DIRECT PHOTON PRODUCTION AT DØ

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ABSTRACT

A preliminary cross section for the inclusive production of central isolated direct photons is presented, as measured by the DØ detector at the Fermilab Tevatron $p\bar{p}$ Collider. Photon candidates with transverse momentum greater than 9 GeV/c and within the pseudorapidity range $\mid \eta \mid < 0.9$ are considered. Selection criteria for photon candidates are discussed, as is the estimation of background contributions from jets. The cross section is found to be in good agreement with the next-to-leading-order (NLO) QCD prediction over the whole range of p_T.

1. Introduction

Direct photons have proved to be a valuable tool for studying QCD at hadron colliders.[1] Photons are a direct link to the parton level of the interaction, unlike jets which suffer from ambiguities in identification and energy measurement. At low E_T the dominant mode of production is from gluon-Compton scattering, which makes the outgoing photon a good probe of the incoming gluon. At Tevatron energies ($\sqrt{s} = 1.8$ TeV) the gluon distributions as low as $x_g = 0.001$ can be probed with the DØ detector.[2]

2. Trigger and Event Selection

DØ operates with a multi-tiered triggering system. The first level (called Level 0) consists of scintillator near the beam pipe which fires when a $p\bar{p}$ interaction is detected. The next level, Level 1, is a hardware trigger which makes fast sums of the electromagnetic energy in towers ($\eta = 0.2$, $\phi = 0.2$) in the calorimeter. There are three Level 1 triggers used in this analysis with thresholds of 2.5, 7, and 10 GeV. Level 2, a software based trigger, clusters the calorimeter cells and rejects the candidate if the longitudinal energy deposition is inconsistent with test beam electrons. The three Level 2 thresholds used are 6, 14, and 30 GeV.

Additional cuts are applied to the photon candidates off-line. An $\mid \eta \mid < 0.9$ cut is used to restrict candidates to the central region. The electromagnetic fraction of the calorimeter shower must be greater than 96% and the shower shape is required to be consistent with the shape of test beam electrons. An isolation cut of less than 2 GeV of E_T in the isolation cone ($0.2 < R < 0.4, R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$) is applied. The missing E_T of the event is required to be less than 50% of the photon E_T (if the photon E_T is greater than 20 GeV) to reject electrons from W events.

*Representing the DØ Collaboration.

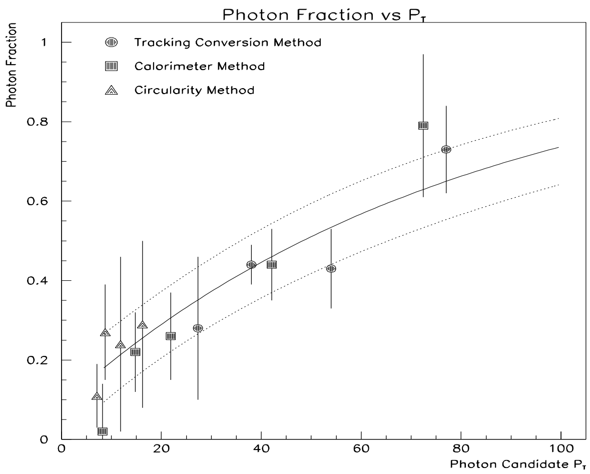

Fig. 1. Photon Fraction (γ) vs p_T^γ for the three methods of background subtraction. The solid line is a fit and the dotted lines are the errors of the fit.

3. Background Subtraction

The data sample detailed above contains a significant amount of background in the form of electromagnetic jets. These are mostly single isolated π^0's and η's which decay into two photons. At this p_T range the photons coalesce and mimic a single photon shower in the calorimeter. Fluctuations in the shower development make background subtraction on an event-by-event basis impossible. There are, however, methods by which the background can be subtracted on a statistical basis.

DØ uses three methods of background subtraction. They are all based on the relationship:

$$\gamma = \frac{\epsilon_\pi - \epsilon}{\epsilon_\pi - \epsilon_\gamma}. \tag{1}$$

where γ is the fraction of candidates that fulfill the selection criteria which are genuine direct photons, and ϵ_γ, ϵ_π, and ϵ are the fraction of candidates passing a specific cut for photons, background, and data respectively.

The first method uses the fact that the two-photon backgrounds tend to convert (produce e^+e^- pairs) roughly twice as often as single photons. This means that calorimeter showers from background develop earlier than single photon showers. The ratio of energy in the first layer of the calorimeter (EM1) to the total shower energy is used as a discriminant.

The second method is also based on backgrounds having a higher conversion probability. Conversions are tagged as tracks with twice minimum ionizing energy using the dE/dx measurement in the Central Drift Chambers.

The third method exploits the opening angle between the two photons from background sources. At lower p_T this angle is large enough to create an asymmetry in the

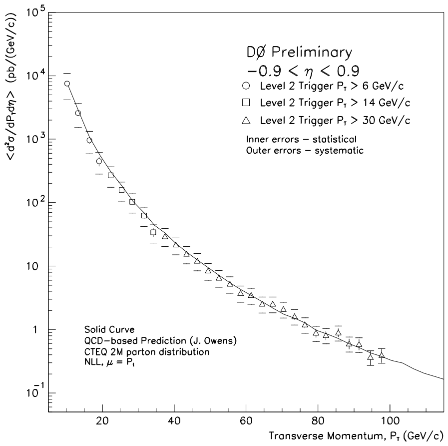

Fig. 2. Differential Direct Photon Cross Section vs. p_T.

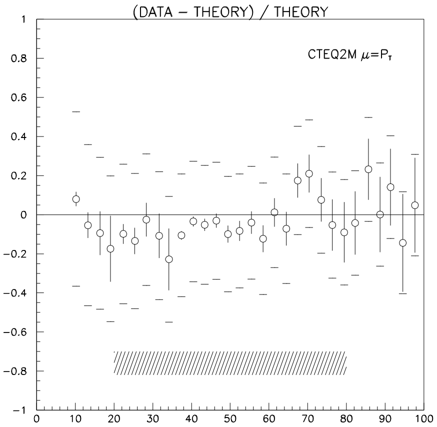

Fig. 3. Comparison between data and NLO QCD theory, CTEQ2M parton distributions.

calorimeter showers. The shower profile in the third layer of the calorimeter (at shower maximum) will look ellipsiodal for two photon showers and circular for single photon showers. The shower profile is diagonalized and a variable called circularity is defined as the ratio between the minor and major axis of the ellipse. For photons circularity should be close to unity, whereas for π^0's and η's this tends to smaller values. This method is only used up to 20 Gev, above which the opening angle between the two photons is too small.

A functional form of $\gamma(p_T)$ is obtained by fitting the three background subtraction methods and this function is used to subtract the background from the cross-section (see Fig. 1). The parameters in the fit are shifted by one standard deviation and the variation in $\gamma(p_T)$ is used as an estimate of the error.

4. Cross Section

The differential cross section vs. p_T is shown in Fig. 2. The theory prediction is generated from a Monte Carlo based on NLO QCD due to J. Owens with CTEQ2M parton distributions[3] and a renormalization scale of $\mu = p_T$. Figure 3 shows a plot of (data - theory) / theory to illustrate the good agreement between the two. The shaded band at the bottom of the plot corresponds to a $\pm 12\%$ normalization error due to luminosity uncertainty.

References

1. B. Bailey, J. F. Owens, and J. Ohnemus, *Phys. Rev.* **D46** (1992) 2018.
2. S. Abachi *et al.*, *Nucl. Instr. and Meth.* **A338** (1994) 185.
3. J. Botts *et al.*, *Phys. Lett.* **B304** (1993) 159.