Fermi National Accelerator Laboratory

FERMILAB Pub-94/239-E
CDF

A Precision Measurement of the Prompt Photon Cross Section in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

Arthur Maghakian
The CDF Collaboration

The Rockefeller University
New York, NY 10021

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

August 1994

Published Proceedings of the *Eighth Meeting of the Division of Particles and Fields of the American Physical Society (DPF'94)*, Albuquerque, NM, August 2-6, 1994.

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CHO3000 with the United States Department of Energy

Disclaimer

CDF/PUB/JET/PUBLIC/2733
FERMILAB-PUB-94/239-E

A PRECISION MEASUREMENT OF THE PROMPT PHOTON CROSS SECTION IN $p\bar{p}$ COLLISIONS AT $\sqrt{s} = 1.8$ TeV

THE CDF COLLABORATION
presented by

ARTHUR MAGHAKIAN
The Rockefeller University, 1230 York Ave., New York, NY 10021, USA

ABSTRACT

A prompt photon cross section measurement from the CDF experiment at the Fermilab $p\bar{p}$ Collider is presented. Detector and trigger upgrades, as well as six times the integrated luminosity compared with our previous publication, have contributed to a much more precise measurement and extended P_T range. As before, QCD calculations agree qualitatively with the measured cross section but the data has an overall steeper slope than the calculations.

1. Introduction

We present a measurement of the cross section for production of isolated prompt photons in proton-antiproton collisions at $\sqrt{s} = 1.8$ TeV using the Collider Detector at Fermilab (CDF). With six times the data sample, plus detector and trigger additions, this measurement is a significant improvement over our previously published results [1]. Prompt photons are produced in the initial collision, in contrast to photons produced by decays of hadrons. In Quantum Chromodynamics (QCD), at lowest order, prompt photon production is dominated by the Compton process ($gq \to \gamma q$), which is sensitive to the gluon distribution of the proton [2]. The precision of the present measurement provides a quantitative test of QCD and parton distributions in a fractional momentum range $.013 < x < .13$.

2. Events Selection

The important components of the CDF detector are the same as used in the previous analysis [1], with one addition. In order to improve the measurement systematic uncertainties, and separate signal from background at higher photon P_T, a set of multiwire proportional chambers, called the Central Preshower (CPR) chambers, was added in front of the central electromagnetic calorimeter. In addition to the detector improvement, the photon hardware trigger was upgraded. Additional electronics were added at the trigger's second level to require the photon to be *isolated.* The selection of prompt photon candidates from the triggered events is essentially the same as those used previously [1], with some minor revisions [3].

To subtract the remaining neutral meson background from our photon candidates statistically, we employ two methods : the *conversion method* counts the fraction

Published Proceedings Eighth Meeting of the Division of Particles and Fields of the American Physical Society (DPF'94), University of New Mexico, Albuquerque, NM, August 2-6, 1994.

of photon conversions in the solenoid magnet material by using the CPR, and the *profile method* uses the transverse profile of the electromagnetic shower in the central electromagnetic strip (CES) chambers. For the conversion method, the probability of a single photon conversion is $\approx 60\%$, while that for the two-photon decay of a π^0 or η is larger, $\approx 84\%$. For the profile method, the transverse profile of each photon candidate was compared to that measured for electrons in a test beam. For both background subtraction methods, the number of photons in a bin of P_T is obtained from the number of photon candidates, the fraction of photon candidates that pass a fixed cut defined below (ϵ), and the corresponding fractions for true photons (ϵ_γ) and background (ϵ_b) For the conversion method, ϵ is the fraction of photon candidates which produce a pulse height of greater than 1 minimum ionizing particle in the CPR. For the profile method, ϵ is the fraction of events which have $\tilde{\chi}^2 < 4$ out of all events with $\tilde{\chi}^2 < 20$. For both methods ϵ_γ and ϵ_b were determined from simulation. The conversion method has the advantage of much smaller systematic uncertainties and an unlimited P_T range. But the profile method has the advantage of a better separation of signal and background than the conversion method in the low P_T region. We thus use the profile method from 10-16 GeV/c P_T and the conversion method everywhere else.

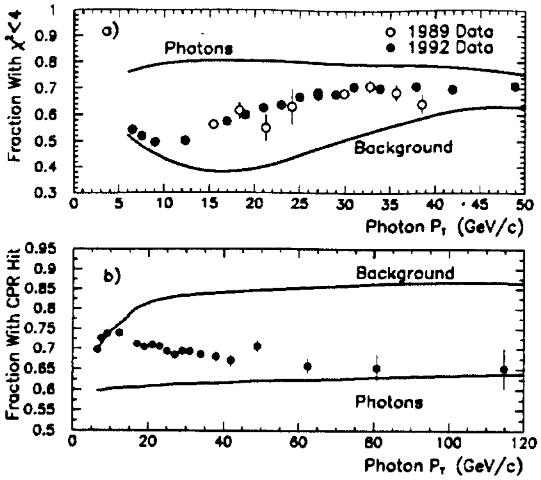
3. Systematic uncertainty and prompt photon cross section

The systematic uncertainty in the prompt photon cross section is due mostly to uncertainties in ϵ_γ and ϵ_b. For both methods we can check these fractions using reconstructed π^0, η, and ρ mesons, shown in figure 2. The measured (expected) CPR conversion rate ϵ_b for the π^0 is $.842 \pm .008$ (.847), for the η is $.831 \pm .012$ (.842), and for the ρ is $.836 \pm .01$ (.834). Excellent agreement between the measured and predicted rates in all three cases, let us use .006 for the uncertainty in ϵ_b, which lead to a 7% uncertainty in the cross section measurement at 16 GeV/c P_T, and a 4.5% uncertainty at 100 GeV/c. There are additional uncertainties due to backscattered photons (2% at 16 GeV/c and 7% at 100 GeV/c), η/π^0 ratio (2% at 16 GeV/c and 0.2% at 100 GeV/c), luminosity (3.6%), selection efficiencies (4.8%), and photon energy scale (4.5%). The uncertainties in the profile method are much larger (30-70%), but the two methods agree to within 5% from 16-30 GeV/c.

From the number of prompt photons in a bin of transverse momentum, along with the acceptance and the integrated luminosity for that bin, we obtain the isolated prompt photon cross section. In Fig. 3 our measurements from both 1989 and 1992 are compared to a next to leading order QCD calculation derived using the CTEQ2M parton distributions [4]. Inset is a comparison of the two background subtraction methods in their overlap region. Although the QCD prediction agrees qualitatively with the measurements over more than 4 orders of magnitude, there is a distinct shape difference between them (Fig. 4). The differences between the predictions and data could indicate that for the first time we are measuring the gluon distribution inside the proton in a fractional momentum range where it has not been measured well before.

References

1. F. Abe *et al.* (CDF Collaboration). *Physical Review*, D(48):2998, 1993.
2. J. Owens. *Reviews of Modern Physics*, 59:465, 1987.
3.F. Abe *et al.* (CDF Collaboration),subm. to Phys. Rev. Lett. 7.25.94 FNAL-PUB-94/208-E
4. J. Botts *et al.* (CTEQ Collaboration). *Physics Letters*, B(304):159, 1993.



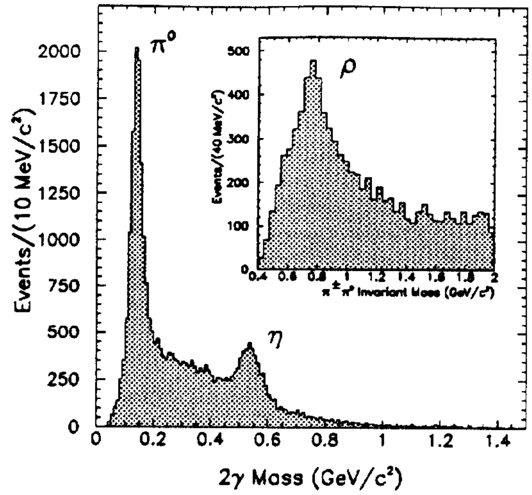
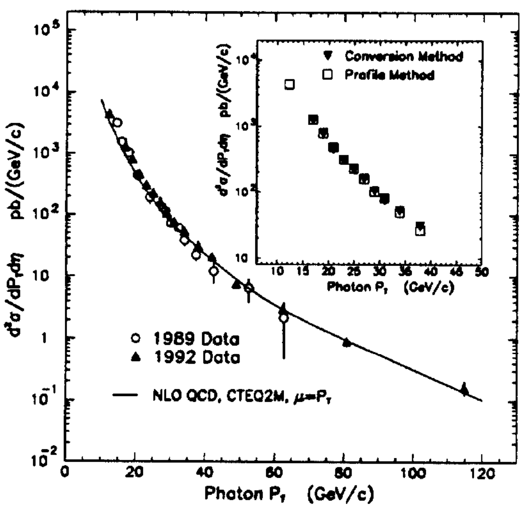


Figure 1 (left): Illustration of the photon background subtraction methods: profile method (a) and coversion method (b).

Figure 2 (right): The 2 photon mass distribution, displaying reconstructed π^0 and η mesons. Inset is the reconstructed charged ρ meson peak.



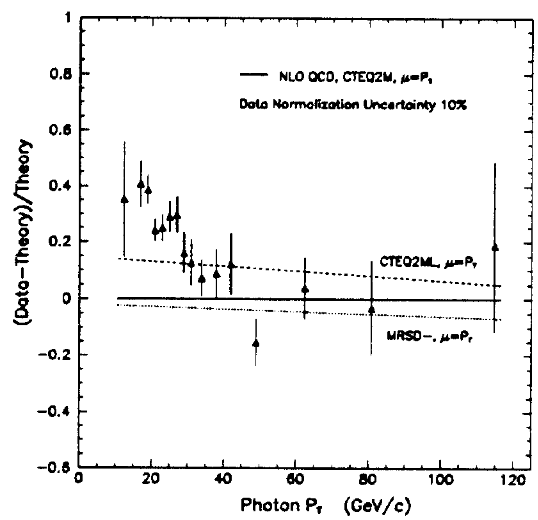


Figure 3 (left): The inclusive isolated prompt photon cross section from 1989 and 1992 compared with a next-to-leading order QCD prediction. Inset is the comparison of the two background subtraction methods in their region of overlap.

Figure 4 (right): The prompt photon cross section measurement is compared with NLO QCD predictions and variations of parton distributions.