A SEARCH FOR NEUTRAL HEAVY VECTOR GAUGE BOSONS IN $pp$ COLLISIONS AT $\sqrt{s} = 1.8$ TeV

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A search for a neutral heavy vector gauge boson, $Z'$, was conducted in $pp$ collisions using 110 pb$^{-1}$ of data obtained at the Collider Detector at Fermilab. We present preliminary 95% CL limits on the production of $Z'$ in different models using its $e^+e^-$ and $\mu^+\mu^-$ decay modes.

The $Z'$ is a heavy neutral vector gauge boson predicted to exist in several Grand Unified Theories and extensions of the Standard Model. The $Z'$ couplings to dileptons are described by theory, but there are no constraints on its mass.

In this paper we describe a direct search for the $Z'$ in its dielectron and dimuon decay modes at CDF.

The calorimeters, the Central Tracking Chamber (CTC) and the Muon chambers are the principal detector components used for this search. Data are collected with a multi-level trigger. The electron trigger requires a minimum $E_t$ in the calorimeter with $\approx 100\%$ efficiency. The muon trigger requires a match between a Central Muon Chamber stub and a high $P_t$ track in the CTC with $\approx 90\%$ efficiency.

Candidate events are selected by requiring one “tight” and one “loose” lepton. Dielectron events are required to have one isolated central electron with $E_t > 25$ GeV/$c^2$, and $P_t > 13$ GeV/$c$. The second electron could be detected in the Central or in the Plug region of the detector. Muons are required to be minimum ionizing with $P_t > 20$ GeV/$c$. One muon is required to be isolated and detected in the Central Muon detector.

We find 7120 dielectron events and 2562 dimuon events. The distribution of these events as a function of invariant mass is shown in Figure 1. The...
highest mass $e^+e^-$ and $\mu^+\mu^-$ events have invariant masses of 511 GeV/c$^2$ and 320 GeV/c$^2$ respectively.

Efficiencies of the lepton identification cuts are determined from a sample of dileptons from $Z$ decays. The geometric and kinematic acceptance were determined from a Monte-Carlo sample of $Z$ and $Z'$ events generated at different masses. The overall acceptance times efficiency rises to a value of 48% for dielectrons and 20% for dimuons at very high $Z'$ invariant mass.

When the data is compared with the Standard Model expectation and backgrounds, we find no significant excess (see Table 1). Systematic errors arising from the choice of structure functions and $P_t$ distributions are less than 3%.

The dielectron and dimuon data are combined by assuming that lepton universality holds for $Z'$ decays. $Z'$ mass limits are obtained by comparing the observed data to a superposition of the Standard Model prediction and the expected distribution from $Z'$ decays using the method of binned likelihood.

Fig 2(a) shows the 95% Confidence limit on the cross-section $\times$ branching ratio for a $Z'$ decaying to dileptons, as a function of the $Z'$ mass. For a $Z'$ with Standard Model couplings, this translates into a limit of $M_{Z'} > 690$ GeV/c$^2$ at the 95% C.L. or a limiting cross-section of 42 fb for $M_{Z'} > 650$ GeV/c$^2$. We have also set limits for other interesting theoretical models (see figure 2(b)).

Table 1: Predicted number of events from Drell-Yan and other backgrounds compared with the data.

| Mass (GeV) | $ee$ DY + QCD pred/data | $\mu\mu$ DY pred/data |
|-----------|-------------------------|-----------------------|
| > 150     | 68.0/70                 | 16.5/17               |
| > 200     | 21.7/19                 | 6.2/7                 |
| > 250     | 8.1/9                   | 2.8/4                 |
| > 300     | 3.3/6                   | 1.4/2                 |
| > 350     | 1.4/2                   | 0.7/0                 |
| > 400     | 0.7/1                   | 0.4/0                 |
| > 450     | 0.3/1                   | 0.2/0                 |
| > 500     | 0.2/1                   | 0.1/0                 |
| > 550     | 0.1/0                   | 0.0/0                 |
| > 600     | 0.0/0                   | 0.0/0                 |

Acknowledgments

We thank the Fermilab staff and the technical staffs of the participating institutions for their vital contributions. This work was supported by the U.S. Department of Energy and National Science Foundation; the Italian Istituto Nazionale di Fisica Nucleare; the Ministry of Education, Science and Culture of Japan; the Natural Sciences and Engineering Research Council of Canada; the National Science Council of the Republic of China; and the A. P. Sloan Foundation.
Limits on $Z'$ production as a function of the $Z'$ mass for a standard model $Z'$

(a) Limits on $Z'$ production as a function of the $Z'$ mass for several models

(b) Limits on $Z'$ production as a function of $Z'$ mass for several models

References

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4. The previous direct search at CDF in the dielectron decay mode using 20 pb$^{-1}$ of data is described in F. Abe *et al*, *Phys. Rev*. D **51**, R949 (1995).
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