Production of Direct Photons and Jets at the Tevatron

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Recent differential cross section measurements of isolated photon and jet production from the CDF and DØ collaborations are presented. NLO pQCD calculations agree, within uncertainties, with the inclusive photon measurements but disagree with the photon+jet cross sections. NLO pQCD agrees very well with both the inclusive jet and dijet data. Limits on several exotic models are set based on the dijet mass distribution.

Large-p_T processes in hadronic interactions originate in the hard scattering of partons. Measurements of direct photon and jet production test next-to-leading order (NLO) perturbative QCD (pQCD) calculations and constrain parton distribution functions (PDFs) [1,2]. Direct photons are produced primarily through $q\bar{q}$ annihilation ($q\bar{q} \to \gamma g$) and quark–gluon Compton-like scattering ($qg \to \gamma q$). Direct photons were therefore considered an important sample for extracting information about the gluon PDF. Unfortunately, direct photons have been excluded from global PDF fits for most of the past decade due to differences between NLO pQCD and many experimental results [3]. Jet production is also dependent on the gluon PDF and jet data have supplanted photons in the global PDF fits. Jet production is also sensitive to the presence of new physical phenomena including quark compositeness, large extra dimensions, and resonances that decay with jets in the final state.

The inclusive isolated-photon cross sections from DØ [4] and CDF [5] are presented in Fig. 1 as a function of photon p_T. Overlayed on the data are the results from the NLO pQCD calculation JETPHOX [6]. While the prediction agrees with the data within uncertainties, the shape is clearly different. This is similar to the shape seen in previous measurements from DØ and CDF as well as from many other direct photon experiments [3]. The differences between theory and data are more obvious in comparisons of theory with the measurements of photon+jet production from DØ [7] shown in Fig. 2. Here, as in the inclusive photon measurements, NLO pQCD [6] basically agrees with data within uncertainties though the discrepancies in the data-to-theory shapes in Fig. 2 (left) are similar to those in Fig. 1 and other photon measurements [3]. The photon+jet cross sections were measured in four regions which combined the central-rapidity photons with both central- and forward-rapidity jets. Uncertainties cancel in ratios of one region to another in both data and theory. These comparisons are shown in Fig. 2 (right). NLO pQCD clearly disagrees with the measurements for several of the ratios of one region to another.

CDF and DØ have recently published precision measurements of the inclusive jet cross section as a function of p_T in multiple rapidity bins [8,9]. Ratios of the data to the NLO pQCD calculation (NLOJET++ [10] calculated with FASTNLO [11]) are shown in Figs. 3 and 4. NLO pQCD agrees very well with the data. Uncertainties from recent CTEQ PDF [1] are shown in Figs. 3 and 4 as the lines. The data systematic uncertainties, shown by the shaded bands and dominated by the energy scale calibration, are smaller than the PDF uncertainties. These data will have a significant impact on the next round of global PDF fits.

CDF has also measured the differential cross section for dijet production as a function of the dijet mass [12]. As shown in Fig. 5 (left), the NLO pQCD calculation [10,11] agrees well with the data. No significant evidence of a dijet mass resonance is observed, so exclusion limits are placed on a variety of exotic models including

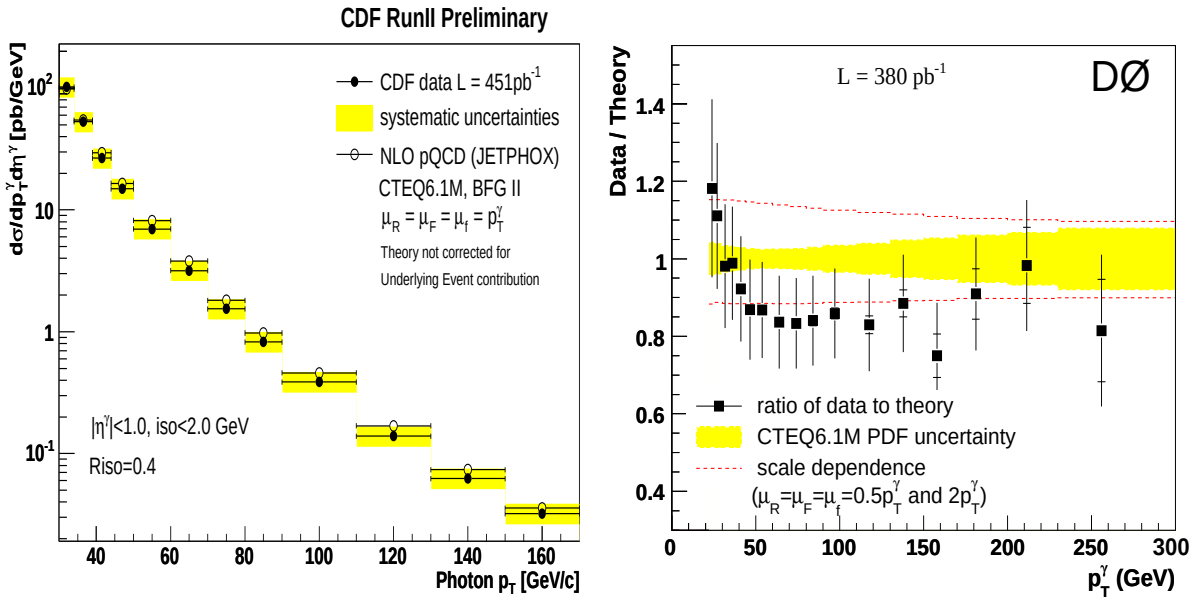

Figure 1. Differential cross section for the production of isolated photons as a function of p_T^γ. Left: theory overlayed on data from CDF. Right: ratio of data-to-theory from DØ.

the production of W' and Z' bosons as shown in Fig. 5 (right).

Recent Tevatron results on isolated photon and jet production were presented. Differences between results from NLO pQCD [6] and the measured inclusive photon cross sections [4,5] were similar to those seen with other photon experiments [3]. The disagreement was larger with the photon+jet measurement [7]. NLO pQCD [10,11] agreed very well with both the inclusive jet [7,8] and dijet [12] differential cross sections. Limits on several exotic models were set based on the dijet mass distribution.

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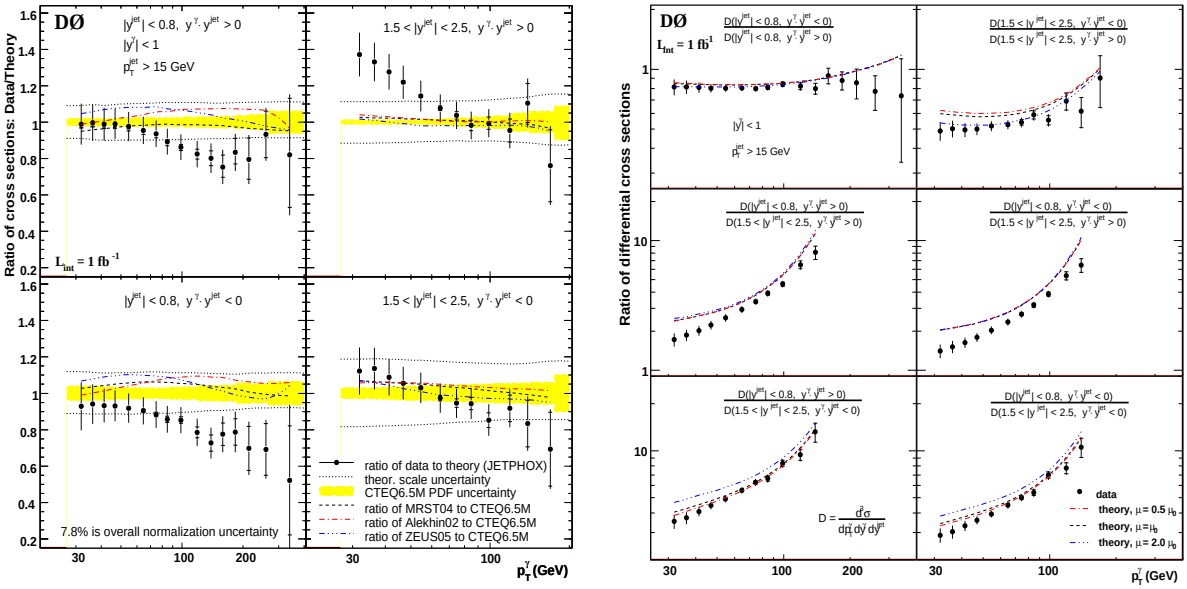

Figure 2. Production of γ+jet events as a function of p_T^γ from DØ. Left: ratio of data-to-theory for four rapidity regions. Right: comparison of theory to data for ratios of rapidity regions.

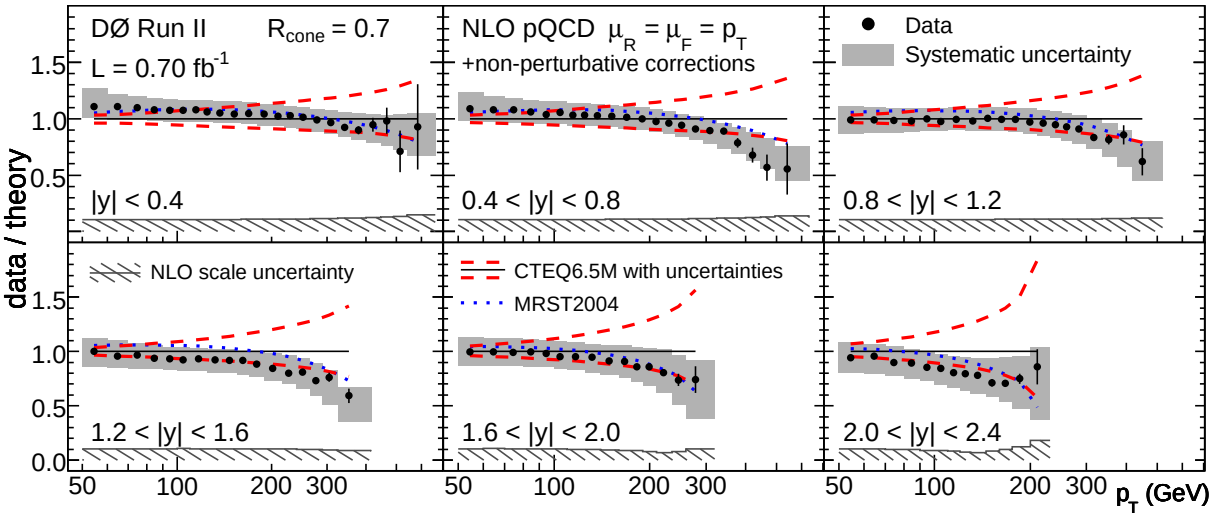

Figure 3. Ratio of theory-to-data for inclusive jet production as a function of $p_T^{\rm jet}$ for several bins in $|y^{\rm jet}|$ from DØ.

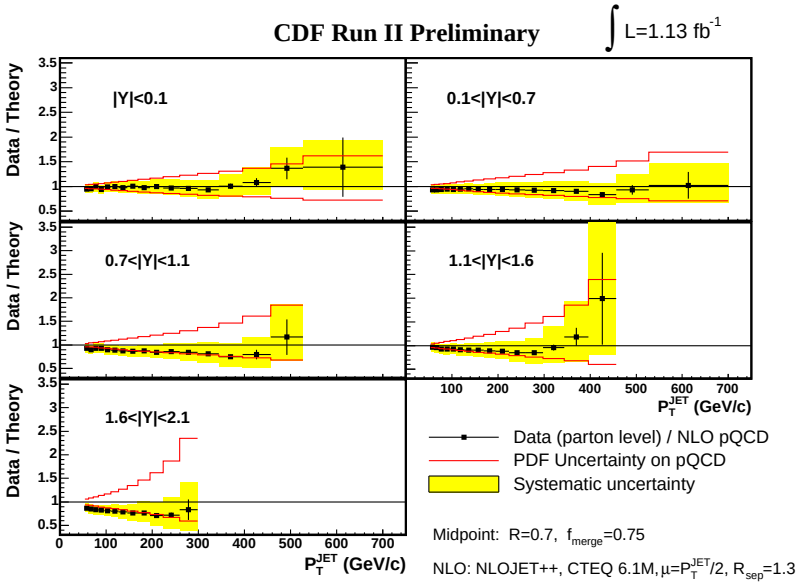

Figure 4. Ratio of theory-to-data for inclusive jet production as a function of $p_T^{\rm jet}$ for several bins in $|y^{\rm jet}|$ from CDF.

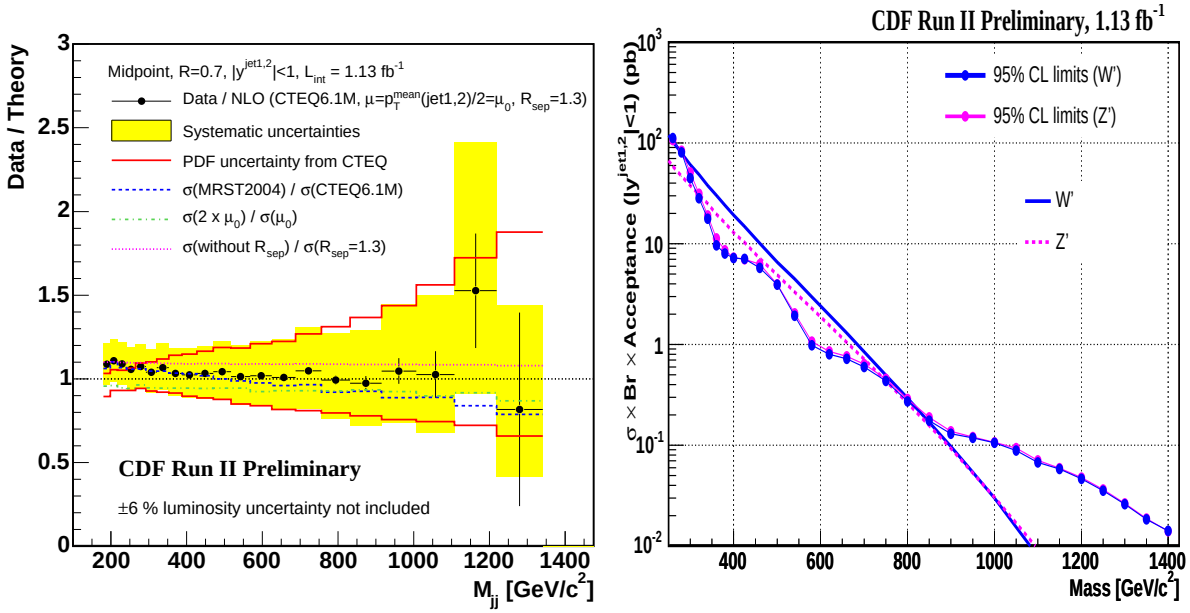

Figure 5. Production of dijet events from CDF. Left: ratio of theory-to-data as a function of M_{jj}. Right: limits for W' and Z' resonant decay into dijets as a function of boson mass.