Addendum to: Predictions for Higgs production at the Tevatron and the associated uncertainties

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Abstract

In a recent paper, we updated the theoretical predictions for the production cross sections of the Standard Model Higgs boson at the Tevatron and estimated the various uncertainties affecting these predictions. We found that there is a large theoretical uncertainty, of order 40%, on the cross section for the main production channel, gluon-gluon fusion into a Higgs boson. Since then, a note from the Higgs working groups of the CDF and D0 collaborations criticizing our modeling of the $gg \to H$ cross section has appeared. In this addendum, we answer to this criticism point by point and, in particular, perform an analysis of $\sigma(gg \to H)$ for a central value of the renormalization and factorization scales $\mu_0 = \frac{1}{2}M_H$ for which higher order corrections beyond next-to-next-to-leading order (that we discarded in our previous analysis) are implicitly included. Our results show that the new Tevatron exclusion bound on the Higgs boson mass, $M_H = 158$–175 GeV at the 95% confidence level, is still largely debatable.

Introduction

In an earlier paper [1], we updated the theoretical predictions for the production cross sections of the Standard Model Higgs boson at the Tevatron collider, focusing on the two main search channels, the gluon–gluon fusion mechanism $gg \to H$ and the Higgs–strahlung processes $q\bar{q} \to VH$ with $V = W/Z$, including all relevant higher order perturbative QCD [2] and electroweak corrections [3, 4]. We then estimated the various theoretical uncertainties affecting these predictions: the scale uncertainties which are viewed as a measure of the unknown higher order effects, the uncertainties from the parton distribution functions (PDFs) and the related errors on the strong coupling constant α_s, as well as the uncertainties due to the use of an effective field theory (EFT) approach in the determination of the radiative corrections in the $gg \to H$ process at next-to-next-to-leading order (NNLO). We found that while the cross sections are well under control in the Higgs–strahlung processes, the uncertainty being less that $\approx 10\%$, the theoretical uncertainties are rather large in the case of the gluon–gluon fusion channel, possibly shifting the central values of the NNLO cross sections by more than $\approx 40\%$. These uncertainties are thus significantly larger than the $\approx 10\%$ error assumed by the CDF and D0 experiments in their earlier analysis that has excluded the Higgs mass range $M_H = 162$–166 GeV at the 95% confidence level (CL) [5]. As $gg \to H$ is by far the dominant production channel in this mass range, we concluded that these exclusion limits should be reconsidered in the light of these large theoretical uncertainties.

After our paper appeared on the archives, some criticisms have been made by the members of the Tevatron New Physics and Higgs working group (TevNPHWG) of the CDF and D0 collaborations [6] concerning the theoretical modeling of the $gg \to H$ production cross section that we proposed. This criticism appeared on the web in May 2010, but we got aware of it only during ICHEP, i.e. end of July 2010, where, incidentally, the new combined analysis of CDF and D0 for the Higgs search at the Tevatron was released [7]. In this addendum, we respond to this criticism point by point and, in particular, perform a new analysis of the $gg \to H$ cross section at NNLO for a central value of the renormalization and factorization scales $\mu_0 = \frac{1}{2} M_H$, for which higher order corrections beyond NNLO (that we discarded with some justification in our previous analysis) are implicitly included. We take the opportunity to also comment on the new CDF/D0 results with which the excluded Higgs mass range was extended to M_H =158–175 GeV at the 95% CL[1].

1. The normalization of the gg → H cross section

One of the points put forward in our paper is to suggest to consider the $gg \to H$ production cross section up to NNLO [2–4], $\sigma^{\rm NNLO}_{\rm gg\to H}$, and not to include the soft–gluon resumation contributions [9]. The main reason is that, ultimately, the observable that is experimentally used is the cross section $\sigma^{\rm cuts}_{\rm gg\to H}$ in which selection cuts have been applied and the theoretical prediction for $\sigma^{\rm cuts}_{\rm gg\to H}$ is available only to NNLO [10]. This argument has been criticized by the TevNPHWG for the reason that we are potentially missing some important higher order contributions to the cross section. It turns out, however, that our point is strengthened in the light of the new CDF/D0 combined analysis [7]. Indeed, in this analysis, the $gg \to H$ cross section has been broken into the three pieces which yield different final state signal topologies for the main decay $H \to WW^{(*0} \to \ell\ell\nu\nu$, namely $\ell\ell\nu\nu$+0 jet, $\ell\ell\nu\nu$+1 jet and $\ell\ell\nu\nu$+2 jets or more:

$$\sigma^{\rm NNLO}_{\rm gg\to H} = \sigma^{\rm 0jet}_{\rm gg\to H} + \sigma^{\rm 1jet}_{\rm gg\to H} + \sigma^{\rm \geq 2jets}_{\rm gg\to H} \qquad (1)$$

These channels have been analyzed separately and these individual components, with $\sigma^{\rm 0jet}_{\rm gg\to H}$ evaluated at NNLO, $\sigma^{\rm 1jet}_{\rm gg\to H}$ evaluated at NLO and $\sigma^{\rm \geq 2jets}_{\rm gg\to H}$ evaluated at LO, represent respectively $\approx 60\%$, $\approx 30\%$ and $\approx 10\%$ of the total $gg \to H$ cross section at NNLO. Since these three pieces add up to $\sigma^{\rm NNLO}_{\rm gg\to H}$, we do not find appropriate to have a different normalization for the jet cross sections and for the total sum and, thus, to include soft–gluon resumation in the latter while it is not taken into account in the former.

Nevertheless, we are ready to admit that we may have underestimated the total production cross section, as with the central value of the renormalization and factorization scales $\mu_R = \mu_F = \mu_0 = M_H$ that we have adopted for evaluating $\sigma^{\rm NNLO}_{\rm gg\to H}$, we are missing the $\gtrsim 10\%$ increase of the cross section due to higher order contributions and, in particular, to soft–gluon resumation. As most criticism on our paper focused on this particular issue (overlooking many other important points that we put forward), we present here an analysis of the cross section in which these higher order effects are implicitly taken into account.

[1] Some of the points that we discuss here have also been presented by one of us (JB) in the Higgs Hunting workshop in Orsay which followed ICHEP [8].

As pointed out by Anastasiou and collaborators some time ago, see e.g. Refs. [4,11] (and also Ref. [12]), the effects of soft–gluon resumation at NNLL [9] can be accounted for in $\sigma^{\rm NNLO}_{\rm gg\to H}$ by lowering the central value of the renormalization and factorization scales[2] from $\mu_0 = M_H$ to $\mu_0 = \frac{1}{2}M_H$. If the scale value $\mu_0 = \frac{1}{2}M_H$ is chosen, the central value of $\sigma^{\rm NNLO}_{\rm gg\to H}$ increases by more than 10% and there is almost no difference between $\sigma^{\rm NNLO}_{\rm gg\to H}(\mu_0 = \frac{1}{2}M_H)$ and $\sigma^{\rm NNLL}_{\rm gg\to H}(\mu_0 = M_H)$ as calculated for instance by de Florian and Grazzini [13].

This is explicitly shown in Fig. 1 where $\sigma^{\rm NNLO}_{\rm gg\to H}$ with central scales $\mu_0 = M_H$ and $\mu_0 = \frac{1}{2}M_H$ (that we calculate following the same lines as the ones discussed in section 2 of our paper) are compared to $\sigma^{\rm NNLL}_{\rm gg\to H}$ with $\mu_0 = M_H$ (for which the numbers are given in Ref. [13]). For instance, for $M_H \approx 160$ GeV, while there is a $\simeq 14\%$ difference between $\sigma^{\rm NNLO}_{\rm gg\to H}(\mu_0 = M_H)$ and $\sigma^{\rm NNLL}_{\rm gg\to H}(\mu_0 = M_H)$, there is almost no difference between the later and $\sigma^{\rm NNLO}_{\rm gg\to H}(\mu_0 = \frac{1}{2}M_H)$

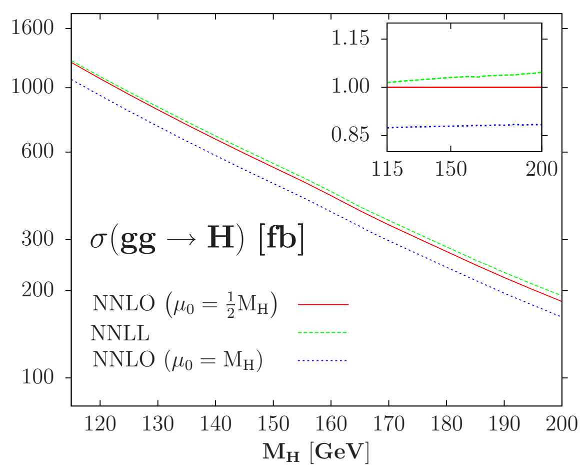


Figure 1: The $gg \to H$ cross section at the Tevatron as a function of M_H: at NNLO for central scales at $\mu_0 = M_H$ and $\mu_0 = \frac{1}{2}M_H$ and at NNLL for a scale $\mu_0 = M_H$. In the insert, shown are the deviations when one normalizes to $\sigma^{\rm NNLO}_{\rm gg\to H}(\mu_0 = \frac{1}{2}M_H)$.

As a result of this choice, our normalization for the inclusive $gg \to H$ cross section is now the same as the ones of Refs. [4,13] which were adopted in the combined CDF/D0 analyses.

2. The scale uncertainty

The next important issue is the range of variation that one should adopt for the renormalization and factorization scales, a variation which leads to an uncertainty band that is supposed to be a measure of the unknown (not yet calculated) higher order contributions to the cross section. In our paper, we have advocated the fact that since the NLO and NNLO QCD corrections in the $gg \to H$ process were so large, it is wiser to extend the range of scale variation from what is usually assumed. From the requirement that the scale variation of the LO or NLO cross sections around the central scale μ_0 catch the central value of $\sigma^{\rm NNLO}_{\rm gg\to H}$, we arrived at the minimal choice, $\frac{1}{3}\mu_0 \leq \mu_R, \mu_F \leq 3\mu_0$ for $\mu_0 = M_H$.

[2] Note that the scale choice $\mu_0 = \frac{1}{2}M_H$ in $gg \to H$ does not only mimic the inclusion of the effect of soft–gluon resumation, but it also improves the convergence of the perturbative series and is more appropriate to describe the kinematics of the process [11].

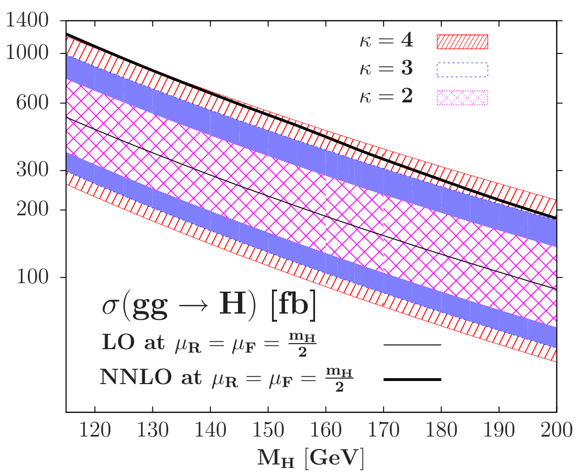
In addition, we proposed that the scales μ_R and μ_F are varied independently and with no restriction such as $\frac{1}{3} \leq \mu_R/\mu_F \leq 3$ for instance. In fact, this was only a general statement and this requirement had absolutely no impact on our analysis as the minimal and maximal values of $\sigma^{\rm NNLO}_{\rm gg\to H}$ due to scale variation were obtained for equal μ_R and μ_F values: for a central scale $\mu_0 = M_H$, one had $\sigma^{\rm NNLO}_{\rm min}$ for $\mu_R = \mu_F = 3\mu_0$ and $\sigma^{\rm NNLO}_{\rm max}$ for $\mu_R = \mu_F = \frac{1}{3}\mu_0$.

Adopting the central scale choice $\mu_0 = \frac{1}{2}M_H$, for the scale variation of the leading–order $gg \to H$ cross section to catch the central value of $\sigma^{\rm NNLO}_{\rm gg\to H}(\mu_0)$, as shown in the left-hand side of Fig. 2, we again need to consider the domain

$$\frac{1}{3}\mu_0 \leq \mu_R = \mu_F \leq 3\mu_0 \ , \ \mu_0 = \frac{1}{2}M_H \tag{2}$$

for the scale variation. Notice that now, we choose for simplicity to equate μ_R and μ_F so that there is no more discussion about the possibility of generating artificially large logarithms if we take two widely different μ_R/μ_F scales.

Adopting this domain for $\mu_F = \mu_R$, we obtain the result shown in the right–hand side of Fig. 2 for the scale variation of the NNLO cross section around the central scale $\mu_0 = \frac{1}{2}M_H$. Averaged over the entire Higgs mass range, the final scale uncertainty is about $\simeq +15\%, -20\%$ which, compared with our previous result for the scale variation of $\sigma^{\rm NNLO}_{\rm gg\to H}$ with $\mu_0 = M_H$ is the same for the minimal value but smaller for the maximal value. Note that if we had chosen the usual domain $\frac{1}{2}\mu_0 \leq \mu_R = \mu_F \leq 2\mu_0$, the scale variation would have been of about $\approx +10\%, -12\%$ for $M_H \approx 160$ GeV.



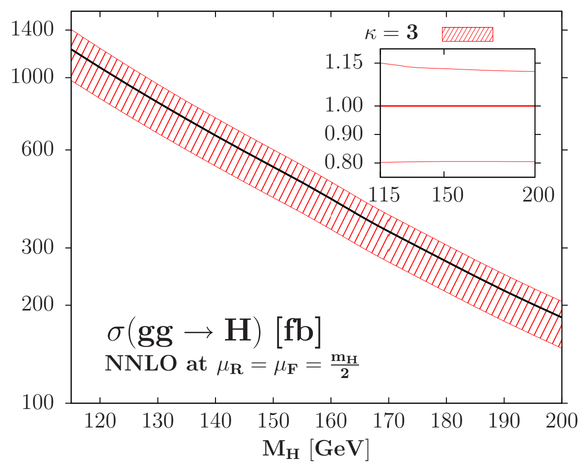


Figure 2: Left: the scale variation of $\sigma^{\rm LO}_{gg\to H}$ as a function of M_H in the domain $\mu_0/\kappa \leq \mu_R = \mu_F \leq \kappa\mu_0$ for $\mu_0 = \frac{1}{2}M_H$ with $\kappa = 2, 3$ and 4 compared to $\sigma^{\rm NNLO}_{gg\to H}(\mu_R = \mu_F = \frac{1}{2}M_H)$. Right: the uncertainty band of $\sigma^{\rm NNLO}_{gg\to H}$ as a function of M_H for a scale variation $\mu_0/\kappa \leq \mu_R = \mu_F \leq \kappa\mu_0$ with $\mu_0 = \frac{1}{2}M_H$ and $\kappa = 3$. In the inserts shown are the relative deviations.

It is important to notice that if the NNLO $gg \to H$ cross section, evaluated at $\mu_0 = M_H$, is broken into the three pieces with 0,1 and 2 jets, and one applies a scale variation for the individual pieces in the range $\frac{1}{2}\mu_0 \leq \mu_R, \mu_F \leq 2\mu_0$, one obtains with selection cuts similar to those adopted by the CDF/D0 collaborations [14]:

$$\Delta\sigma/\sigma|_{\rm scale} = 60\% \cdot \binom{+5\%}{-9\%} + 29\% \cdot \binom{+24\%}{-23\%} + 11\% \cdot \binom{+91\%}{-44\%} = \binom{+20.0\%}{-16.9\%} \tag{3}$$

Averaged over the various final states with their corresponding weights, an error on the "inclusive" cross section which is about $+20\%, -17\%$ is derived[3]. This is very close to the result obtained in the CDF/D0 analysis [7] which quotes a scale uncertainty of $\approx \pm 17.5\%$ on the total cross section, when the weighted uncertainties for the various jet cross sections are added. Thus, our supposedly "conservative" choice $\frac{1}{3}\mu_0 \leq \mu_R = \mu_F \leq 3\mu_0$ for the scale variation of the total inclusive cross section $\sigma^{\rm NNLO}_{\rm gg\to H}$, leads to a scale uncertainty that is very close to that obtained when one adds the scale uncertainties of the various jet cross sections for a variation around the more "consensual" range $\frac{1}{2}\mu_0 \leq \mu_R, \mu_F \leq 2\mu_0$.

We also note that when breaking $\sigma^{\rm NNLO}_{\rm gg\to H}$ into jet cross sections, an additional error due to the acceptance of jets is introduced; the CDF and D0 collaborations, after weighting, have estimated it to be $\pm 7.5\%$. We do not know if this weighted acceptance error should be considered as a theoretical or an experimental uncertainty. But this error, combined with the weighted uncertainty for scale variation, will certainly increase the total scale error in the CDF/D0 analysis, possibly (and depending on how the errors should be added) to the level where it almost reaches or even exceeds our own supposedly "conservative" estimate.

3. PDF and α_s uncertainties

Another issue is the uncertainties due to the parameterization of the PDFs and the corresponding ones from the value of the strong coupling constant α_s. In their updated analysis [7], the CDF and D0 collaborations are now including the uncertainties generated by the experimental error in the value of α_s and considering the PDF+$\Delta^{\rm exp}\alpha_s$ uncertainty, but there is still a little way to go as the problem of the theoretical error on α_s is still pending.

For the new analysis that we present here for $\sigma^{\rm NNLO}_{\rm gg\to H}$ with a central scale $\mu_0 = \frac{1}{2}M_H$, we have only slightly changed our previous recipe for calculating the errors due to PDFs and α_s: we still use the grids provided by the MSTW collaboration [15] for PDF+$\Delta^{\rm exp}\alpha_s$, take the 90%CL result and add in quadrature the impact of the theoretical error $\Delta^{\rm th}\alpha_s$ using again the sets provided by the MSTW collaboration. However, contrary to the case $\mu_0 = M_H$ where the value $\Delta^{\rm th}\alpha_s = 0.003$ at NLO ($\Delta^{\rm th}\alpha_s = 0.002$ at NNLO) as suggested by MSTW [15] was sufficient to achieve a partial overlap of the MSTW and ABKM predictions (which, together with the CTEQ prediction, are given in the left–hand side of Fig. 3) when including their respective error bands, we need in the case $\mu_0 = \frac{1}{2}M_H$ an uncertainty of $\Delta^{\rm th}\alpha_s = 0.004$, to make such that the MSTW and ABKM predictions, which differ by more than 25% in this case, become consistent.

Adopting this value for the α_s theoretical uncertainty, which is approximately the difference between the MSTW and ABKM central α_s values, the results for $\sigma^{\rm NNLO}_{gg\to H}$ using only the MSTW parametrisation are displayed in the right–hand side of Fig. 3. Shown are the 90% confidence level PDF, PDF+$\Delta^{\rm exp}\alpha_s$ and PDF+$\Delta^{\rm exp+th}\alpha_s$ uncertainties, with the PDF+$\Delta^{\rm exp}\alpha_s$ and PDF+$\Delta^{\rm th}\alpha_s$ combined in quadrature. We thus obtain a PDF+$\Delta^{\rm exp+th}\alpha_s$ total uncertainty of $\pm 15\%$ to 20% on the central cross section depending on the M_H value. This is larger than the 12.5% error which has been assumed in the most recent CDF/D0 combined analysis [7] (and even larger than the $\approx \pm 8\%$ assumed in the earlier analysis [5]). We

[3]The error might be reduced when including higher–order corrections in the 1 jet and 2 jet cross sections.

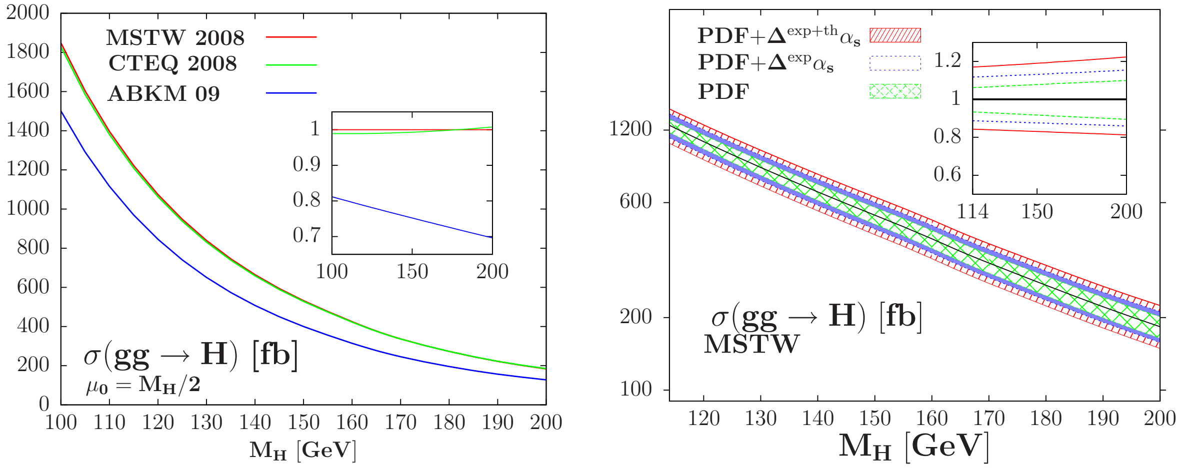


Figure 3: Left: the $gg \to H$ cross section at NNLO for $\mu_0 = \frac{1}{2}M_H$ as a function of M_H when the MSTW, CTEQ and ABKM parameterizations are used. Left: the 90%CL PDF, PDF+$\Delta^{\rm exp}\alpha_s$ and PDF+$\Delta^{\rm exp+th}\alpha_s$ uncertainties on $\sigma^{\rm NNLO}_{gg\to H}$ in the MSTW parametrisation. In the inserts, shown in % are the deviations with respect to the central MSTW value.

believe that if the effect of the theoretical error on α_s is taken into account in the Tevatron analysis of $\sigma(gg \to H)$, we will arrive at a much closer agreement.

We would like to insist on the fact that this recipe is only one particular way, and by no means the only one, of parameterizing the PDF uncertainty. A possibly more adequate procedure to evaluate this theoretical uncertainty would be to consider the difference between the central values given by various PDF sets. In the present $gg \to H$ case, while the MSTW and CTEQ parameterizations give approximately the same result as shown previously, ABKM gives a central NNLO cross section that is $\approx 25\%$ smaller than that obtained using the MSTW set[4]. The PDF uncertainty, in this case, would be thus $\approx -25\%, +0\%$.

We also note that there is another recipe that has been suggested by the PDF@LHC working group for evaluating PDF uncertainties for NNLO cross sections (besides taking the envelope of the predicted values obtained using several PDF sets) [16]: take the MSTW PDF+$\Delta^{\rm exp}\alpha_s$ error and multiply it by a factor of two. In our case, this would lead to an uncertainty of $\approx \pm 25\%$ which, for the minimal value, is close to the recipe discussed just above, and is larger than what we obtain when considering the PDF+$\Delta^{\rm exp+th}\alpha_s$ uncertainty given by MSTW. We thus believe that our estimate of the PDF+α_s uncertainty that we quote here is far from being exaggeratedly conservative.

4. Combination of the various uncertainties

The last issue that remains to be discussed and which, to our opinion is the main one, is the way of combining the various sources of theoretical errors. Let us first reiterate an important comment: the uncertainties associated to the PDF parameterisations are theoretical errors

[4]The $gg \to H$ cross section is even smaller if one uses the new NNLO central PDF sets recently released by the HERAPDF collaboration [17] rather than the ABKM PDF set.

and they have been considered as such since a long time. Indeed, although the PDF sets use various experimental data which have intrinsic errors (and which are at the origin of the misleading "probabilistic" interpretation of the errors given by each PDF set that are generally quoted), the main uncertainty is due to the theoretical assumptions which go into the different parameterizations. This uncertainty cannot be easily quantified within one given parametrisation but it is reflected in the spread of the central values given by the various PDF parameterizations that are available. If one defines the PDF uncertainty as the difference in the cross sections when using the different available PDF sets, this uncertainty has no statistical or probabilistic ground. For the scale uncertainty, the situation is of course clear: it has no statistical ground and any value of the cross section in the uncertainty band is as respectable as another[5].

As a result, the scale and PDF uncertainties, cannot be combined in quadrature as done, for instance, by the CDF and D0 collaborations. This is especially true as in the $gg \to H$ process, a strong correlation between the renormalization and factorization scales that are involved (and that we have equated here for simplicity, $\mu_R = \mu_F$), the value of α_s and the gg densities is present. For instance, decreasing (increasing) the scales will increase (decrease) the $gg \to H$ cross section not only because of the lower (higher) $\alpha_s(\mu_R^2)$ value that is obtained and which decreases (increases) the magnitude of the matrix element squared (that is proportional to α_s^2 at leading order and the cross section is minimal/maximal for the highest/lowest $\mu_R = \mu_F$ values), but also because at the same time, the gg densities become smaller (larger) for higher (smaller) $\mu_F = \sqrt{Q^2}$ values. See Ref. [16] for details.

Thus, not only the scale and PDF uncertainties cannot be added in quadrature, they also cannot be added linearly because of the aforementioned correlation. We therefore strongly believe that the best and safest procedure to combine the scale and PDF+α_s uncertainties is the one proposed in our paper, that is, to estimate directly the PDF+α_s uncertainties on the maximum and minimum cross sections with respect to the scale variation, $\sigma_0 \pm \Delta\sigma_\mu^+$.

In addition, there is a last theoretical error which should be included, related to the use of the EFT approach for the b–quark loop at NNLO QCD (together with the parametric and scheme uncertainty on the b–quark mass) and for the electroweak radiative corrections, which amount to a few %. These uncertainties, discussed in detail in section 3.2 of our paper, are also purely theoretical uncertainties and should be added linearly to the combined scale and PDF+α_s uncertainty (as there is no apparent correlation between them).

Doing so for the $gg \to H$ NNLO cross section with a central scale $\mu_0 = \frac{1}{2}M_H$, we obtain the total error shown in Fig. 4, that we compare to the $\approx \pm 22\%$ error assumed in the CDF/D0 analysis. For $M_H = 160$ GeV for instance, we obtain $\Delta\sigma/\sigma \approx +41\%, -37\%$. Compared to our previous result with a central scale $\mu_0 = M_H$ which amounted to $\Delta\sigma/\sigma \simeq +48\%, -40\%$, this is approximately the same (only a few percent less) for the lower value of the cross section and significantly less for its upper value.

Hence, our procedure for the combination does not reduce to a linear sum of all uncertainties. If we had added linearly all errors, we would have had, for the negative part at $M_H = 160$ GeV, a total uncertainty of $\Delta\sigma/\sigma \approx -42\%$, compared to the value -37% with our procedure. On the other hand, one has an error of $\approx -30\%$, i.e. close to the total error

[5]In statistical language, both the scale and PDF uncertainties have a flat prior. A more elaborated discussion on this issue will appear in a separate publication [18].

assumed by CDF/D0 if the scale and PDF+α_s uncertainties were added in quadrature and the EFT approach error linearly (the latter being ignored by the CDF/D0 collaborations).

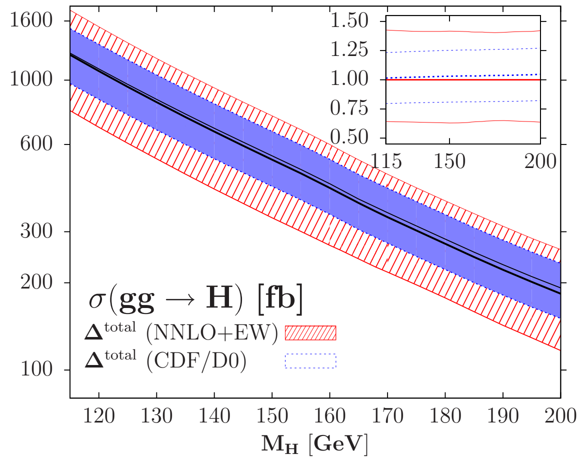


Figure 4: The production cross section $\sigma(gg \to H)$ at NNLO for the QCD and NLO for the electroweak corrections at the Tevatron at a central scale $\mu_F = \mu_R = \frac{1}{2}M_H$ with the uncertainty band when all theoretical uncertainties are added using our procedure. It is compared to $\sigma(gg \to H)$ at NNLL [13] with the errors quoted by the CDF/D0 collaboration [7]. In the insert, the relative deviations compared to the central value are shown.

Summary

We have updated our analysis on the theoretical predictions for the Higgs production cross section in the $gg \to H$ process at the Tevatron, by assuming a central scale $\mu_R = \mu_F = \mu_0 = \frac{1}{2}M_H$ which seems more appropriate to describe the process and implicitly accounts for the bulk of the higher order contributions beyond NNLO. We have then estimated the theoretical uncertainties associated to the prediction: the scale uncertainty, the uncertainties from the PDF parametrisation and the associated error on α_s, as well as uncertainties due to the use of the EFT approach for the mixed QCD-electroweak radiative corrections and the b-quark loop contribution. In Table 1, we summarise the results that we have obtained: the first column shows the central cross section obtained at NNLO with $\mu_0 = \frac{1}{2}M_H$ and the other columns the individual uncertainties and the total absolute and relative uncertainties when the latter are combined using our procedure.

While our central value agrees now with the ones given in Refs. [4,13] and adopted by the CDF/D0 collaborations, the overall theoretical uncertainty that we obtain is approximately twice the error assumed in the latest Tevatron analysis to obtain the exclusion band 158 GeV $\leq M_H \leq$ 175 GeV on the Higgs mass [7]. This is a mere consequence of the different ways to combine the individual scale and PDF+α_s uncertainties and, to a lesser extent, the impact on the theoretical uncertainty on α_s and the EFT uncertainties which have not been considered by the CDF/D0 collaborations. We have provided arguments in favor of our procedure to combine the scale and PDF uncertainties and we therefore still believe that the CDF/D0 exclusion limit on the Higgs mass should be reconsidered.

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[17] The NNLO PDF sets can be found at: `www.desy.de/h1zeus/combined_results`.

[18] J. Baglio et al., in preparation.

M_H	$\sigma^{\rm NNLO}_{\rm gg\to H}$ [fb]	scale	PDF	PDF+$\alpha_s^{\rm exp}$	$\alpha_s^{\rm th}$	EW	b–loop	total	% total
100	1849	$^{+318}_{-371}$	$^{+102}_{-109}$	$^{+210}_{-201}$	$^{+219}_{-199}$	$^{+45}_{-45}$	$^{+42}_{-42}$	$^{+817}_{-648}$	$^{+44.2\%}_{-35.0\%}$
105	1603	$^{+262}_{-320}$	$^{+91}_{-98}$	$^{+184}_{-176}$	$^{+192}_{-174}$	$^{+41}_{-41}$	$^{+39}_{-39}$	$^{+700}_{-565}$	$^{+43.7\%}_{-35.3\%}$
110	1397	$^{+219}_{-277}$	$^{+83}_{-89}$	$^{+163}_{-156}$	$^{+170}_{-152}$	$^{+37}_{-37}$	$^{+35}_{-35}$	$^{+602}_{-496}$	$^{+43.1\%}_{-35.5\%}$
115	1222	$^{+183}_{-242}$	$^{+75}_{-81}$	$^{+144}_{-138}$	$^{+151}_{-134}$	$^{+33}_{-33}$	$^{+32}_{-32}$	$^{+521}_{-437}$	$^{+42.6\%}_{-35.7\%}$
120	1074	$^{+156}_{-211}$	$^{+69}_{-73}$	$^{+129}_{-123}$	$^{+135}_{-119}$	$^{+30}_{-30}$	$^{+29}_{-29}$	$^{+454}_{-386}$	$^{+42.2\%}_{-36.0\%}$
125	948	$^{+134}_{-186}$	$^{+63}_{-67}$	$^{+115}_{-110}$	$^{+121}_{-106}$	$^{+28}_{-28}$	$^{+24}_{-24}$	$^{+397}_{-342}$	$^{+41.9\%}_{-36.1\%}$
130	839	$^{+115}_{-164}$	$^{+57}_{-61}$	$^{+104}_{-99}$	$^{+108}_{-94}$	$^{+25}_{-25}$	$^{+21}_{-21}$	$^{+349}_{-304}$	$^{+41.5\%}_{-36.2\%}$
135	746	$^{+100}_{-145}$	$^{+53}_{-56}$	$^{+94}_{-89}$	$^{+98}_{-84}$	$^{+23}_{-23}$	$^{+18}_{-18}$	$^{+309}_{-272}$	$^{+41.4\%}_{-36.5\%}$
140	665	$^{+88}_{-129}$	$^{+48}_{-51}$	$^{+85}_{-80}$	$^{+88}_{-76}$	$^{+21}_{-21}$	$^{+16}_{-16}$	$^{+275}_{-243}$	$^{+41.4\%}_{-36.6\%}$
145	594	$^{+78}_{-115}$	$^{+45}_{-47}$	$^{+77}_{-73}$	$^{+80}_{-68}$	$^{+19}_{-19}$	$^{+14}_{-14}$	$^{+246}_{-218}$	$^{+41.4\%}_{-36.8\%}$
150	532	$^{+69}_{-103}$	$^{+41}_{-44}$	$^{+70}_{-66}$	$^{+73}_{-61}$	$^{+17}_{-17}$	$^{+13}_{-13}$	$^{+221}_{-197}$	$^{+41.6\%}_{-37.0\%}$
155	477	$^{+61}_{-92}$	$^{+38}_{-40}$	$^{+64}_{-60}$	$^{+67}_{-55}$	$^{+15}_{-15}$	$^{+10}_{-10}$	$^{+198}_{-176}$	$^{+41.5\%}_{-37.0\%}$
160	425	$^{+54}_{-82}$	$^{+35}_{-37}$	$^{+58}_{-54}$	$^{+60}_{-50}$	$^{+11}_{-11}$	$^{+9}_{-9}$	$^{+175}_{-155}$	$^{+41.3\%}_{-36.6\%}$
162	405	$^{+51}_{-78}$	$^{+33}_{-35}$	$^{+56}_{-52}$	$^{+58}_{-48}$	$^{+9}_{-9}$	$^{+8}_{-8}$	$^{+166}_{-146}$	$^{+40.9\%}_{-36.2\%}$
164	386	$^{+48}_{-75}$	$^{+32}_{-34}$	$^{+53}_{-50}$	$^{+55}_{-45}$	$^{+8}_{-8}$	$^{+8}_{-8}$	$^{+158}_{-139}$	$^{+40.9\%}_{-36.0\%}$
165	377	$^{+47}_{-73}$	$^{+31}_{-33}$	$^{+52}_{-48}$	$^{+54}_{-44}$	$^{+7}_{-7}$	$^{+8}_{-8}$	$^{+154}_{-135}$	$^{+40.8\%}_{-35.9\%}$
166	368	$^{+46}_{-71}$	$^{+31}_{-33}$	$^{+51}_{-47}$	$^{+53}_{-44}$	$^{+6}_{-6}$	$^{+8}_{-8}$	$^{+150}_{-132}$	$^{+40.9\%}_{-35.8\%}$
168	352	$^{+44}_{-68}$	$^{+30}_{-31}$	$^{+49}_{-46}$	$^{+51}_{-42}$	$^{+5}_{-5}$	$^{+8}_{-8}$	$^{+144}_{-126}$	$^{+40.9\%}_{-35.7\%}$
170	337	$^{+42}_{-65}$	$^{+29}_{-30}$	$^{+47}_{-44}$	$^{+49}_{-40}$	$^{+4}_{-4}$	$^{+7}_{-7}$	$^{+137}_{-119}$	$^{+40.6\%}_{-35.4\%}$
175	303	$^{+37}_{-59}$	$^{+26}_{-28}$	$^{+43}_{-40}$	$^{+45}_{-36}$	$^{+2}_{-2}$	$^{+6}_{-6}$	$^{+122}_{-106}$	$^{+40.4\%}_{-35.1\%}$
180	273	$^{+33}_{-53}$	$^{+24}_{-26}$	$^{+39}_{-36}$	$^{+41}_{-33}$	$^{+1}_{-1}$	$^{+6}_{-6}$	$^{+111}_{-95}$	$^{+40.6\%}_{-34.9\%}$
185	245	$^{+30}_{-47}$	$^{+22}_{-24}$	$^{+36}_{-33}$	$^{+38}_{-30}$	$^{+1}_{-1}$	$^{+6}_{-6}$	$^{+101}_{-87}$	$^{+41.1\%}_{-35.3\%}$
190	222	$^{+27}_{-43}$	$^{+21}_{-22}$	$^{+33}_{-30}$	$^{+35}_{-27}$	$^{+2}_{-2}$	$^{+5}_{-5}$	$^{+92}_{-79}$	$^{+41.4\%}_{-35.7\%}$
195	201	$^{+24}_{-39}$	$^{+19}_{-20}$	$^{+31}_{-28}$	$^{+32}_{-25}$	$^{+2}_{-2}$	$^{+3}_{-3}$	$^{+83}_{-72}$	$^{+41.4\%}_{-35.8\%}$
200	183	$^{+22}_{-35}$	$^{+18}_{-19}$	$^{+28}_{-26}$	$^{+30}_{-23}$	$^{+2}_{-2}$	$^{+3}_{-3}$	$^{+77}_{-67}$	$^{+42.0\%}_{-36.3\%}$

Table 1: The NNLO total Higgs production cross sections in the $gg \to H$ process at the Tevatron (in fb) for given Higgs mass values (in GeV) at a central scale $\mu_F = \mu_R = \frac{1}{2}M_H$. Shown also are the corresponding shifts due to the theoretical uncertainties from the various sources discussed, as well as the total uncertainty when all errors are added using the procedure described in the text.