View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by CiteSeerX

Fermi National Accelerator Laboratory

FERMILAB-Conf-98/191-E
CDF
DO

Prompt Photon Results from the Tevatron

F.S. Chlebana
For the CDF and D0 Collaborations

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

June 1998

Published Proceedings of the *33rd Rencontres de Moriond: QCD and High Energy Hadronic Interactions*,
Les Arcs, France, March 21-28, 1998

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CH03000 with the United States Department of Energy

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Distribution

Approved for public release; further dissemination unlimited.

Copyright Notification

This manuscript has been authored by Universities Research Association, Inc. under contract No. DE-AC02-76CHO3000 with the U.S. Department of Energy. The United States Government and the publisher, by accepting the article for publication, acknowledges that the United States Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government Purposes.

Prompt Photon Results from the Tevatron

F.S. Chlebana
Fermi National Accelerator Laboratory, MS 318, P.O. Box 500,
Batavia, IL, 60510

Results are presented for prompt photon production in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV from the CDF and DØ experiments at the Tevatron. An updated measurement of the inclusive photon cross section from DØ is presented. Results are compared to QCD predictions and discrepancies with theory are discussed. Angular distributions of the γ - jet system are shown and found to be in good agreement with QCD expectations. The diphoton cross section is presented and compared to QCD calculations. The measurement of the p_T of the diphoton system provides information about soft gluon radiation.

1 The Isolated Photon Cross Section

Results from CDF and DØ are presented for the measurement of the cross section for isolated prompt photon production at $\sqrt{s} = 1.8$ TeV. Prompt photons are produced in the initial collision rather than in the decay of hadrons. For $E_T < 100$ GeV prompt photon production is dominated by the Compton process $gq \rightarrow \gamma q$ which is sensitive to the gluon distribution. A measurement of the cross section can be used as input to global QCD fits to help constrain the gluon density. The measurement of isolated photons is less complicated then jet reconstruction since it is not dependent on fragmentation or the clustering algorithm. The minimum and maximum momentum fraction that can be probed is related to the transverse energy, E_T, and the pseudorapidity, η, and is given by

$$x_{min} = 2\frac{E_T^{min}}{\sqrt{s}}e^{-\eta_{max}}; \qquad x_{max} = 2\frac{E_T^{max}}{\sqrt{s}}e^{+\eta_{max}}. \tag{1}$$

The results from CDF and DØ provide an important quantitative test of QCD in the range $0.013 < x < 0.13$.

Isolated photon candidates are selected at CDF by requiring less than 2 GeV of energy deposited in a cone of radius of $\mathcal{R} = \sqrt{\eta^2 + \phi^2} = 0.7$ centered around the photon candidate. DØ requires less than 2 GeV in an annulus between $\mathcal{R} = 0.2$ and $\mathcal{R} = 0.4$. Both experiments require that the candidates have little hadronic energy, HAD/Total $< 11\%$ for CDF and HAD/Total $< 4\%$ for DØ. The energy deposit is required not to have a track pointing to it, have a good shower profile and be within the central pseudorapidity region, $|\eta| < 0.9$. Cosmic ray muon Bremsstrahlung is removed by a missing E_T cut.

The previously published *DØ* results[3] have been updated and compared with the CDF data[2] in Figure 1. In the top plot the data are compared to the NLO QCD calculation of Ohnemus et al.[3] using the CTEQ4M[4] parton density functions (PDFs) with $\mu = p_T$. Good agreement is observed over almost five orders of magnitude. The bottom plot compares (Data-Theory)/Theory to the

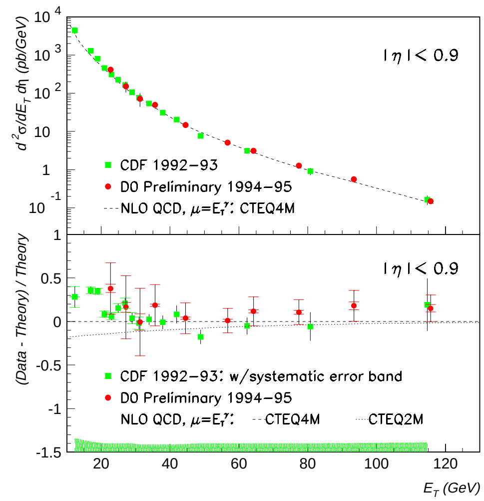

Figure 1: A comparison between the CDF and the new DØ data show that the two experiments are in good agreement.

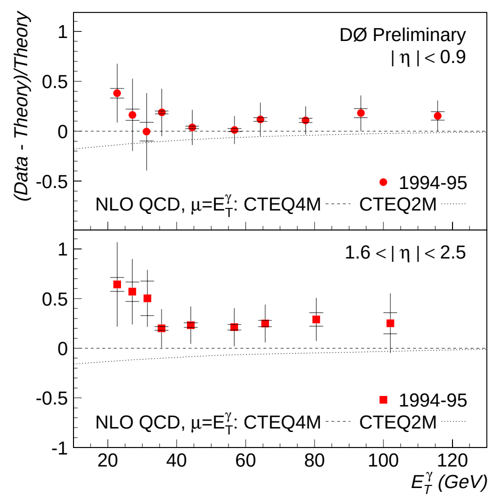

Figure 2: The preliminary DØ isolated photon cross section for the central η region (top) and the forward η region (bottom).

expectation using CTEQ4M shown as the dashed line, and CTEQ2M[5] shown as the dotted line. The CDF data are represented by the squares while the DØ data are shown as the circles. For the CDF points the error bars represent the statistical errors and the one sigma correlated systematic error is shown as a band at the bottom of the plot. For the DØ data the inner error bars show the statistical error and the outer error bars represent the systematic error. The CTEQ4M PDF provides a better description of the data at low E_T. This set includes the Tevatron inclusive jet data[6] resulting in an enhanced the gluon density in the high x region. DØ has also measured the photon production cross section for the forward η region, $1.6 < |\eta| < 2.5$. The results are shown in Figure 2.

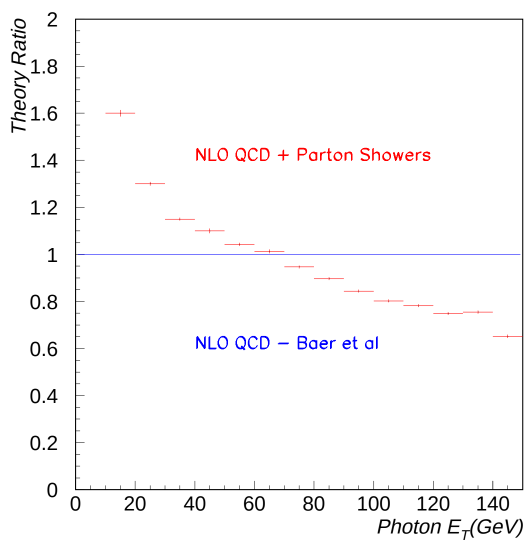

Figure 3: The NLO QCD calculation with added parton showers relative to the NLO QCD.

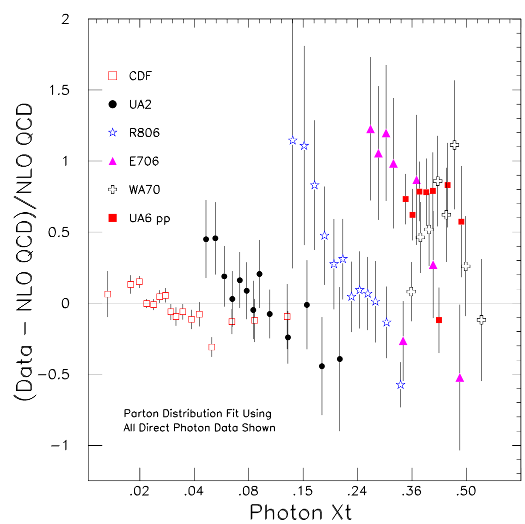

Figure 4: Results from a global QCD fit to direct photon data from several experiments.

At low values of E_T the data tends to be higher than the expectation from the NLO QCD calculation. Several explanations have been suggested to account for this. One explanation is that the QCD calculation does not contain enough initial state gluon radiation. To simulate this effect Baer and Reno performed a calculation [7] which adds parton showers to the NLO QCD calculation. The calculation with additional initial state radiation is compared to the NLO QCD result in Figure 3. The rise at low E_T is reproduced but the calculation predicts a deficit at high E_T. Since both the theory and the data have normalization uncertainties it is difficult to discern an excess at low E_T from a deficit at high E_T. It has also been pointed out that these QCD calculations do not contain p_T resummation.

The results of a global QCD fit [8] to recent direct photon data from CDF and UA6 together with UA2, R806, E706, WA70 and the standard deep inelastic scattering and Drell-Yan data sets used in the CTEQ2M analysis are shown in Figure 4. The ratio of (Data-Theory)/Theory is plotted as a function of $x_T \equiv 2E_T/\sqrt{s}$ which approximates the parton momentum fraction for events with the photon in the central region. The small errors of the CDF data dominate the fit resulting in an increased gluon density in the x region where the CDF data exist. Due to the momentum sum rule, the increase in the gluon density in the low x region is balanced by a decrease in the gluon density at high x. One can get a better description of the Tevatron data at the expense of a worse description of the prompt photon production from other experiments which probe higher x values. A change in the gluon distribution does not lead to a good description of the prompt photon data.

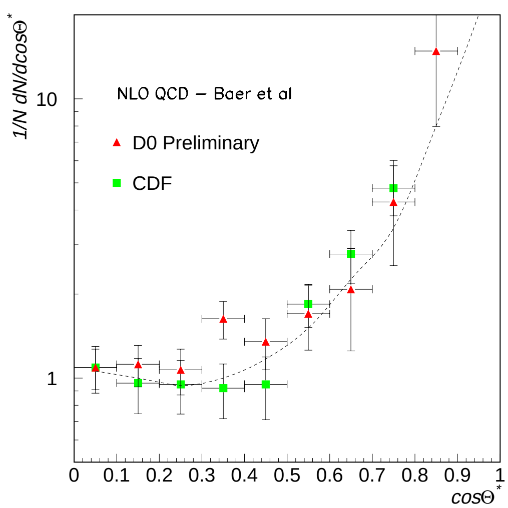

Figure 5: Angular distribution of the γ - jet data.

The calculation of the inclusive isolated photon cross section contains a convolution of the matrix elements and the parton density functions. Information about the matrix elements can be determined from a measurement of the angular distribution in the CM frame. The angular distribution of the γ - jet events is shown in Figure 5. The CDF data are shown as the squares while the DØ data are shown as the triangles. The data are in good agreement with each other and the prediction of the QCD calculation.

2 Diphoton Production

The diphoton cross section measured by CDF is plotted as a function of the photon's E_T in Figure 6. Both photons are required to be within the central pseudorapidity region, $|\eta| < 0.9$. For each event both photons contribute to the plot. The results are compared to the NLO QCD calculation of Bailey et al. [9] using the CTEQ2M PDF. The results from DØ are shown in Figure 7.

An estimate of the intrinsic transverse momentum of the partons can be obtained by measuring the total $p_T = |\vec{p}_T^{\gamma 1} + \vec{p}_T^{\gamma 2}|$ of the two photon system. The p_T of the diphoton system measured by CDF is shown in Figure 8. The inner error bars represent the statistical error while the outer error bars show the systematic error added in quadrature. The DØ measurement is shown in Figure 9. The statistical errors are shown as the error bars while the systematic error is shown as the band at the bottom of the plot. The next to leading order QCD calculation provides a

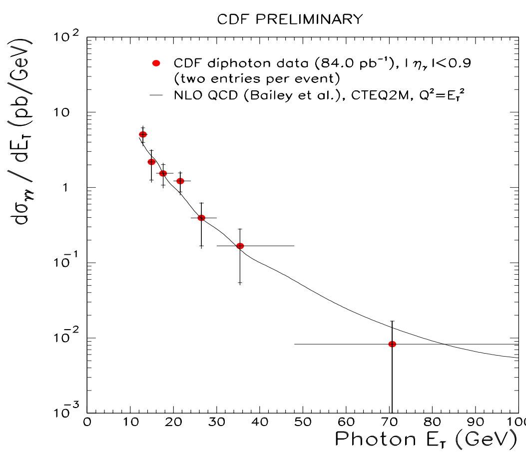

Figure 6: The CDF measurement of the diphoton cross section compared to the calculation of Bailey et al. using the CTEQ2M PDF.

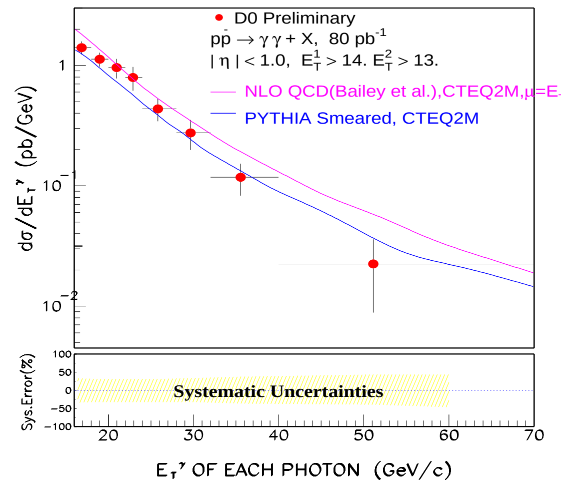

Figure 7: The DØ measurement of the diphoton cross section.

better description of the $D\emptyset$ data at high p_T than the leading order calculations of RESBOS and PYTHIA. At low p_T both experiments observe that the data are lower than that expected from the NLO QCD calculation. The PYTHIA calculation shown in Figure 9 includes multiple gluon emissions and is in better agreement with the data at low p_T.

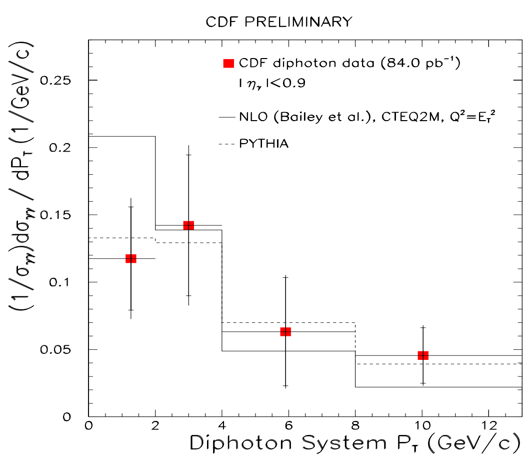

Figure 8: The CDF measurement of the p_T of the diphoton system.

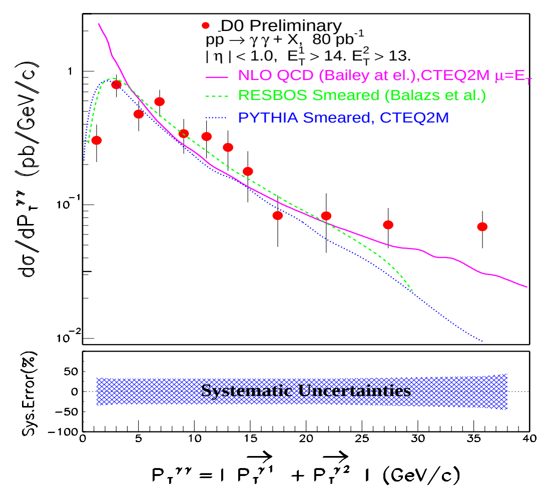

Figure 9: The DØ measurement of the p_T of the diphoton system.

Acknowledgments

We thank the staffs at Fermilab and the collaborating institutions for their contributions to this work, and acknowledge support from the Department of Energy and the National Science Foundation (U.S.A.), Commissariat à L'Energie Atomique (France), State Committee for Science and Technology and Ministry for Atomic Energy (Russia), CNPq (Brazil), Departments of Atomic Energy and Science and Education (India), Colciencias (Columbia), CONACyT (Mexico), Ministry of Education and KOSEF (Korea), and CONICET and UBACyT (Argentina).

References

1. S. Abachi et al., DØ Collab., *Phys. Rev. Lett.* **77**, 5011 (1996).
2. F. Abe et al., CDF Collab., *Phys. Rev. Lett.* **73**, 2662 (1994).
3. J. Ohnemus et al. *Phys. Rev.* D **42**, 62 (1990).
4. H.L. Lai et al., CTEQ Collab., *Phys. Rev.* D **55**, 1280 (1997).
5. H.L. Lai et al., CTEQ Collab., *Phys. Rev.* D **51**, 4763 (1995).
6. F. Abe et al., CDF Collab., *Phys. Rev. Lett.* **77**, 438 (1996).
7. H. Baer and M.H. Reno, PRD **54**, 334 (1995).
8. J. Huston et al., *Phys. Rev.* D **51**, 6139 (1995).
9. B. Bailey et al., *Phys. Rev.* D **46**, 2018 (1992)