy and angular distributions can provide constraints for refining the QCD model as also illustrated in Fig. 6. There are some residual discrepancies which do not seem to be resolved in the usual ways.

5 Two Photon Production

The diphoton E_T distribution, measured for run 0,[11] has been measured for most of run 1 as shown in Fig. 7 and agrees reasonably well with expectations.[12] The p_T of the diphoton system, also shown in Fig. 7, illustrates the need to include k_T or parton shower effects in the model.

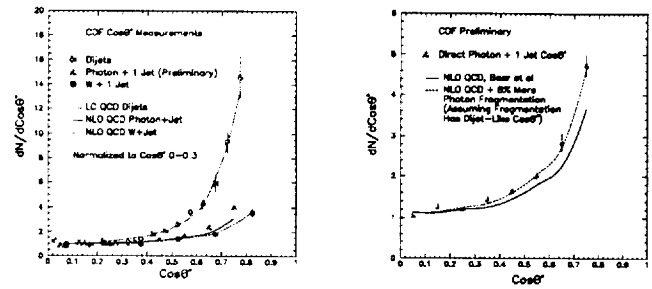

Figure 4: CDF angular distributions for γ plus jet left compared to dijets and W plus jet and right showing the apparent 8% fragmentation contribution.

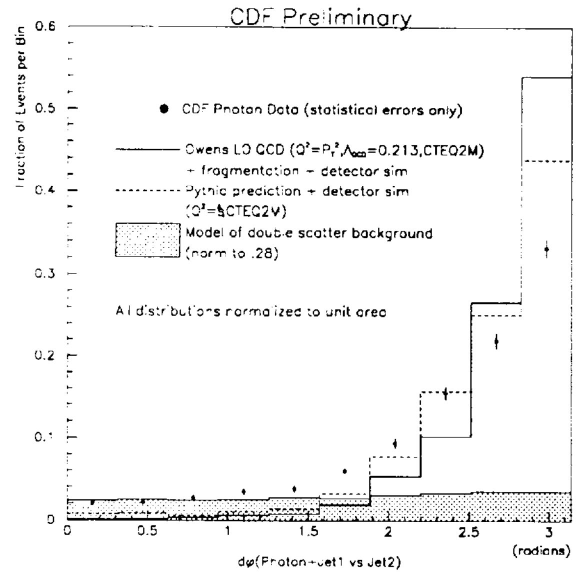

Figure 5: CDF preliminary (γ jet1) jet2 $\delta\phi$ distribution showing double scatter and LO and NLO predictions.

6 Photon plus Charm

Charm production in association with a photon should be sensitive to the charm content of the proton.[13] We have searched for charm production in association with a photon ($|\eta| < 1$) with E_T above 16 GeV in 1a data by looking in the accompanying jet for a D^* as seen in the mass difference shown in Fig. 8. The decay modes $K\pi$ and $K3\pi$ of the D^0 are used and p_t of the $D^{*\pm}$ must be at least 6 GeV/c. The lifetime as observed in the silicon vertex detector associated with this signal is in good agreement with the interpretation as charm as seen in Fig. 8. The cross section measured[14] of 0.38 ± 0.15 nb is a bit higher than that predicted for out selection using PYTHIA, which gives 0.18-0.22 nb depending on PDFs.

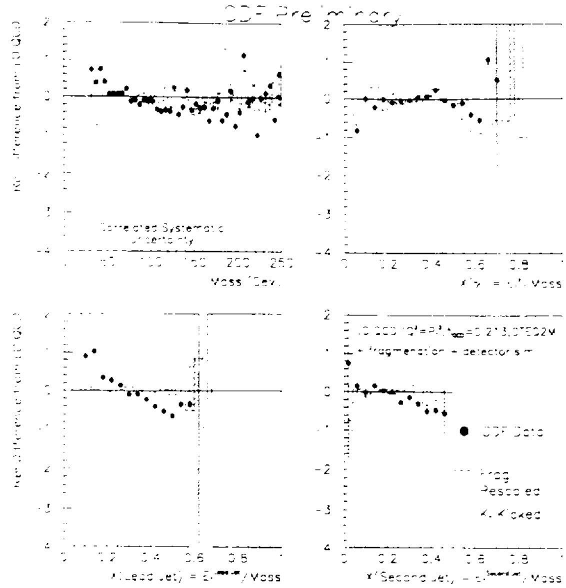

Figure 6: CDF preliminary γ jet jet mass and scaled energy distributions for the γ and each jet normalized to LO prediction. The shaded band illustrates the systematic uncertainty.

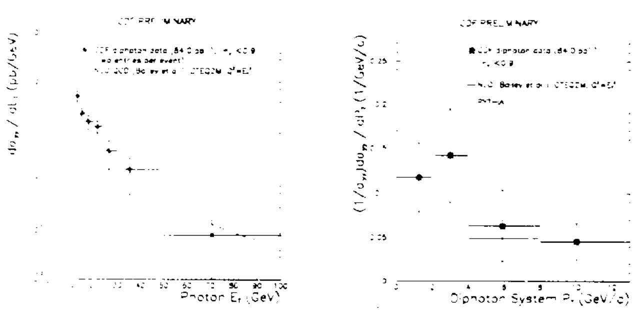

Figure 7: CDF preliminary inclusive isolated diphoton production as a function of photon E_T (left) and the diphoton p_T (right).

7 Conclusions

The study of prompt isolated photon production does not constrain PDFs in the straightforward manner one might have hoped for, but we are continuing to learn about the ability of QCD to give a self consistent picture and describe hadron collider data.

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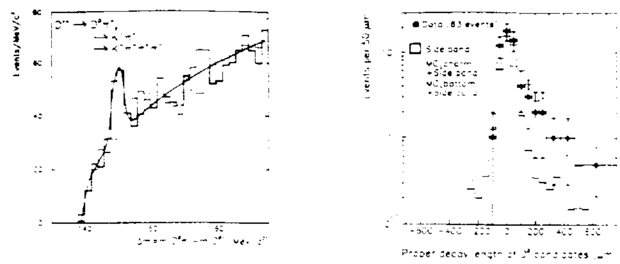

Figure 8: CDF signal for γ plus charm (left) the D^* mass difference and (right) the lifetime distribution for the signal region. The shaded distributions are from side bands.

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