

## EW corrections to Higgs strahlung at the Tevatron and the LHC with HAWK

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We briefly report on the inclusion of NLO QCD and electroweak corrections to the Higgs-strahlung processes  $pp/p\bar{p} \rightarrow HW/Z \rightarrow H + 2\text{leptons}$  in the Monte Carlo program HAWK<sup>†</sup>. The electroweak corrections, which are at the level of  $-(5-10)\%$  for total cross sections, further increase in size with increasing transverse momenta ( $p_T$ ) in differential cross sections. For instance, for  $p_{T,H} \gtrsim 200\text{ GeV}$ , which is the interesting range at the LHC, the electroweak corrections to WH production reach about  $-15\%$  for  $M_H = 120\text{ GeV}$ .

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<sup>†</sup>The program is publically available under <http://omnibus.uni-freiburg.de/sd565/programs/hawk/hawk.html>.

## 1. Introduction

The Higgs-strahlung processes  $pp/p\bar{p} \rightarrow HW/Z \rightarrow H + 2\text{leptons}$  represent important search channels for a Standard Model Higgs boson in the low-mass range, both at the Tevatron and the LHC. The challenge in the corresponding experimental analyses is background control, in particular at the LHC where the Higgs boson is reconstructed from the jet substructure in the decay  $H \rightarrow b\bar{b}$  at high transverse momenta [1].

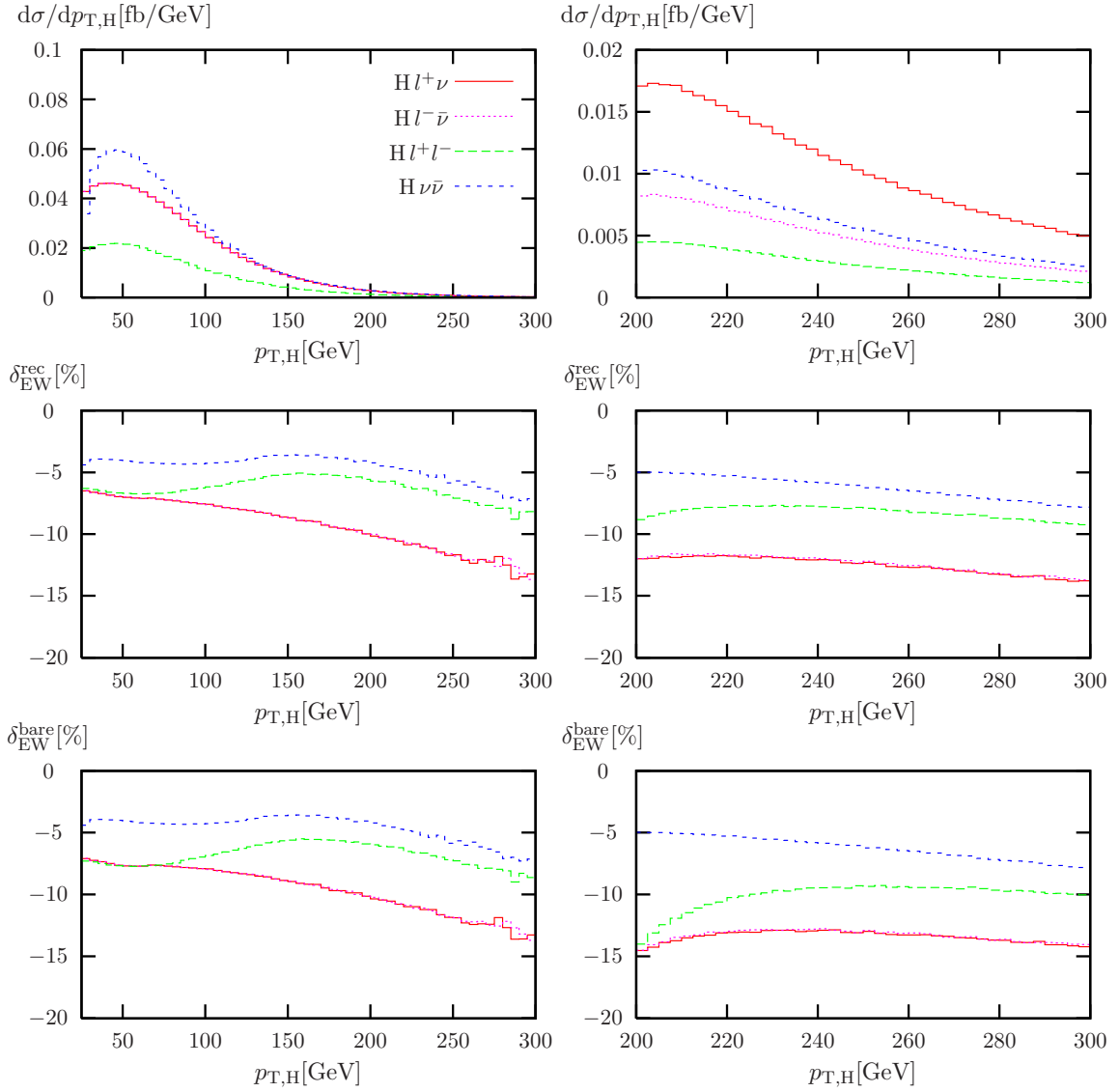
On the theoretical side, at least next-to-leading-order (NLO) corrections should be taken into account to match the required precision in the analyses, keeping as much as possible the differential information. The QCD corrections can be classified into two different categories: the Drell–Yan-like contributions, which respect factorization according to  $pp \rightarrow V^* \rightarrow HV$  and comprise the dominant correction, and a remainder, which contributes at next-to-next-to-leading-order (NNLO) first. The former are known to NNLO for the total cross section [2] and for WH production also for differential distributions [3]; the latter are in progress at NNLO for total cross sections [4]. Electroweak (EW) corrections were first evaluated for the total cross sections in Ref. [5] and turn out to be about  $-(5-10)\%$ . An update of the cross-section prediction for the LHC, together with a thorough estimate of uncertainties, was recently presented in the report [6] of the LHC Higgs Cross Section Working Group. For the LHC with a centre-of-mass (CM) energy of 7(14)TeV the QCD scale uncertainties were assessed to be about 1% and 1–2(3–4)% for WH and ZH production, respectively, while uncertainties of the parton distribution functions (PDFs) turn out to be about 3–4%.

Here we briefly report on results of the first evaluation [7] of EW NLO corrections to the full processes  $pp/p\bar{p} \rightarrow HW/Z \rightarrow H + 2\text{leptons}$ , supporting the complete kinematical information of the decay products. The corresponding calculation is included in the Monte Carlo program HAWK, which was originally designed for the description of Higgs production via vector-boson fusion including NLO QCD and EW corrections [8].

## 2. Numerical results on NLO corrections

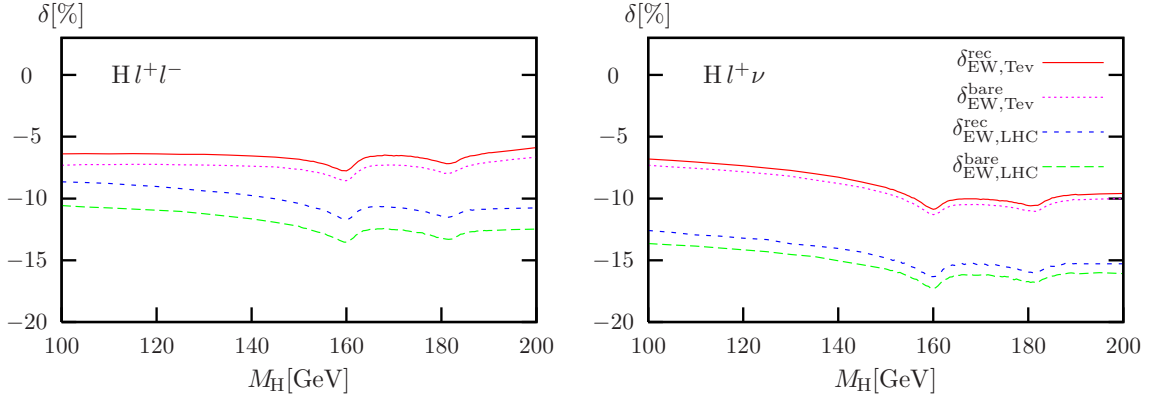
In the following we exemplarily show results on the transverse-momentum ( $p_T$ ) distributions of the Higgs boson for the various leptonic decays of the W/Z bosons at the Tevatron and the LHC with a CM energy of 7TeV, using the input parameters of the LHC Higgs Cross Section Group [6] and the basic identification cuts  $p_{T,l} > 20\text{GeV}$ ,  $|y_l| < 2.5$ ,  $p_T > 25\text{GeV}$ . For the LHC we additionally require  $p_{T,H} > 200\text{GeV}$  and  $p_{T,W/Z} > 190\text{GeV}$  to mimic the analysis that demands a highly-boosted Higgs boson. The slightly asymmetric cuts are chosen to avoid large NLO corrections in the  $p_{T,H}$  distribution near the cut which would appear in fixed-order calculations for symmetric cuts.

Figure 1 shows the differential cross sections with respect to the transverse momentum of the Higgs boson up to 300GeV, along with the EW corrections, and Figure 2 contains the corresponding integrated quantities as a function of the Higgs-boson mass. All results are given for a specific leptonic decay mode and are not summed over lepton generations. The two different versions “rec” and “bare” of the EW corrections refer to different treatments of final-state photons. The latter assumes perfect isolation of photons that are collinear to the lepton, which is then assumed



**Figure 1:** HAWK prediction for the absolute  $p_{T,H}$  distributions (top) and NLO EW corrections for recombined (middle) and bare (bottom) leptons for Higgs strahlung with basic cuts at the Tevatron (left) as well as for boosted Higgs bosons at the 7 TeV LHC (right) for  $M_H = 120$  GeV.

to be a muon, the former recombines photons and leptons that are very close ( $R_{\gamma l} < 0.1$ ), which is closer to the treatment of electrons. The results for invisible Z decays, of course, do not depend on the neutrino flavour and can be trivially obtained by multiplying the  $H\nu_l\bar{\nu}_l$  results by three. For the Higgs-boson sample at the Tevatron and the inclusive sample at the LHC including low  $p_{T,H}$  (not shown here), the EW corrections range between  $-5\%$  and  $-15\%$  and are largest for the W-mediated channels at large  $p_{T,H}$ . For increasing  $p_{T,H}$  the EW corrections become more and more pronounced and show the onset of the large EW logarithms from soft/collinear W/Z exchange at high energies. The difference due to the treatment of final-state photons is small, since the bulk of the correction is of weak origin and not due to final-state radiation. The same observation holds



**Figure 2:** HAWK prediction for the EW corrections to the cross sections for  $Hl^+l^-$  (left) and  $Hl^+\nu_l$  (right) production with basic cuts at the Tevatron and for boosted Higgs bosons at the 7 TeV LHC as a function of the Higgs-boson mass.

for large values of the transverse momentum in the boosted-Higgs analysis at the LHC. Only for  $p_{T,H}$  close to 200 GeV, the influence of final-state radiation is larger, because it may shift the measured value of  $p_{T,V}$ , being equal to  $p_{T,H}$  without radiation, below the corresponding cut value. The EW corrections for the corresponding integrated cross sections (see Fig. 2) are again significantly larger for the LHC setup compared to the inclusive sample which is dominated by events with small  $p_{T,H}$ . For the WH channel they reach  $-15\%$ . There are additional EW corrections at the level of  $+1\%$  (not included in the figures) that are due to photons in the initial state and require a photon distribution function.

Using the complex-mass scheme to consistently treat resonant vector bosons in the calculation, also the threshold regions ( $M_H \sim 2M_W$  and  $M_H \sim 2M_Z$ ), which were not properly described in the past [5], are under theoretical control.

A wider selection of results and a description of the calculational details can be found in Ref. [7].

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