Comments on ILC physics study

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Higgs study

- Higgs physics is the most important and the most urgent.
- The Higgs boson mass will be determined at LHC.
- Many ILC studies for the Higgs mass of 120 GeV.
- Need to make more efforts for the Higgs boson mass other than 120 GeV.
- Processes of $ttH$ and the double Higgs boson production need more attentions.

- Reference
  ILC Wiki page: DCR physics part
Which mass?

The mass less than 200 GeV is likely. The Higgs branching ratios change significantly for 120 -200 GeV. Bench mark values are
mH= 120 GeV (many decay modes)
160 GeV (mostly to WW)
200 GeV (WW and ZZ)
Production cross sections

![Diagram of production cross sections](image)
Single Higgs production

• $E_{cm} \sim m_H + 110 \text{ GeV}$ is an optimal energy.

• No strong constraints on the maximum energy of the first stage ILC.

(As long as $E_{cm} \sim 400 \text{ GeV}$ is reached, the single Higgs production study can be fully exploited.)
ttH production

- Recent LHC study shows that the top Yukawa coupling measurement with H->bb mode is not as easy as we thought.
  (10 % level determination for mH=160 GeV is possible with H->WW mode at a high luminosity run of LHC.)
- There is a threshold enhancement for the ttH production at ILC.
- Important to revisit the Yukawa coupling measurement at as low energy as possible. (Ecm= 500-600 GeV)
**ttH (H→bb)**


Combinatorial background is challenging with 4b-jets and ≥ 6 jets total

Signal efficiency goes like $\epsilon_b^4$

Signal & bkgrd. have similar shape

Estimating $ttjj$ and $ttbb$ background from data difficult, large systematics

- This is (was) one of the few powerful channels near the LEP limit

It’s not clear if this channel will ever reach 5$\sigma$
This is 800 GeV ILC. We need to know what can be done at $E_{cm} = 500 - 600$ GeV for the Higgs mass below 200 GeV.
Calculations by Farrell+Hoang for $t\bar{t}H$ at NLL in vNRQCD:

- Choice of $(e^+ \text{ and } e^-)$ polarization is crucial
- First estimates from Aurelio Juste:
  - Enhancement of $\sigma_{ttb}$ from QCD for $m_H = 120 \text{ GeV} : \times2.4$
  - From use of beam polarization: $\times2.1$
  - Anticipate $\Delta g_{ttH}/g_{ttH} \sim 10\%$ for baseline ILC, $m_H = 120 \text{ GeV}$. 

Top/QCD summary, ILCWS Valencia, November 2006
Higgs self-coupling

Need to know whether the Higgs self-coupling measurement is possible for the Higgs mass other than 120 GeV at energy not much larger than 500 GeV.

Previous ILC studies only for \( m_H = 120 \) GeV at 500 GeV and 1 TeV.

S. Yamashita, LCWS 2004

GLC project, 2003
Summary

- We need to know the precision of the top Yukawa coupling and the Higgs self coupling determination in the wider parameter space of the Higgs mass and the CM energy.
- Higgs mass: 120, 160 and 200 GeV.
- CM energy: 400-600 GeV.
- Two important parameter sets:
  - $m_h=120$ GeV & $E_{cm}=500$ GeV for top Yukawa coupling
  - $m_h=160$ GeV & $E_{cm}=500$ GeV for Higgs self-coupling
Draw contours representing precisions of the top Yukawa coupling and the Higgs self-coupling determinations in the $E_{cm}$-$m_H$ plane.