RECENT RESULTS FROM THE TEVATRON

C. ROYON

DAPNIA/Service de physique des particules, CEA/Saclay, 91191 Gif-sur-Yvette cedex, France

We give the most recent results from the DØ and CDF experiments at the Tevatron.

The luminosity accumulated by the DØ and CDF experiments and used for many analyses shown in this report is of the order of 1 fb^{-1} per experiment and the efficiency of data taking is above 90% for both experiments. We will describe in this paper some of the newest results obtained by both collaborations especially on QCD, diffraction, electroweak, top, b physics as well as the search for the Higgs boson and supersymmetry.

1. QCD results

1.1. *Measurement of the inclusive jet p_T cross section*

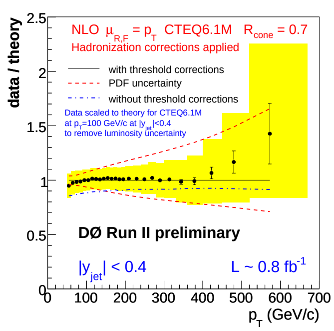

Figure 1. Data/Theory for the jet inclusive p_T cross section in the most central bin in rapidity using the 0.7 jet cone algorithm from the DØ experiment (see text).

Both CDF and DØ collaborations measured the jet inclusive p_T cross section using either the cone or k_T jet algorithm. This measurement can constrain further the gluon density at high x - which is the one of the limiting factors in some analyses beyond the standard model at the Tevatron and the LHC like the search for the stop quark, and extra dimensions - and is also sensitive to quark and gluon substructure. The DØ collaboration performed this measurement in two jet rapidity bins ($|y| < 0.4$ and $0.4 < |y| < 0.8$) using a luminosity of 0.8 fb^{-1}. Data at particle level are compared to NLO calculations including threshold corrections [2,4] using the

CTEQ6.1M parametrisation [3], corrected for hadronisation effects [1]. Let us note that the data have been scaled to NLO predictions for the $|y| < 0.4$ bin at p_T=100 GeV since the evaluation of the luminosity of the full sample was in progress. The results are presented in Fig. 1 for the most central bin in rapidity as the ratio data over theory. The difference in behaviour at high p_T between both bins in rapidity is due mainly to statistical effects in the jet energy scale determination [1]. Data are found to be in good agreeement with NLO calculations. The threshold correction effects are represented by the difference between the blue dashed dotted line and the black horizontal line and the uncertainty on PDFs by the red dashed line. The present systematics displayed as the yellow band is of the same order of magnitude as the uncertainty on PDFs.

The CDF collaboration also performed the measurement of the jet inclusive p_T spectrum using the 0.7 cone algorithm for $0.1 < |y| < 0.7$ at the parton level and the data are also found to be in good agreement with NLO calculations [5].

The CDF collaboration also measured the inclusive jet p_T spectrum using the k_T algorithm with about 1 fb^{-1} and the results are displayed in Fig. 2 in five bins of rapidity [5]. There is a good agreement between theory and experiment within systematics (displayed as a yellow band), and the PDF uncertainties displayed as a red dashed line show the sensitivity of this measurement on the high x gluon density specially at high rapidities.

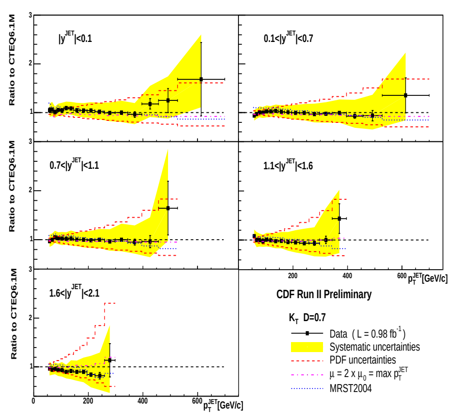

Figure 2. Data/Theory for the jet inclusive p_T cross section in five bins of rapidity using the k_T jet cone algorithm from the CDF experiment (see text).

1.2. *Other measurements sensitive to PDFs*

In this section, we describe briefly some other measurements related to QCD and PDFs measurements. Another measurement performed by the

DØ collaboration sensitive to PDFs relies on the inclusive photon cross section with $|\eta| < 0.9$. The measurement is found to be in good agreement with NLO QCD [6] and the extension of this measurement towards higher rapidity will allow to constrain further the PDFs.

The measurement of the inclusive b jet cross sections has been performed by the CDF collaboration [7] using about 300 pb^{-1} and the comparison with theory suffers large uncertainties related to renormalisation and factorisation scales. The higher order contributions which are not included in the theory might play a major role in b-jet production calculations.

Other observables which have been measured by the DØ and CDF collaborations correspond to the jet and Z or W distributions in Z+jet or W+jet events. In general, there is a good agreement between the Monte Carlo predictions and data, but there are some discrepancies in the third jet distributions like for its transverse momentum for instance [8]. These comparisons are very important to tune the Monte Carlos for the LHC and the Tevatron since they correspond directly to a background to the search for the Higgs boson.

2. Diffraction at the Tevatron

Diffractive events can be analyzed at the Tevatron both in the DØ and CDF experiments. Both experiments installed roman pot detectors in the direction of the outgoing antiprotons which show a good acceptance down to t close to 0. The DØ collaboration installed additional roman pot detectors on both proton and antiproton sides with a good acceptance for $t > 0.8$ GeV^2 and lower ξ.

In addition to the analyses related to inclusive diffraction measurements using dijets for instance, the CDF collaboration performed the first search for exclusive events at the Tevatron. An exclusive production means that the full available energy is used to produce the object in the main detector (diphoton, dijets...), or in other words, there is no pomeron remnant. The existence of the exclusive events is of special interest for the LHC where the Higgs boson might be produced exclusively [9]. The CDF collaboration measured the so-called dijet mass fraction in dijet events - the ratio of the mass carried by the two jets divided by the total diffractive mass - when the antiproton is tagged in the roman pot detectors and when there is a rapidity gap on the proton side to ensure that the event corresponds to a double pomeron exchange. The results are shown in Fig. 3 and are compared with the POMWIG expectation using the gluon and quark densities measured by the H1 collaboration in dashed line [10]. We see a clear deficit of events towards high values of the dijet mass fraction, where exclusive events are supposed to occur (for exclusive events, the dijet mass fraction is 1 by definition at generator level and can be smeared out towards lower values taking into account the detector resolutions). Fig. 3 shows also the comparison between data and the predictions from the POMWIG and DPEMC generators, DPEMC being used to generate exclusive events [9]. There is a good agreement between data and MC. However, this does not prove the existence of exclusive events since the POMWIG prediction shows large uncertainties (the gluon in the pomeron used in POMWIG is not the latest one shown at this workshop and the uncertainty at high β is quite large [12]). In addition, it is not obvious one can use the gluon density measured at HERA at the Tevatron since factorisation is not true, or in other words, this assumes that the survival probability is a constant, not depending on the kinematics of the interaction.

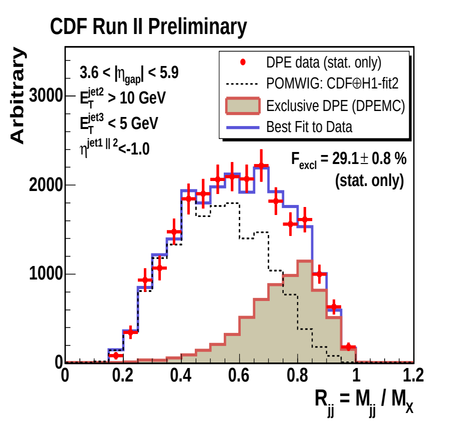

Figure 3. Search for exclusive diffractive events at CDF.

The CDF collaboration also looked for the exclusive production of dilepton and diphoton. Contrary to diphotons, dileptons cannot be produced exclusively via pomeron exchanges since $gg \rightarrow \gamma\gamma$ is possible, but $gg \rightarrow l^+l^-$ directly is impossible. However, dileptons can be produced via QED processes, and the cross section is perfectly known. The CDF measurement is $\sigma = 1.6^{+0.5}_{-0.3}(stat) \pm 0.3(syst)$ pb which is found to be in good agreement with QED predictions and shows that the acceptance, efficiencies of the detector are well understood. 3 exclusive diphoton events have been observed by the CDF collaboration leading to a cross section of $\sigma = 0.14^{+0.14}_{-0.04}(stat) \pm 0.03(syst)$ pb compatible with the expectations for exclusive diphoton production at the Tevatron.

3. B_S oscillation

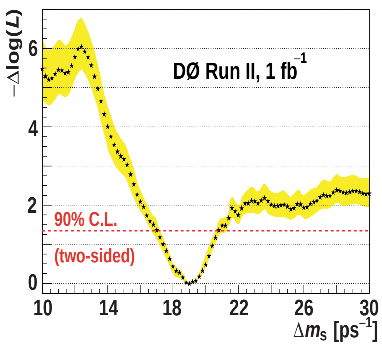

Figure 4. B_S oscillation results from DØ .

The B_S mesons (B_S^0 and $\bar{B_S^0}$) transform via the weak interaction between their own constituents and the rate is characterized by the mass difference between both constituents called Δm_S. The standard models predicts that $16.7 < \Delta m_S < 25.4$ ps^{-1}. For the first time, the DØ and CDF experiments have been able to measure Δm_S directly. The DØ collaboration looked for events where B_S decays in D_S mesons ($\bar{c}s$) and a muon and a neutrino. The D_S decays via $\Phi\pi$ to $K^+K^-\pi$. The intersection of the reconstructed D_S flight path with that of the muon gives the distance the B_S meson travelled before it decayed, which leads to the lifetime of the B_S meson once its momentum is determined. The lifetime is then directly related to Δm_S. The results are displayed in Fig. 4 which leads to $17 < \Delta m_S < 21$ ps^{-1} at 90% CL [13].

The CDF collaboration measured also Δm_S more recently with higher precision benefitting from the layer 0 of their silicon tracker [14]. The results are: $\Delta m_S = 17.33^{+0.42}(stat) \pm 0.07(syst) ps^{-1}$, or $17.00 < \Delta m_S < 17.91$ ps^{-1} at 90% CL , $16.94 < \Delta m_S < 17.97$ ps^{-1} at 95% CL which leads to $V_{td}/Vts = 0.208^{+0.008}_{-0.007}$.

4. Electroweak and top quark results

4.1. *W production*

The WW production cross section was measured recently by the CDF collaboration using 825 pb^{-1}: $\sigma = 13.6 \pm 2.8(stat) \pm 1.6(syst) \pm 1.2(lum)$ pb, to be compared with the DØ published result with 220-250 pb^{-1}, $\sigma = 13.8^{+4.3}_{-3.8}(stat)^{1.2}_{-0.9}(syst) \pm 0.9(lum)$ pb [15].

Both collaborations measured the W asymmetry [1] which is directly sensitive to the d over u quark densities. The measurement stills suffers large statistical uncertainties and will be improved in a near future.

The measurement of the W mass is still in progress and should be presented by Winter 2007. Its precision is expected to be of the order of 20-30 MeV by the end of Run II.

4.2. *Top quark and electroweak fits*

The top quark production cross section as well as mass measurements are one of the main goal of the Tevatron experiments. The measurement of the $t\bar{t}$ production was performed in different multilepton and multijet channels [16] and the combined result for the CDF experiment as an example is: $\sigma = 7.3 \pm 0.5(stat.) \pm 0.6(syst.) \pm 0.4(lum.)$ with 760 pb^{-1}.

A new top mass combination from the DØ and CDF collaborations leads to a much better precision than at Run I (the precision for Run I was 4.4 GeV): $M_{top} = 172.5 \pm 1.3(stat.) \pm 1.9(syst.)$ [17]. The new top mass measurement together with new data on W boson width and mass from the Tevatron and LEP experiments lead to a new Higgs mass from electroweak fits [18]: $M_{Higgs} = 89 + 42 - 30$ GeV at 68% CL, and less than 175 GeV at 95% CL. The final error on the top mass at the end of Run II at the Tevatron will be of the order of 1.5 GeV and will constrain further the Higgs boson mass.

The top quark can also produced singly directly via electroweak production together with a b quark. This process has not yet been observed experimentally which leads to the following limits: 5.0 pb (s-channel production), 4.4 pb with a luminosity of 370 pb^{-1} from the DØ collaboration, and 3.2 pb (s-channel production), 3.1 pb (t channel), 3.3 pb (both channels) with a lumi of 695 pb^{-1} from the CDF collaboration. The SM observation is expected at 3 σ with 1.5 fb^{-1} and at 5 σ with 4 fb^{-1}.

5. Search for the Standard Model Higgs boson

The search for the SM Higgs boson was performed by both DØ and CDF collaborations [19] and the combination is given in Fig. 5. The 95% CL limit divided by the SM expectation is displayed in Fig. 5 and shows the present reach of the Tevatron experiments.

The search for the Higgs boson is made either via associate production with a Z or a W or via a direct production, and the Higgs boson either decays in $b\bar{b}$ where the dijet background is quite large or in WW at higher masses. The present sensitivity of the Tevatron experiments with less than 400 pb^{-1} is about a factor 10 lower than the SM expectation for a Higgs boson mass of about 160 GeV. Without any improvement on the analysis performances, it will be possible to be sensitive on SM Higgs production at the Tevatron with the full luminosity accumulated by each experiment of 4-5 fb^{-1} before 2009.

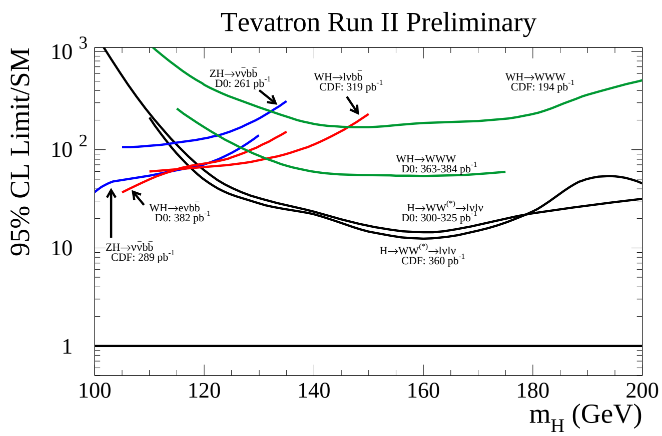

Figure 5. Higgs boson search combination plot.

6. Searches for new phenomena

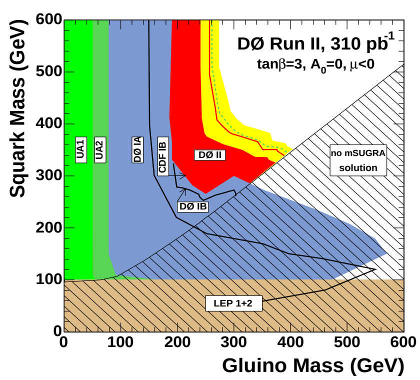

Figure 6. Exclusion plot in the gluino and squark mass plane from the DØ experiment.

In this report, we will describe only one result concerning the search for squarks and gluinos in the multijet and missing transverse energy channel performed by the DØ collaboration. Many other searches are performed at the Tevatron such as stops, leptoquarks, higher dimensions, GMSB and more information can be found in Ref. [20].

The search for squarks and gluinos is performed in the N jets and missing transverse energy channel where N is respectively 2, 3 or 4 when $\tilde{q}\tilde{q}$, $\tilde{q}\tilde{g}$, $\tilde{g}\tilde{g}$ are produced. The limits obtained in the squark and gluino mass planes are given in Fig. 6 with a luminosity of about 310 pb^{-1}. Squarks and gluinos with masses respectively below 325 and 241 GeV are excluded at 95% CL for $\tan\beta = 3$. Let us notice that one of the limiting factors entering in this analysis is related to the uncertainty on the high x gluon density, and this will be even more sensitive at the

LHC. [21].

7. Conclusion

In this talk, we described many results from the Tevatron extending from QCD, diffraction, electroweak, b physics, top, Higgs and new phenomena. The sensitivity of the Tevatron experiments is the highest until the start of the LHC concerning the reach on compositeness, SUSY, Higgs boson production. The precision on jet cross section, W and top quark cross section measurements as well as b physics will increase in the near future. Of special interest before the start of the LHC is the search for the Higgs boson and SUSY, and the top quark properties, as well as the search for exclusive events which is a promising diffractive channel at the LHC.

References

1. M. Voutilainen, these proceedings;
2. Z. Nagy, Phys. Rev. Lett. **88**, 122003 (2002).
3. J. Pumplin *et al.*, JHEP **0207**, 12 (2002).
4. N. Kidonakis, J.F. Owens, Phys. Rev. D63, 054019 (2001).
5. O. Norniella, these proceedings; CDF Collaboration, hep-ex/0512020 and hep-ex/0512062.
6. DØ Coll., hep-ex/0511054.
7. D. Jeans, these proceedings.
8. See http://www-d0.fnal.gov/Run2Physics/WWW/results/higgs.htm and http://www-cdf.fnal.gov /physics/new/qcd/QCD.html
9. C. Royon, Mod. Phys. Lett. A **18**, 2169 (2003) and references therein; M. Boonekamp, R. Peschanski, C. Royon, Phys. Rev. Lett. **87** (2001) 251806 and Nucl. Phys. **B669** (2003) 277; M. Boonekamp, A. De Roeck, R. Peschanski, C. Royon, Phys. Lett. **B550** (2002) 93; V.A. Khoze, A.D. Martin, M.G. Ryskin, Eur. Phys. J. **C19** (2001) 477 and Eur. Phys. J. **C24** (2002) 581.
10. M. Gallinaro, these proceedings.
11. B. Cox, J. Forshaw, Comput. Phys. Commun. **144** (2002) 104.
12. P. Newman, these proceedings.
13. DØ Coll., hep-ex/060404.
14. CDF Coll., hep-ex/0606027.
15. J. Garcia, these proceedings.
16. S. Cabrera, these proceedings.
17. P. Schieferdecker, these proceddings.
18. See http://tevewwg.fnal.gov/top/.
19. M. Tomoto, these proceedings
20. F. Badaud, these proceedings.
21. DØ Coll., Phys. Lett. **B 638** (2006) 119.