Higgs boson searches at the Tevatron

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We report on the searches for the Higgs boson(s) at the Tevatron as of Summer '09 . For the standard model Higgs we present searches in several decay modes, and the combination of all the channels analyzed by the CDF and DØ collaboration. A standard model Higgs having a mass between 160 and 170 GeV is excluded at 95% C.L. We also present searches for Higgs bosons appearing in theories beyond the standard model (SM). With the current datasets analyzed, in all tested models no evidence for Higgs bosons is found. Projections of the sensitivity to the SM Higgs boson at high luminosity are summarized.

1 Introduction

The search for the Higgs boson(s) has been of major importance for fundamental physics for many years, and is a central part of the Fermilab Tevatron physics program. Both the CDF and DØ experiments are reporting new results in different channels, which can then be combined to reach higher sensitivity. The new searches include more data and improved analysis techniques compared to previous analyses. The sensitivity of the current SM Higgs [1] combination significantly exceed previous combinations, while a Tevatron MSSM Higgs combination is reported here for the first time [2].

We report on the search for the standard model in the low mass channels, in which the Higgs boson is produced in association with a W or a Z and decays mostly in $b\bar{b}$ pairs, and in the high mass channels, in which the Higgs is produced mostly by gluon-gluon fusion and decays to WW pairs. We then present the combination of the results in all these channels obtained by the two collaborations. We also present searches for the Higgs bosons in beyond the standard model theories, mostly in supersymmetric (SUSY) models, and their combination.

All standard model Higgs boson signals are simulated using PYTHIA [3], and CTEQ5L or CTEQ6L [4] leading-order (LO) parton distribution functions. The $gg \to H$ production cross section is calculated at NNLL in QCD and also includes two-loop electroweak effects; see Refs. [5, 6] and references therein for the different steps of these calculations. The $gg \to H$ production cross section depends strongly on the PDF set chosen and the accompanying value of α_s. The cross sections used here are calculated with the MSTW 2008 NNLO PDF set [7]. All Higgs production modes are included in the high mass search: besides gluon-gluon fusion through a virtual top quark loop (ggH), are the production in association with a W or Z vector boson (VH) [8, 9, 10], and vector boson fusion (VBF) [8, 11]. The SM Higgs boson decay branching ratio predictions are calculated with HDECAY [12]. For both CDF and DØ, events from multijet (instrumental) backgrounds are measured in data with different methods, in orthogonal samples. For CDF, backgrounds from other SM processes were generated using PYTHIA, ALPGEN [13], MC@NLO [14] and HERWIG [15] programs. For DØ, these backgrounds were generated using PYTHIA, ALPGEN, and COMPHEP [16], with PYTHIA providing parton-showering and hadronization for all the generators. These background processes were normalized using either experimental data or highest order calculationscalculations available (from MCFM [17] for $W+$ heavy flavor process).

For supersymmetric Higgs bosons, the acceptance for signal is determined from Monte-Carlo simulations, using the PYTHIA event generator with CTEQ5L (CDF) and CTEQ6L (DØ) parton sets and TAUOLA [18] to simulate the decays of the taus if present in the final state.

Two production modes, $gg \to \phi$ and $b\bar{b}\phi$ are considered by CDF while only $gg \to \phi$ is considered by DØ but the acceptances are seen to be similar for both production modes. In the interpretation of the results in the framework of the MSSM as limits in the $\tan\beta - M_A$ plan,e both production modes are taken into account as well as an additional factor of two on the cross section due to the near degeneracy of two of the three neutral Higgs bosons. The signal cross sections and branching fractions within each scenario have been calculated using FEYNHIGGS[19] with no theoretical uncertainties considered. All these searches are statistically limited, so the performance of the Tevatron is a crucial ingredient for the sensitivity which can be reached. The Tevatron continues to perform excellently and, as of August 2009, 6.8 fb^{-1} of data have been delivered, and 6.0 fb^{-1} have been recorded by each experiment. The analyses presented here are based on up to 5 fb^{-1} of data.

2 Searches for Standard Model Higgs bosons at low mass

The searches for the Higgs boson at the Tevatron are now in a rather mature state, so event selections are similar for the corresponding CDF and DØ analyses. The description for each low mass ($m_H < 135$ GeV) analysis are detailed in Refs. [20] to [31], and briefly described below.

For the $WH \to \ell\nu b\bar{b}$ channel, an isolated lepton (ℓ = electron or muon) and two (and three in the DØ analysis) jets are required, with one or more b-tagged jet. Selected events must also display a significant imbalance in transverse momentum (missing transverse energy or $\not\!\!E_T$). Events with more than one isolated lepton are vetoed. For the DØ $WH \to \ell\nu b\bar{b}$ analyses, the two and three jet events are analyzed separately, and in each of these samples two non-overlapping b-tagged samples are defined, one being a single "tight" b-tag (ST) sample, and the other a double "loose" b-tag (DT) sample. The tight and loose b-tagging criteria are defined with respect to the mis-identification rate that the b-tagging algorithm yields for light quark or gluon jets ("mistag rate") typically $\leq 0.5\%$ or $\leq 1.5\%$, respectively. The final variable is a neural network (NN) output for the two-jet sample, while for the three-jet sample the dijet invariant mass is used. DØ also performs a $WH \to \tau\nu b\bar{b}$ analysis in which the τ is identified through its hadronic decays. This analysis is sensitive to $ZH \to \tau\tau b\bar{b}$ as well, in those cases where a τ fails to be identified. The analysis is carried out according to the type of reconstructed τ. A boosted decision tree is used as the final discriminant.

For the CDF $WH \to \ell\nu b\bar{b}$ analysis, the events are grouped into six categories. In addition to the selections requiring an identified lepton, events with an isolated track failing lepton selection requirements are grouped into their own categories. This provides acceptance for single prong tau decays. Within the lepton categories there are three b-tagging categories – two tight b-tags (TDT), one tight b-tag and one loose b-tag (LDT), and a single, tight, b-tag (ST). These b-tag category names are also used in the $\not\!\!E_T b\bar{b}$ and $\ell^+\ell^- b\bar{b}$ channel descriptions. In each category, two discriminants are calculated for each event. One NN discriminant is trained at each m_H in the test range, separately for each category. A second discriminant is a boosted decision tree, featuring not only event kinematic and b-tagging observables, but matrix element discriminants as well. These two discriminants are then combined together using another NN to form a single discriminant with optimal performance. In Figures 1a-d we display one dijet mass distribution and one of the discriminants obtained by each collaboration.

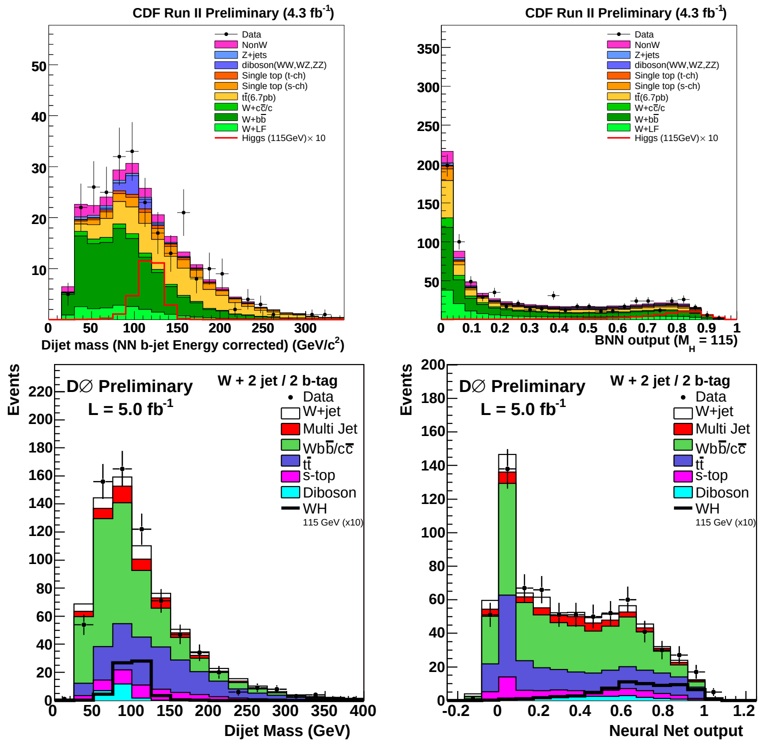

Figure 1: Dijet distributions (a,c) and discriminant output for events with two identified b-jets

For the $ZH \rightarrow \nu\bar{\nu}b\bar{b}$ analyses, the selection is similar to the WH selection, except all events with isolated leptons are vetoed and stronger multijet background suppression techniques are applied. Both CDF and DØ analyses use a track-based missing transverse momentum calculation as a discriminant against false $\not\!\!E_T$. In addition DØ train a boosted decision tree against the multijet background. There is a sizeable fraction of $WH \rightarrow \ell\nu b\bar{b}$ signal in which the lepton is undetected, that is selected in the $ZH \rightarrow \nu\bar{\nu}b\bar{b}$ samples, so these analyses are also refered to as $VH \rightarrow \not\!\!E_T b\bar{b}$. The CDF analysis uses three non-overlapping samples of events (TDT, LDT and ST as for WH). DØ uses one DT channel, but with one tight and one loose requirements on the b-identification of the two jets. CDF used NN discriminants as the final variables, while DØ uses boosted decision trees as advanced analysis technique.

The $ZH \rightarrow \ell^+\ell^- b\bar{b}$ analyses require two isolated leptons and at least two jets. They use non-overlapping samples of events with one tight b-tag and two loose b-tags. For the DØ analysis boosted decision trees are the final variables for setting limits, while CDF uses the output of a two-dimensional NN. For this combination CDF and DØ have increased the signal acceptance by loosening the selection criteria for one of the leptons. In addition a kinematic fit is now applied to the $Z-$boson and jets. CDF corrects jet energies for $\not{E}_T$ using a NN approach. In the CDF analysis the events are divided into three tagging categories: TDT, LDT, ST. Both CDF and DØ further subdivide the channels into lepton categories with different signal-to-background characteristics.

The DØ collaboration also searched for:

– direct Higgs boson production decaying to a photon pair. In this analysis, the final variable is the invariant mass of the two-photon system. At the Tevatron, this channel is not very sensitive due to the low branching ratio, but it is included in the combination and can gain sensitivity in beyond the standard model scenarios, as described in section 6.

–$t\bar{t}H \to t\bar{t}b\bar{b}$. Here the samples are analyzed independently according to the number of b-tagged jets (1,2,3, i.e. ST,DT,TT) and the total number of jets (4 or 5). The total transverse energy of the reconstructed objects (H_T) is used as discriminant variable.

– the final state $\tau\tau$ jet jet, which is sensitive to the $VH \to jj\tau\tau$, $ZH \to \tau\tau b\bar{b}$, VBF and gluon gluon fusion (with two additional jets) mechanisms. A NN output is used as discriminant variable for the first fb^{-1} of data; a boosted decision tree is used subsequently.

The CDF collaboration also searched for:

– Higgs bosons decaying to a tau lepton pair, in three separate production channels: direct $gg \to H$ production, associated WH or ZH production, or vector boson production with H and forward jets in the final state. Two jets are required in the event selection. The final variable for setting limits is a combination of several NN discriminants.

Table 1: Luminosity, explored mass range, 95% C.L. limits normalized to the SM expectation for $m_H = 115$ GeV, and references for the different low mass channels ($\ell = e, \mu$), for CDF.

Channel (CDF analyses)	Lumi. (fb^{-1})	m_H range (GeV)	Expected limit	Observed limit	Reference
$WH \to \ell\nu b\bar{b}$ 2×(TDT,LDT,ST)	4.3	100-150	4.0	5.3	[20]
$ZH \to \nu\bar{\nu}b\bar{b}$ (TDT,LDT,ST)	3.6	105-150	4.1	6.9	[21]
$ZH \to \ell^+\ell^- b\bar{b}$ (low,high s/b)					
× (TDT,LDT,ST)	4.1	100-150	6.8	5.9	[22]
$H + X \to \tau^+\tau^- + 2$ jets	2.0	110-150	27	24	[23]
$WH + ZH \to jjb\bar{b}$	2.0	100-150	37	38	[24]

Table 2: Luminosity, explored mass range, 95% C.L. limits normalized to the SM expectation for $m_H = 115$ GeV, and references for the different low mass channels ($\ell = e, \mu$), for DØ.

Channel (DØ analyses)	Luminosity (fb^{-1})	m_H range (GeV)	Expected limit	Observed limit	Reference
$WH \to \ell\nu bb$ 2×(ST,DT)	5.0	100-150	5.1	6.9	[25]
$WH \to \tau\nu b\bar{b}$ (ST,DT)	0.9	100-150	42	35	[26]
$VH \to \tau\tau b\bar{b}/q\bar{q}\tau\tau$	4.9	105-145	18	27	[27]
$ZH \to \nu\bar{\nu}b\bar{b}$ (DT)	2.1	100-150	8.4	7.5	[28]
$ZH \to \ell^+\ell^- b\bar{b}$ 2×(ST,DT)	4.2	100-150	8.0	9.7	[29]
$H \to \gamma\gamma$	4.2	100-150	18	13	[30]
$t\bar{t}H \to t\bar{t}b\bar{b}$ 2×(ST,DT,TT)	2.1	105-155	45	64	[31]

– the all-hadronic channel, $WH + ZH \to jjb\bar{b}$. Events are selected with four jets, at least two of which are b-tagged with the tight b-tagger. The large multijet backgrounds are estimated with the use of data control samples, and the final variable is a matrix element signal probability discriminant.

The limits obtained for $m_H = 115$ GeV in all these analyses together with the luminosity and mass range searched for, are summarized in Tables 1 and 2 for CDF and DØ.

3 Searches for Standard Model Higgs bosons at high mass

At high mass ($m_H > 135$ GeV), the Higgs boson decays predominantly in a WW pair, so by using the leptonic decays it is possible to also use the dominant direct gluon-gluon fusion production (all production modes are included in the high mass analyses). Event selections are similar for the corresponding $H \to W^+W^-$ CDF and DØ analyses. DØ has a dedicated analysis for the $WH \to WW^+W^-$ channel, while it is included in the $H \to W^+W^-$analysis in the CDF case. The luminosity and mass range searched for these analyses, together with their sensitivity are summarized in Table 3. The description for each analysis are detailed in Refs. [32] to [34], and briefly described below.

Table 3: Luminosity, explored mass range, 95% C.L. limits normalized to the SM expectation for $m_H = 165$ GeV, and references for the different high mass channels ($\ell = e, \mu$), for the CDF and DØ analyses.

Channel	Luminosity (fb^{-1})	m_H (GeV)	Expected limit	Observed limit	Refs
CDF: $H \to W^+W^-$ (low,high s/b)					
$\times$ (0,1 jets)+(2+ jets)+Low-$m_{\ell\ell}$	4.8	110-200	1.2	1.2	[32]
DØ: $H \to W^+W^- \to \ell^\pm\nu\ell^\mp\nu$	4.2	115-200	1.7	1.3	[33]
DØ: $WH \to WW^+W^- \to \ell^\pm\nu\ell^\pm\nu$	3.6	120-200	11	18	[34]

For the $H \to W^+W^-$ analyses, signal events are characterized by a large $\not\!\!E_T$ and two opposite-signed, isolated leptons. The presence of neutrinos in the final state prevents the reconstruction of the candidate Higgs boson mass. DØ selects events containing electrons and muons, dividing the data sample into three final states: e^+e^-, $e^\pm\mu^\mp$, and $\mu^+\mu^-$. CDF separates the $H \to W^+W^-$ events in six non-overlapping samples, labeled "high s/b" and "low s/b" for the lepton selection categories, and also split by the number of jets: 0, 1, or 2+ jets. The sample with two or more jets is not split into low s/b and high s/b lepton categories. The sixth CDF channel is a new low-$m_{\ell^+\ell^-}$ channel, which accepts events with $m_{\ell^+\ell^-} < 16$ GeV. This channel increases the sensitivity of the $H \to W^+W^-$ analyses at low m_H, adding 10% additional acceptance at $m_H = 120$ GeV. CDF's division of events into jet categories allows the analysis discriminants to separate three different categories of signals from the backgrounds more effectively. The signal production mechanisms considered are $gg \to H \to W^+W^-$, $WH + ZH \to jjW^+W^-$, and the vector-boson fusion process.

The final discriminants are neural-network outputs for DØ and neural-network outputs including likelihoods constructed from matrix-element probabilities (ME) as input to the NNs, for CDF, in the 0-jet bin, else the ME are not used. All analyses in this channel have been updated with more data and analysis improvements.

The DØ collaboration analyzes separately the $WH \to WW^+W^-$ channel, where the associated W boson and the W boson from the Higgs boson decay which has the same charge are required to decay leptonically, thereby defining three like-sign dilepton final states ($e^{\pm}e^{\pm}$, $e^{\pm}\mu^{\pm}$, and $\mu^{\pm}\mu^{\pm}$) containing all decays of the third W boson. In this analysis the final variable is a likelihood discriminant formed from several topological variables. CDF analyzes the $WH \to WW^{+}W^{-}$ channel using a selection of like-sign dileptons and a NN to further purify the signal.

4 Combination of the standard model Higgs results

Using the combination procedures described in Refs. [35, 36, 37, 38], we extract limits on SM Higgs boson production $\sigma \times B(H \to X)$ in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for m_H between 100 and 200 GeV. The analyses used in the combination have sometimes lower luminosity than presented above, since the combination presented here was performed in March 2009, i.e. before the latest updates presented at this conference became available. See Reference [1] for details of the differences. In short, the low mass channels had an average luminosity of about 2.5 fb^{-1} for the current combination, while the updated analyses have an average closer to 4 fb^{-1}.

The results are presented in terms of the ratio of obtained limits to cross section in the SM, as a function of Higgs boson mass, for test masses for which both experiments have performed dedicated searches in different channels. A value of the combined limit ratio which is less or equal to one would indicate that that particular Higgs boson mass is excluded at the 95% C.L. The expected and observed limit ratios are shown in Figure 2 for the combined CDF and DØ analyses. The observed and median expected ratios are listed for some typical Higgs boson masses in Table 4 with observed (expected) values of 2.5 (2.4) at $m_H = 115$ GeV, 0.99 (1.1) at $m_H = 160$ GeV, 0.86 (1.1) at $m_H = 165$ GeV, and 0.99 (1.4) at $m_H = 170$ GeV. The Tevatron experiments exclude at 95% C.L. the production of a standard model Higgs boson with mass between 160 and 170 GeV.

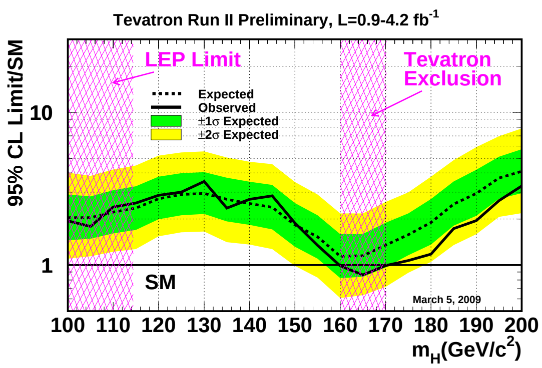

Figure 2: Observed and expected 95% C.L. upper limits on the ratios to the SM cross section, as functions of the Higgs boson mass for the combined CDF and DØ analyses. The limits are expressed as a multiple of the SM prediction. The bands indicate the 68% and 95% probability regions where the limits can fluctuate, in the absence of signal.

Table 4: Ratios of median expected and observed 95% CL limit to the SM cross section for the combined CDF and DØ analyses as a function of the Higgs boson mass in GeV.

	105	115	125	135	140	150	155	160	165	170	175	180	190	200
Expected	2.0	2.4	2.9	2.7	2.5	1.8	1.5	1.1	1.1	1.4	1.6	1.9	2.7	4.2
Observed	1.8	2.5	3.0	2.4	2.7	1.9	1.4	0.99	0.86	0.99	1.1	1.2	2.0	3.3

5 Search for MSSM Higgs bosons

The most appealing extensions of the SM are the supersymmetric models. In the minimal (MSSM) extension [39], there are three neutral Higgs bosons, and two charged ones. Searches for the MSSM neutral Higgs bosons decaying into tau lepton pairs ($\phi = H, h, A \to \tau\tau$) have been performed by the CDF and D0 Collaboration with integrated luminosities of 1.8 and 2.2 fb-1 of Run II data, respectively. The searches require the tau pairs to decay into $\tau_e\tau_\mu$, $\tau_e\tau_{had}$, and $\tau_\mu\tau_{had}$, where τ_e, τ_μ are the leptonic decays of the tau and τ_{had} represent the hadronic decay modes. The searches are described in detail in [40, 41, 42]. The visible mass spectrum, with an example shown in Fig. 3a and defined in [42], is used in the limit calculation. Correlations in systematic uncertainties between the different tau decay channels are taken into account. No signicant excess in signal over background has been observed and thus CDF-DØ combined limits on the production cross section for neutral Higgs boson times the branching fraction into tau leptons are given for neutral Higgs bosons in the range $100 < M_A < 200$ GeV. The results are shown in Figure 3b.

Though at leading order the Higgs sector of the MSSM can be described with just two parameters, with higher order corrections comes a dependence on other model parameters. To interpret the exclusion within the MSSM, these parameters are fixed in four benchmark scenarios [43]. The four scenarios considered are defined in terms of: M_{SUSY}, the mass scale of squarks, μ, the Higgs sector bilinear coupling, M_2, the gaugino mass term, A_t, the trilinear coupling of the stop sector, A_b, the trilinear coupling of the sbottom sector and $m_{\tilde{g}}$ the gluino mass term. The maximal-mixing, m_h^{max}, scenario is defined as:

$$M_{\rm SUSY} = 1 \text{ TeV}, \mu = 200 \text{ GeV}, M_2 = 200 \text{ GeV},$$
$$X_t = 2M_{\rm SUSY},\ A_b = A_t,\ m_{\tilde{g}} = 0.8M_{\rm SUSY}.$$

and the no-mixing scenario - with vanishing mixing in the stop sector and a higher SUSY mass scale to avoid the LEP Higgs bounds:

$$M_{\rm SUSY} = 2 \text{ TeV}, \mu = 200 \text{ GeV}, M_2 = 200 \text{ GeV},$$
$$X_t = 0,\ A_b = A_t,\ m_{\tilde{g}} = 0.8M_{\rm SUSY}.$$

Four scenarios are constructed from these two by the consideration of both + and - signs for μ. The results are shown in Figure 4b,c for two of the four scenarios.

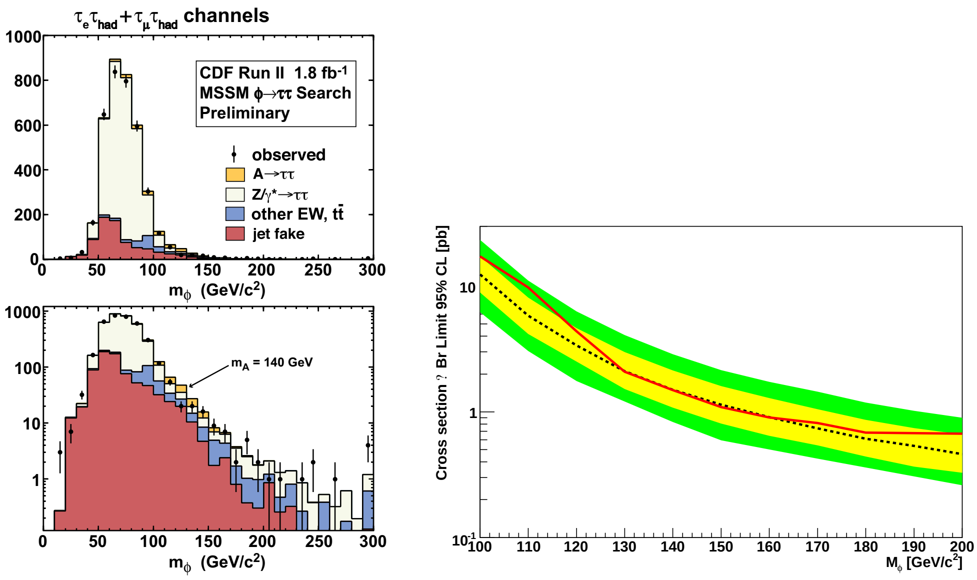

Figure 3: a) Visible mass distribution in the CDF $h \to \tau\tau$ analysis ; b) 95% C.L. limits on cross section $\times$ branching ratio in the $h \to \tau\tau$ CDF-DØ combination. The solid red and dashed black lines show the observed and expected limits respectively. The yellow and green shaded bands show the 1 and 2σ deviations from the expectation.

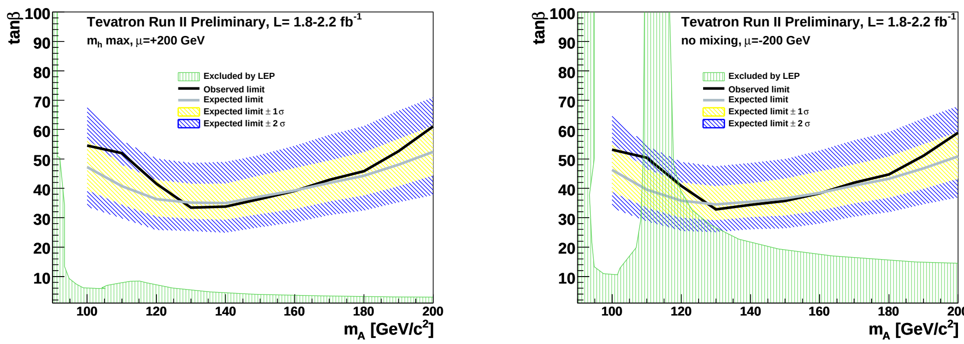

Figure 4: 95% C.L. limits obtained from the $h \to \tau\tau$ CDF-DØ combination in the tanβ-M$_A$ plane for two benchmark scenarios: maximal mixing (a) and no mixing (b) for $\mu > 0$ and $\mu < 0$ respectively. The black line denotes the observed limit, the grey line the expected limit.

For this result the signal cross sections and branching fractions within each scenario have been calculated using FEYNHIGGS with no theoretical uncertainties considered. Tanβ dependent width effects have not been included, though in the region of the tanβ-M_A plane where limits have been set these are not expected to strongly impact on the limit.

The DØ collaboration has also done a combination of its 2.2 fb^{-1} $h \to \tau\tau$ channel with the $bh \to b\tau\tau$ channel (1.2 fb^{-1}[44]) and the $bh \to bbb$ channel (2.6 fb^{-1}[45]). This last analysis is divided into three channels with 3, 4 or 5 jets in the final state and the final discriminant is the invariant mass of the 2 b-jets of highest p_T. The results are displayed in Figure 5 for the two same benchmark scenarios, and show that the $bh \to b\tau\tau$ channel provides a visible gain in sensitivity at low m_A.

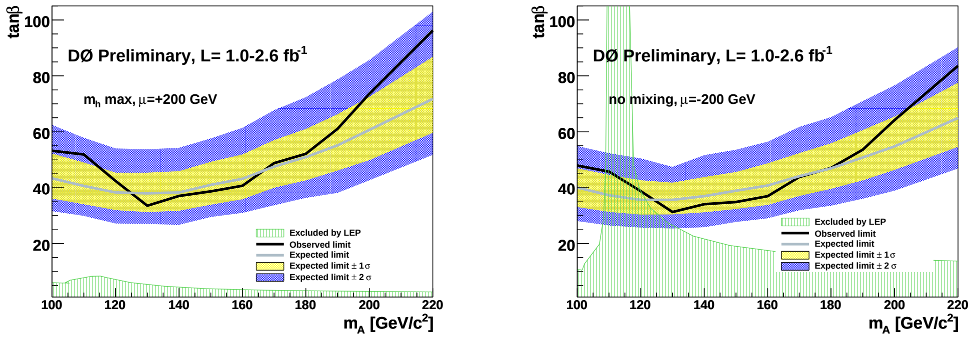

Figure 5: 95% C.L. limits obtained from the DØ combination ($h \to \tau\tau$, $bh \to b\tau\tau$, $bh \to bbb$) in the tanβ-M$_\mathrm{A}$ plane for two benchmark scenarios: maximal mixing (a) and no mixing (b) for $\mu > 0$ and $\mu < 0$ respectively. .

6 Beyond MSSM Higgs

Searches are also performed in models beyond the MSSM. In the next-to-MSSM model, the Higgs sector has three neutral CP-even Higgs (h), two CP-odd Higgs bosons (a). A scenario not excluded by LEP is a light Higgs boson with m_h between 100 and 130 GeV and m_a of a few GeV. In such configuration the Higgs boson h would decay preferentially in aa pairs, which are difficult to detect. DØ performed a search in this mode, assuming a decays in muon or tau pairs, with 4.2 fb^{-1} of data. In the case where $2m_\mu < m_a < 2m_\tau$, DØ sets a limit on the production cross section time branching ratio $\sigma(p\bar{p}) \to h\times$ BR$(h \to aa \to 4\mu) <\simeq 10$ fb [46].

In fermiophobic models, the Higgs boson decays only in bosons, and at low mass such decay is dominated by diphoton pairs. A higgs boson would appear as a "bump" in the diphoton invariant mass spectrum shown in Figure 6a. We can thus reinterpret the diphoton SM analyses, and derive limits as a function of the $h \to \gamma\gamma$ branching ratio, as shown in Figure 6b. Both CDF and DØ have reached sensitivity similar to LEP, excluding fermiophobic Higgs bosons below $\simeq 105$ GeV, and with more luminosity and improved analysis techniques are expected to reach sensitivity up to $\simeq 125$ GeV.

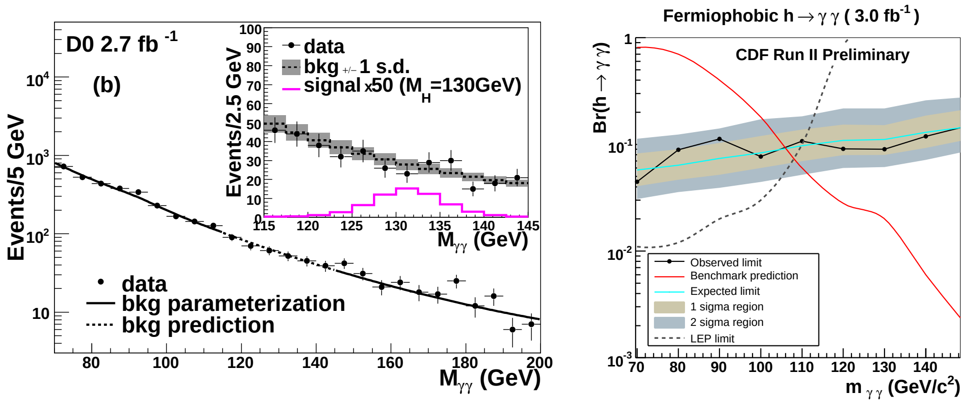

Figure 6: a) invariant diphoton invariant mass distribution in the DØ analysis, compared to the background prediction and to a simulated signal at $m_h = 130$ GeV increased by a factor of 50; b) 95% C.L. limit on the $h \rightarrow \gamma\gamma$ branching ratio as a function of the Higgs mass. The Fermiophobic scenario (red line) is excluded for m_h below approximately 105 GeV, both by CDF and, independently, by DØ(not shown).

7 Projections at high luminosity for the sensitivity to a SM Higgs boson

The Tevatron,CDF and DØ being now in a mature state, it is possible to estimate what will be the sensitivity to a SM Higgs boson by the end of 2011. At that time, the machine is expected to have delivered 12 fb^{-1}. Taken into account the recording efficiency and the data quality criteria currently applied by both experiments, this will result in analyses being done with 10 fb^{-1} of data. The analyses are being improved on several aspects (trigger and lepton detection efficiency, improvement in multivariate techniques, and, for low mass Higgs searches, b-tagging efficiency and dijet mass resolution), which lead to an expected improvement of approximately 50% in intrinsic sensitivity (i.e. outside the gain due to the luminosity increase). Injecting the luminosity increase and the analysis improvements in the current CDF-DØ combination, we can derive the probability to observe a Higgs signal at the 3 standard deviation level, depending on the Higgs mass, as shown in Figure 7. The projection shows that for masses close to two times the W mass the Tevatron has excellent sensitivity (which explain why this mass region is already excluded at 95% C.L.), but also that for $m_H = 115$ GeV, the probability to have evidence for the Higgs boson is about 50%. Such an evidence would be particularly important since the observation of a low mass Higgs boson in the dominant $b\bar{b}$ decay mode is not foreseen at the LHC before many years, if at all possible. Similarly, the reach for beyond the standard model Higgs bosons will increase significantly with luminosity and analysis improvements. In conclusion, with the complete dataset of the Tevatron Run II, whose end has already been postponed several times given the Higgs sensitivity potential and the LHC ramp-up schedule, we expect to have a first sight of this elusive particle, if it is indeed of the standard model type, or if it is supersymmetric with favorable SUSY phase space parameters.

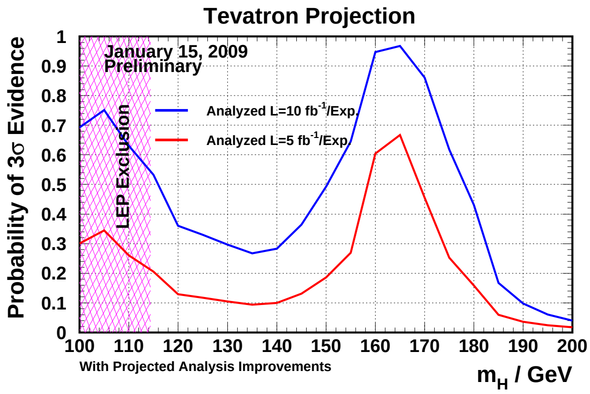

Figure 7: Probability to have evidence at the 3 σ level for a SM Higgs boson between 100 and 200 GeV, for 5 and 10 fb^{-1} of data analyzed by CDF and DØ and subsequently combined.

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Discussion

Guido Altarelli, CERN/ Roma Tre: You said that from the new improved results from CDF and D0 in the SM Higgs search we can extrapolate and guess what the new combined result would be. What is your guess then on the new excluded region for the SM Higgs?
Answer: Since I am speaking on behalf on CDF and D0, I prefer not to provide personal guesses in this forum, but we expect these new combined limits to be available in the fall. Besides, note that there also improvements on the Higgs theoretical cross-sections which will have some influence on the next exclusion region we will provide.
Majid Hashemi (University of Antwerp): Is there any update of charged Higgs search from Tevatron?
Answer: Not yet, those are expected for fall 2009.