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 a final draft available at <u>http://www.linearcollider.org/wiki/doku.php</u>

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



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Single Higgs production

- Ecm ~ mH+110 GeV is an optimal energy.
- No strong constraints on the maximum energy of the first stage ILC.
 - (As long as Ecm ~400 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)



J. Cammin & M. Schumacher, ATL-PHYS-2003-024 (nice thesis by J. Cammin)



 This is (was) one of the few powerful channels near the LEP limit Combinatorial background is challenging with 4b-jets and ≥ 6 jets total

Signal efficiency goes like ϵ_b^4

Signal & bkgnd. have similar shape

Estimating ttjj and ttbb background from data difficult, large systematics

It's not clear if this channel will ever reach 5σ

Precision of top Yukawa coupling



Ecm = 500 -600 GeV for the Higgs mass below 200 GeV.

Calculations by Farrell+Hoang for $t\bar{t}H$ at NLL in vNRQCD:



lower lines: $(P_+, P_-) = (0, 0)$, upper lines: $(P_+, P_-) = (+0.6, -0.8)$

- Choice of $(e^+$ and $e^-)$ polarization is crucial
- First estimates from Aurelio Juste:
 - Enhancement of σ_{tth} from QCD for $m_H = 120 \text{ GeV}$: $\times 2.4$
 - From use of beam polarization: $\times 2.1$
 - \rightarrow Anticipate $\Delta g_{ttH}/g_{ttH} \sim 10\%$ for baseline ILC, $m_H = 120$ 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 mH=120 GeV at 500 GeV and 1 TeV. S.Yamashita, LCWS 2004 @1TeV 2 1.8 $I_{\text{lumi}}=1 \text{ ab}^{-1}$ $Pol_{beam} = -80\%$ 1.6 Measured A/A_{SM} 95%CL upper bound 1.4 M_b=120 GeV 1.2 (SM Higgs Br) 1 Use only hh→4b 0.8 67%CL range (Br(hh→4b)~47%) 0.6 Eff.(4b) 80% 95%CL lower bound 0.4 0.2 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 True Λ/Λ_{SM}



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: mh=120 GeV & Ecm=500 GeV for top Yukawa coupling mh=160 GeV & Ecm=500 GeV for Higgs self-coupling

