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Search for *W* Pair Production with Dilepton Decay Modes at DØ

Nobuaki Oshima
The DØ Collaboration

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

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NOBUAKI OSHIMA, for the D0 Collaboration
Fermi National Accelerator Laboratory
P.O.Box 500 Batavia, Illinois 60510, USA

ABSTRACT

We present the results of a search of 13.5 pb^{-1} of p$\bar{\rm p}$ collisions at $\sqrt{s} = 1.8$ TeV for $WW \rightarrow$ dileptons $+ X$ using the D0 detector. One $WW \rightarrow e\mu\nu\bar{\nu} + X$ candidate was found with an expected background of about 0.96 ± 0.44 events. One $WW \rightarrow ee\nu\bar{\nu} + X$ candidate was found with an expected background of about 1.23 ± 0.87 events. The 95% C.L. upper limit for the W pair production cross section is 133 pb without background subtraction. Making the constraint $\kappa = 1$ ($\Delta\kappa = 0$) implies $-2.6 \leq \lambda \leq 2.7$(95% C.L.) and making the constraint $\lambda = 0$ implies $-3.3 \leq \Delta\kappa \leq 3.5$(95% C.L.) assuming $\kappa_\gamma = \kappa_Z$ and $\lambda_\gamma = \lambda_Z$. We also present the contour of excluded couplings when κ and λ are allowed to simultaneously vary from their standard model values.

1. Introduction

1.1. Physics in W Pair Production

Vector boson pair production is interesting as a probe of many aspects of physics, for example, the standard model decay mode of the Higgs boson,[1] a measurement of possible non-standard model couplings or processes,[2] background for $t\bar{t}$ production which is also background for W^+W^- pair production and a measurement of vector boson self-couplings as test of the standard model.[3] Since the Tevatron experiments D0 and CDF have accumulated data from their 1992-1993 collider runs, the last aspect becomes an interesting study experimentally.

1.2. The D0 Detector

The D0 detector[4] can be divided into three major subsystems; central tracking, calorimeters and the muon system.
- The central tracking system contains a vertex drift chamber, a transition radiation detector, a central drift chamber and forward drift chambers.
-The uranium-liquid argon calorimeters consist of three calorimeters; the central calorimeter and the two mirror-image end calorimeters. These finely segmented calorimeters provide essentially uniform, nearly hermetic coverage over the full range of pseudorapidity $|\eta| \leq 4$ and azimuthal angle ϕ. The resolutions of electromagnetic(EM) and

hadronic(HAD) energy measurement are roughly $15\%/\sqrt{E}$ and $50\%/\sqrt{E}$ respectively. - The muon system is divided into the wide angle part which has an acceptance down to pseudorapidity $|\eta| = 1.7$, and the small angle part which has far forward and backward($1.7 < |\eta| < 3.4$) coverage. The wide angle muon system has three large iron toroidal magnets($B \approx 2$ Tesla) and 11434 Proportional Drift Tubes and the resolution is about $(\delta p/p)^2 = (0.2)^2 + (0.01p)^2$.

2. Event Selection

Both data sets were selected from the "expressline sample" which was created for rapid physics analysis. The corresponding integrated luminosity of both data sets is $13.5 \pm 1.6\ pb^{-1}$ after excluding bad runs and correcting for dead time created to mask high loss periods of main ring operation. Requirements to identify electron are the electromagnetic(EM) energy fraction $E_{em}/E_{total} \geq 0.9$, isolation ($E_{total}$(cone=0.4) - E_{em}(cone=0.2))/E_{em}(cone=0.2) ≤ 0.1, the η dependant calorimeter cluster shape and the calorimeter cluster and track matching. For muon identification, we required the cosmic ray veto, the track matching between muon chamber and central drift chamber, the confirmation by MIP energy deposition in calorimeter and fiducial cuts to avoid inter-toroid gaps.

2.1. $WW \rightarrow e\mu\nu\bar{\nu} + X$

Events in this sample were required to pass the $e\mu$ trigger which was the combination of electron and muon requirements. Those for electron were No. of EM tower $\geq$ 1 with $E_t > 7$ GeV(Hardware Trigger; Level 1) and No. of EM cluster ≥ 1 with $E_t > 7$ GeV(Software Filter; Level 2) and No. of muon ≥ 1 with $|\eta| \leq 1.7$(Level 1) and No. of muon ≥ 1 with $P_t > 5$ GeV/c(Level 2) for muon. After the loose filtering,[5] we applied the event selection which is described in Table 1.

Table 1. Event Selection for $WW \rightarrow e\mu\nu\bar{\nu} + X$.

Event Selection Description	No. of Events Passed
μ and e ID	82
$\Delta R(\mu - \gamma) > 0.25$	80
$\lvert\eta_\mu\rvert \leq 1.0$	70
$\Delta R(\mu - jet) > 0.5$	16
$E_t^e \geq 20$ GeV and $P_t^\mu \geq 15 GeV/c$	5
$\not{E}_t \geq 20$ GeV	1

An expected total background in this channel was 0.96 ± 0.44 events, mostly from $Z \rightarrow \tau\tau(0.39 \pm 0.11)$ and Fake electron of W + jets event(0.43 ± 0.43). The efficiency calculation was done using PYTHIA(V5.6)/JETSET(V7.3) $\rightarrow$ GEANT(V3.14) $\rightarrow$ D0RECO(V11.19) Monte Carlo sample for event selection and using data for triggers.

2.2. $WW \to ee\nu\bar{\nu} + X$

There are three kinds of trigger for this sample. So called "W" which is $E_t^{EMtower} \geq$ 10 GeV(Level 1) and $E_t^{EM} \geq 20$ GeV with $\not{E}_t \geq 20$ GeV(Level 2), "Z" which is two of $E_t^{EMtower} \geq 7$ GeV(Level 1) and two of $E_t^{EM} \geq 20$ GeV(Level 2), and "W+Jets" which is $E_t^{EMtower} \geq 10$ GeV with two $E_t^{Jet} \geq 3$ GeV(Level 1) and $E_t^{EM} \geq 15$ GeV with $\not{E}_t \geq 20$ GeV plus two of $E_t^{Jet} \geq 16$ GeV(Level 2). The reason for including "W+Jets" trigger is that electrons were counted as jets in the triggers. The event selection for this channel is shown in Table 2.

Table 2. Event Selection for $WW \to ee\nu\bar{\nu} + X$.

Event Selection Description	No. Events Passed
Two em clusters	2201
Two electrons $E_t^e \geq 20$ GeV	844
$\not{E}_t \geq 20$ GeV	7
$M_{ee} \leq 77$; $M_{ee} \geq 105$ GeV/c^2	5
$M_T(ee, \not{P}_T) \geq 100$ GeV/c^2	1

We expect 1.23 ± 0.87 total background events which is mostly came from Fake electron of W + jets event(0.85 ± 0.85). The efficiency calculation was done by the same way for the $WW \to e\mu\nu\bar{\nu} + X$.

3. Results and Conclusions

We observe one $e\mu\nu\bar{\nu} + X$ and one $ee\nu\bar{\nu} + X$ as a candidate event of the W pair production. Based on two candidate events and the efficiencies, $\epsilon_{e\mu} = 0.10 \pm 0.01$ and $\epsilon_{ee} = 0.12 \pm 0.01$, we obtained 133 pb as the cross section upper limit for the W pair production at 95% C.L. without background subtraction. In the standard model W pair production[6] we expect about 0.5 events in the two channels combined. We calculated limits on the CP conserving couplings, κ and λ using the event generator for the W pair production[7] and a fast detector simulation. We assumed $\Delta\kappa_\gamma = \Delta\kappa_Z$ and $\lambda_\gamma = \lambda_Z$ in this calculation. Simultaneosly varying κ and λ at compositness scale 800 GeV we obtained limits in the form of a contour. Figure 1 shows the coupling limits with the unitarity limit($\Lambda = 800 GeV$) which allows $\Delta\kappa$ and λ to vary from their standard model values, $\Delta\kappa_V = \kappa_V$ - 1 = 0 and $\lambda_V = 0$. Finally limits on the trilinear gauge boson couplings, -3.3< $\Delta\kappa$ <3.5 with constraint $\lambda = 0$ and -2.6< λ <2.7 with constraint $\Delta\kappa = 0$ are obtained at 95% C.L..

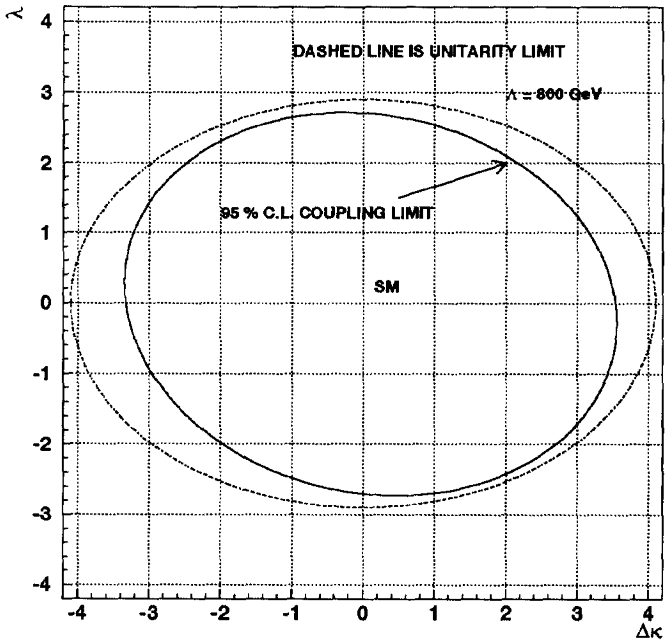

Fig. 1. 95 % C.L. Trilinear Gauge Boson Coupling Limits.

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