Charged Higgs production with a W boson or a top quark

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- **Charged Higgs production**
- **Higher-order corrections**
- **tH^- production**
- **H^-W^+ production**

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Charged Higgs production

A charged Higgs would be sure sign of new physics

2-Higgs doublet models

LHC has good potential for discovery

I will discuss two production processes

$bg \to tH^-$ **and** $b\bar{b} \to H^-W^+$

Higher-order corrections are significant

very massive final states

Soft-gluon corrections are important

tH^- production

Top is the heaviest known elementary particle

Decays before hadronization

Born cross section for $bg \to tH^- \propto \alpha\alpha_s(m_b^2 \tan^2\beta + m_t^2 \cot^2\beta)$

$\tan\beta = v_2/v_1$ **ratio of vevs of two Higgs doublets**

Higher-order corrections

$b(p_b) + g(p_g) \longrightarrow t(p_t) + H^-(p_H)$

Define $s = (p_b + p_g)^2$, $t = (p_b - p_t)^2$, $u = (p_g - p_t)^2$
and $s_4 = s + t + u - m_t^2 - m_H^2$

At partonic threshold $s_4 \to 0$

Soft corrections $\left[\frac{\ln^k(s_4/m_H^2)}{s_4}\right]_+$

For the order α_s^n **corrections** $k \leq 2n-1$

Resum these soft corrections for the double-differential cross section

At NNLL accuracy we need two-loop soft anomalous dimensions

Derive approximate cross sections at NNLO

Soft-gluon Resummation

moments of the partonic cross section with moment variable N:
$\hat{\sigma}(N) = \int (ds_4/s)\, e^{-Ns_4/s} \hat{\sigma}(s_4)$

factorized expression for the cross section:

$$\hat{\sigma}^{bg\to tH^-}(N,\epsilon) = \left(\prod_{i=b,g} J_i\left(N,\mu,\epsilon\right) \right) H^{bg\to tH^-}\left(\alpha_s(\mu)\right)\; S^{bg\to tH^-}\left(\frac{m_H}{N\mu},\alpha_s(\mu)\right)$$

Soft function S satisfies the renormalization group equation

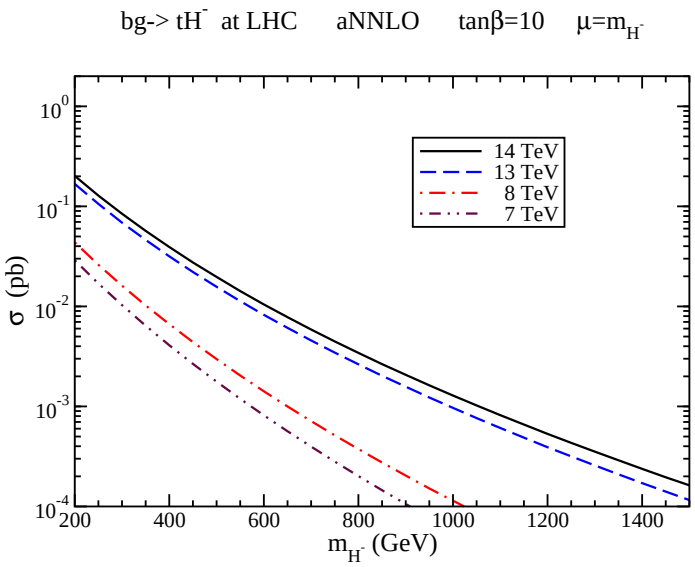
$$\left(\mu\frac{\partial}{\partial\mu} + \beta(g_s,\epsilon)\frac{\partial}{\partial g_s}\right) S^{bg\to tH^-} = -2\, S^{bg\to tH^-}\, \Gamma_S^{bg\to tH^-}$$

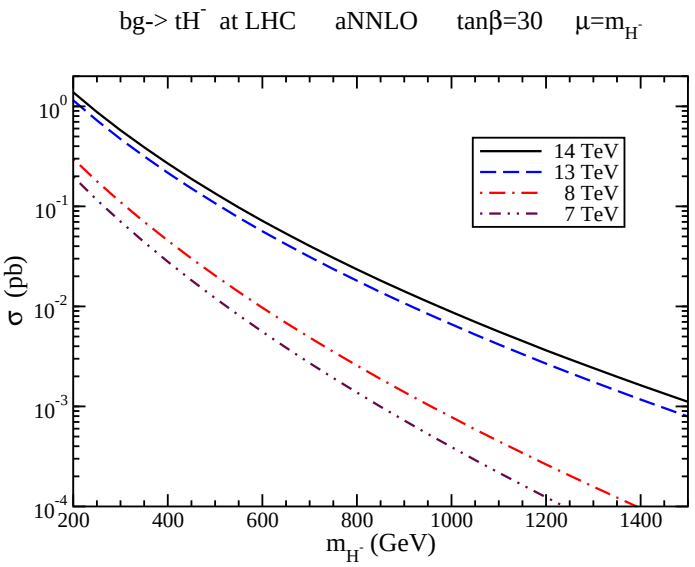
Soft anomalous dimension $\Gamma_S^{bg\to tH^-}$ calculated at two loops
-controls evolution of $S^{bg\to tH^-}$ resulting in exponentiation of logarithms of N

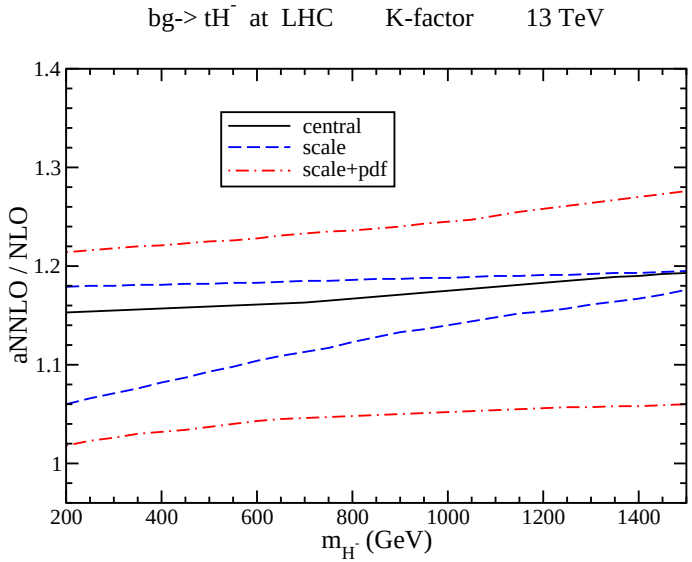
The aNNLO soft-gluon corrections are:

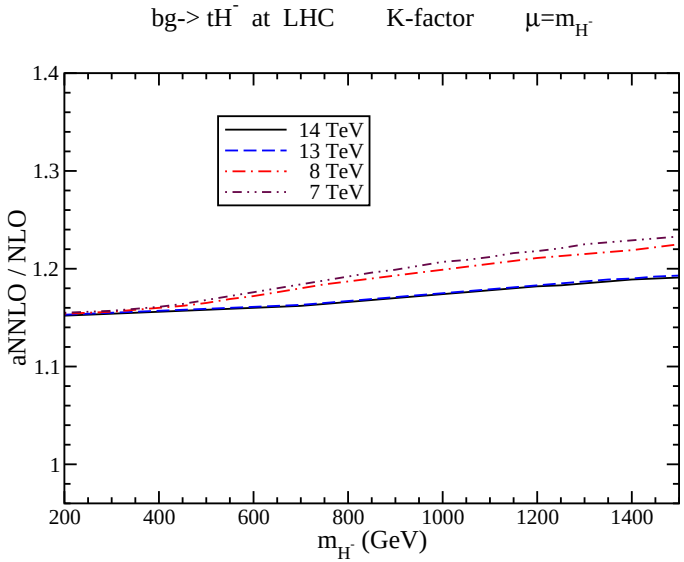
$$\frac{d^2\hat{\sigma}^{(2)\,bg\to tH^-}_{\rm aNNLO}}{dt\,du} = F^{bg\to tH^-}_{\rm LO}\,\frac{\alpha_s^2}{\pi^2}\sum_{k=0}^{3} C_k^{(2)}\left[\frac{\ln^k(s_4/m_H^2)}{s_4}\right]_+$$

tH^- production Total cross sections

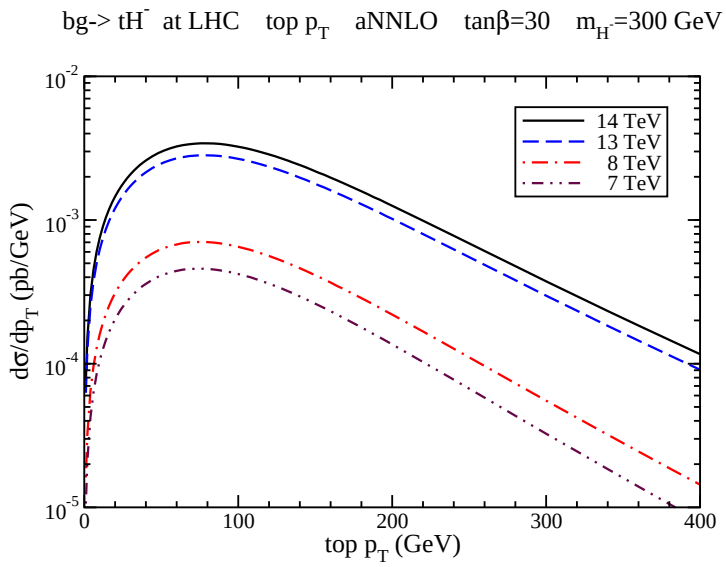


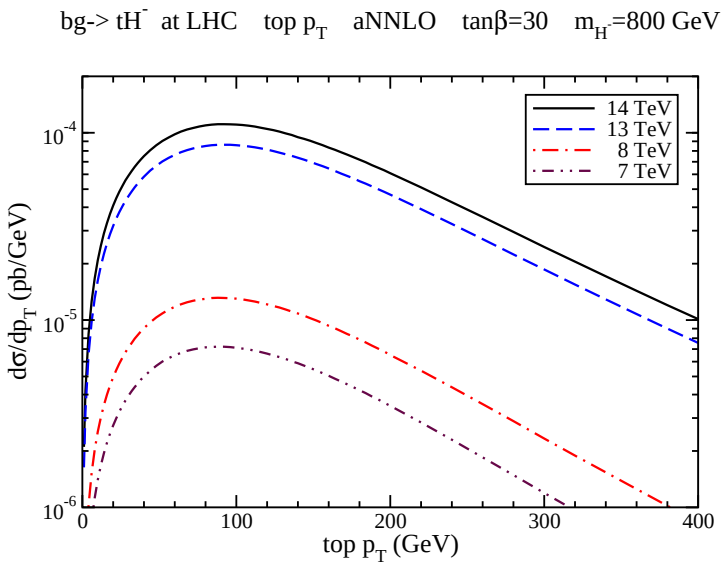


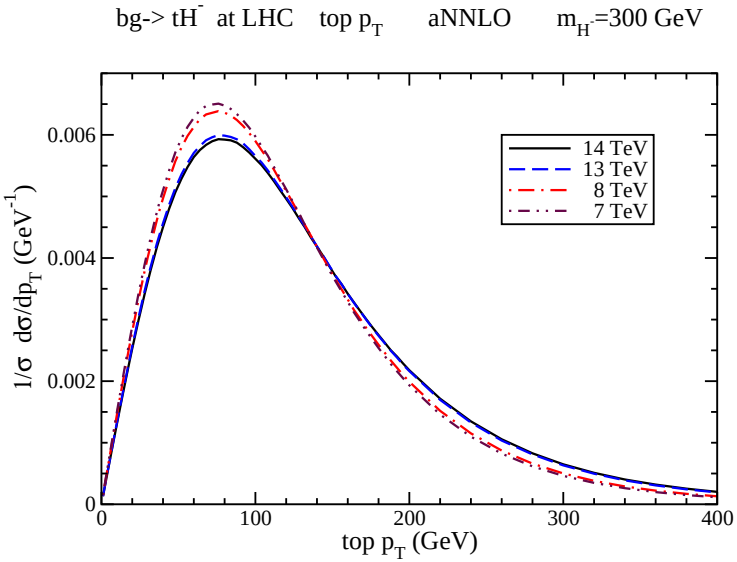


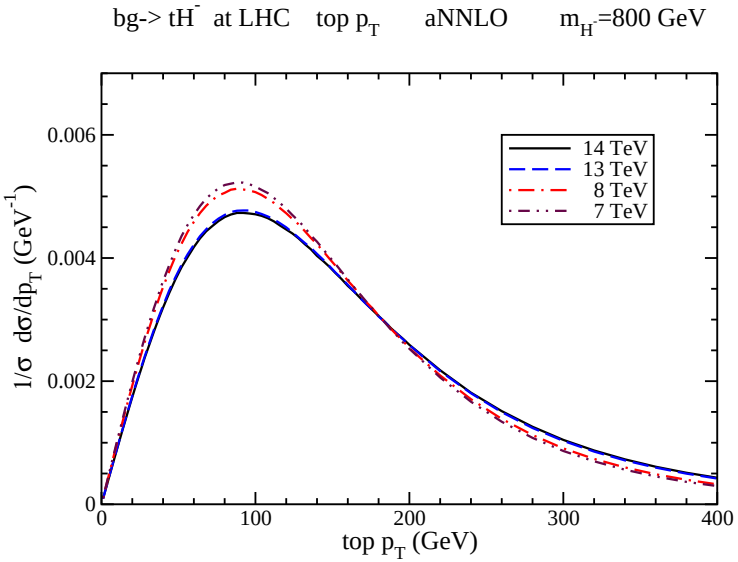


tH^- production Top p_T distributions



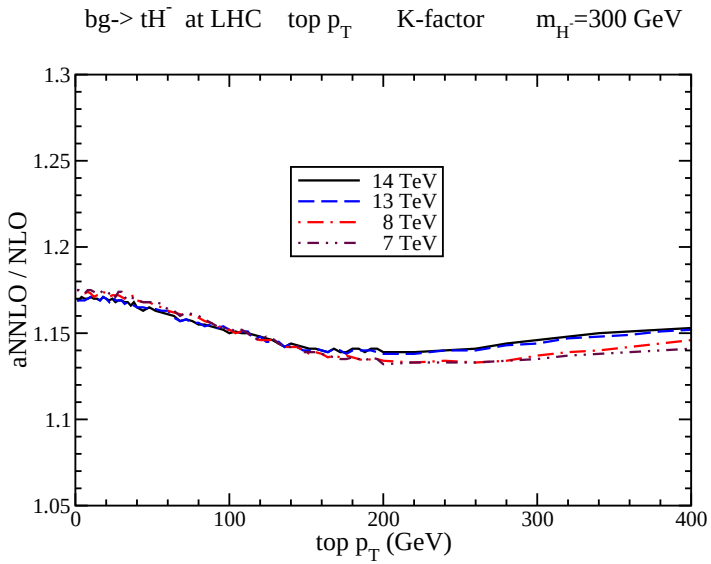


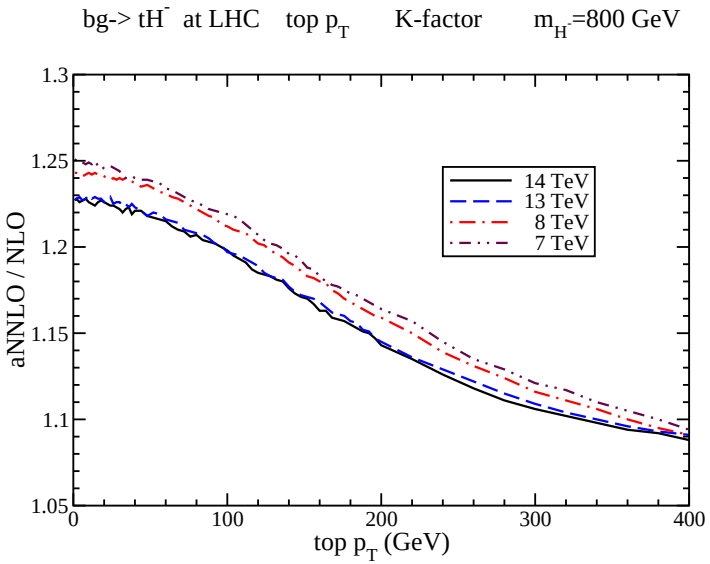




tH^- production

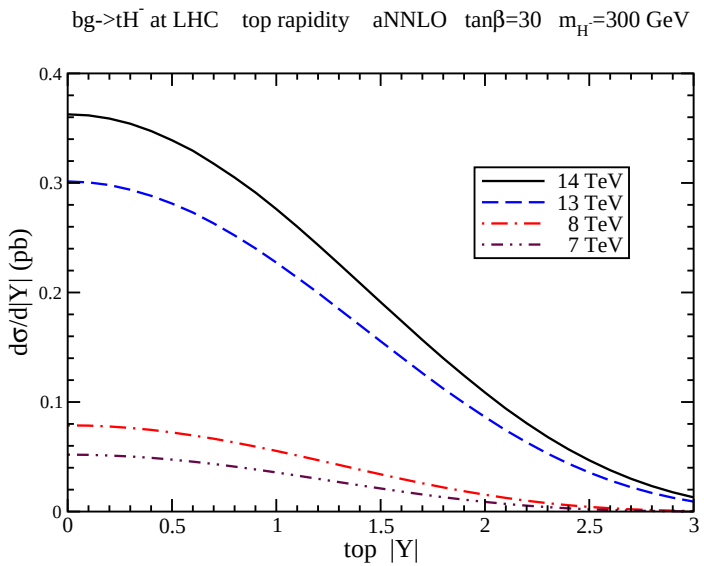
K-factors for top p_T distributions

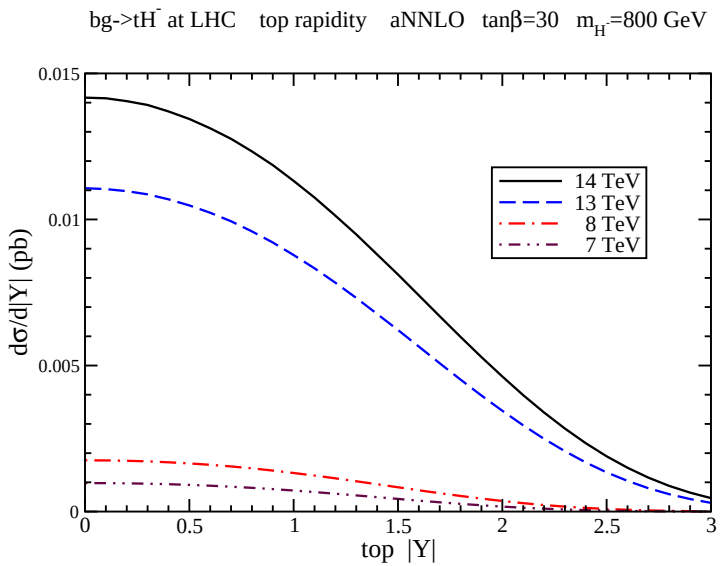


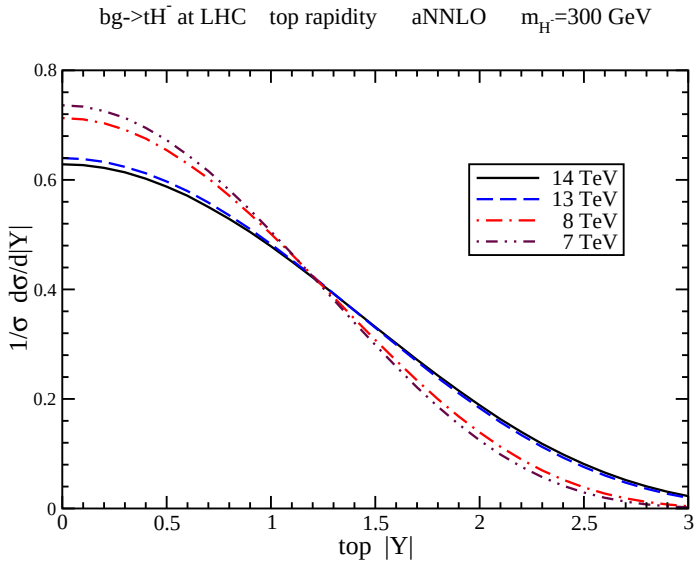


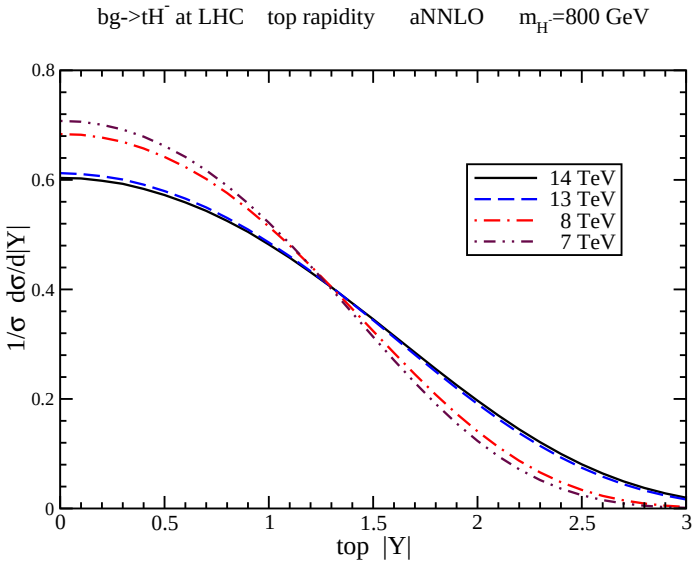
Significant corrections at all LHC energies

tH^- production Top rapidity distributions



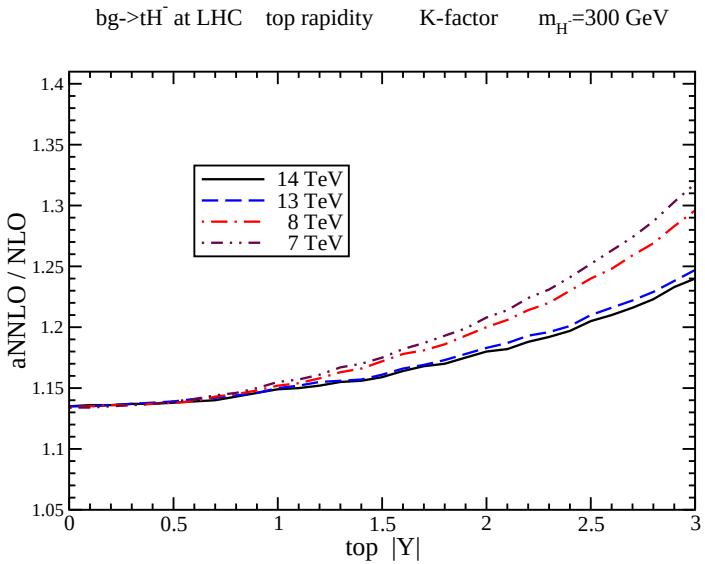


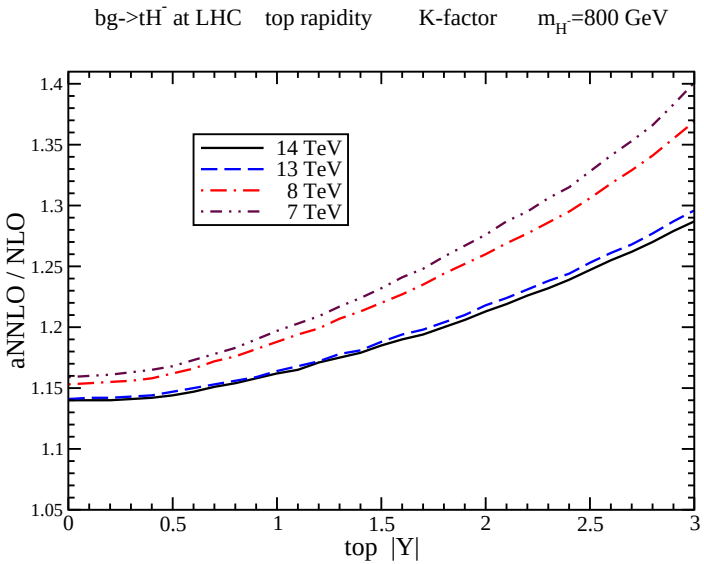




tH^- production

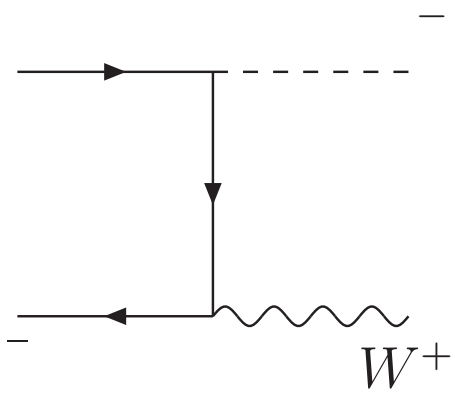
K-factors for top rapidity distributions





Significant corrections especially at large rapidities

H^-W^+ production



$$b(p_1) + \bar{b}(p_2) \to H^-(p_3) + W^+(p_4)$$

Define $s = (p_1 + p_2)^2$, $t = (p_1 - p_3)^2$, $u = (p_2 - p_3)^2$
and $s_4 = s + t + u - m_H^2 - m_W^2$

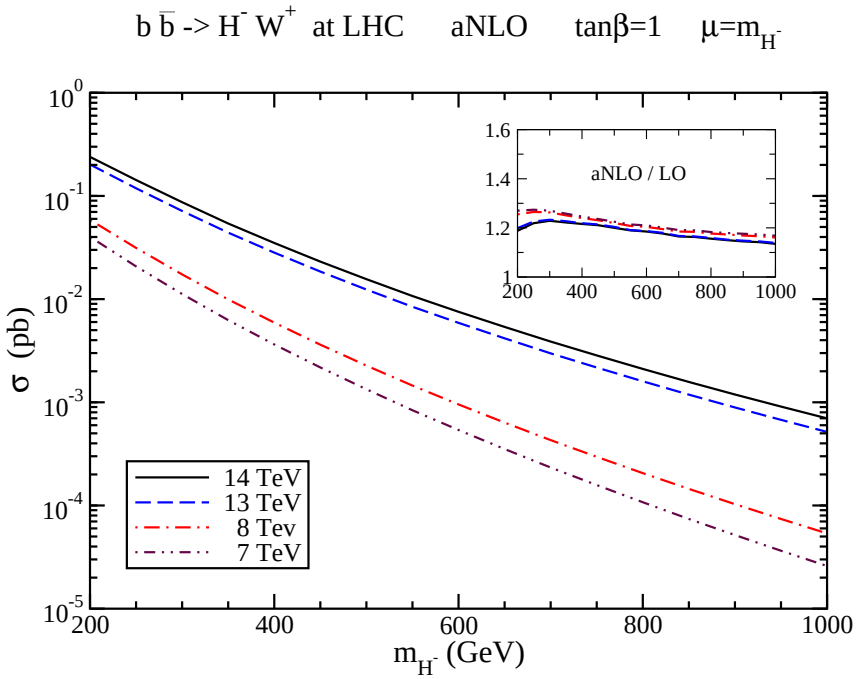
At partonic threshold $s_4 \to 0$

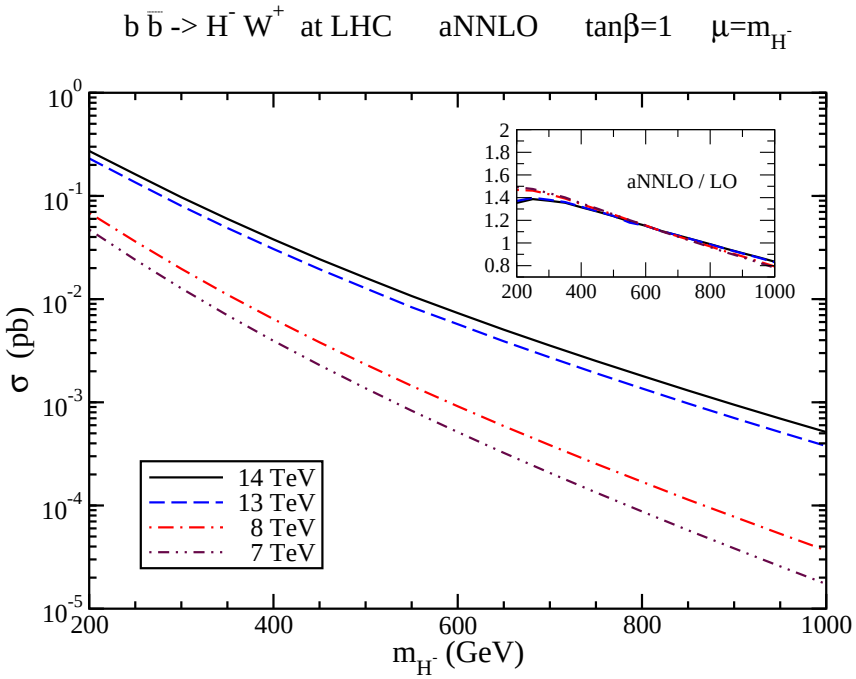
The NNLO collinear and soft-gluon corrections are

$$\frac{d^2\hat{\sigma}^{(2)\, b\bar{b}\to H^-W^+}_{\rm aNNLO}}{dt\, du} = F_{LO}^{b\bar{b}\to H^-W^+} \frac{\alpha_s^2}{\pi^2} \left\{ -C_3^{(2)} \frac{1}{m_H^2} \ln^3\left(\frac{s_4}{m_H^2}\right) + \sum_{k=0}^{3} C_k^{(2)} \left[\frac{\ln^k(s_4/m_H^2)}{s_4}\right]_+ \right\}$$

H^-W^+ production

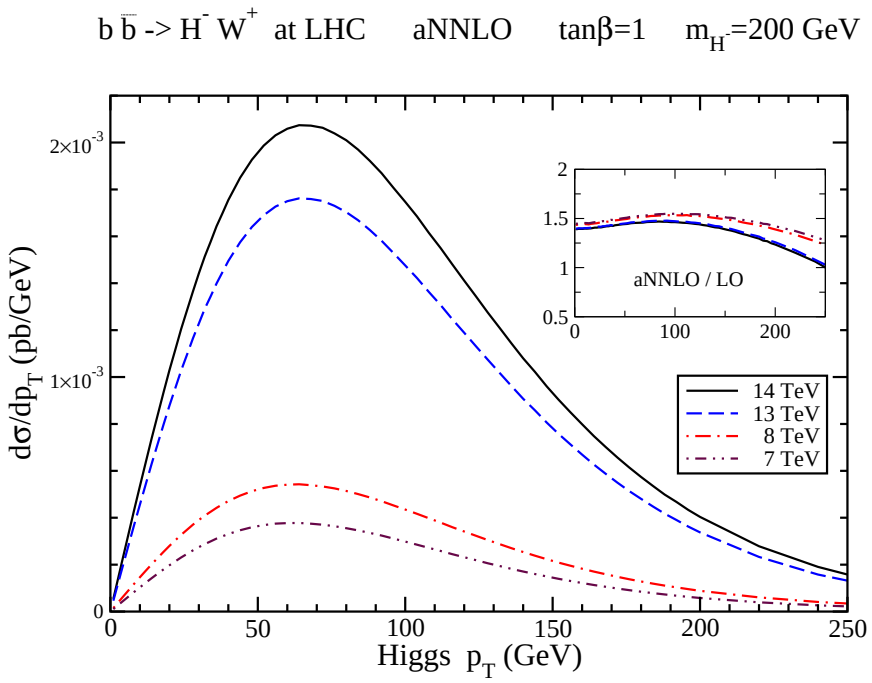
Total cross sections

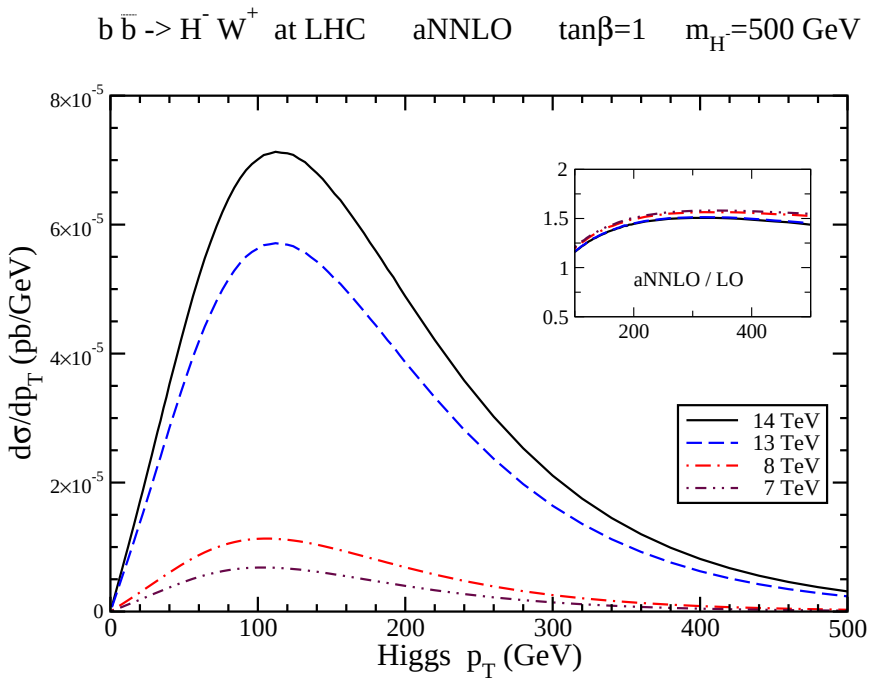




H^-W^+ production

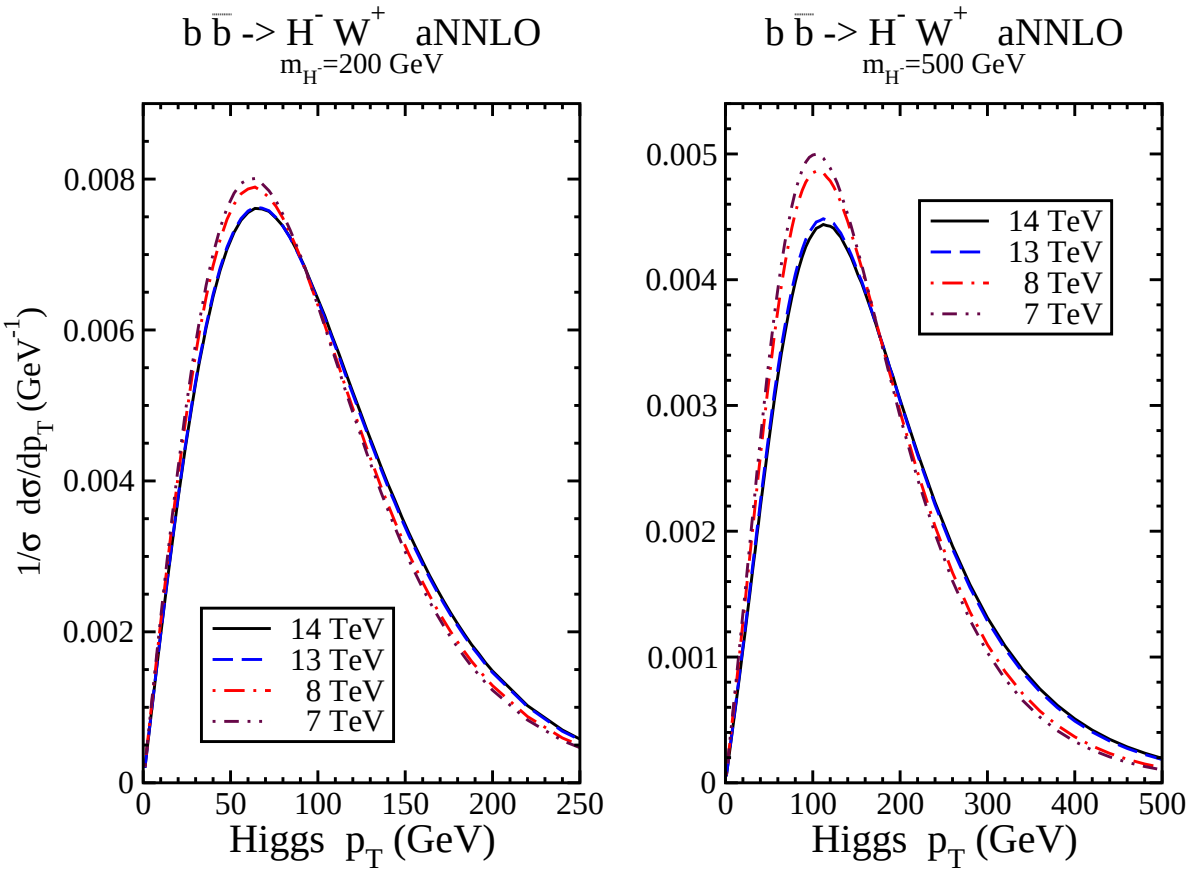
Charged Higgs p_T distributions





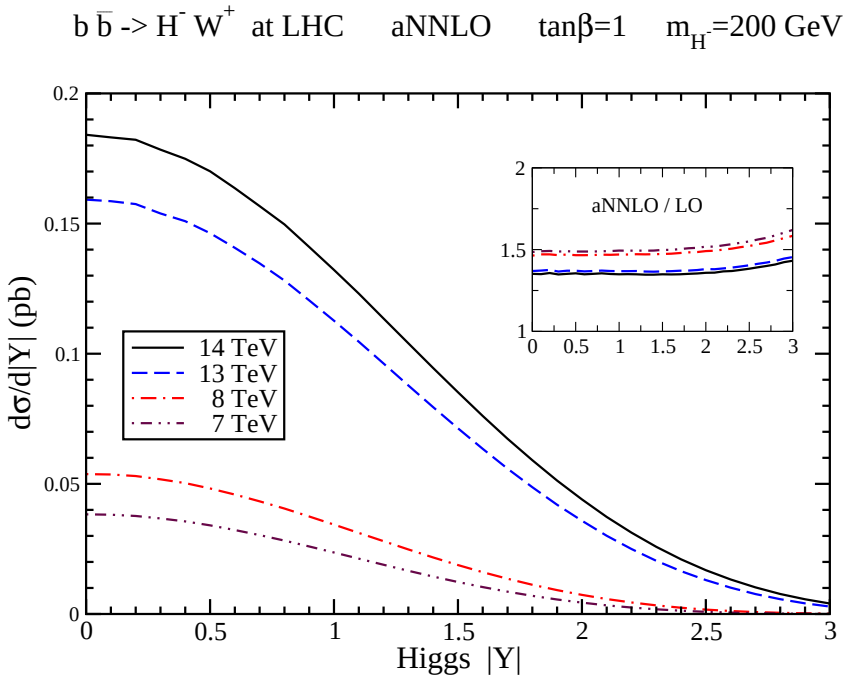
H^-W^+ production

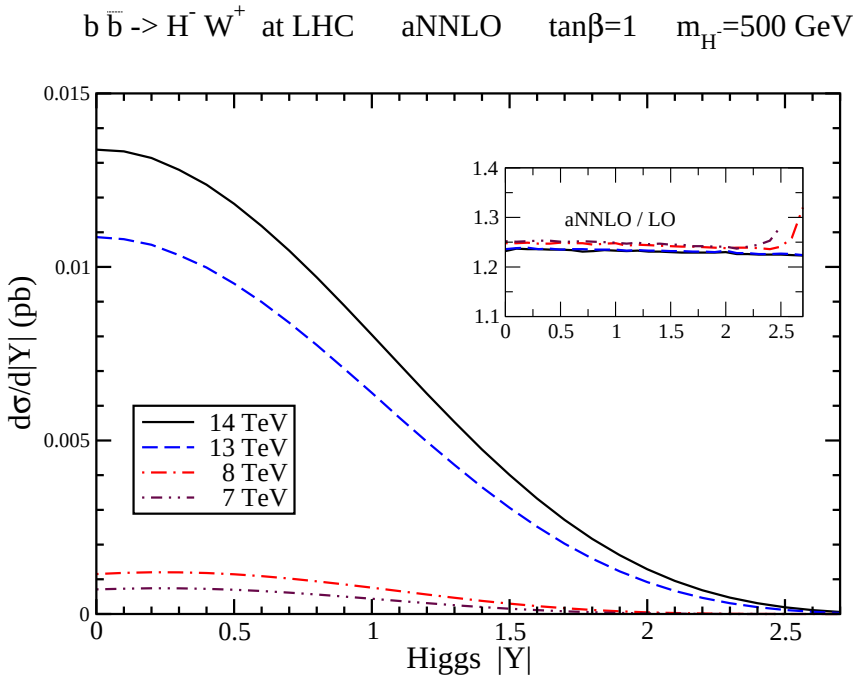
Normalized charged Higgs p_T distributions



H^-W^+ production

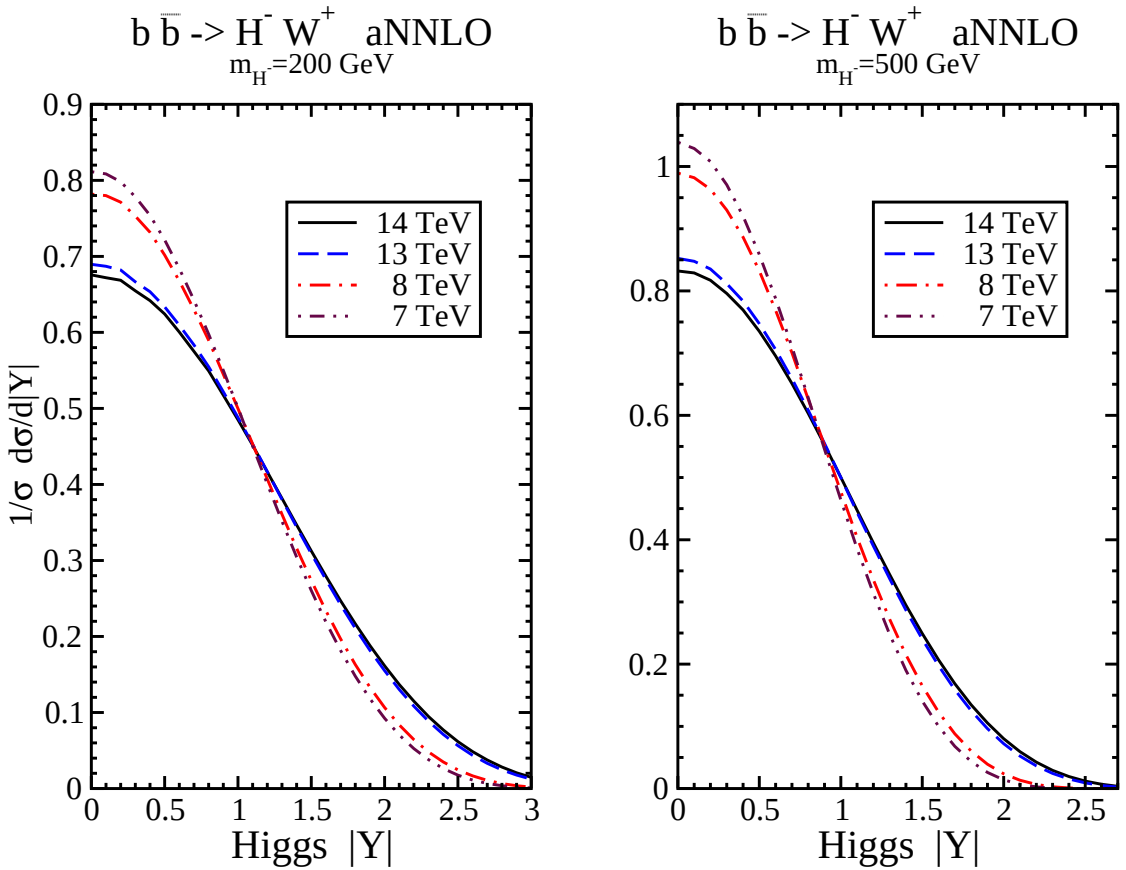
Charged Higgs rapidity distributions





H^-W^+ production

Normalized charged Higgs rapidity distributions



Summary

- **many new results in charged Higgs production**
- **total cross sections for tH^- production**
- **top-quark p_T and rapidity distributions in tH^- production**
- **total cross sections for H^-W^+ production**
- **charged-Higgs p_T and rapidity distributions in H^-W^+ production**
- **higher-order corrections are very significant**