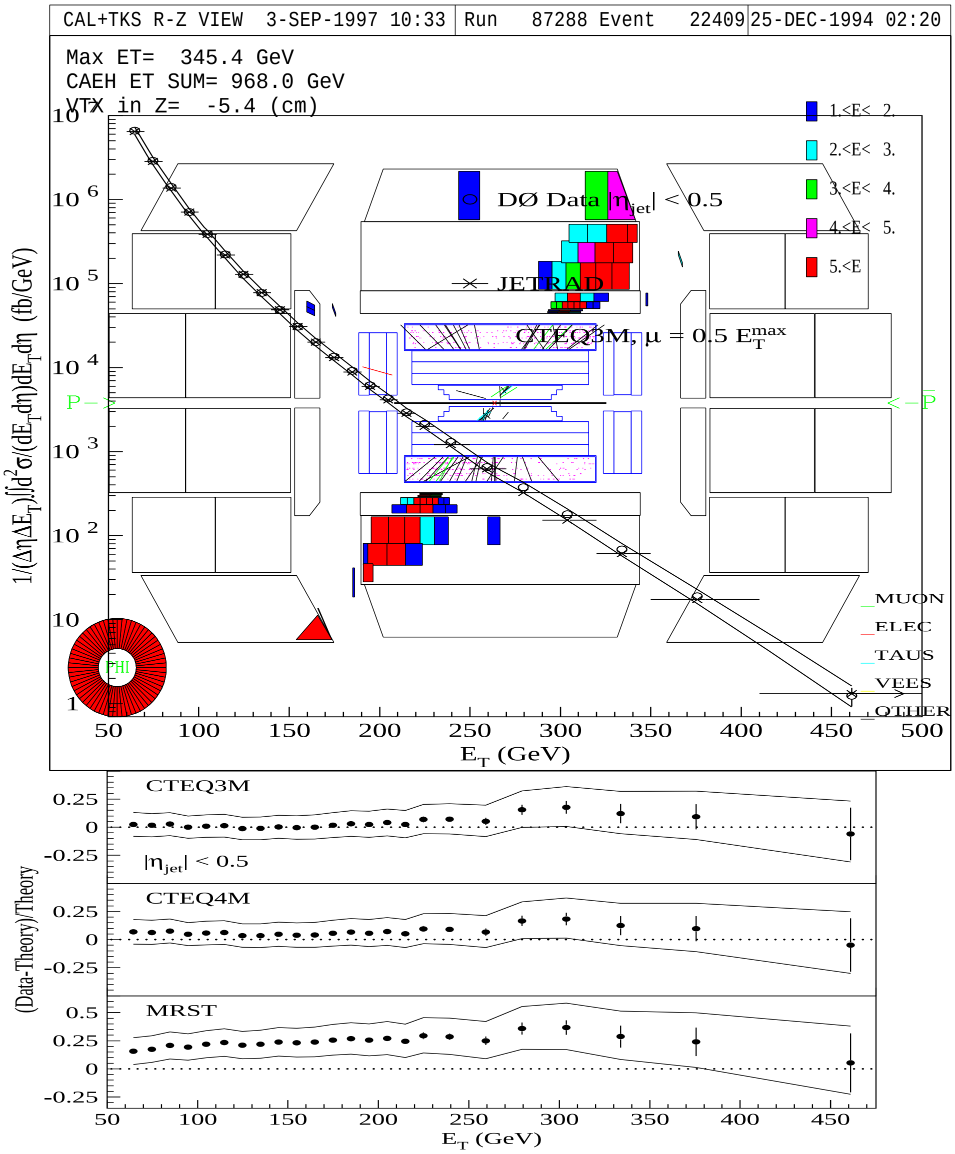
New Results from DØ :
1998 Summer Conferences

The DØ Collaboration



Abstract

This paper contains a brief summary of the physics results presented at the 1998 Summer Conferences by the DØ experiment at the Tevatron $\overline{p}p$ collider.

1 Introduction

This document is a brief summary of the results from papers presented by the DØ Experiment at the biennial Rochester Conference, The International Conference in High Energy Physics, *ICHEP98* held this year in Vancouver, Canada, July 23-29. Results from DØ can also be obtained on the World Wide Web at `http://www-d0.fnal.gov/public/d0_physics_v2.html`.

2 QCD Results

During the past year, a final calibration of the jet energy scale of the detector has resulted in a much reduced uncertainty on jet energies and a more reliable statement of the uncertainties and their correlations in terms of a covariance matrix [1]. In turn, this has permitted a corresponding improvement in the accuracy of several jet measurements and more incisive comparisons with theoretical predictions.

2.1 Jet Production

The final determination of the inclusive jet production cross section [2] agrees well with predictions of Next-to-Leading Order QCD out to a transverse energy of 450 GeV. With the reduced errors, these data can now provide more quantitative limits on the possible deviations from QCD at high transverse energies, and thereby restrict sources for new physics. Previously measured dijet angular distributions are also in good accord with NLO QCD.

2.2 The Dijet Mass Spectrum

We have measured [3] the dijet mass spectrum up to masses of nearly one TeV, and once again find good quantitative agreement with the Next-to-Leading Order QCD predictions. By taking the ratio of the dijet mass distributions in two regions of pseudorapidity, systematic uncertainties are reduced, enhancing the sensitivity to quark compositeness. This measurement excludes compositeness scales less than 2.4 TeV at the 95% confidence level.

2.3 Hard Color-Singlet Exchange

Jets produced in configurations that have a large regions of rapidity that contain few particles, (*rapidity gaps*), suggest a mechanism involving the exchange of a colorless object [4]. This exchanged state is often called the hard pomeron. The fraction of such events, and the dependence of that fraction on kinematic variables, can be used to characterize the coupling of the exchanged pomeron. Preliminary results favor pomeron models such as those involving soft color rearrangement, where the coupling is preferentially to quarks in the proton, rather than the more popular two-gluon models of the pomeron.

2.4 Hard Diffraction

Diffraction has long been considered a “soft” process in which produced particles are limited in transverse energy. Diffractively produced dijets have been observed [3] at both 1800 GeV and at 630 GeV, assuming that single rapidity gaps at relatively high $|\eta|$ are indicative of diffractive production. This suggests the presence of a "hard" component to diffraction. In a different event topology, with rapidity gaps near both beams, two central jets are observed in a smaller fraction of the events at each center of mass energy. This topology is expected for hard double pomeron exchange.

2.5 Forward b-quark Production

The production cross section of b-quarks has been measured [6], through the decay of the b-quark to a muon, in the forward rapidity regions ($2.4 < y^{\mu} < 3.2$). This complements earlier measurements in the central region. The standard QCD predictions are a factor of four below the data, although recent calculations are starting to find explanations for this difference. The difference is about a factor of two greater than for central rapidities.

2.6 Forward J/ψ Production

Forward production of J/ψ vector mesons [7] shows an excess compared to predictions. Recent advances in the theoretical calculations suggest that this excess may be the result of color octet production mechanisms which add to the expected color singlet exchanges. Similar mechanisms augment the previously measured central J/ψ cross sections.

2.7 Direct Photon Production

Inclusive single-photon production measurements [8] are available for two regions of rapidity, $|\eta| < 0.9$ and $1.6 < |\eta| < 2.5$, and QCD calculations are in agreement with the data. At high transverse momenta just the Next-to-Leading Order perturbative description suffices while at low transverse momenta, calculations including resummation of higher order gluon emission diagrams are needed for obtaining agreement. This is also true for the diphoton production.

2.8 Transverse Momentum Distributions for Inclusive W- and Z-Boson Production

The large sample of intermediate vector bosons has also been used to study QCD. These measurements are in a sense an extension of direct-photon physics. The backgrounds are small and well understood, and the statistics sufficient to permit comparisons out to transverse momenta of 200 GeV. The p_T distributions [9] of the W and Z bosons are well described by Next-to Leading Order QCD calculations both in the high and low p_T regions, and as in the case of photons, there is a need to include a resummation of soft gluon emission at low p_T.

2.9 Drell-Yan Production and Compositeness

The production of vector bosons proceeds primarily through the fusion of a quark and an antiquark in the colliding proton and anti-proton. This process is well described by QCD. DØ presented measurements [10] that extend the mass of the dilepton system to 600 GeV/c^2. The good description of these data by QCD permits limits to be placed on various compositeness models with a scale of up to 6 TeV at 95% confidence level. The specific limits depend on the details assumed for the space-time character of the interaction of the sub-constituents.

3 Electroweak Physics

During the first run of DØ over fifty thousand W bosons and several thousand Z bosons were observed through their decay into electrons. This sample has provided rather sensitive tests and precise measurements of electroweak parameters.

3.1 Diboson Production, Trilinear Couplings

DØ has pursued an aggressive program to determine the gauge couplings between the three electroweak vector bosons, the photon, the Z and the W. These couplings are accessed [11] through diboson production processes. In several cases, our measurements provide the sharpest results available. They refine the earlier DØ finding that self-couplings of gauge bosons are required by the data, in agreement with expectations from the standard model.

Many of the measurements have been combined to set more stringent limits on couplings. In particular, with the inclusion [12] of the recent measurements from LEP, the typical limit on WWZ and $WW\gamma$ couplings are at the level of less than a few tenths of a unit for unitarity cutoff scales exceeding 1 TeV.

3.2 Properties of the W-Boson

Several characteristics of the W boson and its production have been measured.

3.2.1 Production and Width of the W-Boson

The ratio between the W and Z cross sections times branching ratio, combining both electron and muon decay channels, is 10.48 ± 0.43. The partial width for invisible decays of the W is limited to <109 MeV.

The ratio between the production cross sections for W and Z is sensitive to several parameters of the standard model. It can be used to determine the ratio of the total to the leptonic width, or the total W decay width(Γ_W), assuming the standard model prediction for the leptonic rate. We determine a preliminary value of $\Gamma_W = 2.126 \pm 0.092$ GeV.

3.2.2 Lepton Universality

By studying the decays of the W to the τ lepton, we can compare the couplings of the W to the electron and τ. The result obtained for the ratio of the couplings, g_τ^W/g_e^W, is 1.004 ± 0.032[14]. This is the best test so far of the universality between $W-e$ and $W-\tau$ couplings at high energy.

3.2.3 W-Boson Mass

DØ has now obtained its final result for the mass of the W based on measurements using the central calorimeter [15]. The value from the 1994-95 data sample is $M_W = 80.45 \pm 0.070(\mathrm{stat}) \pm 0.065(\mathrm{scale}) \pm 0.070(\mathrm{syst})$ GeV. When combined with the earlier 1992-93 measurement from DØ we obtain $M_W = 80.42 \pm 0.11$ GeV. This is the most precise result to date from any single experiment.

4 Results for Top Quark Physics

The results for top physics are now based on the full 1992-96 data sample of approximately 120 pb^{-1}. In most cases the results are final.

4.1 Top Mass

The mass of the top quark has been determined [16] by DØ from both the lepton + jets sample and from the di-lepton + jets sample. The combined result is 172.1 ± 7.1 GeV. When CDF measurements are included, the averaged value is 173.8 ± 5.0 GeV.

4.2 Top Production in the All-jets Channel

DØ has a preliminary measurement of the top [17] cross section in the channel in which both W bosons decay to light quarks, the all-jets channel. In this channel, we measure the cross section to be 7.1 ± 3.2 pb. This is in agreement with that measured in the leptonic channels and results in an average value of 5.9 ± 1.7 pb.

5 Results on New Phenomena

At the highest energy collider in the world, searches for *unexpected* phenomena are imperative and during this past year we have extended our searches in several directions.

5.1 High-Mass Photon Pairs

Certain models contain a Higgs that decays with standard model strength, but only to bosons. For such a Higgs, at low mass only the two photon decay channel is available. We have therefore searched [18] for associated production of a Higgs and a W or Z boson with the W/Z decaying to two hadronic jets. No signal is found, and cross section limits exclude a bosonic Higgs with a mass less than 81.4 GeV at a 95% confidence level.

5.2 Searches for Supersymmetric Particle

Searches for supersymmetric partners of the quarks, gluons and gauge bosons have been conducted in frameworks several models, including gauge-mediated and gravity-mediated

SUSY, and R-parity violating models. The results provide limits in multidimensional parameter space. Conventionally, the limits are often quoted for the particular point where the squark and gluino masses are equal.

5.2.1 Squarks and Gluinos in Jet Channels

Squarks and gluinos are partners of the quarks and gluons in a supersymmetric description of the world. Being strongly interacting, they would be easily produced at a hadron collider, mass permitting. Looking for multi-jet events with missing transverse energy gives[19] lower limits on their masses of 260 GeV for equal squark and gluino mass.

5.2.2 SUSY with Single Photons and Missing Transverse Energy

There is a class of models in which the cascade decays of the supersymmetric spectrum produce photons. One example decay that results in a single photon and missing enery is $\tilde{\chi}_2^0 \rightarrow \gamma\tilde{\chi}_1^0$, where χ_1^0 is the lightest supersymmetric particle. If the masses of the $\tilde{\chi}$ states differ by at least 20 GeV we obtain [20] a mass limit of 311 GeV on the masses of squarks and gluinos for the case in which their masses are equal.

5.2.3 R-Parity Violating SUSY

Although much of the phenomenology of SUSY production is carried through assuming conservation of R parity, in fact, this is an assumption not imposed by any demands of data. Searches without such assumptions tend to be more difficult, nevertheless they can be conducted. DØ has searched [21] for final states with two electrons and four jets. For the case in which their masses are equal, the lower limit on gluino and squark masses is 283 GeV.

5.3 Leptoquarks

Leptoquarks containing both lepton and quark flavor quantum numbers arise in a variety of compositeness and extended technicolor models. Limits from flavor changing neutral currents confine the models to the cases where any given leptoquark decays to leptons and quarks of the same generation.

5.3.1 Scalar Leptoquarks

First generation leptoquarks were a popular explanation for the high mass events in the HERA experiments. Recently the 95% lower mass limit from DØ (225 GeV) for a first generation scalar leptoquark decaying exclusively to electron and a quark has been combined with that from CDF (213 GeV) to provide a combined limit of 242 GeV from the Tevatron. Previous DØ studies also restrict the cases with finite branching ratios to νq.

5.3.2 Vector Leptoquarks

While calculations of cross sections and distributions for scalar leptoquark production [22] have been available for some time, those for vector leptoquarks have appeared more recently. DØ has used these to develop [22] mass limits on vector leptoquarks. In general, the limits exceed those for scalar leptoquarks, but depend on the assumptions made about the couplings. For Yang-Mills couplings, the lower mass limits for branching ratios to electron and a quark of 1, 0.5 and 0, are 340 GeV, 325 GeV and 200, GeV respectively.

5.4 Colorons

A model that can lead to deviations from QCD at high transverse jet energiesadds a second color SU(3) multiplet of gluon-like objects (colorons), but no additional quarks, to the Standard Model. Colorons lead to modifications of jet angular distributions, similar to those expected from contact terms associated with substructure of partons. Our published dijet angular distributions [23] are very well described by Next-to-Leading-Order QCD. DØ has translated [23] that agreement into a mass limit on possible colorons. At a 95% confidence level, masses less than $759 \times \cot\theta$ are excluded where $\cot\theta$ is the relative coupling of the two multiplets.

5.5 Dirac Monopoles

High transverse momentum photon pairs can be produced via a box diagram with a Dirac monopole running around the box. DØ has searched for such pairs. The yield observed is consistent with background, and is used [24] to set a lower limit on the mass of such monopoles of 870 GeV at 95% confidence level for spin 1/2 monopoles.

6 Conclusions

The DØ Experiment has presented a large number of incisive measurements at the summer conferences of 1998. Particularly important this year are the final results of the measurement of the inclusive jet cross section. As shown on the cover page, there is no hint of deviation from QCD predictions, even at the highest values of transverse energy available.

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