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QCD RESULTS FROM THE TEVATRON*

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We present results from QCD studies at the Tevatron from Run 1 data, including jet and direct photon production, and a measurement of the strong coupling constant.

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1. Introduction

The Tevatron hadron collider provides the unique opportunity to study Quantum Chromodynamics, QCD, at the highest energies. The results summarized in this talk, although representing different experimental objects, as hadronic jets and electromagnetic clusters, serve to determine the fundamental input ingredients of QCD as well as to search for new physics. For example, results from Tevatron jet production are used extensively to derive new parton distribution functions, and photon data are applied to discriminate between different approaches used to understand the disagreement with theory at small photon transverse momenta. The measurement of $\alpha_{\rm s}$ from the inclusive jet cross section, by itself, serves as a proof that Tevatron QCD results are in the 'precision' study regime now and already started Run II, with significantly increased data samples, will expand our knowledge of QCD.

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2. Jet production at the Tevatron

The inclusive jet cross section measurement from CDF is based on a data sample of integrated luminosity 87 pb^{-1} collected during the 1994–95 run (Run 1B) of the Fermilab Tevatron $\bar{p}p$ collider operating at $\sqrt{s} = 1.8$ TeV. Details of the measurement of the inclusive jet differential cross section can be found in [1]. Briefly, jets are reconstructed using the iterative fixed cone

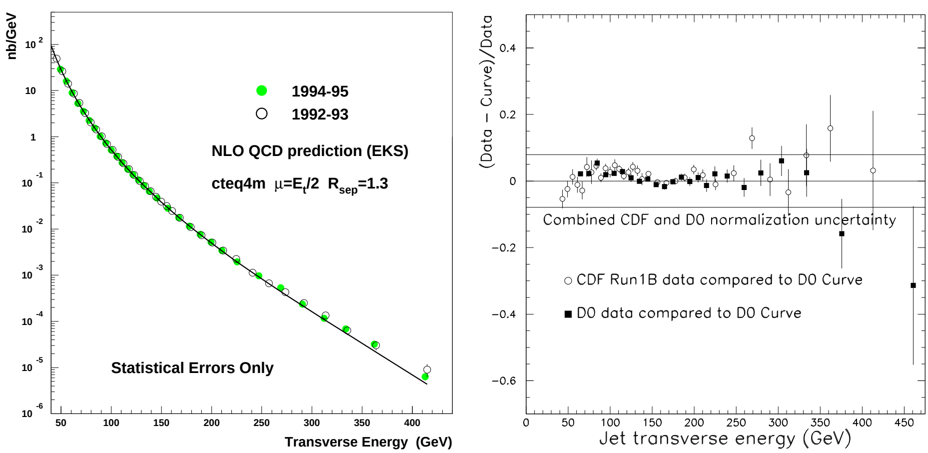


Fig. 1. (left) CDF inclusive jet cross section from Run 1B data (1994–1995) compared to a QCD prediction and to the published Run 1A results; (right) Comparison of CDF and DØ data to DØ smooth curve.

algorithm with cone radius $R = 0.7$ [1]. The inclusive jet cross section includes all jets in an event in the pseudorapidity range $0.1 < |\eta| < 0.7$. The measured spectrum is corrected for calorimeter response, resolution and underlying event energy using an iterative unsmearing procedure, which changes both the energy scale and the normalization simultaneously. Fig. 1(left) shows the corrected Run 1B cross section compared to Run 1A results. The results of Run 1B and Run 1A are in good agreement. A comparison between CDF and DØ results [2] is shown in Fig. 1(right). The χ^2 between the CDF data and the DØ curve (see Fig. 1(right)) for 29 CDF points is 28.7, if all systematic uncertainties are included and the relative normalization is taken into account, demonstrating that the CDF and DØ data are in good agreement. A new procedure was developed to compare data with theoretical predictions for each PDF, by directly comparing "raw" uncorrected experimental data to theoretical predictions "smeared" with detector resolution effects. It was found that the data are best described by QCD

[1] For all jet measurements reported in this proceedings jets were reconstructed using cone algorithm.

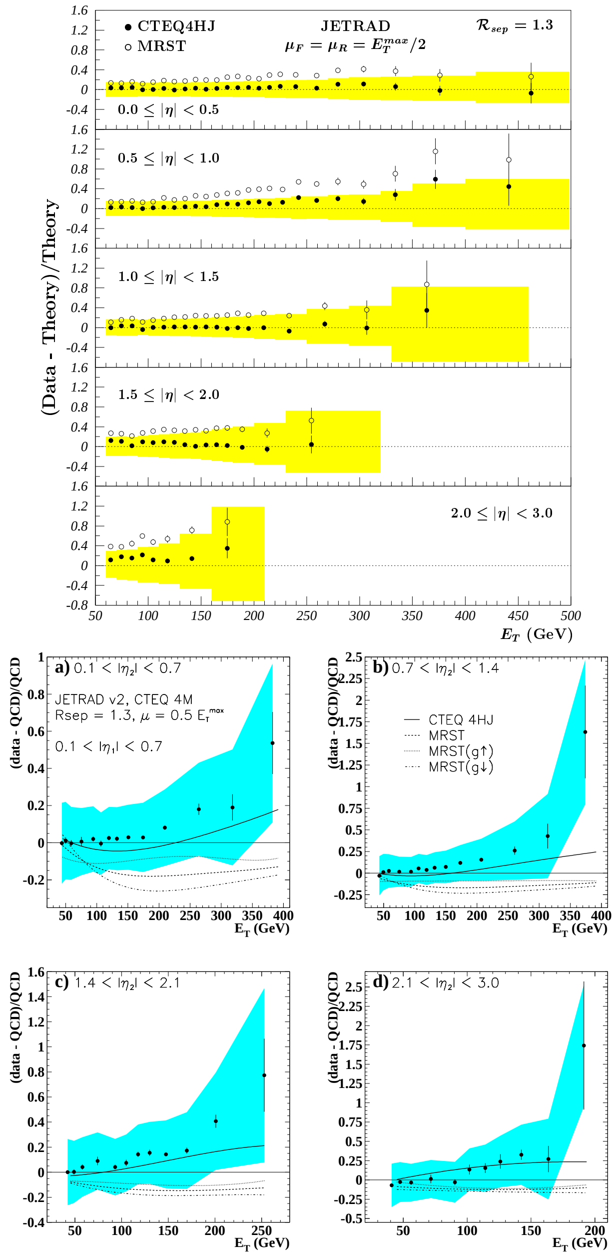


Fig. 2. (upper) Comparisons between the DØ data and NLO QCD predictions calculated by JETRAD using CTEQ4HJ and MRSTg↑; (lower) percent difference between the CDF dijet differential cross section and theoretical predictions for four PDFs.

predictions using the PDFs which have a large gluon content at high E_{T}-CTEQ4HJ. The data are consistent with QCD predictions and the excess at high E_{T} could be accommodated within the flexibility allowed from the current knowledge of PDFs.

Both collaborations worked on analyses which provide information for new regions of x and Q^2. The DØ collaboration studied the inclusive jet cross section as a function of jet E_{T} in five intervals of pseudorapidity, η, up to $|\eta|=3$ [3]. This measurement, based on 95 pb^{-1} of data, has significantly extended the kinematic reach by covering the new low x region. Fig. 2(upper) provides comparisons to theoretical predictions with renormalization and factorization scales set to half of the leading jet E_{T}, where the error bars are statistical and the shaded bands represent $\pm\sigma$ systematic uncertainties. The theoretical predictions are in good quantitative agreement with the experimental results, with the data indicating preference for CTEQ4HJ, MRSTg↑ and CTEQ4M PDFs.

CDF also measured the two-jet differential cross-section as a function of E_{T} of the leading jet with $0.1 <|\eta|< 0.7$ for four different pseudorapidity bins of a second jet covering $0.1 <|\eta|< 3.0$, see Fig. 2(lower). This measurement [4] probes regions of both low and high x (from 0.05 to 0.8) and shows the same excess in the high E_{T} region as the results from the inclusive jet cross section.

3. Measurement of the strong coupling

The value of α_{s}, a free parameter of QCD, is one of the fundamental constants of nature. Its determination is the essential measurement of QCD, and the observation of its evolution, or *running*, with momentum transfer is one of the key tests of the theory. The measurement of the strong coupling constant at CDF [5], see Fig. 3, is based on the inclusive jet cross section. By comparing the experimental data with the theoretical prediction one can extract $\alpha_{\mathrm{s}}(E_{\mathrm{T}})$ values for all E_{T} bins, and evolve them to the common reference scale $\alpha_{\mathrm{s}}(M_Z)$. The value of the strong coupling constant averaged over the E_{T} range of 40–250 GeV was found to be $\alpha_{\mathrm{s}}(M_Z) = 0.1178 \pm 0.0001(\mathrm{stat.}) \pm 0.0081/0.0095(\mathrm{exp.syst.})$ The theoretical uncertainties due to the choice of the renormalization/factorization scale and choice of PDF are estimated to be $\pm 5\%$ each. The result, which provides measurement of α_{s} from a single experiment over a very wide range of energies, agrees well with the world average.

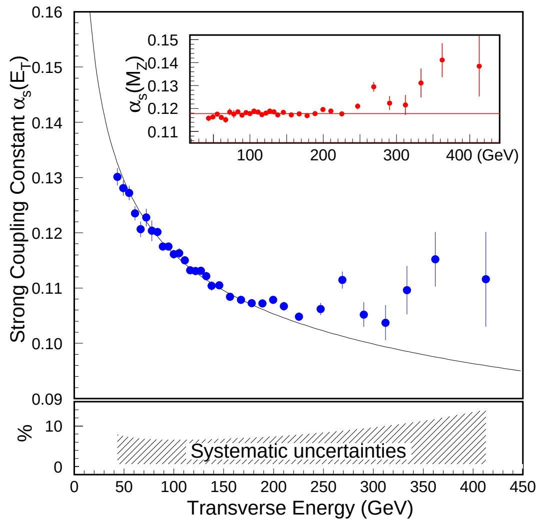
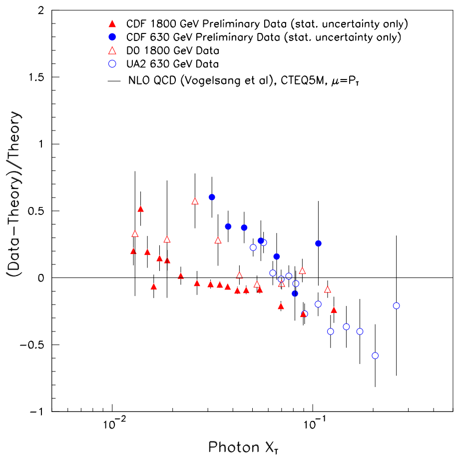


Fig. 3. CDF $\alpha_s(E_T^{\rm jet})$ and $\alpha_s(M_Z)$ (inset).

4. Direct photon production

Direct photons, which are produced directly from $p\bar{p}$ collisions, as distinguished from photons produced in decays of secondary hadrons, provide a probe of the hard scattering dynamics which complements that of jet production. Compared to hadronic jet production, direct photons have the advantage of lower $P_{\rm T}$ reach, and most important, the ability to measure $E_{\rm T}$ more precisely. However, one has to deal with lower statistics and background from neutral pion production. Experimental results from the CDF and DØ collaborations show disagreement with NLO QCD predictions at low transverse momentum. CDF results [6] show good agreement with DØ data [7] at 1800 GeV, and results at 630 GeV agree very well with UA2 measurement. However, there is significant disagreement with theory at the low $x_{\rm T} = 2P_{\rm T}/\sqrt{s}$ region, see Fig. 4(left), which is difficult to explain with conventional theoretical uncertainties, such as scale dependence and parton distribution parametrizations. The D0 collaboration measured the direct photon cross section at 630 GeV in two rapidity regions, $|\ \eta\ | < 0.9$ and $1.6 < |\ \eta\ | < 2.5$, and compared it with results at 1800 GeV. The measurement [8] is higher than the theoretical prediction at low $E_{\rm T}$ in the central rapidity region, see Fig. 4(right), but the deviation is not significant in light of combined statistical and systematic uncertainties of the ratio measurement.



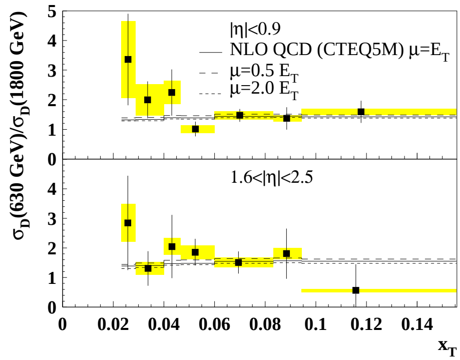


Fig. 4. (left) Comparison of the 1800 GeV and 630 GeV CDF data to a NLO QCD calculation as a function of photon x_{T}; (right) ratios of dimensionless cross sections from DØ .

5. Run II results

Both Collaborations have started to collect and analyse Run II data produced by the Tevatron collider with increased center-of-mass energy (1960 GeV). Increased statistics (with an expected data sample of 2 fb^{-1} for each experiment) will allow to obtain higher precision in QCD measurements. Preliminary results for jet and photon production show that the CDF and DØ detectors operate properly after upgrade, and that Run 2 QCD measurements are well under way.

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