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The Two-Jet Differential Cross-Section in 1992-1993 Data

R. Plunkett, S. Behrends, A. Bhatti

Results for production of two or more hadronic jets at $\sqrt{s} = 1800$ GeV are presented. The data are compared with the results predicted from perturbative QCD. Ratios of cross-sections are also given.

INTRODUCTION

We report in this note on status and preliminary results of a measurement of the differential cross-section for production of two energetic jets at $\sqrt{s} = 1800$ GeV. This measurement should provide a sensitive test of Next-to-Leading Order (NLO) QCD, which must predict the absolute normalizations and shapes of the cross-section over a wide range of the kinematic variables E_T and jet psueudo rapidity. It is expected that this measurement, or straightforward extensions of it, will provide a useful tool for probing the parton distribution functions. The measurement is complementary to the measurement of the dijet CM angular distribution [1] , which probes the vector nature of the gluon and is largely free of structure-function effects.

This analysis will use greatly improved statistics to perform a significant extension of previous CDF published work. We also have structured the analysis to be readily comparable with NLO calculations.

METHODOLOGY

The process $\bar{p}p \longrightarrow$ jet1 + jet2 + X may be described by the differential cross section $\frac{d^3\sigma}{dE_t\, d\eta_1 d\eta_2}$, where η_1 and η_2 are the pseudo-rapidities of the two leading jets and E_T is the transverse energy of the leading jet. We use the variables η_1, η_2, and E_T instead of the related set y_1, y_2, and P_T, in order to establish a direct connection with experimentally measured quantities. A previous, low-statistics measurement of the jet $|\eta|$ distributions has been published by CDF using 1987 data [2]. In that measurement events are assigned to E_T bins as determined by a central "trigger jet" (selected from the first two jets in terms of E_T). The $|\eta|$ distribution of the other of the two leading jets (referred to as the "probe jet") was then plotted. In the case that both of the leading jets were capable of generating good central triggers, both combinations were plotted to ensure correct normalization. A 2-dimensional unsmearing in the η-E_T plane was then performed to achieve a result that could be compared with lowest-order QCD theory.

In our analysis we retain the terminology of probe and trigger jets. We note however, that the dominant source of η resolution in the earlier analysis was QCD radiation expressed in the forms of additional jets and K_T kick. This resolution was studied by examining the perpendicular component of the residual K_T using the jet-balancing technique. The resulting resolution was more than 3 times larger than the intrinsic η resolution of the CDF detector for energetic jets [3].

In what follows we do not attempt to correct the data to compare with a lowest-order theoretical model, preferring to leave the data in a form that can be directly compared with NLO theory which should predict the effects of additional radiation. We exploit the good η resolution of the CDF detector to simplify our unsmearing problem. To lowest order, we assume jets do not migrate in η . We fix the $|\eta|$ of the probe jet to be the measured $|\eta|$. We are then left with a family of trigger jet E_T spectra for each bin of probe jet $|\eta|$. These E_T spectra can be unsmeared with conventional means previously used for our published results on the inclusive E_T spectra and X_T scaling. Figure 1 shows such a family of curves derived from a simple theoretical calculation [4].

DATA SET AND EVENT SELECTION

The data used in this analysis was collected in the 1992-93 run. We take advantage of ntuples created from STREAM1 PAD's for J*Q1 data streams and residing in CDF$JET_DATA:[ANA]. The luminosities for the streams used were:

J1Q1	(Jet 100)	3174 nb^{-1}
J2Q1	(Jet 70)	3936 nb^{-1}
J3Q1	(Jet 50)	3910 nb^{-1}
J4Q1	(Jet 20)	4338 nb^{-1}

Events were taken with prescale factors of 500, 20, 6, and 1 for Jet 20, 50, 70, and 100, respectively. For the Jet 20 sample, we use only data taken with the NOT_GAS varient of the trigger.

The total number of events (before cuts) considered for the various samples was:

Jet 100	16,516
Jet 70	20,903
Jet 50	32,703
Jet 20	85,632

We make offline cuts on the E_T of the trigger jet at 35, 70, 90, and 125 GeV for the four samples. We consider only Jet 20 events in the interval 35-70 GeV, and similarly for the other samples. Trigger overlaps for the band of trigger jet η_1 , $0.1 < |\eta_1| < 0.7$, are shown in Figure 2.

Events are next required to have $|z_{vert}| < 60$ cm and a value of MET/SUMET < 0.45. The latter cut is motivated by the presence of residual background in the sample from cosmic rays and main ring splash. Figure 3a indicates the structure of this background for a typical sample of Jet 100 data, along with our cut. Figs. 3b and 3c show the jet electromagnetic fraction (EMF) before and after the cut. Figure 3d shows the EMF of the rejected events. We estimate the residual events removed by the MET cut and **not** in the ranges EMF < 0.05 or EMF > 0.95 to be approximately 2% of the total sample. Some of these events have unreasonable values of the jet E_T 's, so that this 2% should be treated as an upper bound on the efficiency loss due to the cut on MET.

RAW CROSS-SECTION

We form the raw differential cross-section as follows: In each event the two highest-E_T jets are examined for their suitability as a trigger jet by comparison with the applicable offline E_T threshold. In addition, the trigger jet is required to fall in the range $0.1 < |\eta_1| < 0.7$. If the first jet passes, its E_T is entered into a binned E_T histogram; the choice of histogram depends on the pseudo-rapidity of the second jet, $|\eta_2|$. We use slices in $|\eta_2|$ of 0.1-0.7, 0.7-1.2, 1.2-1.6, and 1.6-2.0. These were chosen on the basis of statistics. The above process is repeated with the second jet playing the role of trigger jet and the leading E_T jet used to specify $|\eta_2|$. In both cases the jet specifying η_2 is required to have a minimum (measured) E_T of at least 10 GeV.

Figure 4 shows the raw cross-section for the data sample described above. Data have been multiplied by the relevant prescales, but are not yet corrected for the z-vertex efficiency . All luminosities are from LUMSUM.

CORRECTED CROSS-SECTION

The raw inclusive jet E_T spectra were corrected for detector effects (calorimeter energy loss and resolution). The correction procedure we employed was identical to that used for the 1988-89 inclusive jet analyses (5). Our justification for applying these corrections to the new data comes from the excellent agreement seen in the raw jet cross-sections for the two runs. We are presently evaluating the systematic error on the corrected cross-sections. Figure 5 shows the corrected cross-section for the four η_2 slices described in the previous section, together with the resulting parametrized curves from the unsmearing procedure. Here the data has been corrected by a factor of 0.94 for the events lost by the z-vertex cut. In Figure 6 we have replotted the data together with the results of a Leading Order QCD calculation using MT-LO structure functions with $Q^2=E_T^2$. Only statistical errors are shown.

To quantify the differences seen in the E_T spectra as a function of second-jet η , we form the ratios of the spectra to the spectrum for the first η slice ($0.1 < |\eta_1| < 0.7$). This also has the advantage of providing a measured quantity with minimal systematic error, and one which is relatively insensitive to various theoretical uncertainties (such as choice of Q^2 scale). Figure 7 shows the three sets of ratios constructed from our data-sets. Also shown are a set of Lowest Order QCD calculations using the LO-evolved MT structure function and $Q^2=E_T^2$.

SYSTEMATICS AND FURTHER WORK

Further work needs to be done to refine our measurement and permit detailed comparisons with theory. In particular we need to address the following points:

1) Systematic errors on the cross-section and on the ratios. In principal, the bulk of the systematic error calculation will be a straightforward extension of what has been done before. For the ratios of cross-sections we expect the systematic error to come about almost exclusively due to the difference in slope in the various distributions, which makes for a different translation of, say, jet energy response into effect on cross-section. This systematic error may be as small as 10%.

2) Continue to examine the data set for residual background.

3) Generate NLO calculations and compare with the result.

4) ADD NEW DATA TO THE SAMPLE TO IMPROVE STATISTICS.

5) Explore related quantities to find the best sensitivities for structure function work.

REFERENCES

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2) F. Abe et al., Phys. Rev. Lett. 64, 157 (1990)

3) R. Harris, Ph.D. Thesis, LBL-27246, 1989.

4) B. Combridge and C. Maxwell, Nucl. Phys. **B239**, 429 (1984).

5) T. Hessing, and S. Behrends, CDF-1132 (1990).
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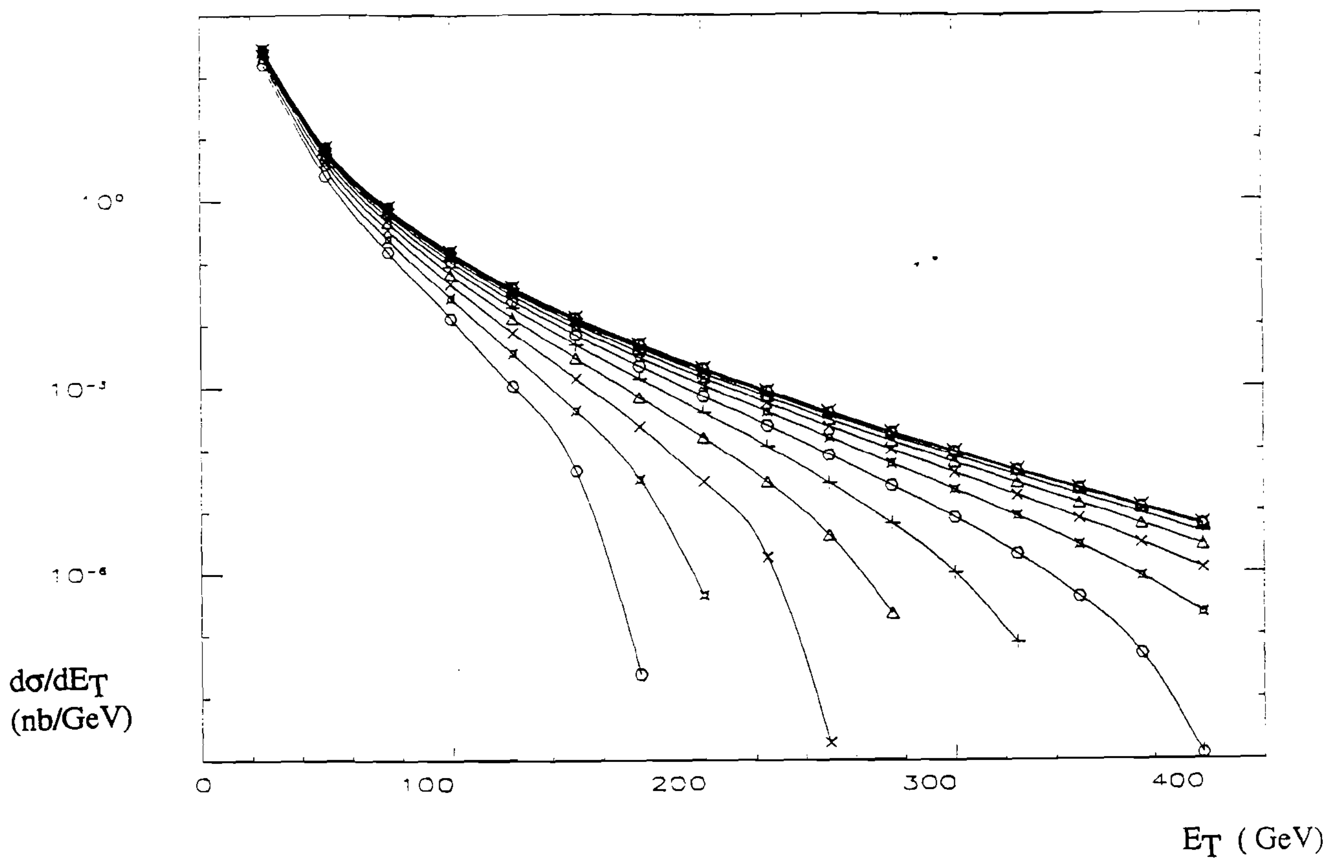

Figure 1: Predictions for the two-jet differential cross-section, with $\eta_1 = 0$. The top curve is for $\eta_2=0$; the lowest is for $\eta_2 = 2.2$. Each curve differs from the one above by an 0.2 in η_2. Curves were generated using the SES approximation of Combridge and Maxwell.

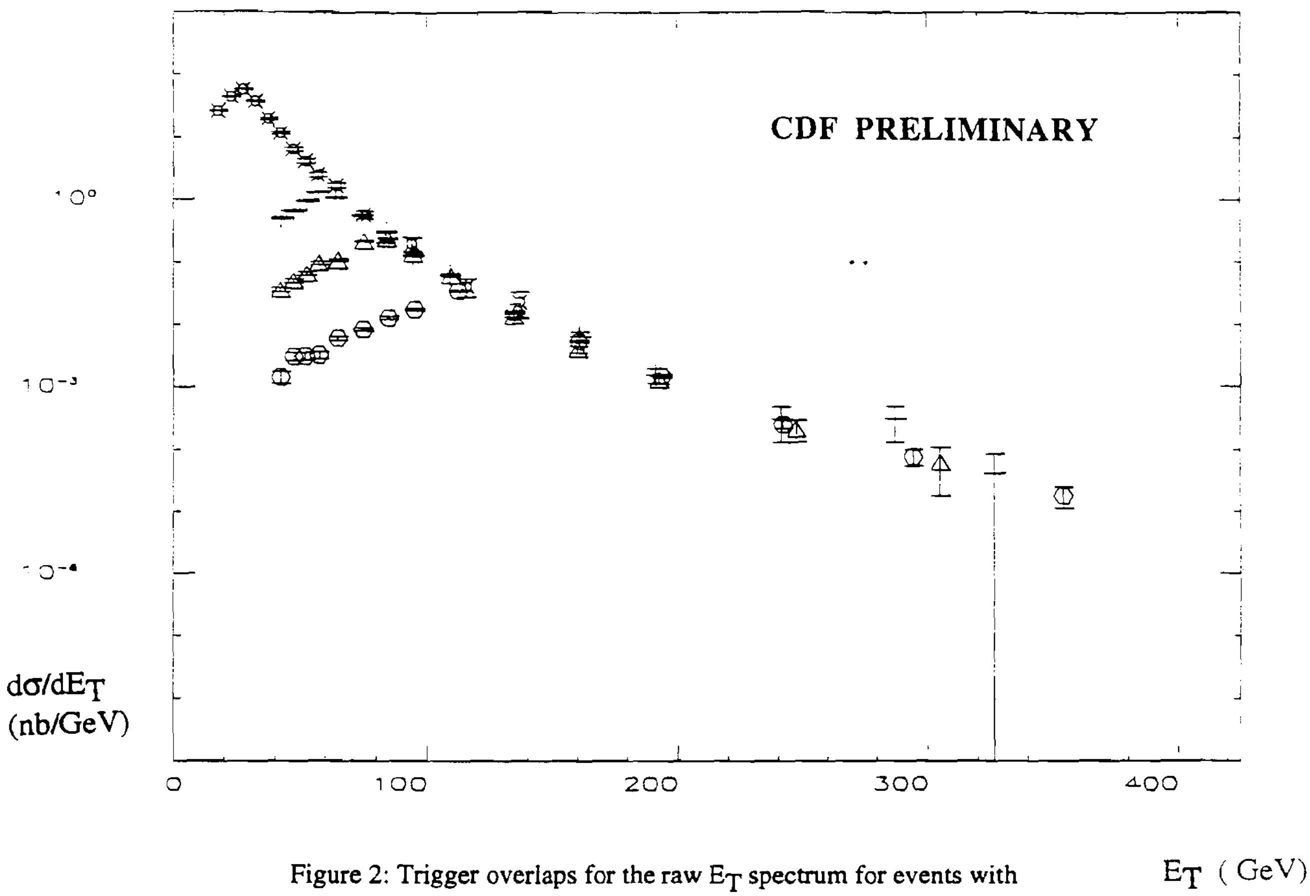

Figure 2: Trigger overlaps for the raw E_T spectrum for events with $0.1 < |\eta_1, \eta_2| < 0.7$. Curves are for JET20, JET50, JET70, and JET100 triggers, proceeding from left to right.

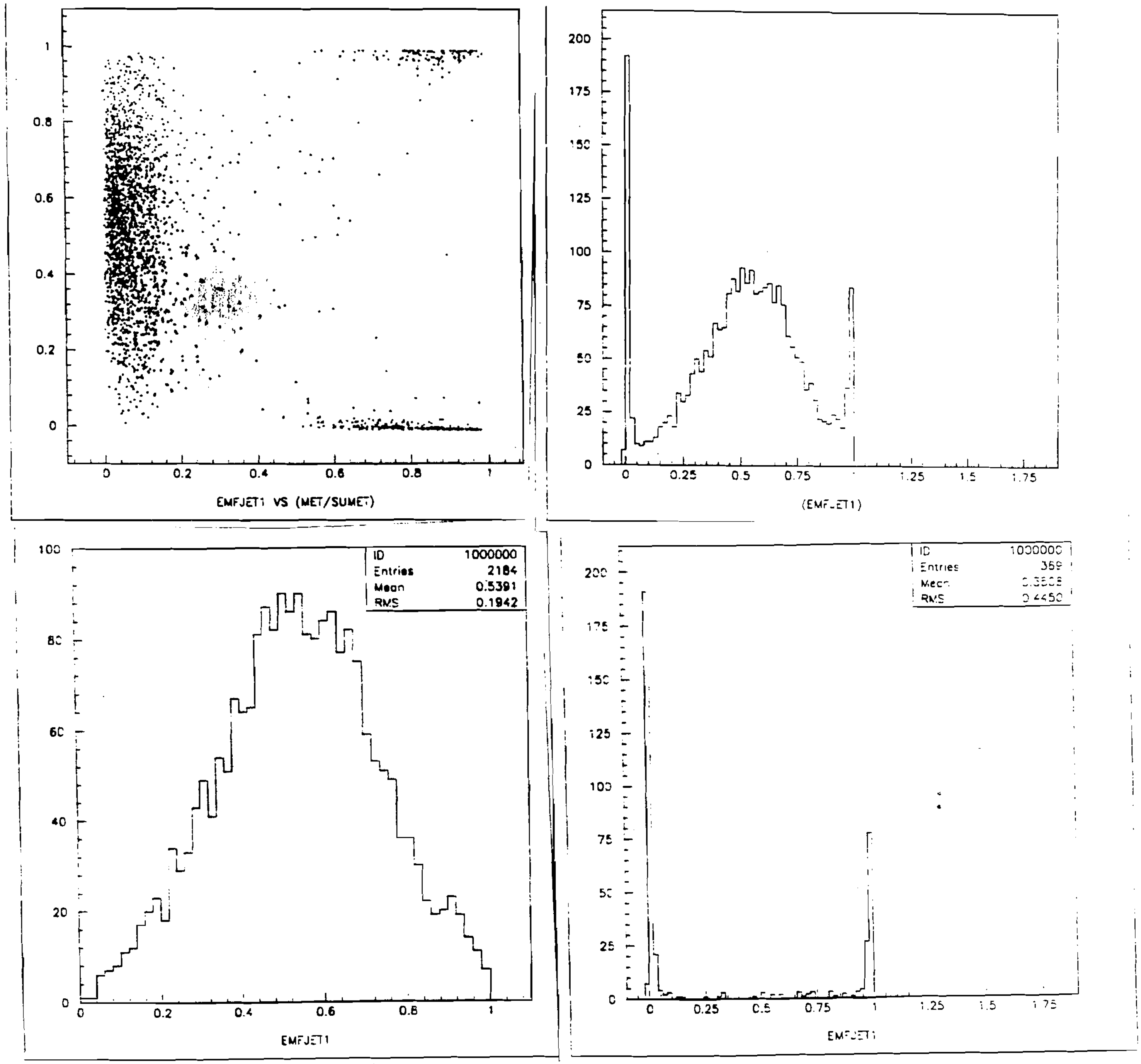

Figure 3a: EMF vs. MET/SUMET for JET100 data.

3b: EMF of JET100 data.

3c: As 3b, but with a cut of MET/SUMET < 0.45.

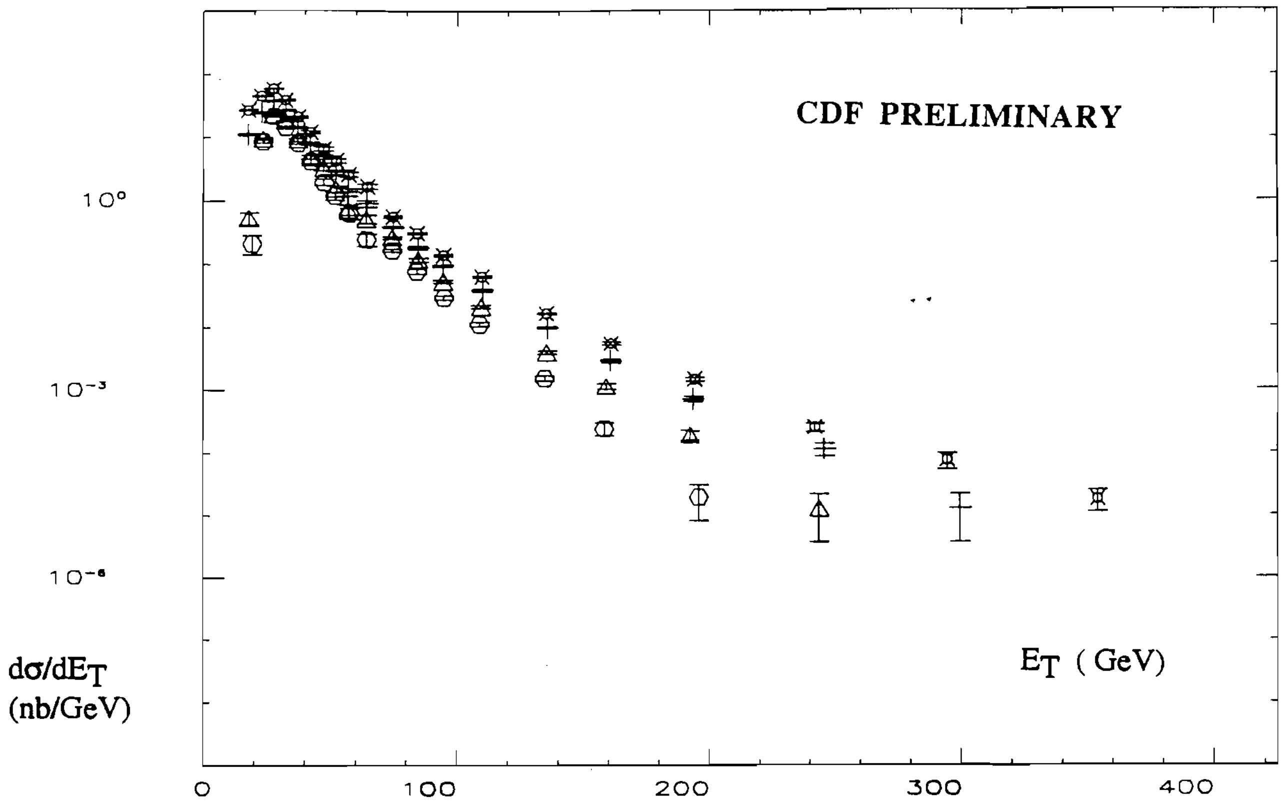

Figure 4: Raw cross-sections for slices in η_2. $|\eta_1|$ is restricted to the range 0.1 - 0.7. Errors are statistical. The ranges of η_2 are described in the text.

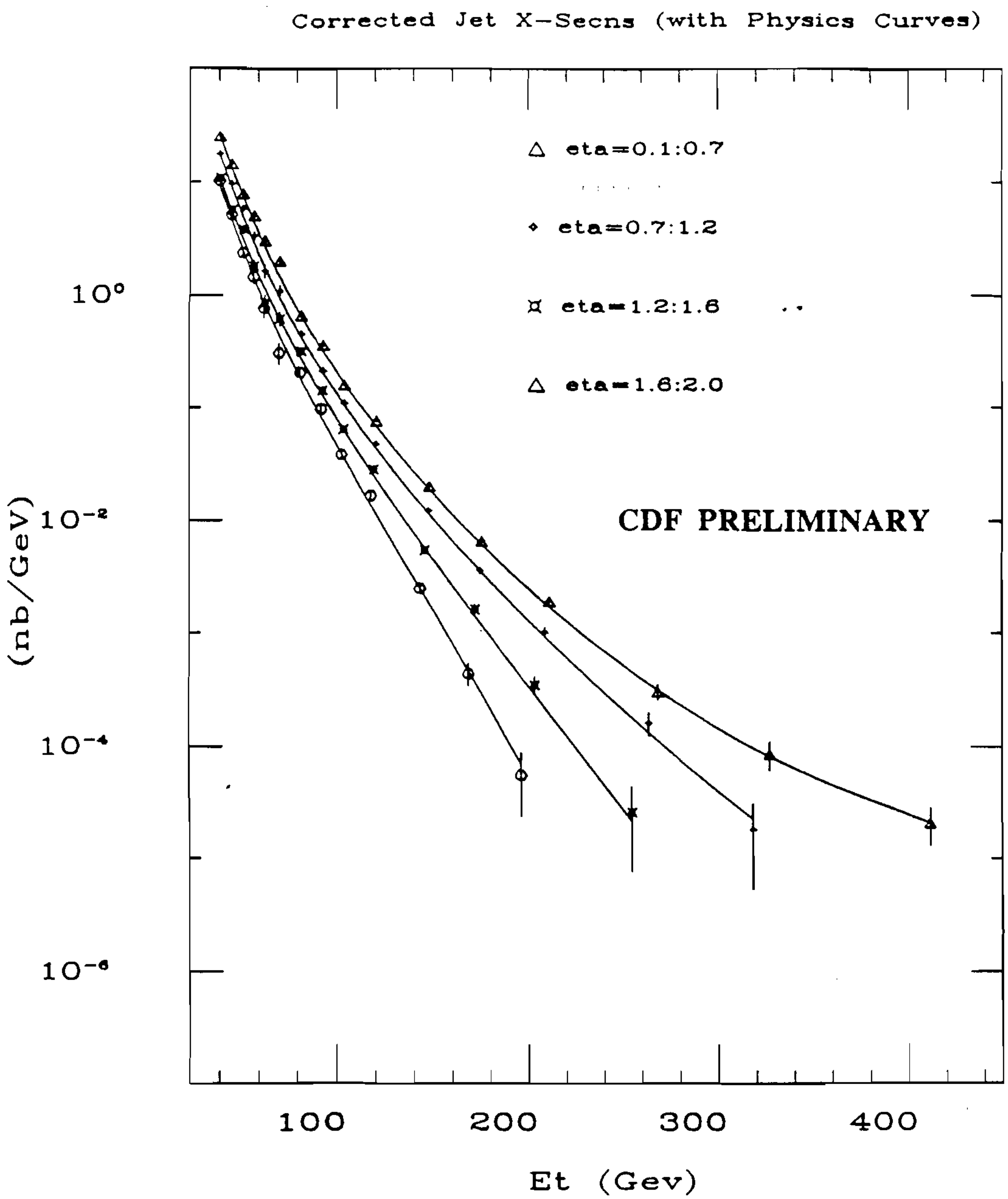

Figure 5: Corrected cross-sections for slices in η_2. Also displayed are the parametrized results of the unsmearing program used to generate the jet corrections for this measurement.

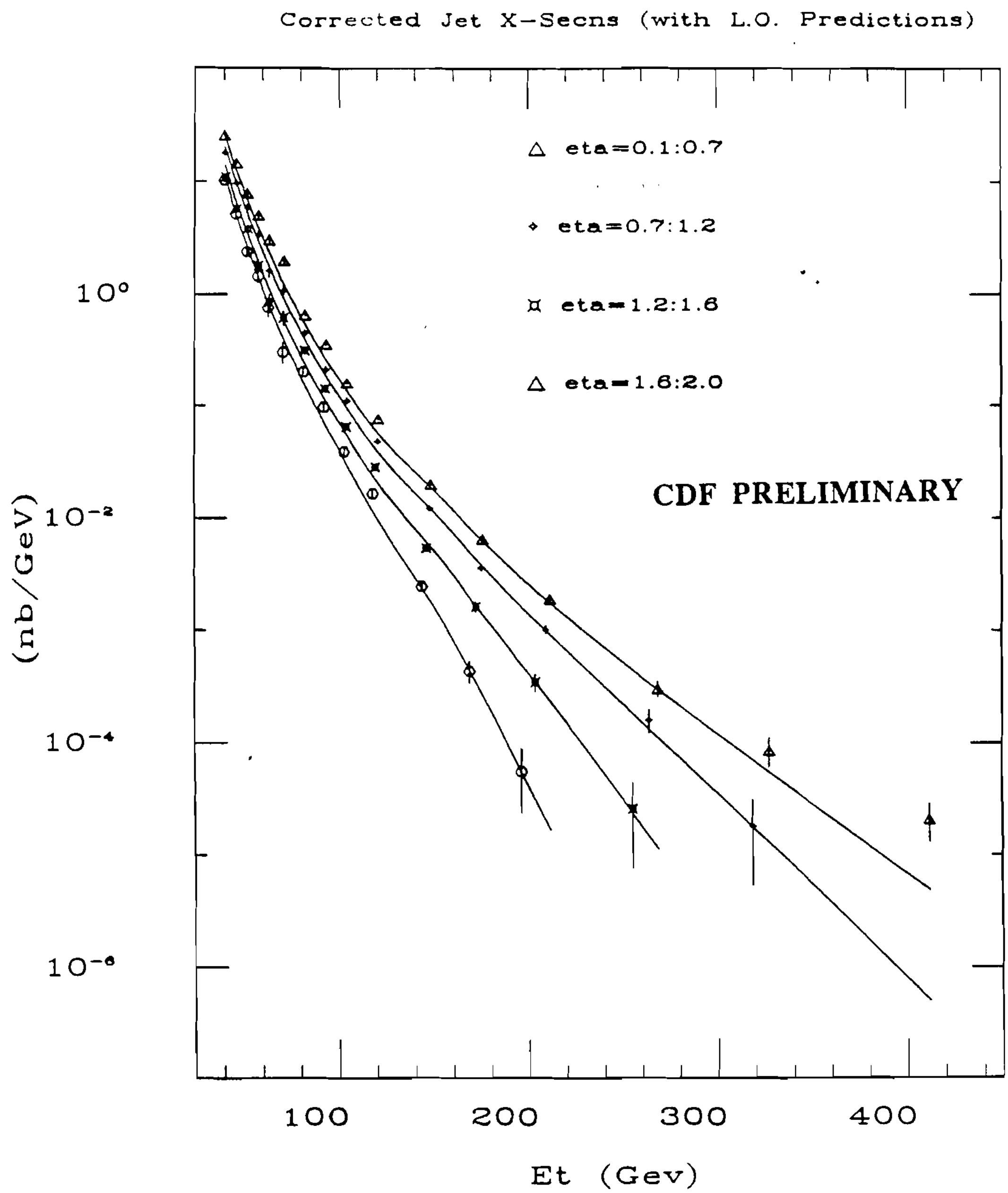

Figure 6: As fig. 5, but with LO QCD superimposed. MT-LO structure functions and $Q^2=E_T^2$ were used. Absolute normalization.

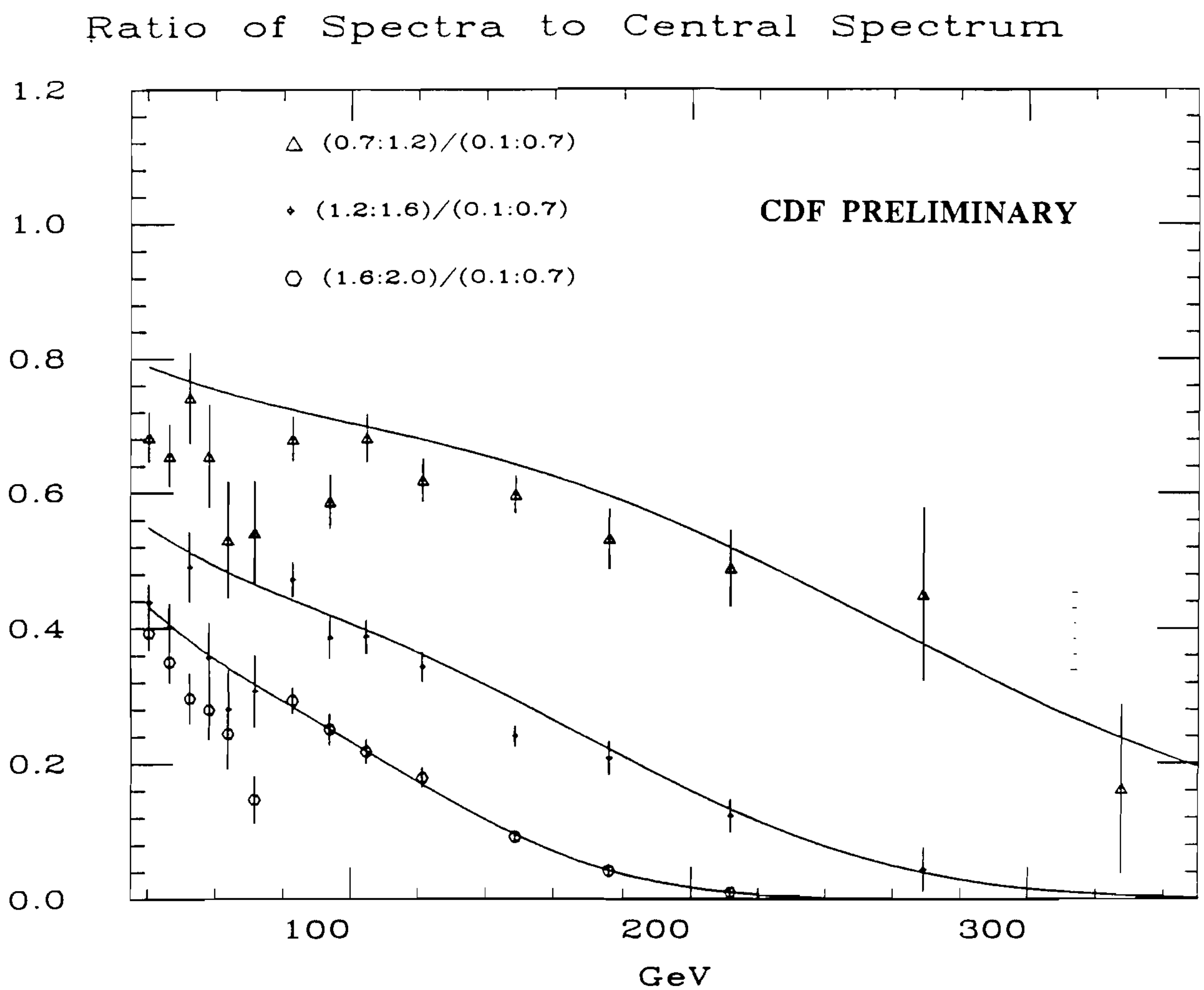

Figure 7: Ratios of corrected cross-sections for slices of η_2, with respect to the slice $0.1 < |\eta_2| < 0.7$. Also displayed are analogous ratios for the LO QCD curves of figure 6.