tth study

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tth (h→bb) significance

- optimize cut point of event selection to maximize $S/\sqrt{S+B}$

$S/\sqrt{S+B}$

(Pe^-,Pe^+)	(-0.8,+0.3)		(+0.8,-0.3)	
Lumi. (fb^{-1})	500	1600	500	1600
8 jets	2.17	3.89	1.40	2.53
lv + 6 jets	2.00	3.58	1.29	2.32
2l2v + 4 jets	1.02	1.83	0.72	1.31

event selection

Event Selection 8 jets

- Jet clustering : Durham algorithm $Y_{ij} = \frac{2\min\{E_i^2, E_j^2\}(1-\cos\theta)}{E_{\rm cm}^2}$
  - forced 8 jet clustering for tth→8jets channel
  - ✓ "$Y_{87} > 0.00038$" + "$Y_{87} <= 0.00038$ && $Y_{76} > 0.004$"
- Isolated Lepton ID with BDT
  - ✓ require no Isolated lepton
- ✓ b candidate jets ≥ 4 (b likeness >=0.85 ,0.8, 0.6, 0.2)
- reject events with very forward jets
- ✓ |Jet cosθ| ≤ 0.99
- Jet paring, χ2> 13.3
- Mjjj > 140 (top candidate 3 jet mass)
- Leading 2 jets energy sum < 188 (Gev)
- smallest 3 jets energy sum > 60 (GeV)
- 95 < Mjj < 160 (GeV) (range of higgs candidate Mjj)

Event Selection ln+6 jets

- Jet clustering : Durham algorithm $Y_{ij} = \frac{2\min\{E_i^2, E_j^2\}(1-\cos\theta)}{E_{\rm cm}^2}$
  - forced 6 jet clustering for tth→6jets channel
  - ✓ "Y_{65} > 0.0016" + "Y_{65}<=0.0016 && Y_{54}>0.006"
- Isolated Lepton ID with BDT
  - ✓ require exact one Isolated lepton
- ✓ b candidate jets ≥ 4 (b likeness >=0.85 ,0.8, 0.6, 0.2)
- reject events with very forward jets
- ✓ |Jet cosθ| ≤ 0.99
- Missing Energy > 20 GeV
- Jet paring, χ2> 30.5
- Mjjj > 140 (top candidate 3 jet mass)
- Leading 2 jets energy sum < 197 Gev
- smallest 2 jets energy sum > 66 GeV
- 95 < Mjj < 160 GeV (range of higgs candidate Mjj)

Event Selection 2l2n+4 jets

- Jet clustering : Durham algorithm $Y_{ij} = \frac{2\min\{E_i^2, E_j^2\}(1-\cos\theta)}{E_{\rm cm}^2}$
  - forced 6 jet clustering for tth→4jets channel
  - ✓ "$Y_{43} > 0.002$"
- Isolated Lepton ID with BDT
  - ✓ require exact two Isolated leptons
- ✓ 4 b jets (b likeness >=0.85 ,0.8, 0.6, 0.2)
- reject events with very forward jets
- ✓ |Jet cosθ| ≤ 0.99
- Missing Energy > 20 GeV
- Jet paring, χ2> 12.5
- Leading jet energy < 112 (Gev)
- smallest jet energy > 38 (GeV)
- 100 < Mjj < 155 (GeV) (range of higgs candidate Mjj)

Backup

MC stat.

tth, ttz, ttbb: 100k~200k events

tbW(DBD samples): 10k~100k events

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

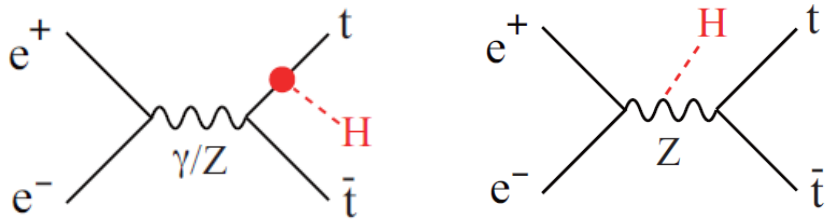
Decay mode	Branching ratio
h→bb	0.577
tt→bqqbqq	0.457
tt→blvbqq	0.438
tt→blvblv	0.105

- 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

tth analysis

- interference term is negligible
- counting analysis with cut based event selection
- Use Kt clustering only for removing low Pt background
- lepton ID (cut base)
  - muon selection
  - electron selection
  - tau (leptonic decay)
  - tau (hadronic decay)



- forced 8 jets clustering & 0 isolated lepton → 8jets channel
- forced 6 jets clustering & 1 isolated lepton → lv6jets channel
- forced 4 jets clustering & 2 isolated leptons → 2l2v 4jets channel

In this analysis, higgs decays into two b jets

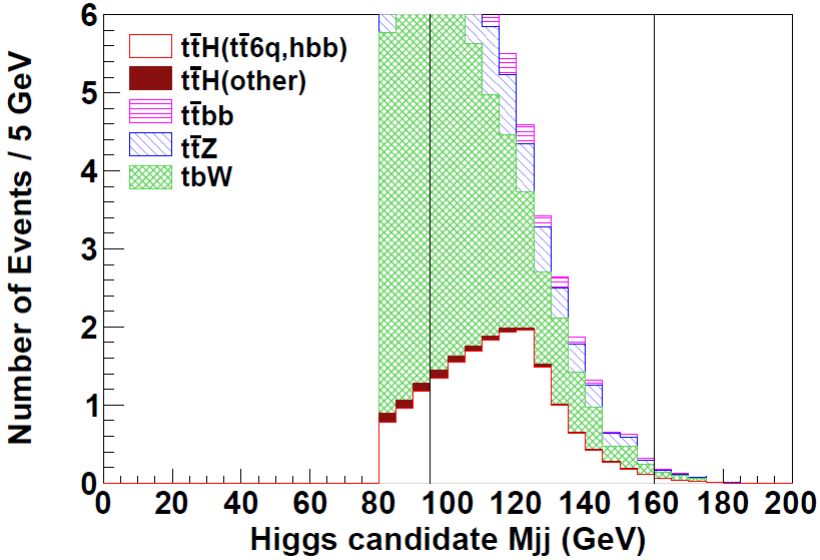
- require at least 4 b jets (b tagging: LCFIPlus)

tth→8jets

cut base lepton ID

number of events passed all selection

before optimization of event selection



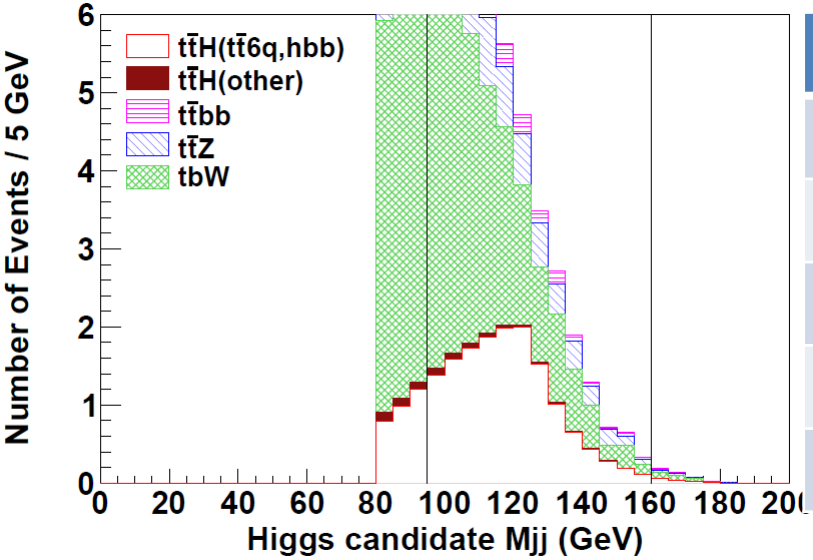
Process	# of evt
tth→4q+4b	14.4
tth (other)	0.46
ttZ	7.29
ttbb	2.59
tbW	25.0

tth→8jtes

- Nsig = 14.4
- Nbkgd = 35.4
- $S/\sqrt{S+B} = 2.04$

previous result (low MC stat)
$S/\sqrt{S+B} = 2.38$

lepton ID with BDT



Process	# of evt
tth→4q+4b	14.7
tth (other)	0.44
ttZ	7.35
ttbb	2.71
tbW	25.7

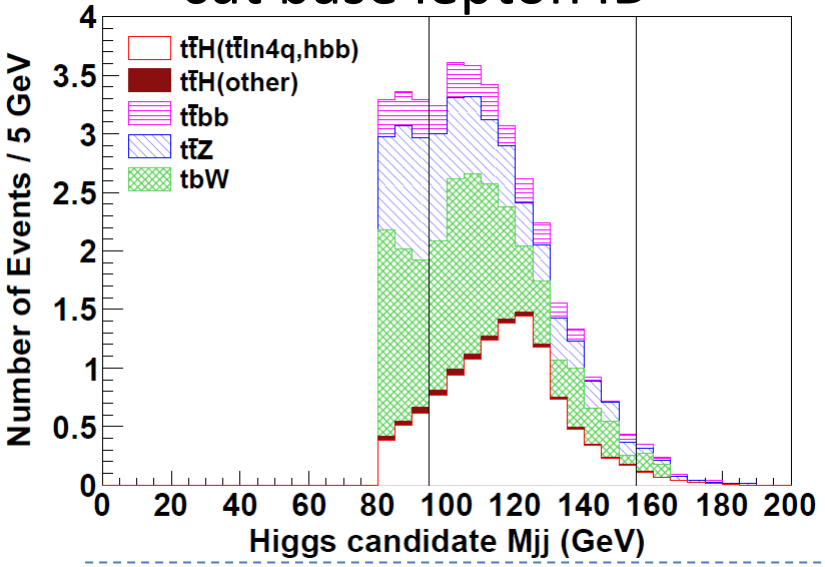
tth→8jtes

- Nsig = 14.7
- Nbkgd = 36.2
- $S/\sqrt{S+B} = 2.06$

tth→ln+6jets

before optimization of event selection

cut base lepton ID



number of events passed all selection

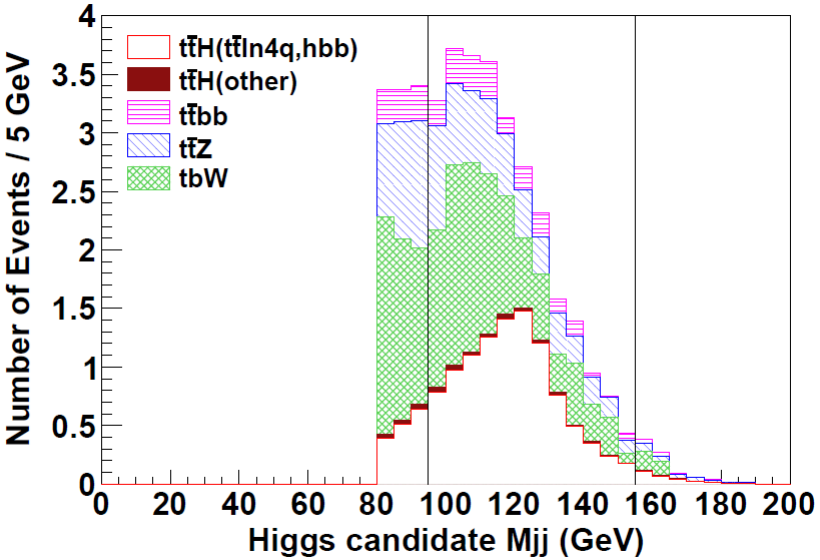
Process	# of evt
tth→ ln+2q+4b	9.99
tth (other)	0.25
ttZ	5.12
ttbb	1.99
tbW	9.30

tth→lv+6jtes

- Nsig = 9.99
- Nbkgd = 16.6
- $S/\sqrt{S+B}$ = 1.93

previous result (low MC stat)
$S/\sqrt{S+B}$ = 2.11

lepton ID with BDT



Process	# of evt
tth→ ln+2q+4b	10.2
tth (other)	0.25
ttZ	5.17
ttbb	2.02
tbW	9.80

tth→lv+6jtes

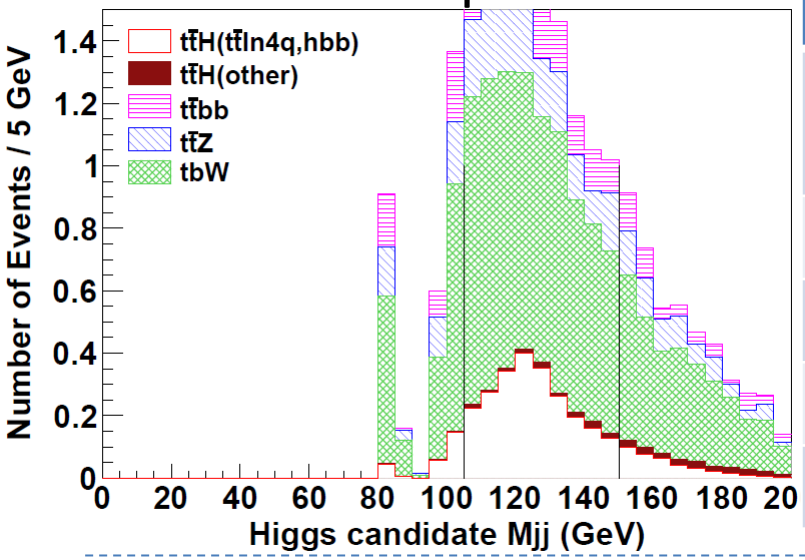
- Nsig = 10.2
- Nbkgd = 17.2
- $S/\sqrt{S+B}$ = 1.95

tth→2l2n+4b jets

number of events passed all selection

before optimization of event selection

cut base lepton ID



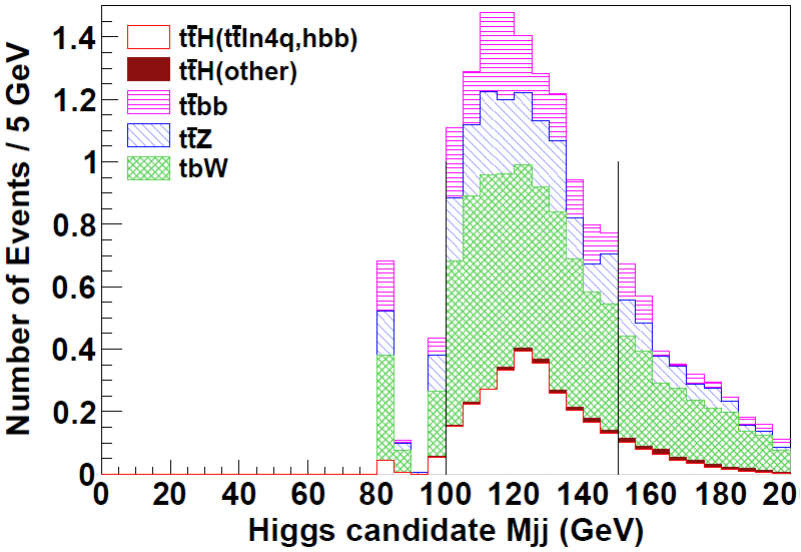
Process	# of evt
tth→ 2l2n+4b	2.34
tth (other)	0.12
ttZ	1.78
ttbb	1.61
tbW	7.32

tth→2l2v+4b jtes

- Nsig = 2.34
- Nbkgd = 10.8
- $S/\sqrt{S+B} = 0.64$

previous result (low MC stat)
$S/\sqrt{S+B} = 0.77$

lepton ID with BDT



Process	# of evt
tth→ 2l2n+4b	2.48
tth (other)	0.08
ttZ	1.98
ttbb	1.72
tbW	5.49

tth→2l2v+4b jtes

- Nsig = 2.48
- Nbkgd = 9.28
- $S/\sqrt{S+B} = 0.72$

Lepton ID

- muon selection
- electron selection
- tau (e)
- tau(muon)
- tau (1-prong)
- tau(3-prong)

Jet pairing, χ2 Cut (8 jets mode)

- $\sqrt{s}$ = 500GeV is near by threshold of the tth production
  - P_{higgs} should be small
  - Dijet angle becomes large

→ Angle information between higgs candidate jets is effective to choose correct jet pair.

- try all combination and choose a pair with minimum χ^2 value

$$\chi^2 = \left(\frac{\Delta angle(j_1, j_2) - \Delta angle(higgs\ jj)}{\sigma_{\Delta angle(higgs\ jj)}}\right)^2 + \left(\frac{m_{j_3 j_4 j_5} - M_{top}}{\sigma_{M_{top}}}\right)^2 + \left(\frac{m_{j_4 j_5} - M_W}{\sigma_{M_W}}\right)^2 + \left(\frac{m_{j_6 j_7 j_8} - M_{top}}{\sigma_{M_{top}}}\right)^2 + \left(\frac{m_{j_7 j_8} - M_W}{\sigma_{M_W}}\right)^2$$

require b likeness $\geq$ 0.2 to j_1, j_2, j_3, j_6

- Reference values are made from reconstructed jets which are matched with MC information
  - Mtop = 171.5GeV
  - sigma Mtop = 16.8 GeV
  - MW = 80. 5GeV
  - sigma MW = 9.9 GeV
  - angle(jj) = 2.448
  - sigma angle(jj) = 0.277

higgs and top pairing, χ2 Cut (6 jets mode)

$$\chi^2 = \left(\frac{\Delta angle(j_1, j_2) - \Delta angle(higgs\ jj)}{\sigma_{\Delta angle(higgs\ jj)}}\right)^2 + \left(\frac{m_{j_3 j_4 j_5} - M_{top}}{\sigma_{M_{top}}}\right)^2 + \left(\frac{m_{j_4 j_5} - M_W}{\sigma_{M_W}}\right)^2 + \left(\frac{m_{j_6 l\nu} - M_{top}}{\sigma_{M_{top}}}\right)^2$$

Angle information between higgs candidate jets is effective to choose correct jet pair.

A W mass is reconstructed with Isolated lepton and Missing P

- try all combination and choose a pair with minimum χ^2 value

require b likeness $\geq$ 0.2 to j_1, j_2, j_3, j_6

- Reference values are made from reconstructed jets which are matched with MC information

- Mtop = 171.5GeV
- sigma Mtop = 16.8 GeV
- MW = 80. 5GeV
- sigma MW = 9.9 GeV
- angle(jj) = 2.448
- sigma angle(jj) = 0.277

higgs and top pairing, χ2 Cut (4 jets mode)

$$\chi^2 = \left(\frac{\Delta angle(j_1, j_2) - \Delta angle(higgs\ jj)}{\sigma_{\Delta angle(higgs\ jj)}} \right)^2$$

Angle information between higgs candidate jets is used to choose a jet pair.

try all combination and choose a pair with minimum χ^2 value

- Reference values are made from reconstructed jets which are matched with MC information
  - angle(jj) = 2.448
  - sigma angle(jj) = 0.277