ttH Study in GLD

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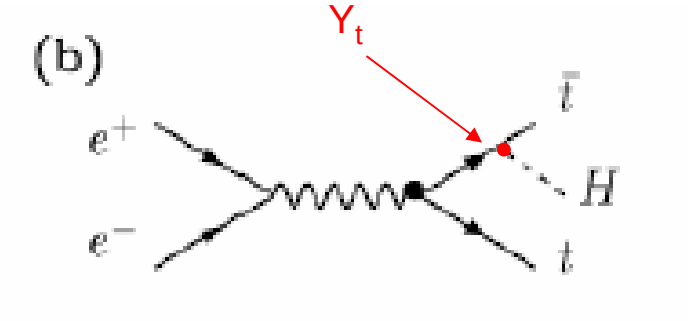
2007 Nov 14

Introduction

- Top Yukawa coupling(Yt) is a fundamental parameter in the SM.
- New physics modify Yt.
  - ex. 2HDM, Little Higgs, Extra Dimension...
- Recent study shows that LHC seems difficult to measure Yt.
- ILC is the only place to measure Yt precisely (SLHC also?)
  - But optimum CM energy is ~800GeV for M_H=120GeV
- Threshold effect of tt system + e^+ polarization enhance the $\sigma(e^+e^- \rightarrow ttH)$ by factor 4. hep-ph/0512246

- Measure Yt at ILC 1st stage! (Ecm~500GeV)
  - If physics requires, we propose to extend the Ecm up to 550GeV at ILC 1st stage.



Current Activity

- Signal Generator
  - Implementation of threshold enhancement
  - Calculation of cross section
- Background
  - Calculation of cross section

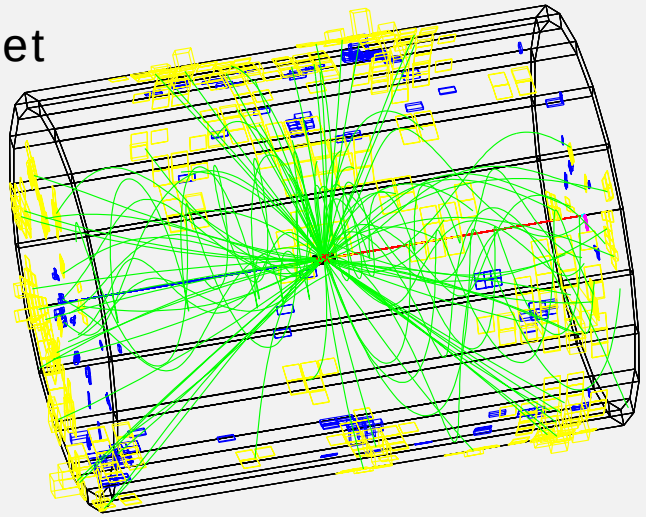
- Preparation of analysis code
  - Inclusive study
  - Exclusive study

ttH Signature

- If Higgs is lighter than 135GeV, dominant decay mode is H→bb.
  - Final state is 8 fermions.
  - ttH → (bW)(bW)(bb) → (bff)(bff)(bb)
- If not, H→VV (V=W or Z)
  - Final state is 10 fermions!
  - ttH → (bW)(bW)(VV) → (bff)(bff)(ffff)
- High jet multiplicity 8 or 10 fermions
  - Challenging for detector and reconstruction
    - Track finding
    - Jet clustering
    - Bottom tagging
- Background should be also high fermion multiplicity

ttH→(bW)(bW)(bb)→(bcs)(bcs)(bb)

8 jet

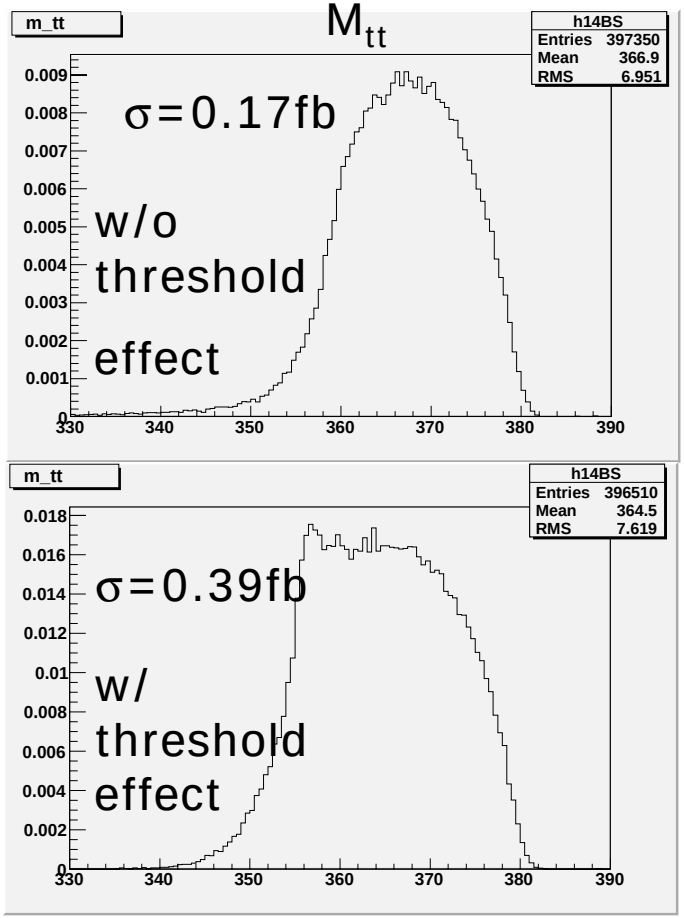


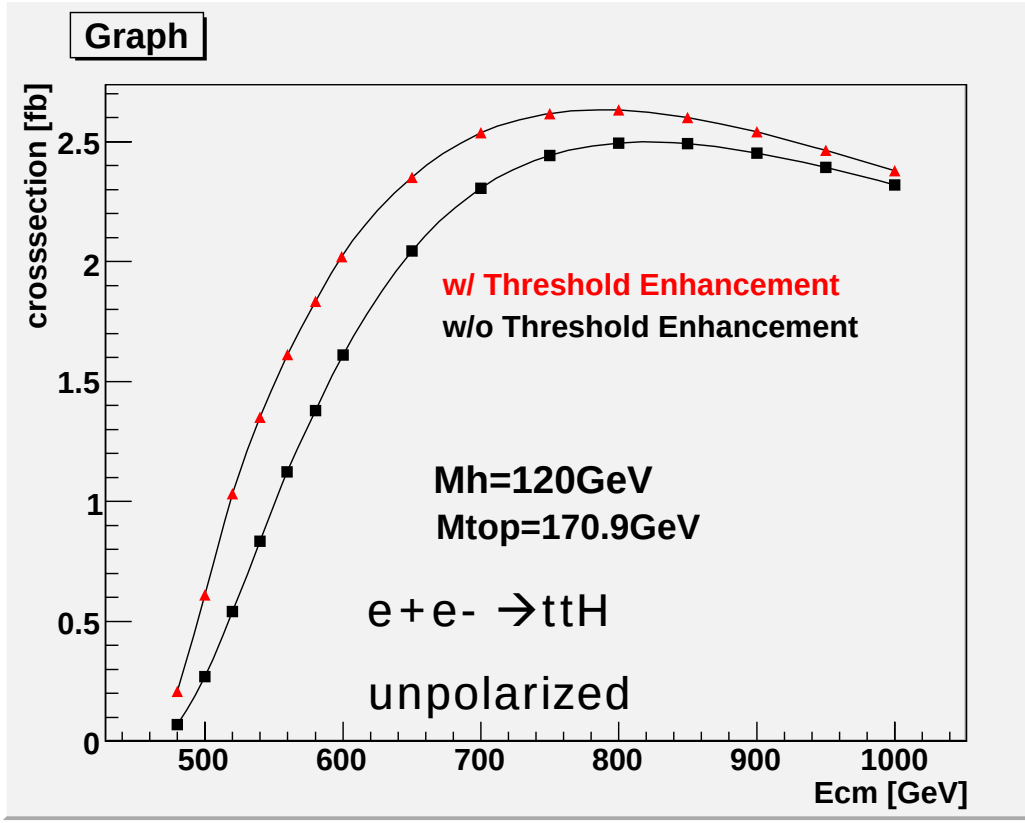
Ecm=500GeV

MH=120GeV

Signal Generator with Threshold Enhancement

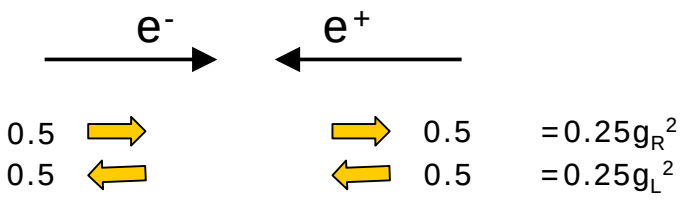
- We have implemented the threshold enhancement to our HELAS based ttH generator.
- The effect is significant for threshold Ecm region.



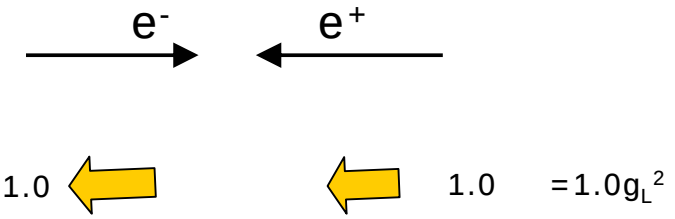


Beam Polarization

- Electron and positron polarizations are one of the key issues for LC physics since they increase the signal σ or suppress BG σ.
- There are two effects
  - spin 1 combinations



$P=(P_{e^-},P_{e^+})=(0,0)$



$P=(-1,+1)$

  - Coupling to $SU(2)_L$ gauge boson
    - EM interaction respects Parity but weak interaction does not.
    - Coupling to Z boson is

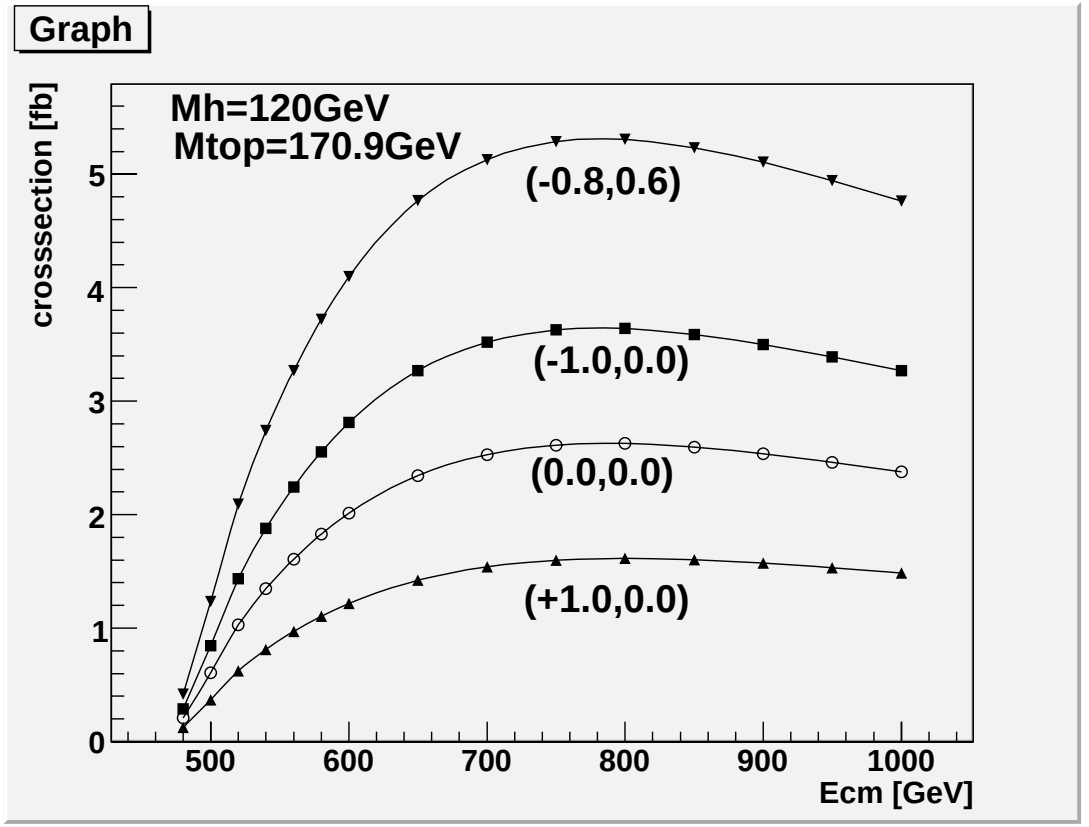
$$g_v = T_3 - 2Q\sin^2\theta_w$$

$$g_a = T_3$$

    - For electron positron case, the coupling is not so different for left handed or right handed polarization since the Weiburg angle is close to quarter. But top case, left handed electron gives larger cross section.

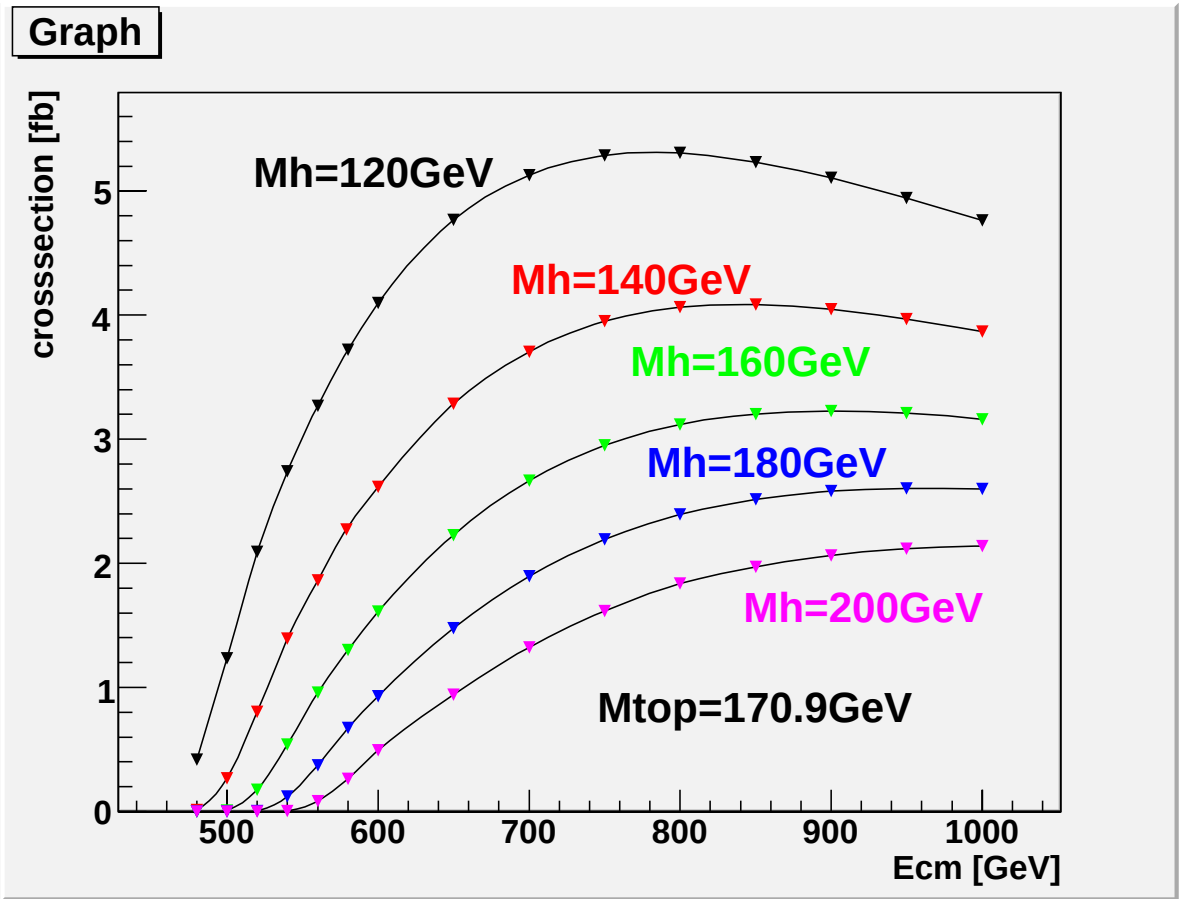
Beam Polarization for ttH

- I have calculated the cross section as a function of Ecm for P=(Pe- ,Pe+)=(-1.0, 0.0), P=(1.0, 0.0) and P=(-0.8, 0.6) with M_H = 120 GeV and M_t = 170.9GeV
  - Pe- =-0.8 is nominal value but Pe+ =0.6 is upgraded value.
- σ = 1.2fb for Ecm=500GeV and P=(-0.8, 0.6)!!



Mass dependence

- Mass dependence of cross section is also calculated with P=(-0.8, 0.6).
- Mh>170GeV seems difficult at ILC 1st stage (Ecm<550GeV)
  - If Ecm=500GeV, Mh>140GeV is diffucult



Background Signature

- High fermion multiplicity modes
  - 10 fermions : ttWW, ttZZ
  - 8 fermions : ttg, ttZ
  - 6 or 8 fermions : WWH, ZZH
  - 6 fermions : tt, WWZ, ZZZ
- Large cross section modes
  - 4 fermions : WW
  - 2 fermions : qq
- Cross section with Ecm=500GeV and Mh=120GeV
  - ttWW, ttZZ ... too small to calculate
  - ttg ... 33.7 fb
  - ttg → ttbb ... 0.67 fb
  - ttZ ... 1.07 fb (without threshold enhancement)
  - WWH ... 5.69 fb
  - ZZH ... 0.56 fb
  - tt ... ~600fb
  - WWZ ...39.6 fb
  - ZZZ ... 1.12 fb
  - WW ... ~1600fb
  - qq ... ~2500fb

Analysis

- Exclusive Analysis based on decay mode
  - Cleaner but efficiency should be low
    - All jet mode
    - Lepton mode
    - Tau mode
    - Neutrino mode
- Inclusive analysis based on fermion counting
  - Count the number of fermions (jet, lepton and neutrino)
  - Event topology selection (sphericity, FW moment, etc.)
  - b tagging
  - Loose mass selection on the W, Z, t or H.
  - Dirtier against exclusive one, but efficiency is high.
- Number of signal is low O(100) for Ecm~500GeV, so inclusive one is better?
- Coding is ongoing.

Summary and Plan

- Yukawa coupling can be only measured at ILC.
- The final state is 8 or 10 fermions.
  - Challenging for detector and reconstruction

- Threshold enhancement has been implemented to signal generator.
- ttH may be measured at Ecm=500GeV if M_H=<140GeV
  - At Ecm=550GeV, M_H<160GeV
- Background cross sections are calculated with MadGraph.

- Preparation of Analysis code is ongoing.