Search for a Low Mass Standard Model Higgs Boson at D0 in ppbar Collisions at $\sqrt{s} = 1.96TeV$

M. Rangel

PROCEEDINGS OF SCIENCE

Search for a Low Mass Standard Model Higgs Boson at DØ in ppbar Collisions at $\sqrt{s} = 1.96 TeV$

Murilo Rangel[∗†]
Laboratoire de l'Accélérateur Linéaire
E-mail: rangel@fnal.gov

We present combined searches for the Low Mass Standard Model Higgs boson at a center-of-mass energy of $\sqrt{s}$ =1.96 TeV, using up to 5 fb^{-1} of data collected with the D0 detector at the Fermilab Tevatron collider. The major contributing processes are associated production ($WH \rightarrow l\nu bb$, $ZH \rightarrow \nu\nu bb$, $ZH \rightarrow llbb$). The significant improvements across the full mass range resulting from the larger data sets and improved analyses as well as future prospects are discussed.

XXth Hadron Collider Physics Symposium
November 16 – 20, 2009
Evian, France

[∗]Speaker.
[†]On behalf the DØ collaboration

 http://pos.sissa.it/

PoS(HCP2009)093

The standard model (SM) of particle physics is a succefull theory despite from the fact that the electroweak symmetry breaking mechanism is still unknown. The simplest proposed mechanism involves the introduction of a complex doublet of scalar fields that generate the masses of elementary particles via their mutual interactions. After accounting for longitudinal polarizations for the electroweak bosons, this so-called Higgs mechanism also gives rise to a single scalar boson (SM Higgs) with an unpredicted mass.

We combined results of different direct searches for Low Mass SM Higgs (mass less than 135 GeV) recorded by the DØ experiment [1]. The analyses serch for a signal of Higgs bosons produced in association with vector bosons ($q\bar{q} \to W/ZH$), through gluon-gluon fusion (GGF) ($gg \to H$), through vector boson fusion (VBF) ($q\bar{q} \to q'\bar{q}'H$), and in association with top quarks ($t\bar{t} \to t\bar{t}H$). The analyses utilize data corresponding to integrated luminosities ranging from 2.1 to 5.4 fb^{-1}, collected during the period 2002-2009. The Higgs boson decay modes studied are $H \to b\bar{b}$, $H \to W\bar{W}$, $H \to \tau\bar{\tau}$ and $H \to \gamma\gamma$. The analyses were designed to be mutually exclusive after analysis selections.

Since the most recent DØ SM combined Higgs boson search results [2], from the analyses sensitive to Low Mass Higgs, the $ZH \to \nu\bar{\nu}b\bar{b}$ was updated [3].

The main Higgs decay at Low Mass is $H \to b\bar{b}$, therefore, an algorithm for identifying jets consistent with the decay of a heavy-flavor quark is applied to each jet (b-tagging). Several kinematic variables sensitive to displaced jet vertices and jet tracks with large transverse impact parameters relative to the hard-scatter vertices are combined in a neural network (NN) discriminant trained to identify heavy-flavor quark decays and reject jets arising from light-flavor quarks or gluons [4].

We combine results using the CL_s method with a negative log-likelihood ratio (LLR) test statistic. The value of CL_s is defined as $CL_s = CL_{s+b} / CL_b$ where CL_{s+b} and CL_b are the confidence levels for the signal-plus-background hypothesis and the background-only hypothesis, respectively. The confidence levels are evaluated by integrating corresponding LLR distributions populated by simulating outcomes via Poisson statistics. Separate channels and bins are combined by summing LLR values over all bins and channels. Systematics are treated as Gaussian uncertainties on the expected number of signal and background events, not the outcomes of the limit calculations. The CL_s approach used in this combination uses binned final-variable distributions rather than a single-bin (fully integrated) value for each contributing analysis. The exclusion criteria are determined by increasing the signal cross section until $CL_s = 1 - \alpha$, which defines a signal cross section excluded at 95% confidence level for α = 0.95.

In order to minimize the degrading effects of systematics on the search sensitivity, the individual background contributions are fitted to the data observation by maximizing a likelihood function for each hypothesis [5]. The likelihood is a joint Poisson probability over the number of bins in the calculation and is a function of the nuisance parameters in the system and their associated uncertainties, which are given an additional Gaussian constraint associated with their prior predictions. The maximization of the likelihood function is performed over the nuisance parameters. A fit is performed to both the background-only (b) and signal-plus-background (s+b) hypothesis separately for each Poisson MC trial.

We derive limits on SM Higgs boson production cross section times the SM Higgs branch ratio. The limits are derived at 95% C.L. To facilitate model transparency and to accommodate analyses with different degrees of sensitivity, we present our results in terms of the ratio of 95%

C.L. upper cross section limits to the SM predicted cross section as a function of Higgs boson mass. The SM prediction for Higgs boson production would therefore be considered excluded at 95% C.L. when this limit ratio falls below unity.

The expected and observed 95% C.L. cross section limit ratios to the SM cross sections for all analyses combined over the probed mass region ($100 \leq m_H \leq 135$ GeV/c^2) are presented in Table 1. These limits and the LLR distributions for the full combination are shown in Fig. 1.

Table 1: Combined 95% C.L. limits for SM Higgs boson production. The limits are reported in units of the SM production cross section times branching fraction.

m_H (GeV/c^2)	100	105	110	115	120	125	130	135
Expected:	2.35	2.40	2.85	2.80	3.25	3.31	3.30	3.35
Observed:	3.53	3.40	3.47	4.05	4.03	4.19	4.53	5.58

We have presented upper limits on standard model Higgs boson production derived from 60 Higgs search analyses including data corresponding to 2.1-5.4 fb^{-1}. We have combined these analyses and form new limits more sensitive than each individual limit. The observed (expected) 95% C.L. upper limit ratios to the SM Higgs boson production cross sections are 4.0 (2.8) at m_H = 115 GeV/c2

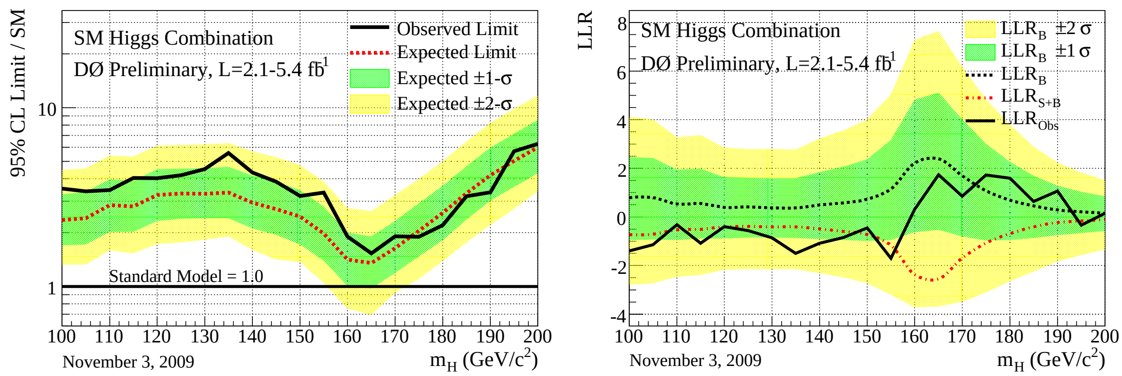

Figure 1: Left: Expected (median) and observed 95% C.L. cross section upper limit ratios for the combined Higgs analyses over the $100 \leq m_H \leq 200$ GeV/c^2 mass range. Right: Log-likelihood ratio distribution for the combined analyses over the $100 \leq m_H \leq 200$ GeV/c^2 mass range.

References

[1] DØ Collaboration, DØ Note 6008-CONF.

[2] DØ Collaboration, DØ Note 5984-CONF.

[3] DØ Collaboration, DØ Note 5872-CONF.

[4] T. Scanlon, FERMILAB-THESIS-2006-43.

[5] W. Fisher, FERMILAB-TM-2386-E.