Search for Higgs Boson in CDF

YOSHIO ISHIZAWA
Institute of Physics, University of Tsukuba, Tsukuba-shi, Ibaraki-ken, Japan, 305-8571

Introduction

For several decades, the Standard Model has been remarkably successful in explaining and predicting experimental data. However, the mechanism of electroweak symmetry breaking is still not known. One of the most popular mechanism to induce spontaneous symmetry breaking of a gauge theory, resulting in the gauge bosons and fermions acquiring masses, is the Higgs mechanism. This mechanism predicts a Higgs boson but not its mass. In this poster we present a search for the Higgs boson in CDF.

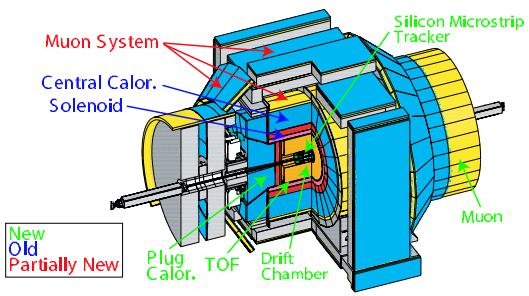
Tevatron and CDF Detector

Tevatron Run II

Data taking period started in spring 2001 with the upgraded energy $\sqrt{s} = 1.96$ TeV ($\sqrt{s} = 1.8$ TeV for Run I). Current instantaneous luminosity is approximately 5×10^{31} cm^{-2}s^{-1}.

CDF Detector

The CDF detector includes a set of upgrades to the detector used in Run I. A new plug calorimeter, a Time-of-Flight (TOF) detector, tracking detectors and an intermediate muon detector were installed.



Search for the Standard Model Higgs Boson

Data Sample and Event Selection

The data used for this analysis were taken between March 2002 and September 2003, and amounts to an integrated luminosity of 162 pb^{-1}. We search $W^{\pm}H$ events in which the $W^{\pm}$ decays to an electron or a muon, and the H decays to two b quarks. The signature is the following:

- Single high-p_T lepton ($p_T > 20$ GeV/c),
- Large missing E_T (> 20 GeV),
- 2 jets ($E_T > 15$ GeV),
- In order to enhance the signal over background ratio, we require at least one of the jet to be identified as a b-jet.

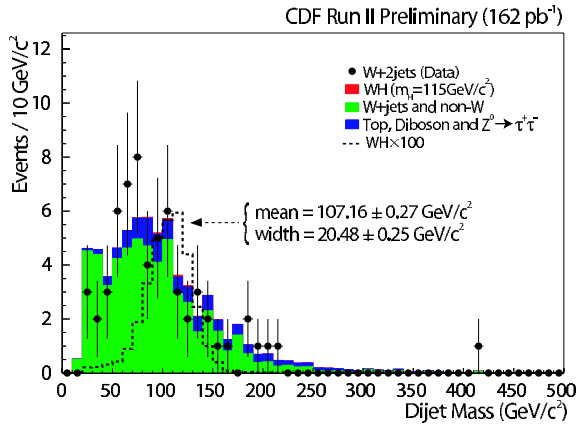
Event Estimation

The table below shows the number of background events as a function of jet multiplicity. The total backgrounds are consistent with the observed events.

Backgrounds	$W^{\pm}+1$ jet	$W^{\pm}+2$ jets	$W^{\pm}+3$ jets	$W^{\pm}+\geq 4$ jets
mistags	36.20 ± 5.40	14.07 ± 2.10	3.97 ± 0.68	2.04 ± 0.39
$W+b\bar{b}$	18.58 ± 4.82	12.05 ± 2.19	2.82 ± 0.57	0.99 ± 0.25
$W+c\bar{c}$	9.44 ± 2.94	5.19 ± 1.14	1.04 ± 0.25	0.35 ± 0.11
$W+c$	33.08 ± 7.83	7.86 ± 2.08	1.36 ± 0.39	0.28 ± 0.10
Diboson/$Z^0 \to \tau^+\tau^-$	1.74 ± 0.30	2.25 ± 0.34	0.59 ± 0.13	0.10 ± 0.03
non-W	22.24 ± 2.69	10.31 ± 1.66	2.44 ± 0.57	0.58 ± 0.18
$t\bar{t}$	0.42 ± 0.07	5.05 ± 0.64	12.65 ± 1.57	20.10 ± 2.49
single top	1.14 ± 0.15	3.76 ± 0.49	0.90 ± 0.12	0.17 ± 0.03
Total Backgrounds	122.84 ± 11.40	60.55 ± 4.43	25.77 ± 2.16	24.62 ± 2.59
Observed Positive Tags	135	62	23	21

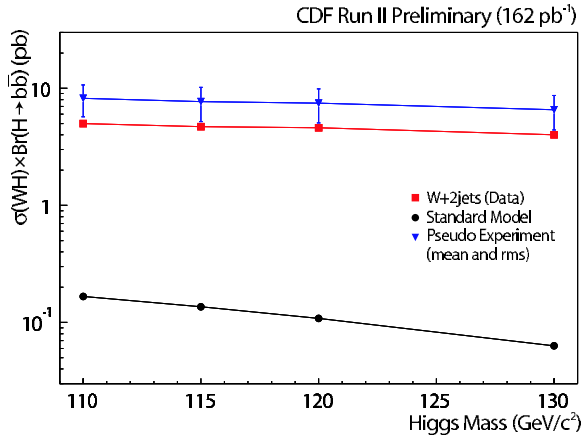
Dijet Mass Distribution

We perform a direct search for a resonant mass peak in the reconstructed dijet invariant mass distribution of $W^{\pm}+2$ jets events. The dijet mass distribution is shown in the figure below. The predicted mass distribution from the Standard Model backgrounds is consistent with the data distribution.



95% C.L. Upper Limit

Since there is no mass peak as expected from Higgs boson, we set an upper limit on the production cross section times branching ratio of $p\bar{p} \to W^{\pm}H$ as a function of Higgs boson mass. We use a binned maximum likelihood technique to estimate the number of $W^{\pm}H$ signal events by constraining the number of background events to the expectation within the statistical and systematic uncertainties. The 22% systematic uncertainty mainly comes from uncertainties in the modeling of initial and final state radiation (19%). The figure below shows the 95% C.L. upper limit. Although we have much improved limit over Run I (14 $\sim$ 19 pb), the sensitivity of the present search is limited by statistics to a cross section approximately one order of magnitude higher than the predicted production cross section for the Standard Model Higgs boson.

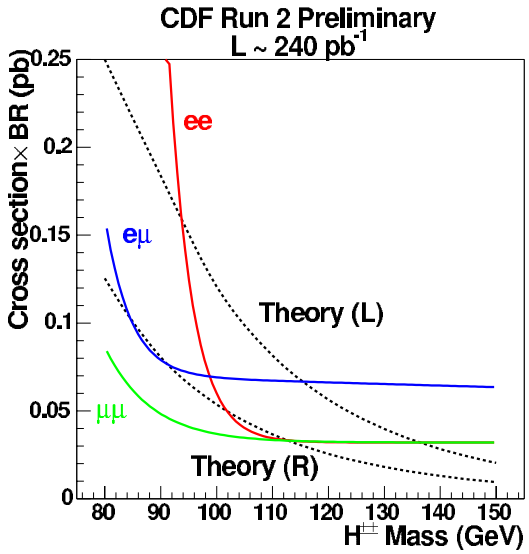


Search for the Double Charged Higgs Boson

Double charged Higgs bosons are predicted by left-right (LR) symmetric models, and especially SUSY LR models predict low-mass $H^{\pm\pm}$ ($\sim$100 GeV to 1 TeV). These particles decay to leptons, and we have searched 240 pb^{-1} data, taken between March 2002 and November 2003, for evidence of such production. We searched in same-sign electron/muon mass windows of $\pm 10\%$ of a given $H^{\pm\pm}$ mass ($\sim 3\sigma$ of the detector resolution). Our search is sensitive to any double charged particle decaying to dilepton, whether produced singly or in pairs.

95% C.L. Lower Limit

In our search region, we observe 0 events. These results provide a 95% C.L. limit for pair-production of double charged particles. The figure below shows the limit. The result in lower mass limits of 135 GeV, 135 (110) GeV, and 114 (89) GeV for $H_L^{\pm\pm}$ ($H_R^{\pm\pm}$) particles decaying exclusively to ee, $\mu\mu$, $e\mu$ respectively.



Summary

We performed a search for the Standard Model and the double charged Higgs bosons. We set a preliminary 95% C.L. upper limit using 162 pb^{-1} for the Standard Model Higgs boson and a preliminary 95% C.L. lower limit using 240 pb^{-1} for the double charged Higgs boson.

- Standard Model Higgs boson

  $\sigma(WH) \times Br\,(H \to b\bar{b}) < 5$ pb

- Double charged Higgs boson

  $m_H > 135$ GeV for $H_L^{\pm\pm}$ decaying to ee

  $m_H > 135\,(110)$ GeV for $H_L^{\pm\pm}$ ($H_R^{\pm\pm}$) decaying to $\mu\mu$

  $m_H > 114\,(89)$ GeV for $H_L^{\pm\pm}$ ($H_R^{\pm\pm}$) decaying to $e\mu$

Tevatron and CDF detector are working very well. Therefore significant improvements of the Higgs boson sensitivity are expected in the near future.