Search for Heavy Neutral Gauge Bosons At DØ

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Abstract

We report preliminary results of a search for a heavy neutral gauge boson, Z', using the decay channel $Z' \rightarrow ee$. The data were collected with the DØ detector at the Fermilab Tevatron during the 1994–1995 $p\overline{p}$ collider run at $\sqrt{s}$ = 1.8 TeV and correspond to an integrated luminosity of $\approx$ 90 pb^{-1}. Limits are set on the cross section times branching ratio for the process $\overline{p}p \rightarrow Z' \rightarrow ee$ as a function of the Z' mass. We exclude the existence of a heavy neutral gauge boson of mass less than 660 GeV/c^2 (95% CL), assuming a Z' with the same coupling strengths to quarks and leptons as the standard model Z boson. Combining this analysis with DØ's 1992–1993 data set increases the limit to $m_{Z'} > 670$ GeV/c^2 .

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I. INTRODUCTION

The standard model is the generally accepted theory describing elementary particles and their interactions. Despite its success, it is not considered to be the ultimate theory. Numerous extensions to the standard model have been proposed [1], many of which include additional neutral gauge bosons, believed to be heavier than the standard model Z. In this analysis we consider a reference model of Z' with the same coupling strengths to quarks and leptons as the standard model Z and with decay to W and Z bosons suppressed. The width of the Z' is taken as the Z width, scaled with the mass, allowing appropriate decays to top.

Using ≈ 90 pb^{-1} of data collected by the DØ detector [2] at the Fermilab $p\overline{p}$ collider with a center of mass energy of 1.8 TeV, we search for the Breit-Wigner peak of a Z' superimposed on the invariant mass spectrum expected in the standard model from Z production and Drell-Yan continuum decaying to electron-positron pairs. We set a limit on the cross section times branching ratio for the process $p\overline{p} \to Z' \to ee$ and use this limit to set a lower bound on the mass of our reference model Z'.

II. EVENT SELECTION

At DØ, electrons are detected in hermetic, uranium liquid-argon calorimeters [3,4] with an energy resolution of about $15\%/\sqrt{E(\mathrm{GeV})}$. The calorimeters have a granularity of $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$, where η is the pseudorapidity and ϕ is the azimuthal angle.

The trigger requires two isolated EM clusters with transverse energy $E_T > 20$ GeV. The offline electron identification requirements are applied to both EM candidates and consist of the following: *i*) the electron has to deposit at least 95% of its energy in the 21 radiation length electromagnetic calorimeter, *ii*) the transverse and longitudinal shower shapes have to be consistent with those expected for an electron (based on test beam measurements), and *iii*) the electron has to be isolated [5]. In addition, at least one of the electrons has to have a good match between a reconstructed track in the drift chamber system and the shower position in the calorimeter.

The fiducial region for electrons accepted in this analysis is $|\eta| < 1.1$ (central) or $1.5 < |\eta| < 2.5$ (forward). For electrons in the central region, energy clusters within 0.01 radians in ϕ of module boundaries located every 0.2 radians in ϕ are excluded. At least one of the electrons has to be central. The kinematic selection requires one electron with $E_T > 30$ GeV and the second electron with $E_T > 25$ GeV.

The dielectron invariant mass spectrum for the 5707 events that pass this selection is shown in Fig. 1.

III. BACKGROUNDS

The QCD multijet background remaining in the sample is determined from data. To select the background sample, we keep events with two electromagnetic jets that pass the fiducial and kinematic cuts, but fail the electron identification. We then fit the invariant mass distribution of the candidate sample to a linear sum of a Monte Carlo simulated Z line shape plus the multijet background. We estimate the amount of background in the candidate sample to be $\approx 3\%$. For $m_{ee} > 300$ GeV/c^2 we expect 5.8 events from Z continuum and Drell-Yan production and observe six events. Above 500 GeV/c^2 we expect 0.3 events and observe one.

IV. RESULTS

A limit is obtained for our reference model Z' production by studying the ratio $\sigma(p\overline{p} \rightarrow Z' + X)BR(Z' \rightarrow e^+e^-)/\sigma(p\overline{p} \rightarrow Z + X)BR(Z \rightarrow e^+e^-)$. The relative acceptance for Z' to Z production is determined from Monte Carlo simulation [6]; a conservative uncertainty of 10% due to the choice of PDF's is assigned at this stage of the analysis. The integrated luminosity and event selection efficiency for Z' and Z are taken to be the same. The production limit is obtained for a range of Z' masses by constructing probability distributions for Z' production based on the events observed in a mass window given by $m_{Z'} \pm 4\Gamma_{Z'}$. The region above the limit curve in Fig. 2 is excluded. From the intersection of the limit and theory [7] curves, we exclude the existence of a Z' from the process $p\overline{p} \rightarrow Z' \rightarrow ee$ for $m_{Z'} < 660$ GeV/c^2 , at 95% CL. Combining this analysis with ≈ 15 pb^{-1} of data taken by DØ during 1992–1993 increases the limit to $m_{Z'} > 670$GeV/c^2 .

V. CONCLUSIONS

Based on a preliminary analysis of ≈ 105 pb^{-1} of data taken by the DØ $p\overline{p}$ collider detector, we exclude the existence of a heavy neutral gauge boson of mass less than 670 GeV/c^2 (95% CL), assuming a Z' with the same coupling strengths to quarks and leptons as the standard model Z boson.

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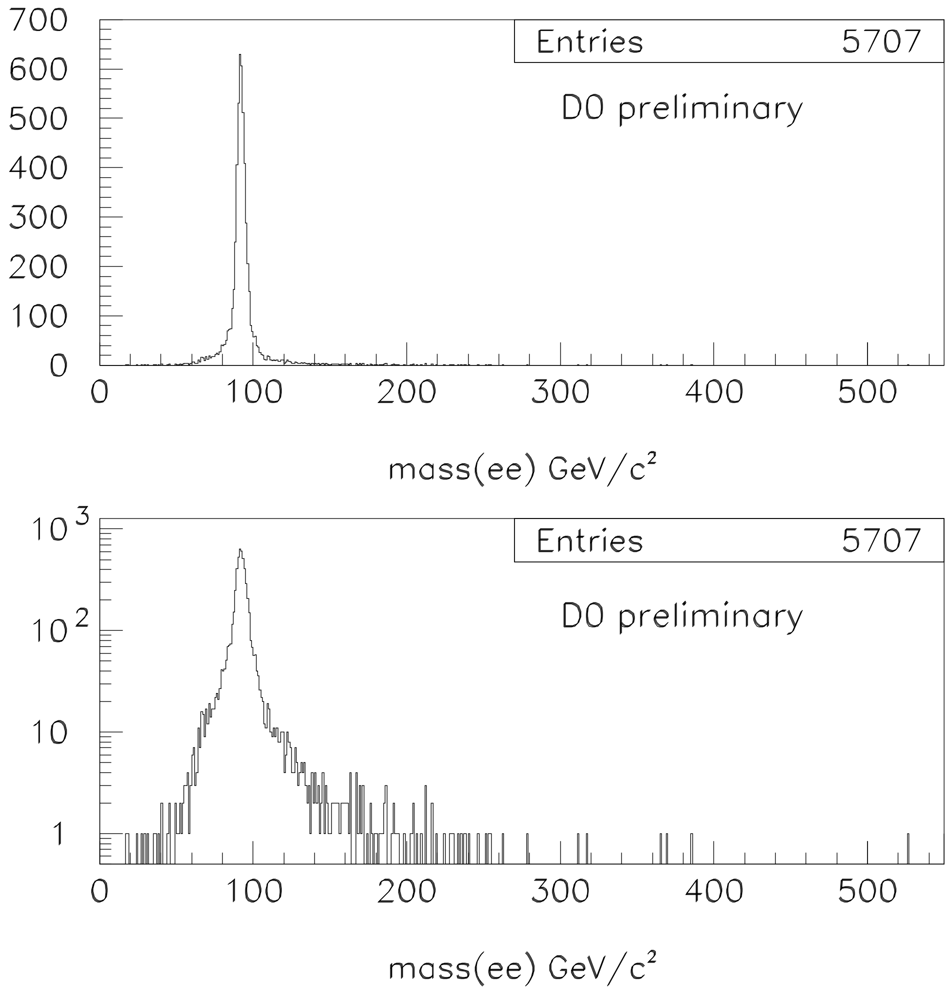

FIG. 1. The dielectron invariant mass spectrum from 90 pb^{-1}.

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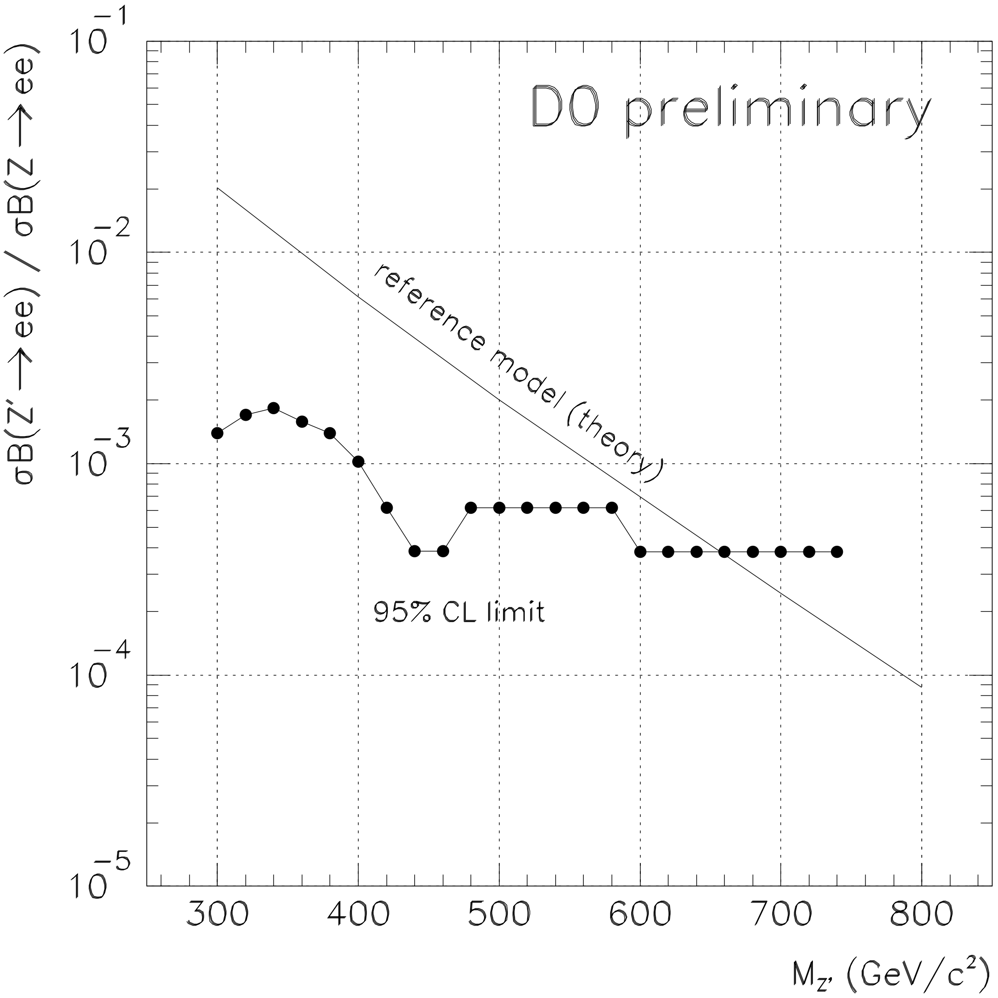

FIG. 2. DØ's 95% CL upper limit as a function of $m_{Z'}$ compared to the theoretical prediction from reference 7.

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