

# Towards a better understanding of charged Higgs production

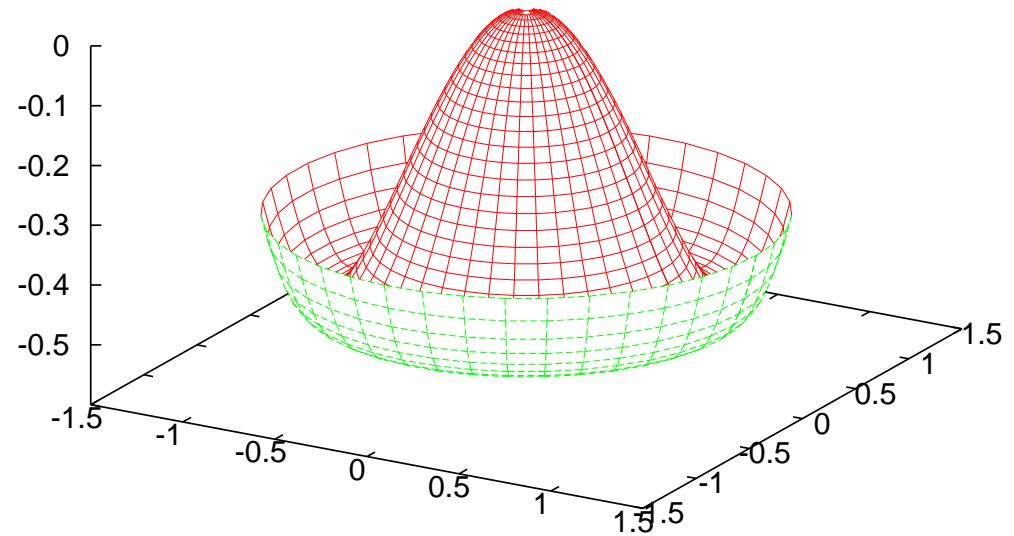
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Theoretical High Energy Physics, Uppsala

Partikeldagarna, Karlstad, 31 Mar 2004

## The Higgs mechanism in the Standard Model

- One of the Higgs components gets a **vacuum expectation value (vev)  $v$**
- Three of the four Higgs degrees of freedom are absorbed by the three massive vector fields
- Fermions get mass from **Yukawa couplings**



## Supersymmetric extensions

- One Higgs doublet can't give mass to both up and down type fermions
- Anomalies don't cancel because of extra fermions (Higgsinos)



Must have (at least) **two Higgs doublets** with opposite hypercharge

This is an example of a (type II) **Two Higgs Doublet Model (2HDM)**

## Two Higgs Doublet Models

- 8 scalar degrees of freedom  $\implies$  5 Higgs particles:

$h, H^0, H^+, H^-, A$  (pseudoscalar)

- Two parameters in MSSM (7 in general 2HDM):

$\tan(\beta) = \frac{v_1}{v_2}$       Ratio of vev's for the doublets

$M_A$       One of the masses, usually the pseudoscalar

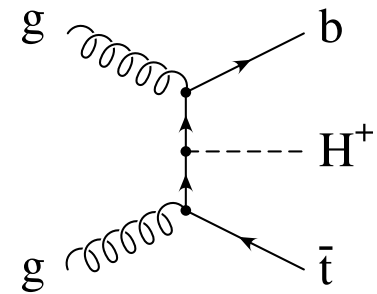
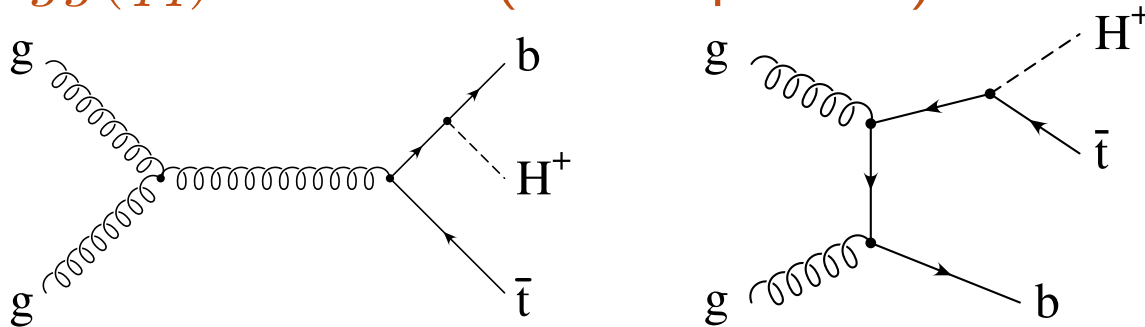
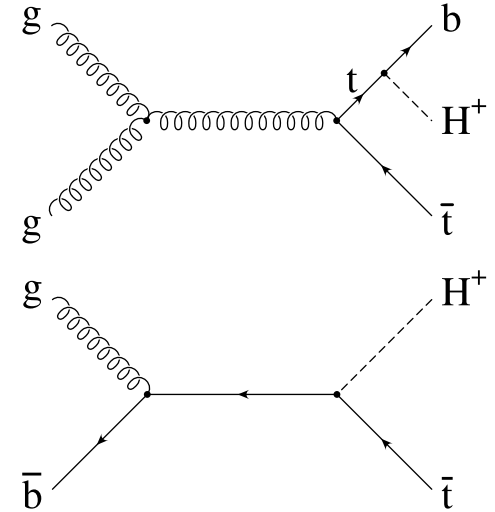
- Finding a charged Higgs would be a clear signal of physics beyond the Standard Model!

## Production channels for single charged Higgs

- $gg(q\bar{q}) \rightarrow t\bar{t} \rightarrow bH^+\bar{t}$  ( $m_{H^+} \leq m_t - m_b$ ):

- $g\bar{b} \rightarrow \bar{t}H^+$  ( $2 \rightarrow 2$  process):

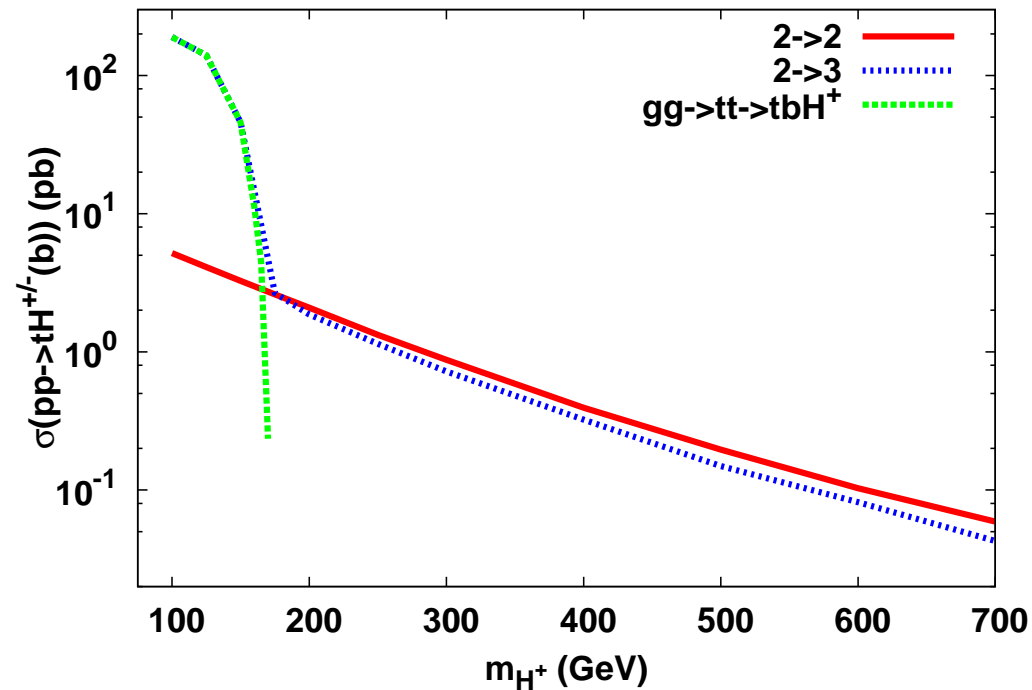
- $gg(q\bar{q}) \rightarrow \bar{t}bH^+$  ( $2 \rightarrow 3$  process):



# Importance of the $H^+$ production processes

Contribution to integrated cross-section dependent on  $H^+$  mass

$\tan(\beta)=30, E_{\text{CM}} = 14 \text{ TeV}$

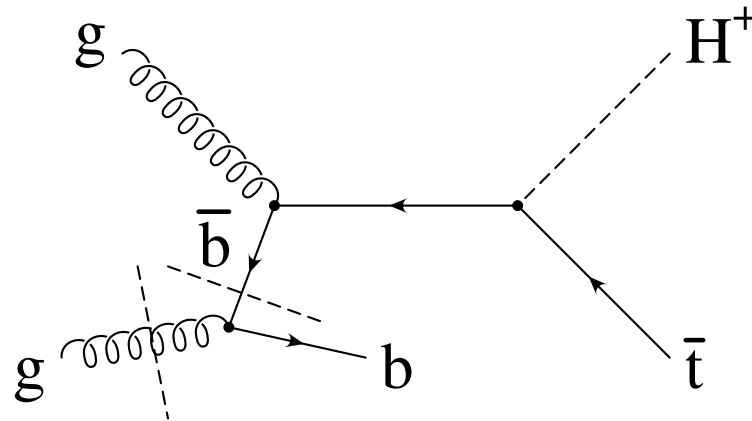


## Matching the $2 \rightarrow 2$ and $2 \rightarrow 3$ processes

$2 \rightarrow 2$ : The  $b$ -density resums collinear logs  $\left( \alpha_s \ln \frac{m_b^2 + p_{\perp,b}^2}{m_b^2} \right)^n$

$2 \rightarrow 3$ : Gives a better description of large  $p_{\perp}$  cross-section

Overlap when the  $b$  of the  $2 \rightarrow 3$  process is collinear with the beam



$\implies$  Must subtract **collinear double counting term**

## Matching the $2 \rightarrow 2$ and $2 \rightarrow 3$ processes (cont)

Using Monte Carlo:

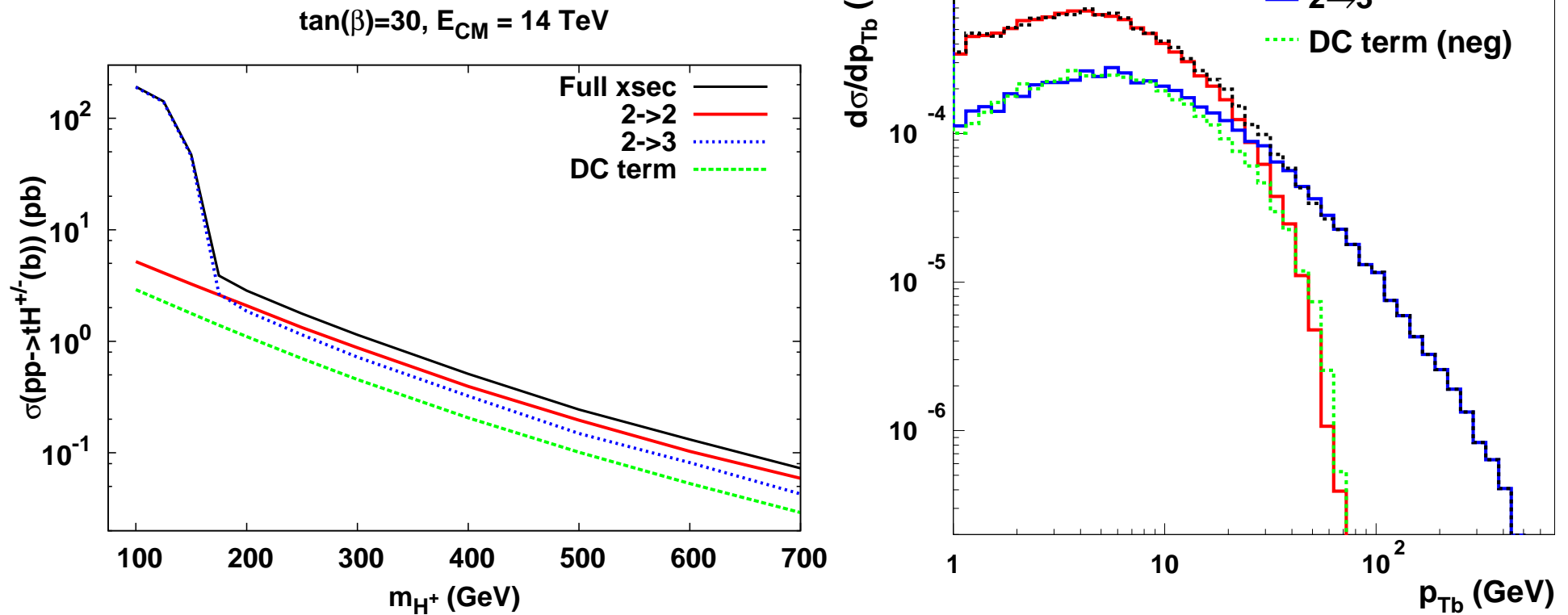
Choose events from **DC distribution** and add with **negative weight**

$$\sigma = \sigma_{2 \rightarrow 2} + \sigma_{2 \rightarrow 3} - \sigma_{\text{DC}}$$

$$\sigma_{\text{DC}} = \int dx_1 dx_2 \left[ g(x_1) b'(x_2) \frac{d\sigma_{2 \rightarrow 2}}{dx_1 dx_2}(x_1, x_2) + x_1 \leftrightarrow x_2 \right]$$

$$b'(x, \mu^2) = \frac{\alpha_s(\mu^2)}{\pi} \int \frac{dQ^2}{Q^2 + m_b^2} \int P_{gb}(z) g(x/z, \mu^2) dz$$

# Results from matching of processes



## Conclusions

- Discovery of a charged scalar particle would be a clear signal of new physics
- Cross-section calculations need both  $gb \rightarrow tH^+$  and  $gg \rightarrow tbH^+$ 
  - For  $H^+$  mass close to  $t$  mass
  - To get transverse momentum dependence right
- These two processes must be properly matched, which we do by Monte Carlo-simulation
- Look for article on hep-ph before summer