

Search for the Higgs boson in $H \rightarrow \gamma\gamma$ decays in $p\bar{p}$ collisions at 1.96 TeV

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Recent searches conducted at the Fermilab Tevatron for the Higgs boson in the diphoton decay channel are reported using 7.0 fb^{-1} and 8.2 fb^{-1} of data collected at the CDF and D0 experiments, respectively. Although the standard model (SM) branching fraction is small, the diphoton final state is appealing due to better diphoton mass resolution compared with dijet final states. In addition, other models — such as fermiophobic models where the Higgs does not couple to fermions — predict much larger branching fractions for the diphoton decay. Here, results are presented for both a SM and fermiophobic Higgs boson as well as a SM search based on a combination of the CDF and D0 analyses.

1. Introduction

The standard model (SM) of particle physics has proven to be a robust theoretical model that very accurately describes the properties of elementary particles observed in nature and the forces of interaction between them. In this model, the electromagnetic and weak forces are unified into a single electroweak theory. The measured masses of the particles that mediate the electroweak force, however, are vastly different — the photon has zero mass while the W and Z bosons have masses almost 100 times heavier than the mass of a proton. To explain this difference, the theory predicts the existence of a Higgs field which interacts with the electroweak field via electroweak symmetry breaking to produce masses for the W and Z bosons while leaving the photon massless. Interaction with the Higgs field would also explain how other fundamental particles acquire mass. An additional spin-0 particle, the Higgs boson, is also predicted to arise from the Higgs field. This particle is the only SM particle that has not been observed in nature and evidence of this boson would be a direct test of the theory.

The Higgs mechanism is predicted to give mass to other particles, yet the mass of the Higgs boson itself is a free parameter of the theory that must be determined experimentally. Direct searches at the Large Electron-Positron Collider (LEP) at CERN and indirect electroweak measurements result in a preferred SM Higgs boson mass M_H between 114.4 and 185 GeV/c^2 at 95% confidence level (C.L). In this region, the range $156 < M_H < 177 \text{ GeV}/c^2$ has additionally been excluded at 95% C.L. by direct searches at the Fermilab Tevatron $p\bar{p}$ Collider [1] and the range above $M_H > 146$ (145) GeV/c^2 at 95% C.L. by direct searches at the ATLAS (CMS) experiment from the pp Large Hadron Collider at CERN [2, 3].

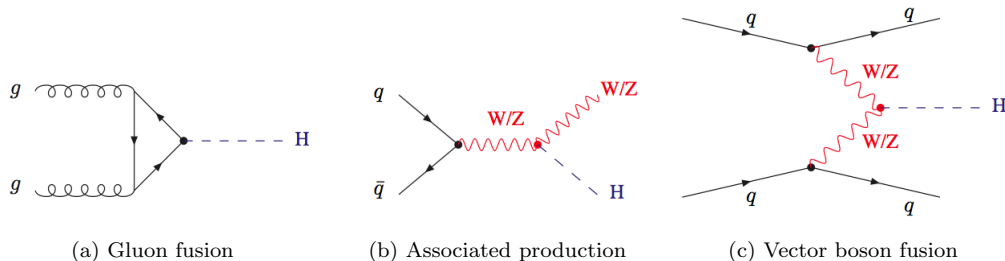


Figure 1: The dominant Higgs boson production mechanisms at the Tevatron for the SM Higgs boson. For the fermiophobic benchmark model, SM couplings are assumed, however the gluon fusion process is suppressed and is therefore not included.

At the Tevatron, the Higgs boson would be produced most often through gluon fusion ($gg \rightarrow H$), followed by associated production with either a W or Z vector boson ($q\bar{q} \rightarrow VH$, $V = W, Z$) and vector boson fusion ($q\bar{q} \rightarrow q'\bar{q}'H$). Figure 1 shows diagrams of these processes and Table I gives the predicted SM cross sections for Higgs boson masses between 100 and 150 GeV/c^2 . The SM Higgs boson search strategy at the Tevatron is driven by the most dominant decay modes. At lower mass ($M_H < 135 \text{ GeV}/c^2$), $H \rightarrow b\bar{b}$ provides the greatest sensitivity to Higgs boson observation despite the exclusion of the gluon fusion process for this channel due to large multijet backgrounds. For $M_H > 135 \text{ GeV}/c^2$, $H \rightarrow WW$ provides the greatest sensitivity. Further sensitivity to a SM Higgs observation at the Tevatron is obtained by the inclusion of more challenging channels

such as $H \rightarrow \gamma\gamma$.

The SM branching fraction for a Higgs boson decaying to a photon pair $B(H \rightarrow \gamma\gamma)$ is very small, reaching a maximal value of about 0.2% at $M_H = 120 \text{ GeV}/c^2$ (see Table I). The greatest sensitivity for this channel, however, is obtained for $110 < M_H < 140 \text{ GeV}/c^2$, in the preferred region from electroweak constraints and in a region where combined Tevatron Higgs boson searches are least sensitive [1]. The diphoton final state is also appealing due to its cleaner signature compared to b jets. The better reconstruction efficiency for photons provides a larger relative acceptance of $H \rightarrow \gamma\gamma$ events and the photon's better energy resolution leads to a narrow $M_{\gamma\gamma}$ mass peak for the Higgs boson, which is a powerful discriminant against smoothly falling diphoton backgrounds. These experimental signatures help make the diphoton final state one of the most promising search modes for Higgs boson masses below $140 \text{ GeV}/c^2$ at ATLAS and CMS experiments at CERN's Large Hadronic Collider (LHC), which have recently presented first results in this channel [4, 5].

In addition to SM $H \rightarrow \gamma\gamma$ production, one can devise many possible Beyond the Standard Model (BSM) scenarios where $B(H \rightarrow \gamma\gamma)$ is enhanced¹. Any resonance observed could also then be evidence for a BSM Higgs. In the SM, the spontaneous symmetry breaking mechanism requires a single doublet of a complex scalar field. However, it is likely that nature does not follow this minimal version and that a multi-Higgs sector may be required. Here, we also consider a model which requires a doublet Higgs field for which the symmetry breaking mechanism responsible for giving Higgs masses to gauge bosons is separate from that which generates the fermion masses. In the benchmark model considered, a "fermiophobic" Higgs boson (H_f) is predicted that assumes SM couplings to bosons and vanishing couplings to all fermions. The gluon fusion process is then suppressed and only VH and VBF processes remain, which results in a reduction in the production cross section by a factor of four. This reduction is compensated, however, by the branching fraction for this model, which can be larger than that predicted by the SM scenario by more than two orders of magnitude for low Higgs boson masses (see Table I). The higher branching fraction causes a larger number of predicted fermiophobic Higgs boson events compared to the SM Higgs boson. Direct searches at LEP set a lower limit on the fermiophobic Higgs boson mass of $109.7 \text{ GeV}/c^2$ with 95% C.L.

Here, we present a search for both a SM and fermiophobic Higgs boson in the diphoton final state from $p\bar{p}$ collisions at $\sqrt{s} = 1.96 \text{ TeV}$ from the Fermilab Tevatron Collider. An inclusive sample of diphoton data are collected by the D0 and CDF experiments, corresponding to an integrated luminosity of 8.2 and 7.0 fb^{-1} , respectively. By combining the results from each analysis, Tevatron limits on the SM cross section multiplied by $B(H \rightarrow \gamma\gamma)$ are also presented relative to the SM prediction.

2. Prompt Photon Signature

The dominant backgrounds to prompt photons originating from the event vertex are electrons faking photons and jets faking photons. The latter is more frequent and typically occurs when a jet fragments into a π^0

Table I: SM Higgs boson production cross sections for several M_H values [7] are shown for gluon fusion, associated production and vector boson fusion (see also Fig. 1). The fermiophobic Higgs boson benchmark model assumes SM couplings, however the gluon fusion process is suppressed and is not included. The branching fractions for the decay to a photon pair are shown for both the SM Higgs boson and benchmark fermiophobic Higgs boson, calculated from HDECAY [8].

M_H (GeV/ c^2)	$\sigma_{gg \rightarrow H}$ (fb)	σ_{WH} (fb)	σ_{ZH} (fb)	σ_{VBF} (fb)	$B(H \rightarrow \gamma\gamma)$ (%)	$B(H_f \rightarrow \gamma\gamma)$ (%)
100	1821.8	291.9	169.8	100.1	0.15	18.5
110	1385.0	212.0	125.7	85.1	0.19	6.03
120	1072.3	150.1	90.2	72.7	0.21	2.33
130	842.9	112.0	68.5	62.1	0.22	1.07
140	670.6	84.6	52.7	53.2	0.19	0.54
150	539.1	64.4	40.8	45.8	0.14	0.27

¹An informative summary of the various models that modify $B(H \rightarrow \gamma\gamma)$ can be found in Reference [6].

or η meson which then decays to multiple photons. These delayed photons are collinear and are often misreconstructed as a single photon. In order to identify high-energy prompt photons and reduce these backgrounds, both the D0 and CDF analyses start by searching for photon candidates with the following signature: (i) the majority of the energy should be deposited in the EM calorimeter rather than the hadronic calorimeter, (ii) the EM cluster should be isolated in the calorimeter, (iii) there should be no high-momentum tracks originating from the primary event vertex that are associated with the EM cluster, and (iv) the EM shower profile is consistent with that of a prompt photon. More details on this identification can be obtained from the primary references, Ref. [7] for D0 and Ref. [9, 10] for CDF².

3. D0 Analysis

At D0, we select events with at least two photon candidates with $|\eta| < 1.1$ and transverse momentum $p_T > 25$ GeV/c. In addition to the basic photon selection outlined above, a Neural Network (NN) is used to further discriminate jet backgrounds from prompt photons. This NN discriminant is trained using photon and jet Monte Carlo (MC) samples and constructed from well-understood detector variables sensitive to differences between photons and jets. The output for this discriminant (O_{NN}) is shown in Fig. 2 for the photon and jet MC samples, where the signal peaks near one and the background near zero. The photon efficiency ϵ_γ for any cut on this output is determined from a true photon sample in the data obtained from $Z \rightarrow l^+l^-\gamma$ events ($l = e$ or μ). The jet efficiency ϵ_{jet} (fraction of jets misidentified as a photon) is determined from a sample of jets misidentified as photons in the data. A cut of 0.1 is applied which retains more than 98% of true photons and rejects 40% of misidentified jets.

The two highest p_T photons that pass this selection are used to form the diphoton system and the diphoton mass $M_{\gamma\gamma}$ is then required to be greater than 60 GeV/c². The difference in azimuthal angle of the two photons $\Delta\phi^{\gamma\gamma}$ is also required to be greater than 0.5, which keeps 99% of the Higgs boson signal but reduces prompt QCD photons originating from fragmentation, a process not well modeled in the simulation.

For a Higgs boson signal decaying to two photons, data with the above selection is composed of both an irreducible and a reducible background. The irreducible background is from two SM QCD photons from the hard interaction where the shape for different kinematic variables is modeled from SHERPA MC and the normalization of this background is obtained from a fit made to the final discriminant distribution when setting limits on Higgs boson production. The reducible background is composed of fake events where at least one photon candidate is misidentified as a prompt photon. Both the shape and normalization of kinematic distributions for Drell-Yan $Z/\gamma^* \rightarrow e^+e^-$ events are obtained from PYTHIA MC prediction. The shape for γ +jet and jet+jet background distributions is obtained from an independent data sample selected from diphoton events that pass all other photon selection requirements but have a reversed requirement on the O_{NN} output for one or both photon candidates. The normalization for this sample is determined from the data using a 4×4 matrix method. For each data event that passes the full selection, a 4-component vector is constructed $(w_{pp}, w_{pf}, w_{fp}, w_{ff})$ where the value of one element is 1 and other elements are 0 based on whether one or both photon candidates pass a stronger requirement of $O_{NN} > 0.75$. The weight w_{pp} (w_{ff}) then represents events where both photon candidates pass (fail) and w_{pf} (w_{fp}) represents events where only the leading (subleading)³ photon candidate passes. The efficiency of this cut for the photon and jet samples (ϵ_γ and ϵ_{jet}) are parametrized as a function of η and used to construct a 4×4 efficiency matrix \mathcal{E} . A system of linear equations

$$(w_{pp}, w_{pf}, w_{fp}, w_{ff})^T = \mathcal{E} \times (w_{\gamma\gamma}, w_{\gamma j}, w_{j\gamma}, w_{jj})^T \quad (1)$$

is then solved on an event-by-event basis in order to obtain a weight for events with two true photons $w_{\gamma\gamma}$, a weight for events with two jets faking a photon w_{jj} , and a weight for events where only the leading (subleading) candidate is a true photon $w_{\gamma j}$ ($w_{j\gamma}$). Then, for example, the number of dijet events is taken as the sum of the dijet weights obtained for each data event:

$$N_{jj} = \sum_{i=1}^{N_{\text{data}}} w_{jj}^i. \quad (2)$$

²See Ref. [11] for CDF results with updated systematic uncertainties on the expected signal.

³The leading photon refers to the highest p_T photon candidate in the event and subleading refers to the second highest.

Similarly, the γ +jet background is determined from the sum of the $w_{\gamma j}$ and $w_{j\gamma}$ components.

The resulting background composition is then determined for each Higgs boson mass hypothesis ($M_H \pm 30$ GeV) where the approximate percentage of $\gamma\gamma$ events is 53%, of $\gamma j + jj$ events is 44%, and of Drell-Yan events is 3%. The simulated shape of the Higgs boson signal is generated separately for each production process and normalized using cross section and branching fraction values shown in Table I. See the primary D0 reference for more detail on signal expectation (Ref. [7]).

The most recent searches for a Higgs boson in the diphoton final state exploit the narrow M_H resolution to discriminate between the signal and background. With a good understanding of the background modeling for different kinematic distributions, however, further sensitivity is gained at D0 by using these variables with a multivariate technique. In addition to the diphoton mass $M_{\gamma\gamma}$, four other variables with kinematic differences between the signal and background are also considered for this analysis: the transverse momentum of the diphoton system $p_T^{\gamma\gamma}$, $\Delta\phi_{\gamma\gamma}$, and the transverse momentum of the leading and subleading photon, p_T^1 and p_T^2 respectively. These five well-modeled kinematic variables are used to construct a single discriminant from a boosted decision tree (BDT) algorithm, trained to distinguish a Higgs boson signal from the backgrounds. This process is repeated for each Higgs mass hypothesis for $100 < M_H < 150$ GeV/ c^2 in 2.5 GeV/ c^2 steps, and is trained separately for a SM and fermiophobic Higgs boson signal. As an example, the $M_{\gamma\gamma}$ and $p_T^{\gamma\gamma}$ distributions ($M_H = 115$ GeV/ c^2) for the data, background, and expected SM and fermiophobic Higgs boson signal are shown in Fig. 2, along with the resulting BDT response for both the SM and fermiophobic scenario (Figure 3).

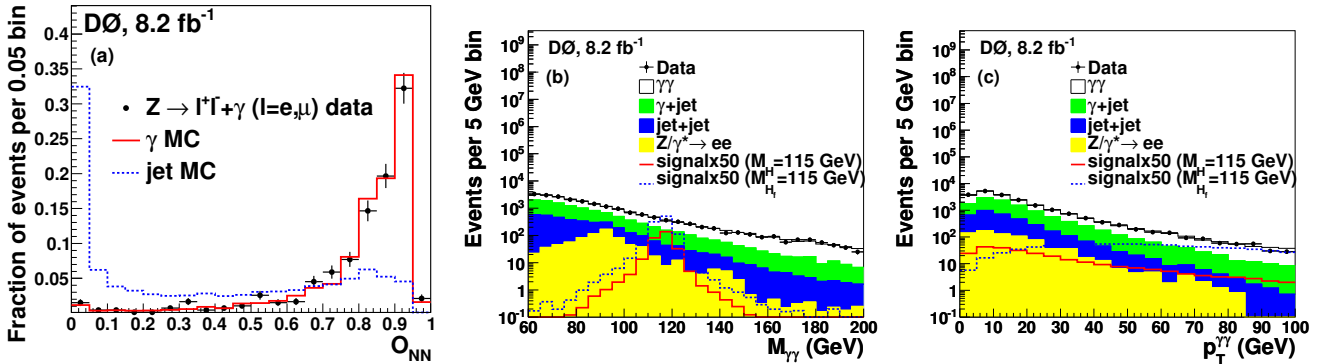


Figure 2: (a) Neural net output response for photon candidates from diphoton MC, jet MC, and radiative Z boson decays in the data. The signal photons have an O_{NN} peaked towards 1 and jet backgrounds have an O_{NN} peaked towards 0. For diphoton events that pass the full selection, the (b) diphoton mass and (c) diphoton p_T with signal shapes (for a Higgs boson mass of 115 GeV/ c^2) are shown for both the SM and fermiophobic scenario. These are two of the five kinematic variables used as inputs for the BDT training (see Fig. 3).

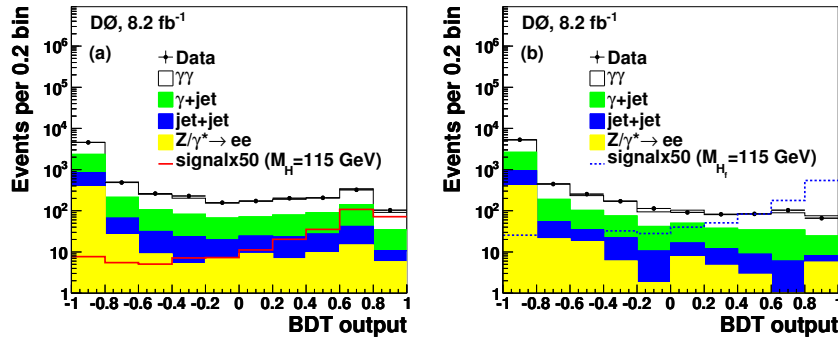


Figure 3: The BDT output distributions for the (a) SM and (b) fermiophobic Higgs boson searches for a Higgs boson mass of 115 GeV/ c^2 . The data and background predictions are shown, along with the signal prediction multiplied by a factor of 50.

4. CDF Analysis

At CDF, the leading two photons are required to have $p_T > 15$ GeV/c. Plug photons ($1.2 < |\eta| < 2.8$) are selected using a standard ID used at CDF. Central photons ($|\eta| < 1.05$) are identified in a similar manner as in the D0 analysis, using a NN output constructed from variables sensitive to distinguishing prompt photons from jet backgrounds. This NN discriminant, used for the first time at CDF in this analysis, increases photon signal efficiency by 5% and background rejection by 12% relative to standard photon ID at CDF. Photon efficiencies for both central and plug photons are validated using $Z \rightarrow e^+e^-$ decays in both data and MC.

$H \rightarrow \gamma\gamma$ signal acceptance is further increased by reconstructing events in which a single central photon converts into an electron-positron pair, which is found to occur approximately 15% of the time for $|\eta| < 1.05$. A base set of selection requirements is applied that searches for a central electron⁴ with a colinear, oppositely signed track nearby⁵. The proximity of the two electron tracks is determined from their $r - \phi$ separation at the radius of the conversion and from the difference in $\cot\theta$ of the two tracks, where $\cot\theta = p_z/p_T$. The tracks from both electrons are required to point to a fiducial electromagnetic energy cluster. Photons of a higher p_T range are selected by requiring the secondary electron to have $p_T > 1.0$ GeV/c and the reconstructed conversion photon to have $p_T > 15$ GeV/c. In order to reject jet backgrounds, only a small fraction of hadronic E_T associated with the primary electron's cluster is allowed. Additionally, requirements are made on the conversion candidate's calorimeter isolation which is obtained from the primary electron's isolation energy with the secondary electron's p_T subtracted if its track points to a different calorimeter phi tower. The shape describing the ratio of transverse energy to transverse momentum (E/p) is peaked at one for isolated photon conversions, but has a long tail for photon conversions from π^0 or $\eta \rightarrow \gamma\gamma$ decays due to the extra energy from the unconverted photon. Restrictions on this ratio then provide a further way to remove jet backgrounds. The conversion E_T is obtained from the primary electron's E_T with the secondary electron's p_T added if it is in a different calorimeter tower while the photon's reconstructed transverse momentum is obtained by adding the vector sum of the two track's momenta at the radius of the conversion. A final requirement removes events with a small radius of conversion, primarily to reduce prompt electron-positron pairs from Dalitz decays of neutral pions $\pi^0 \rightarrow e^+e^-\gamma$. The direction of the conversion photon's momentum is obtained by taking the vector sum of the individual track momenta; however, better $H \rightarrow \gamma\gamma$ mass resolution is obtained by setting the total momentum to be the conversion's energy obtained from EM calorimeters, which additionally constrains the photon's mass to zero. Reconstruction of photon conversions in the CDF analysis provides an improvement of about 13% in sensitivity to a Higgs boson signal.

Data events in the CDF analysis are divided into four independent subsamples according to the position and type of the photon candidate. In CC events (the most sensitive category), there are two photons in the central region of the detector. In CP events, one photon is in the central region and one is the plug region. For each of these categories, the two highest p_T photons in the sample are selected. If a CC or CP event is not identified, then two additional categories are considered. In C'C events, both photons are central but one has converted and is reconstructed from its $e + e^-$ decay products. Finally, in C'P events, one photon is in the plug region and the other is a central conversion photon.

For the fermiophobic model, the Higgs boson is typically produced in association with either a W or Z boson or two jets from the VBF process. As a result, the fermiophobic Higgs boson has a higher than average $p_T^{\gamma\gamma}$ relative to the background processes as it is typically recoiling against another object⁶. Therefore, in the fermiophobic scenario, the data are further divided into three regions of $p_T^{\gamma\gamma}$, where the highest $p_T^{\gamma\gamma}$ region provides the greatest H_f sensitivity, retaining about 30% of the signal and removing 99.5% of the background. By also including the two lower $p_T^{\gamma\gamma}$ regions, a gain in H_f sensitivity of about 15% is obtained compared to using just the higher $p_T^{\gamma\gamma}$ region alone.

At CDF, we use a data-driven background model which takes advantage of the Higgs boson mass resolution (3 GeV or less) and smoothly falling background in the signal region of the diphoton mass spectrum. Fits are made to the data excluding a 12 GeV window centered around each Higgs mass hypothesis. The fit is interpolated into the signal region to determine the background estimation in that region and the process is repeated for each subsample (CC, CP, C'C, C'P and also each $p_T^{\gamma\gamma}$ region for the fermiophobic Higgs search). Fits are performed

⁴“Electron” is used to refer to either e^+ or e^- .

⁵The EM object with a higher E_T track associated with it is referred to as the primary electron that with a lower E_T track is referred to as the secondary electron.

⁶The D0 analysis is sensitive to this in both the SM and fermiophobic Higgs boson searches by including this variable in the BDT training.

separately for each Higgs boson mass hypothesis for $100 < M_H < 150 \text{ GeV}/c^2$ in $5 \text{ GeV}/c^2$ steps. The statistical uncertainties on the total background in the signal region, taken from the fit, are considered when setting limits. Fits for the CC channel are shown in Figure 4 for the whole $p_T^{\gamma\gamma}$ region used in the SM search and for each of the three $p_T^{\gamma\gamma}$ regions used in the fermiophobic search.

5. Results

No obvious evidence of a signal is observed in the Tevatron diphoton data and BDT discriminants (invariant mass distributions) are used by the D0 (CDF) analysis to set upper limits on the cross section multiplied by the branching ratio $\sigma \times B(H \rightarrow \gamma\gamma)$ for both the SM and fermiophobic Higgs boson searches at 95% confidence level (C.L.). Systematic uncertainties on both the predicted number of signal and background events are considered, in addition to systematics on the shape of the BDT discriminant for the D0 analysis. Correlations between uncertainties are also taken into account. The D0 analysis uses a modified frequentist approach to set upper limits on the Higgs boson production rate and CDF uses a Bayesian method.

5.1. SM Higgs Boson Search

The CDF and D0 observed and expected (median, background-only hypothesis) limits are shown relative to the SM prediction in Figure 5. The bands indicate the 68% and 95% probability regions where the limits can fluctuate, in the absence of signal. For the CDF limit at $m_H = 120 \text{ GeV}/c^2$, we observe a deviation of greater than two sigma from the expectation is observed. However, the statistical significance of this discrepancy is reduced below two sigma after the trial factor associated with performing multiple mass points is considered.

Results from the individual searches from CDF and D0 are combined [12] in order to extract limits on SM Higgs production $\sigma \times B(H \rightarrow \gamma\gamma)$ relative to the SM prediction for $100 \leq M_H \leq 150 \text{ GeV}/c^2$ in $5 \text{ GeV}/c^2$ steps. Figure 6 shows these results obtained from a Bayesian method. In order to reduce model dependence from the SM predictions, limits are also calculated on the inclusive cross section times the branching ratio $\sigma(p\bar{p} \rightarrow H + X) \times B(H \rightarrow \gamma\gamma)$ with theoretical uncertainties on the total production cross section removed (Fig. 6).

5.2. Fermiophobic Higgs Boson Search

In the fermiophobic Higgs boson search, SM cross sections and uncertainties are assumed with the $gg \rightarrow H$ process excluded, and the limits on $\sigma \times B(H_f \rightarrow \gamma\gamma)$ are converted into limits on $B(H_f \rightarrow \gamma\gamma)$, seen in Fig. 7.

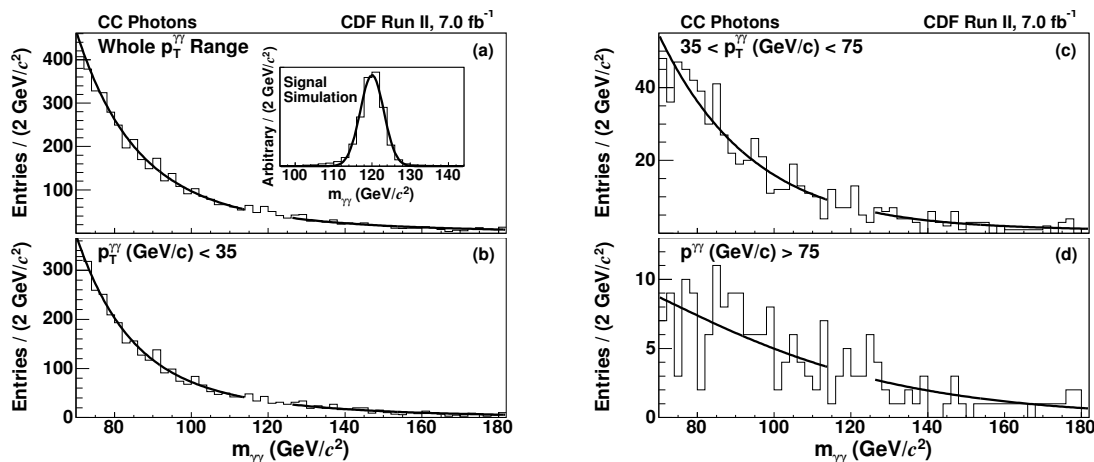


Figure 4: As an example, the invariant mass distribution of central-central photon pairs is shown for (a) the entire $p_T^{\gamma\gamma}$ region used for the SM Higgs boson search and then divided into three $p_T^{\gamma\gamma}$ regions (b)–(d) used for the H_f search. Each distribution shows a fit to the data for the Higgs boson mass hypothesis of $120 \text{ GeV}/c^2$. The gap in the fit centered at $120 \text{ GeV}/c^2$ represents the signal region for this mass point that was excluded from the fit. The expected shape of the signal from simulation is also shown in the inset in (a).

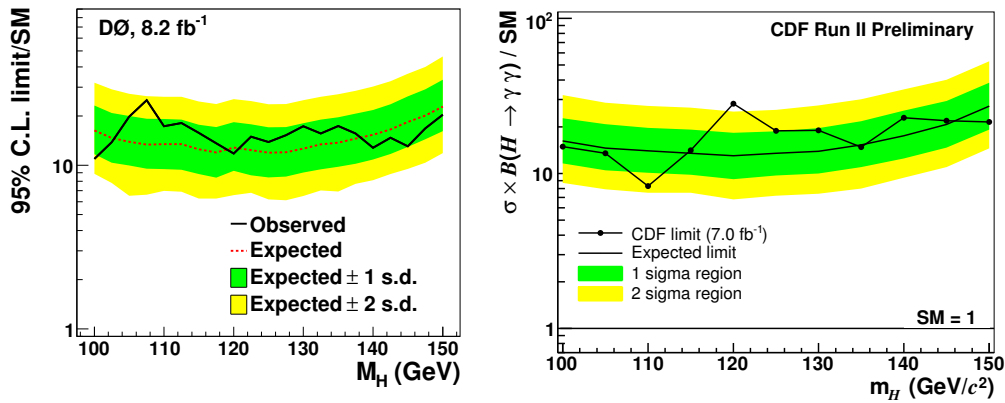


Figure 5: Observed and expected 95% C.L. upper limits on $\sigma \times B(H \rightarrow \gamma\gamma)$ relative to the SM prediction, as a function of the SM Higgs boson mass for D0 (left) and CDF (right). The shaded regions represent the 1σ and 2σ probability of fluctuations of the observed limit away from the expected limit based on the distribution of simulated experimental outcomes under the background-only hypothesis.

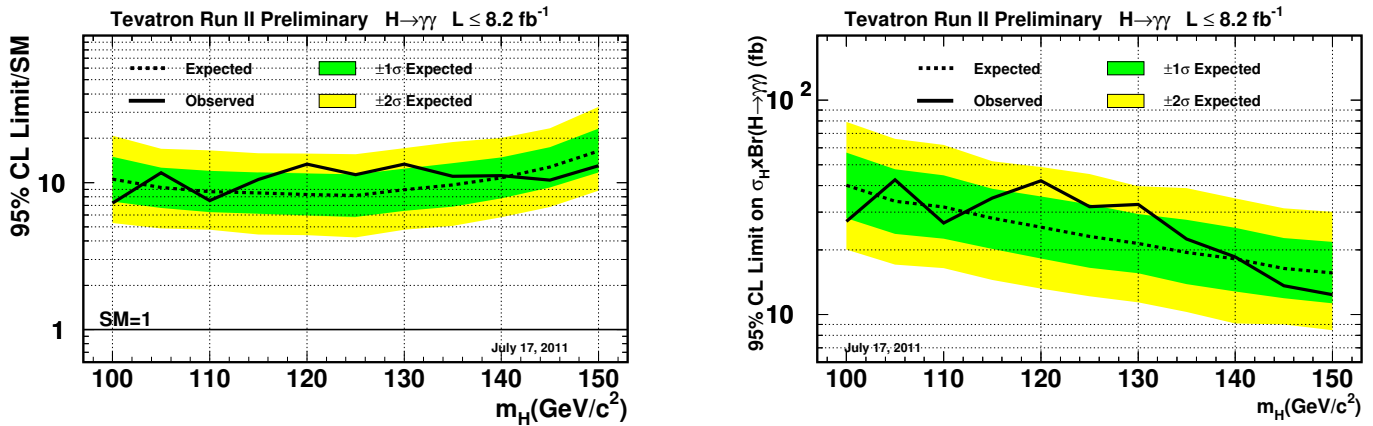


Figure 6: At left, limits based on combined D0 and CDF analyses (Fig. 5) searching for a SM Higgs bosons decaying to two photons. At right, limits on the inclusive production cross section times the branching ratio to two photons, with theoretical uncertainties on the cross section removed. The limit results are calculated using a Bayesian method.

Based on an intersection between the observed limit and the model prediction, fermiophobic Higgs boson masses are excluded below 112.9 (114) GeV/c² for the D0 (CDF) analysis.

6. Conclusions

Analyses for the D0 and CDF experiments were discussed which searched for a Higgs boson in the diphoton final state from data corresponding to 8.2 and 7.0 fb⁻¹, respectively. The results are interpreted in the context of both a SM and fermiophobic Higgs boson and are found to significantly improve upon the most recent diphoton searches from the Tevatron [13, 14] by more than doubling the amount of data included and by implementing enhanced search techniques. The D0 analysis uses a neural network to identify photons with $|\eta| < 1.1$ and gains considerable improvement by implementing a boosted decision tree technique to better separate the Higgs boson signal from the background. The CDF analysis now also uses a NN to identify central photons with $|\eta| < 1.1$ and additionally gains signal acceptance by including forward ($1.2 < |\eta| < 2.8$) and central photon conversions.

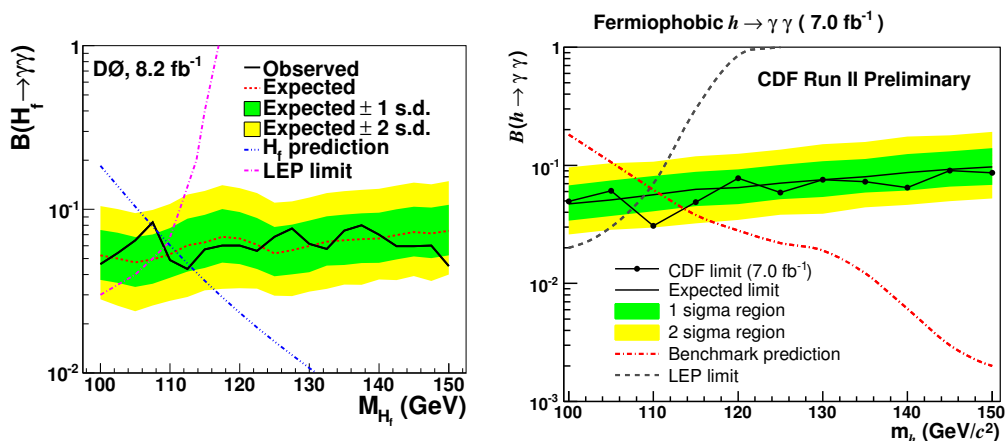


Figure 7: Observed and expected 95% C.L. upper limits on fermiophobic $B(H_f \rightarrow \gamma\gamma)$ as a function of the Higgs boson mass for D0 (left) and CDF (right).

The combined results from these analyses are used to set 95% C.L. upper limits on SM Higgs boson production. For a Higgs boson mass of $M_H = 115$ GeV/c², the observed (expected) limit is a factor of 10.5 (8.5) times the SM prediction. These results significantly extend the sensitivity of the separate D0 and CDF results and are the most stringent limits on the SM $H \rightarrow \gamma\gamma$ process obtained from Tevatron data.

In the fermiophobic interpretation, the D0 (CDF) data set a lower limit on the fermiophobic Higgs boson mass of 112.9 (114) GeV/c² at 95% C.L. Each experiment alone, therefore, produces a more stringent lower limits than that of 109.7 GeV/c² obtained from combined searches at LEP⁷.

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⁷See Ref. [15] for the Tevatron H_f results obtained by combining the D0 and CDF data (after the DPF conference). This yields a lower limit of $M_{H_f} = 119$ GeV/c², the most stringent limit on the fermiophobic Higgs model.