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Isolated Prompt Photon Production at CDF

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ISOLATED PROMPT PHOTON PRODUCTION AT CDF

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ABSTRACT

This note describes measurements of isolated prompt photon production at $\sqrt{s} =$ 1.8 TeV using the CDF experiment. The measurements are compared to recent NLO QCD calculations, including recently obtained parton distribution functions. Qualitatively, the QCD calculation with the new parton distribution functions agrees better with the data than the previous parton distribution functions.

1. Introduction

Prompt photon production in hadronic interations provides a test of Quantum Chromodynamics. The high center of mass energy of the Tevatron allows us to test QCD at high momentum transfer in a previously unexplored range of $X_T = 2P_T/\sqrt{s}$ $(.016 < x_t < .07)$ where gluons are the dominant parton.

We present the inclusive isolated prompt photon cross-section and the angular distribution, $\frac{dN}{d\cos\theta^*}$, which probes the spin of the propagator in photon production. Both measurements are compared to recent NLO calculations.

2. Event Selection

The CDF detector is described elsewhere[1] however relevant details are presented here. Photons are identified with the aid of the central tracking chamber (CTC), a surrounding array of drift tubes (CDT), the central electromagnetic calorimeter (CEM), the central hadronic calorimeter (CHA) and a position detector located near shower maximum in the CEM (CES).

The data presented here were collected during the 1988-1989 Tevatron run. The sample consists of 3.28 pb^{-1} (101 nb^{-1}) of events where the trigger required an electromagnetic cluster whose energy is greater than 23 GeV (10 GeV), hadronic fraction / electromagnetic fraction < 12.5%, and $(\sum_{\Delta R<0.7} E_T - E_T^{\gamma})/E_T^{\gamma} < 0.15$ where $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$.

Futhermore, the sample is purified offline by requiring that there be no track pointing at the cluster (CTC), there be no second cluster in either transverse view of the shower (CES) with energy greater than 1 GeV, that the cluster be inside the good fiducial region of the detector, that the measured z vertex be within 50 cm., that there be no significant missing energy, that excess energy in a cone of $\Delta R < 0.7$ be less than 2 GeV, and lastly that the transverse profile be reasonably consistent

[1] CDF Institutions: ANL, Bologna, Brandeis, UCLA, Chicago, Duke, Fermilab, Frascati, Harvard, Illinois, IOPP, Johns Hopkins, KEK, LBL, MIT, MSU, Michigan, New Mexico, Osaka, Padova, Pennsylvania, Pisa, Pittsburgh, Purdue, Rockefeller, Rutgers, SSCL, Texas A&M, Tskuba, Tufts, Wisconsin, Yale.

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with that of a photon. These cuts reduce the background contamination (where the background is mesons decaying to several photons) to the same level as that of the signal.

One method for measuring the photon cross-section uses the transverse profile of the shower to estimate and subtract the background. Both transverse profiles of the shower are fit to the shower shape expected for single photons. The quality of the fits are used to distinguish the broader showers of π^0 and η decays from the narrower showers due to single photons. Setting a cut on the quality of the fit (χ^2), and using the efficiencies for both signal and background to pass this cut, enables us to measure the rate of photon production.

The other method is to look for conversion electrons in the CDT. There is 18% of a radiation length in front of the CDT. Using the rate of photon conversion, one can extract, in a p_T independant manner, the rate of photon production from the hit rate in the CDT.

3. Prompt Single Photon Cross-section

The cross-section is obtained by counting the number of photons in each bin of p_T and using the known efficiencies and luminosities to obtain the final number. The cross-section is shown in figure 1a. Also shown are the UA2[2] results and a QCD calculation of the expected cross-section[3]. It should be noted that the QCD calculation does not include the possibility of charm in either the proton or the antiproton, and it uses the parton distribution functions KMRS B_0^4 with $\Lambda = 190$ MeV and $\mu^2 = p_T^2$. The data and the calculation agree qualitatively but there appears to be a discrepancy at low p_T.

Recently, new fits to DIS data have changed estimates of the parton distribution functions. Figure 1b shows a comparison on a linear scale of the data to several new calculations. The default theory is the previous calculation; including charm in the proton, the HMRS B parton distribution functions[5]. The default scale is taken to be $\mu^2 = p_T^2/4$. Using recently obtained parton distributions (MRS D0[6]) functions, the calculation appears to better match the data at low p_T, but it is not clear whether the theory is succeeding in predicting the observed spectrum in photon production.

4. Measurement of $\frac{dN}{d\cos\theta^*}$

To further probe the nature of the prompt photon events, the angular distribution of the photon-jet system is studied. The events are transformed so as to have no net momentum along the beam using the photon and all jets greater than 10 GeV in the hemisphere opposite the photon. The events are selected so that the acceptance is uniform in boost and transformed momentum over the entire range in θ^*.

Figure 2 gives the angular distribution of the data, as well as the jet-jet angular distribution and a theoretical calculation. The excess of events at large values of $\cos\theta^*$ suggests that the Bremsstrahlung contribution might be larger than expected.

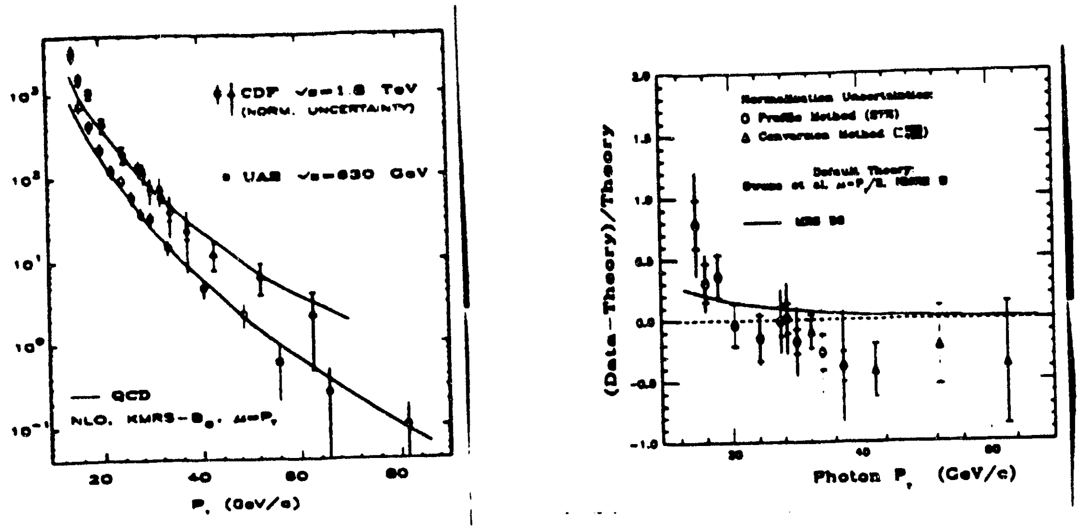

Figure 1a : The prompt isolated photon cross-section from CDF and that of UA2 compared to a recent NLO calculation. Figure 1b: A comparison of the data and a more recent theoretical calculation.

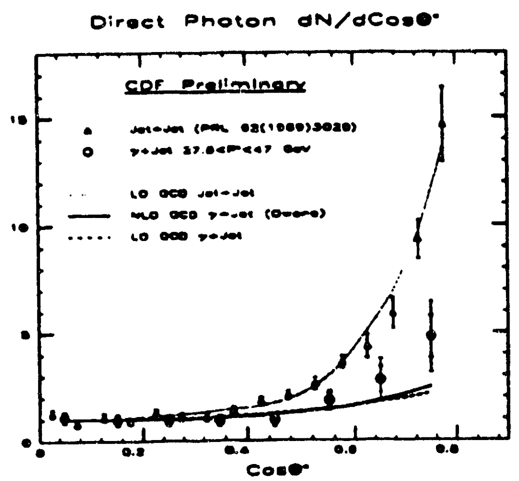

Figure 2: $\frac{dN}{d\cos\theta^*}$ for photon-jet events and dijet events.

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