



Search for New Particles in High Mass Dileptons at CDF Run II

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Abstract

We present searches for new neutral gauge boson Z' and Randall-Sundrum graviton in dilepton decay mode using data collected by the CDF experiment at the Fermilab Tevatron in Run II. The analysis has been carried out with approximately 126 pb^{-1} of a sample of high transverse momentum leptons (electrons and muons). We compare our observations to models beyond the Standard Model. 95% confidence level limits on the production cross section times branching ratio for a Z' decaying into an lepton pair $\sigma \cdot Br(Z' \rightarrow \ell^+ \ell^-)$ and a graviton decaying into an lepton pair $\sigma \cdot Br(G \rightarrow \ell^+ \ell^-)$ are presented. In addition, we set lower mass limits for these new particles.

Introduction

Z' Bosons

Additional heavy gauge boson predicted by many theories. Standard Model Z' is Z' boson with same SM coupling. E_6 GUT Z' has 4 models, Z_ψ, Z_η, Z_χ and Z_I with different mixing angle in $Z' = Z_\psi \sin \theta_{E6} + Z_\chi \cos \theta_{E6}$

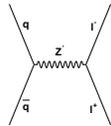


Figure 1. Feynman diagram for Z' production and decay into dilepton.

Randall-Sundrum Graviton

Excited graviton in 5 dimensions. This model warps space-time by $e^{-2kr_0 r}$. There are two new parameters, graviton mass and coupling parameter (k/M_{Pl}).

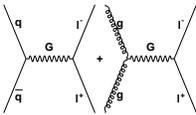


Figure 2. Feynman diagram for Randall-Sundrum graviton production and decay into dilepton.

Tevatron & CDF Detector

Tevatron Run II

Data taking period started in spring 2001 with the upgraded energy $\sqrt{s} = 1.96 \text{ TeV}$ (Run I: $\sqrt{s} = 1.8 \text{ TeV}$). Current instantaneous luminosity is approximately $4 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$.

CDF Detector Upgrade

Plug calorimeter, Time-of-Flight detector, tracking detector and intermediate Muon detector are newly installed or replaced with old ones.

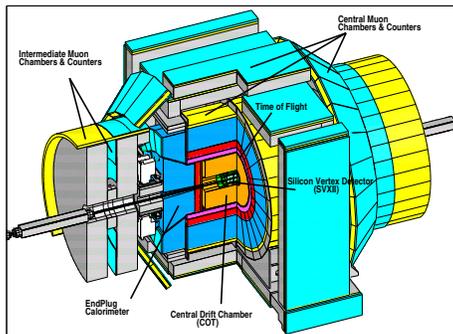


Figure 3. Sketch map of CDF detector upgrade.

Event Selection

The requirement on the selection of dielectron and dimuon is :

- ee
- One good Central electron $E_T > 25 \text{ GeV}$
- Second good Central electron or good Plug electron $E_T > 25 \text{ GeV}$
- $E_T / \sqrt{\Sigma E_T} < 2.5$
- $\mu\mu$
- Two good muons with $P_T > 20 \text{ GeV}$
- Cosmic ray rejection by impact parameter and timing cuts

Figure 4 shows the dielectron invariant mass distribution and dimuon invariant mass distribution with expected background. Table 1 shows the number of observed events and background expected for various mass ranges. In general, data are in good agreement with background estimation.

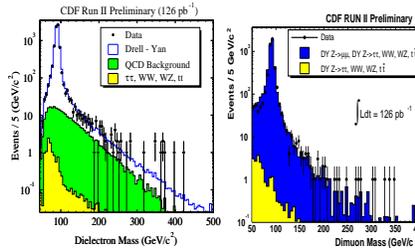


Figure 4. Dielectron invariant mass distribution (left) and dimuon invariant mass distribution (right) with comparison of background expected.

Mass (GeV/c ²)	ee		μμ	
	observed events	expected background	observed events	expected background
$M > 250$	15	13.9 ± 6.5	8	8.3 ± 1.8
$M > 300$	9	5.7 ± 2.1	5	5.2 ± 1.7
$M > 350$	6	2.3 ± 0.6	0	2.7 ± 0.9
$M > 400$	1	0.9 ± 0.1	0	2.3 ± 0.9
$M > 450$	0	0.3 ± 0.0	0	1.5 ± 0.9

Table 1. Number of observed data with the number of background expected for various mass ranges.

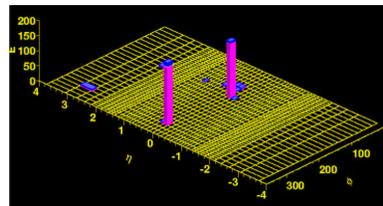
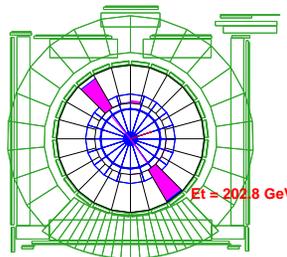


Figure 5. Typical high mass dilepton events ($\sim 370 \text{ GeV}$). The transverse energy of one electron candidate is $E_T = 203 \text{ GeV}$ and the other candidate has $E_T = 180 \text{ GeV}$

Limits on Z'

Limits on $\sigma \cdot Br(Z' \rightarrow \ell^+ \ell^-)$ is obtained by a Bayesian approach. Figure 7 shows the 95% C.L. limits on $\sigma \cdot Br(Z' \rightarrow \ell^+ \ell^-)$ as a function of the Z' mass. The solid lines are predicted cross section and the intersections of the limit curve determines the 95% C.L. lower limit on the Z' mass. Table 2 shows the history of CDF Z' searches in dielectron and dimuon channels.

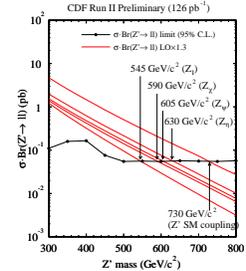


Figure 7. 95% C.L. upper limits on $\sigma \cdot Br(Z' \rightarrow \ell^+ \ell^-)$ with 126 pb^{-1} of integrated luminosity.

CDF Run	Luminosity (pb ⁻¹)	ee	μμ	ee + μμ	95% C.L. Z' mass limit (GeV/c ²)
Run I	110	640	575	690	
Run II	72	650	455	665	
Run II	126	720	585	730	

Table 2. History of CDF Z' searches in dielectron and dimuon channels.

Limits on Randall-Sundrum Graviton

Limits on $\sigma \cdot Br(G \rightarrow \ell^+ \ell^-)$ is obtained by a Bayesian approach. Figure 8 shows the 95% C.L. limits on $\sigma \cdot Br(G \rightarrow \ell^+ \ell^-)$ as a function of the graviton mass and 95% C.L. excluded region on the plane for mass vs. k/M_{Pl} . The solid lines are predicted cross section for $k/M_{Pl} = 0.01, 0.03$ and 0.1 and the intersections of the limit curve determines the 95% C.L. lower limit on the graviton mass.

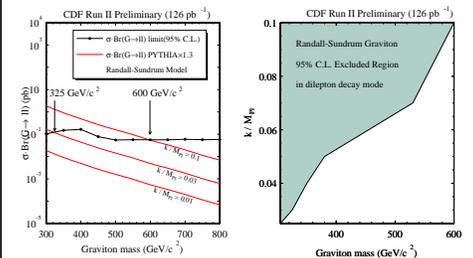


Figure 8. 95% C.L. upper limits on $\sigma \cdot Br(G \rightarrow \ell^+ \ell^-)$ (left) and 95% C.L. excluded region (right) with 126 pb^{-1} of integrated luminosity.

Summary

We set preliminary cross section limits combined with dielectron and dimuon at 95% C.L. on the high mass region with 126 pb^{-1} of integrated luminosity of CDF Run II data. We also set preliminary mass limits on two new particles :

- Z' (SM coupling) :

$$M_{Z'} > 730 \text{ GeV}/c^2$$

- Randall-Sundrum graviton for $k/M_{Pl} = 0.1$:

$$M_G > 600 \text{ GeV}/c^2$$

These limits exceed any published results of direct searches in the world.