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Combined CDF and D0 Search for Standard Model Higgs Boson Production with up to 10.0 fb^{-1} of Data

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We combine results from CDF and D0 on direct searches for the standard model (SM) Higgs boson (H) in $p\bar{p}$ collisions at the Fermilab Tevatron at $\sqrt{s} = 1.96$ TeV. Compared to the previous Tevatron Higgs boson search combination more data have been added, additional channels have been incorporated, and some previously used channels have been reanalyzed to gain sensitivity. With up to 10 fb^{-1} of luminosity analyzed, the 95% C.L. median expected upper limits on Higgs boson production are factors of 0.94, 1.10, and 0.49 times the values of the SM cross section for Higgs bosons of mass m_H =115 GeV/c^2, 125 GeV/c^2,and 165 GeV/c^2, respectively. We exclude, at the 95% C.L., two regions: $100 < m_H < 106$ GeV/c^2, and $147 < m_H < 179$ GeV/c^2. We expect to exclude the regions $100 < m_H < 119$ GeV/c^2 and $141 < m_H < 184$ GeV/c^2. There is an excess of data events with respect to the background estimation in the mass range $115 < m_H < 135$ GeV/c^2 which causes our limits to not be as stringent as expected. At $m_H = 120$ GeV/c^2, the p-value for a background fluctuation to produce this excess is $\sim 3.5\times10^{-3}$, corresponding to a local significance of 2.7 standard deviations. The global significance for such an excess anywhere in the full mass range is approximately 2.2 standard deviations. We also combine separately searches for $H \to b\bar{b}$ and $H \to W^+W^-$, and find that the excess is concentrated in the $H \to b\bar{b}$ channel, although the results in the $H \to W^+W^-$ channel are also consistent with the possible presence of a low-mass Higgs boson.

Preliminary Results

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I. INTRODUCTION

Understanding the mechanism for electroweak symmetry breaking, specifically by testing for the presence or absence of the standard model (SM) Higgs boson, has been a major goal of particle physics for many years, and is a central part of the Fermilab Tevatron physics program. Both the CDF and D0 collaborations have performed new combinations [1, 2] of multiple direct searches for the SM Higgs boson. The new searches include more data, additional channels, and improved analysis techniques compared to previous analyses. Precision electroweak data, including the recently updated measurements of the W-boson mass from the CDF and D0 Collaborations [3, 4], yield an indirect constraint on the allowed mass of the Higgs boson, $m_H < 152$ GeV/c^2 [5], at 95% confidence level (C.L.). The Large Electron Positron Collider (LEP) has excluded Higgs boson masses below 114.4 GeV/c^2 [6], and the LHC experiments, ATLAS and CMS, now limit the SM Higgs boson to have a mass between 115.5 and 127 GeV/c^2 [7, 8] at the 95% C.L. Both LHC experiments report local ~ 3 standard deviation (s.d.) excesses at approximately 125 GeV/c^2. The sensitivities of the new combinations presented here significantly exceeds those of previous Tevatron combinations [9, 10], providing sensitivity within the allowed Higgs boson mass range.

In this note, we combine the most recent results of all such searches in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV in the Higgs boson mass range from 100–200 GeV/c^2. The analyses combined here seek signals of Higgs bosons produced in association with a vector boson ($q\bar{q} \rightarrow W/ZH$), through gluon-gluon fusion ($gg \rightarrow H$), and through vector boson fusion (VBF) ($q\bar{q} \rightarrow q'\bar{q}'H$) corresponding to integrated luminosities up to 10.0 fb^{-1} at CDF and up to 9.7 fb^{-1} at D0. The Higgs boson decay modes studied are $H \rightarrow b\bar{b}$, $H \rightarrow W^+W^-$, $H \rightarrow ZZ$, $H \rightarrow \tau^+\tau^-$ and $H \rightarrow \gamma\gamma$. For Higgs boson masses greater than 125 GeV/c^2, $H \rightarrow W^+W^-$ modes with leptonic decay provide the greatest sensitivity [11–14], while below 125 GeV/c^2 sensitivity comes mainly from ($q\bar{q} \rightarrow W/ZH$) where H decays to $b\bar{b}$ and the W or Z decays leptonically [13, 15, 16]. The dominant decay mode for a low mass Higgs boson is $H \rightarrow b\bar{b}$, and thus measurements of this process provide constraints on possible Higgs boson phenomenology that are complementary to those provided by the LHC.

To simplify the combination, the searches are separated into mutually exclusive final states referred to as "analysis sub-channels" in this note. Listings of these analysis sub-channels are provided in Tables I and II. The selection procedures for each analysis are detailed in Refs. [17] through [38], and are briefly described below.

II. ACCEPTANCE, BACKGROUNDS, AND LUMINOSITY

Event selections are similar for the corresponding CDF and D0 analyses, consisting typically of a preselection followed by the use of a multivariate analysis technique with a final discriminating variable to separate signal and background. For the case of $WH \rightarrow \ell\nu b\bar{b}$, an isolated lepton ($\ell =$ electron or muon) and two or three jets are required, with one or more of the jets being b-tagged, i.e., identified as containing a weakly-decaying b hadron. Selected events must also display a significant imbalance in transverse momentum (referred to as missing transverse energy or $\not\!\!E_T$). Events with more than one isolated lepton are rejected.

For the D0 $WH \rightarrow \ell\nu b\bar{b}$ analyses, the data are split by lepton type and jet multiplicity (two or three jet sub-channels), and on the number of b-tagged jets. Orthogonal selections corresponding to events with exactly one tight b-tagged jet (TST), exactly two loose but not tight b-tagged jets (LDT) and exactly two tight b-tagged jets (TDT) are made. Every event is placed into one of these mutually exclusive categories. As with other D0 analyses targeting the $H \rightarrow b\bar{b}$ decay, a boosted decision tree based b-tagging algorithm, which builds and improves upon the previous neural network b-tagger [39], is used. For example, the loose b-tagging criterion corresponds to an identification efficiency of $\approx 80\%$ for true b-jets for a mis-identification rate of $\approx 10\%$. The outputs of boosted decision trees, trained separately for each sample (i.e. jet multiplicity, lepton flavor and b-tag category) and for each Higgs boson mass, are used as the final discriminating variables.

For the CDF $WH \rightarrow \ell\nu b\bar{b}$ analyses, events are analyzed in two and three jet sub-channels separately, and in each of these samples the events are grouped into various lepton and b-tag categories. Events are broken into separate analysis categories based on the quality of the identified lepton. Separate categories are used for events with a high quality muon or central electron candidate, an isolated track or identified loose muon in the extended muon coverage, a forward electron candidate, and a loose central electron or isolated track candidate. The final two lepton categories, which provide some acceptance for lower quality electrons and single prong tau decays, are used only in the case of two-jet events. Within the lepton categories there are five b-tagging categories considered for two-jet events: two tight b-tags (TT), one tight b-tag and one loose b-tag (TL), a single tight b-tag (Tx), two loose b-tags (LL), and a single loose b-tag. For three jet categories only the TT and TL b-tagging categories are considered. The tight and loose b-tag definitions are taken for the first time from a neural network tagging algorithm [40] based on sets of kinematic variables sensitive to displaced decay vertices and tracks within jets with large transverse impact parameters relative to the hard-scatter vertices. Using an operating point which gives an equivalent rate of false tags, the new algorithm improves upon previous b-tagging efficiencies by $\sim$20%. A Bayesian neural network discriminant is trained at each Higgs boson mass within the test range for each of the specific categories (defined by lepton type, b-tagging type, and number of jets) to separate signal from backgrounds.

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 rejected and stronger multijet background suppression techniques are applied. Both the CDF and D0 analyses use a track-based missing transverse momentum calculation as a discriminant against false $\not\!\!E_T$. In addition both CDF and D0 utilize multivariate techniques, a boosted decision tree at D0 and a neural network at CDF, to further discriminate against the multijet background before b-tagging. There is a sizable fraction of the $WH \rightarrow \ell\nu b\bar{b}$ 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 referred to as $VH \rightarrow \not\!\!E_T b\bar{b}$. The CDF analysis uses three non-overlapping categories of b-tagged events (SS, SJ and 1S). These categories are based on two older CDF b-tagging algorithms, an algorithm for reconstructing displaced, secondary vertices of b-quark decays (S) and an algorithm for assigning a likelihood for tracks within a jet to have originated from a displaced vertex (J). The D0 analysis requires exactly two jets. The b-tagging criteria have been re-optimized to reduce the loss in sensitivity due to systematic uncertainties. The $b-$tagger output values for each of the two jets are added to form an event b-tag, the value of which is used to define two high purity samples: the medium b-tag sample (MS) and the tight b tag-sample (TS). After applying a multijet veto, these samples have a signal-to-background ratio of 0.3% and 1.5% respectively. Boosted decision trees, trained separately for the different b-tagging categories and at each test mass, are used as the final discriminant. Overall, the sensitivity has been improved by $\approx$ 25% with respect to the previous result. The CDF analysis uses a second layer of neural network discriminants for separating signal from backgrounds.

The $ZH \rightarrow \ell^+\ell^- b\bar{b}$ analyses require two isolated leptons and at least two jets. D0's $ZH \rightarrow \ell^+\ell^- b\bar{b}$ analyses separate events into non-overlapping samples of events with either one tight b-tag (TST) or one tight and one loose b-tag (TLDT). CDF has incorporated its new neural network b-tagging algorithm in this analysis and uses four out of the five WH tagging categories (TT, TL, Tx, and LL). CDF now also separates events with two or three jets into independent analysis channels. To increase signal acceptance D0 loosens the selection criteria for one of the leptons to include an isolated track not reconstructed in the muon detector ($\mu\mu_{trk}$) or an electron from the inter-cryostat region of the D0 detector (ee_{ICR}). Combined with the dielectron (ee) and dimuon ($\mu\mu$) analyses, these provide four orthogonal analyses, and each uses 9.7 fb^{-1} of data in this combination. CDF uses neural networks to select loose dielectron and dimuon candidates. D0 applies a kinematic fit to optimize reconstruction, while CDF corrects jet energies for $\not\!\!E_T$ using a neural network approach. D0 uses random forests of decision trees to provide the final variables for setting limits. CDF utilizes a multi-layer discriminant based on neural networks where separate discriminant functions are used to define four separate regions of the final discriminant function.

For the $H \rightarrow W^+W^-$ analyses, signal events are characterized by large $\not\!\!E_T$ and two opposite-signed, isolated leptons. The presence of neutrinos in the final state prevents the accurate reconstruction of the candidate Higgs boson mass. D0 selects events containing electrons and/or muons, dividing the data sample into three final states: e^+e^-, $e^\pm\mu^\mp$, and $\mu^+\mu^-$. Each final state is further subdivided according to the number of jets in the event: 0, 1, or 2 or more ("2+") jets. The dimuon and dielectron channels use boosted decision trees to reduce the dominant Drell-Yan background. Decays involving tau leptons are included in two orthogonal ways. A dedicated analysis ($\mu\tau_{\rm had}$) using 7.3 fb^{-1} of data studying the final state involving a muon and a hadronic tau decay plus up to one jet is included in the Tevatron combination. Final states involving other tau decays and mis-identified hadronic tau decays are included in the e^+e^-, $e^\pm\mu^\mp$, and $\mu^+\mu^-$ final state analyses. CDF separates the $H \rightarrow W^+W^-$ events in five non-overlapping samples, split into "high s/b" and "low s/b" categories defined by lepton types and the number of reconstructed 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 due to the smaller statistics in this channel. A sixth CDF channel is the low dilepton mass ($m_{\ell^+\ell^-}$) channel, which accepts events with $m_{\ell^+\ell^-} < 16$ GeV/c^2. CDF has further improved its analysis of the low dilepton mass channel by reducing the ΔR cut applied to dilepton pairs down to 0.1, which increases Higgs signal acceptance in this channel $\sim$10%.

The division of events into categories based on the number of reconstructed jets allows the analysis discriminants to separate differing contributions of signal and background processes more effectively. The signal production mechanisms considered are $gg \to H \to W^+W^-$, $WH/ZH \to jjW^+W^-$, and vector-boson fusion. The relative fractions of the contributions from each of the three signal processes and background processes, notably W^+W^- production and $t\bar{t}$ production, are very different in the different jet categories. Dividing our data into these categories provides more statistical discrimination, but introduces the need to evaluate the systematic uncertainties carefully in each jet category. A discussion of these uncertainties is found in Section III.

The D0 e^+e^-, $e^\pm\mu^\mp$, and $\mu^+\mu^-$ final state channels use boosted decision trees as the final discriminants; for categories with non-zero jet multiplicity b-tagging information is included. The $\mu\tau_{\rm had}$ channel uses neural networks as the final discriminant. CDF uses neural-network outputs, including likelihoods constructed from calculated matrix-element probabilities as additional inputs for the 0-jet bin.

D0 includes a $VH \to \ell^\pm\ell'^\pm + X$ analysis in which the associated vector boson and the W boson from the Higgs boson decay are required to decay leptonically, giving like-sign dilepton final states. Previously the three final $e^\pm e^\pm$, $e^\pm\mu^\pm$, and $\mu^\pm\mu^\pm$ were considered. In this combination, only the most sensitive $e^\pm\mu^\pm$ final state is included. The combined output of two decision trees, trained against the instrumental and diboson backgrounds respectively, is used as the final discriminant. For the first time however, D0 includes tri-lepton analyses to increase the sensitivity to associated production and other decay modes, such as $H \to ZZ$. The $ee\mu$, $\mu\mu e$ and $\tau\tau\mu$ final states are considered. The $ee\mu$ and $\mu\mu e$ final states use boosted decision trees as the final discriminants. The $\tau\tau\mu$ final states are sub-divided according to the jet multiplicity to improve the sensitivity and a kinematic variable based on the event P_T used as the discriminating variable.

CDF also includes a separate analysis of events with same-sign leptons to incorporate additional potential signal from associated production events in which the two leptons (one from the associated vector boson and one from a W boson produced in the Higgs boson decay) have the same charge. CDF additionally incorporates three tri-lepton channels to include additional associated production contributions in which leptons result from the associated W boson and the two W bosons produced in the Higgs boson decay or where an associated Z boson decays into a dilepton pair and a third lepton is produced in the decay of either of the W bosons resulting from the Higgs boson decay. In the latter case, CDF separates the sample into one jet and two or more jet sub-channels to take advantage of the fact that the Higgs boson candidate mass can be reconstructed from the invariant mass of the two jets, the lepton, and the missing transverse energy. CDF also includes for the first time a new tri-lepton channel focusing on WH production in which one of the three leptons is reconstructed as a hadronic tau.

CDF includes a search for $H \to ZZ$ using four lepton events. In addition to the simple four-lepton invariant mass discriminant used previously for separating potential Higgs boson signal events from the non-resonant ZZ background, the $\not\!\!E_T$ in these events is now used as a second discriminating variable to better identify four lepton signal contributions from $ZH \to ZWW$ and $ZH \to Z\tau\tau$ production. CDF has also updated its opposite-sign channels in which one of the two lepton candidates is a hadronic tau. Events are separated into e-τ and μ-τ channels. The final discriminants are obtained from boosted decision trees which incorporate both hadronic tau identification and kinematic event variables as inputs.

D0 also includes channels in which one of the W bosons in the $H \to W^+W^-$ process decays leptonically and the other decays hadronically. Electron and muon final states are studied separately. Random forests are used for the final discriminants.

CDF includes an updated, generic analysis searching for Higgs bosons decaying to tau lepton pairs incorporating contributions from direct $gg \to H$ production, associated WH or ZH production, and vector boson fusion production. CDF also includes an analysis of events that contain one or more reconstructed leptons ($\ell = e$ or μ) in addition to a tau lepton pair focusing on associated production where $H \to \tau\tau$ and additional leptons are produced in the decay of the W or Z boson. For these searches multiple Support Vector Machine (SVM) [41] classifiers are obtained using separate trainings for the signal against each of the primary backgrounds. In the generic search, events with either one or two jets are separated into two independent analysis channels. The final discriminant for setting limits is obtained using the minimum score of four SVM classifiers obtained from trainings against the primary backgrounds ($Z \to \tau\tau$, $t\bar{t}$, multi-jet, and W+jet production). In the extended analysis events are separated into five separate analysis channels ($\ell\ell\ell$, $e\mu\tau_{\rm had}$, $\ell\ell\tau_{\rm had}$, $\ell\tau_{\rm had}\tau_{\rm had}$, and $\ell\ell\ell\ell$). The four lepton category includes $\tau_{\rm had}$ candidates. The final discriminants are likelihoods based on outputs obtained from independent SVM trainings against each of the primary backgrounds (Z+jets, $t\bar{t}$, and dibosons). These channels are included in the combination only for lower Higgs masses to avoid overlap with other search channels.

The D0 $\ell^{\pm}\tau^{\mp}_{\rm had}jj$ analyses likewise include direct $gg \rightarrow H$ production, associated WH or ZH production, and vector boson fusion production. Decays of the Higgs boson to tau, W and Z boson pairs are considered. A final state consisting of one leptonic tau decay, one hadronic tau decay and two jets is required. Both muonic and electronic sub-channels are considered. Recent improvements include increased trigger efficiencies. The output of boosted decision trees is used as the final discriminant.

CDF incorporates an updated all-hadronic analysis based on the older CDF b-tagging algorithms, which results in two sub-channels (SS and SJ). Both WH/ZH and VBF production contribute to the $jjb\bar{b}$ final state. Events with either four or five reconstructed jets are selected, and at least two must be b-tagged. The large QCD multijet backgrounds are modeled from the data by applying a measured mistag probability to the non b-tagged jets in events containing a single b-tag. Neural network discriminants based on kinematic event variables including those designed to separate quark and gluon jets are used to obtain the final limits.

D0 and CDF both contribute analyses searching for Higgs bosons decaying into diphoton pairs. The CDF analysis looks for a signal peak in the diphoton invariant mass spectrum above the smooth background originating from QCD production. Events are separated into four independent analysis channels based on the photon candidates contained within the event: two central candidates (CC), one central and one plug candidate (CP), one central and one central conversion candidate (C$'$C), or one plug and one central conversion candidate (C$'$P). In the D0 analysis the contribution of jets misidentified as photons is reduced by combining information sensitive to differences in the energy deposition from these particles in the tracker, calorimeter and central preshower in a neural network (ONN). The output of boosted decision trees, rather than the diphoton invariant mass, is used as the final discriminating variable. Previously, the transverse energies of the leading two photons along with the azimuthal opening angle between them and the diphoton invariant mass and transverse momentum were used as input variables. Additional variables, including the ONN output value for the two photons have been included, resulting in a sizeable improvement in sensitivity of $\approx 20\%$.

CDF incorporates three non-overlapping sets of analysis channels searching for the process $t\bar{t}H \rightarrow t\bar{t}b\bar{b}$. One set of channels selects events with a reconstructed lepton, large missing transverse energy, and four or more reconstructed jets. Events containing four, five, and six or more jets are are analyzed separately and further sub-divided into five b-tagging categories based on the older CDF tagging algorithms (three tight b-tags (SSS), two tight and one loose b-tags (SSJ), one tight and two loose b-tags (SJJ), two tight b-tags (SS), and one tight and one loose b-tags (SJ)). Neural network discriminants trained at each mass point are used to set limits. A second set of channels selects events with no reconstructed lepton. These events are separated into two categories, one containing events with large missing transverse energy and five to nine reconstructed jets and another containing events with low missing transverse energy and seven to ten reconstructed jets. Events in these two channels are required to have a minimum of two b-tagged jets based on an independent neural network tagging algorithm. Events with three or more b-tags are analyzed in separate channels from those with exactly two tags. Two stages of neural network discriminants are used (the first to help reject large multijet backgrounds and the second to separate potential $t\bar{t}H$ signal events from $t\bar{t}$ background events).

For both CDF and D0, events from QCD multijet (instrumental) backgrounds are typically measured in independent data samples using several different methods. For CDF, backgrounds from SM processes with electroweak gauge bosons or top quarks were generated using PYTHIA [42], ALPGEN [43], MC@NLO [44], and HERWIG [45] programs. For D0, these backgrounds were generated using PYTHIA, ALPGEN, and COMPHEP [46], with PYTHIA providing parton-showering and hadronization for all the generators. These background processes were normalized using either experimental data or next-to-leading order calculations (including MCFM [47] for the $W+$ heavy flavor process). All Monte Carlo samples are passed through detailed GEANT-based simulations [48] of the CDF and D0 detectors.

Tables I and II summarize, for CDF and D0 respectively, the integrated luminosities, the Higgs boson mass ranges over which the searches are performed, and references to further details for each analysis.

TABLE I: Luminosity, explored mass range and references for the different processes and final states ($\ell = e$ or μ) for the CDF analyses. The generic labels "2×", "3×", and "4×" refer to separations based on lepton categories.

Channel	Luminosity (fb^{-1})	m_H range (GeV/c^2)	Reference
$WH \rightarrow \ell\nu bb$ 2-jet channels 4×(TT,TL,Tx,LL,Lx)	9.45	100-150	[17]
$WH \rightarrow \ell\nu b\bar{b}$ 3-jet channels 3×(TT,TL)	9.45	100-150	[17]
$ZH \rightarrow \nu\bar{\nu}b\bar{b}$ (SS,SJ,1S)	9.45	100-150	[18]
$ZH \rightarrow \ell^+\ell^-b\bar{b}$ 2-jet channels 2×(TT,TL,Tx,LL)	9.45	100-150	[19]
$ZH \rightarrow \ell^+\ell^-b\bar{b}$ 3-jet channels 2×(TT,TL,Tx,LL)	9.45	100-150	[19]
$H \rightarrow W^+W^-$ 2×(0 jets,1 jet)+(2 or more jets)+(low-$m_{\ell\ell}$)	9.7	110-200	[20]
$H \rightarrow W^+W^-$ (e-τ_{had})+(μ-τ_{had})	9.7	130-200	[21]
$WH \rightarrow WW^+W^-$ (same-sign leptons)+(tri-leptons)	9.7	110-200	[20]
$WH \rightarrow WW^+W^-$ tri-leptons with 1 τ_{had}	9.7	130-200	[21]
$ZH \rightarrow ZW^+W^-$ (tri-leptons with 1 jet)+(tri-leptons with 2 or more jets)	9.7	110-200	[20]
$H \rightarrow ZZ$ four leptons	9.7	120-200	[22]
$H + X \rightarrow \tau^+\tau^-$ (1 jet)+(2 jets)	8.3	100-150	[23]
$WH \rightarrow \ell\nu\tau^+\tau^-/ZH \rightarrow \ell^+\ell^-\tau^+\tau^-$ ℓ-τ_{had}-τ_{had}	6.2	100-150	[24]
$WH \rightarrow \ell\nu\tau^+\tau^-/ZH \rightarrow \ell^+\ell^-\tau^+\tau^-$ (ℓ-ℓ-τ_{had})+(e-μ-τ_{had})	6.2	100-125	[24]
$WH \rightarrow \ell\nu\tau^+\tau^-/ZH \rightarrow \ell^+\ell^-\tau^+\tau^-$ ℓ-ℓ-ℓ	6.2	100-105	[24]
$ZH \rightarrow \ell^+\ell^-\tau^+\tau^-$ four leptons including τ_{had} candidates	6.2	100-115	[24]
$WH + ZH \rightarrow jjb\bar{b}$ (SS,SJ)	9.45	100-150	[25]
$H \rightarrow \gamma\gamma$ (CC,CP,CC-Conv,PC-Conv)	10.0	100-150	[26]
$t\bar{t}H \rightarrow WWb\bar{b}b\bar{b}$ (lepton) (4jet,5jet,≥6jet)×(SSS,SSJ,SJJ,SS,SJ)	9.45	100-150	[27]
$t\bar{t}H \rightarrow WWb\bar{b}b\bar{b}$ (no lepton) (low met,high met)×(2 tags,3 or more tags)	5.7	100-150	[28]

TABLE II: Luminosity, explored mass range and references for the different processes and final states ($\ell = e, \mu$) for the D0 analyses.

Channel	Luminosity (fb^{-1})	m_H range (GeV/c^2)	Reference
$WH \rightarrow \ell\nu bb$ (TST,LDT,TDT)×(2,3 jet)	9.7	100-150	[29]
$ZH \rightarrow \nu\bar{\nu}b\bar{b}$ (MS,TS)	9.5	100-150	[30]
$ZH \rightarrow \ell^+\ell^-b\bar{b}$ (TST,TLDT)×(ee,$\mu\mu$,ee_{ICR},$\mu\mu_{trk}$)	9.7	100-150	[31]
H+X→$\ell^{\pm}\tau^{\mp}_{\mathrm{had}}jj$	4.3-6.2	105-200	[32]
$VH \rightarrow e^{\pm}\mu^{\pm} + X$	9.7	115-200	[33]
$H \rightarrow W^+W^- \rightarrow \ell^{\pm}\nu\ell^{\mp}\nu$ (0,1,2+ jet)	8.6-9.7	115-200	[34]
$H \rightarrow W^+W^- \rightarrow \mu\nu\tau_{\mathrm{had}}\nu$	7.3	115-200	[32]
$H \rightarrow W^+W^- \rightarrow \ell\bar{\nu}jj$	5.4	130-200	[35]
$VH \rightarrow \ell\ell\ell + X$	9.7	100-200	[36]
$VH \rightarrow \tau\tau\mu + X$	7.0	115-200	[37]
$H \rightarrow \gamma\gamma$	9.7	100-150	[38]

III. SIGNAL PREDICTIONS

In order to predict the kinematic distributions of Higgs boson signal events, CDF and D0 use the PYTHIA [42] Monte Carlo program, with CTEQ5L and CTEQ6L1 [49] leading-order (LO) parton distribution functions. We scale these Monte Carlo predictions to the most recent higher-order calculations of inclusive cross sections, and differential cross sections, such as in the Higgs boson p_T spectrum and the number of associated jets, as described below. The $gg \rightarrow H$ production cross section we use is calculated at next-to-next-to leading order (NNLO) in QCD with a next-to-next-to leading log (NNLL) resummation of soft gluons; the calculation also includes two-loop electroweak effects and handling of the running b quark mass [50, 51]. The numerical values in Table III are updates [52] of these predictions with m_t set to 173.1 GeV/c^2 [53], and with a treatment of the massive top and bottom loop corrections up to next-to-leading-order (NLO) + next-to-leading-log (NLL) accuracy. The factorization and renormalization scale choice for this calculation is $\mu_F = \mu_R = m_H$. These calculations are refinements of the earlier NNLO calculations of the $gg \rightarrow H$ production cross section [54–56]. Electroweak corrections were computed in Refs. [57, 58]. Soft gluon resummation was introduced in the prediction of the $gg \rightarrow H$ production cross section in Ref. [59]. The $gg \rightarrow H$ production cross section depends strongly on the gluon parton density function, and the accompanying value of $\alpha_s(q^2)$. The cross sections used here are calculated with the MSTW 2008 NNLO PDF set [60], as recommended by the PDF4LHC working group [61]. The inclusive Higgs boson production cross sections are listed in Table III.

For analyses that consider inclusive $gg \rightarrow H$ production but do not split it into separate channels based on the number of reconstructed jets, we use the inclusive uncertainties from the simultaneous variation of the factorization and renormalization scale up and down by a factor of two. We use the prescription of the PDF4LHC working group for evaluating PDF uncertainties on the inclusive production cross section. QCD scale uncertainties that affect the cross section via their impacts on the PDFs are included as a correlated part of the total scale uncertainty. The remainder of the PDF uncertainty is treated as uncorrelated with the QCD scale uncertainty.

For analyses seeking $gg \rightarrow H$ production that divide events into categories based on the number of reconstructed jets, we employ a new approach for evaluating the impacts of the scale uncertainties. Following the recommendations of Ref. [62, 63], we treat the QCD scale uncertainties obtained from the NNLL inclusive [50, 51], NLO one or more jets [64], and NLO two or more jets [65] cross section calculations as uncorrelated with one another. We then obtain QCD scale uncertainties for the exclusive $gg \rightarrow H + 0$ jet, 1 jet, and 2 or more jet categories by propagating the uncertainties on the inclusive cross section predictions through the subtractions needed to predict the exclusive rates. For example, the $H+0$ jet cross section is obtained by subtracting the NLO $H + 1$ or more jet cross section from the inclusive NNLL+NNLO cross section. We now assign three separate, uncorrelated scale uncertainties which lead to correlated and anticorrelated uncertainty contributions between exclusive jet categories. The procedure in Ref. [64] is used to determine PDF model uncertainties. These are obtained separately for each jet bin and treated as 100% correlated between jet bins and between D0 and CDF.

The scale choice affects the p_T spectrum of the Higgs boson when produced in gluon-gluon fusion, and this effect changes the acceptance of the selection requirements and also the shapes of the distributions of the final discriminants. The effect of the acceptance change is included in the calculations of Ref. [64] and Ref. [65], as the experimental requirements are simulated in these calculations. The effects on the final discriminant shapes are obtained by reweighting the p_T spectrum of the Higgs boson production in the Monte Carlo simulations to higher-order calculations. The Monte Carlo signal simulation used by CDF and D0 is provided by the LO generator PYTHIA [42] which includes a parton shower and fragmentation and hadronization models. We reweight the Higgs boson p_T spectra in our PYTHIA Monte Carlo samples to that predicted by HQT [66] when making predictions of differential distributions of $gg \rightarrow H$ signal events. To evaluate the impact of the scale uncertainty on our differential spectra, we use the RESBOS [67] generator, and apply the scale-dependent differences in the Higgs boson p_T spectrum to the HQT prediction, and propagate these to our final discriminants as a systematic uncertainty on the shape, which is included in the calculation of the limits.

We include all significant Higgs boson production modes in the high-mass search. Besides gluon-gluon fusion through virtual quark loops (ggH), we include Higgs boson production in association with a W or Z vector boson (VH), and vector boson fusion (VBF). For the low-mass searches, we target the WH, ZH, VBF, and $t\bar{t}H$ production modes with specific searches, including also those signal components not specifically targeted but which fall in the acceptance nonetheless. Our WH and ZH cross sections are from Ref. [68]. This calculation starts with the NLO calculation of V2HV [69] and includes NNLO QCD contributions [70], as well as one-loop electroweak corrections [71]. A similar calculation of the WH cross section is available in Ref. [72]. We use the VBF cross section computed at NNLO in QCD in Ref. [73]. Electroweak corrections to the VBF production cross section are computed with the HAWK program [74], and are small and negative (2-3%) in the Higgs boson mass range considered here. We include these corrections in the VBF cross sections used for this result. The $t\bar{t}H$ production cross sections we use are from Ref. [75].

The Higgs boson decay branching ratio predictions used for this result are those of Ref. [63, 76]. In this calculation, the partial decay widths for all Higgs boson decays except to pairs of W and Z bosons are computed with HDECAY [77], and the W and Z pair decay widths are computed with PROPHECY4F [78]. The relevant decay branching ratios are listed in Table III. The uncertainties on the predicted branching ratios from uncertainties in m_b, m_c, α_s, and missing higher-order effects are presented in Ref. [79, 80].

IV. DISTRIBUTIONS OF CANDIDATES

All analyses provide binned histograms of the final discriminant variables for the signal and background predictions, itemized separately for each source, and the observed data. The number of channels combined is large, and the number of bins in each channel is large. Therefore, the task of assembling histograms and visually checking whether the expected and observed limits are consistent with the input predictions and observed data is difficult. We therefore provide histograms that aggregate all channels' signal, background, and data together. In order to preserve most of the sensitivity gain that is achieved by the analyses by binning the data instead of collecting them all together and counting, we aggregate the data and predictions in narrow bins of signal-to-background ratio, s/b. Data with similar s/b may be added together with no loss in sensitivity, assuming similar systematic uncertainties on the predictions. The aggregate histograms do not show the effects of systematic uncertainties, but instead compare the data with the central predictions supplied by each analysis.

The range of s/b is quite large in each analysis, and so $\log_{10}(s/b)$ is chosen as the plotting variable. Plots of the distributions of $\log_{10}(s/b)$ are shown for Higgs boson masses of 115, 125, and 165 GeV/c^2 in Figure 1, demonstrating agreement with background over five orders of magnitude. These distributions can be integrated from the high-s/b side downwards, showing the sums of signal, background, and data for the most pure portions of the selection of all channels added together. The integrals of the ≈ 100 highest s/b events are shown in Figure 2, plotted as functions of the number of signal events expected. The most significant candidates are found in the bins with the highest s/b; an excess in these bins relative to the background prediction drives the Higgs boson cross section limit upwards, while a deficit drives it downwards. The lower-s/b bins show that the modeling of the rates and kinematic distributions of the backgrounds is very good. The integrated plots show an excess consistent with signal for the analyses seeking a Higgs boson mass of 125 GeV/c^2, and a deficit of events in the highest-s/b bins for the analyses seeking a Higgs boson of mass 165 GeV/c^2.

We also show the distributions of the data after subtracting the expected background, and compare that with the expected signal yield for a Standard Model Higgs boson, after collecting all bins in all channels sorted by s/b. These background-subtracted distributions are shown in Figure 3 for Higgs boson masses of 115, 125, and 165 GeV/c^2. These graphs also show the remaining uncertainty on the background prediction after fitting the background model to the data within the systematic uncertainties on the rates and shapes in each contributing channel.

V. COMBINING CHANNELS

To gain confidence that the final result does not depend on the details of the statistical formulation, we perform two types of combinations, using Bayesian and Modified Frequentist approaches, which yield limits on the Higgs boson production rate that agree within 10% at each value of m_H, and within 1% on average. Both methods rely on distributions in the final discriminants, and not just on their single integrated values. Systematic uncertainties enter on the predicted number of signal and background events as well as on the distribution of the discriminants in each analysis ("shape uncertainties"). Both methods use likelihood calculations based on Poisson probabilities.

A. Bayesian Method

Because there is no experimental information on the production cross section for the Higgs boson, in the Bayesian technique [1] we assign a flat prior for the total number of selected Higgs boson events. For a given Higgs boson mass, the combined likelihood is a product of likelihoods for the individual channels, each of which is a product over histogram bins:

TABLE III: The production cross sections and decay branching fractions for the SM Higgs boson assumed for the combination.

m_H (GeV/c^2)	$\sigma_{gg\to H}$ (fb)	σ_{WH} (fb)	σ_{ZH} (fb)	σ_{VBF} (fb)	$\sigma_{t\bar{t}H}$ (fb)	$B(H\to b\bar{b})$ (%)	$B(H\to c\bar{c})$ (%)	$B(H\to \tau^+\tau^-)$ (%)	$B(H\to W^+W^-)$ (%)	$B(H\to ZZ)$ (%)	$B(H\to \gamma\gamma)$ (%)
100	1821.8	281.1	162.7	97.3	8.0	79.1	3.68	8.36	1.11	0.113	0.159
105	1584.7	238.7	139.5	89.8	7.1	77.3	3.59	8.25	2.43	0.215	0.178
110	1385.0	203.7	120.2	82.8	6.2	74.5	3.46	8.03	4.82	0.439	0.197
115	1215.9	174.5	103.9	76.5	5.5	70.5	3.27	7.65	8.67	0.873	0.213
120	1072.3	150.1	90.2	70.7	4.9	64.9	3.01	7.11	14.3	1.60	0.225
125	949.3	129.5	78.5	65.3	4.3	57.8	2.68	6.37	21.6	2.67	0.230
130	842.9	112.0	68.5	60.5	3.8	49.4	2.29	5.49	30.5	4.02	0.226
135	750.8	97.2	60.0	56.0	3.3	40.4	1.87	4.52	40.3	5.51	0.214
140	670.6	84.6	52.7	51.9	2.9	31.4	1.46	3.54	50.4	6.92	0.194
145	600.6	73.7	46.3	48.0	2.6	23.1	1.07	2.62	60.3	7.96	0.168
150	539.1	64.4	40.8	44.5	2.3	15.7	0.725	1.79	69.9	8.28	0.137
155	484.0	56.2	35.9	41.3	2.0	9.18	0.425	1.06	79.6	7.36	0.100
160	432.3	48.5	31.4	38.2	1.8	3.44	0.159	0.397	90.9	4.16	0.0533
165	383.7	43.6	28.4	36.0	1.6	1.19	0.0549	0.138	96.0	2.22	0.0230
170	344.0	38.5	25.3	33.4	1.4	0.787	0.0364	0.0920	96.5	2.36	0.0158
175	309.7	34.0	22.5	31.0	1.3	0.612	0.0283	0.0719	95.8	3.23	0.0123
180	279.2	30.1	20.0	28.7	1.1	0.497	0.0230	0.0587	93.2	6.02	0.0102
185	252.1	26.9	17.9	26.9	1.0	0.385	0.0178	0.0457	84.4	15.0	0.00809
190	228.0	24.0	16.1	25.1	0.9	0.315	0.0146	0.0376	78.6	20.9	0.00674
195	207.2	21.4	14.4	23.3	0.8	0.270	0.0125	0.0324	75.7	23.9	0.00589
200	189.1	19.1	13.0	21.7	0.7	0.238	0.0110	0.0287	74.1	25.6	0.00526

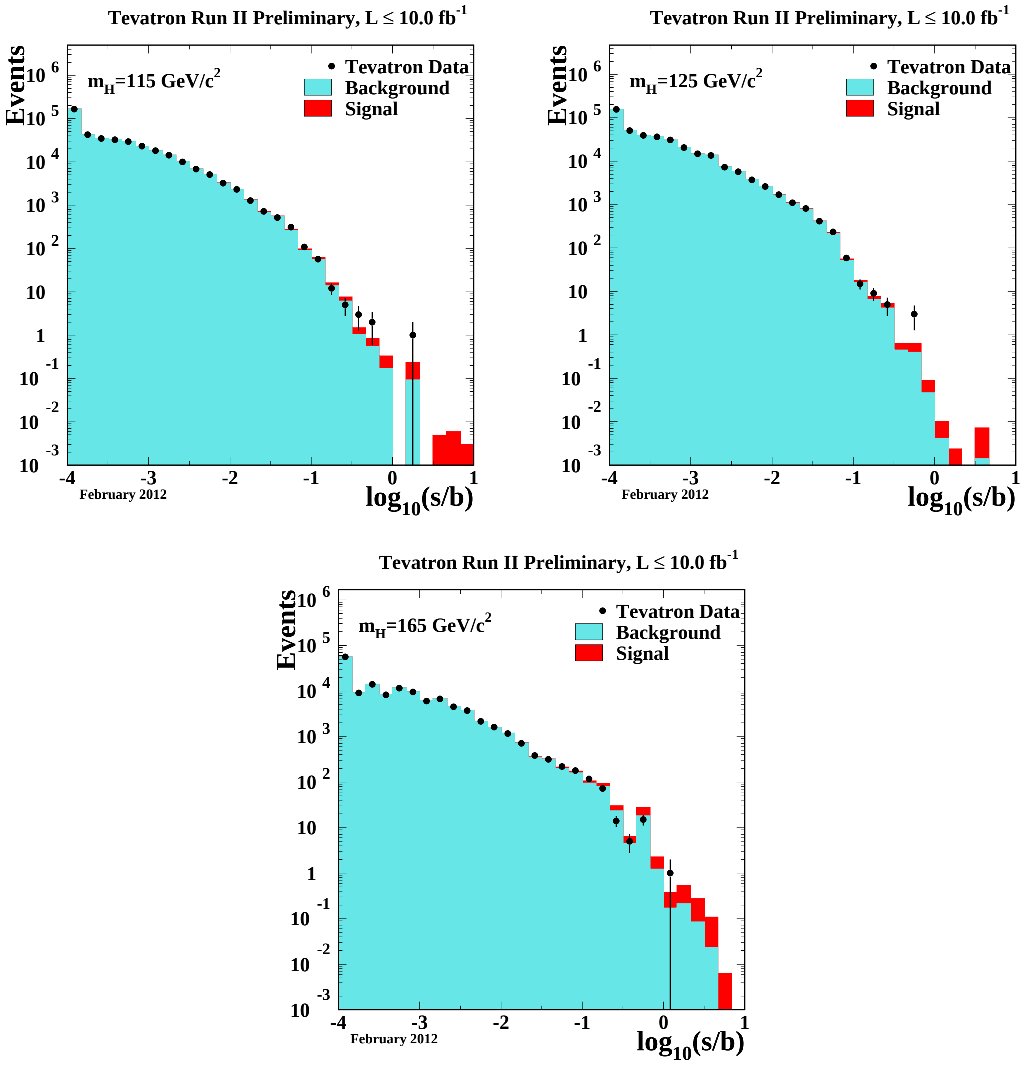

FIG. 1: Distributions of $\log_{10}(s/b)$, for the data from all contributing channels from CDF and D0, for Higgs boson masses of 115, 125, and 165 GeV/c^2. The data are shown with points, and the expected signal is shown stacked on top of the backgrounds. Underflows and overflows are collected into the leftmost and rightmost bins.

$$\mathcal{L}(R,\vec{s},\vec{b}|\vec{n},\vec{\theta})\times\pi(\vec{\theta})=\prod_{i=1}^{N_C}\prod_{j=1}^{N_b}\mu_{ij}^{n_{ij}}e^{-\mu_{ij}}/n_{ij}!\times\prod_{k=1}^{n_{np}}e^{-\theta_k^2/2} \tag{1}$$

where the first product is over the number of channels (N_C), and the second product is over N_b histogram bins containing n_{ij} events, binned in ranges of the final discriminants used for individual analyses, such as the dijet mass, neural-network outputs, or matrix-element likelihoods. The parameters that contribute to the expected bin contents are $\mu_{ij} = R \times s_{ij}(\vec{\theta}) + b_{ij}(\vec{\theta})$ for the channel i and the histogram bin j, where s_{ij} and b_{ij} represent the expected background and signal in the bin, and R is a scaling factor applied to the signal to test the sensitivity level of the experiment. Truncated Gaussian priors are used for each of the nuisance parameters θ_k, which define the sensitivity of

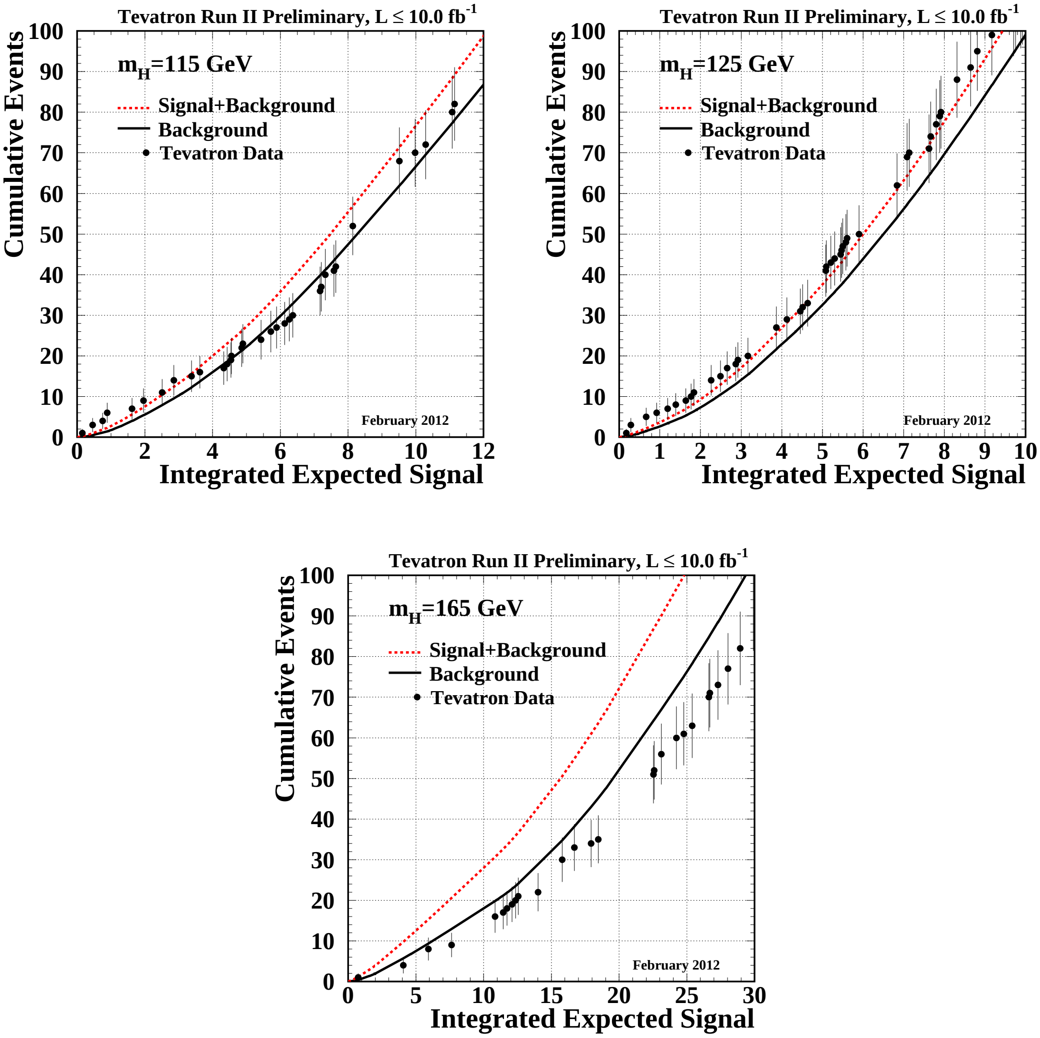

FIG. 2: Integrated distributions of s/b, starting at the high s/b side, for Higgs boson masses of 115, 125, and 165 GeV$/c^2$. The total signal+background and background-only integrals are shown separately, along with the data sums. Data are only shown for bins that have data events in them.

the predicted signal and background estimates to systematic uncertainties. These can take the form of uncertainties on overall rates, as well as the shapes of the distributions used for combination. These systematic uncertainties can be far larger than the expected SM Higgs boson signal, and are therefore important in the calculation of limits. The truncation is applied so that no prediction of any signal or background in any bin is negative. The posterior density function is then integrated over all parameters (including correlations) except for R, and a 95% credibility level upper limit on R is estimated by calculating the value of R that corresponds to 95% of the area of the resulting distribution. This posterior density function may also be used to estimate the best-fit value of R by finding that value which maximizes the posterior density. The fitted uncertainties are given by the shortest interval containing 68% of the integrated posterior density. These values are compared with those obtained from a profile likelihood fit to R, maximizing over the values of the nuisance parameters, and give good agreement.

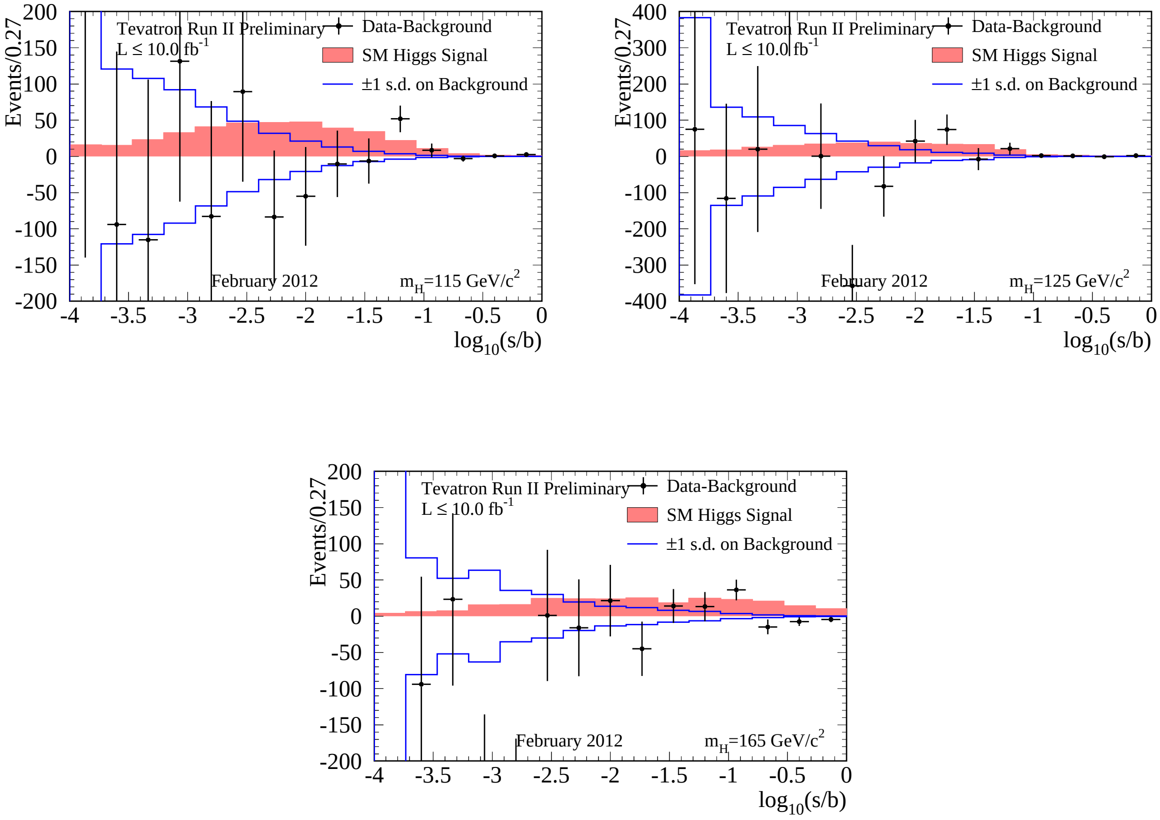

FIG. 3: Background-subtracted data distributions for all channels, summed in bins of s/b, for Higgs boson masses of 115, 125, and 165 GeV/c^2. The background has been fit, within its systematic uncertainties and assuming no Higgs boson signal is present, to the data. The points with error bars indicate the background-subtracted data; the sizes of the error bars are the square roots of the predicted background in each bin. The unshaded (blue-outline) histogram shows the systematic uncertainty on the best-fit background model, and the shaded histogram shows the expected signal for a Standard Model Higgs boson.

B. Modified Frequentist Method

The Modified Frequentist technique relies on the CL$_s$ method, using a log-likelihood ratio (LLR) as test statistic [2]:

$$LLR = -2\ln\frac{p(\mathrm{data}|H_1)}{p(\mathrm{data}|H_0)}, \tag{2}$$

where H_1 denotes the test hypothesis, which admits the presence of SM backgrounds and a Higgs boson signal, while H_0 is the null hypothesis, for only SM backgrounds and 'data' is either an ensemble of pseudo-experiment data constructed from the expected signal and backgrounds, or the actual observed data. The probabilities p are computed using the best-fit values of the nuisance parameters for each pseudo-experiment, separately for each of the two hypotheses, and include the Poisson probabilities of observing the data multiplied by Gaussian priors for the values of the nuisance parameters. This technique extends the LEP procedure [81] which does not involve a fit, in order to yield better sensitivity when expected signals are small and systematic uncertainties on backgrounds are large [82].

The $\mathrm{CL_s}$ technique involves computing two p-values, $\mathrm{CL_{s+b}}$ and $\mathrm{CL_b}$. The latter is defined by

$$1 - \mathrm{CL_b} = p(LLR \leq LLR_{\mathrm{obs}}|H_0), \tag{3}$$

where LLR_{obs} is the value of the test statistic computed for the data. $1 - \mathrm{CL_b}$ is the probability of observing a signal-plus-background-like outcome without the presence of signal, i.e. the probability that an upward fluctuation of the background provides a signal-plus-background-like response as observed in data. The other p-value is defined by

$$\mathrm{CL_{s+b}} = p(LLR \geq LLR_{\mathrm{obs}}|H_1), \tag{4}$$

and this corresponds to the probability of a downward fluctuation of the sum of signal and background in the data. A small value of $\mathrm{CL_{s+b}}$ reflects inconsistency with H_1. It is also possible to have a downward fluctuation in data even in the absence of any signal, and a small value of $\mathrm{CL_{s+b}}$ is possible even if the expected signal is so small that it cannot be tested with the experiment. To minimize the possibility of excluding a signal to which there is insufficient sensitivity (an outcome expected 5% of the time at the 95% C.L., for full coverage), we use the quantity $\mathrm{CL_s} = \mathrm{CL_{s+b}}/\mathrm{CL_b}$. If $\mathrm{CL_s} < 0.05$ for a particular choice of H_1, that hypothesis is deemed to be excluded at the 95% C.L. In an analogous way, the expected $\mathrm{CL_b}$, $\mathrm{CL_{s+b}}$ and $\mathrm{CL_s}$ values are computed from the median of the LLR distribution for the background-only hypothesis.

Systematic uncertainties are included by fluctuating the predictions for signal and background rates in each bin of each histogram in a correlated way when generating the pseudo-experiments used to compute $\mathrm{CL_{s+b}}$ and $\mathrm{CL_b}$.

An alternate computation of the p-value $1 - \mathrm{CL_b}$ is to use the fitted value of R as a test statistic instead of LLR. This method is nearly as optimal as using LLR in our searches, and has been applied in the single top quark observation [83]. The background-only p-value is the probability of obtaining the fitted cross section observed in the data or more, assuming that a signal is absent. We use this method to quote our p-values and significances.

C. Systematic Uncertainties

Systematic uncertainties differ between experiments and analyses, and they affect the rates and shapes of the predicted signal and background in correlated ways. The combined results incorporate the sensitivity of predictions to values of nuisance parameters, and include correlations between rates and shapes, between signals and backgrounds, and between channels within experiments and between experiments. More on these issues can be found in the individual analysis notes [17] through [38]. Here we discuss only the largest contributions and correlations between and within the two experiments.

1. *Correlated Systematics between CDF and D0*

The uncertainties on the measurements of the integrated luminosities are 6% (CDF) and 6.1% (D0). Of these values, 4% arises from the uncertainty on the inelastic $p\bar{p}$ scattering cross section, which is correlated between CDF and D0. CDF and D0 also share the assumed values and uncertainties on the production cross sections for top-quark processes ($t\bar{t}$ and single top) and for electroweak processes (WW, WZ, and ZZ). In order to provide a consistent combination, the values of these cross sections assumed in each analysis are brought into agreement. We use $\sigma_{t\bar{t}} = 7.04^{+0.24}_{-0.36}$ (scale) $\pm\, 0.14$(PDF) $\pm\, 0.30$(mass), following the calculation of Moch and Uwer [84], assuming a top quark mass $m_t = 173.1 \pm 1.2$ GeV/c^2 [53], and using the MSTW2008nnlo PDF set [60]. Other calculations of $\sigma_{t\bar{t}}$ are similar [85].

For single top, we use the next-to-next-to-next-to-leading-order (NNNLO) at next-to-leading logarithmic (NLL) t-channel calculation of Kidonakis [86], which has been updated using the MSTW2008nnlo PDF set [60] [87]. For the s-channel process we use [88], again based on the MSTW2008nnlo PDF set. Both of the cross section values below are the sum of the single t and single $\bar{t}$ cross sections, and both assume $m_t = 173.1 \pm 1.2$ GeV/c^2.

$$\sigma_{t-\mathrm{chan}} = 2.10 \pm 0.027 \text{ (scale)} \pm 0.18 \text{ (PDF)} \pm 0.045 \text{ (mass) pb.} \tag{5}$$

$$\sigma_{s-\mathrm{chan}} = 1.05 \pm 0.01\ (\mathrm{scale}) \pm 0.06\ (\mathrm{PDF}) \pm 0.03\ (\mathrm{mass})\ \mathrm{pb}. \tag{6}$$

Other calculations of $\sigma_{\mathrm{SingleTop}}$ are similar for our purposes [89].

MCFM [47] has been used to compute the NLO cross sections for WW, WZ, and ZZ production [90]. Using a scale choice $\mu_0 = M_V^2 + p_T^2(V)$ and the MSTW2008 PDF set [60], the cross section for inclusive W^+W^- production is

$$\sigma_{W^+W^-} = 11.34\ {}^{+0.56}_{-0.49}\ (\mathrm{scale})\ {}^{+0.35}_{-0.28}\ (\mathrm{PDF})\ \mathrm{pb} \tag{7}$$

and the cross section for inclusive $W^{\pm}Z$ production is

$$\sigma_{W^{\pm}Z} = 3.22\ {}^{+0.20}_{-0.17}\ (\mathrm{scale})\ {}^{+0.11}_{-0.08}\ (\mathrm{PDF})\ \mathrm{pb} \tag{8}$$

The calculation is done using $Z \to \ell^+\ell^-$ and therefore necessarily includes contributions from $\gamma^* \to \ell^+\ell^-$. The cross sections quoted above have the requirement $75 \leq m_{\ell^+\ell^-} \leq 105\ \mathrm{GeV}/c^2$ for the leptons from the neutral current exchange. The same dilepton invariant mass requirement is applied to both sets of leptons in determining the ZZ cross section which is

$$\sigma_{ZZ} = 1.20\ {}^{+0.05}_{-0.04}\ (\mathrm{scale})\ {}^{+0.04}_{-0.03}\ (\mathrm{PDF})\ \mathrm{pb} \tag{9}$$

For the diboson cross section calculations, $|\eta_\ell| < 5$ for all calculations. Loosening this requirement to include all leptons leads to ∼+0.4% change in the predictions. Lowering the factorization and renormalization scales by a factor of two increases the cross section, and raising the scales by a factor of two decreases the cross section. The PDF uncertainty has the same fractional impact on the predicted cross section independent of the scale choice. All PDF uncertainties are computed as the quadrature sum of the twenty 68% C.L. eigenvectors provided with MSTW2008 (MSTW2008nlo68cl).

In many analyses, the dominant background yields are calibrated with data control samples. Since the methods of measuring the multijet ("QCD") backgrounds differ between CDF and D0, and even between analyses within the collaborations, there is no correlation assumed between these rates. Similarly, the large uncertainties on the background rates for W+heavy flavor (HF) and Z+heavy flavor are considered at this time to be uncorrelated. The calibrations of fake leptons, unvetoed $\gamma \to e^+e^-$ conversions, b-tag efficiencies and mistag rates are performed by each collaboration using independent data samples and methods, and are therefore also treated as uncorrelated.

2. *Correlated Systematic Uncertainties for CDF*

The dominant systematic uncertainties for the CDF analyses are shown in the Appendix in Tables IX and VIII for the $WH \to \ell\nu b\bar{b}$ channels, in Table XII for the $WH, ZH \to \not{E}_T b\bar{b}$ channels, in Tables XIV and XV for the $ZH \to \ell^+\ell^- b\bar{b}$ channels, in Tables XVII, XVIII, and XIX for the $H \to W^+W^- \to \ell'^{\pm}\nu\ell'^{\mp}\nu$ channels, in Table XX for the $WH \to WWW \to \ell'^{\pm}\ell'^{\pm}$ and $WH \to WWW \to \ell^{\pm}\ell'^{\pm}\ell''^{\mp}$ channels, in Table XXI for the $ZH \to ZWW \to \ell^{\pm}\ell^{\mp}\ell'^{\pm}$ channels, In Table XXVIII for the $H \to 4\ell$ channel, in Tables XXIX, XXX, and XXXI for the $t\bar{t}H \to W^+bW^-\bar{b}b\bar{b}$ channels, in Table XXXII for the $H \to \tau^+\tau^-$ channels, in Table XXXIII for the $WH \to \ell\nu\tau^+\tau^-$ and $ZH \to \ell^+\ell^-\tau^+\tau^-$ channels, in Table XXXIV for the WH/ZH and VBF $\to jjb\bar{b}$ channels, and in Table XXXV for the $H \to \gamma\gamma$ channel. Each source induces a correlated uncertainty across all CDF channels' signal and background contributions which are sensitive to that source. For $H \to b\bar{b}$, the largest uncertainties on signal arise from measured b-tagging efficiencies, jet energy scale, and other Monte Carlo modeling. Shape dependencies of templates on jet energy scale, b-tagging, and gluon radiation ("ISR" and "FSR") are taken into account for some analyses (see tables). For $H \to W^+W^-$, the largest uncertainties on signal acceptance originate from Monte Carlo modeling. Uncertainties on background event rates vary significantly for the different processes. The backgrounds with the largest systematic uncertainties are in general quite small. Such uncertainties are constrained by fits to the nuisance parameters, and they do not affect the result significantly. Because the largest background contributions are measured using data, these uncertainties are treated as uncorrelated for the $H \to b\bar{b}$ channels. The differences in the resulting limits when treating the remaining uncertainties as either correlated or uncorrelated is less than 5%.

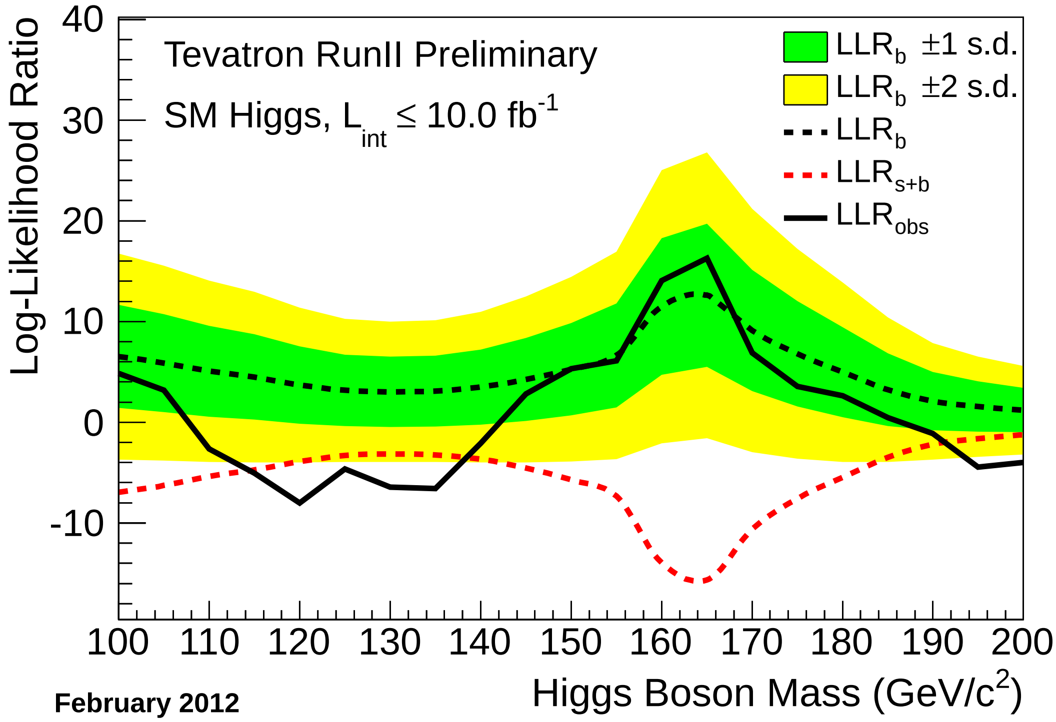

FIG. 4: Distributions of the log-likelihood ratio (LLR) as a function of Higgs boson mass obtained with the CL_s method for the combination of all CDF and D0 analyses. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations around the median expected value assuming only background is present, respectively. The red dashed curve shows the median expected value assuming a Higgs boson signal is present, separately at each m_H.

3. Correlated Systematic Uncertainties for D0

The dominant systematic uncertainties for the D0 analyses are shown in the Appendix, in Tables X, XI, XIII, XVI, XXII, XXIII, XXIV, XXVI, XXV, XXVII, and XXXVI. Each source induces a correlated uncertainty across all D0 channels sensitive to that source. Wherever appropriate the impact of systematic effects on both the rate and shape of the predicted signal and background is included. For the low mass, $H \rightarrow b\bar{b}$ analyses, significant sources of uncertainty include the measured b-tagging rate and the normalization of the W and Z plus heavy flavor backgrounds. For the $H \rightarrow W^+W^-$and $VH \rightarrow leptons + X$ analyses, significant sources of uncertainty are the measured efficiencies for selecting leptons. For analyses involving jets the determination of the jet energy scale, jet resolution and the multijet background contribution are significant sources of uncertainty. Significant sources for all analyses are the uncertainties on the luminosity and the cross sections for the simulated backgrounds. All systematic uncertainties arising from the same source are taken to be correlated among the different backgrounds and between signal and background.

VI. COMBINED RESULTS

Before extracting the combined limits we study the distributions of the log-likelihood ratio (LLR) for different hypotheses to quantify the expected sensitivity across the mass range tested. Figure 4 and Table VI display the LLR distributions for the combined analyses as functions of m_H. Included are the median of the LLR distributions for the background-only hypothesis (LLR$_b$), the signal-plus-background hypothesis (LLR$_{s+b}$), and the observed value for the data (LLR$_{\rm obs}$). The shaded bands represent the one and two s.d. departures for LLR$_b$ centered on the median. The separation between the medians of the LLR$_b$ and LLR$_{s+b}$ distributions provides a measure of the discriminating power of the search. The sizes of the one- and two-s.d. LLR$_b$ bands indicate the width of the LLR$_b$ distribution, assuming no signal is truly present and only statistical fluctuations and systematic effects are present. The value of LLR$_{\rm obs}$ relative to LLR$_{s+b}$ and LLR$_b$ indicates whether the data distribution appears to resemble what we expect if a signal is present (i.e. closer to the LLR$_{s+b}$ distribution, which is negative by construction) or whether it resembles the background expectation more closely; the significance of departures of LLR$_{\rm obs}$ from LLR$_b$ can be evaluated by the width of the LLR$_b$ bands. The data are consistent with the prediction of the background-only hypothesis (the black dashed line) above ~ 145 GeV/c^2. For m_H from 110 to 140 GeV/c^2, an excess in the data has an amplitude consistent with the expectation for a standard model Higgs boson in this mass range (dashed red line). In this region our ability to distinguish the signal-plus-background and background-only hypotheses is, as indicated by the separation of the LLR$_{s+b}$ and LLR$_b$ values, at the 2 s.d. level.

Using the combination procedures outlined in Section III, we extract limits on the SM Higgs boson production $\sigma \times B(H \to X)$ in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV for $100 \leq m_H \leq 200$ GeV/c^2. To facilitate comparisons with the standard model and to accommodate analyses with different degrees of sensitivity and acceptance for more than one signal production mechanism, we present our resulting limit divided by the SM Higgs boson production cross section, 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 than or equal to one indicates that that particular Higgs boson mass is excluded at the 95% C.L.

The combinations of results [1, 2] of each single experiment, as used in this Tevatron combination, yield the following ratios of 95% C.L. observed (expected) limits to the SM cross section: 2.37 (1.16) for CDF and 2.17 (1.58) for D0 at $m_H = 115$ GeV/c^2, 2.90 (1.41) for CDF and 2.53 (1.85) for D0 at $m_H = 125$ GeV/c^2, and 0.42 (0.69) for CDF and 0.94 (0.76) for D0 at $m_H = 165$ GeV/c^2.

TABLE IV: Ratios of median expected and observed 95% C.L. limit to the SM cross section for the combined CDF and D0 analyses as a function of the Higgs boson mass in GeV/c^2, obtained with the Bayesian and with the CL$_{\rm s}$ method.

Bayesian	100	105	110	115	120	125	130	135	140	145	150
Expected	0.76	0.79	0.85	0.94	1.01	1.10	1.12	1.10	1.02	0.93	0.85
Observed	0.86	0.92	1.44	1.82	2.36	2.22	2.52	2.46	1.96	1.08	0.83

CL$_{\rm s}$	100	105	110	115	120	125	130	135	140	145	150
Expected	0.76	0.80	0.86	0.92	1.02	1.11	1.13	1.12	1.05	0.95	0.84
Observed	0.84	0.97	1.52	1.88	2.20	2.23	2.65	2.62	1.93	1.07	0.83

TABLE V: Ratios of median expected and observed 95% C.L. limit to the SM cross section for the combined CDF and D0 analyses as a function of the Higgs boson mass in GeV/c^2, obtained with the Bayesian and with the CL$_{\rm s}$ method.

Bayesian	155	160	165	170	175	180	185	190	195	200
Expected	0.70	0.52	0.49	0.60	0.69	0.84	1.05	1.33	1.58	1.73
Observed	0.80	0.43	0.39	0.70	0.89	1.05	1.42	1.97	3.45	3.73

CL$_{\rm s}$	155	160	165	170	175	180	185	190	195	200
Expected	0.74	0.53	0.50	0.62	0.73	0.87	1.10	1.38	1.61	1.84
Observed	0.74	0.43	0.38	0.68	0.89	1.04	1.47	2.09	3.56	4.06

The ratios of the 95% C.L. expected and observed limit to the SM cross section are shown in Figure 5 for the combined CDF and D0 analyses. The observed and median expected ratios are listed for the tested Higgs boson masses in Table IV for $m_H \leq 150$ GeV/c^2, and in Table V for $m_H \geq 155$ GeV/c^2, as obtained by the Bayesian and the CL$_\mathrm{s}$ methods. In the following summary we quote only the limits obtained with the Bayesian method, which was decided upon *a priori*. The corresponding limits and expected limits obtained using the CL$_\mathrm{s}$ method are shown alongside the Bayesian limits in the tables. We obtain the observed (expected) values of 0.92 (0.79) at $m_H = 105$ GeV/c^2, 1.82 (0.94) at $m_H = 115$ GeV/c^2, 2.22 (1.10) at $m_H = 125$ GeV/c^2, 1.08 (0.93) at $m_H = 145$ GeV/c^2, 0.39 (0.49) at $m_H = 165$ GeV/c^2, and 1.42 (1.05) at $m_H = 185$ GeV/c^2.

We choose to use the intersections of piecewise linear interpolations of our observed and expected rate limits in order to quote ranges of Higgs boson masses that are excluded and that are expected to be excluded. The sensitivities of our searches to Higgs bosons are smooth functions of the Higgs boson mass and depend most strongly on the predicted cross sections and the decay branching ratios (the decay $H \to W^+W^-$ is the dominant decay for the region of highest sensitivity). We therefore use the linear interpolations to extend the results from the 5 GeV/c^2 mass grid investigated to points in between. The regions of Higgs boson masses excluded at the 95% C.L. thus obtained are

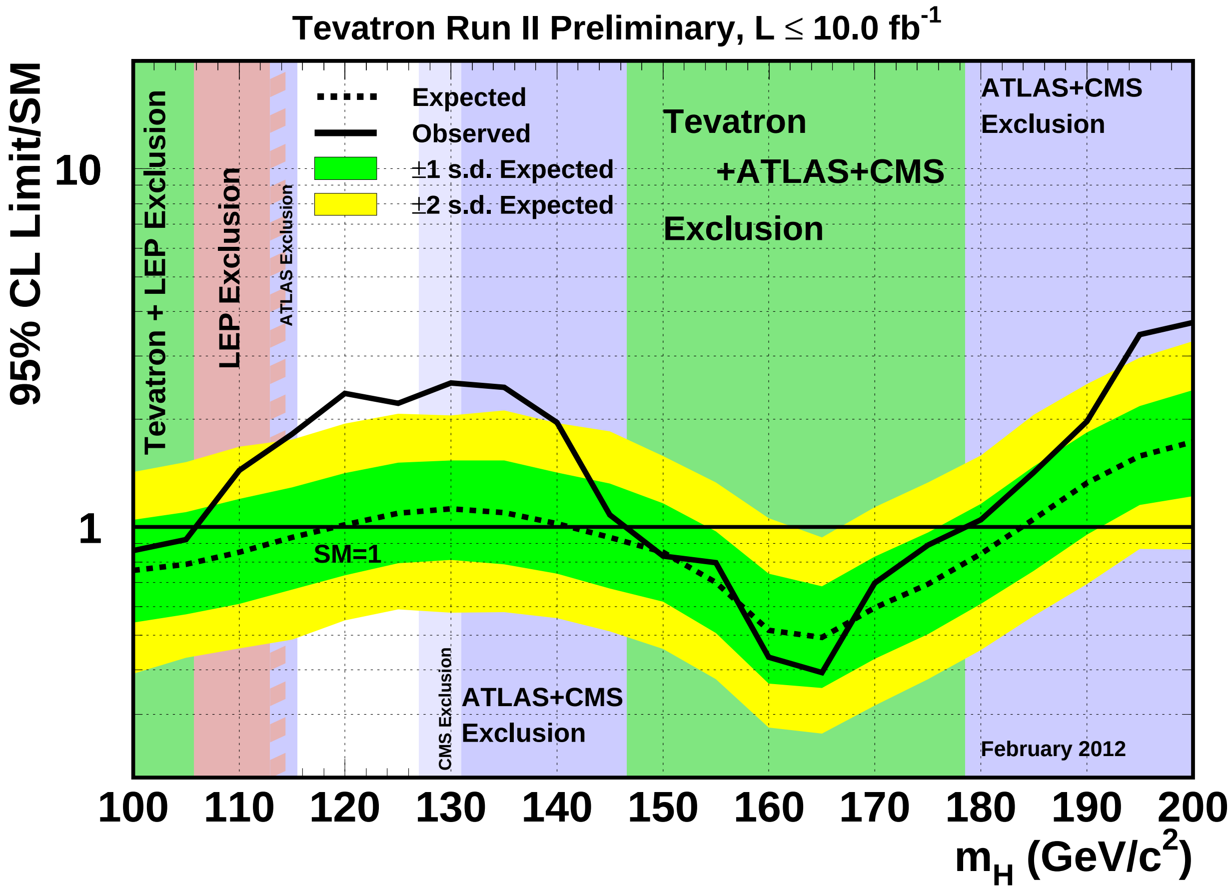

FIG. 5: Observed and expected (median, for the background-only hypothesis) 95% C.L. upper limits on the ratios to the SM cross section, as functions of the Higgs boson mass for the combined CDF and D0 analyses. The limits are expressed as a multiple of the SM prediction for test masses (every 5 GeV/c^2) for which both experiments have performed dedicated searches in different channels. The points are joined by straight lines for better readability. The bands indicate the 68% and 95% probability regions where the limits can fluctuate, in the absence of signal. The limits displayed in this figure are obtained with the Bayesian calculation.

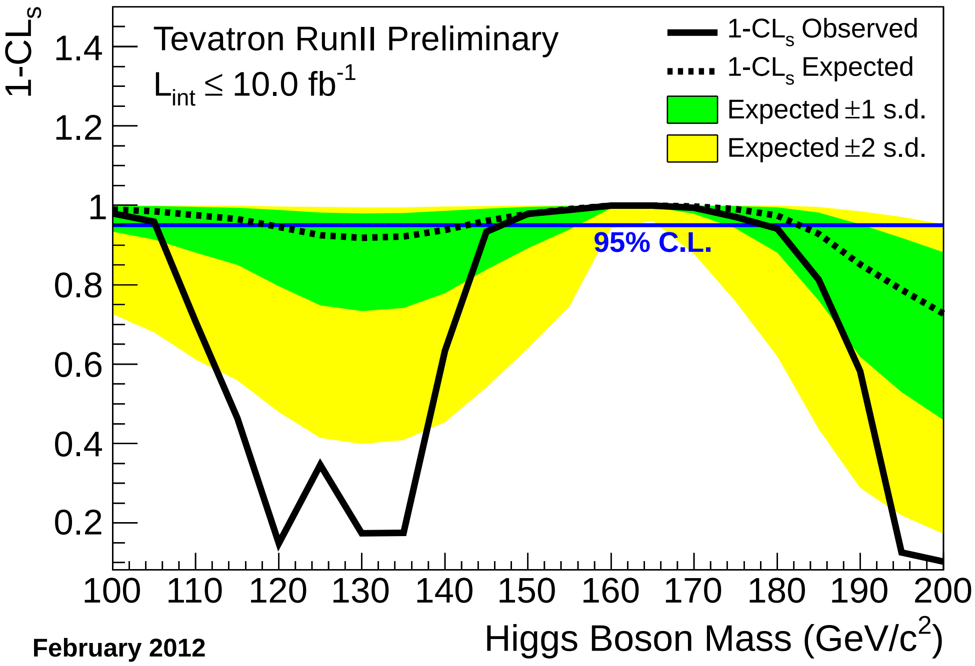

FIG. 6: The exclusion strength 1-CL$_s$ as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of the CDF and D0 analyses. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations around the median predicted value in the background-only hypothesis, respectively.

$100 < m_H < 106$ GeV/c^2 and $147 < m_H < 179$ GeV/c^2. The expected exclusion regions are, given the current sensitivity, $100 < m_H < 119$ GeV/c^2 and $141 < m_H < 184$ GeV/c^2. Higgs boson masses below 100 GeV/c^2 were not studied. We also show in Figure 6, and list in Table VII, the observed values of 1-CL$_s$ and their expected distributions for the background-only hypothesis as functions of the Higgs boson mass. The excluded regions obtained by finding the intersections of the linear interpolations of the observed $1 - \mathrm{CL_s}$ curve are nearly identical to those obtained with the Bayesian calculation.

Figure 7 shows the p-value CL$_{s+b}$ as a function of m_H as well as the expected distributions in the absence of a Higgs boson signal. Figure 8 shows the p-value 1-CL$_b$ as a function of m_H, i.e., the probability that an upward fluctuation of the background can give an outcome as signal-like as the data or more. In the absence of a Higgs boson signal, the observed p-value is expected to be uniformly distributed between 0 and 1. A small p-value indicates that the data are not easily explained by the background-only hypothesis, and that the data prefer the signal-plus-background prediction. Our sensitivity to a Higgs boson with a mass of 165 GeV/c^2 is such that we would expect to see a p-value corresponding to $\sim$ 4 s.d. in half of the experimental outcomes. The smallest observed p-value corresponds to a Higgs boson mass of 120 GeV/c^2. The fluctuations seen in the observed p-value as a function of the tested m_H result from excesses seen in different search channels, as well as from point-to-point fluctuations due to the separate discriminants at each m_H, and are discussed in more detail below. The width of the dip in the p-values from 115 to 135 GeV/c^2 is consistent with the resolution of the combination of the $H \rightarrow b\bar{b}$ and $H \rightarrow W^+W^-$ channels. The effective resolution of this search comes from two independent sources of information. The reconstructed candidate masses help constrain m_H, but more importantly, the expected cross sections times the relevant branching ratios for the $H \rightarrow b\bar{b}$ and $H \rightarrow W^+W^-$ channels are strong functions of m_H in the SM. The observed excesses in the $H \rightarrow b\bar{b}$ channels coupled with a more background-like outcome in the $H \rightarrow W^+W^-$ channels determines the shape of the observed p-value as a function of m_H.

We perform a fit of the signal-plus-background hypothesis to the observed data, allowing the signal strength to vary as a function of m_H. The resulting best-fit signal strength is shown in Figure 9, normalized to the SM prediction. The

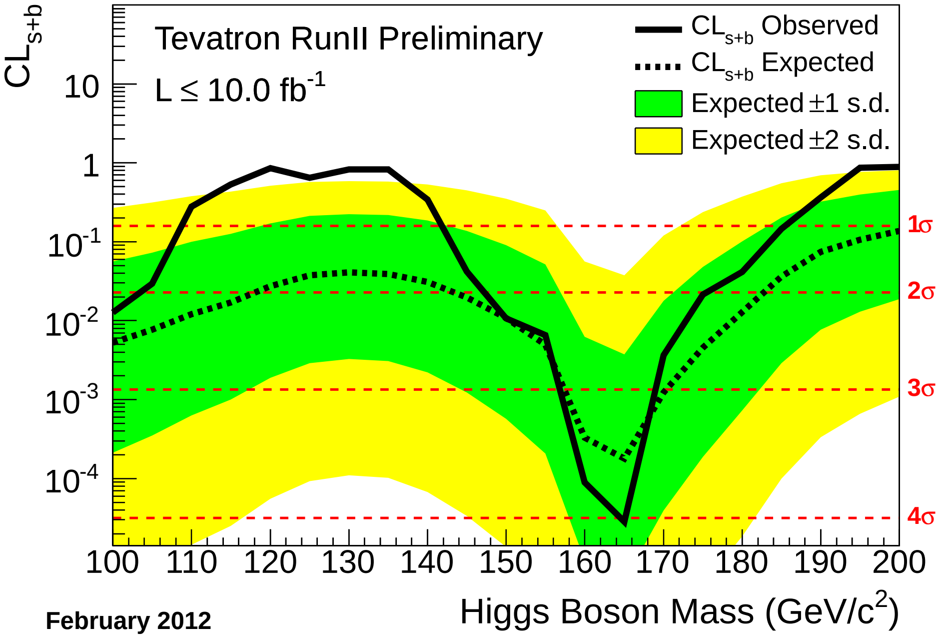

FIG. 7: The signal p-values $\mathrm{CL_{s+b}}$ as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of the CDF and D0 analyses. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations around the median predicted value in the background-only hypothesis, respectively.

signal strength is within 1 s.d. of the SM expectation with a Higgs boson signal in the range $110 < m_H < 140$ GeV/c^2. The largest signal fit in this range, normalized to the SM prediction, is obtained at 130 GeV/c^2. The reason the highest signal strength is at 130 GeV/c^2 while the smallest p-value from Figure 8 is at 120 GeV/c^2 is because a signal at 120 GeV/c^2 would have a higher cross section than a signal at 130 GeV/c^2, and since the resolution of the discriminants cannot distinguish very well such a small mass difference, a signal at 120 GeV/c^2 would be similar to a signal at 130 GeV/c^2 with a larger scale factor for the predicted cross section.

Figure 10 shows $\Delta\chi^2 = \mathrm{LLR_{obs}} - \mathrm{LLR_b}$, which is an estimate of how discrepant the observed data are with the median expectation from the prediction of the background-only hypothesis, as a function of m_H. Significantly negative values of$\Delta\chi^2$ indicate a preference in the data for the signature of Higgs boson production.

We also investigate combinations of CDF and D0 searches based on the $H \to b\bar{b}$ and $H \to W^+W^-$ decay modes. Below 125 GeV/c^2, the $H \to b\bar{b}$ searches contribute the majority of our sensitivity. The $WH \to \ell\nu b\bar{b}$, $ZH \to \nu\bar{\nu}b\bar{b}$, and $ZH \to \ell^+\ell^- b\bar{b}$ channels from both experiments are included in this combination. The result is shown in Figure 11. The distribution of the LLR demonstrates the compatibility of the observed data with both the background-only and signal-plus-background hypotheses, and is shown in Figure 12. An interesting feature of this graph is that as m_H increases towards the high end of the range shown, $Br(H \to b\bar{b})$ falls rapidly, and the expected signal yield becomes small. Thus LLR approaches zero as m_H gets larger, independent of the experimental outcome. This feature can also be seen with the shaded bands which also converge on zero at high m_H. If there is a broad excess in the $H \to b\bar{b}$ searches, then LLR will fall to a minimum value and rise again.

Figure 13 shows the observed and expected values of CL_{s+b} as functions of m_H. Figure 14 shows the p-value for the background-only hypothesis 1 - CL_b, which represents the probability for the background to fluctuate to produce an outcome as signal-like as the observed data or more. The smallest p-value within the mass range where these searches are performed, $100 < m_H < 150$ GeV/c^2, corresponds to a significance of approximately 2.8 s.d.

These probabilities do not include the look-elsewhere effect (LEE), and are thus local p-values, corresponding to searches at each value of m_H separately. The LEE accounts for the probability of observing an upwards fluctuation

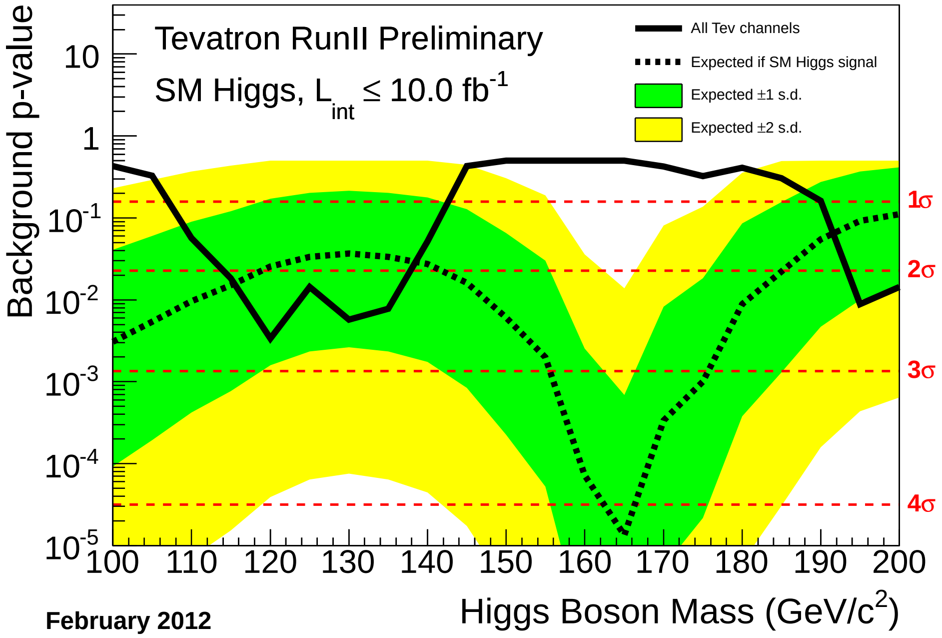

FIG. 8: The background p-values 1-CL$_b$ as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of the CDF and D0 analyses. The green and yellow bands correspond respectively to the regions enclosing 1 s.d. and 2 s.d. fluctuations around the median prediction in the signal plus background hypothesis at each value of m_H.

of the background at any of the tested values of m_H in our search region, at least as significant as the one observed at the value of m_H with the most significant local excess. A simple and correct method of calculating the LEE, and thus the global significance of the excess, is to simulate many possible experimental outcomes assuming the absence of a signal, and for each one, compute the LLR and the fitted cross section curves and find the deviation with the smallest background-only-hypothesis p-value. Using this minimum p-value as a test statistic, another p-value is then computed, which is the probability of observing that minimum p-value or less. This method is difficult to pursue in the Tevatron Higgs boson searches due to the fact that in most search analyses, a distinct multivariate analysis (MVA) discriminant function is trained for each value of m_H that is tested. This step is an important optimization, because the kinematic distributions and signal branching ratios are functions of m_H, but it introduces the difficulty of running the same set of simulated events separately through many MVA functions in order to compute the LEE with the simple method. The use of a separate MVA function at each m_H also introduces additional point-to-point randomness as individual events are reclassified from bins with lower s/b to higher s/b and vice versa. Even though the discriminants are nearly optimal and are thus highly similar from one m_H value to the next, small variations are amplified by the discrete nature of the data which are processed through these MVAs. One may see this in the variations of observed limits, LLR values and p-values from one mass point to the next which show more rapid variation than can be explained from mass resolution effects alone.

Gross and Vitells [91] provide a technique that extrapolates from a smaller sample of background-only Monte Carlo simulations fully propagated through the MVA discriminant functions. We lack the ability to perform this propagation through all of our channels, as we rely on exchanged histograms of distributions of selected events. We therefore estimate the LEE effect in a simplified manner. In the mass range 100–130 GeV/c^2, where the low-mass $H \rightarrow b\bar{b}$ searches dominate, the reconstructed mass resolution is approximately 10-15%, or about 15 GeV/c^2. We therefore estimate a LEE factor of ~ 2 for the low-mass region. The $H \rightarrow \gamma\gamma$ searches have a much better mass resolution, of order 3%, but their contribution to the final LLR is small due to the much smaller s/b in those searches. They introduce more rapid oscillations of LLR as a function of m_H, but the magnitude of these oscillations is much smaller than those induced by the $H \rightarrow b\bar{b}$ searches. The $H \rightarrow \tau^+\tau^-$ searches have both worse reconstructed mass

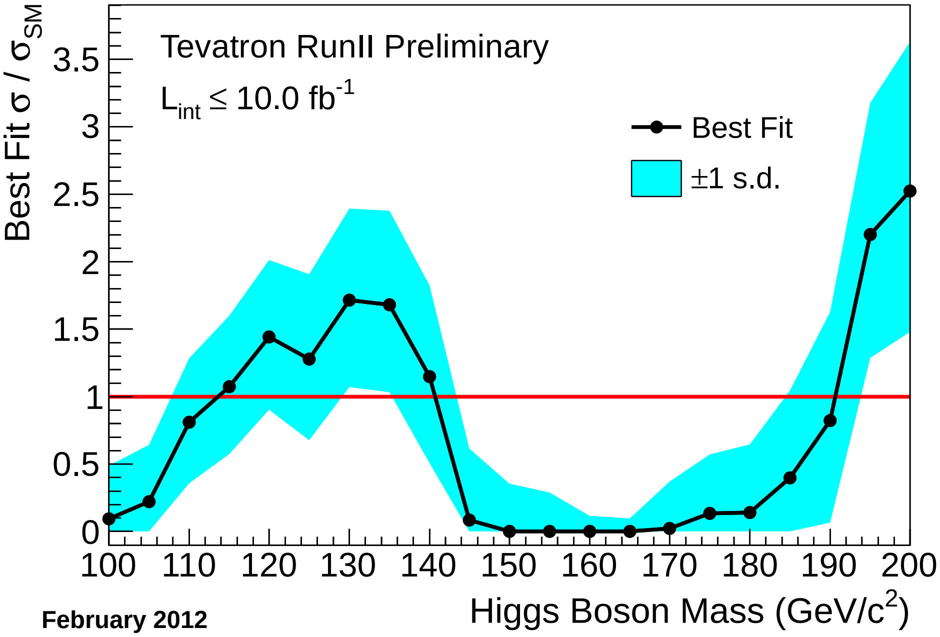

FIG. 9: The best fit signal cross section of all CDF and D0 search channels combined shown as a ratio to the standard model cross section as a function of the tested Higgs boson mass. The horizontal line at 1 represents the signal strength expected for a standard model Higgs boson hypothesis. The blue band shows the 1 s.d. uncertainty on the signal fit.

resolution and lower s/b than the $H \rightarrow b\bar{b}$ searches and therefore similarly do not play a significant role in the estimation of the LEE. Applying the LEE of 2 to the most significant local p-value obtained from our $H \rightarrow b\bar{b}$ combination, we obtain a global significance of approximately 2.6 s.d.

We perform a fit of the signal-plus-background hypothesis to the observed data, allowing the signal strength to vary as a function of m_H. The resulting best-fit signal strength is shown in Figure 15, normalized to the SM prediction. The $H \rightarrow b\bar{b}$ excess comes mainly from the CDF channels, which have combined $>$ 2 s.d. excesses, with the most signal-like candidates coming from CDF's $ZH \rightarrow \ell\ell b\bar{b}$ channel. The $WH \rightarrow \ell\nu b\bar{b}$, $ZH \rightarrow \nu\bar{\nu}b\bar{b}$, and $ZH \rightarrow \ell\ell b\bar{b}$ search channels all contribute to the increase in significance of the CDF excess with respect to previous combinations. The larger excesses found in each individual channel are consistent with the large numbers of new events being added to the searches through the analysis of new data and use of the improved neural-network b-tagging algorithm. For the $ZH \rightarrow \ell\ell b\bar{b}$ channel, which sees the largest change in the significance of its observed excess, more than half of the currently analyzed data events were not contained within previous analyses of this channel. The D0 $H \rightarrow b\bar{b}$ channels see a $\sim$ 1 s.d. excess, consistent with the signal-plus-background hypothesis.

Above 125 GeV/c^2, the $H \rightarrow W^+W^-$ channels contribute the majority of our search sensitivity. We combine all $H \rightarrow W^+W^-$ searches from CDF and D0, incorporating potential signal contributions from $gg \rightarrow H$, WH, ZH, and VBF production. The result of this combination is shown in Figure 16. The distribution of the LLR is shown in Figure 17, which shows good agreement overall with the background-only hypothesis. Where the sensitivity is low, for $m_H = 115$ GeV/c^2 and $m_H \geq 190$ GeV/c^2, the data are slightly more compatible with the signal-plus-background hypothesis. Figure 18 shows the observed and expected CL$_{s+b}$ distribution as a function of m$_H$. Figure 19 shows the p-value for the background-only hypothesis. We perform a fit of the observed data to the signal-plus-background hypothesis, allowing the signal strength to vary in the fit as a function of m_H as shown in Figure 20. Consistent with Figure 17 the combined observed data do not indicate any significant excesses, though the D0 $H \rightarrow W^+W^-$ analysis has a slight excess ($\sim$ 1.5 s.d.) from 130 to 140 GeV/c^2 consistent with the signal-plus-background hypothesis.

The $H \rightarrow W^+W^-$ analyses which dominate the sensitivity of our high mass searches have poor resolution for reconstructing m_H due to the presence of two neutrinos in the final states of the most sensitive channels, and we

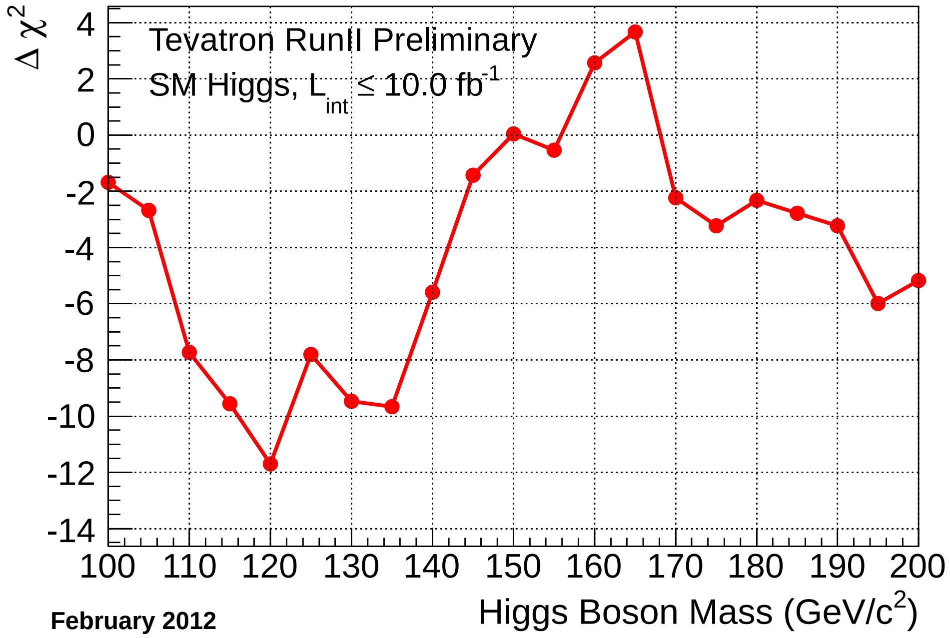

FIG. 10: The curve shows $\Delta\chi^2 = \mathrm{LLR}_{\mathrm{obs}} - \mathrm{LLR}_{\mathrm{b}}$, an estimate of how discrepant the observed data are with the median expectation from the prediction of the background-only hypothesis, as a function of m_H. Significantly negative values of $\Delta\chi^2$ indicate a preference in the data for the signature of Higgs boson production.

thus expect the outcomes in these searches at each m_H in the high-mass range to be highly correlated with each other. Above $m_H = 2M_W$, the W bosons are on shell, and the kinematic variables take on different weights in the training of the MVAs than they do at masses below $2M_W$. At very high masses, the discriminating variable $\Delta R_{\mathrm{leptons}} = \sqrt{\Delta\phi^2_{\mathrm{leptons}} + \Delta\eta_{\mathrm{leptons}}}$ [20, 34] plays less of a role than it does near the W^+W^- threshold. We therefore expect a LEE factor of approximately two for our high-mass searches in the mass range $130 < m_H < 200$ GeV/c^2. Over the entire mass range of our Higgs searches, $100 < m_H < 200$ GeV/c^2, we therefore expect that there are roughly four possible independent locations for uncorrelated excesses to appear in our analysis. The global p-value associated with our entire suite of Higgs searches is therefore $1 - (1 - p_{\mathrm{min}})^4$, using the Dunn-Ŝidák correction [92]. Based on this approach, if we simply chose to consider the region not currently excluded by other experiments, our resulting LEE factor would be one, making the global significance equivalent to the local significance. The smallest local p-value obtained from the full combination of CDF and D0 SM Higgs searches has a significance of approximately 2.7 s.d. Applying a LEE of 4 to this value, we obtain a global significance of approximately 2.2 s.d.

As a final step, we separately combine CDF and D0 searches for $H \to \gamma\gamma$, and display the resulting limits on the production cross section times the decay branching ratio normalized to the SM prediction in Figure 21.

In summary, we combine all available CDF and D0 results on SM Higgs boson searches, based on luminosities ranging from 4.3 to 10.0 fb^{-1}. Compared to our previous combination, more data have been added to the existing channels, additional channels have been included, and analyses have been further optimized to gain sensitivity. The results presented here significantly extend the individual limits of each collaboration and those obtained in our previous combination. The sensitivity of our combined search is sufficient to exclude a Higgs boson at high mass and is, in the absence of signal, expected to grow in the future as further improvements are made to our analysis techniques. There is an excess of data events with respect to the background estimation in the mass range $115 < m_H < 135$ GeV/c^2 which causes our limits to not be as stringent as expected. At $m_H = 120$ GeV/c^2, the p-value for a background fluctuation to produce this excess is $\sim 3.5\times10^{-3}$, corresponding to a local significance of 2.7 standard deviations. The global significance for such an excess anywhere in the full mass range is approximately 2.2 standard deviations, after accounting for the look-elsewhere effect.

In addition, we separate the CDF and D0 searches into combinations focusing on the $H \to b\bar{b}$ and $H \to W^+W^-$ channels. The largest excess is observed in the $H \to b\bar{b}$ channels, corresponding to a local significance of ≈ 2.8 s.d. prior to accounting for the look elsewhere effect of ∼2, which, when included, yields a global significance of ≈ 2.6 s.d.

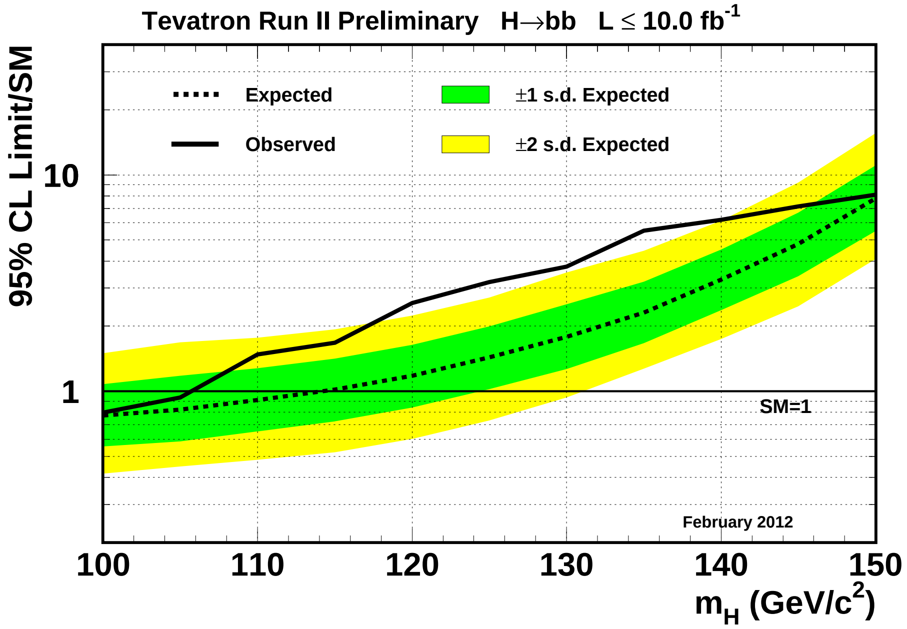

FIG. 11: Observed and expected (median, for the background-only hypothesis) 95% C.L. upper limits on the ratios to the SM cross section, as functions of the Higgs boson mass for the combination of CDF and D0 analyses focusing on the $H \to b\bar{b}$ decay channel. The limits are expressed as a multiple of the SM prediction for test masses (every 5 GeV/c^2) for which both experiments have performed dedicated searches in different channels. The points are joined by straight lines for better readability. The bands indicate the 68% and 95% probability regions where the limits can fluctuate, in the absence of signal. The limits displayed in this figure are obtained with the Bayesian calculation.

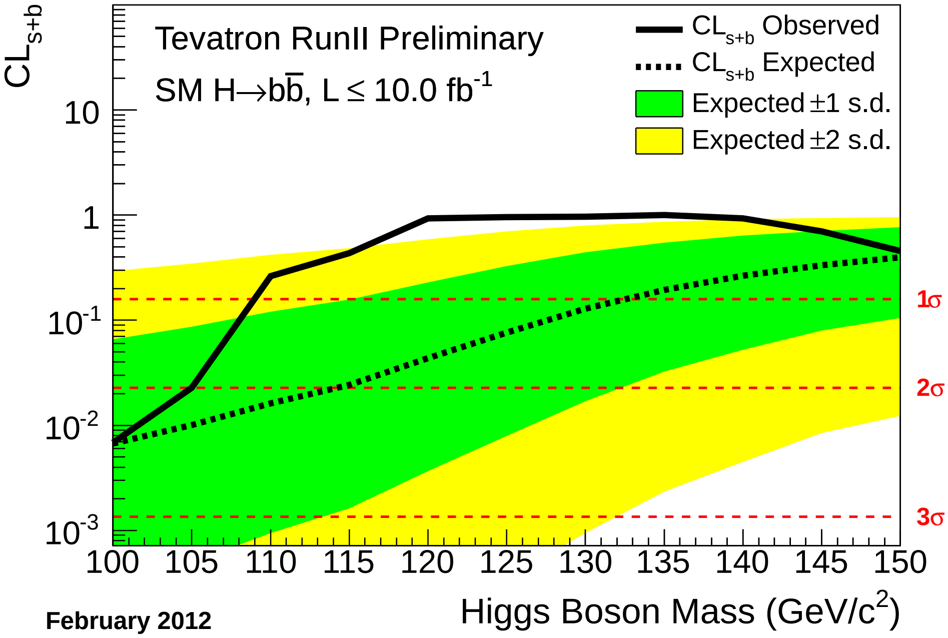

FIG. 13: The signal p-values $\mathrm{CL}_{\mathrm{s+b}}$ for the signal plus background hypothesis as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of all CDF and D0 analyses in the $H \rightarrow b\bar{b}$ channels. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations of the background, respectively.

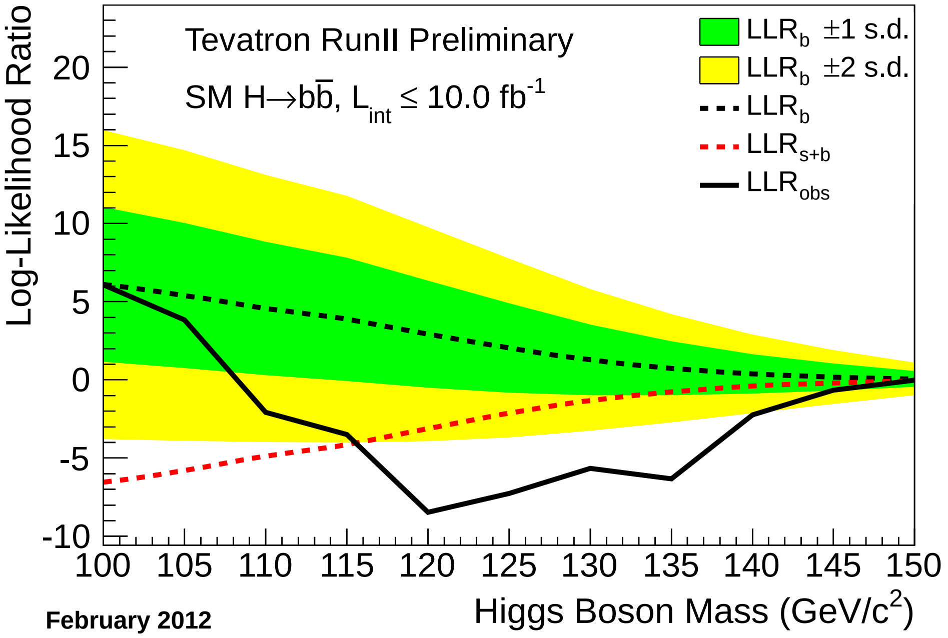

FIG. 12: Distributions of the log-likelihood ratio (LLR) as a function of Higgs boson mass obtained with the CL_{s} method for the combination of all CDF and D0 analyses in the $H \rightarrow b\bar{b}$ channels. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations of the background, respectively.

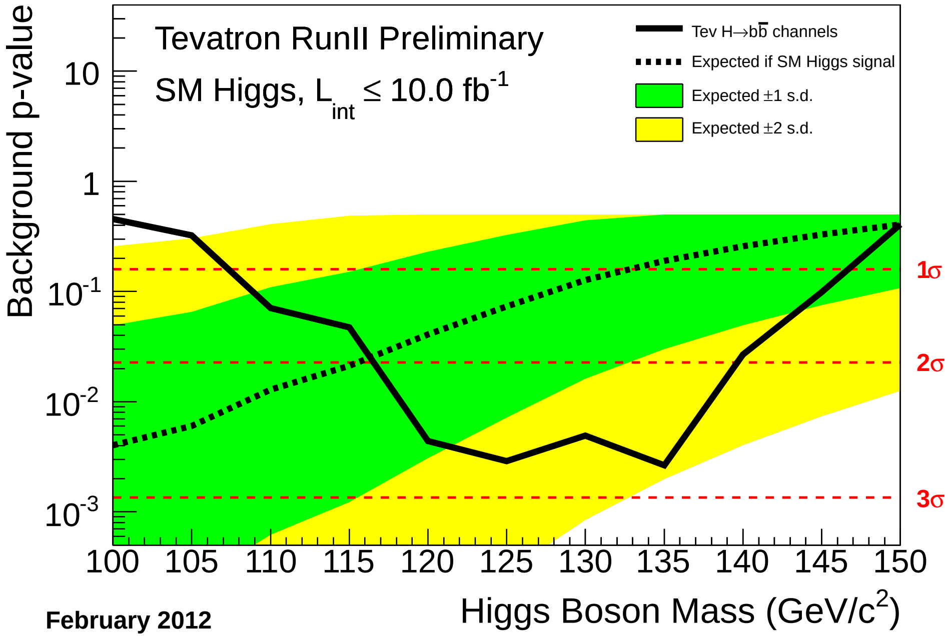

FIG. 14: The background p-values 1-CL$_b$ for the null hypothesis as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of all CDF and D0 analyses in the $H \rightarrow b\bar{b}$ channels. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations of the background, respectively.

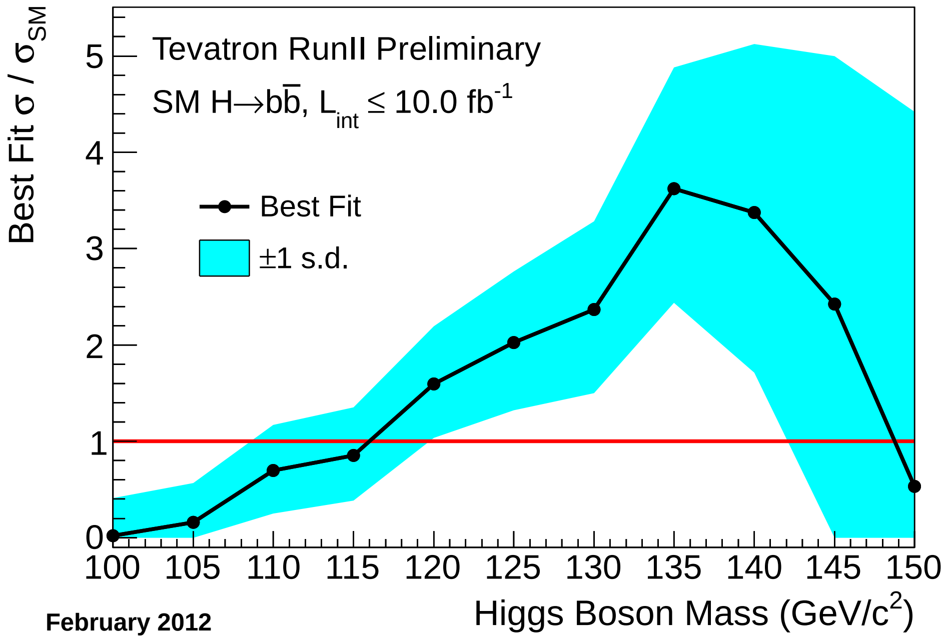

FIG. 15: The best fit of the signal cross section as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of all CDF and D0 analyses in the $H \rightarrow b\bar{b}$ channels. The blue band shows the 1 s.d. uncertainty on the signal fit.

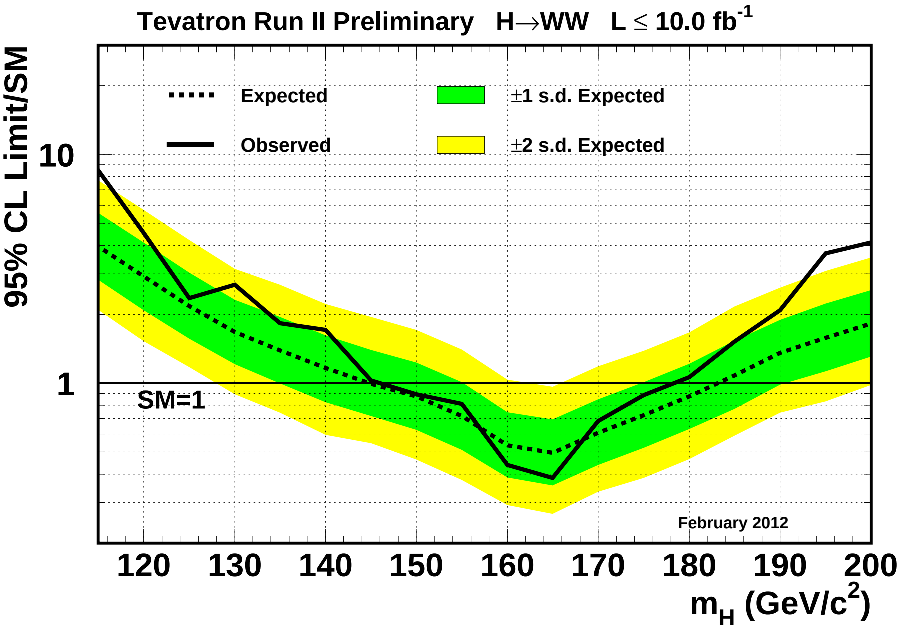

FIG. 16: Observed and expected (median, for the background-only hypothesis) 95% C.L. upper limits on the ratios to the SM cross section, as functions of the Higgs boson mass for the combination of CDF and D0 analyses focusing on the $H \to W^+W^-$ decay channel. The limits are expressed as a multiple of the SM prediction for test masses (every 5 GeV/c^2) for which both experiments have performed dedicated searches in different channels. The points are joined by straight lines for better readability. The bands indicate the 68% and 95% probability regions where the limits can fluctuate, in the absence of signal. The limits displayed in this figure are obtained with the Bayesian calculation.

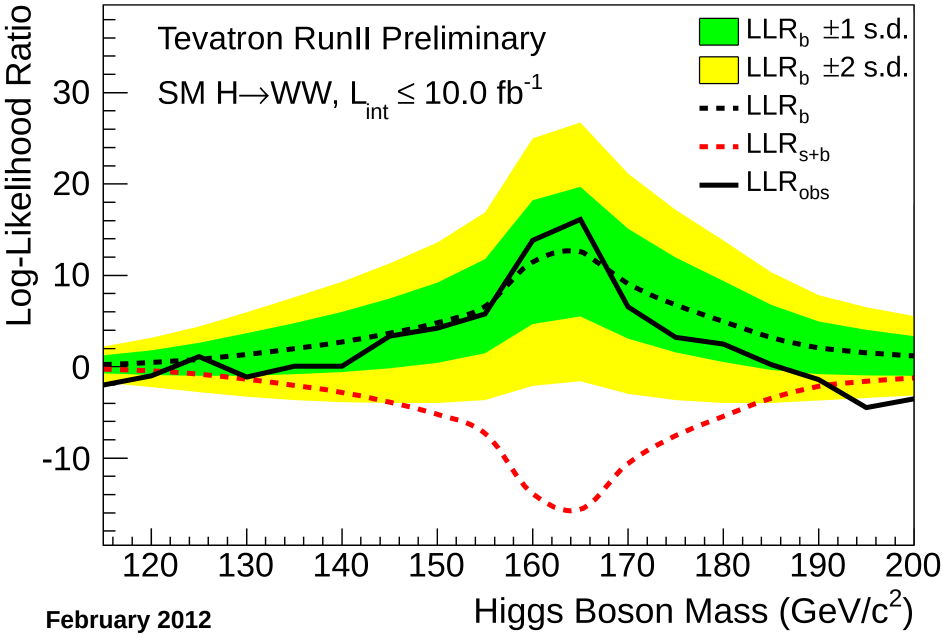

FIG. 17: Distributions of the log-likelihood ratio (LLR) as a function of Higgs boson mass obtained with the CL$_s$ method for the combination of all CDF and D0 analyses in the $H \to W^+W^-$ channels. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations of the background, respectively.

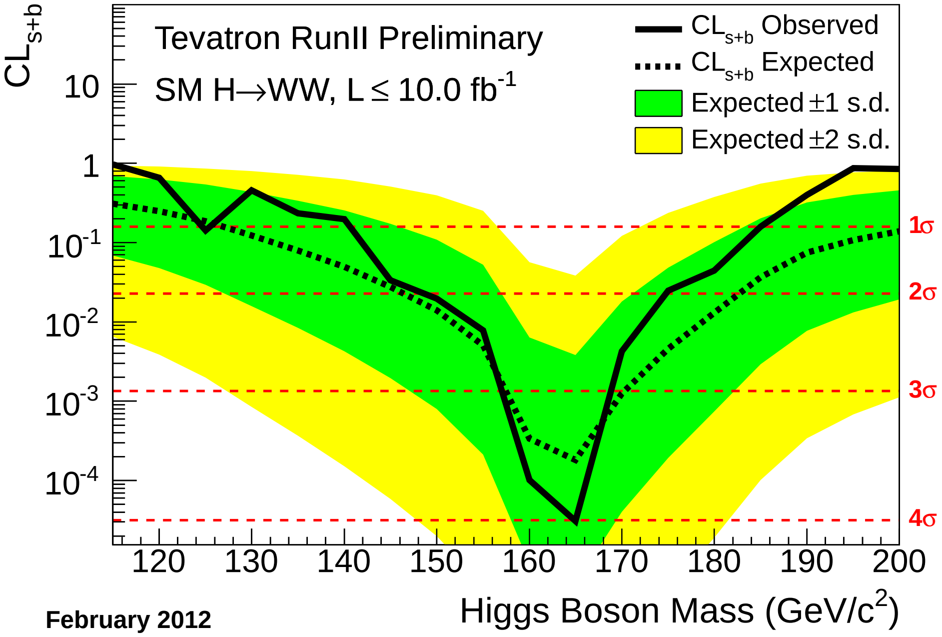

FIG. 18: The signal p-values CL$_{s+b}$ for the signal plus background hypothesis as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of all CDF and D0 analyses in the $H \to W^+W^-$ channels. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations of the background, respectively.

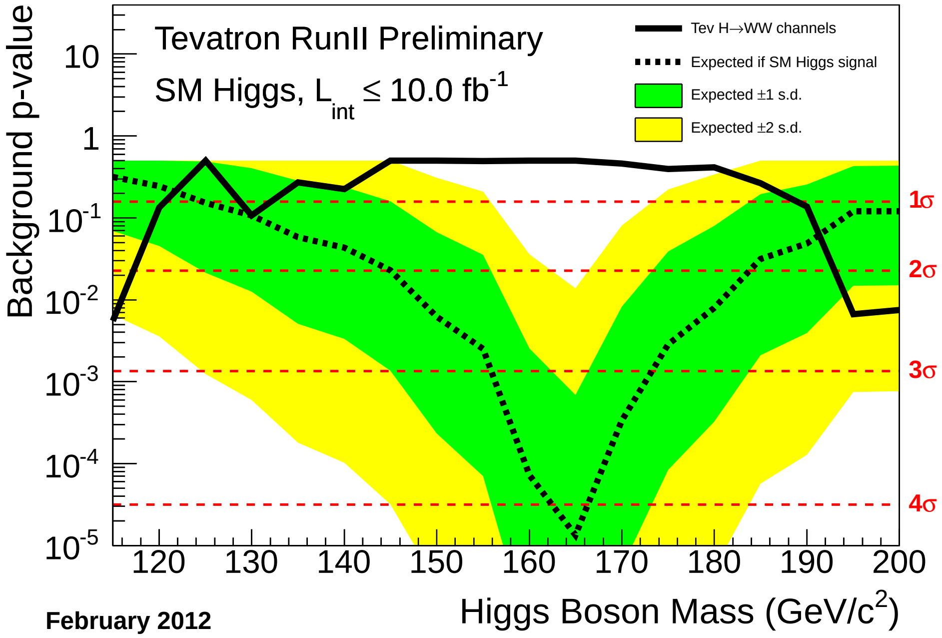

FIG. 19: The background p-values 1-CL$_b$ for the null hypothesis as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of all CDF and D0 analyses in the $H \to W^+W^-$ channels. The green and yellow bands correspond to the regions enclosing 1 s.d. and 2 s.d. fluctuations of the background, respectively.

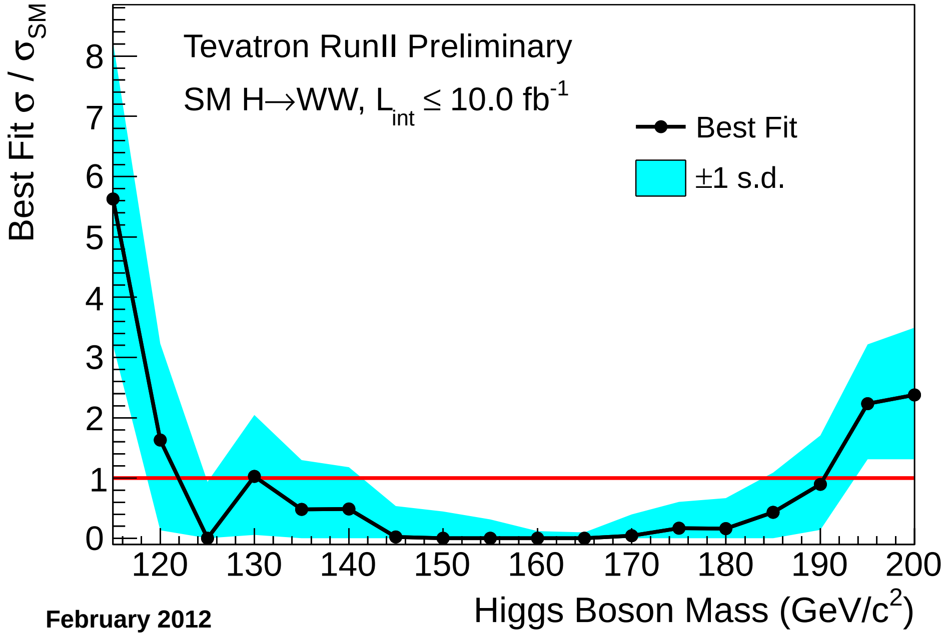

FIG. 20: The best fit of the signal cross section as a function of the Higgs boson mass (in steps of 5 GeV/c^2), for the combination of all CDF and D0 analyses in the $H \to W^+W^-$ channels. The blue band shows the 1 s.d. uncertainty on the signal fit.

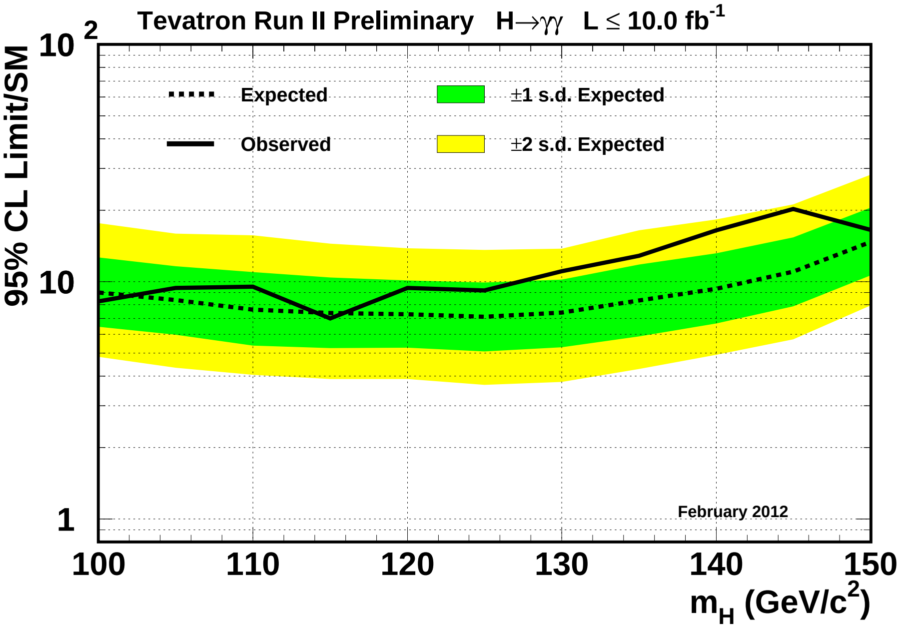

FIG. 21: Observed and expected (median, for the background-only hypothesis) 95% C.L. upper limits on the ratios to the SM cross section, as functions of the Higgs boson mass for the combination of CDF and D0 analyses focusing on the $H \rightarrow \gamma\gamma$ decay channel. The limits are expressed as a multiple of the SM prediction for test masses (every 5 GeV/c^2). The points are joined by straight lines for better readability. The bands indicate the 68% and 95% probability regions where the limits can fluctuate, in the absence of signal. The limits displayed in this figure are obtained with the Bayesian calculation.

Acknowledgments

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TABLE VI: Log-likelihood ratio (LLR) values for the combined CDF + D0 Higgs boson search obtained using the CL_S method.

m_H (GeV/c^2	$\mathrm{LLR}_{\mathrm{obs}}$	$\mathrm{LLR}_{S+B}^{\mathrm{med}}$	$\mathrm{LLR}_{B}^{-2\mathrm{s.d.}}$	$\mathrm{LLR}_{B}^{-1\mathrm{s.d.}}$	$\mathrm{LLR}_{B}^{\mathrm{med}}$	$\mathrm{LLR}_{B}^{+1\mathrm{s.d.}}$	$\mathrm{LLR}_{B}^{+2\mathrm{s.d.}}$
100	4.84	-6.96	16.75	11.64	6.53	1.42	-3.69
105	3.18	-6.27	15.56	10.71	5.87	1.02	-3.82
110	-2.66	-5.36	14.08	9.57	5.07	0.57	-3.94
115	-5.07	-4.74	12.96	8.72	4.49	0.25	-3.99
120	-8.01	-3.90	11.38	7.54	3.69	-0.15	-3.99
125	-4.63	-3.29	10.28	6.73	3.17	-0.39	-3.95
130	-6.45	-3.15	9.98	6.50	3.02	-0.45	-3.93
135	-6.56	-3.23	10.14	6.62	3.10	-0.42	-3.94
140	-2.10	-3.66	10.97	7.23	3.49	-0.25	-3.98
145	2.82	-4.55	12.48	8.36	4.24	0.12	-4.00
150	5.29	-5.72	14.43	9.84	5.26	0.67	-3.91
155	6.11	-7.33	16.95	11.80	6.64	1.49	-3.67
160	14.06	-13.94	25.05	18.27	11.49	4.71	-2.07
165	16.27	-15.66	26.81	19.71	12.61	5.51	-1.60
170	6.88	-10.62	21.18	15.15	9.11	3.07	-2.96
175	3.57	-7.58	17.22	12.00	6.79	1.58	-3.63
180	2.64	-5.47	13.88	9.43	4.97	0.51	-3.95
185	0.45	-3.48	10.41	6.82	3.23	-0.37	-3.96
190	-1.14	-2.18	7.87	4.98	2.09	-0.80	-3.69
195	-4.44	-1.61	6.54	4.05	1.55	-0.94	-3.43
200	-3.97	-1.24	5.59	3.39	1.20	-0.99	-3.18

TABLE VII: The observed and expected 1-CL_s values as functions of m_H, for the combined CDF and D0 Higgs boson searches.

m_H (GeV/c^2)	1-$\mathrm{CL}_\mathrm{s}^{\mathrm{obs}}$	1-$\mathrm{CL}_\mathrm{s}^{-2\mathrm{s.d.}}$	1-$\mathrm{CL}_\mathrm{s}^{-1\mathrm{s.d.}}$	1-$\mathrm{CL}_\mathrm{s}^{\mathrm{median}}$	1-$\mathrm{CL}_\mathrm{s}^{+1\mathrm{s.d.}}$	1-$\mathrm{CL}_\mathrm{s}^{+2\mathrm{s.d.}}$
100	0.980	1.000	0.999	0.989	0.933	0.726
105	0.958	1.000	0.998	0.985	0.914	0.680
110	0.707	0.999	0.996	0.976	0.881	0.612
115	0.463	0.999	0.994	0.966	0.850	0.559
120	0.148	0.998	0.988	0.945	0.796	0.479
125	0.347	0.996	0.982	0.925	0.748	0.415
130	0.174	0.995	0.979	0.918	0.734	0.400
135	0.175	0.996	0.981	0.922	0.742	0.409
140	0.634	0.997	0.986	0.938	0.779	0.454
145	0.934	0.999	0.992	0.961	0.838	0.541
150	0.979	0.999	0.996	0.978	0.892	0.639
155	0.988	1.000	0.999	0.990	0.939	0.745
160	1.000	1.000	1.000	0.999	0.993	0.943
165	1.000	1.000	1.000	1.000	0.996	0.961
170	0.994	1.000	1.000	0.998	0.979	0.877
175	0.971	1.000	0.999	0.991	0.943	0.758
180	0.941	0.999	0.995	0.974	0.881	0.619
185	0.813	0.996	0.982	0.928	0.760	0.436
190	0.582	0.985	0.952	0.852	0.619	0.288
195	0.125	0.971	0.918	0.787	0.530	0.219
200	0.103	0.952	0.882	0.727	0.459	0.173

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Appendices

APPENDIX A: SYSTEMATIC UNCERTAINTIES

TABLE VIII: Systematic uncertainties on the signal and background contributions for CDF's $WH \rightarrow \ell\nu b\bar{b}$ single tight b-tag (Tx) and single loose b-tag (Lx) categories. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for WH shown in this table are obtained for $m_H = 115$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "S".

CDF: single tight b-tag (Tx) $WH \rightarrow \ell\nu b\bar{b}$ channel relative uncertainties (%)

Contribution	W+HF	Mistags	Top	Diboson	Non-W	WH
Luminosity ($\sigma_{\text{inel}}(p\bar{p})$)	3.8	0	3.8	3.8	0	3.8
Luminosity Monitor	4.4	0	4.4	4.4	0	4.4
Lepton ID	2.0-4.5	0	2.0-4.5	2.0-4.5	0	2.0-4.5
Jet Energy Scale	3.2-6.9(S)	0.9-1.8(S)	0.8-9.7(S)	3.6-13.2(S)	0	3.0-5.0(S)
Mistag Rate (tight)	0	19	0	0	0	0
Mistag Rate (loose)	0	0	0	0	0	0
B-Tag Efficiency (tight)	0	0	3.9	3.9	0	3.9
B-Tag Efficiency (loose)	0	0	0	0	0	0
$t\bar{t}$ Cross Section	0	0	10	0	0	0
Diboson Rate	0	0	0	6.0	0	0
Signal Cross Section	0	0	0	0	0	5
HF Fraction in W+jets	30	0	0	0	0	0
ISR+FSR+PDF	0	0	0	0	0	3.8-6.8
Q^2	3.2-6.9(S)	0.9-1.8(S)	0	0	0	0
QCD Rate	0	0	0	0	40	0

CDF: single loose b-tag (Lx) $WH \rightarrow \ell\nu b\bar{b}$ channel relative uncertainties (%)

Contribution	W+HF	Mistags	Top	Diboson	Non-W	WH
Luminosity ($\sigma_{\text{inel}}(p\bar{p})$)	3.8	0	3.8	3.8	0	3.8
Luminosity Monitor	4.4	0	4.4	4.4	0	4.4
Lepton ID	2	0	2	2	0	2
Jet Energy Scale	2.2-6.0(S)	0.9-1.8(S)	1.6-8.6(S)	4.6-9.6(S)	0	3.1-4.8(S)
Mistag Rate (tight)	0	0	0	0	0	0
Mistag Rate (loose)	0	10	0	0	0	0
B-Tag Efficiency (tight)	0	0	0	0	0	0
B-Tag Efficiency (loose)	0	0	3.2	3.2	0	3.2
$t\bar{t}$ Cross Section	0	0	10	0	0	0
Diboson Rate	0	0	0	6.0	0	0
Signal Cross Section	0	0	0	0	0	10
HF Fraction in W+jets	30	0	0	0	0	0
ISR+FSR+PDF	0	0	0	0	0	2.4-4.9
QCD Rate	2.1-6.0(S)	0.9-1.8(S)	0	0	40	0

TABLE IX: Systematic uncertainties on the signal and background contributions for CDF's $WH \rightarrow \ell\nu b\bar{b}$ two tight b-tag (TT), one tight b-tag and one loose b-tag (TL), and two loose b-tag (LL) channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for WH shown in this table are obtained for $m_H = 115$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "S".

CDF: two tight b-tag (TT) $WH \rightarrow \ell\nu b\bar{b}$ channel relative uncertainties (%)

Contribution	W+HF	Mistags	Top	Diboson	Non-W	WH
Luminosity ($\sigma_{\mathrm{inel}}(p\bar{p})$)	3.8	0	3.8	3.8	0	3.8
Luminosity Monitor	4.4	0	4.4	4.4	0	4.4
Lepton ID	2.0-4.5	0	2.0-4.5	2.0-4.5	0	2.0-4.5
Jet Energy Scale	4.0-16.6(S)	0.9-3.3(S)	0.9-10.4(S)	4.7-19.7(S)	0	2.3-13.6(S)
Mistag Rate (tight)	0	40	0	0	0	0
Mistag Rate (loose)	0	0	0	0	0	0
B-Tag Efficiency (tight)	0	0	7.8	7.8	0	7.8
B-Tag Efficiency (loose)	0	0	0	0	0	0
$t\bar{t}$ Cross Section	0	0	10	0	0	0
Diboson Rate	0	0	0	6.0	0	0
Signal Cross Section	0	0	0	0	0	5
HF Fraction in W+jets	30	0	0	0	0	0
ISR+FSR+PDF	0	0	0	0	0	6.4-12.6
Q^2	4.0-8.8(S)	0.9-1.8(S)	0	0	0	0
QCD Rate	0	0	0	0	40	0

CDF: one tight and one loose b-tag (TL) $WH \rightarrow \ell\nu b\bar{b}$ channel relative uncertainties (%)

Contribution	W+HF	Mistags	Top	Diboson	Non-W	WH
Luminosity ($\sigma_{\mathrm{inel}}(p\bar{p})$)	3.8	0	3.8	3.8	0	3.8
Luminosity Monitor	4.4	0	4.4	4.4	0	4.4
Lepton ID	2.0-4.5	0	2.0-4.5	2.0-4.5	0	2.0-4.5
Jet Energy Scale	3.9-12.4(S)	0.9-3.3(S)	1.4-11.5(S)	5.0-16.0(S)		2.5-16.1(S)
Mistag Rate (tight)	0	19	0	0	0	0
Mistag Rate (loose)	0	10	0	0	0	0
B-Tag Efficiency (tight)	0	0	3.9	3.9	0	3.9
B-Tag Efficiency (loose)	0	0	3.2	3.2	0	3.2
$t\bar{t}$ Cross Section	0	0	10	0	0	0
Diboson Rate	0	0	0	6.0	0	0
Signal Cross Section	0	0	0	0	0	5
HF Fraction in W+jets	30	0	0	0	0	0
ISR+FSR+PDF	0	0	0	0	0	3.3-10.3
Q^2	3.9-7.7(S)	0.9-1.9(S)	0	0	0	0
QCD Rate	0	0	0	0	40	0

CDF: two loose b-tag (LL) $WH \rightarrow \ell\nu b\bar{b}$ channel relative uncertainties (%)

Contribution	W+HF	Mistags	Top	Diboson	Non-W	WH
Luminosity ($\sigma_{\mathrm{inel}}(p\bar{p})$)	3.8	0	3.8	3.8	0	3.8
Luminosity Monitor	4.4	0	4.4	4.4	0	4.4
Lepton ID	2	0	2	2	0	2
Jet Energy Scale	3.6-6.9(S)	0.9-1.8(S)	1.7-7.9(S)	1.2-8.5	0	2.7-5.4(S)
Mistag Rate (tight)	0	0	0	0	0	0
Mistag Rate (loose)	0	20	0	0	0	0
B-Tag Efficiency (tight)	0	0	0	0	0	0
B-Tag Efficiency (loose)	0	0	6.3	6.3	0	6.3
$t\bar{t}$ Cross Section	0	0	10	0	0	0
Diboson Rate	0	0	0	6.0	0	0
Signal Cross Section	0	0	0	0	0	10
HF Fraction in W+jets	30	0	0	0	0	0
ISR+FSR+PDF	0	0	0	0	0	2.0-13.6
QCD Rate	3.6-6.9(S)	0.9-1.8(S)	0	0	40	0

TABLE X: Systematic uncertainties on the signal and background contributions for D0's $WH \rightarrow \ell\nu b\bar{b}$ single and double tag channels. Systematic uncertainties are listed by name, see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for WH shown in this table are obtained for $m_H = 115$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "(S)", and "SH" represents shape only uncertainty.

$WH \rightarrow \ell\nu b\bar{b}$ Single Tag (TST) channels relative uncertainties (%)

Contribution	Dibosons	$W + b\bar{b}/c\bar{c}$	W+l.f.	$t\bar{t}$	single top	Multijet	WH
Luminosity	6.1	6.1	6.1	6.1	6.1	–	6.1
Electron ID/Trigger eff. (S)	1–5	2–4	2–4	1–2	1–2	–	2–3
Muon Trigger eff. (S)	1	1	1	1	1	–	1
Muon ID/Reco eff./resol.	4.1	4.1	4.1	4.1	4.1	–	4.1
Jet ID/Reco eff.	2	2	2	2	2	–	2
Jet Resolution (S)	1–2	2–4	2–3	2–5	1–2	–	2
Jet Energy Scale (S)	4–7	1–5	2–5	2–7	1–2	–	2–6
Vertex Conf. Jet (S)	4–6	3–4	2–3	6–10	2–4	–	3–7
b-tag/taggability (S)	1–3	1–4	7–10	1–6	1–2	–	2–9
Heavy-Flavor K-factor	–	20	–	–	–	–	–
Inst.-WH $e\nu b\bar{b}$ (S)	1–2	2–4	1–3	1–2	1–3	15	1–2
Inst.-WH $\mu\nu b\bar{b}$	–	2.4	2.4	–	–	20	–
Cross Section	6	9	6	7	7	–	6.1
Signal Branching Fraction	–	–	–	–	–	–	1-9
ALPGEN MLM pos/neg(S)	–	–	SH	–	–	–	–
ALPGEN Scale (S)	–	SH	SH	–	–	–	–
Underlying Event (S)	–	SH	SH	–	–	–	–
PDF, reweighting	2	2	2	2	2	–	2

$WH \rightarrow \ell\nu b\bar{b}$ Loose Double Tag (LDT) channels relative uncertainties (%)

Contribution	Dibosons	$W + b\bar{b}/c\bar{c}$	W+l.f.	$t\bar{t}$	single top	Multijet	WH
Luminosity	6.1	6.1	6.1	6.1	6.1	–	6.1
Electron ID/Trigger eff. (S)	2–5	2–3	2–3	1–2	1–2	–	1–2
Muon Trigger eff. (S)	1	1	1	1	1	–	1
Muon ID/Reco eff./resol.	4.1	4.1	4.1	4.1	4.1	–	4.1
Jet ID/Reco eff.	2	2	2	2	2	–	2
Jet Resolution (S)	1–7	2–7	2–3	2–7	2–4	–	1–5
Jet Energy Scale (S)	2–11	2–5	2–7	2–7	2–5	–	2–8
Vertex Conf. Jet (S)	2–11	2–12	2–3	4–15	2–3	–	3–7
b-tag/taggability (S)	2–15	2–6	6–10	2–5	2–3	–	1–5
Heavy-Flavor K-factor	–	20	–	–	–	–	–
Inst.-WH $e\nu b\bar{b}$ (S)	1–2	2–4	1–3	1–2	1–3	15	1–2
Inst.-WH $\mu\nu b\bar{b}$	–	2.4	2.4	–	–	20	–
Cross Section	6	9	6	7	7	–	6.1
Signal Branching Fraction	–	–	–	–	–	–	1-9
ALPGEN MLM pos/neg(S)	–	–	SH	–	–	–	–
ALPGEN Scale (S)	–	SH	SH	–	–	–	–
Underlying Event (S)	–	SH	SH	–	–	–	–
PDF, reweighting	2	2	2	2	2	–	2

$WH \rightarrow \ell\nu b\bar{b}$ Tight Double Tag (TDT) channels relative uncertainties (%)

Contribution	Dibosons	$W + b\bar{b}/c\bar{c}$	W+l.f.	$t\bar{t}$	single top	Multijet	WH
Luminosity	6.1	6.1	6.1	6.1	6.1	–	6.1
Electron ID/Trigger eff. (S)	2–5	2–3	2–3	1–2	1–2	–	1–2
Muon Trigger eff. (S)	1	1	1	1	1	–	1
Muon ID/Reco eff./resol.	4.1	4.1	4.1	4.1	4.1	–	4.1
Jet ID/Reco eff.	2	2	2	2	2	–	2
Jet Resolution (S)	2–5	2–4	2–6	2–7	1–2	–	4–6
Jet Energy Scale (S)	3–8	2–5	1–8	2–9	2–4	–	2–6
Vertex Conf. Jet (S)	2–3	2–4	2–5	5–7	2–3	–	2–4
b-tag/taggability (S)	3–15	4–15	10–15	5–10	5–9	–	4–12
Heavy-Flavor K-factor	–	20	–	–	–	–	–
Inst.-WH $e\nu b\bar{b}$ (S)	1–2	2–4	1–3	1–2	1–3	15	1–2
Inst.-WH $\mu\nu b\bar{b}$	–	2.4	2.4	–	–	20	–
Cross Section	6	9	6	7	7	–	6.1
Signal Branching Fraction	–	–	–	–	–	–	1-9
ALPGEN MLM pos/neg(S)	–	–	SH	–	–	–	–
ALPGEN Scale (S)	–	SH	SH	–	–	–	–
Underlying Event (S)	–	SH	SH	–	–	–	–
PDF, reweighting	2	2	2	2	2	–	2

TABLE XI: Systematic uncertainties on the signal and background contributions for D0's $\tau\tau jj$ Run IIb channel. Systematic uncertainties for the Higgs signal shown in this table are obtained for $m_H = 135$ GeV/c^2. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "(S)."

$\mu\tau_{had}jj$ Run IIb channel relative uncertainties (%)

Contribution	VH	VBF	ggH	W+jets	Z+jets	Top	Dibosons	Multijet
Luminosity	6.1	6.1	6.1	6.1	6.1	6.1	6.1	–
μ ID	2.9	2.9	2.9	2.9	2.9	2.9	2.9	–
$Single\mu$ trigger	5.0	5.0	5.0	5.0	5.0	5.0	5.0	–
inclusive trigger relative	7.0	7.0	7.0	7.0	7.0	7.0	7.0	–
τ energy correction	9.8	9.8	9.8	9.8	9.8	9.8	9.8	–
τ track efficiency	1.4	1.4	1.4	1.4	1.4	1.4	1.4	–
τ selection by type	10,4,5	10,4,5	10,4,5	10,4,5	10,4,5	10,4,5	10,4,5	–
Cross section	6.2	4.9	33	6.0	6.0	10.0	7.0	–
GGF Signal PDF	–	–	29	–	–	–	–	–
GGF Hp_T Reweighting (S)	–	– ~5.0	–	–	–	–	–	–
Signal Branching Fraction	0-7.3	0-7.3	0-7.3	–	–	–	–	–
Vertex confirmation for jets(S)	~ 5.0	~5.0	~5.0	~5.0	~5.0	~5.0	~5.0	–
Jet ID(S)	~5	~5	~5	~5	~5	~5	~5	–
Jet Energy Resolution (S)	~5	~5	~5	~5	~5	~5	~5	–
Jet energy Scale (S)	~5	~5	~5	~5	~5	~5	~5	–
Jet pT	5.5	5.5	5.5	5.5	5.5	5.5	5.5	–
PDF reweighting	1.6	1.6	1.6	1.6	2	2	2	–
Multijet Normalization	–	–	–	–	–	–	–	5.3
Multijet Shape	–	–	–	–	–	–	–	~15

$e\tau_{had}jj$ Run IIb relative uncertainties (%)

Contribution	VH	VBF	ggH	W+jets	Z+jets	Top	Dibosons	Multijet
Luminosity	6.1	6.1	6.1	6.1	6.1	6.1	6.1	–
Electron ID	4	4	4	4	4	4	4	–
Electron trigger	2	2	2	2	2	2	2	–
τ energy correction	9.8	9.8	9.8	9.8	9.8	9.8	9.8	–
τ track efficiency	1.4	1.4	1.4	1.4	1.4	1.4	1.4	–
τ selection by type	10,4,5	10,4,5	10,4,5	10,4,5	10,4,5	10,4,5	10,4,5	–
Cross section	6.1	4.9	33	6.0	6.0	10.0	7.0	–
GGF Signal PDF	–	–	29	–	–	–	–	–
GGF Hp_T Reweighting (S)	–	–	~ 5.0	–	–	–	–	–
Signal Branching Fraction	0-7.3	0-7.3	0-7.3	–	–	–	–	–
Vertex confirmation for jets(S)	~ 5.0	~5.0	~5.0	~5.0	~5.0	~5.0	~5.0	–
Jet ID(S)	~10	~5	~5	~5	~5	~5	~5	–
Jet Energy Resolution (S)	~10	~10	~10	~10	~10	~10	~10	–
Jet energy Scale (S)	~10	~10	~10	~10	~10	~10	~10	–
Jet pT	5.5	5.5	5.5	5.5	5.5	5.5	5.5	–
PDF reweighting	1.6	1.6	1.6	1.6	2	2	2	–
Multijet Normalization	–	–	–	–	–	–	–	4.7
Multijet Shape	–	–	–	–	–	–	–	~15

TABLE XII: Systematic uncertainties on the signal and background contributions for CDF's $WH, ZH \rightarrow \not\!\!E_T b\bar{b}$ tight double tag (SS), loose double tag (SJ), and single tag (1S) channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for ZH and WH shown in this table are obtained for $m_H = 120$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "S".

CDF: tight double-tag (SS) $WH, ZH \rightarrow \not\!\!E_T b\bar{b}$ channel relative uncertainties (%)

Contribution	ZH	WH	Multijet	Mistags	Top Pair	S. Top	Diboson	W + HF	Z + HF
Luminosity	3.8	3.8			3.8	3.8	3.8	3.8	3.8
Lumi Monitor	4.4	4.4			4.4	4.4	4.4	4.4	4.4
Tagging SF	10.4	10.4			10.4	10.4	10.4	10.4	10.4
Trigger Eff. (S)	0.9	1.4	0.9		0.9	1.6	2.0	1.8	1.2
Lepton Veto	2.0	2.0			2.0	2.0	2.0	2.0	2.0
PDF Acceptance	3.0	3.0			3.0	3.0	3.0	3.0	3.0
JES (S)	$^{+1.7}_{-1.8}$	$^{+2.4}_{-2.3}$			$^{+0.0}_{-0.1}$	$^{+2.5}_{-2.4}$	$^{+4.1}_{-4.5}$	$^{+4.3}_{-4.6}$	$^{+8.8}_{-3.2}$
ISR/FSR	$^{+3.0}_{+3.0}$								
Cross-Section	5	5			10	10	6	30	30
Multijet Norm. (shape)			2.5						
Mistag (S)				$^{+36.7}_{-30}$					

CDF: loose double-tag (SJ) $WH, ZH \rightarrow \not\!\!E_T b\bar{b}$ channel relative uncertainties (%)

Contribution	ZH	WH	Multijet	Mistags	Top Pair	S. Top	Diboson	W + HF	Z + HF
Luminosity	3.8	3.8			3.8	3.8	3.8	3.8	3.8
Lumi Monitor	4.4	4.4			4.4	4.4	4.4	4.4	4.4
Tagging SF	8.3	8.3			8.3	8.3	8.3	8.3	8.3
Trigger Eff. (S)	1.2	1.7	1.6		0.9	1.8	2.0	2.5	1.9
Lepton Veto	2.0	2.0			2.0	2.0	2.0	2.0	2.0
PDF Acceptance	3.0	3.0			3.0	3.0	3.0	3.0	3.0
JES (S)	$^{+1.9}_{-1.9}$	$^{+2.4}_{-2.4}$			$^{+3.0}_{-2.8}$	$^{-0.6}_{0.2}$	$^{+4.2}_{-4.2}$	$^{+6.8}_{-5.9}$	$^{+8.3}_{-3.1}$
ISR/FSR	$^{+2.4}_{-2.4}$								
Cross-Section	5.0	5.0			10	10	6	30	30
Multijet Norm.			1.6						
Mistag (S)				$^{+65.2}_{-38.5}$					

CDF: single-tag (1S) $WH, ZH \rightarrow \not\!\!E_T b\bar{b}$ channel relative uncertainties (%)

Contribution	ZH	WH	Multijet	Mistags	Top Pair	S. Top	Diboson	W + HF	Z + HF
Luminosity	3.8	3.8			3.8	3.8	3.8	3.8	3.8
Lumi Monitor	4.4	4.4			4.4	4.4	4.4	4.4	4.4
Tagging SF	5.2	5.2			5.2	5.2	5.2	5.2	5.2
Trigger Eff. (S)	1.2	1.7	1.6		0.9	1.8	2.0	2.5	1.9
Lepton Veto	2.0	2.0			2.0	2.0	2.0	2.0	2.0
PDF Acceptance	3.0	3.0			3.0	3.0	3.0	3.0	3.0
JES (S)	$^{+2.6}_{-2.6}$	$^{+3.3}_{-3.1}$			$^{-0.8}_{+0.6}$	$^{+2.7}_{-2.8}$	$^{+5.1}_{-5.1}$	$^{+8.2}_{-6.8}$	$^{+10.8}_{-3.4}$
ISR/FSR	$^{+2.0}_{-2.0}$								
Cross-Section	5.0	5.0			10	10	6	30	30
Multijet Norm.			0.7						
Mistag (S)				$^{+17.9}_{-17.4}$					

TABLE XIII: Systematic uncertainty ranges on the signal and background contributions and the error on the total background for D0's $ZH \to \nu\nu b\bar{b}$ medium-tag and tight-tag channels. Systematic uncertainties are listed by name, see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for VH (WH+ZH) shown in this table are obtained for $m_H = 115$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "(S)", and "SH" represents shape only uncertainty.

$ZH \to \nu\nu b\bar{b}$ medium-tag channel relative uncertainties (%)

Contribution	Top	$V + b\bar{b}/c\bar{c}$	V+l.f.	Dibosons	Total Bkgd	VH
Jet ID/Reco Eff (S)	2.0	2.0	2.0	2.0	1.9	2.0
Jet Energy Scale (S)	1.3	1.5	2.8	1.5	1.9	0.3
Jet Resolution (S)	0.5	0.4	0.5	0.8	0.5	0.9
Vertex Conf. / Taggability (S)	3.4	2.2	2.0	2.3	2.2	2.1
b Tagging (S)	1.5	2.6	8.0	3.6	3.7	0.6
Lepton Identification	1.5	0.9	0.8	0.9	0.9	0.9
Trigger	2.0	2.0	2.0	2.0	1.9	2.0
Heavy Flavor Fractions	–	20.0	–	–	8.4	–
Cross Sections	10.0	10.2	10.2	7.0	9.8	7.0
Signal Branching Fraction	–	–	–	–	–	1-9
Luminosity	6.1	6.1	6.1	6.1	5.8	6.1
Multijet Normalilzation	–	–	–	–	1.1	–
ALPGEN MLM (S)	–	–	SH	–	–	–
ALPGEN Scale (S)	–	SH	SH	–	–	–
Underlying Event (S)	–	SH	SH	–	–	–
PDF, reweighting (S)	SH	SH	SH	SH	SH	SH
Total uncertainty	12.8	23.8	15.1	10.8	14.2	10.0

$ZH \to \nu\nu b\bar{b}$ tight-tag channel relative uncertainties (%)

Contribution	Top	$V + b\bar{b}/c\bar{c}$	V+l.f.	Dibosons	Total Bkgd	VH
Jet ID/Reco Eff (S)	2.0	2.0	2.0	2.0	2.0	2.0
Jet Energy Scale (S)	1.0	1.6	3.9	1.6	1.6	0.5
Jet Resolution (S)	0.7	0.6	2.6	1.4	0.8	1.3
Vertex Conf. / Taggability (S)	3.0	1.9	2.4	2.0	2.3	1.9
b Tagging (S)	8.9	7.3	12.5	6.4	7.4	7.8
Lepton Identification	1.9	0.8	0.3	0.7	1.1	0.8
Trigger	2.0	2.0	2.0	2.0	2.0	2.0
Heavy Flavor Fractions	–	20.0	–	–	11.0	–
Cross Sections	10.0	10.2	10.2	7.0	10.0	7.0
Signal Branching Fraction	–	–	–	–	–	1-9
Luminosity	6.1	6.1	6.1	6.1	6.1	6.1
Multijet Normalilzation	–	–	–	–	0.2	–
ALPGEN MLM (S)	–	–	SH	–	–	–
ALPGEN Scale (S)	–	SH	SH	–	–	–
Underlying Event (S)	–	SH	SH	–	–	–
PDF, reweighting (S)	SH	SH	SH	SH	SH	SH
Total uncertainty	15.5	24.7	18.3	12.0	16.8	12.7

TABLE XIV: Systematic uncertainties on the signal and background contributions for CDF's $ZH \rightarrow \ell^+\ell^- b\bar{b}$ tight double tag (TT) and one tight tag and one loose tag (TL) channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Uncertainties are relative, in percent on the event yield. Shape uncertainties are labeled with an "(S)".

CDF: tight double tag (TT) $\ell\ell b\bar{b}$ channels relative uncertainties (%)

Contribution	Fakes	$t\bar{t}$	WW	WZ	ZZ	$Z+c\bar{c}$	$Z+b\bar{b}$	Mistags	ZH
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)		3.8	3.8	3.8	3.8	3.8	3.8		3.8
Luminosity Monitor		4.4	4.4	4.4	4.4	4.4	4.4		4.4
Lepton ID		1	1	1	1	1	1		1
Lepton Energy Scale		1.5	1.5	1.5	1.5	1.5	1.5		1.5
Fake $Z \rightarrow e^+e^-$	50								
Fake $Z \rightarrow \mu^+\mu^-$	5								
Tight Mistag Rate								40	
Loose Mistag Rate									
JES [e^+e^-, 2 jet]		$^{+0.8}_{-0.7}$	$^{+14.4}_{-13.2}$	$^{+6.2}_{-6.2}$	$^{+8.2}_{-8.3}$	$^{+5.6}_{-5.6}$	$^{+8.1}_{-7.9}$	$^{+10.4}_{-10.4}$	$^{+3.6}_{-4.2}$
JES [e^+e^-, 3 jet]		$^{+8.3}_{-8.2}$	$^{-0.7}_{+1.7}$	$^{-4.2}_{+4.3}$	$^{+14.4}_{-13.3}$	$^{+10.6}_{-10.5}$	$^{+13.2}_{-13.2}$	$^{+12.4}_{-12.4}$	$^{+15.1}_{-14.9}$
JES [$\mu^+\mu^-$, 2 jet]		$^{+1.0}_{-0.9}$	$^{+5.4}_{+2.1}$	$^{+13.4}_{-13.4}$	$^{+7.7}_{-7.7}$	$^{-1.5}_{+1.5}$	$^{+8.2}_{-8.2}$	$^{+5.7}_{-5.8}$	$^{+3.1}_{-3.5}$
JES [$\mu^+\mu^-$, 3 jet]		$^{+9.3}_{-9.1}$	$^{+3.9}_{-3.0}$	$^{+4.8}_{-5.7}$	$^{+15.5}_{-15.5}$	$^{+7.3}_{-7.3}$	$^{+14.2}_{-14.5}$	$^{+20.5}_{-18.0}$	$^{+12.5}_{-13.3}$
Tight b-tag Rate		7.8	7.8	7.8	7.8	7.8	7.8		7.8
Loose b-tag Rate									
$t\bar{t}$ Cross Section		10							
Diboson Cross Section			6	6	6				
Z+HF Cross Section						40	40		
ZH Cross Section									5
ISR/FSR									5.5–7.6
Electron Trigger Eff.		1	1	1	1	1	1		1
Muon Trigger Eff.		5	5	5	5	5	5		5

CDF: one tight and one loose tag (TL) $\ell\ell b\bar{b}$ channels relative uncertainties (%)

Contribution	Fakes	$t\bar{t}$	WW	WZ	ZZ	$Z+c\bar{c}$	$Z+b\bar{b}$	Mistags	ZH
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)		3.8	3.8	3.8	3.8	3.8	3.8		3.8
Luminosity Monitor		4.4	4.4	4.4	4.4	4.4	4.4		4.4
Lepton ID		1	1	1	1	1	1		1
Lepton Energy Scale		1.5	1.5	1.5	1.5	1.5	1.5		1.5
Fake $Z \rightarrow e^+e^-$	50								
Fake $Z \rightarrow \mu^+\mu^-$	5								
Tight Mistag Rate								19	
Loose Mistag Rate								10	
JES [e^+e^-, 2 jet]		$^{+0.9}_{-1.0}$	$^{+13.0}_{-12.6}$	$^{+9.3}_{-9.4}$	$^{+10.3}_{-10.2}$	$^{+10.3}_{-10.3}$	$^{+8.9}_{-9.3}$	$^{+10.4}_{-10.4}$	$^{+4.0}_{-4.2}$
JES [e^+e^-, 3 jet]		$^{+6.9}_{-7.0}$	$^{+10.3}_{-8.3}$	$^{+16.2}_{-16.0}$	$^{+14.6}_{-14.5}$	$^{+22.8}_{-23.4}$	$^{+15.1}_{-15.2}$	$^{+18.5}_{-18.5}$	$^{+14.3}_{-14.4}$
JES [$\mu^+\mu^-$, 2 jet]		$^{+1.1}_{-1.1}$	$^{+3.7}_{1.8}$	$^{+6.5}_{-6.5}$	$^{+7.5}_{-7.5}$	$^{+12.5}_{-12.4}$	$^{+10.1}_{-10.1}$	$^{+11.0}_{-11.0}$	$^{+4.0}_{-4.1}$
JES [$\mu^+\mu^-$, 3 jet]		$^{+8.0}_{-8.0}$	$^{+2.0}_{-1.6}$	$^{+14.4}_{-14.5}$	$^{+24.1}_{-24.1}$	$^{+16.0}_{-14.7}$	$^{+17.5}_{-17.6}$	$^{+14.3}_{-14.2}$	$^{+13.1}_{-14.0}$
Tight b-tag Rate		3.9	3.9	3.9	3.9	3.9	3.9		3.9
Loose b-tag Rate		3.2	3.2	3.2	3.2	3.2	3.2		3.2
$t\bar{t}$ Cross Section		10							
Diboson Cross Section			6	6	6				
Z+HF Cross Section						40	40		
ZH Cross Section									5
ISR/FSR									3.4–7.0
Electron Trigger Eff.		1	1	1	1	1	1		1
Muon Trigger Eff.		5	5	5	5	5	5		5

TABLE XV: Systematic uncertainties on the signal and background contributions for CDF's $ZH \rightarrow \mu^+\mu^- b\bar{b}$ single tight tag (Tx) and double loose tag (LL) channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Uncertainties are relative, in percent on the event yield. Shape uncertainties are labeled with an "(S)".

CDF: single tight tag (TT) $\ell\ell b\bar{b}$ channels relative uncertainties (%)

Contribution	Fakes	$t\bar{t}$	WW	WZ	ZZ	$Z + c\bar{c}$	$Z + b\bar{b}$	Mistags	ZH
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)		3.8	3.8	3.8	3.8	3.8	3.8		3.8
Luminosity Monitor		4.4	4.4	4.4	4.4	4.4	4.4		4.4
Lepton ID		1	1	1	1	1	1		1
Lepton Energy Scale		1.5	1.5	1.5	1.5	1.5	1.5		1.5
Fake $Z \rightarrow e^+e^-$	50								
Fake $Z \rightarrow \mu^+\mu^-$	5								
Tight Mistag Rate								19	
Loose Mistag Rate									
JES [e^+e^-, 2 jet]		$^{-0.3}_{+0.3}$	$^{+13.7}_{-13.5}$	$^{+8.5}_{-8.5}$	$^{+6.5}_{-6.3}$	$^{+13.2}_{-13.2}$	$^{+11.0}_{-11.1}$	$^{+12.0}_{-12.0}$	$^{+3.5}_{-3.8}$
JES [e^+e^-, 3 jet]		$^{+7.1}_{-7.1}$	$^{+8.9}_{-8.2}$	$^{+17.0}_{-17.0}$	$^{+15.4}_{-15.4}$	$^{+16.4}_{-16.4}$	$^{+15.8}_{-15.9}$	$^{+18.6}_{-18.5}$	$^{+15.4}_{-15.7}$
JES [$\mu^+\mu^-$, 2 jet]		$^{+0.6}_{-0.7}$	$^{+3.9}_{-3.3}$	$^{+8.6}_{-8.6}$	$^{+7.6}_{-7.7}$	$^{+10.2}_{-10.5}$	$^{+9.3}_{-9.3}$	$^{+11.1}_{-11.1}$	$^{+3.4}_{-3.7}$
JES [$\mu^+\mu^-$, 3 jet]		$^{+5.5}_{-5.5}$	$^{+5.7}_{-1.9}$	$^{+16.6}_{-16.6}$	$^{+16.8}_{-16.8}$	$^{+16.1}_{-16.2}$	$^{+16.1}_{-16.2}$	$^{+17.5}_{-17.5}$	$^{+13.8}_{-13.9}$
Tight b-tag Rate		3.9	3.9	3.9	3.9	3.9	3.9		3.9
Loose b-tag Rate									
$t\bar{t}$ Cross Section		10							
Diboson Cross Section			6	6	6				
Z+HF Cross Section						40	40		
ZH Cross Section									5
ISR/FSR									0.9–12.8
Electron Trigger Eff.		1	1	1	1	1	1		1
Muon Trigger Eff.		5	5	5	5	5	5		5

CDF: double loose tag (LL) $\ell\ell b\bar{b}$ channels relative uncertainties (%)

Contribution	Fakes	$t\bar{t}$	WW	WZ	ZZ	$Z + c\bar{c}$	$Z + b\bar{b}$	Mistags	ZH
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)		3.8	3.8	3.8	3.8	3.8	3.8		3.8
Luminosity Monitor		4.4	4.4	4.4	4.4	4.4	4.4		4.4
Lepton ID		1	1	1	1	1	1		1
Lepton Energy Scale		1.5	1.5	1.5	1.5	1.5	1.5		1.5
Fake $Z \rightarrow e^+e^-$	50								
Fake $Z \rightarrow \mu^+\mu^-$	5								
Tight Mistag Rate									
Loose Mistag Rate								20	
JES [e^+e^-, 2 jet]		$^{+0.5}_{-0.5}$	$^{+7.5}_{-4.8}$	$^{+8.6}_{-8.7}$	$^{+9.0}_{-8.9}$	$^{+10.0}_{-9.3}$	$^{+11.3}_{-11.0}$	$^{+12.5}_{-12.5}$	$^{+4.0}_{-4.4}$
JES [e^+e^-, 3 jet]		$^{+8.6}_{-8.6}$	$^{+32.9}_{-29.5}$	$^{+14.6}_{-14.9}$	$^{+16.5}_{-15.2}$	$^{+20.8}_{-20.8}$	$^{+17.8}_{-17.9}$	$^{+18.9}_{-19.0}$	$^{+14.6}_{-15.4}$
JES [$\mu^+\mu^-$, 2 jet]		$^{+2.5}_{-2.5}$	$^{+4.5}_{-3.0}$	$^{+6.7}_{-6.7}$	$^{+10.2}_{-9.9}$	$^{+9.2}_{-9.3}$	$^{+7.7}_{-7.6}$	$^{+11.5}_{-11.5}$	$^{+3.9}_{-4.3}$
JES [$\mu^+\mu^-$, 3 jet]		$^{+9.2}_{-9.2}$	$^{+13.4}_{-10.4}$	$^{+14.1}_{-14.1}$	$^{+16.6}_{-16.6}$	$^{+14.7}_{-14.7}$	$^{+16.8}_{-16.9}$	$^{+17.5}_{-17.5}$	$^{+11.6}_{-12.2}$
Tight b-tag Rate									
Loose b-tag Rate		6.3	6.3	6.3	6.3	6.3	6.3		6.3
$t\bar{t}$ Cross Section		10							
Diboson Cross Section			6	6	6				
Z+HF Cross Section						40	40		
ZH Cross Section									5
ISR/FSR									3.1–15.2
Electron Trigger Eff.		1	1	1	1	1	1		1
Muon Trigger Eff.		5	5	5	5	5	5		5

TABLE XVI: Systematic uncertainties on the contributions for D0's $ZH \rightarrow \ell^+\ell^- b\bar{b}$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for ZH shown in this table are obtained for $m_H = 115$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "(S)".

$ZH \rightarrow \ell\ell b\bar{b}$ Single Tag (ST) channels relative uncertainties (%)

Contribution	ZH	Multijet	Z+l.f.	Z+$b\bar{b}$	Z+$c\bar{c}$	Dibosons	Top
Jet Energy Scale (S)	4.2	–	6.8	4.9	5.2	6.7	3.3
Jet Energy Resolution (S)	1.2	–	5.2	3.3	3.2	2.2	0.4
Jet ID (S)	0.3	–	0.7	0.3	0.5	0.5	0.6
Taggability (S)	1.5	–	1.0	1.0	1.3	1.3	0.8
Zp_T Model (S)	–	–	2.7	1.4	1.5	–	–
HF Tagging Efficiency (S)	0.4	–	–	1.1	4.0	–	1.3
LF Tagging Efficiency (S)	–	–	73	–	–	3.0	–
ee Multijet Shape (S)	–	54	–	–	–	–	–
Multijet Normalization	–	1-70	–	–	–	–	–
Z+jets Jet Angles (S)	–	–	1.7	2.9	3.4	–	–
Alpgen MLM (S)	–	–	0.3	–	–	–	–
Alpgen Scale (S)	–	–	0.4	0.4	0.4	–	–
Underlying Event (S)	–	–	0.2	0.4	0.3	–	–
Trigger (S)	0.4	–	0.03	0.2	0.2	0.2	0.5
Cross Sections	6	–	–	20	20	7	10
Signal Branching Fraction	1-9	–	–	–	–	–	–
Normalization	2.5	–	0.3	0.3	0.3	2.5	2.5
PDFs	0.6	–	1.0	2.4	1.1	0.7	5.9

$ZH \rightarrow \ell\ell b\bar{b}$ Double Tag (DT) channels relative uncertainties (%)

Contribution	ZH	Multijet	Z+l.f.	Z+$b\bar{b}$	Z+$c\bar{c}$	Dibosons	Top
Jet Energy Scale (S)	2.6	–	7.4	6.5	5.1	5.8	1.0
Jet Energy Resolution(S)	1.0	–	4.0	4.4	4.7	0.9	0.9
JET ID (S)	0.8	–	0.8	0.1	0.1	0.8	0.8
Taggability (S)	0.9	–	0.5	1.0	0.8	0.7	0.9
Z_{p_T} Model (S)	–	–	1.3	1.3	2.0	–	–
HF Tagging Efficiency (S)	5.3	–	–	5.7	5.9	–	4.0
LF Tagging Efficiency (S)	–	–	47	–	–	6.2	–
ee Multijet Shape (S)	–	59	–	–	–	–	–
Multijet Normalization	–	1-70	–	–	–	–	–
Z+jets Jet Angles (S)	–	–	1.4	3.7	3.7	–	–
Alpgen MLM (S)	–	–	0.2	–	–	–	–
Alpgen Scale (S)	–	–	0.3	0.4	0.4	–	–
Underlying Event(S)	–	–	0.3	0.4	0.4	–	–
Trigger (S)	0.4	–	0.4	0.3	0.2	0.3	0.5
Cross Sections	6	–	–	20	20	7	10
Signal Branching Fraction	1-9	–	–	–	–	–	–
Normalization	2.5	–	0.3	0.3	0.3	2.5	2.5
PDFs	0.6	–	1.0	2.4	1.1	0.7	5.9

TABLE XVII: Systematic uncertainties on the signal and background contributions for CDF's $H \rightarrow W^+W^- \rightarrow \ell^\pm\ell'^\mp$ channels with zero, one, and two or more associated jets. These channels are sensitive to gluon fusion production (all channels) and WH, ZH and VBF production. Systematic uncertainties are listed by name (see the original references for a detailed explanation of their meaning and on how they are derived). Systematic uncertainties for H shown in this table are obtained for $m_H = 160$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. The uncertainties associated with the different background and signal processed are correlated within individual jet categories unless otherwise noted. Boldface and italics indicate groups of uncertainties which are correlated with each other but not the others on the line.

CDF: $H \rightarrow W^+W^- \rightarrow \ell^\pm\ell'^\mp$ with no associated jet channel relative uncertainties (%)

Contribution	WW	WZ	ZZ	$t\bar{t}$	DY	$W\gamma$	W+jet	$gg \rightarrow H$	WH	ZH	VBF
Cross Section											
ScaleInclusive								13.4			
Scale1+Jets								−23.0			
Scale2+Jets								0.0			
PDF Model								7.6			
Total	*6.0*	*6.0*	*6.0*	7.0					**5.0**	**5.0**	10.0
Acceptance											
Scale (jets)	*0.3*s										
PDF Model (leptons)								2.7			
PDF Model (jets)	*1.1*							5.5			
Higher-order Diagrams		*10.0*	*10.0*	10.0		10.0			**10.0**	**10.0**	**10.0**
$\not\!\!E_T$ Modeling					19.0						
Conversion Modeling						6.8					
Jet Fake Rates											
(Low S/B)							15.0				
(High S/B)							24.0				
Jet Energy Scale	*3.1*	*6.2*	*3.5*	*28.2*	*18.0*	*3.5*		*5.7*	*9.9*	*5.3*	*12.9*
Lepton ID Efficiencies	*3.8*	*3.8*	*3.8*	*3.8*	*3.8*			*3.8*	*3.8*	*3.8*	*3.8*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*			*2.0*	*2.0*	*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*	*5.9*			*5.9*	*5.9*	*5.9*	*5.9*

CDF: $H \rightarrow W^+W^- \rightarrow \ell^\pm\ell'^\mp$ with one associated jet channel relative uncertainties (%)

Contribution	WW	WZ	ZZ	$t\bar{t}$	DY	$W\gamma$	W+jet	$gg \rightarrow H$	WH	ZH	VBF
Cross Section											
ScaleInclusive								0.0			
Scale1+Jets								35.0			
Scale2+Jets								−12.7			
PDF Model								17.3			
Total	*6.0*	*6.0*	*6.0*	7.0					**5.0**	**5.0**	10.0
Acceptance											
Scale (jets)	*-4.0*s										
PDF Model (leptons)								3.6			
PDF Model (jets)	*4.7*							-6.3			
Higher-order Diagrams		*10.0*	*10.0*	10.0		10.0			**10.0**	**10.0**	**10.0**
$\not\!\!E_T$ Modeling					21.0						
Conversion Modeling						6.8					
Jet Fake Rates											
(Low S/B)							16.0				
(High S/B)							27.0				
Jet Energy Scale	*-5.8*	*-1.1*	*-4.8*	*-13.1*	*-6.5*	*-9.5*		*-3.8*	*-8.5*	*-7.8*	*-6.8*
Lepton ID Efficiencies	*3.8*	*3.8*	*3.8*	*3.8*	*3.8*			*3.8*	*3.8*	*3.8*	*3.8*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*			*2.0*	*2.0*	*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*	*5.9*			*5.9*	*5.9*	*5.9*	*5.9*

CDF: $H \rightarrow W^+W^- \rightarrow \ell^\pm\ell'^\mp$ with two or more associated jets channel relative uncertainties (%)

Contribution	WW	WZ	ZZ	$t\bar{t}$	DY	$W\gamma$	W+jet	$gg \rightarrow H$	WH	ZH	VBF
Cross Section											
ScaleInclusive								0.0			
Scale1+Jets								0.0			
Scale2+Jets								33.0			
PDF Model								29.7			
Total	*6.0*	*6.0*	*6.0*	7.0					**5.0**	**5.0**	10.0
Acceptance											
Scale (jets)	*-8.2*s										
PDF Model (leptons)								4.8			
PDF Model (jets)	*4.2*							-12.3			
Higher-order Diagrams		*10.0*	*10.0*	10.0		10.0			**10.0**	**10.0**	**10.0**
$\not\!\!E_T$ Modeling					26.0						
Conversion Modeling						6.8					
Jet Fake Rates							19.0				
Jet Energy Scale	*-20.5*	*-13.2*	*-13.3*	*-1.7*	*-32.7*	*-22.0*		*-15.1*	*-4.0*	*-2.5*	*-3.8*
b-tag Veto				3.6							
Lepton ID Efficiencies	*3.8*	*3.8*	*3.8*	*3.8*	*3.8*			*3.8*	*3.8*	*3.8*	*3.8*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*			*2.0*	*2.0*	*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*	*5.9*			*5.9*	*5.9*	*5.9*	*5.9*

TABLE XVIII: Systematic uncertainties on the signal and background contributions for CDF's low-$M_{\ell\ell}$ $H \rightarrow W^+W^- \rightarrow \ell^\pm\ell'^\mp$ channel with zero or one associated jets. This channel is sensitive to only gluon fusion production. Systematic uncertainties are listed by name (see the original references for a detailed explanation of their meaning and on how they are derived). Systematic uncertainties for H shown in this table are obtained for $m_H = 160$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. The uncertainties associated with the different background and signal processed are correlated within individual categories unless otherwise noted. In these special cases, the correlated uncertainties are shown in either italics or bold face text.

CDF: low $M_{\ell\ell}$ $H \rightarrow W^+W^- \rightarrow \ell^\pm\ell'^\mp$ with zero or one associated jets channel relative uncertainties (%)

Contribution	WW	WZ	ZZ	$t\bar{t}$	DY	$W\gamma$	W+jet(s)	$gg \rightarrow H$	WH	ZH	VBF
Cross Section											
ScaleInclusive								8.1			
Scale1+Jets								0.0			
Scale2+Jets								-5.1			
PDF Model								10.5			
Total	*6.0*	*6.0*	*6.0*	7.0	5.0				**5.0**	**5.0**	10.0
Acceptance											
Scale (jets)	*-0.4*s										
PDF Model (leptons)								1.0			
PDF Model (jets)	*1.6*							2.1			
Higher-order Diagrams		*10.0*	*10.0*	10.0	10.0				**10.0**	**10.0**	**10.0**
Conversion Modeling						8.4					
Jet Fake Rates							13.8				
Jet Energy Scale	*1.2*	*2.2*	*2.0*	*13.3*	*15.4*	*1.2*		*2.4*	*9.2*	*6.5*	*7.8*
Lepton ID Efficiencies	*3.8*	*3.8*	*3.8*	*3.8*	*3.8*			*3.8*	*3.8*	*3.8*	*3.8*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*			*2.0*	*2.0*	*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*	*5.9*			*5.9*	*5.9*	*5.9*	*5.9*

TABLE XIX: Systematic uncertainties on the signal and background contributions for CDF's $H \rightarrow W^+W^- \rightarrow e^{\pm}\tau^{\mp}$ and $H \rightarrow W^+W^- \rightarrow \mu^{\pm}\tau^{\mp}$ channels. These channels are sensitive to gluon fusion production, WH, ZH and VBF production. Systematic uncertainties are listed by name (see the original references for a detailed explanation of their meaning and on how they are derived). Systematic uncertainties for H shown in this table are obtained for $m_H = 160$ GeV$/c^2$. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. The uncertainties associated with the different background and signal processed are correlated within individual categories unless otherwise noted. In these special cases, the correlated uncertainties are shown in either italics or bold face text.

CDF: $H \rightarrow W^+W^- \rightarrow e^{\pm}\tau^{\mp}$ channel relative uncertainties ( )

Contribution	WW	WZ	ZZ	$t\bar{t}$	$Z \rightarrow \tau\tau$	$Z \rightarrow \ell\ell$	W+jet	$W\gamma$	$gg \rightarrow H$	WH	ZH	VBF
Cross section	6.0	6.0	6.0	10.0	5.0	5.0			10.3	5	5	10
Measured W cross-section							12					
PDF Model	1.6	2.3	3.2	2.3	2.7	4.6	2.2	3.1	2.5	2.0	1.9	1.8
Higher order diagrams	10	10	10	10	10	10		10		10	10	10
Conversion modeling								10				
Trigger Efficiency	0.5	0.6	0.6	0.6	0.7	0.5	0.6	0.6	0.5	0.5	0.6	0.5
Lepton ID Efficiency	0.4	0.5	0.5	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4
τ ID Efficiency	1.0	1.3	1.9	1.3	2.1			0.3	2.8	1.6	1.7	2.8
Jet into τ Fake rate	5.8	4.8	2.0	5.1		0.1	8.8			4.2	4.0	0.4
Lepton into τ Fake rate	0.2	0.1	0.6	0.2		2.3		2.1	0.15	0.06	0.15	0.11
W+jet scale							1.6					
MC Run dependence	2.6	2.6	2.6				2.6					
Luminosity	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Luminosity Monitor	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4

CDF: $H \rightarrow W^+W^- \rightarrow \mu^{\pm}\tau^{\mp}$ channel relative uncertainties (%)

Contribution	WW	WZ	ZZ	$t\bar{t}$	$Z \rightarrow \tau\tau$	$Z \rightarrow \ell\ell$	W+jet	$W\gamma$	$gg \rightarrow H$	WH	ZH	VBF
Cross section	6.0	6.0	6.0	10.0	5.0	5.0			10.4	5	5	10
Measured W cross-section							12					
PDF Model	1.5	2.1	2.9	2.1	2.5	4.3	2.0	2.9	2.6	2.2	2.0	2.2
Higher order diagrams	10	10	10	10				11		10	10	10
Trigger Efficiency	1.3	0.7	0.7	1.1	0.9	1.3	1.0	1.0	1.3	1.3	1.2	1.3
Lepton ID Efficiency	1.1	1.4	1.4	1.1	1.2	1.1	1.4	1.3	1.0	1.0	1.0	1.0
τ ID Efficiency	1.0	1.2	1.4	1.6	1.9				2.9	1.6	1.7	2.8
Jet into τ Fake rate	5.8	5.0	4.4	4.4		0.2	8.8			4.5	4.2	0.4
Lepton into τ Fake rate	0.06	0.05	0.09	0.04		1.9		1.2	0.04	0.02	0.02	0.04
W+jet scale							1.4					
MC Run dependence	3.0	3.0	3.0				3.0					
Luminosity	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Luminosity Monitor	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4

TABLE XX: Systematic uncertainties on the signal and background contributions for CDF's $WH \to WWW \to \ell^{\pm}\ell'^{\pm}$ channel with one or more associated jets and $WH \to WWW \to \ell^{\pm}\ell'^{\pm}\ell''^{\mp}$ channel. These channels are sensitive to only WH and ZH production. Systematic uncertainties are listed by name (see the original references for a detailed explanation of their meaning and on how they are derived). Systematic uncertainties for H shown in this table are obtained for $m_H = 160$ GeV$/c^2$. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. The uncertainties associated with the different background and signal processed are correlated within individual categories unless otherwise noted. In these special cases, the correlated uncertainties are shown in either italics or bold face text.

CDF: $WH \to WWW \to \ell^{\pm}\ell'^{\pm}$ channel relative uncertainties (%)

Contribution	WW	WZ	ZZ	$t\bar{t}$	DY	$W\gamma$	W+jet	WH	ZH
Cross Section									
Total	*6.0*	*6.0*	*6.0*	7.0	5.0			**5.0**	**5.0**
Acceptance									
Scale (jets)	-6.1								
PDF Model (jets)	5.7								
Higher-order Diagrams		*10.0*	*10.0*	10.0	10.0	10.0		**10.0**	**10.0**
Conversion Modeling						6.8			
Jet Fake Rates							37.7		
Charge Mismeasurement Rate	*25.0*				*25.0*				
Jet Energy Scale	*-4.1*	*-4.2*s	*-3.3*s	*-0.3*	*-4.9*s	*-9.1*		*-1.0*s	*-0.7*s
Lepton ID Efficiencies	*3.8*	*3.8*	*3.8*	*3.8*	*3.8*			*3.8*	*3.8*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*	*2.0*			*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*	*5.9*			*5.9*	*5.9*

CDF: $WH \to WWW \to \ell^{\pm}\ell'^{\pm}\ell''^{\mp}$ channel relative uncertainties (%)

Contribution	WZ	ZZ	$Z\gamma$	$t\bar{t}$	Fakes	WH	ZH
Cross Section							
Total	*6.0*	*6.0*	10.0	7.0		**5.0**	**5.0**
Acceptance							
Higher-order Diagrams	*10.0*	*10.0*	15.0	10.0		**10.0**	**10.0**
Jet Fake Rates					22.3		
b-Jet Fake Rates				27.3			
Jet Energy Scale			*-3.0*				
Lepton ID Efficiencies	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*		*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*		*5.9*	*5.9*

TABLE XXI: Systematic uncertainties on the signal and background contributions for CDF's $ZH \rightarrow ZWW \rightarrow \ell^{\pm}\ell^{\mp}\ell'^{\pm}$ channels with 1 jet and 2 or more jets. These channels are sensitive to only WH and ZH production. Systematic uncertainties are listed by name (see the original references for a detailed explanation of their meaning and on how they are derived). Systematic uncertainties for H shown in this table are obtained for $m_H = 160$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. The uncertainties associated with the different background and signal processed are correlated within individual categories unless otherwise noted. In these special cases, the correlated uncertainties are shown in either italics or bold face text.

CDF: $ZH \rightarrow ZWW \rightarrow \ell^{\pm}\ell^{\mp}\ell'^{\pm}$ with one associated jet channel relative uncertainties (%)

Contribution	WZ	ZZ	$Z\gamma$	$t\bar{t}$	Fakes	WH	ZH
Cross Section							
Total	*6.0*	*6.0*	10.0	7.0		**5.0**	**5.0**
Acceptance							
Higher-order Diagrams	*10.0*	*10.0*	15.0	10.0		**10.0**	**10.0**
Jet Fake Rates					23.6		
b-Jet Fake Rates				42.0			
Jet Energy Scale	*-7.8*	*-2.4*	*-6.4*	*2.2*		*-7.0*	*7.1*
Lepton ID Efficiencies	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*		*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*		*5.9*	*5.9*

CDF: $ZH \rightarrow ZWW \rightarrow \ell^{\pm}\ell^{\mp}\ell'^{\pm}$ with two or more associated jets channel relative uncertainties (%)

Contribution	WZ	ZZ	$Z\gamma$	$t\bar{t}$	Fakes	WH	ZH
Cross Section							
Total	*6.0*	*6.0*	10.0	7.0		**5.0**	**5.0**
Acceptance							
Higher-order Diagrams	*10.0*	*10.0*	15.0	10.0		**10.0**	**10.0**
Jet Fake Rates					18.4		
b-Jet Fake Rates				22.2			
Jet Energy Scale	*-18.0*	*-15.4*	*-16.8*	*-2.3*		*-20.1*	*-5.5*
Lepton ID Efficiencies	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*
Trigger Efficiencies	*2.0*	*2.0*	*2.0*	*2.0*		*2.0*	*2.0*
Luminosity	*5.9*	*5.9*	*5.9*	*5.9*		*5.9*	*5.9*

TABLE XXII: Systematic uncertainties on the signal and background contributions for D0's $H \rightarrow W^+W^- \rightarrow \ell^\pm\ell^\mp$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Shape uncertainties are labeled with the "s" designation. Systematic uncertainties given in this table are obtained for the $m_H = 165$ GeV/c^2 Higgs selection. Cross section uncertainties on the $gg \rightarrow H$ signal depend on the jet multiplicity, as described in the main text. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

$H \rightarrow W^+W^- \rightarrow \ell^\pm\ell^\mp$ channels relative uncertainties (%)

Contribution	Dibosons	$Z/\gamma^* \rightarrow \ell\ell$	W+jet/γ	$t\bar{t}$	Multijet	$gg \rightarrow H$	$qq \rightarrow qqH$	VH
Luminosity/Normalization	4	–	4	4	4	4	4	4
Cross Section (Scale/PDF)	5-7	–	–	7	–	13-33/8-30	5	6
$Z/\gamma^* \rightarrow \ell\ell$ n-jet norm	–	2-15	–	–	–	–	–	–
$Z/\gamma^* \rightarrow \ell\ell$ MET model	–	5-19	–	–	–	–	–	–
W+jet/γ norm	–	–	6-30	–	–	–	–	–
W+jet/γ ISR/FSR model (s)	–	–	2-20	–	–	–	–	–
Vertex Confirmation (s)	1-5	1-5	1-5	5-6	–	1-5	1-5	1-5
Jet identification (s)	1	1	1	1	–	1	1	1
Jet Energy Scale (s)	1-5	1-5	1-5	1-4	–	1-5	1-5	1-4
Jet Energy Resolution(s)	1-4	1-4	1-4	1-4	–	1-3	1-4	1-3
B-tagging (s)	–	–	–	1-5	–	–	–	–

TABLE XXIII: Systematic uncertainties on the signal and background contributions for D0's $H \rightarrow W^+W^- \rightarrow \mu\nu\tau_{\rm had}\nu$ channel. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Shape uncertainties are labeled with the shape designation (S). Systematic uncertainties shown in this table are obtained for the $m_H = 165$ GeV/c^2 Higgs selection. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

D0: $H \rightarrow W^+W^- \rightarrow \mu\nu\tau_{\rm had}\nu$ channel relative uncertainties (%)

Contribution	Diboson	$Z/\gamma^* \rightarrow \ell\ell$	W+jets	$t\bar{t}$	Multijet	$gg \rightarrow H$	$qq \rightarrow qqH$	VH
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)	4.6	4.6	-	4.6	-	4.6	4.6	4.6
Luminosity Monitor	4.1	4.1	-	4.1	-	4.1	4.1	4.1
Trigger	5.0	5.0	-	5.0	-	5.0	5.0	5.0
Lepton ID	3.7	3.7	-	3.7	-	3.7	3.7	3.7
EM veto	5.0	-	-	5.0	-	5.0	5.0	5.0
Tau Energy Scale (S)	1.0	1.1	-	<1	-	<1	<1	<1
Jet Energy Scale (S)	8.0	<1	-	1.8	-	2.5	2.5	2.5
Jet identification (S)	<1	<1	-	7.5	-	5.0	5.0	5.0
Multijet (S)	-	-	-	-	20-50	-	-	-
Cross Section (scale/PDF)	7.0	4.0	-	10	-	7/8	4.9	6.1
Signal Branching Fraction	-	-	-	-	-	0-7.3	0-7.3	0-7.3
Modeling	1.0	-	10	-	-	3.0	3.0	3.0

TABLE XXIV: Systematic uncertainties on the signal and background contributions for D0's $VH \rightarrow e^{\pm}\nu_e\mu^{\pm}\nu_\mu (V = W, Z)$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Shape uncertainties are labeled with the "shape" designation. Systematic uncertainties shown in this table are obtained for the $m_H = 165$ GeV/c^2 Higgs selection. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

$VH \rightarrow e^{\pm}\nu_e\mu^{\pm}\nu_\mu$ like charge electron muon pair channel relative uncertainties (%)

Contribution	VH	$Z + jet/\gamma$	$W + jet/\gamma$	$t\bar{t}$	Diboson	Multijet
Cross section	6.2	–	–	6	7	–
Luminosity/Normalization	4	–	4	4	4	–
Multijet	–	–	–	–	–	30
Trigger	2	2	2	2	2	2
Charge flip	–	50	–	50	50	–
W+jets/γ	–	–	10	–	–	–
$W - p_T$ model	–	–	shape	–	–	–
$Z - p_T$ model	–	shape	–	–	–	–
W+jets/γ ISR/FSR model	–	–	shape	–	–	–

TABLE XXV: Systematic uncertainties on the signal and background contributions for D0's $VH \rightarrow VWW \rightarrow ee\mu, \mu\mu e$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Shape uncertainties are labeled with the "s" designation. Systematic uncertainties given in this table are obtained for the $m_H = 145$ GeV Higgs selection. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

$VH \rightarrow VWW \rightarrow$ Trilepton channels relative uncertainties (%)

Contribution	Dibosons	$Z/\gamma^* \rightarrow \ell\ell$	W+jet/γ	$t\bar{t}$	$Z\gamma$	VH	$gg \rightarrow H$	$qq \rightarrow qqH$
Luminosity	6.1	6.1	6.1	6.1	–	6.1	6.1	6.1
Cross Section (Scale/PDF)	6	6	6	7	–	6.2	7	4.9
PDF	2.5	2.5	2.5	2.5	–	2.5	2.5	2.5
Electron Identification	2.5	2.5	2.5	2.5	–	2.5	2.5	2.5
Muon Identification	4	4	4	4	–	4	4	4
Trigger	3.5	3.5	3.5	3.5	–	3.5	3.5	3.5
$Z\gamma$	–	–	–	–	8	–	–	–
$V + jets$ lepton fake rate	–	30	30	–	–	–	–	–
Z-p_T reweighting (s)	–	$\pm1\sigma$	–	–	–	–	–	–
Electron smearing (s)	$\pm1\sigma$	$\pm1\sigma$	$\pm1\sigma$	$\pm1\sigma$	–	$\pm1\sigma$	$\pm1\sigma$	$\pm1\sigma$
Muon smearing (s)	$\pm1\sigma$	$\pm1\sigma$	$\pm1\sigma$	$\pm1\sigma$	–	$\pm1\sigma$	$\pm1\sigma$	$\pm1\sigma$

TABLE XXVI: Systematic uncertainties on the signal and background contributions for D0's $\tau\tau\mu$ +X channel. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Shape uncertainties are labeled with the "s" designation. Cross section uncertainties on the $gg \to H$ signal depend on the jet multiplicity, as described in the main text. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

$\tau\tau\mu$ +X channels relative uncertainties (%)

Contribution	Dibosons	Z/γ^*	$t\bar{t}$	Instrumental	$gg \to H$	$qq \to qqH$	VH
Luminosity/Normalization	6	6	6	24	6	6	6
Trigger	3	3	3	–	3	3	3
Cross Section (Scale/PDF)	7	6	10	–	13-33/7.6-30	4.9	6.2
PDF	2.5	2.5	2.5	–	2.5	2.5	2.5
Tau Id per τ (Type 1/2/3)	7/3.5/5	7/3.5/5	7/3.5/5	–	7/3.5/5	7/3.5/5	7/3.5/5
Tau Energy Scale	1	1	1	–	1	1	1
Tau Track Match per τ	1.4	1.4	1.4	–	1.4	1.4	1.4
Muon Identification	2.9	2.9	2.9	–	2.9	2.9	2.9

TABLE XXVII: Systematic uncertainties on the signal and background contributions for D0's $H \to WW^* \to \ell\nu jj$ electron and muon channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Signal uncertainties are shown for $m_H = 160$ GeV/c^2 for all channels except for WH, shown for $m_H = 115$ GeV/c^2. Those affecting the shape of the RF discriminant are indicated with "Y." Uncertainties are listed as relative changes in normalization, in percent, except for those also marked by "S," where the overall normalization is constant, and the value given denotes the maximum percentage change from nominal in any region of the distribution.

D0: $H \to WW^* \to \ell\nu jj$ Run II channel relative uncertainties (%)

Contribution	Shape	W+jets	Z+jets	Top	Diboson	$gg \to H$	$qq \to qqH$	WH
Jet energy scale	Y	$\binom{+6.7}{-5.4}^S$	< 0.1	± 0.7	± 3.3	$\binom{+5.7}{-4.0}$	± 1.5	$\binom{+2.7}{-2.3}$
Jet identification	Y	$\pm 6.6^S$	< 0.1	± 0.5	± 3.8	± 1.0	± 1.1	± 1.0
Jet resolution	Y	$\binom{+6.6}{-4.1}^S$	< 0.1	± 0.5	$\binom{+1.0}{-0.5}$	$\binom{+3.0}{-0.5}$	± 0.8	± 1.0
Association of jets with PV	Y	$\pm 3.2^S$	$\pm 1.3^S$	± 1.2	± 3.2	± 2.9	± 2.4	$\binom{+0.9}{-0.2}$
Luminosity	N	n/a	n/a	± 6.1	± 6.1	± 6.1	± 6.1	± 6.1
Muon trigger	Y	$\pm 0.4^S$	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Electron identification	N	± 4.0	± 4.0	± 4.0	± 4.0	± 4.0	± 4.0	± 4.0
Muon identification	N	± 4.0	± 4.0	± 4.0	± 4.0	± 4.0	± 4.0	± 4.0
ALPGEN tuning	Y	$\pm 1.1^S$	$\pm 0.3^S$	n/a	n/a	n/a	n/a	n/a
Cross Section	N	± 6	± 6	± 10	± 7	± 10	± 10	± 6
Heavy-flavor fraction	Y	± 20	± 20	n/a	n/a	n/a	n/a	n/a
Signal Branching Fraction	N	n/a	n/a	n/a	n/a	0-7.3	0-7.3	0-7.3
PDF	Y	$\pm 2.0^S$	$\pm 0.7^S$	$< 0.1^S$	$< 0.1^S$	$< 0.1^S$	$< 0.1^S$	$< 0.1^S$
			Electron channel			Muon channel		
Multijet Background	Y		± 6.5			± 26		

TABLE XXVIII: Systematic uncertainties on the signal and background contributions for CDF's $H \to \ell^{\pm}\ell^{\mp}\ell'^{\pm}\ell'^{\mp}$ channel. This channel is sensitive to gluon fusion production and WH, ZH and VBF production. Systematic uncertainties are listed by name (see the original references for a detailed explanation of their meaning and on how they are derived). Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. The uncertainties associated with the different background and signal processed are correlated unless otherwise noted. Boldface and italics indicate groups of uncertainties which are correlated with each other but not the others within a line. Shape uncertainties are labeled with an "s".

CDF: $H \to \ell^{\pm}\ell^{\mp}\ell'^{\pm}\ell'^{\mp}$ channel relative uncertainties (%)

Contribution	ZZ	$Z(/\gamma^*)$+jets	$gg \to H$	WH	ZH	VBF
Cross Section :						
Scale			7.0			
PDF Model			7.7			
Total	*10.0*			**5.0**	**5.0**	10.0
$\mathcal{BR}(H \to VV)$			3.0	3.0	3.0	3.0
Acceptance :						
PDF Model	2.7					
Higher-order Diagrams	2.5					
Jet Fake Rates		50.0				
$\not{E}_T$ Resolution	s		s		s	s
Lepton ID Efficiencies	*3.6*		*3.6*	*3.6*	*3.6*	*3.6*
Trigger Efficiencies	*0.4*		*0.5*	*0.5*	*0.5*	*0.5*
Luminosity	*5.9*		*5.9*	*5.9*	*5.9*	*5.9*

TABLE XXIX: Systematic uncertainties on the signal and background contributions for CDF's $t\bar{t}H \to \ell$+jets channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for $t\bar{t}H$ shown in this table are obtained for $m_H = 115$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

CDF: $t\bar{t}H$ $\ell + \not\!\!E_T$ 4 jets channel relative uncertainties (%)

	1 tight, 1 loose		1 tight, ≥ 2 loose		2 tight, 0 loose		2 tight, ≥ 1 loose		≥ 3 tight, ≥ 0 loose	
Contribution	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$
$t\bar{t}$ Cross Section		10		10		10		10		10
$t\bar{t}H$ Cross Section	10		10		10		10		10	
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Luminosity Monitor	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
B-Tag Efficiency	$^{+1.79}_{-1.89}$	$^{-0.23}_{-0.86}$	$^{+4.77}_{-4.75}$	$^{-1.74}_{-1.84}$	$^{+9.09}_{-9.75}$	$^{+7.50}_{-5.98}$	$^{+14.42}_{-9.41}$	$^{+5.14}_{-6.72}$	$^{+14.79}_{-19.02}$	$^{+15.46}_{-14.28}$
Mistag Rate	$^{+1.89}_{-0.72}$	$^{+1.09}_{-0.11}$	$^{+12.41}_{-6.71}$	$^{+5.14}_{-4.84}$	$^{-0.27}_{+0.64}$	$^{-0.14}_{+0.39}$	$^{+9.61}_{-3.56}$	$^{+1.92}_{+1.75}$	$^{+2.99}_{-5.14}$	$^{+1.13}_{-1.37}$
Jet Energy Scale	$^{+2.77}_{-4.38}$	$^{-8.80}_{+8.06}$	$^{+3.57}_{-0.33}$	$^{-8.33}_{+11.92}$	$^{+2.52}_{-3.80}$	$^{-9.06}_{+7.42}$	$^{+3.77}_{-0.48}$	$^{-9.77}_{+8.77}$	$^{+1.48}_{-2.61}$	$^{-5.66}_{+6.74}$
ISR+FSR+PDF	0.36	3.04	0.38	0.75	1.29	2.73	3.86	5.28	0.33	5.13

CDF: $t\bar{t}H$ $\ell + \not\!\!E_T$ 5 jets channel relative uncertainties (%)

	1 tight, 1 loose		1 tight, ≥ 2 loose		2 tight, 0 loose		2 tight, ≥ 1 loose		≥ 3 tight, ≥ 0 loose	
Contribution	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$
$t\bar{t}$ Cross Section		10		10		10		10		10
$t\bar{t}H$ Cross Section	10		10		10		10		10	
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Luminosity Monitor	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
B-Tag Efficiency	$^{+1.25}_{-0.55}$	$^{-1.96}_{+2.06}$	$^{+1.99}_{-5.21}$	$^{-0.99}_{+0.89}$	$^{+8.69}_{-9.74}$	$^{+5.80}_{-7.30}$	$^{+11.36}_{-12.13}$	$^{+4.48}_{-4.50}$	$^{+14.94}_{-16.28}$	$^{+12.96}_{-15.87}$
Mistag Rate	$^{+2.81}_{-0.78}$	$^{+1.96}_{-0.66}$	$^{+12.47}_{-11.50}$	$^{+1.19}_{-2.53}$	$^{-1.94}_{+0.92}$	$^{-0.57}_{-0.77}$	$^{+10.70}_{-7.19}$	$^{+0.87}_{-2.66}$	$^{+4.02}_{-9.48}$	$^{+1.15}_{-0.23}$
Jet Energy Scale	$^{+14.48}_{-11.71}$	$^{-1.02}_{+2.51}$	$^{+9.96}_{-12.79}$	$^{-0.64}_{-1.34}$	$^{+11.84}_{-13.49}$	$^{-2.21}_{+0.66}$	$^{+13.07}_{-9.15}$	$^{-3.40}_{+1.48}$	$^{+6.51}_{-7.57}$	$^{-3.12}_{+2.45}$
ISR+FSR+PDF	3.42	2.41	11.28	0.79	5.24	2.30	3.89	3.26	3.95	2.88

CDF: $t\bar{t}H$ $\ell + \not\!\!E_T$ 6 or more jets channel relative uncertainties (%)

	1 tight, 1 loose		1 tight, ≥ 2 loose		2 tight, 0 loose		2 tight, ≥ 1 loose		≥ 3 tight, ≥ 0 loose	
Contribution	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$	$t\bar{t}$	$t\bar{t}H$
$t\bar{t}$ Cross Section		10		10		10		10		10
$t\bar{t}H$ Cross Section	10		10		10		10		10	
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Luminosity Monitor	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
B-Tag Efficiency	$^{+1.52}_{-1.47}$	$^{-2.07}_{+1.85}$	$^{+4.07}_{-1.53}$	$^{-0.89}_{+2.99}$	$^{+9.02}_{-8.39}$	$^{+4.27}_{-8.07}$	$^{+17.30}_{-8.32}$	$^{+4.78}_{-3.91}$	$^{+12.00}_{-14.59}$	$^{+13.13}_{-12.00}$
Mistag Rate	$^{+1.76}_{-2.29}$	$^{+1.72}_{+0.21}$	$^{+17.63}_{-16.95}$	$^{+4.43}_{-3.03}$	$^{-1.46}_{+2.68}$	$^{-2.55}_{-1.33}$	$^{+15.68}_{-12.32}$	$^{+2.25}_{+0.98}$	$^{+8.47}_{-11.76}$	$^{-0.12}_{-2.05}$
Jet Energy Scale	$^{+25.07}_{-21.07}$	$^{+12.17}_{-12.62}$	$^{+17.29}_{-20.68}$	$^{+11.78}_{-9.86}$	$^{+25.58}_{-22.19}$	$^{+10.81}_{-13.16}$	$^{+26.49}_{-17.30}$	$^{+10.02}_{-8.69}$	$^{+23.29}_{-19.76}$	$^{+8.58}_{-11.05}$
ISR+FSR+PDF	13.17	0.75	17.33	2.32	12.38	1.42	20.89	1.15	14.84	0.38

TABLE XXX: Systematic uncertainties on the signal and background contributions for CDF's $t\bar{t}H$ 2-tag and 3-tag $\not\!\!E_T$+jets channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for $t\bar{t}H$ shown in this table are obtained for $m_H = 120$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

CDF: $t\bar{t}H$ $\not\!\!E_T$+jets 2-tag channel relative uncertainties (%)

Contribution	non-$t\bar{t}$	$t\bar{t}$	$t\bar{t}H$
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)	0	3.8	3.8
Luminosity Monitor	0	4.4	4.4
Jet Energy Scale	0	2	11
Trigger Efficiency	0	7	7
B-Tag Efficiency	0	7	7
ISR/FSR	0	2	2
PDF	0	2	2
$t\bar{t}$ Cross Section	0	10	0
$t\bar{t}b\bar{b}$ Cross Section	0	3	0
Signal Cross Section	0	0	10
Background Modeling	6	0	0
Background B-tagging	5	0	0

CDF: $t\bar{t}H$ $\not\!\!E_T$+jets 3-tag channel relative uncertainties (%)

Contribution	non-$t\bar{t}$	$t\bar{t}$	$t\bar{t}H$
Luminosity ($\sigma_{\rm inel}(p\bar{p})$)	0	3.8	3.8
Luminosity Monitor	0	4.4	4.4
Jet Energy Scale	0	3	13
Trigger Efficiency	0	7	7
B-Tag Efficiency	0	9	9
ISR/FSR	0	2	2
PDF	0	2	2
$t\bar{t}$ Cross Section	0	10	0
$t\bar{t}b\bar{b}$ Cross Section	0	5	0
Signal Cross Section	0	0	10
Background Modeling	6	0	0
Background B-tagging	10	0	0

TABLE XXXI: Systematic uncertainties on the signal and background contributions for CDF's $t\bar{t}H$ 2-tag and 3-tag all jets channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for $t\bar{t}H$ shown in this table are obtained for $m_H = 120$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

CDF: $t\bar{t}H$ all jets 2-tag channel relative uncertainties (%)

Contribution	non-$t\bar{t}$	$t\bar{t}$	$t\bar{t}H$
Luminosity ($\sigma_{\text{inel}}(p\bar{p})$)	0	3.8	3.8
Luminosity Monitor	0	4.4	4.4
Jet Energy Scale	0	11	20
Trigger Efficiency	0	7	7
B-Tag Efficiency	0	7	7
ISR/FSR	0	2	2
PDF	0	2	2
$t\bar{t}$ Cross Section	0	10	0
$t\bar{t}b\bar{b}$ Cross Section	0	3	0
Signal Cross Section	0	0	10
Background Modeling	9	0	0
Background B-tagging	5	0	0

CDF: $t\bar{t}H$ all jets 3-tag channel relative uncertainties (%)

Contribution	non-$t\bar{t}$	$t\bar{t}$	$t\bar{t}H$
Luminosity ($\sigma_{\text{inel}}(p\bar{p})$)	0	3.8	3.8
Luminosity Monitor	0	4.4	4.4
Jet Energy Scale	0	13	22
Trigger Efficiency	0	7	7
B-Tag Efficiency	0	9	9
ISR/FSR	0	2	2
PDF	0	2	2
$t\bar{t}$ Cross Section	0	10	0
$t\bar{t}b\bar{b}$ Cross Section	0	6	0
Signal Cross Section	0	0	10
Background Modeling	9	0	0
Background B-tagging	10	0	0

TABLE XXXII: Systematic uncertainties on the signal and background contributions for CDF's $H \to \tau^+\tau^-$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for the Higgs signal shown in these tables are obtained for $m_H = 120$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. Shape uncertainties are labeled with an "S".

CDF: $H \to \tau^+\tau^-(e/\mu + \tau_{had})$ channel relative uncertainties (%)

Contribution	$Z/\gamma^* \to \tau\tau$	$Z/\gamma^* \to ee$	$Z/\gamma^* \to \mu\mu$	$t\bar{t}$	diboson	fakes from SS	W+jets	WH	ZH	VBF	$gg \to H$
PDF Uncertainty	-	-	-	-	-	-	-	1.2	0.9	2.2	4.9
ISR/FSR 1 JET	-	-	-	-	-	-	-	6.7	8.7	8.8	3.6
ISR/FSR $\geq$ 2 JETS	-	-	-	-	-	-	-	4.8	3.8	3.9	19.1
JES (S) 1 JET	9.5	8.5	8.5	14.5	0.5	-	4.2	2.8	6.4	6.5	4.3
JES (S) $\geq$ 2 JETS	18.9	22.3	22.3	1.3	10.7	-	15.4	5.1	3.9	3.7	14.5
Normalization 1 JET	2.0	5.0	5.0	10.0	6.0	1.3	14.8	5.0	5.0	10.0	23.5
Normalization $\geq$2 JETS	2.0	5.0	5.0	10.0	6.0	2.5	14.8	5.0	5.0	10.0	33.0
ε_{trig} (e leg)	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	0.3	0.3
ε_{trig} (μ leg)	1.0	-	1.0	1.0	1.0	-	-	1.0	1.0	1.0	1.0
ε_{trig} (τ leg)	3.0	3.0	3.0	3.0	3.0	-	-	3.0	3.0	3.0	3.0
$\varepsilon_{ID}e$	2.4	2.4	-	2.4	2.4	-	-	2.4	2.4	2.4	2.4
$\varepsilon_{ID}\mu$	2.6	-	2.6	2.6	2.6	-	-	2.6	2.6	2.6	2.6
$\varepsilon_{ID}\tau$	3.0	3.0	3.0	3.0	3.0	-	-	3.0	3.0	3.0	3.0
ε_{vtx}	0.5	0.5	0.5	0.5	0.5	-	-	0.5	0.5	0.5	0.5
Luminosity	5.9	5.9	5.9	5.9	5.9	-	-	5.9	5.9	5.9	5.9

TABLE XXXIII: Systematic uncertainties on the signal and background contributions for CDF's $WH \to \ell\nu\tau^+\tau^-$ and $ZH \to \ell^+\ell^-\tau^+\tau^-$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Systematic uncertainties for the Higgs signal shown in these tables are obtained for $m_H = 120$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

CDF: $WH \to \ell\nu\tau^+\tau^-$ and $ZH \to \ell^+\ell^-\tau^+\tau^-$ $\ell\ell\tau_h + X$ channel relative uncertainties (%)

Contribution	ZZ	WZ	WW	$DY(ee)$	$DY(\mu\mu)$	$DY(\tau\tau)$	$Z\gamma$	$t\bar{t}$	$W\gamma$	$W+jet$	WH	ZH	VBF	$gg \to H$
Luminosity	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Cross Section	11.7	11.7	11.7	5.0	5.0	5.0	11.7	14.1	11.7	5.0	5.0	5.0	10.0	10.0
Z-vertex Cut Efficiency	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Trigger Efficiency	1.1	1.1	1.0	1.0	1.0	1.1	1.1	1.0	0.8	1.0	1.2	1.2	1.2	1.1
Lepton ID Efficiency	2.4	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.4	2.4	2.4	2.4	2.4
Lepton Fake Rate	10.7	8.0	26.7	26.0	26.6	15.1	27.1	22.4	22.8	28.7	2.9	2.3	15.1	13.6
Jet Energy Scale	1.3	1.1	0.0	3.2	5.1	0.6	6.6	0.1	2.0	0.2	0.1	0.03	0.6	0.4
MC stat	3.7	2.9	7.6	1.5	1.7	2.2	4.1	3.1	20.0	3.1	1.5	1.4	3.8	9.4
PDF Model	-	-	-	-	-	-	-	-	-	-	1.2	0.9	2.2	4.9
ISR/FSR Uncertainties	-	-	-	-	-	-	-	-	-	-	1.3	2.1	0.6	0.2

CDF: $WH \to \ell\nu\tau^+\tau^-$ and $ZH \to \ell^+\ell^-\tau^+\tau^-$ $e\mu\tau_h + X$ channel relative uncertainties (%)

Contribution	ZZ	WZ	WW	$DY(ee)$	$DY(\mu\mu)$	$DY(\tau\tau)$	$Z\gamma$	$t\bar{t}$	$W\gamma$	$W+jet$	WH	ZH	VBF	$gg \to H$
Luminosity	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Cross Section	11.7	11.7	11.7	5.0	5.0	5.0	11.7	14.1	11.7	5.0	5.0	5.0	10.0	10.0
Z-vertex Cut Efficiency	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Trigger Efficiency	1.4	1.4	1.1	1.1	1.3	1.1	1.4	1.1	1.0	0.7	1.3	1.3	1.2	1.2
Lepton ID Efficiency	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Lepton Fake Rate	9.0	6.5	26.6	20.8	31.4	25.2	39.4	27.8	19.3	41.9	1.6	2.5	28.5	29.2
Jet Energy Scale	0.0	0.3	2.2	0.0	0.8	1.5	0.5	0.8	0.0	0.0	0.2	0.1	1.7	0.0
MC stat	12.9	7.2	20.9	57.7	12.6	7.7	10.2	12.4	35.4	25.8	2.1	3.9	13.0	44.7
PDF Model	-	-	-	-	-	-	-	-	-	-	1.2	0.9	2.2	4.9
ISR/FSR Uncertainties	-	-	-	-	-	-	-	-	-	-	0.6	0.2	0.1	0.0

CDF: $WH \to \ell\nu\tau^+\tau^-$ and $ZH \to \ell^+\ell^-\tau^+\tau^-$ $\ell\tau_h\tau_h + X$ channel relative uncertainties (%)

Contribution	ZZ	WZ	WW	$DY(ee)$	$DY(\mu\mu)$	$DY(\tau\tau)$	$Z\gamma$	$t\bar{t}$	$W\gamma$	$W+jet$	WH	ZH	VBF	$gg \to H$
Luminosity	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Cross Section	11.7	11.7	11.7	5.0	5.0	5.0	11.7	14.1	11.7	5.0	5.0	5.0	10.0	10.0
Z-vertex Cut Efficiency	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Trigger Efficiency	1.0	1.1	0.9	1.0	1.1	1.1	1.1	1.0	0.7	0.9	1.1	1.1	1.1	1.1
Lepton ID Efficiency	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Lepton Fake Rate	10.4	6.8	38.1	43.3	39.9	24.8	32.8	34.2	28.8	34.8	3.1	5.9	28.1	26.3
Jet Energy Scale	5.5	0.0	0.0	3.3	1.6	1.2	1.6	0.0	0.0	1.1	0.1	0.6	1.8	1.7
MC stat	12.5	8.1	16.9	18.3	12.5	4.9	12.6	14.7	70.7	8.7	2.0	3.3	9.4	18.3
PDF Model	-	-	-	-	-	-	-	-	-	-	1.2	0.9	2.2	4.9
ISR/FSR Uncertainties	-	-	-	-	-	-	-	-	-	-	1.2	0.5	0.4	0.04

TABLE XXXIV: Systematic uncertainties on the signal and background contributions for CDF's $WH+ZH \rightarrow jjbb$ and $VBF \rightarrow jjbb$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Uncertainties with provided shape systematics are labeled with "s". Systematic uncertainties for H shown in this table are obtained for $m_H = 115$ GeV/c^2. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated. The cross section uncertainties are uncorrelated with each other (except for single top and $t\bar{t}$, which are treated as correlated). The QCD uncertainty is also uncorrelated with other channels' QCD rate uncertainties.

CDF: $WH+ZH \rightarrow jjbb$ and $VBF \rightarrow jjbb$ channel relative uncertainties (%)

Contribution	QCD	$t\bar{t}$	single-top	diboson	W/Z+Jets	VH	VBF
Jet Energy Correction		9 s	9 s	9 s	9 s	9 s	9 s
PDF Modeling						2	2
SecVtx+SecVtx		7.1	7.1	7.1	7.1	7.1	7.1
SecVtx+JetProb		6.4	6.4	6.4	6.4	6.4	6.4
Luminosity		6	6	6	6	6	6
ISR/FSR modeling						3 s	3 s
Jet Width		s	s	s	s	s	s
Trigger		3.6	3.6	3.6	3.6	3.6	3.6
QCD Interpolation	s						
QCD MJJ Tuning	s						
QCD NN Tuning	s						
cross section		7	7	6	50	5	10

TABLE XXXV: Systematic uncertainties on the signal and background contributions for CDF's $H \rightarrow \gamma\gamma$ channels. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

CDF: $H \rightarrow \gamma\gamma$ channel relative uncertainties (%)

Channel	CC	CP	C′C	C′P
Signal Uncertainties :				
Luminosity	6	6	6	6
$\sigma_{ggH}/\sigma_{VH}/\sigma_{VBF}$	14/7/5	14/7/5	14/7/5	14/7/5
PDF	5	2	5	2
ISR/FSR	3	4	2	5
Energy Scale	0.2	0.8	0.1	0.8
Trigger Efficiency	1.0	1.3	1.5	6.0
z Vertex	0.07	0.07	0.07	0.07
Conversion ID	–	–	7	7
Detector Material	0.4	3.0	0.2	3.0
Photon/Electron ID	1.0	2.8	1.0	2.6
Run Dependence	3.0	2.5	1.5	2.0
Data/MC Fits	0.4	0.8	1.5	2.0
Background Uncertainties :				
Fit Function	2.8	0.9	6.1	3.3

TABLE XXXVI: Systematic uncertainties on the signal and background contributions for D0's $H \rightarrow \gamma\gamma$ channel. Systematic uncertainties for the Higgs signal shown in this table are obtained for $m_H = 125$ GeV/c^2. Systematic uncertainties are listed by name; see the original references for a detailed explanation of their meaning and on how they are derived. Uncertainties are relative, in percent, and are symmetric unless otherwise indicated.

D0: $H \rightarrow \gamma\gamma$ channel relative uncertainties (%)

Contribution	Background	Signal
Luminosity	6	6
Acceptance	–	2
electron ID efficiency	2	–
electron track-match inefficiency	10	–
Photon ID efficiency	3	3
Photon energy scale	2	1
Cross Section	4	10
Background subtraction	15	-
ONN Shape	1-5	-