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

The 39th general meeting of the ILC physics working group

Nov. 1st 2014

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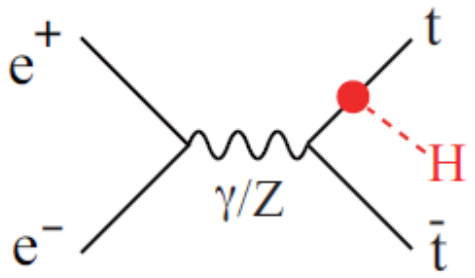
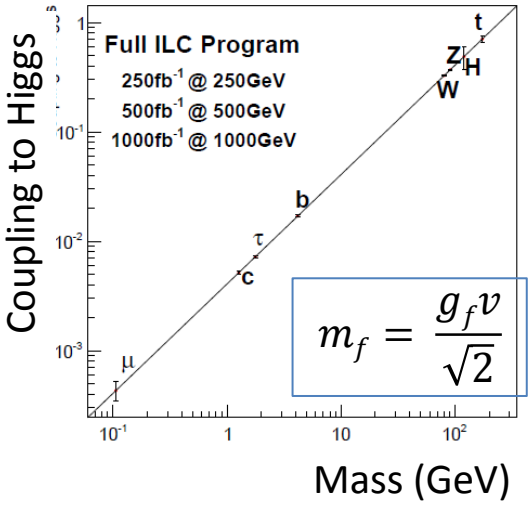
Reminder

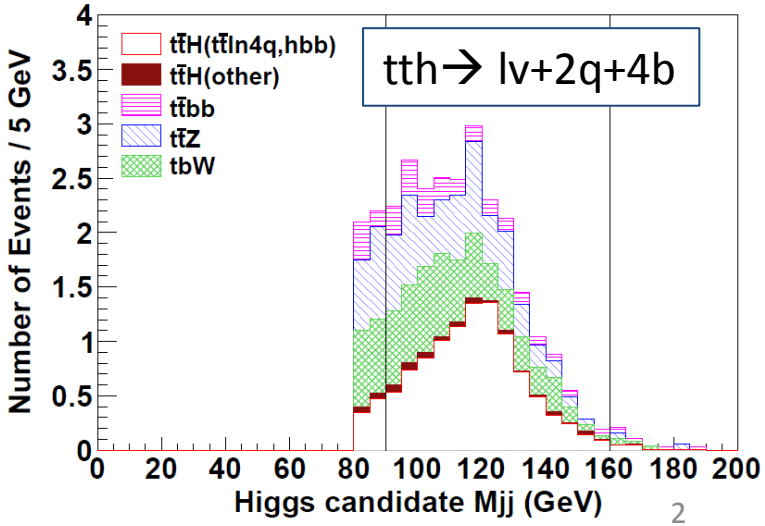


- direct top Yukawa coupling measurement
- $\sqrt{s}$ = 500 GeV ILC, L = 500 fb^{-1} , Mh = 125 GeV
- interference term is negligible
- cut based event selection and counting analysis
- target signal: tth→4q+4b, lv+2q+4b
- backgrounds: ttZ, ttg, tbW
- tth→8jets $S/\sqrt{S+B}$ = 2.35
- tth→ln+6jets $S/\sqrt{S+B}$ = 2.04
- estimte JESF and b tag systematics

systematic uncertainties degrade significance <5%



- update cut based lepton selection
- add tth→2l2v + 4b channel



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(ttlvlv2b, hbb)	**14.6**	ttg(bb)	529
		tbW	489902

Isolated Lepton Selection

- Isolated Lepton

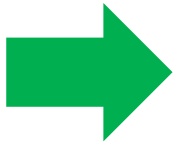
Previous Definition

$\cos\theta_{cone} = 0.98$

$E_{cone} < \sqrt{6(E\mathrm{pfo} - 15)}$

current lepton ID

- muon selection



muon selection

- E_{PFO} with track > 9 GeV
- Deposited energy in yoku >1.2 GeV
- $E_{HCAL}/E_{EMCAL} > 0.5$
- $E_{CAL}/E_{PFO} < 0.5$
- $E_{cone} < \sqrt{6(E_{\mathrm{PFO}} - 15)}$ ($\cos\theta_{cone} = 0.98$)
- r0 < 0.02 mm

- electron selection

- tau (leptonic decay)

- tau (hadronic decay)

Isolated Lepton Selection

- Isolated Lepton

Previous Definition

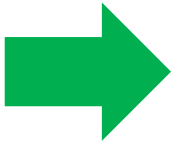
$\cos\theta_{cone} = 0.98$

$E_{cone} < \sqrt{6(Epfo - 15)}$

current lepton ID

- muon selection

- electron selection



- tau (leptonic decay)

- tau (hadronic decay)

electron selection

- ✓ E_{PFO} with track > 2 GeV
- ✓ Deposited energy in yoku < 0.2
- ✓ $E_{HCAL}/E_{EMCAL} < 0.1$

- $E_{cone} < \sqrt{6(E_{PFO} - 15)}$ ($\cos\theta_{cone} = 0.98$)
- r0 < 0.05 mm

or

- r0 < 0.05 mm
- $E_{EMCAL} > 15$ GeV
- $E_{HCAL}/E_{EMCAL} < 0.03$
- $\frac{E_{cone}(\cos\theta_{cone} = 0.99)}{E_{cone}(\cos\theta_{cone} = 0.98)} > 0.99$
- $E_{cone}(0.93 < \cos\theta_{cone} < 0.98) < 2$ GeV

Isolated Lepton Selection

- Isolated Lepton

Previous Definition

$\cos\theta_{cone} = 0.98$

$E_{cone} < \sqrt{6(E\mathrm{pfo} - 15)}$

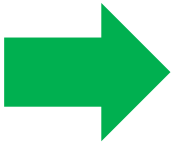
current lepton ID

- muon selection

- electron selection

- tau (leptonic decay)

- tau (hadronic decay)



tau (muon)

- same as muon selection except r0 requirement → r0 > 0.02 mm

tau (electron)

- $E_{cone} < \sqrt{6(E_{\mathrm{PFO}} - 15)}$ ($\cos\theta_{cone} = 0.98$)
- r0 >= 0.05 mm

Isolated Lepton Selection

- Isolated Lepton

Previous Definition

$\cos\theta_{cone} = 0.98$

$E_{cone} < \sqrt{6(E\text{pfo} - 15)}$

current lepton ID

- muon selection
- electron selection
- tau (leptonic decay)
- tau (hadronic decay)

hadronic tau selection

- E_{PFO} with track >= 5 GeV
- $\frac{E_{cone}(\cos\theta_{cone} = 0.99)}{E_{cone}(\cos\theta_{cone} = 0.98)} > 0.8$
- $M_{cone}(\cos\theta_{cone} = 0.99) < 2$ GeV
- $M_{cone}(\cos\theta_{cone} = 0.93) < 2$ GeV
- no energetic(> 2 GeV) track in $0.93 < \cos\theta_{cone} < 0.99$
- 1 or 3 tracks in $\cos\theta_{cone} > 0.99$

in hadronic tau category, purity of tau is ~80%.
There are ~10% contamination from electron and another ~10% comes from light flavor.

Isolated lepton Selection

amount of change from previous lepton ID

	amount of change
mu	-0.16%
e	+7.55%
tau	+93%
b jet	0%
light flavor	-40.6%

Isolated lepton selection

- ✓ require no Isolated lepton to 8jet (lν+6jet) channel
- ✓ require one Isolated lepton to 6jet (lν+6jet) channel
- ✓ require two Isolated lepton to 4jet (2l2ν+4jet) channel

current status of event selection

500 GeV, 500fb^{-1}

tth → 8jets

number of events passed all selection

Process	prev.	now
tth→4q+4b	14.7	15.6
tth (other)	0.6	0.5
ttZ	8.7	8.98
ttbb	3.3	3.44
tbW	11.9	14.4

tth→8jtes
- Nsig = 15.6
- Nbkgd = 27.4
- $S/\sqrt{S+B}$ = 2.38 (2.35)

tth → lv+6jets

number of events passed all selection

Process	prev.	now
tth→ ln+2q+4b	9.77	10.6
tth (other)	0.4	0.27
ttZ	5.33	6.29
ttbb	1.96	1.99
tbW	5.69	6.06

tth→lv+6jtes
- Nsig = 10.6
- Nbkgd = 14.6
- $S/\sqrt{S+B}$ = 2.11 (2.04)

new

tth → 2l2v+4b jets

number of events passed all selection

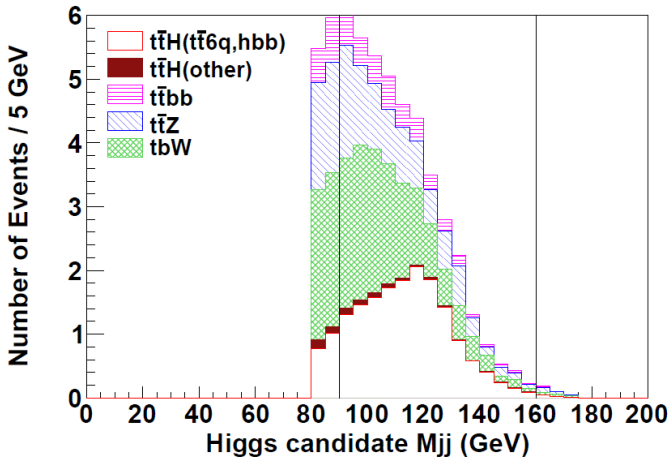
Process	prev.	now
tth→ 2l2n+4b		2.56
tth (other)		0.17
ttZ		2.17
ttbb		1.85
tbW		3.44

tth→2l2v+4b jtes
- Nsig = 2.56
- Nbkgd = 5.24
- $S/\sqrt{S+B}$ = 0.8

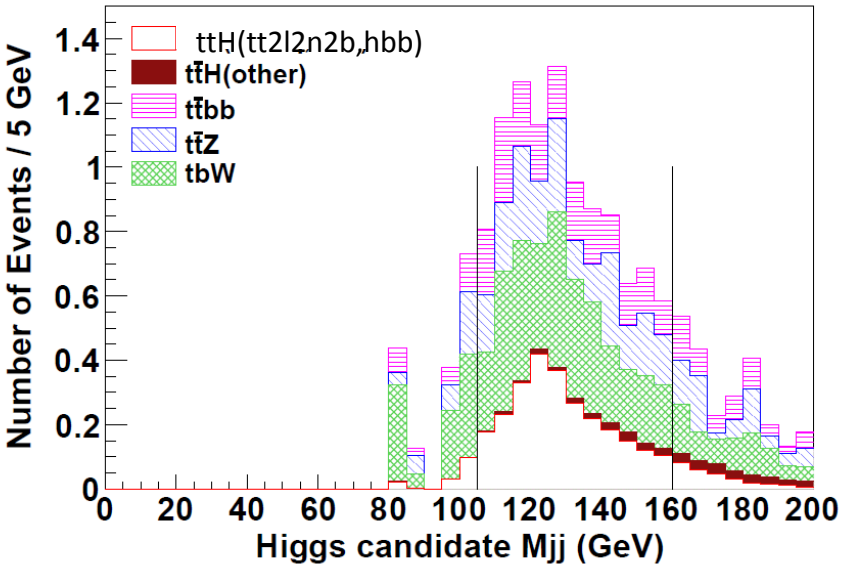
need to check why tth→ 8jets is also improved.

higgs candidate Mjj

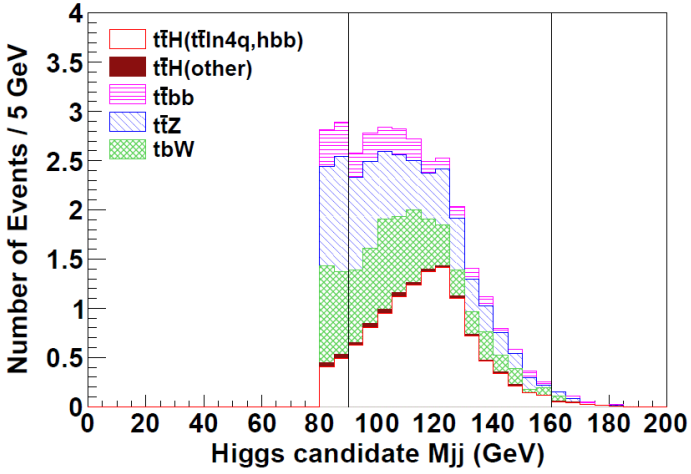
tth→8jets



tth→2l2v+4b jets



tth→lv+6jets



- W→e, μ, τ +ν inclusive analysis
- tth→2l2v+4b channel has tail in high mass direction.
  (I used only angle information of higgs candidate jets when reconstruct Mjj)

Summary

- update cut based lepton ID method
- analyze tth→2l2v+4b channel

to do
lepton ID using cluster shape (need Kurata-san's help)
process more tbw MC sample
MC sample production to use MVA
optimize event selection for tth→2l2v+4b channel

Backup

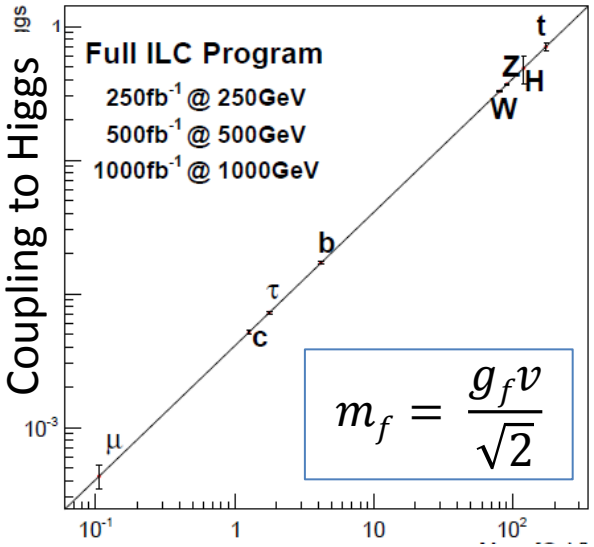
Introduction

- 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

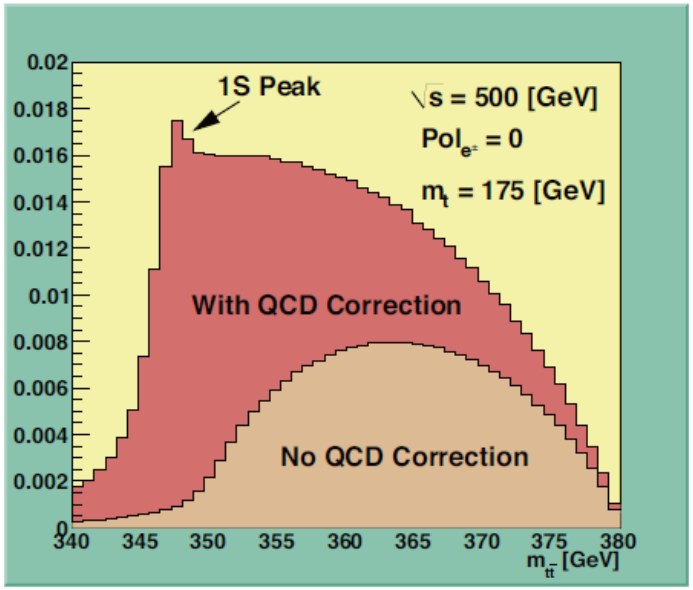
- tth cross section is enhanced
- ttZ cross section is also increased

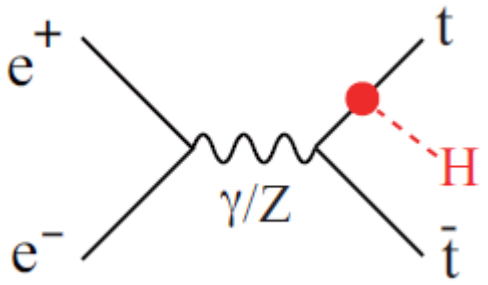
Signals

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

Main Backgrounds

- ttZ, ttg(bb), tbW





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