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SCALING BEHAVIOR OF JET PRODUCTION AT CDF

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ABSTRACT

Inclusive jet cross-sections have been measured in $\bar{p}p$ collisions at $\sqrt{s} = 546$ and 1800 GeV, using the CDF detector at the Fermilab Tevatron. The ratio of jet cross-sections is compared to predictions from simple scaling and $O(\alpha_s^3)$ QCD.

1. Introduction

1.1. Theoretical Motivation

The hypothesis of "scaling" predicts that jet production cross-sections, if scaled in a way that makes them dimensionless, will be independent of $\bar{p}p$ CM energy. By contrast, perturbative QCD calculations of parton hard scattering exhibit non-scaling behavior through the evolution of the proton structure functions and the running of the strong coupling constant, α_s.

1.2. Experimental History

Scaling violation in jet production at hadron colliders has been observed previously in data from CERN experiments (AFS and UA2 [1]) and in CERN/Tevatron comparisons (AFS and CDF [2]). For the present measurement it has been possible to conduct the test within a single experiment, using CDF data taken at the widely separated CM energies of 546 and 1800 GeV. This has led to smaller systematic uncertainties, and a more precise investigation into scaling behavior.

2. Cross-section Measurement

2.1. Triggering and Data Samples

Triggering for jet events required one or more clusters of energy within the calorimeter above a set of transverse energy (E_T) thresholds. Details of triggering and event selection are given in References [3] and [2]. Jets in the offline analysis were restricted to the central rapidity interval ($0.1 \leq |\eta| \leq 0.7$). Two inclusive jet data sets were used in this analysis: (1) the full 1988-89 run at $\sqrt{s}$=1800 GeV (integrated luminosity = 4.43 pb^{-1}), and (2) a short run at $\sqrt{s}$=546 GeV (8.58 nb^{-1}).

2.2. Corrections to the Cross-Sections

Observed inclusive jet E_T spectra were corrected for energy loss and resolu-

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tion effects. Corrections were obtained using a tuned Monte Carlo detector simulation described elsewhere [3]. Confirmation of Monte Carlo modeling of jet losses and resolution has come from comparing data and Monte Carlo predictions for momentum balance in photon-jet and di-jet events. Detector effects were de-convoluted from the measured 546 and 1800 GeV cross-sections.

2.3. Systematic Uncertainty on the Cross-Sections

The largest sources of systematic uncertainty on the cross-sections are the knowledge of calorimeter response to hadrons, knowledge of jet resolution, and uncertainty on the non-jet energy correction. Overall systematic uncertainty on the 546 GeV jet cross-section is $\pm^{23}_{26}\%$ in quadrature sum. The 1800 GeV systematic uncertainty is ±16% for that part of the spectrum (91-238 GeV) which overlaps the 546 GeV data in the dimensionless energy variable x_T ($\equiv 2E_T/\sqrt{s}$).

We note that our 546 GeV inclusive cross-section agrees well with previous measurements from the UA1 and UA2 experiments at the CERN Sp$\bar{p}$S Collider when similar definitions of corrected E_T are applied. To compare to CERN, CDF data were reprocessed using set of jet E_T corrections analogous to CERN's. Figure 1 compares the corrected CDF jet cross-section at 546 GeV (both standard CDF data and "CERN-corrected" CDF data) against UA2 results [1].

3. Scaling Ratio

To test scaling behavior we form the ratio, R, of dimensionless invariant cross-sections ($E_T^4(E\frac{d^3\sigma}{dp^3})$), 546 GeV to 1800 GeV. Ratio data are plotted in Fig. 2. Statistical uncertainties and a band of systematic uncertainty are shown. The total systematic uncertainty is approximately ±15%; thus about half of the systematic error on the individual cross-sections cancels in the ratio.

The deviation of our ratio data from the scaling hypothesis (R=1) was tested by comparing the average value of R against unity. The average R for our data, constructed in a weighted fashion using statistical and systematic errors, is 1.51±0.04±0.21. Comparing the data average to the scaling prediction yields a confidence level of 1.7%. We conclude that scaling in jet production is excluded by our data. We have also compared our R data against next-to-leading order QCD calculations [5] for a variety of structure functions and choices of renormalization scale (Q^2). Figure 2 shows two such calculations. Predictions for average R range from 1.83 to 2.01, and thus lie 1.5-2.4 σ above our data.

4. Conclusions

In summary, the ratio of dimensionless inclusive central jet cross-sections measured in CDF data at 546 and 1800 GeV has provided a test of QCD predictions with greater precision than that of the individual cross-sections; likewise, theoretical uncertainty is reduced by more than a factor of three in the ratio. Using an average ratio test, our ratio data are inconsistent with scaling, and consistent at the 1.5-2.4 σ level with a range of next-to-leading order predictions, although our data favor a level for the ratio that is lower than that of the predictions tested.

6. References

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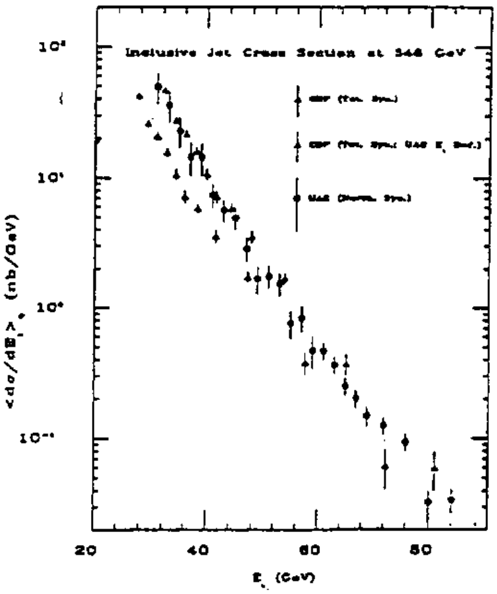

FIGURE 1

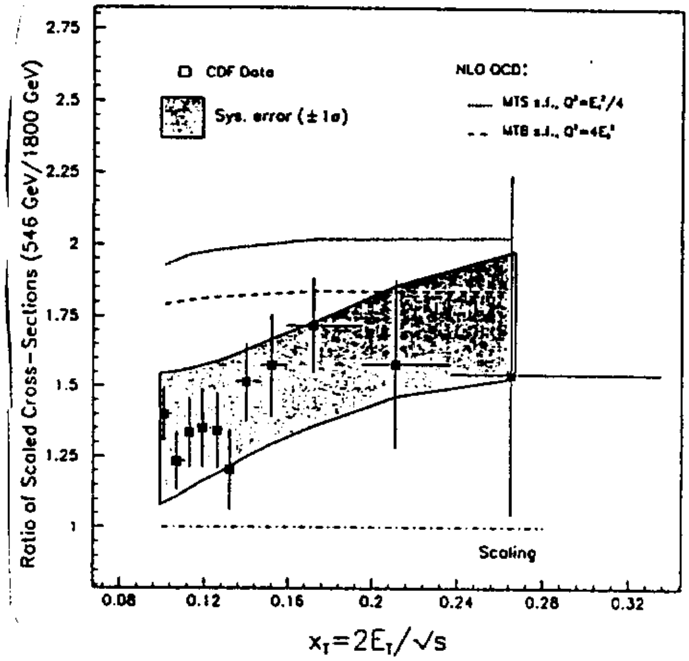

FIGURE 2