FERMILAB-CONF-08-150-E

Tevatron Searches for Resonances Decaying to Fermion Pairs

Carsten Magass on behalf of the DØ and CDF Collaborations

Universität Bonn - Physikalisches Institut
Nussallee 12, 53115 Bonn - Germany

The latest results of searches in the dijet, dielectron, four-electron, and electron plus missing transverse energy channels obtained by the DØ and CDF experiments at the Tevatron Collider are reported. Since no significant excess is observed in the data in all cases, limits are set that improve on previous searches.

1 Introduction

The standard model (SM) describes the fundamental fermions and their interactions via gauge bosons at a high level of accuracy, but it is not considered to be a complete theory. Many possible extensions to the SM have been proposed, usually predicting new particles and containing new parameters. These new particles and their decays can be looked for at a collider experiment like the proton-antiproton collider Tevatron which currently operates at a center-of-mass energy of $\sqrt{s} = 1.96$ TeV (Run II).

The Tevatron collider is performing very well; an integrated luminosity of more than 3 fb^{-1} has already been delivered to each experiment. Recent analyses are presented [1] using data taken with the DØ and CDF II detectors and corresponding to luminosities between 1 and 2.5 fb^{-1}. The data are searched for generic resonances and new particles introduced in different extensions to the SM, via their decays into highly energetic jets, electrons, and neutrinos, where the latter give rise to missing transverse energy ($\not\!\!E_T$).

2 Dijet Resonance Search (CDF)

CDF has analyzed the dijet mass spectrum in 1.13 fb^{-1} of data [2]. The jets are reconstructed using a cone algorithm with eta-phi radius $R = 0.7$. The agreement between the measured dijet mass spectrum and next-to-leading order (NLO) predictions is very good. In order to be able to find narrow resonances the data are fit to a parameterization of the NLO prediction plus gaussian peaks (see left-hand plot in Fig. 1). Since no significant deviations from the NLO prediction are found, the following 95% C.L. limits for new massive particles are given (see right-hand plot in Fig. 1):

- 260 GeV $< m <$ 870 GeV for the excited quark $q^* \to qg$ [3] ($f = f' = f_s = 1$);
- 260 GeV $< m <$ 1250 GeV for the axigluon and flavor-universal coloron [4] (mixing of the two SU(3), $\cot\theta = 1$);
- 290 GeV $< m <$ 630 GeV for the diquark state in E_6 [5];
- 260 GeV $< m <$ 1100 GeV for the color-octet techni-ρ [6] (mass-degenerate techni-ρ with standard topcolor-assisted-technicolor (TC2) couplings and technicolor mass parameters $M_8' = 0$, $M(\pi_{22}^8) = 5M(\rho)/6$, $M(\pi_{22}^1) = M(\pi_{22}^8)/2$, and $M_8 = 5M(\rho)/6$);

- 280 GeV $< m <$ 840 GeV for SM-like additional charged gauge boson W';
- 320 GeV $< m <$ 740 GeV for SM-like additional neutral gauge boson Z'.

These limits are the most restrictive limits, except for Z' (see Sec. 4) and W' (see next section).

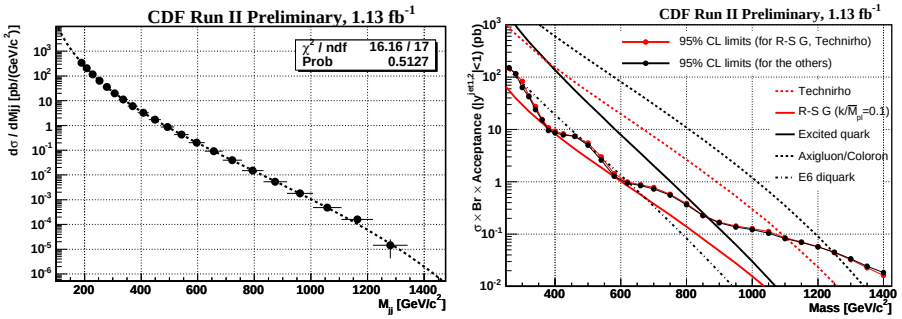

Figure 1: The measured and fitted dijet mass spectrum (left) and 95% C.L. upper limits on the cross sections for selected processes (right).

3 Electron + $\not\!\!E_T$ Resonance Search (DØ)

DØ has looked for production of SM-like additional charged gauge bosons (W') decaying into electron and neutrino [7]. The neutrino is reconstructed using the energy balance in the transverse plane. The main background comes from SM W production and is estimated using PYTHIA Monte Carlo (MC) samples; contributions from QCD multijet processes are estimated from data. The search is performed in the transverse mass region of 140-1000 GeV (see left-hand plot in Fig. 2) using a binned likelihood. Since no evidence is found for a signal, a lower limit on the mass of the W' boson of $m_{W'} > 1$ TeV is given, which represents the most stringent limit to date (see right-hand plot in Fig. 2).

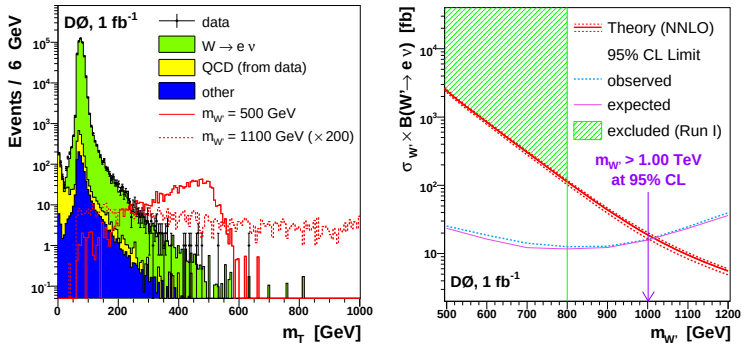

Figure 2: Transverse mass spectrum in the electron + $\not\!\!E_T$ channel (left) and 95% C.L. limit on the cross section (right).

4 Dielectron Resonance Searches (DØ and CDF)

CDF has performed a search for resonances in the dielectron channel using 2.5 fb^{-1} of data [8]. The mass spectrum compared to backgrounds is shown in Fig. 3. The main background is Drell-Yan production, which is estimated using PYTHIA MC samples. The background from QCD jet production is derived from data. Minor contributions come from other SM processes, e. g. diboson production.

First, a generic search for resonances in the high-mass range of 150-1000 GeV is performed using an unbinned likelihood ratio. The most significant region of excess of data over background (3.8σ) occurs at $m_{ee} = 240$ GeV, see inset in Fig. 3. The probability to observe such a fluctuation of background has been estimated to be 0.6% using 100,000 background-only pseudo-experiments.

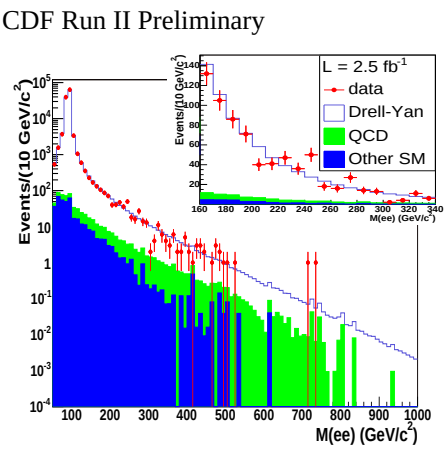

Figure 3: Invariant mass distribution of the dielectron final state.

Further, the data are searched for possible contributions from various signal processes beyond the SM. In this analysis a generic model with an additional Z boson (Z'_{SM} with SM couplings) as well as six Z' bosons that appear in the E_6 [5] model are considered. Since no significant excess is found, lower limits on the masses of the new particles are given, see Table 1. The limits are the most stringent ones for these models. Gravitons in the Randall-Sundrum (RS) model with one extra dimension [9] can also produce resonances in dielectron final states. In this case excluded regions are given as a function of the graviton mass M_G and the coupling $k/\bar{M}_{Pl}$, see left-hand plot in Fig. 4.

DØ has also searched for RS gravitons in 1 fb^{-1} of data, but they include in the analysis final states with two photons in addition to the dielectron final state [10]. Despite the lower luminosity used by DØ, the limits are comparable due to the increased sensitivity from the photon channel, see right-hand plot in Fig. 4.

5 Four-Electron Resonance Search (CDF)

CDF has analyzed the four-electron final state in 1.1 fb^{-1} of data [11]. In this analysis a heavy particle is assumed to decay via Z bosons into electrons, $X \to ZZ \to eeee$. A χ^2 variable is introduced in order to check the consistency between an electron combination and the $ZZ \to eeee$ final state. All combinations are taken into account. The main source of background in the signal region ($m_{eeee} > 500$ GeV, $\chi^2 < 50$) are jets reconstructed as electrons. This contribution is estimated from data. The contribution from SM ZZ

Z' model	Z'_{SM}	Z'_{ψ}	Z'_{χ}	Z'_{η}	Z'_{I}	Z'_{sq}	Z'_{N}
Exp. Limit (GeV)	965	849	860	932	757	791	834
Obs. Limit (GeV)	966	853	864	933	737	800	840

Table 1: 95% C.L. lower limits on Z' masses from the dielectron resonance search performed by CDF.

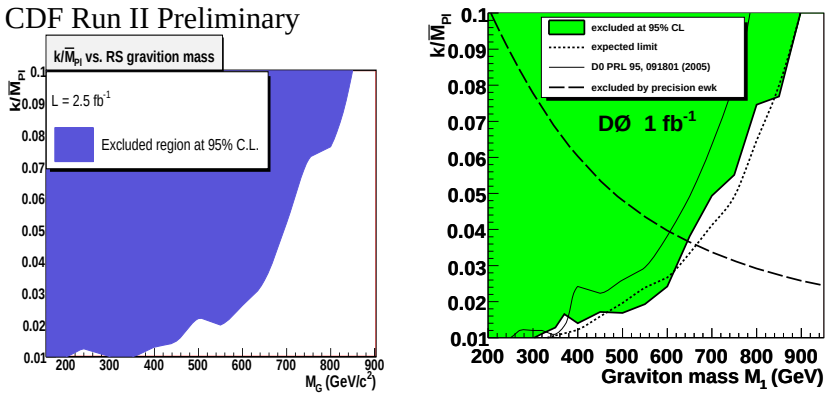

Figure 4: Excluded regions (95% C.L.) in the graviton mass and coupling plane from CDF (left) and DØ (right).

production is estimated using PYTHIA MC samples. No events are found in the signal region, with a background expectation of 0.028 ± 0.014. The RS model [9] with a graviton decaying into two Z bosons is used in order to determine the sensitivity. The limits on the cross sections that can be excluded at 95% C.L. range from 4-6 pb.

6 Summary

The mass spectrum of fermion pairs is sensitive to a broad array of new physics. Five recent analyses have been presented which investigate the dijet, dielectron, four-electron and electron plus missing transverse energy final states using 1-2.5 fb^{-1} of data taken with the DØ and CDF detectors at the Tevatron proton-antiproton collider. No significant excess is observed in the data.

References

[1] Slides:
`http://indico.cern.ch/contributionDisplay.py?contribId=86&sessionId=15&confId=24657`

[2] CDF Collaboration, CDF Note 9246 (2008), `http://www-cdf.fnal.gov/physics/physics.html`.

[3] U. Baur, I. Hinchliffe and D. Zeppenfeld, Int. J. Mod. Phys. A **2**, 1285 (1987); U. Baur, M. Spira and P. M. Zerwas, Phys. Rev. D **42**, 815 (1990).

[4] J. Bagger, C. Schmidt and S. King, Phys. Rev. D **37**, 1188 (1988); P. H. Frampton and S. L. Glashow, Phys. Lett. B **190**, 157 (1987).

[5] J. L. Hewett and T. G. Rizzo, Phys. Rep. **183**, 193 (1989); D. London and J. L. Rosner, Phys. Rev. D **34**, 1530 (1986).

[6] K. D. Lane and M. V. Ramana, Phys. Rev. D **44**, 2678 (1991); E. Eichten and K. D. Lane, Phys. Lett. B **327**, 129 (1994); K. Lane and S. Mrenna, Phys. Rev. D **67**, 115011 (2003).

[7] DØ Collaboration, Phys. Rev. Lett. **100**, 031804 (2008).

[8] CDF Collaboration, CDF Note 9160 (2008), `http://www-cdf.fnal.gov/physics/physics.html`.

[9] L. Randall and R. Sundrum, Phys. Rev. Lett. **83**, 3370 (1999); *ibid.* **83**, 4690 (1999).

[10] DØ Collaboration, Phys. Rev. Lett. **100**, 091802 (2008).

[11] CDF Collaboration, arXiv:0801.1129 [hep-ex].