tth study @ $\sqrt{s}$ = 500 GeV

The 38th general meeting of the ILC physics working group

Aug. 30 2014

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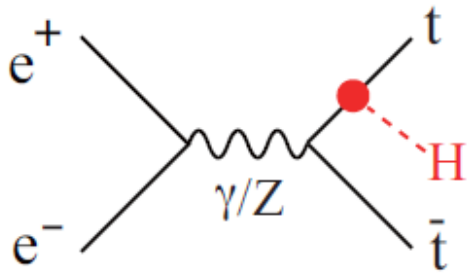
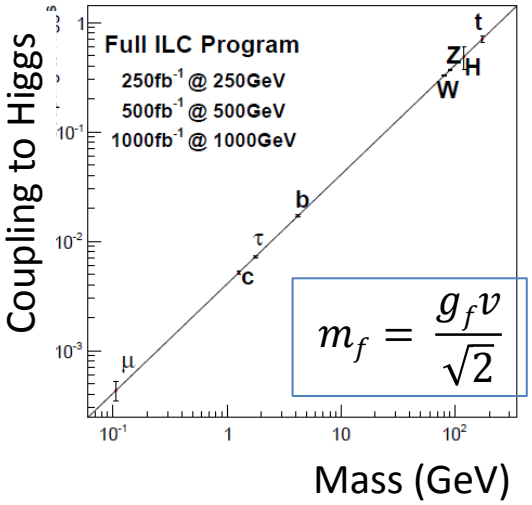
Reminder

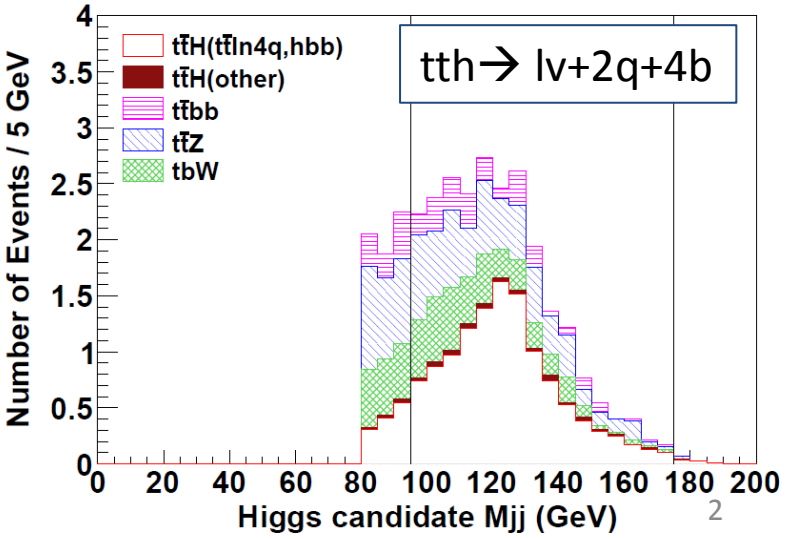


- direct top Yukawa coupling measurement
- $\sqrt{s}$ = 500 GeV ILC, L = 500 fb^{-1} , Mh = 125 GeV
- interference term is negligible
- cut based event selection and counting analysis
- target signal: tth→4q+4b, lv+2q+4b
- backgrounds: ttZ, ttg, tbW
- tth→8jets $S/\sqrt{S+B}$ = 2.04
- tth→ln+6jets $S/\sqrt{S+B}$ = 2.42

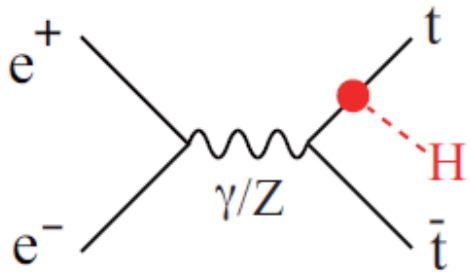


Kt clustering works well
- signal acceptance is increased ~5%
- background acceptance is also increased

next steps
- estimate systematic uncertainties



tau problem



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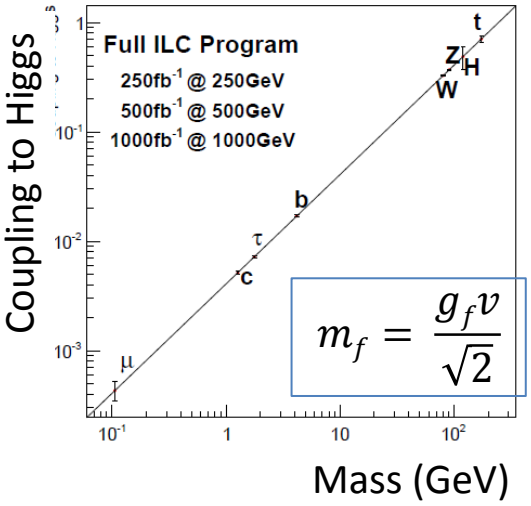
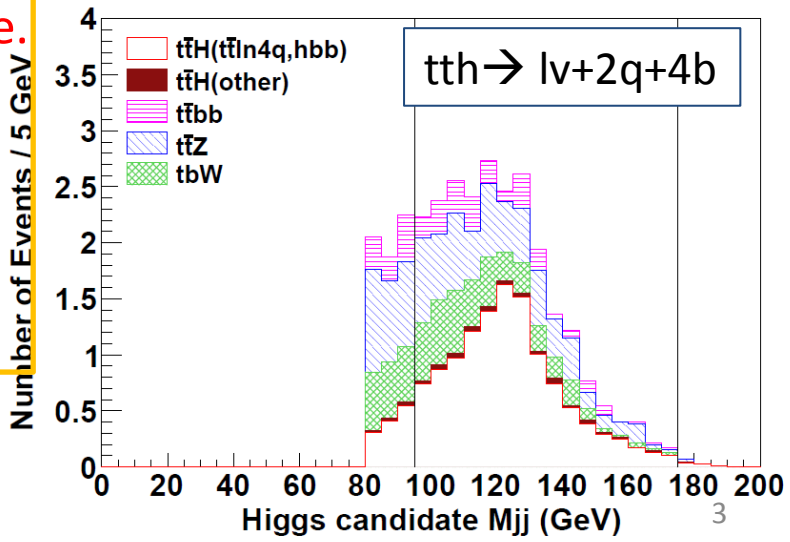


t→bW→bτν events are not stored in stdhep file.

next steps

- make new MC samples
- estimate systematic uncertainties

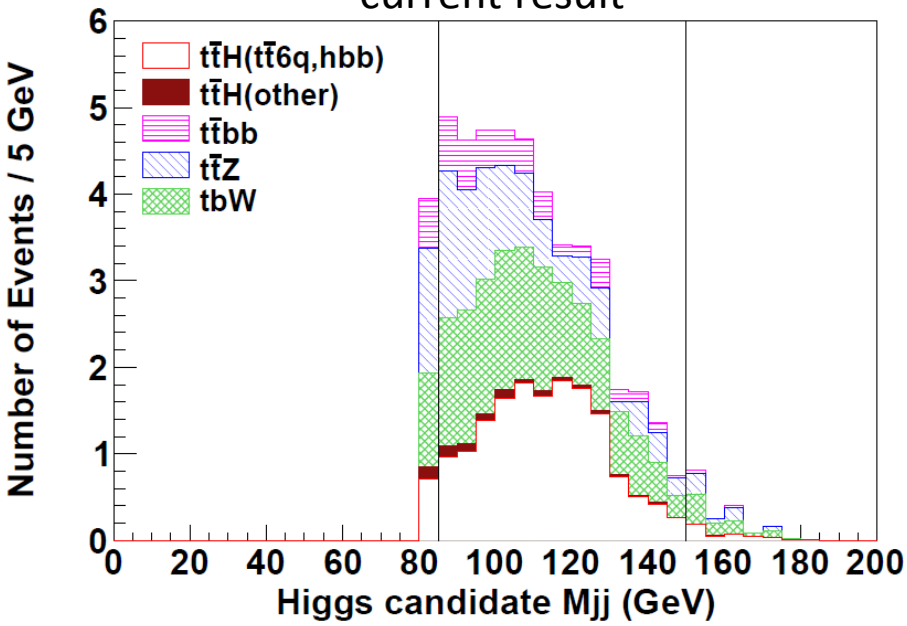


new MC samples and Result

use Miyamoto-san setting of /home/ilc/miyamoto/work/121101-physsim/
t→bW→bτν events are stored

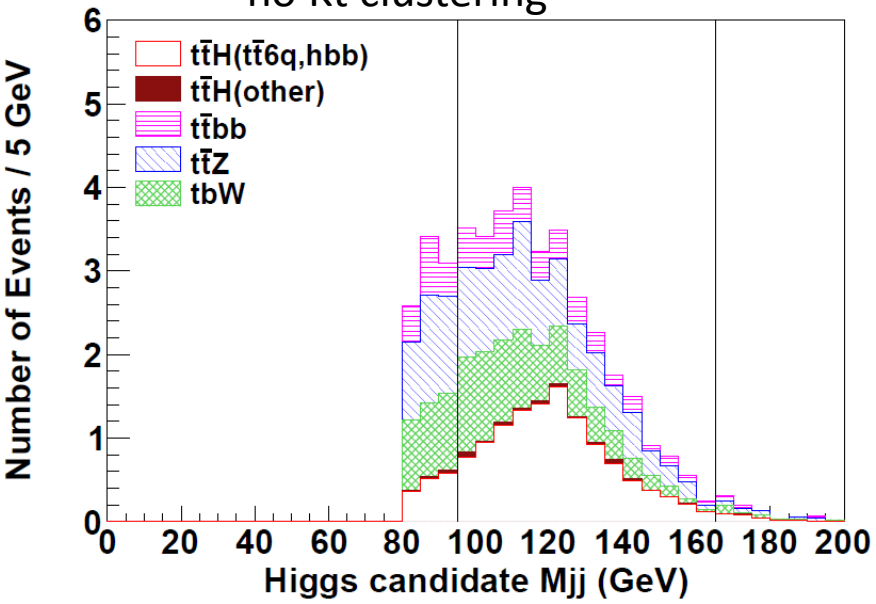
tth→8jets

current result



- $\sqrt{s}$ = 500 GeV, 500 fb^{-1}
- Nsig/$\sqrt{\text{Nsig} + \text{Nbkgd}}$ = 2.35,

previous result
no t→bW→bτν events
no Kt clustering



- $\sqrt{s}$ = 500 GeV, 500 fb^{-1}
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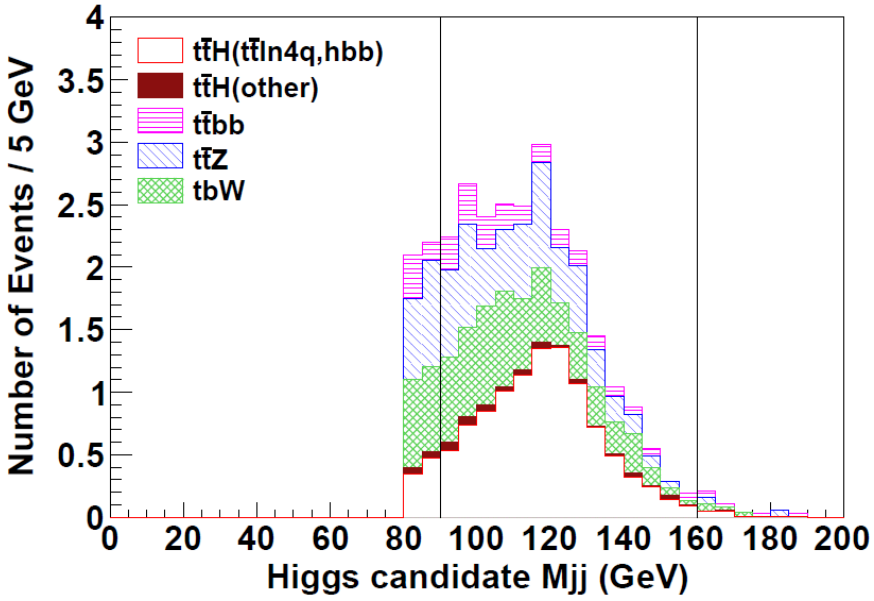
new MC samples and Result2

tth→ln+6jets

current result



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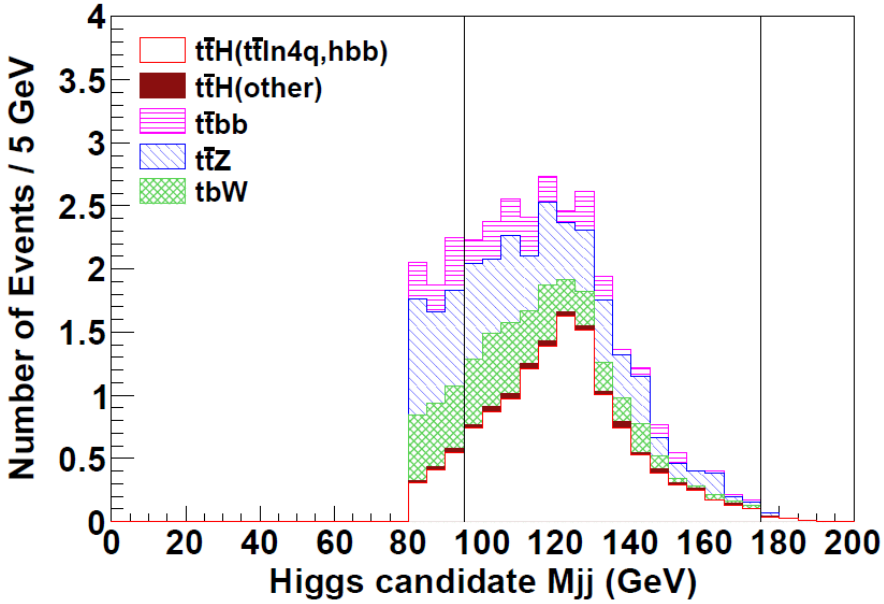

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Systematic uncertainties

$$(\Delta\sigma/\sigma) = \sqrt{\frac{S+B}{S^2} + \left(\frac{\Delta B}{S}\right)^2 + \left(\frac{\Delta L}{L}\right)^2 + \left(\frac{\Delta Br}{Br}\right)^2 + \left(\frac{\Delta Pol}{Pol}\right)^2 + \left(\frac{\Delta\varepsilon}{\varepsilon}\right)^2}$$

Systematic uncertainties

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- statistical
- systematics related Background
- systematics Luminosity
- systematics Branching ratio
- systematics polarization
- systematics signal event selection

$\left(\frac{\Delta L}{L}\right) \sim 0.1\%$

$\left(\frac{\Delta Br}{Br}\right) \sim 1\%$

$\left(\frac{\Delta Pol}{Pol}\right) \sim 0.1\%$

$\left(\frac{\Delta\varepsilon}{\varepsilon}\right)^2 = (\Delta S(btag)/S)^2 + (\Delta S(JESF)/S)^2$

$\left(\frac{\Delta B}{S}\right)^2 = (\Delta B^2(btag) + \Delta B^2(JESF))/S^2$

Systematic uncertainties on tbW events

$\left(\frac{\Delta B}{S}\right)^2$ = (ΔB^2(btag)+ΔB^2(JESF))/S^2

in signal category (4 b tagged),
0~a few events are passed all event selection
too low statistics to estimate systematic uncertainty

I used 2 b tagged category to estimate uncertainty on background event selection.
In this analysis, definition of ΔN(tbW,4btag) is

$\Delta N(tbW,4btag) = N(tbW,4btag) \times \left(\frac{\Delta N(tbW,2btag)}{N(tbW,2btag)}\right)$

Current status of Systematic uncertainties

condition
b likeness +3%
Jet energy scale factor +3%

tth→8 jets	btag	JESF
signal	< 3%	< 5%
ttZ	< 3%	< 10%
ttbb	< 5%	< 5%
tbW	< 3%	< 10%

tth→8 jets	btag	JESF
signal	< 5%	< 3%
ttZ	< 20%	< 20%
ttbb	< 5%	< 20%
tbW	< 10%	< 20%

Result and Summary

- $\sqrt{s}$ = 500 GeV, 500 fb^{-1}

tth→8 Jets

- Nsig/$\sqrt{\mathrm{Nsig} + \mathrm{Nbkgd}}$ = 2.35,
- with systematics → 2.31

tth→ln+6jets

- Nsig/$\sqrt{\mathrm{Nsig} + \mathrm{Nbkgd}}$ = 2.04,
- with systematics → 1.92

Summary

- Use Kt clustering to reject low Pt backgroun
- inclusive analysis of W→e,μ,τ+ν events
- estimate btag and JESF systematic uncertainties
- systematic uncertainties are not small,
  but statistical uncertainty is dominant in this study

Backup

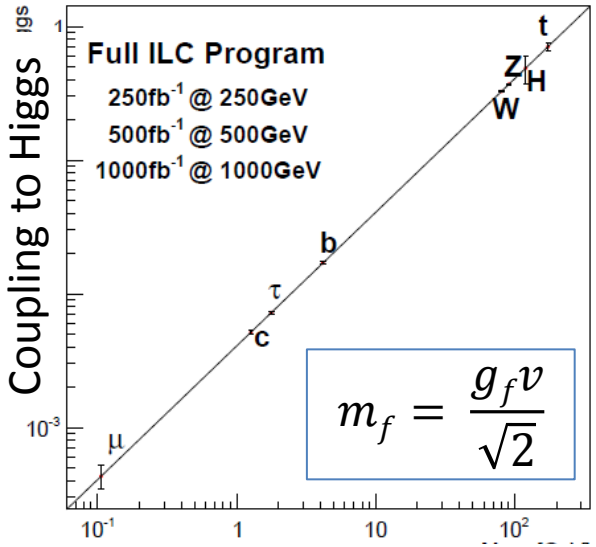
Introduction

- We can directory measure the top quark Yukawa coupling via tth channel with $\sqrt{s}$ = 500 GeV ILC.
- Previous tth analysis was performed assuming Mh = 120GeV.

(R. Yonamine et al., PHYSICAL REVIEW D 84, 014033(2011))

- Higgs boson mass is ~125 GeV.
- We are working on tth study assuming Mh=125 GeV.
- ILD full simulation
- Polarization : $(Pe^-,Pe^+)=(-0.8,+0.3)$

	Mh=120GeV	→	Mh=125GeV
production cross section (fb)	0.641	→	0.485
Branching ratio of h→bb	0.68	→	0.577



Signal and Background

ttbar cross section is increased
around ttbar threshold
by ttbar bound-state effect

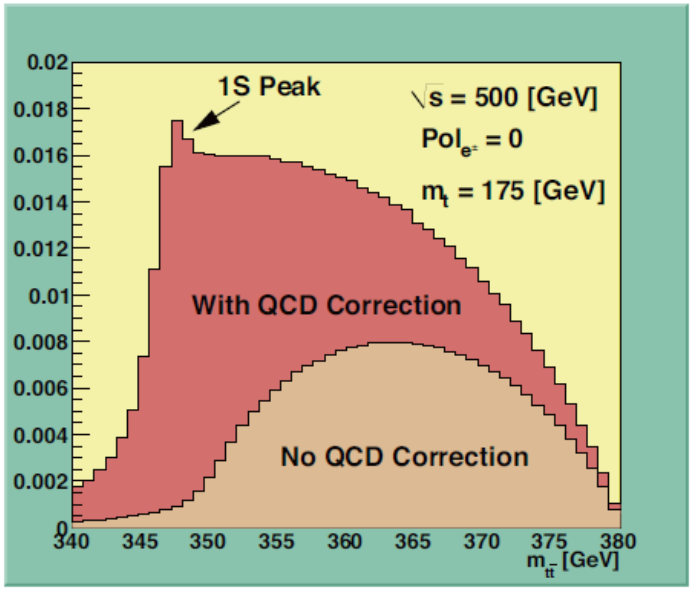
- tth cross section is enhanced
- ttZ cross section is also increased

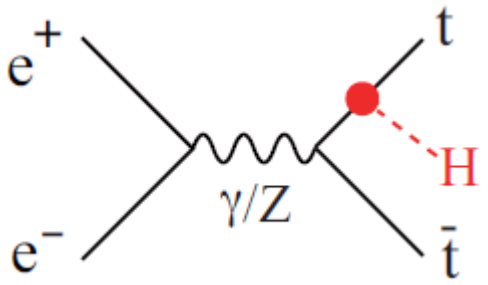
Signals

- tth→8jets (h→bb)
  tth→ln+6jets (h→bb)

Main Backgrounds

- ttZ, ttg(bb), tbW





expected # of events @ 500fb^{-1}

- $\sqrt{s}$ = 500 GeV, Mh = 125 GeV, (Pe^-,Pe^+)=(-0.8,+0.3)
- production cross section

Process	σ (fb)
$e^-e^+ \rightarrow$ tth	0.485
$e^-e^+ \rightarrow$ ttZ	1.974
$e^-e^+ \rightarrow$ ttg(bb)	1.058
$e^-e^+ \rightarrow$ tbW	979.8

- Branching ratio

Decay mode	Branching ratio
h→bb	0.577
tt→bqqbqq	0.457
tt→blvbqq	0.438
tt→blvblv	0.105

- expected # of signals and Backgrounds(@500fb^{-1})

tth(tt6j, hbb)	63.9	tth(ttln4j,hbb)	61.3
tth(ttall, hnobb)	102.6	ttZ	987
tth(ttlvlv2j, hbb)	14.6	ttg(bb)	529
		tbW	489902

tth→8jets(ln+6jets) analysis

- interference term is negligible
- counting analysis with cut based event selection

In this analysis, higgs decays into two b jets

- 4 b jets out of 8(6) jets
- No (one) isolated lepton

Event Selection

- signal topology

✓ Y cut (6, 8 jet event)
✓ No(one Isolated Lepton)
✓ B jet candidate ≥ 4

- detector acceptance

$|\text{Jet } \cos\theta| \leq 0.99$

- jet pairing

✓ $\chi 2 \leq 9.5$ (34.5)

- kinematics

✓ Leading 2 Jet Energy Sum
✓ Lowest 3 Jet Energy Sum (for 8jets mode)
(Lowest 2 Jet Energy Sum (for 6jets mode))
✓ Missing momentum > 20 GeV (for 6jtes mode)

- reconstructed mass

✓ top candidate Mjjj $\geq$ 140 GeV
✓ higgs candidate Mjj $\geq$ 80 GeV
✓ 95GeV $\leq$ h candidate Mjj $\leq$ 165(175)GeV