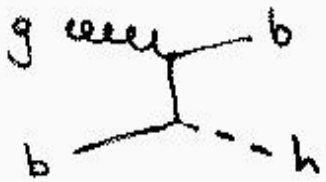
SUSY Higgs:

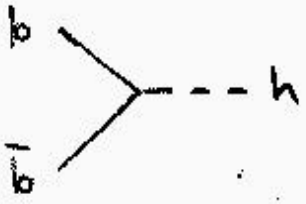
Two b or not two b

Scott Willenbrock

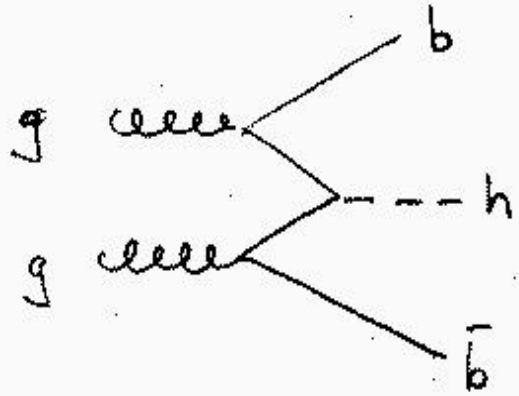
U. of Illinois at Urbana-Champaign



J. Campbell, K. Ellis, F. Maltoni, S.W.



F. Maltoni, Z. Sullivan, S.W.



h + 2 high-p_T b's

NLO: Dittmaier, Kramer, Spira

Dawson, Jackson, Reina, Wackeroth

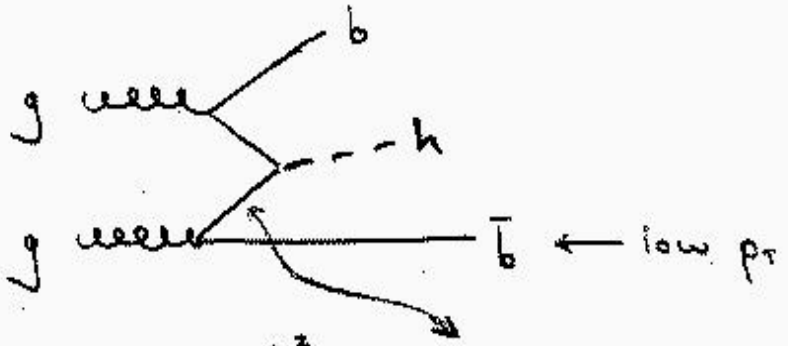
Are <u>two</u> high-p_T b's necessary or desirable?

<u>One</u> high-p_T b is enough to

a. reduce backgrounds

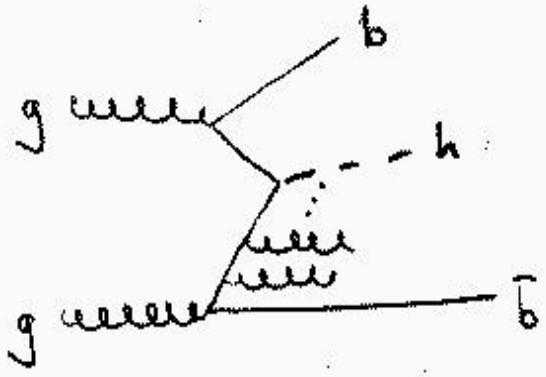
b. identify production process

Two b tags is less efficient



$$\int_0^{m_h^2} dp_T^2 \frac{1}{p_T^2 + m_b^2} \approx \ln \frac{m_h^2}{m_b^2}$$ Collinear enhancement

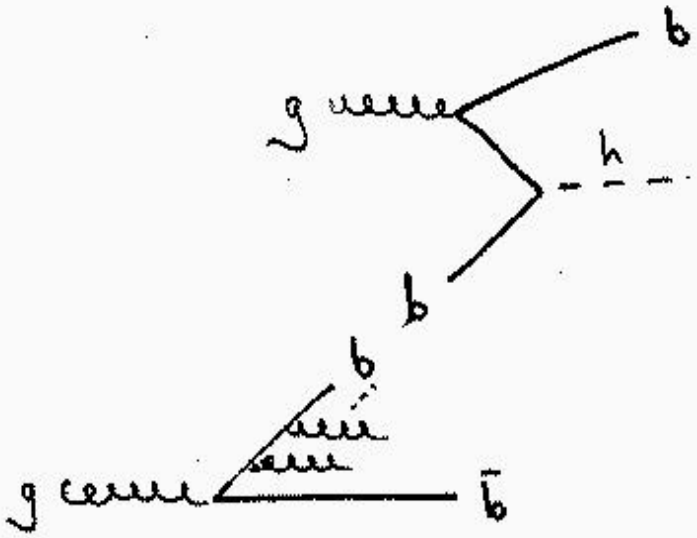
Enhancement desirable, but...



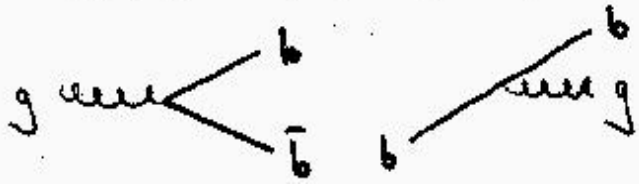
$$\approx \alpha_s^n \ln^n \frac{m_h^2}{m_b^2}$$

... convergence of perturbation series is degraded

<u>Solution:</u> Sum collinear logs to all orders via DGLAP equations



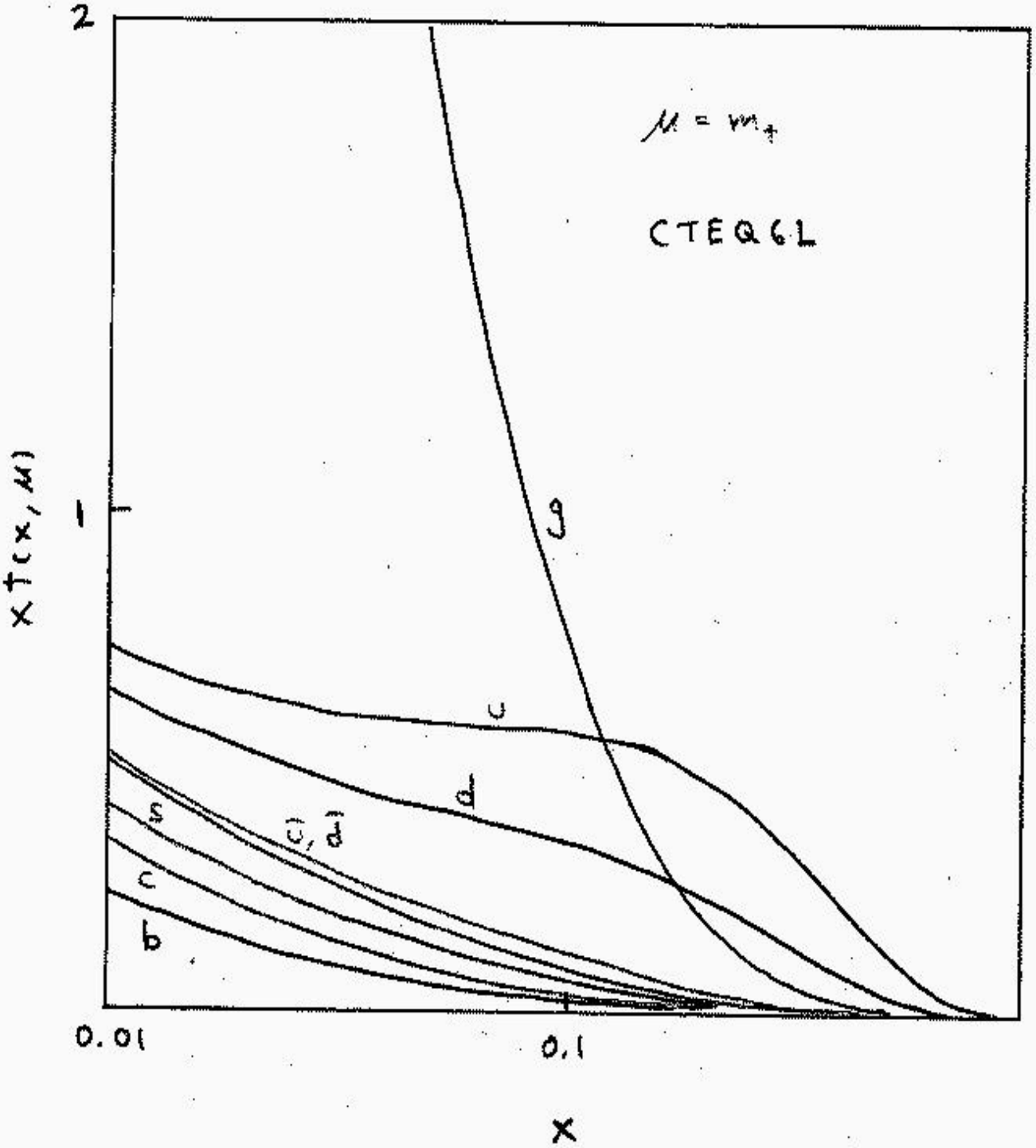
$$\frac{d}{d\ln\mu}\, b(x,\mu) = \frac{\alpha_s(\mu)}{2\pi}\int_x^1 \frac{dz}{z}\Big[\underbrace{P_{qg}(z)\, g\left(\tfrac{x}{z},\mu\right)}_{} + \underbrace{P_{qq}(z)\, b\left(\tfrac{x}{z},\mu\right)}_{}$$



Generates $b(x,\mu)$ from initial condition $b(x,\mu=m_b)=0$ $\overline{MS}$

Aivazis, Collins, Olness, Tung

(ACOT)

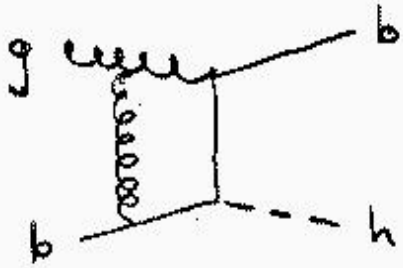

2
1
0.01
0.1
x
$xf(x,\mu)$
$\mu = m_t$
CTEQ6L
g
u
d
s
c
b
$\bar{u}$, $\bar{d}$

LO:

Choudhury, Datta, Raychoudhuri

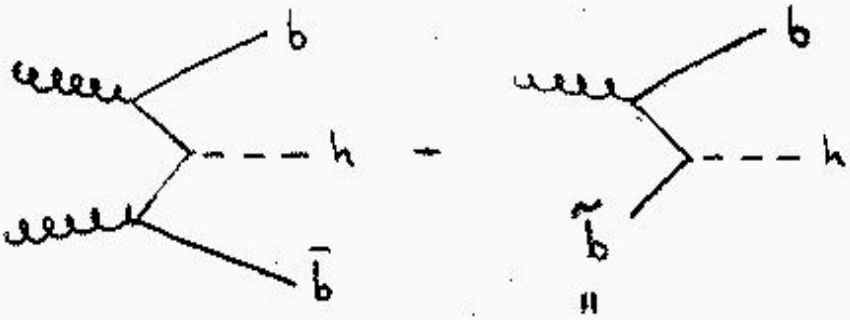
Huang + Zhu

NLO:



+ ...

Campbell, Ellis, Maltoni, S.W.



< 10%

$$\frac{\alpha_s(\mu)}{2\pi} \ln \frac{\mu^2}{m_b^2} \int_x^1 \frac{dz}{z} P_{qg}(z)\, g\left(\frac{x}{z}, \mu\right)$$

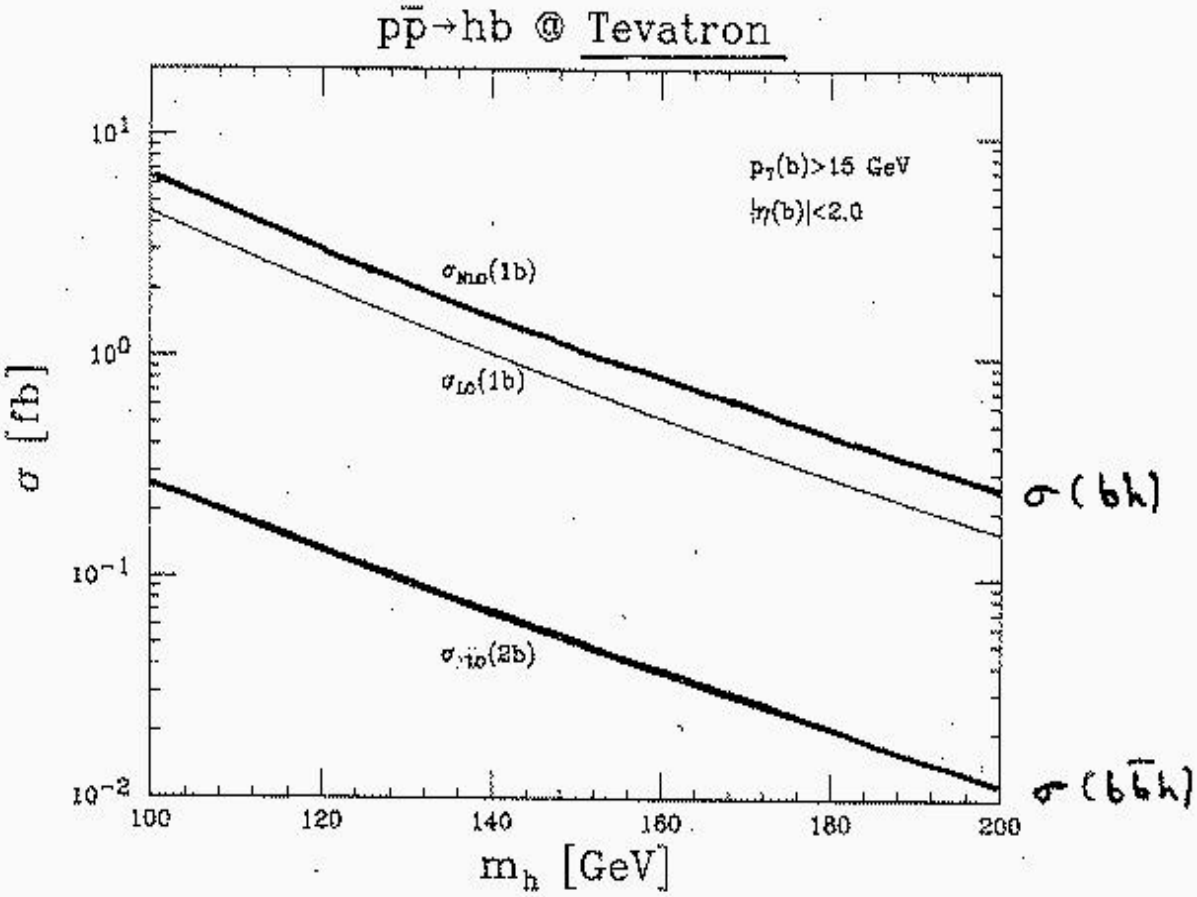


Figure 6: Cross section for the associated production of the Higgs boson and a single b quark at the Tevatron. The b quark is within the tagging region of the silicon vertex detector ($p_T > 15$ GeV, $|\eta| < 2$). The curve labeled $\sigma_{LO}(1b)$ is the leading-order cross section, evaluated with LO parton distribution functions (CTEQ5L) and couplings evolved at LO, evaluated at $\mu = m_h$. The notation indicates that there is only one b quark at high p_T. The curve labeled $\sigma_{NLO}(1b)$ is the next-to-leading-order cross section, evaluated with NLO parton distribution functions (CTEQ5M1) and couplings evolved at NLO, evaluated at $\mu = m_h$. Only the subprocesses that yield a single b quark in the tagging region are included. The cross section for NLO subprocesses that yield two b quarks in the tagging region is labeled $\sigma_{NLO}(2b)$.

$\sigma(bh) \gg \sigma(b\bar{b}h)$!

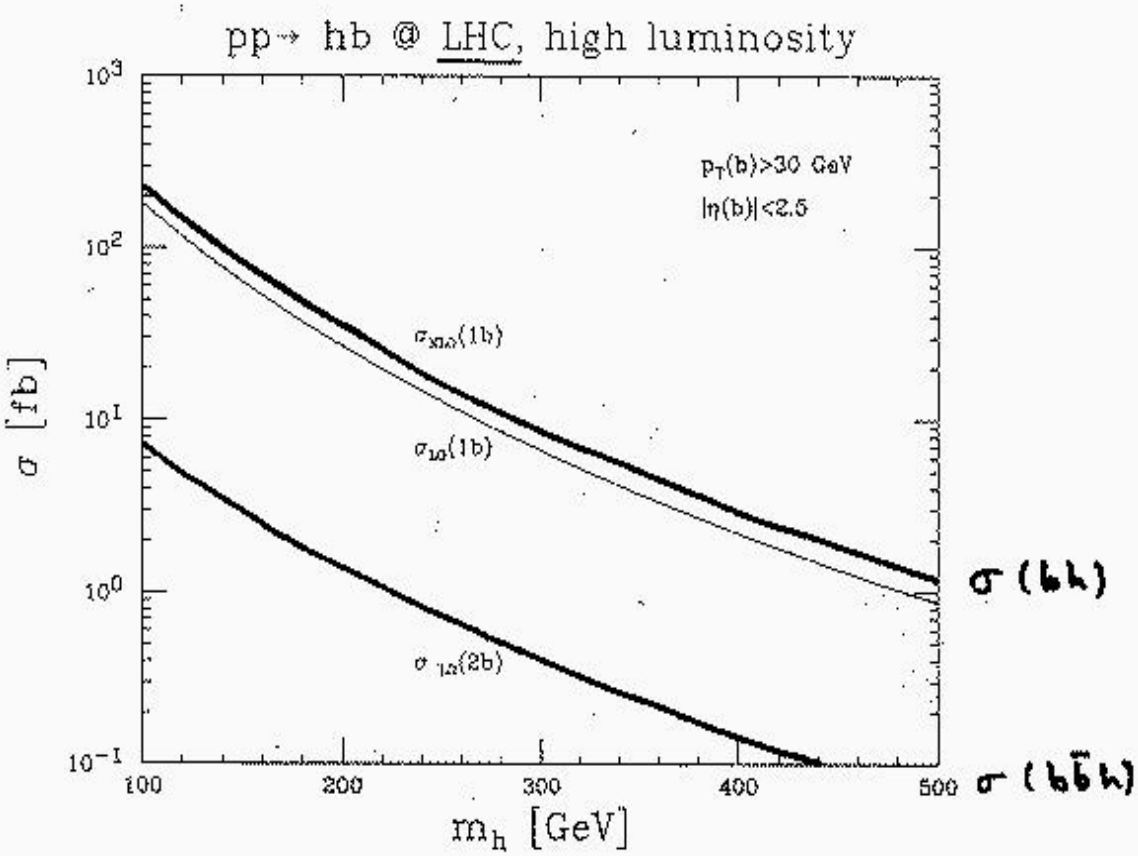


Figure 8: Same as Fig. 6, but at the LHC, and with a b-tagging region of $p_T > 30$ GeV, $|\eta| < 2.5$.

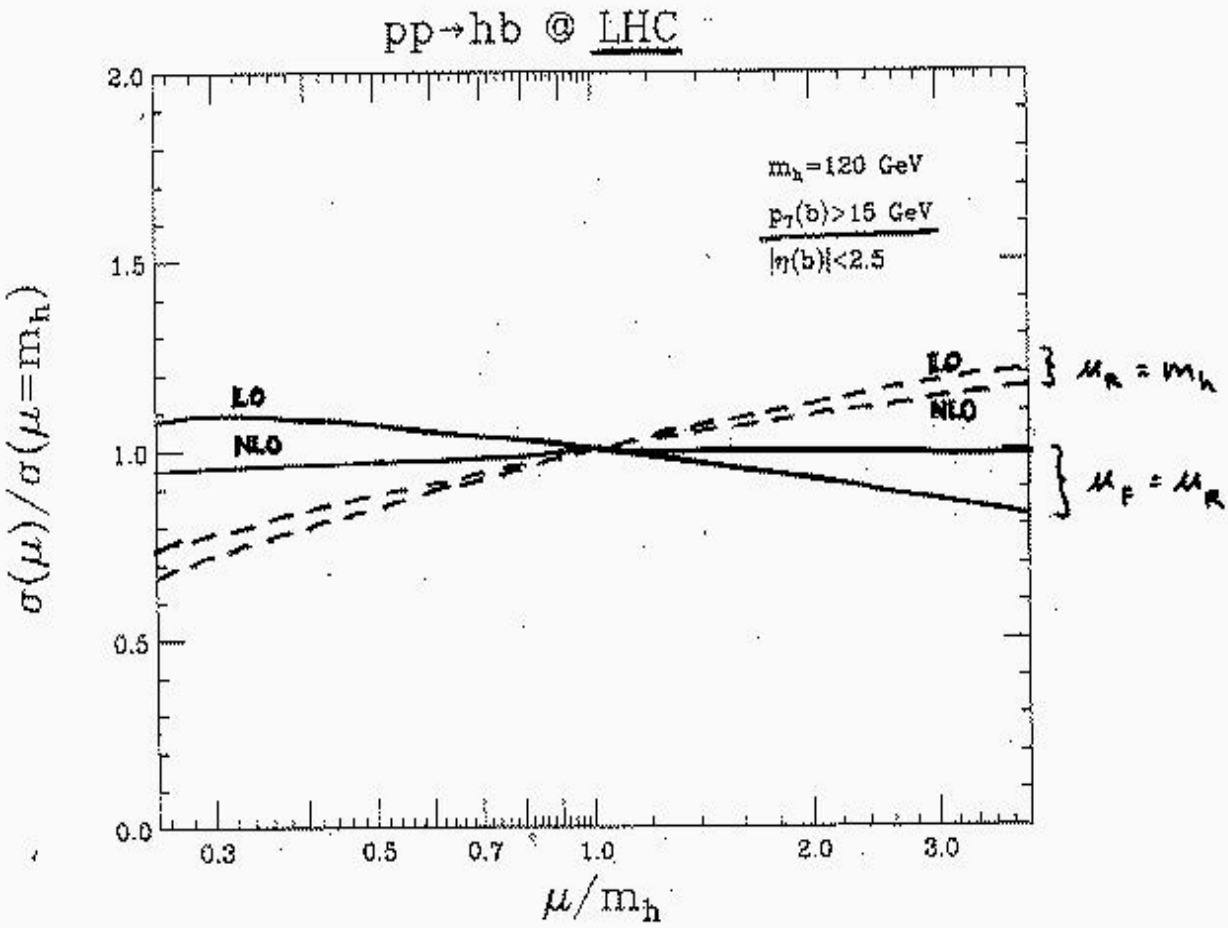
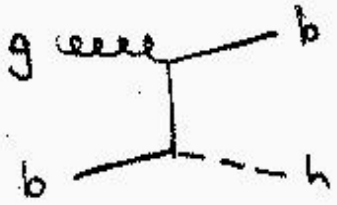
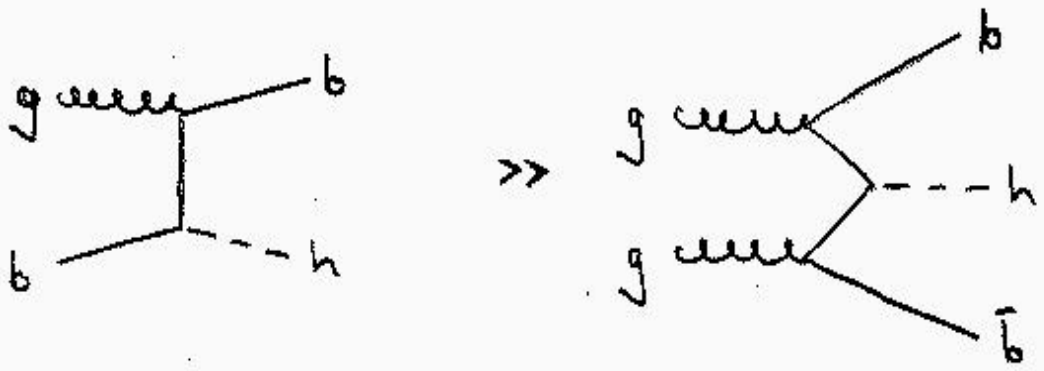


Figure 10: Same as Fig. 9, but at the LHC.



Result:

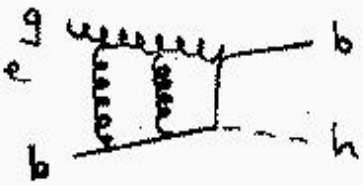


h + 1 high-p_T b h + 2 high-p_T b's

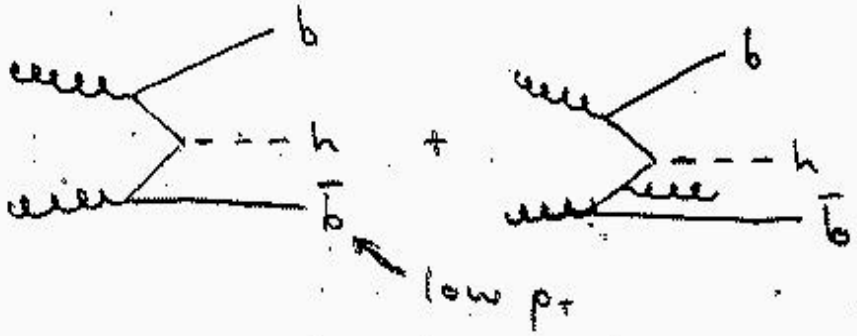
NLO code available in MCFM Campbell + Ellis

LO process in Pythia, HERWIG, MadEvent, CompHEP

NNLO foreseeable



$gg \to b\bar{b}h$ at NLO should also be accurate if m_h not too large

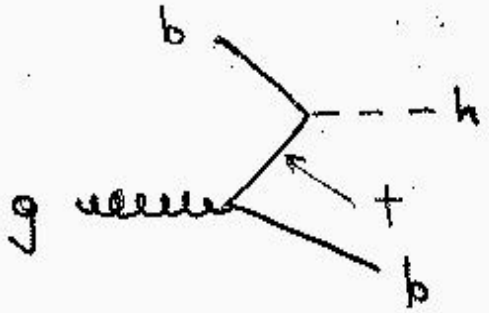


Inclusive h production:

LO:

What is factorization scale $b(x, \mu_F)$? $\mu_F = m_h$?

Study NLO correction:



$\frac{d\sigma}{dt} \sim \frac{1}{t}$ in collinear region

Plot $-t \frac{d\sigma}{dt}$ vs. $\sqrt{-t}/m_h$

Indicates $\mu_F \approx \frac{m_h}{4}$

Plehn + Boos
Maltoni, Sullivan,
S.W.

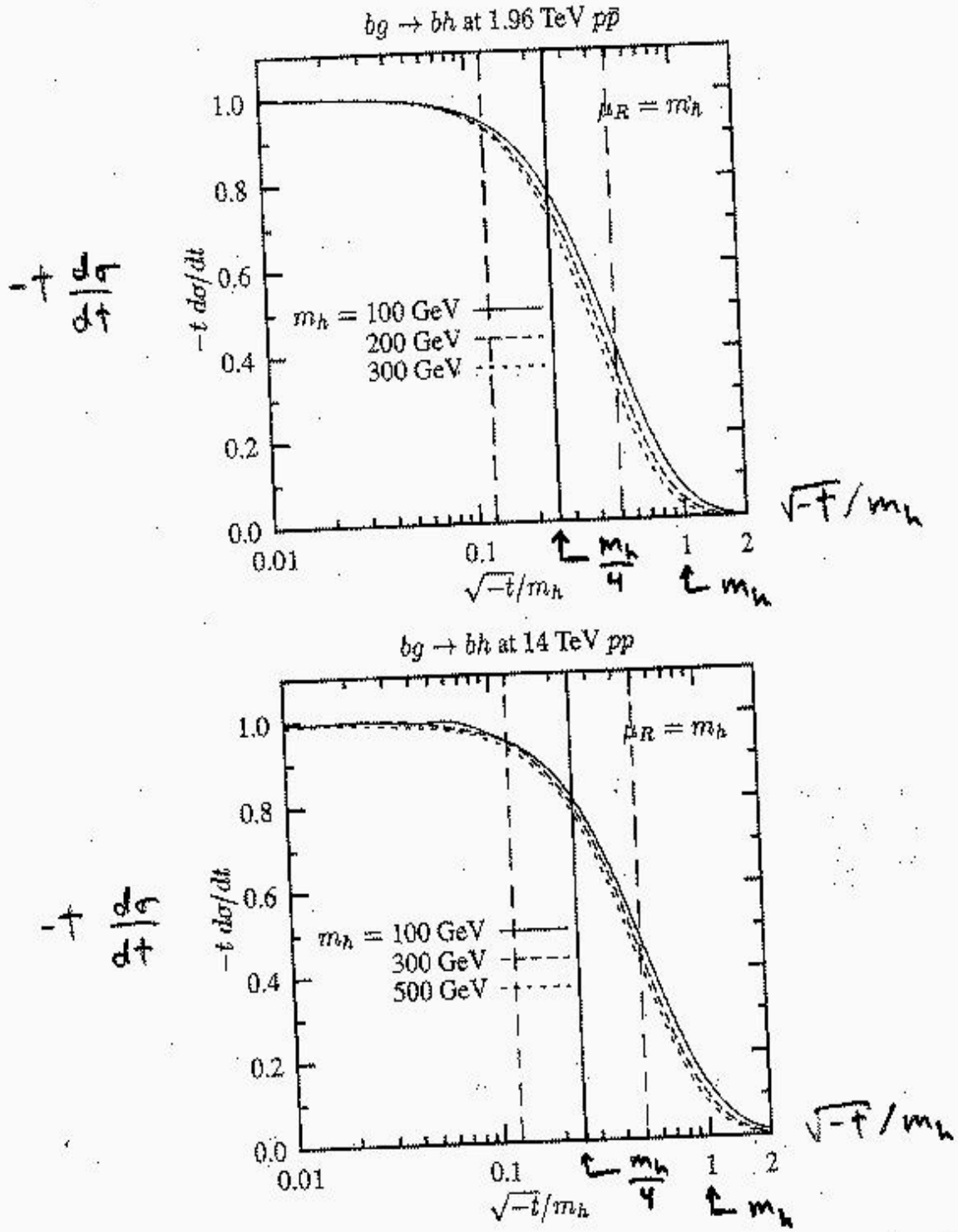
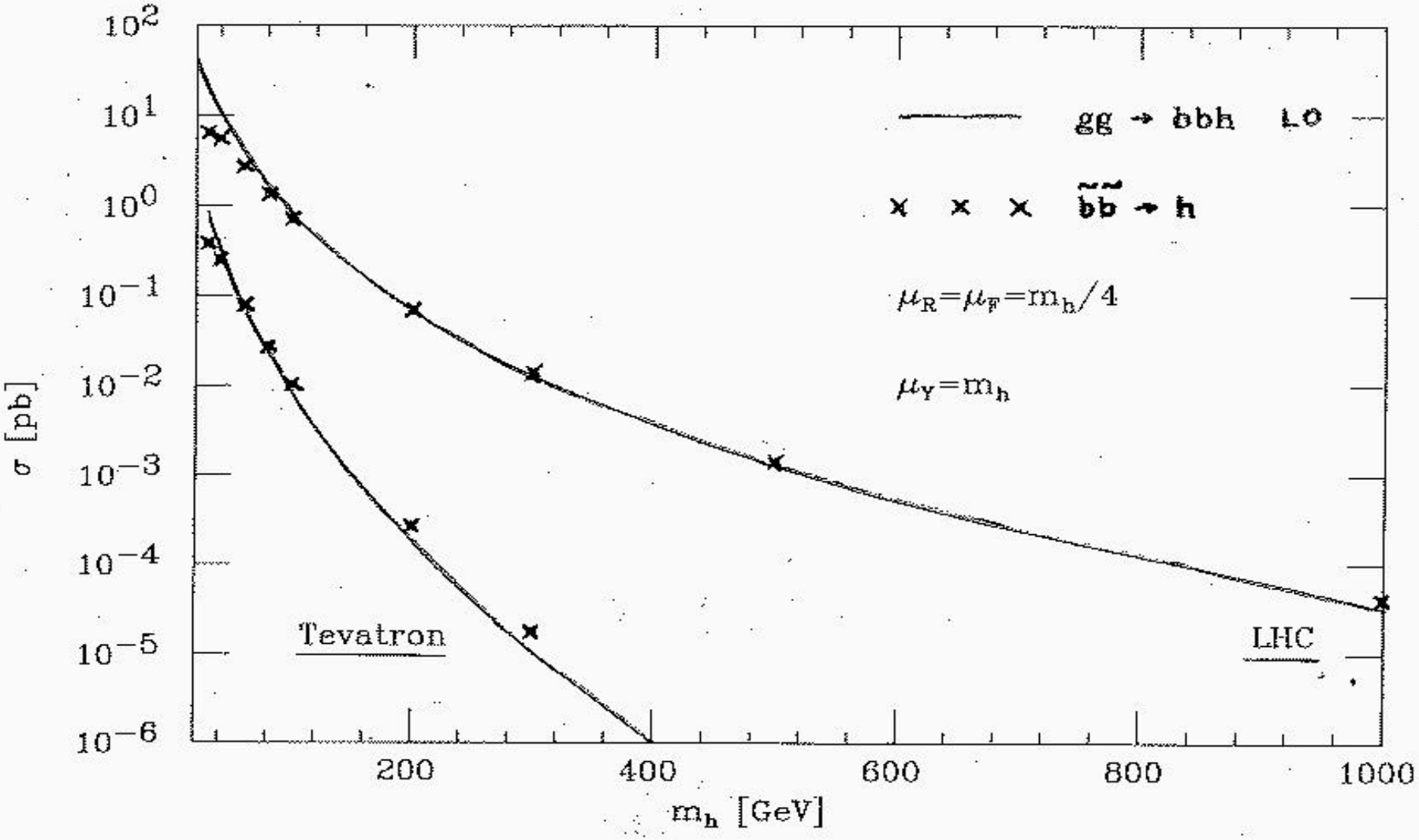


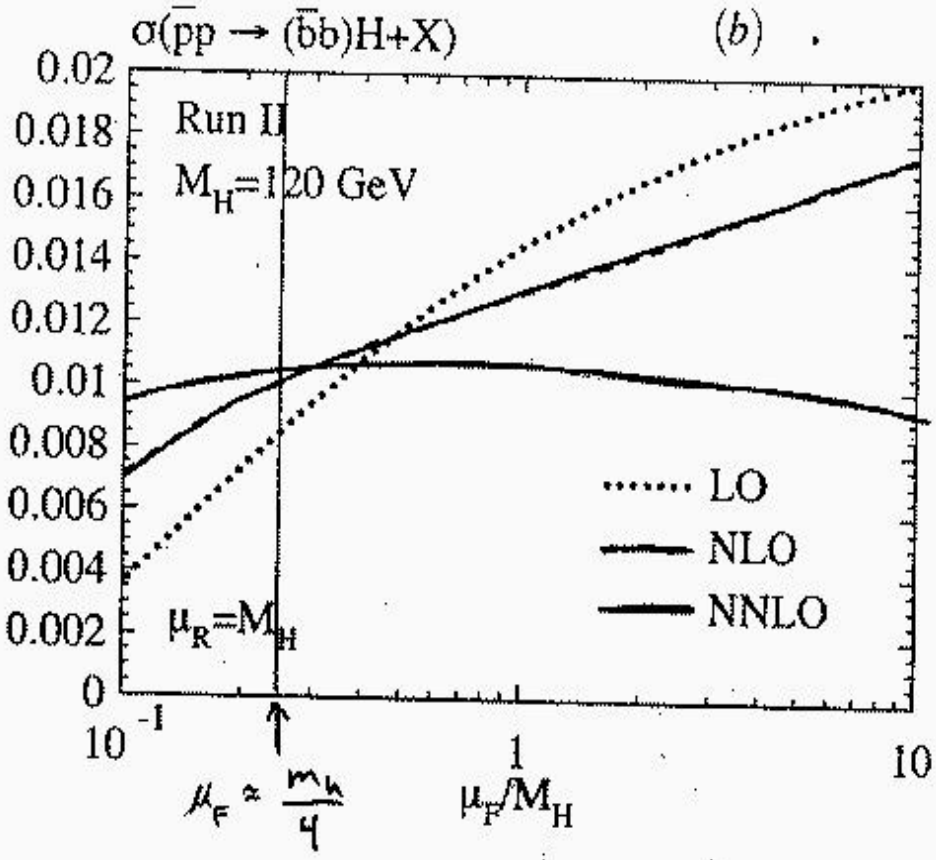
FIG. 5: Hadronic differential cross section times the squared virtuality for the subprocess $bg \to bh$ *vs.* the virtuality (scaled to the Higgs-boson mass) at both the Tevatron (upper plot) and the LHC (lower plot). Curves are shown for a variety of Higgs-boson masses, scaled such that they overlap at small virtuality.

Inclusive cross section

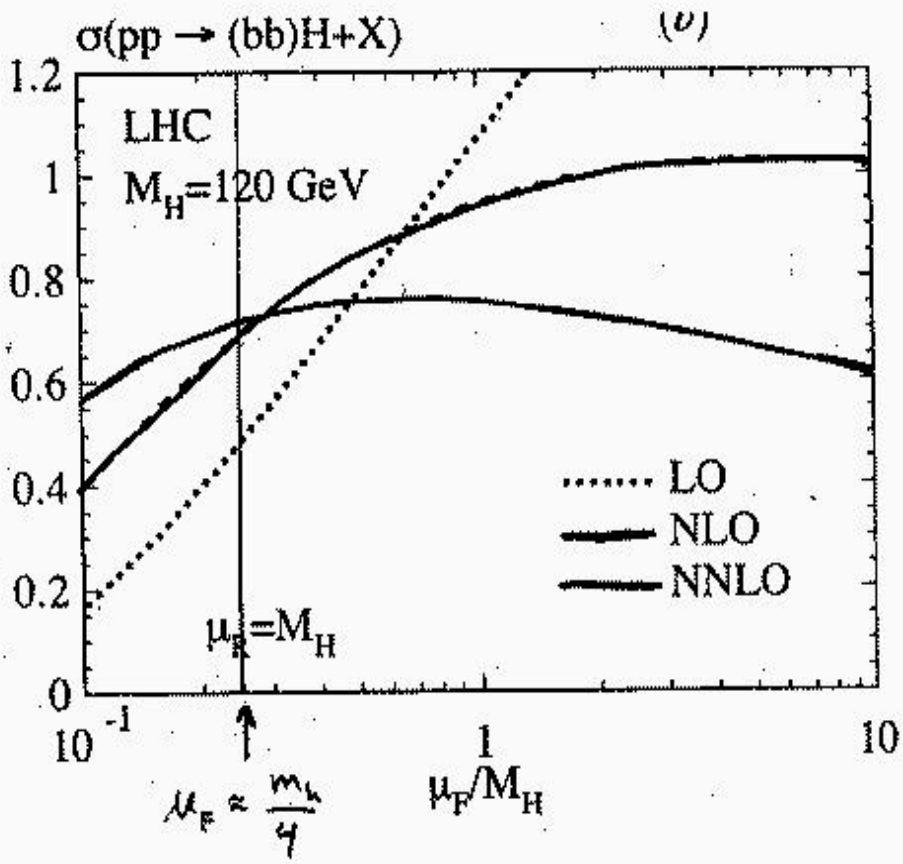


NLO: Maltoni, Sullivan, S.W.

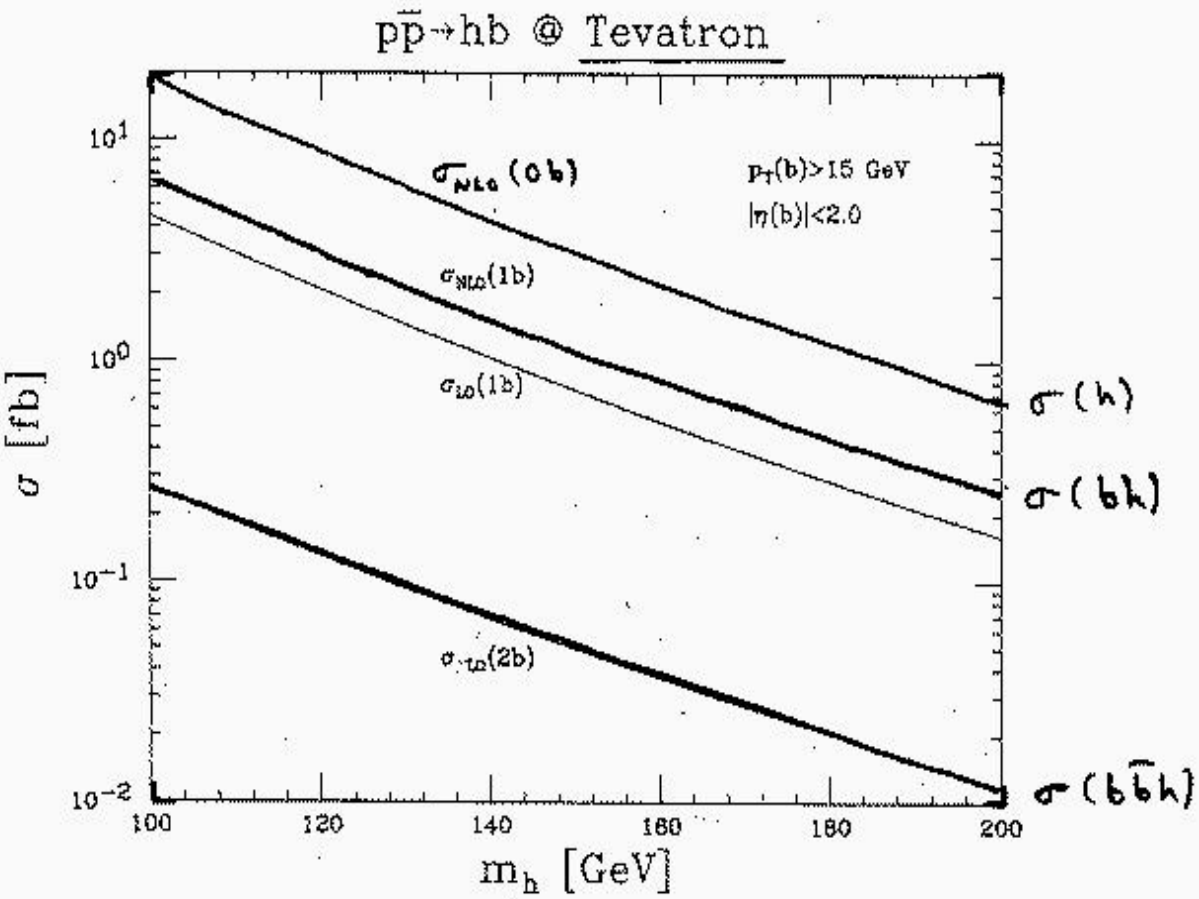
Balazs, He, Yuan



NNLO: Harlander + Kilgore



NNLO correction small for $\mu_F \approx \frac{m_h}{4}$



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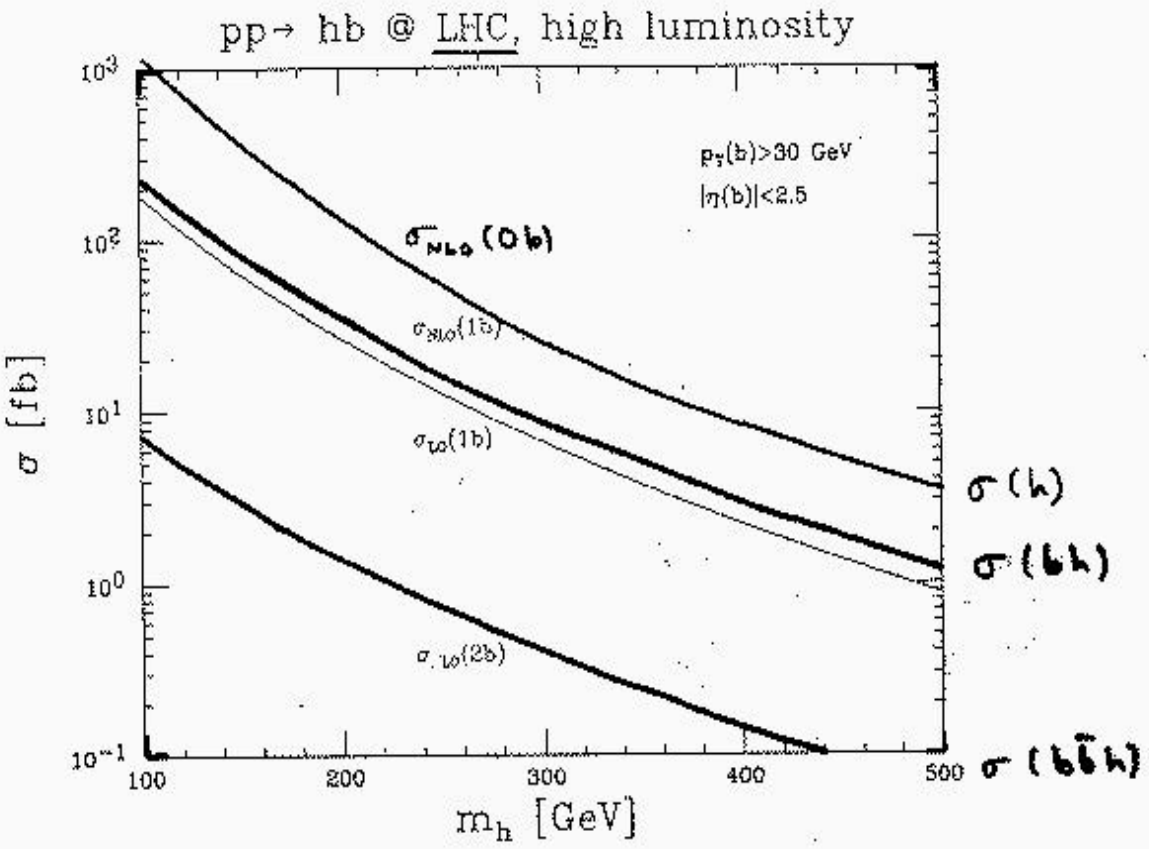
$$\sigma(h) > \sigma(bh) \gg \sigma(b\bar{b}h) \quad !$$

10.b



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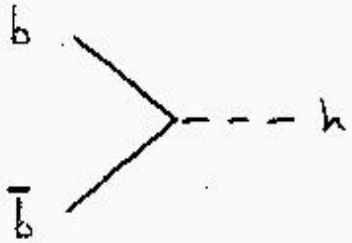
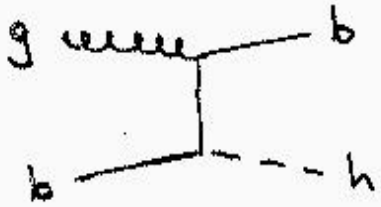
Conclusions

h



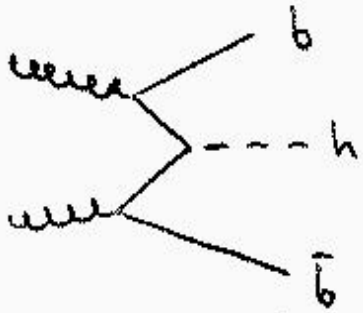
NNLO

hb



NLO

$hb\bar{b}$



NLO

Analogous to Z, Zj, Zjj