HIGGS RADIATION OFF TOP AND BOTTOM QUARKS

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I Introduction

II $e^+e^- \to t\bar{t}/b\bar{b} + \phi^0$: QCD corrections

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in collaboration with S. Dittmaier, M. Krämer, Y. Liao and P.M. Zerwas

I Introduction

- measurement of Yukawa couplings

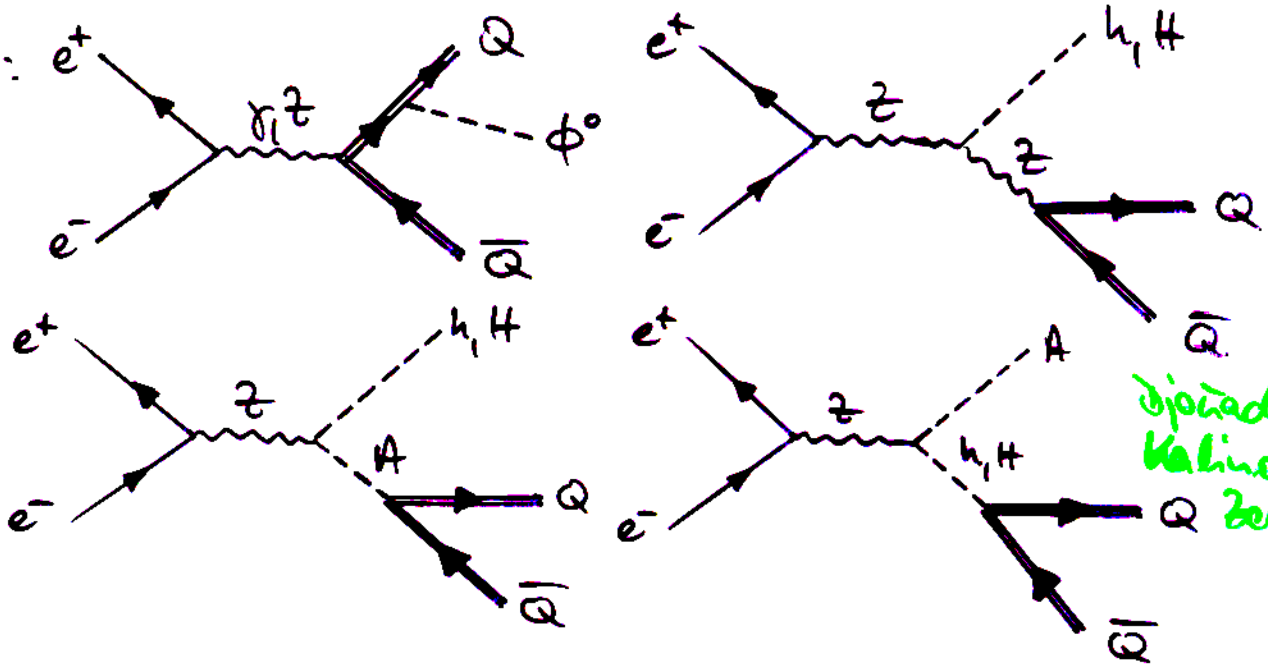
  → fundamental test of Higgs mechanism

- SM: $g_{ttH} = \frac{m_t}{v}$ largest Yukawa coupling

- MSSM: large $tg\beta$ → b couplings enhanced

  ← measurable in $e^+e^- \to t\bar{t}/b\bar{b} + \phi^0$

- LO:



Djouadi, Kalinowski, Zerwas

$t\bar{t}\phi^0$: $\sigma_{LO} \sim g^2_{tt\phi}$ [other diagrams suppressed]

Dawson, Reina

$b\bar{b}\phi^0$: resonances: $e^+e^- \to HZ \to Hb\bar{b}$

$e^+e^- \to hA \to hb\bar{b}$ etc.

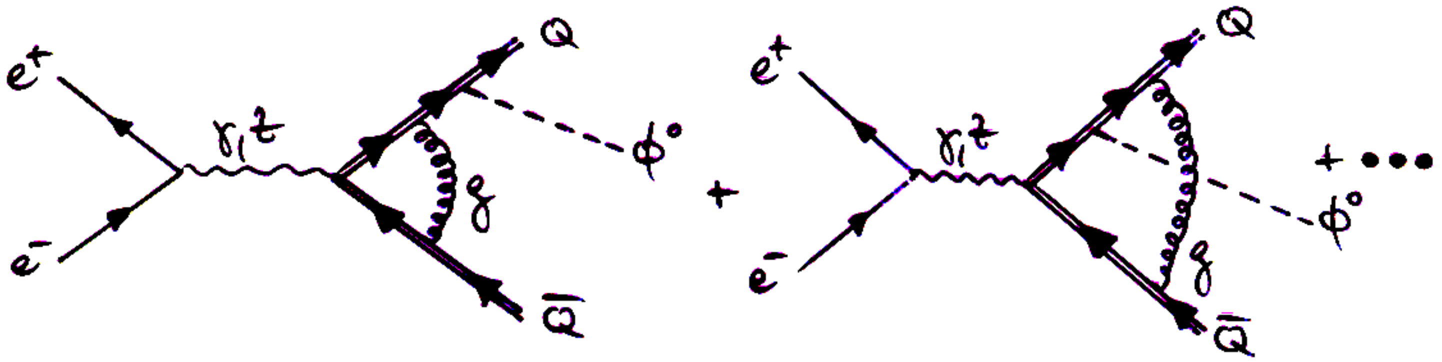
→ completely dominant

NLO needed → reduction of theoretical uncert.

→ sizeable contributions

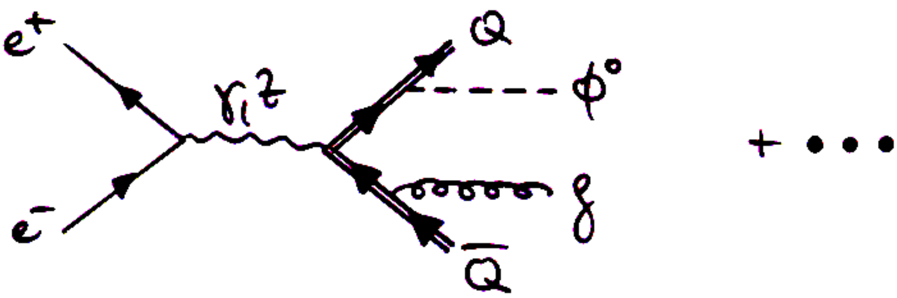
II $e^+e^- \to t\bar{t}/b\bar{b} + \phi^0$: QCD Corrections

(i) Virtual corrections



- $n = 4 - 2\varepsilon$ dimensions $\Rightarrow$ UV, IR $\frac{1}{\varepsilon}$
- naive γ_5 [checked]
- m_t on-shell

(ii) Real corrections



- phase space in $n = 4 - 2\varepsilon$ dimensions $\to$ IR $\frac{1}{\varepsilon}$
- IR: Eikonal factor $\to$ subtraction method

  $\Rightarrow$ IR cancellation against virtual

  [alternative: gluon mass $\lambda \to \frac{1}{\varepsilon} \leftrightarrow \log \frac{\lambda^2}{\mu^2}$]

- second approach for σ_{tot}:

$\sigma_{tot} \propto \text{Im}$ 

III Results

- threshold $[\sqrt{s} \gtrsim M_H + 2m_t]$: Coulomb singularity

$$K_{thr} \to 1 + \frac{\alpha_s}{\pi} \frac{64}{9} \frac{\pi m_t}{\sqrt{(\sqrt{s}-M_H)^2 - 4m_t^2}}$$

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↑ regularized by PS

- large $\sqrt{s}$: fragmentation process $[\sqrt{s} \gg m_t \gg M_H]$

$$e^+e^- \to t\bar{t} \to t\bar{t}H$$

$$\sigma(e^+e^- \to t\bar{t}H) = 2\,\hat{\sigma}(e^+e^- \to t\bar{t}) \otimes f_{H/t}$$

Dawson, Reina

$$\hat{\sigma}_{t\bar{t}} = \hat{\sigma}^{LO}_{t\bar{t}} \left\{1 + \frac{\alpha_s}{\pi}\right\}$$

$$f_{H/t}(x) = \frac{g^2_{ttH}}{(4\pi)^2}\, 4\, \frac{1-x}{x} \left\{1 + c\,\frac{\alpha_s}{\pi}\right\}$$

LET:

$$c\,\frac{\alpha_s}{\pi} = 2\,\frac{m_0\,\partial}{\partial m_0}\,\delta m = -4\,\frac{\alpha_s}{\pi}$$

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$$\delta m = m_0\,\Gamma(1+\varepsilon)\left(\frac{4\pi\mu^2}{m_0^2}\right)^{\varepsilon} \frac{\alpha_s}{\pi}\left(\frac{1}{\varepsilon} + \frac{4}{3}\right)$$

$$\Rightarrow K_{as} \sim 1 - 3\,\frac{\alpha_s}{\pi} \sim 0.9$$

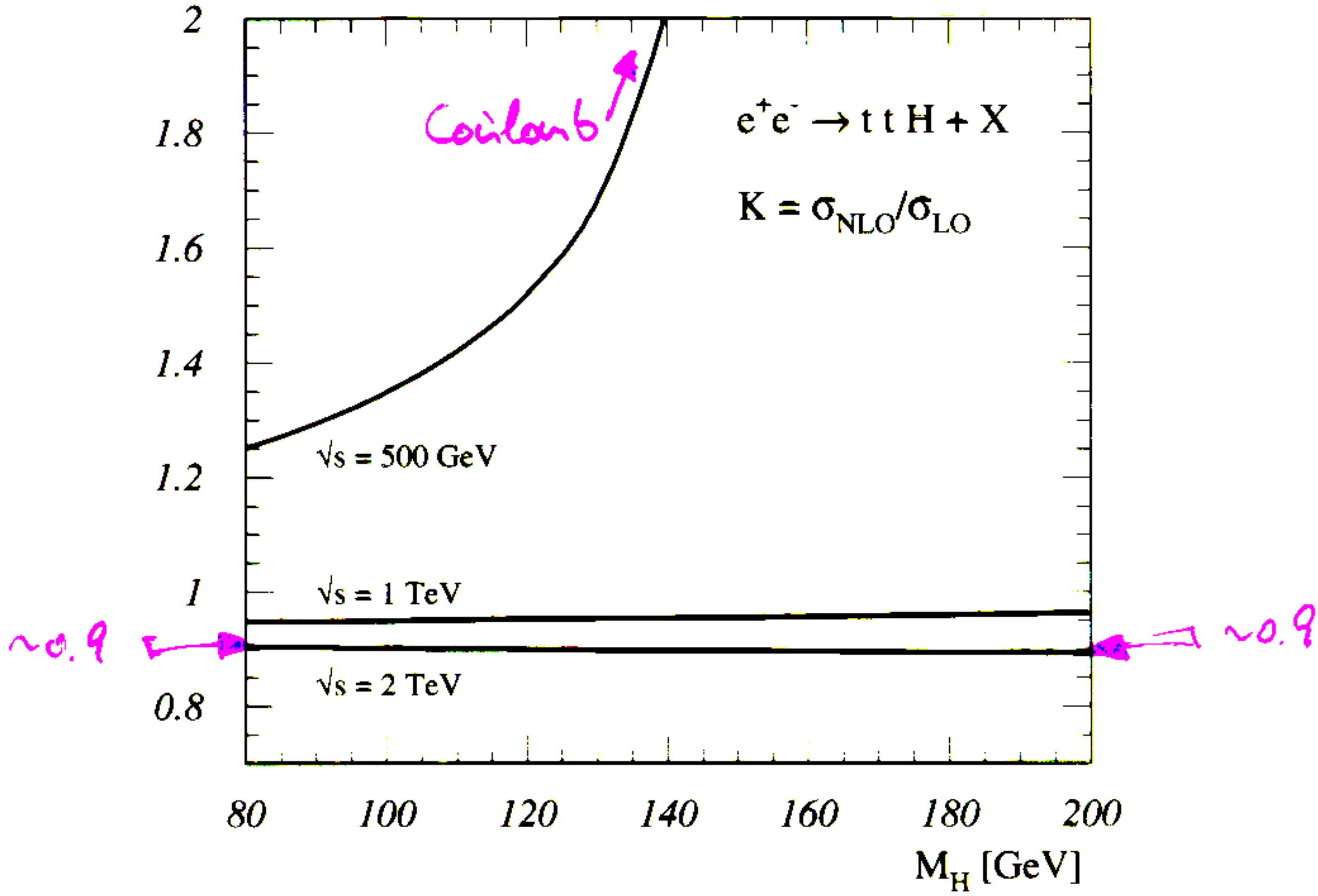
Dawson, Reina

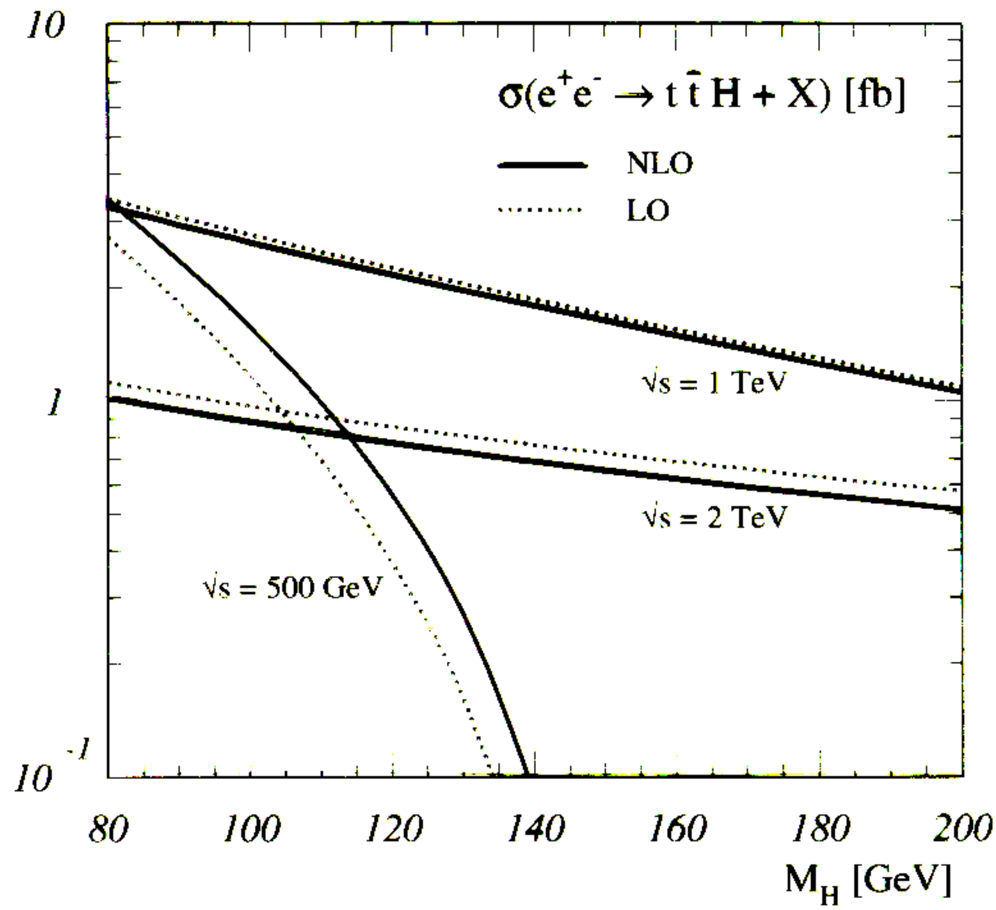
- $b\bar{b}\phi^0$: $g_{bb\phi} \to \bar{g}_{bb\phi}(\mu = M_\phi)$ → cancels in BR!

$\Rightarrow$ absorption of large logs

- numerical agreement with Dawson, Reina [only γ exchange]

SM





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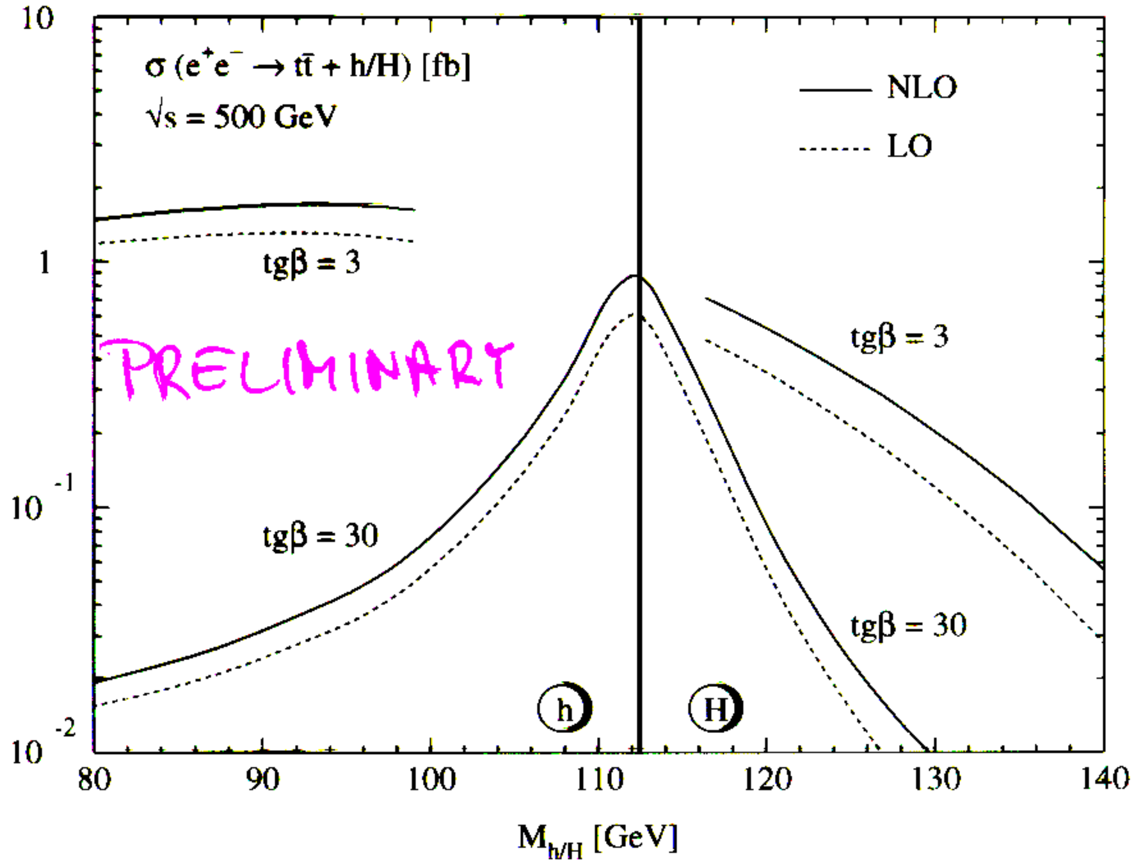
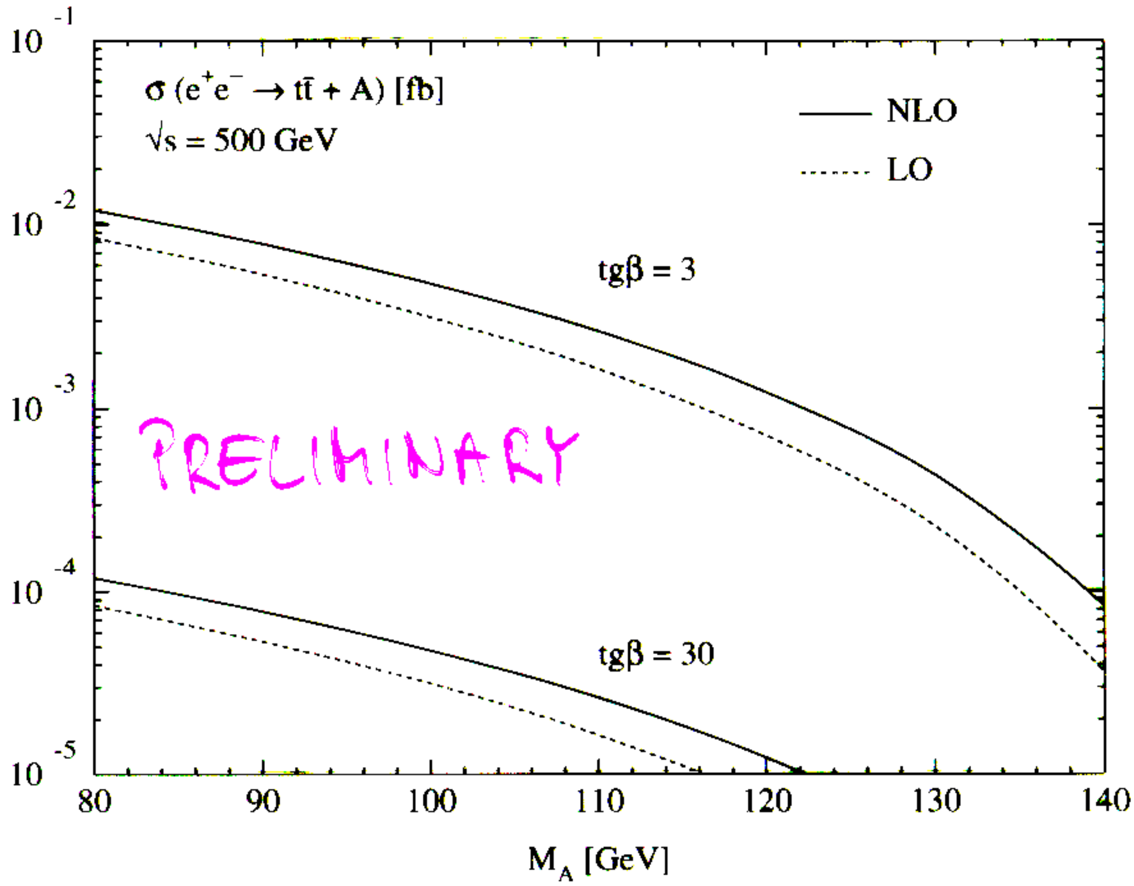
MSSM





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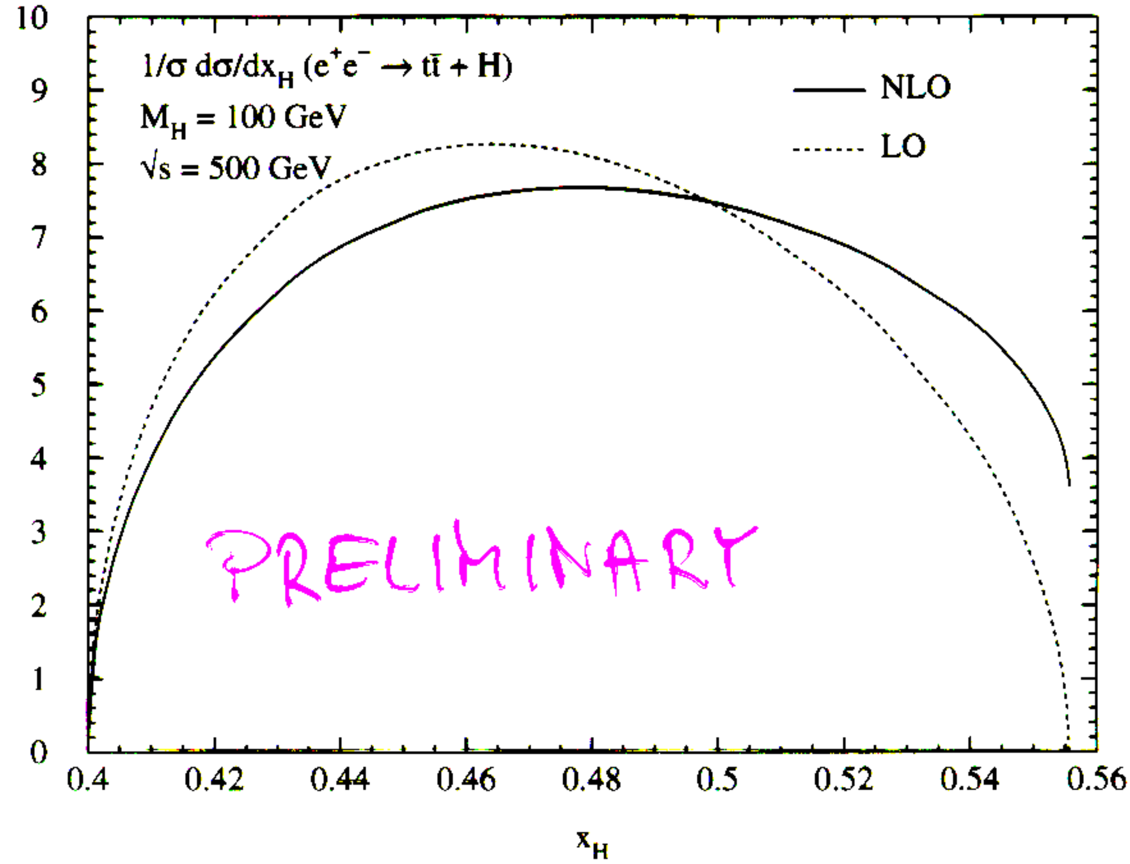
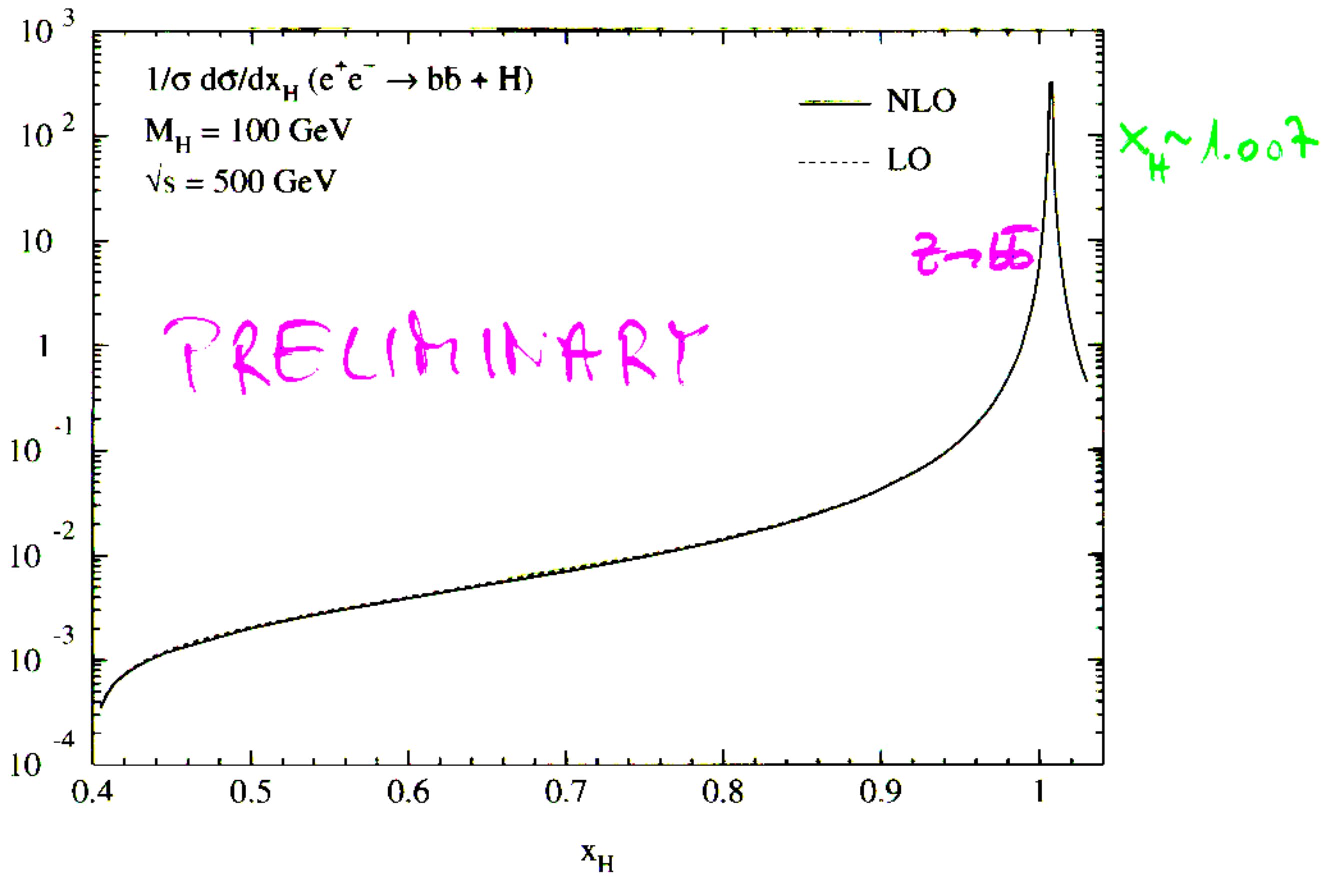
$$E_H = x_H \frac{\sqrt{s}}{2}$$

$$2\frac{M_H}{\sqrt{s}} < x_H < 1 + \frac{M_H^2 - 4m_Q^2}{s}$$





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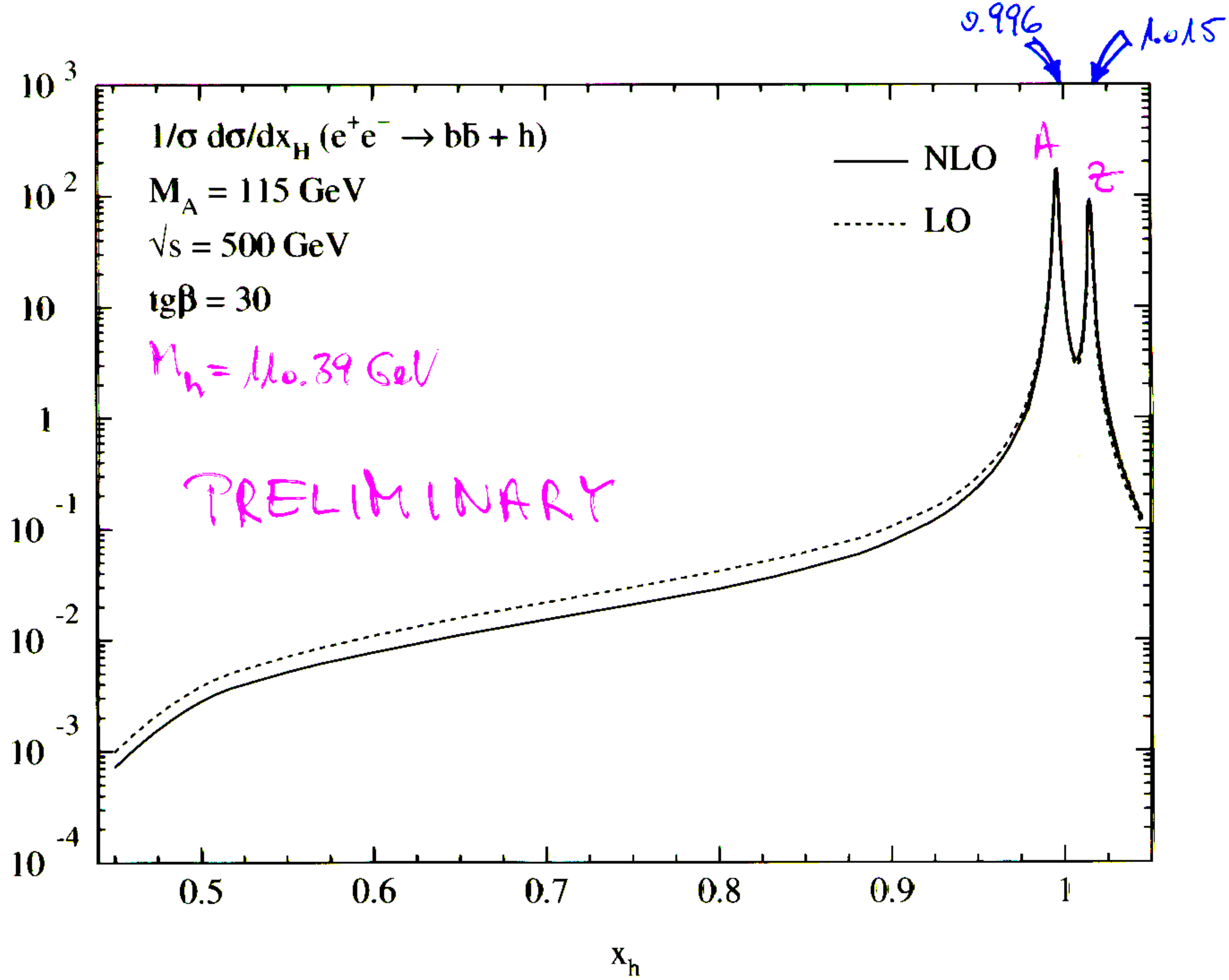

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IV Conclusions

- QCD corrections large for $M_H \lesssim \sqrt{s} - 2m_t$

  $\leftarrow$ Coulomb singularity

  $\Rightarrow$ important for $\sqrt{s} = 500$ GeV

- QCD corrections moderate at large $\sqrt{s}$ for $t\bar{t}\phi$

  [fragmentation process]

- $t\bar{t}H$: energy distribution shifted to larger x_H

- $b\bar{b}\phi$: dominated by $e^+e^- \to ZH \to b\bar{b}H$

  $e^+e^- \to A + h/H \to b\bar{b} + h/H/A$

  $\Rightarrow$ QCD corrections from $Z, \phi^0 \to b\bar{b}$

  [energy distribution nearly unchanged]