NON-SUSY SEARCHES AT THE TEVATRON

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We present results from several new searches for physics beyond the Standard Model using up to 5.4 fb^{-1} of data collected with CDF and DØ experiments at the Fermilab Tevatron.

1 Search for Randall Sundrum Graviton

The Standard Model (SM) is a very successful description of particle physics up to the weak scale. One of the remaining puzzles, known as gauge hierarchy, is the large disparity between the Planck scale, $M_{Pl} = 10^{16}$ TeV and the weak scale of the order of 1 TeV. Solution was proposed by Randall and Sundrum (RS) [1] in which a fifth dimension with a warped spacetime metric exists, bounded by two three-dimensional branes, the SM brane and the Planck brane. We assumed the simplest RS model, in which the SM fields are localized on the SM brane and gravity originates on the Planck brane with the graviton wave function exponentially suppressed away from the brane along the extra dimension. In this model, TeV scales are naturally generated from the Planck scale due to a geometrical exponential factor (the warp factor), $\Lambda_\pi = \overline{M_{Pl}} e^{-k\pi r_c}$, where $\overline{M_{Pl}} = M_{Pl}/\sqrt{8}\pi$ is the reduced Planck scale, k and r_c are the curvature scale and compactification radius of the extra dimension respectively.

We searched with a DØ detector for the first Klauza Klein (KK) graviton in the simplest RS model, where graviton decays to a pair of electrons or photons in a 5.4 fb^{-1} of data [2]. We select events with two electromagnetic clusters, each with transverse momentum $p_T > 25$ GeV and we search for narrow mass resonance in dielectron or diphoton final state. Figure 1 shows dielectron (left) and diphoton (right) invariant mass for data (black points), total background (white area with a blue line), and graviton signals with masses 300, 450 and 600 GeV and $k/\overline{M_{Pl}} = 0.02$.

Since we did not observe any signal above SM prediction we set an upper limit on the production of KK gravitons times the branching fraction into the ee final state using a Poisson log-likelihood ratio (LLR) test. Figure 2 (left) shows the resulting limits for several values of $k/\overline{M_{Pl}}$. Figure 2 (right) shows 95% C.L. upper limit on $k/\overline{M_{Pl}}$ versus graviton mass M_1 compared with the expected limit and the previously published exclusion.

2 Heavy Gauge Bosons decaying to dileptons

Many models predict new heavy gauge boson that will decay into two leptons [3]. The E6 Z's are examples of specific new particles decaying to a lepton-antilepton final state. The Z'_ψ, Z'_χ, Z'_η, Z'_I, Z'_{sec} and Z'_N are chosen to test the E6 model. We searched for a heavy resonances that decay into two electrons with CDF detector [4] in a 2.5 fb^{-1}, and with DØ detector [5] in a 3.6 fb^{-1}. We selected two isolated electrons with $p_T > 25$ GeV at both experiments. The

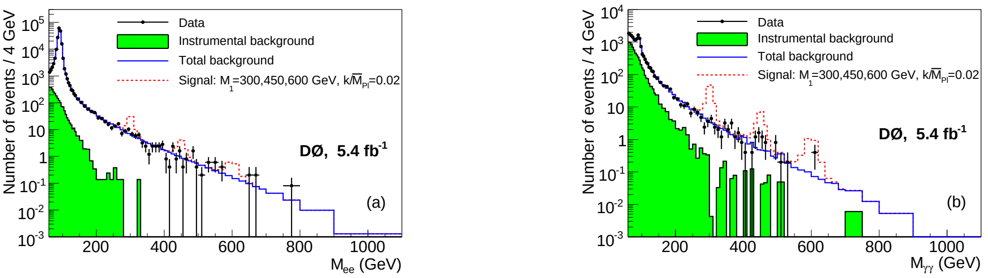

Figure 1: Invariant mass of ee (left) and $\gamma\gamma$ (right).

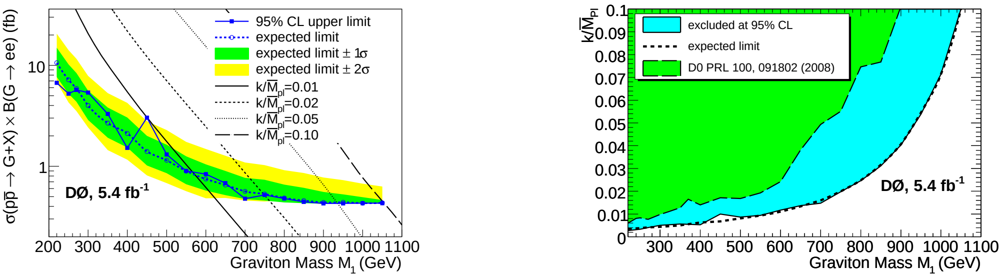

Figure 2: Upper limit on $\sigma(p\bar{p} \to G+X) \times BR(G \to ee)$ compared with the expected limit and the theoretical predictions for different couplings$k/\bar{M}_{Pl}$ (left) and an upper limit on $k/\bar{M}_{Pl}$ versus graviton mass M_1 (right).

main irreducible background is Drell Yan production. Other backgrounds include instrumental backgrounds where one or both electrons were missidentified, and smaller SM processes.

Figure 3 (left) shows the observed dielectron invariant mass spectrum from 2.5 fb^{-1} of data collected with CDF detector together with the expected backgrounds. The most significant region of excess of data over background occurs for a dielectron invariant mass window of 240 GeV, and is 3.8 standard deviations above the SM prediction. Figure 3 (right) shows the observed upper limits from data and the expected limits from background-only simulated events for spin 1 particles as a function of the e+e invariant mass, together with the expected cross sections for Z'.

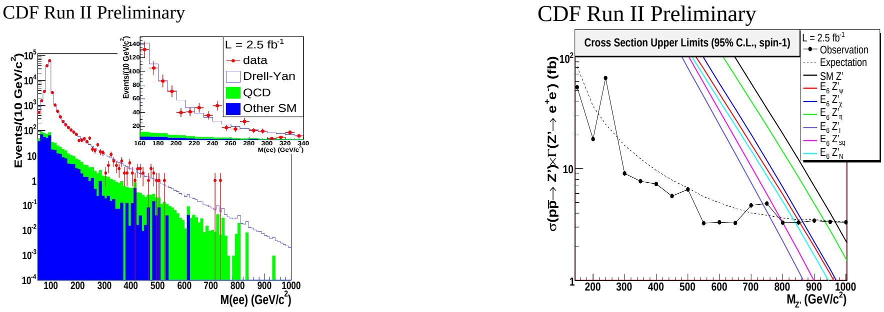

Figure 3: Dielectron invariant mass (left) and an upper limit on cross section for various Z' models.

Figure 4 (left) shows the observed dielectron invariant mass spectrum from 3.6 fb^{1} of data collected with DØ detector together with the expected backgrounds. At DØ we did not observe any excess in a mass region around 240 GeV, as shown in Figure 4 (middle). In the absence of any significant signal, we set upper limits on the production cross section. Figure 4 (right) shows the expected and observed 95% confidence-level upper limits on $\sigma(p\bar{p} \to Z') \times BR(Z' \to ee)$ for Z_{SSM} and E6 Z' models as a function of Z' mass.

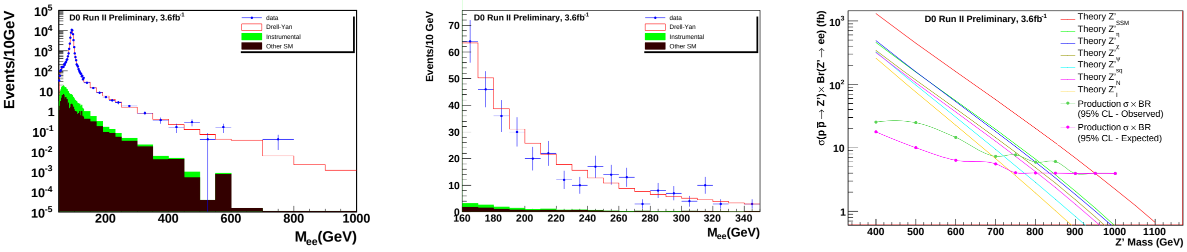

Figure 4: Dielectron invariant mass (left), also shown zoomed around 240 GeV (right), and an upper limit on cross section for various Z' models..

3 Search for diboson resonances

Many extensions of the SM predict new heavy gauge boson that will decay into pair of SM gauge bosons. We searched for such resonances in electron, missing E_T and two jets final state, with CDF detector[6] in 2.9 fb^{-1} of data. This final state has the advantage of searching for two types of diboson resonances, $W^{\pm}W^{\mp}$ and $W^{\pm}Z$, with the same final state. We select events with an isolated electron with $E_T > 30$ GeV, a missing $E_T > 30$ GeV, 2 or 3 jets with $E_T > 30$ GeV, and an overall $H_T > 150$ GeV, where H_T is defined as the sum of the electron E_T , the missing E_T and the jet E_T of all jets with raw $E_T > 8$ GeV. Since the real missing E_T in the event is coming only from one neutrino fro the W decay, we used energy and momentum conservation to calculate E_Z component, and thus to reconstruct the invariant mass of the resonance. We further optimized cuts on object p_T to be greater than 40-120 depending on signal mass. Figure 5 shows invariant mass of WW(Z) system in a three scenarios that we investigated, W' (left), Z' (middle) and RS graviton (right).

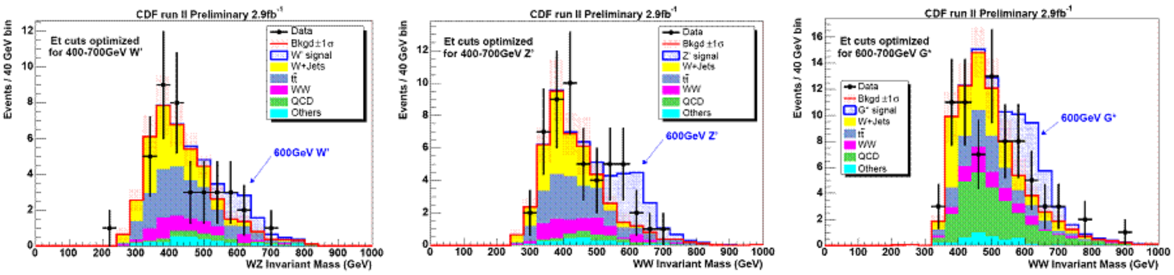

Figure 5: Diboson invariant mass for W' (left), Z' (middle) and RS graviton (right).

In the absence of signal we set an upper limit on the cross section of the resonance decaying to two gauge bosons decaying further to electron, missing E_T and two jets, where resonance is W' (see Figure 6 (left)), Z' (see Figure 6 (middle)) and RS graviton (see Figure 6 (right))

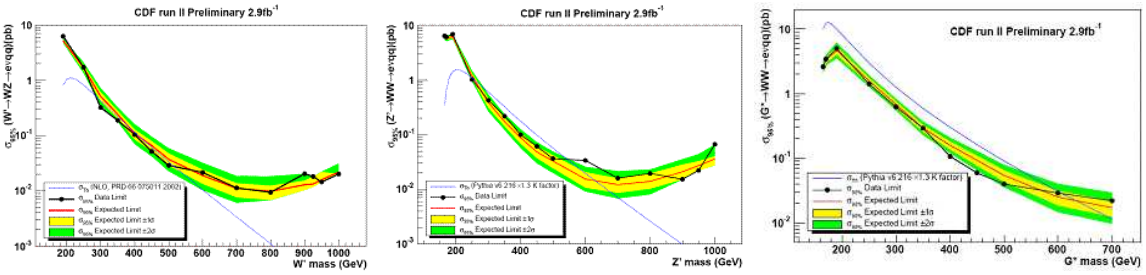

Figure 6: An upper limit on cross section for heavy resonance, W' (left), Z' (middle) and RS graviton (right) decaying to two bosons.

With DØ detector [7], we searched for a heavy charged boson decaying to WZ that further decay to three leptons and missing E_T in 4.1 fb^{-1} of data. The events are required to have missing transverse energy greater than 30 GeV and at least three charged leptons with transverse momenta $p_T > 20$ GeV satisfying the electron or muon identification criteria. We require the presence of a candidate Z boson by selecting the electron pairs and muon pairs with opposite electric charges that have invariant mass nearest to the mass of the Z boson. Then, we select the highest transverse momentum lepton among the remaining lepton candidates in the event as the lepton from the W boson decay. The WZ transverse mass shown in Figure 7 (left) is used to discriminate between the W' signal and the backgrounds in the limit setting procedure. Since we did not observe any excess in a data over SM background we set upper limit on the $\sigma \times BR(W' \to WZ)$ in Sequential Standard Model (see Figure 7). We also studied the sensitivity to other models that predict heavy charged boson. We interpreted the results in terms of the $W'WZ$ trilinear coupling normalized to the SSM value as function of the W' mass (see Figure 7).

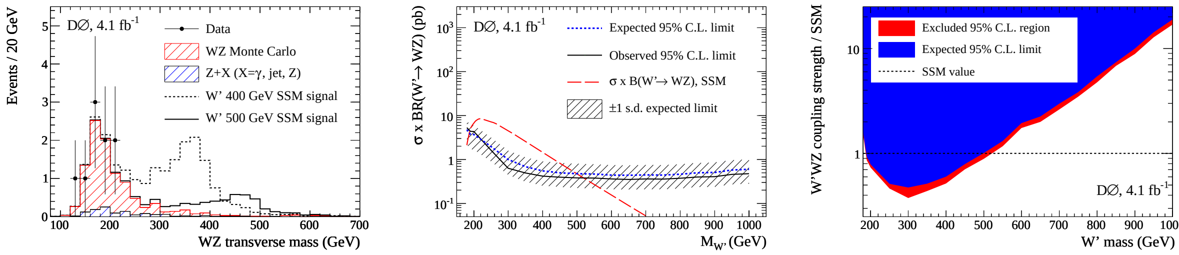

Figure 7: Transverse mass of WZ system (left), an upper limit on cross section for W' in SSM (middle), and expected and excluded area of the $W'WZ$ coupling strength normalized to the SSM value as a function of the W' mass (right).

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References

1. L. Randall and R. Sundrum, Phys. Rev. Lett. **83**, 3370 (1999)
2. V. M. Abazov *et al.* [The DØ Collaboration], Phys. Rev. Lett. **104**, 241802 (2010)
3. P. Langacker, Rev. Mod. Phys. **81**, 1199 (2008)
4. T. Aaltonen *et al.* [CDF Collaboration], Phys. Rev. Lett. **102**, 031801 (2009)
5. DØ Collaboration, Conference Note **5923**, (2009)
6. T. Aaltonen *et al.* [The CDF Collaboration], Phys. Rev. Lett. **104**, 241801 (2010)
7. V. M. Abazov *et al.* [DØ Collaboration], Phys. Rev. Lett. **104**, 061801 (2010)