Charged Higgs production with a W boson via b-quark annihilation

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- **Charged Higgs**

- **Higher-order corrections**

- H^-W^+ **production**

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Charged Higgs

A charged Higgs would be sign of new physics

2-Higgs doublet models

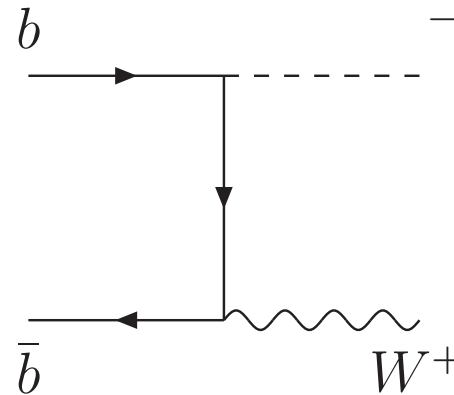**LHC has good potential for discovery**

I will discuss the production process $b\bar{b} \to H^- W^+$

Higher-order corrections are significant

very massive final states

Soft-gluon corrections are important

$H^- W^+$ **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 $s_4 \to 0$

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

Higher-order corrections

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 in $4 - \epsilon$ dimensions

$$\hat{\sigma}^{b\bar{b} \to H^- W^+}(N, \epsilon) = \left(\prod_{i=b,\bar{b}} J_i \left(N, \mu, \epsilon \right) \right) H^{b\bar{b} \to H^- W^+} \left(\alpha_s(\mu) \right) \, S^{b\bar{b} \to H^- W^+} \left(\frac{m_H}{N\mu}, \alpha_s(\mu) \right)$$

where $H^{b\bar{b} \to H^- W^+}$ is hard function and $S^{b\bar{b} \to H^- W^+}$ is soft function

Soft function S satisfies the renormalization group equation

$$\left(\mu \frac{\partial}{\partial \mu} + \beta(g_s, \epsilon) \frac{\partial}{\partial g_s} \right) S^{b\bar{b} \to H^- W^+} = -2 \, S^{b\bar{b} \to H^- W^+} \, \Gamma_S^{b\bar{b} \to H^- W^+}$$

where $\Gamma_S^{b\bar{b} \to H^- W^+}$ is the soft anomalous dimension

Resummed cross section

$$\hat{\sigma}_{\text{res}}^{b\bar{b}\to H^-W^+}(N) = \exp\left[\sum_{i=b,\bar{b}} E_i(N_i)\right] H^{b\bar{b}\to H^-W^+}\left(\alpha_s(\sqrt{s})\right) S^{b\bar{b}\to H^-W^+}\left(\alpha_s(\sqrt{s}/\tilde{N}')\right)$$

$$\times \exp\left[2\int_{\sqrt{s}}^{\sqrt{s}/\tilde{N}'} \frac{d\mu}{\mu}\, \Gamma_S^{b\bar{b}\to H^-W^+}(\alpha_s(\mu))\right]$$

The NNLO collinear and soft-gluon corrections are

$$\frac{d^2\hat{\sigma}_{\text{aNNLO}}^{(2)\,b\bar{b}\to H^-W^+}}{dt\,du} = F_{LO}^{b\bar{b}\to H^-W^+}\frac{\alpha_s^2}{\pi^2}\left\{-C_3^{(2)}\frac{1}{m_H^2}\ln^3\left(\frac{s_4}{m_H^2}\right) + \sum_{k=0}^{3} C_k^{(2)}\left[\frac{\ln^k(s_4/m_H^2)}{s_4}\right]_+\right\}$$
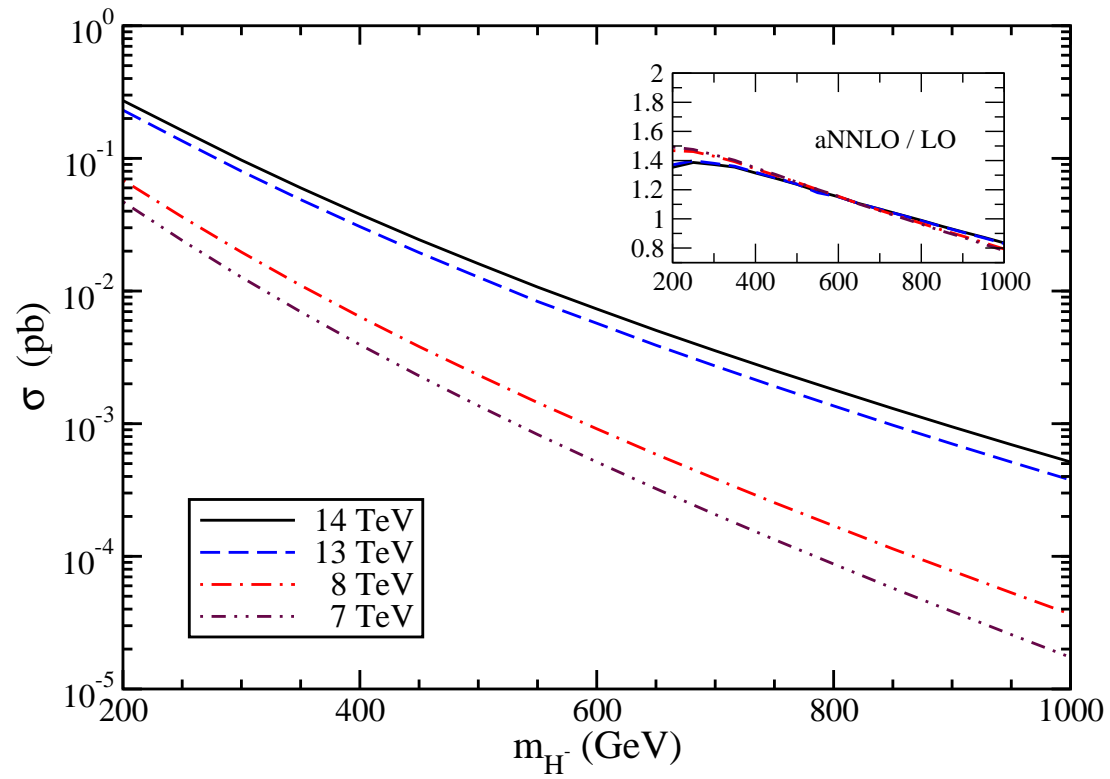
with $C_3^{(2)} = 8C_F^2$

$$C_2^{(2)} = -12C_F^2\left(\ln\left(\frac{(t-m_W^2)(u-m_W^2)}{m_H^4}\right) + \ln\left(\frac{\mu_F^2}{s}\right)\right) - \frac{11}{3}C_F C_A + \frac{2}{3}C_F n_f$$

H^-W^+ **production**
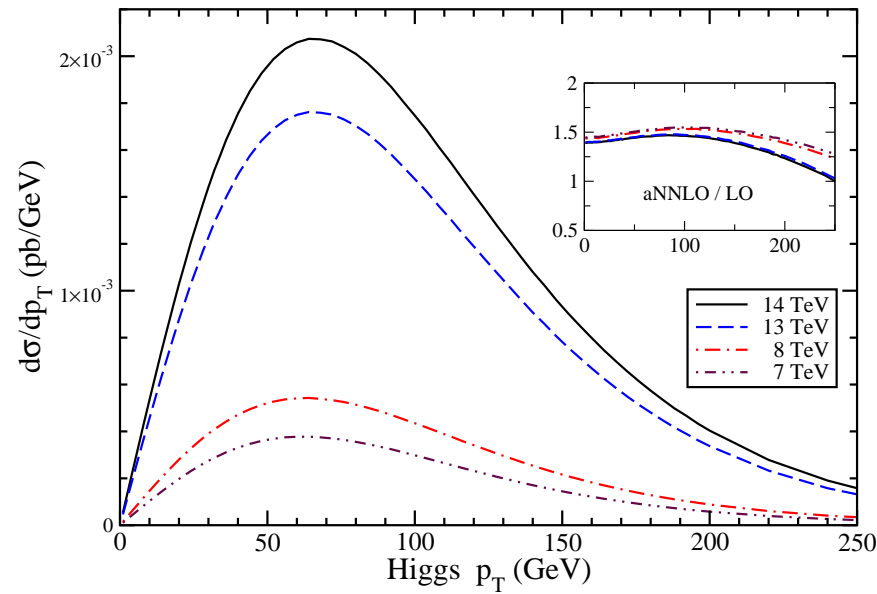
Total cross sections

b b̄ -> H⁻ W⁺ at LHC   aNNLO   tanβ=1   μ=m$_{H^-}$

σ (pb) vs m$_{H^-}$ (GeV)

aNNLO / LO

Legend:
- 14 TeV
- 13 TeV
- 8 TeV
- 7 TeV

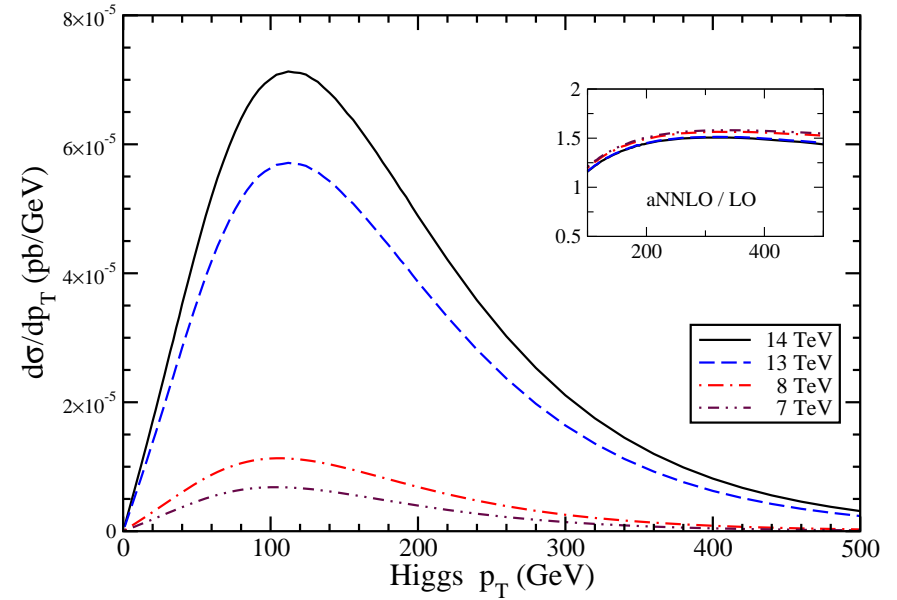# H^-W^+ production

Charged Higgs p_T distributions

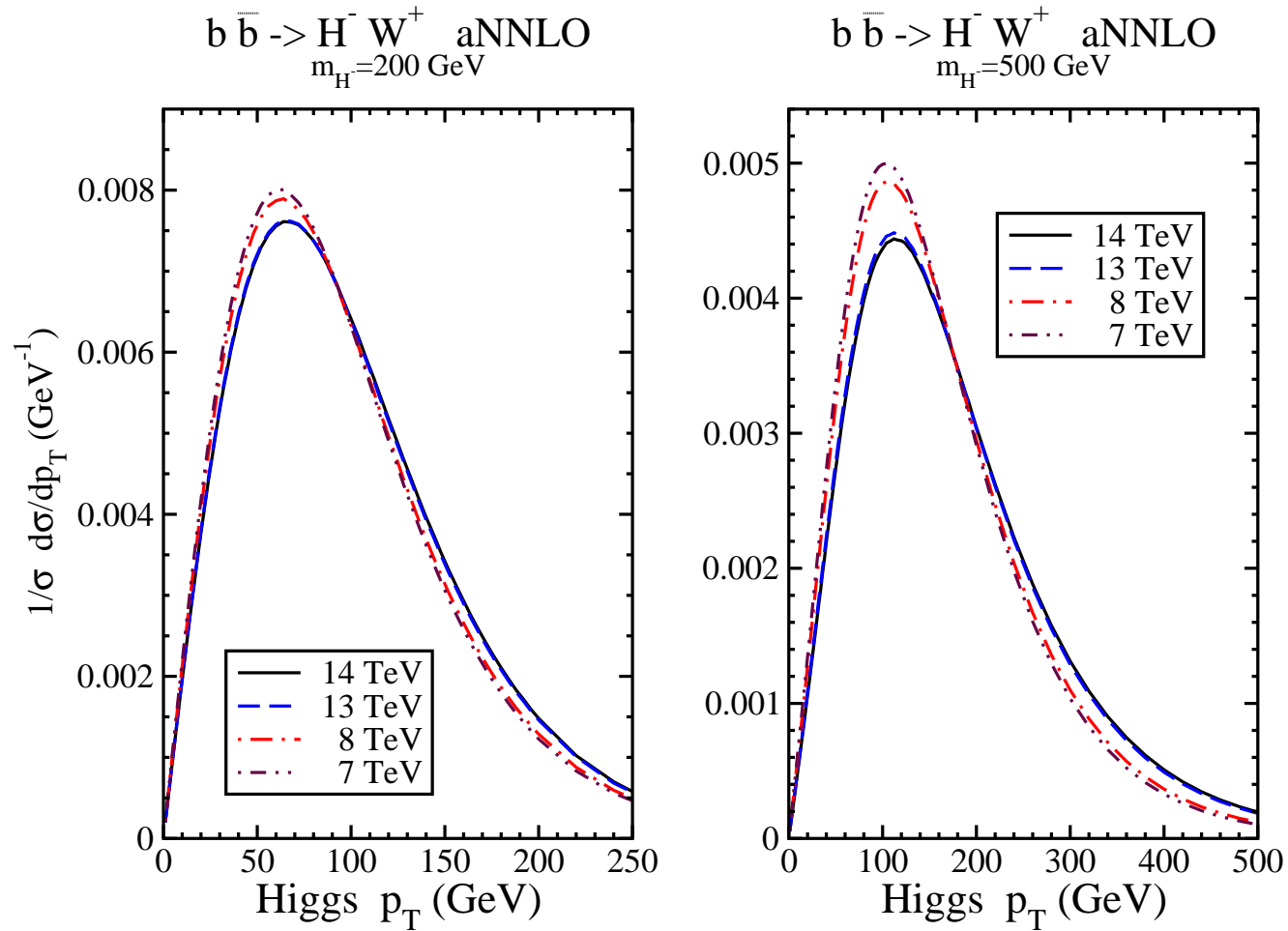$b\,\bar{b} \to H^-W^+$ at LHC   aNNLO $\tan\beta=1$ $m_H=200$ GeV

$b\,\bar{b} \to H^-W^+$ at LHC   aNNLO $\tan\beta=1$ $m_H=500$ GeV
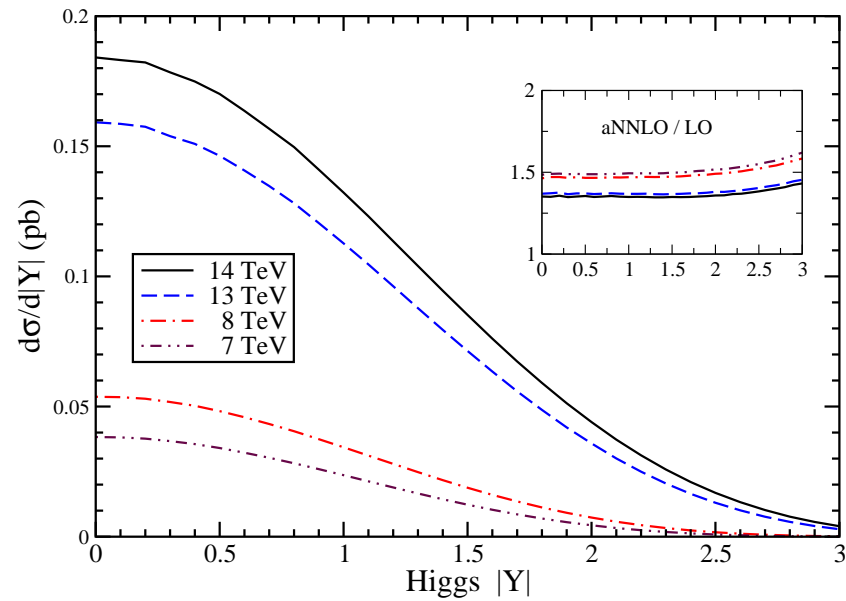
H^-W^+ production
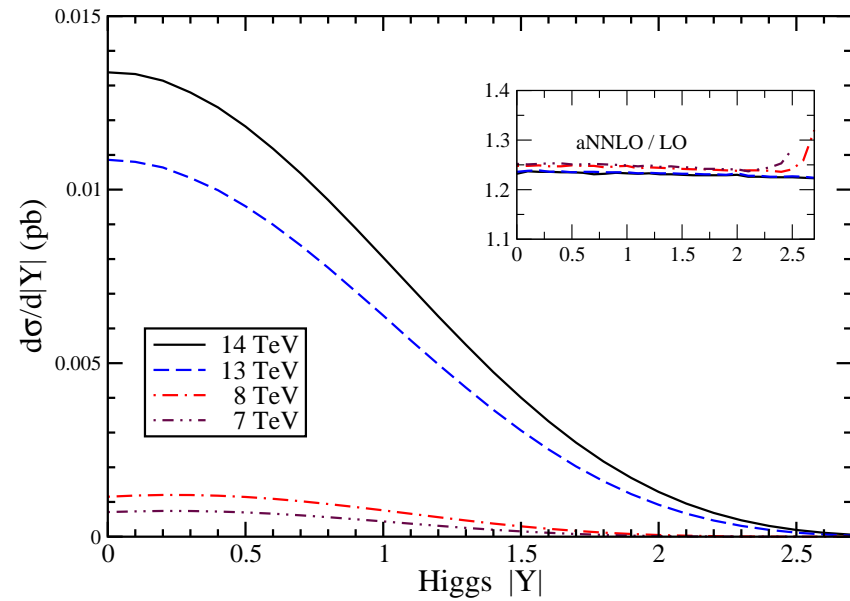
Normalized charged Higgs p_T distributions

b b̄ -> H⁻ W⁺ aNNLO
m_H=200 GeV

b b̄ -> H⁻ W⁺ aNNLO
m_H=500 GeV

H^-W^+ **production**

Charged Higgs rapidity distributions

b b̄ -> H⁻ W⁺ at LHC   aNNLO   tanβ=1 m_H=200 GeV

b b̄ -> H⁻ W⁺ at LHC   aNNLO   tanβ=1 m_H=500 GeV

H^-W^+ production

Normalized charged Higgs rapidity distributions
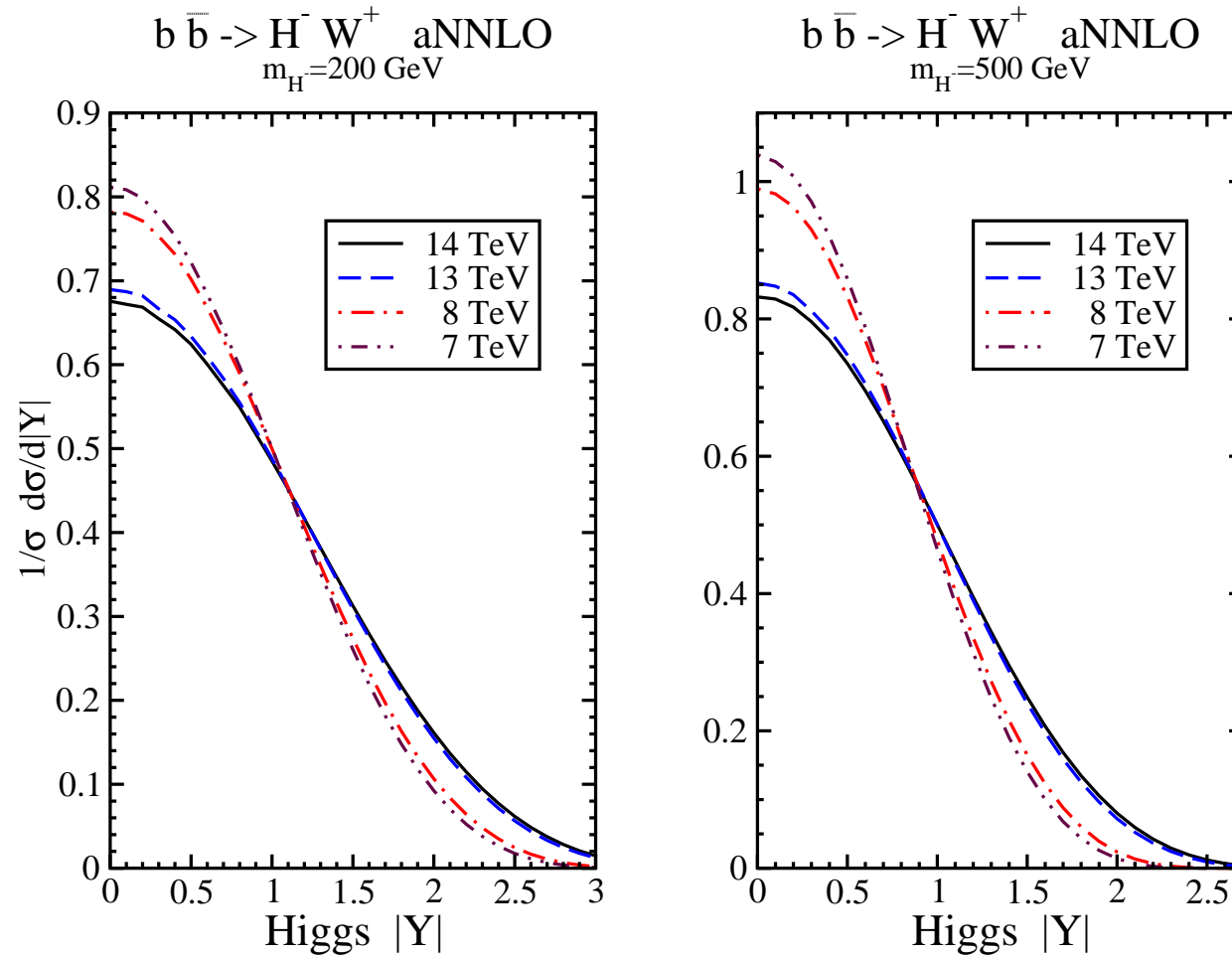
Summary

- **new results for charged Higgs 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**