RECENT PHYSICS RESULTS FROM CDF II

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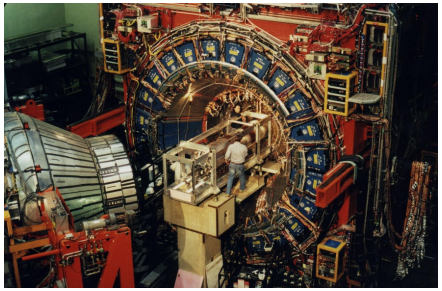
EXECUTIVE SUMMARY

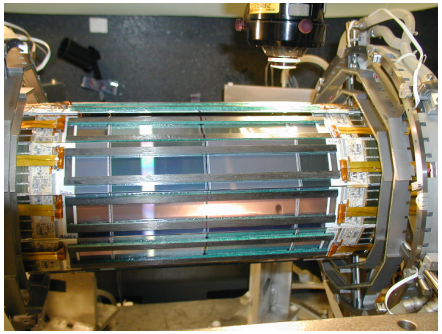
Since 2001, the CDF II detector at Fermilab has been taking data at $\sqrt{s}$=1.96 TeV during Run II of the Tevatron. We present recent physics results from CDF II which use data collected through January 2003. These results represent a first look at physics at these new, higher energies in a variety of topics ranging from B physics to top physics and beyond.

CDF II Detector

The CDF II detector includes a set of upgrades from the CDF detector used in Run I. A new plug calorimeter in the forward region is a sampling device which uses fast scintillator for readout. New chambers have been added to the muon detector systems to close gaps and extend coverage to high $|\eta|$. The data acquisition and trigger systems have been updated to allow for deadtimeless operation and to include impact parameter information in the trigger decision.



In addition, an entirely new tracking system has been commissioned during the early part of Run II. The system consists of a large wire drift chamber (the Central Outer Tracker) and an upgraded silicon detector system with three subsystems at different radii. The SVX II detector on its assembly frame is shown in the photo below.

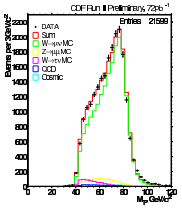


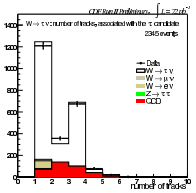
Electroweak Physics Results

Recent results in electroweak physics showcase the performance of the upgraded CDF II detector. In particular, well-developed lepton identification algorithms and precise knowledge of lepton momenta and energy make it possible to select events in which W or Z bosons decay leptonically.

Measurements of W Production

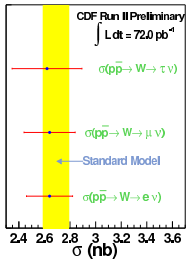
The production cross sections $\sigma(p\bar{p} \to W) \cdot \mathrm{BR}(W \to \ell\nu)$ have been measured in each of the three lepton channels, validating the lepton identification and peformance of the relevant detector subsystems.





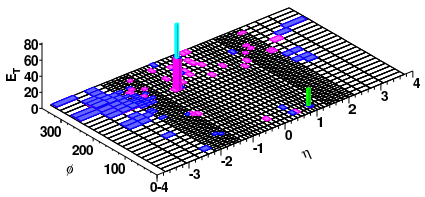
The reconstructed W transverse mass in the $\mu\nu_\mu$ channel and the charged track multiplicity of τ candidates in $W \to \tau\nu_\tau$ events (above left and right, respectively) illustrate the results of the event selections.

The results of the W cross section measurements (at right) agree well with the Standard Model calculation.
A comparison of the channels also serves as a sensitive test of lepton universality: $g_\tau/g_e = 0.99 \pm 0.02$ (stat) $\pm$ 0.04 (sys) for two of the coupling constants.



WW Production

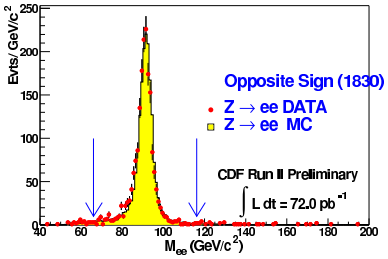
W boson pairs are produced and decay in the dilepton channel $W^+W^- \to \ell^+\ell^-\nu\bar{\nu}$. In this Run II event display, an electron (cyan) and a muon (green) are observed along with missing E_T of 60.2 GeV.



The expected number of background events in 72 pb^{-1} is 1.52 ± 0.64, and the expected WW signal is 2.74 ± 0.59 events. Two events are observed in the data.

Measurements of Z Production

The Z cross section is measured with dilepton pairs, so lepton identification and trigger efficiency impact doubly the signal acceptance. The invariant mass distribution of $Z \to e^+e^-$ events is plotted below for selected events; cross section results are determined for dilepton invariant masses between 66 and 116 GeV/c^2.

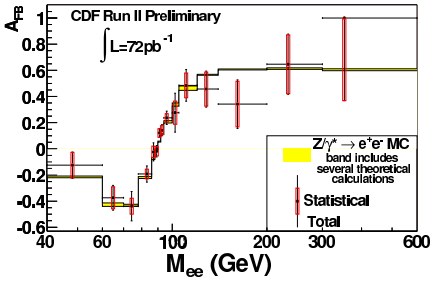


Channel	Cross section (pb)
$Z \to e^+e^-$	267 ± 6 (stat.) $\pm$ 15 (syst.) $\pm$ 16 (lumi.)
$Z \to \mu^+\mu^-$	246 ± 6 (stat.) $\pm$ 12 (syst.) $\pm$ 15 (lumi.)
NNLO $Z \to \ell^+\ell^-$	250 ± 9

The ratio of the W and Z cross section results depends on the width of the W. Given the measurements at $\sqrt{s}$=1.96 TeV, the W widths extracted in the muon and electron channels are 2.11 ± 0.09 GeV and 2.29 ± 0.12 GeV, respectively, compared to the PDG average of 2.12 ± 0.04 GeV.

Forward-Backward Asymmetry

The forward-backward asymmetry A_{FB} is a direct probe of the relative strengths of the vector and axial-vector couplings. It also impacts any additional heavy neutral gauge bosons (such as a Z').
This measurement of A_{FB} with electron pairs is performed in non-uniform bins of di-electron invariant mass. Events are required to have at least one central electron with $|\eta| < 1$, but the second electron may be identified in the plug calorimeter.



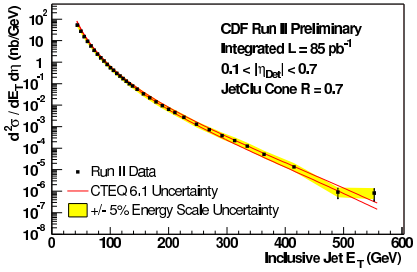
The measured values of A_{FB} in the plot above have been corrected for detector acceptance, lepton identification efficiencies, and QED radiation. The experimental results are consistent with calculations from Pythia Monte Carlo.

QCD Physics Results

Measurements of jet production in high energy proton-antiproton collisions provide stringent tests of Quantum Chromodynamics (QCD). Jet measurements at large transverse energies probe perturbative QCD (pQCD) at very small distances where we are sensitive to possible quark substructure and/or new physics beyond the Standard Model. In addition, these measurements are necessary to constrain the parton density functions (PDFs) within the proton. Studies of diffractive jet production at CDF explore the transition region between the pQCD and non-pQCD regimes and increase our understanding of soft gluon emission and the formation of rapidity gaps in hadronic interactions.

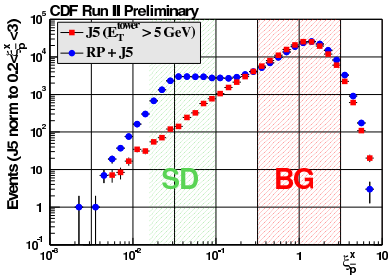
Measurements of Inclusive Jet Cross Sections

The inclusive jet cross section has been extended beyond 550 GeV using Run II data. Comparisons to NLO pQCD calculations allow us to validate the theoretical predictions over nine orders of magnitude (see figure below). These measurements will be used in future global PDF fits to further constrain the gluon distribution in the proton at high x.



Diffractive Physics

Diffractive events with hard scattering are tagged using the very forward detectors of CDF II. "Roman pot" spectrometers are located 60 meters from the interaction point and tag the scattered leading antiproton.



The number of events vs. the fractional momentum loss of the antiproton is shown both for a 5 GeV jet trigger and for a trigger imposing an additional Roman Pot requirement. The enhancement in the Roman pot-triggered sample is interpreted as single diffractive events.
These data have been used to study ratios of diffractive to non-diffractive dijet production rates and the diffractive structure function of the antiproton.