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

Outline

- Introduction
- Event selection
- tbW shape
- Result of $S/\sqrt{S+B}$

2014/3/14

Physics meeting

Sudo (Kyushu Univ.)

introduction

- Direct measurement of Yukawa coupling
- Update tth study to reflect a change in Mh 120 to 125 GeV
- Production cross section(eLpR) : 1.07 → 0.809 fb
- Decay branch h→bb : 0.68 → 0.577
- Nsignal (Mh125) ~0.64 × Nsignal(Mh120)

signal
tth → bWbWbb → bqqbqqbb

Main Background
ttZ → bWbW+(bb, qq, ll, vv) → bqqbqq+bb, qq
ttg → bWbWbb → bqqbqqbb
tbW → bWbW→ bqqbqq

Expected Number of Events @ 1000fb^{-1}

- Mh = 125 GeV
- Production cross section

Process	σ (fb)
$e_L^- e_R^+ \to t\bar{t}h$	0.809
$e_L^- e_R^+ \to t\bar{t}Z$	4.04
$e_L^- e_R^+ \to t\bar{t}g^*(b\bar{b})$	1.93
$e_L^- e_R^+ \to tbW$	1633
$e_R^- e_L^+ \to t\bar{t}h$	0.340
$e_R^- e_L^+ \to t\bar{t}Z$	1.32
$e_R^- e_L^+ \to t\bar{t}g^*(b\bar{b})$	0.86
$e_R^- e_L^+ \to tbW$	700

- Branching ratio

Decay mode	BR
$h \to bb(Mh = 125\text{GeV})$	0.577
$t\bar{t} \to bqqbqq$	0.457
$t\bar{t} \to bl\nu bqq$	0.438
$t\bar{t} \to bl\nu bl\nu$	0.105

- Scale factor related to polarization

	Wight for $(P_{e^-}, P_{e^+}) = (-0.8, +0.3)$
$e_L^- e_R^+, (P_{e^-}, P_{e^+}) = (-1.0, +1.0)$	0.585 (=0.9*0.65)
$e_R^- e_L^+, (P_{e^-}, P_{e^+}) = (+1.0, -1.0)$	0.035 (=0.1*0.35)

- MC samples and expected number of events with no cut

	$t\bar{t}h(t\bar{t}6j\ hbb)$	$t\bar{t}h(t\bar{t}all\ hnobb)$	$t\bar{t}h(t\bar{t}ln4j\ hbb)$	$t\bar{t}h(t\bar{t}2l2n2j\ hbb)$	$t\bar{t}Z$	$t\bar{t}g^*(b\bar{b})$	tbW
# of events (1000 fb^{-1})	127.9	205.2	122.6	29.3	2409.6	1159.1	979807.7
# of events $(e_L^- e_R^+)$	2100	3400	2000	500	24527	12200	269054
# of events $(e_R^- e_L^+)$	900	1400	900	200	11000	8000	92200

Event Selection

- Y8→7 (8 jet event)
- No Isolated Lepton
- B jet candidate ≥ 4
- $|\text{Jet } \cos\theta| \leq 0.99$
- $\chi 2 \leq 9.5$
- Leading 2 Jet Energy Sum
- Lowest 3 Jet Energy Sum
- top candidate Mjjj $\geq$ 140 GeV
- h candidate Mjj $\geq$ 80 GeV
- 100 GeV $\leq$ h candidate Mjj $\leq$ 155 GeV

Y8→7 (8 jet event)
No Isolated Lepton

Jet clustering : Durham algorithm

$$Y_{ij} = \frac{\min\{E_i^2, E_j^2\}(1-\cos\theta)}{E_{\rm cm}^2}$$

- ✓ Used forced 8 jet mode
- ✓ apply "Y8→7 > 0.0009" to select 8 jet event

- Isolated Lepton

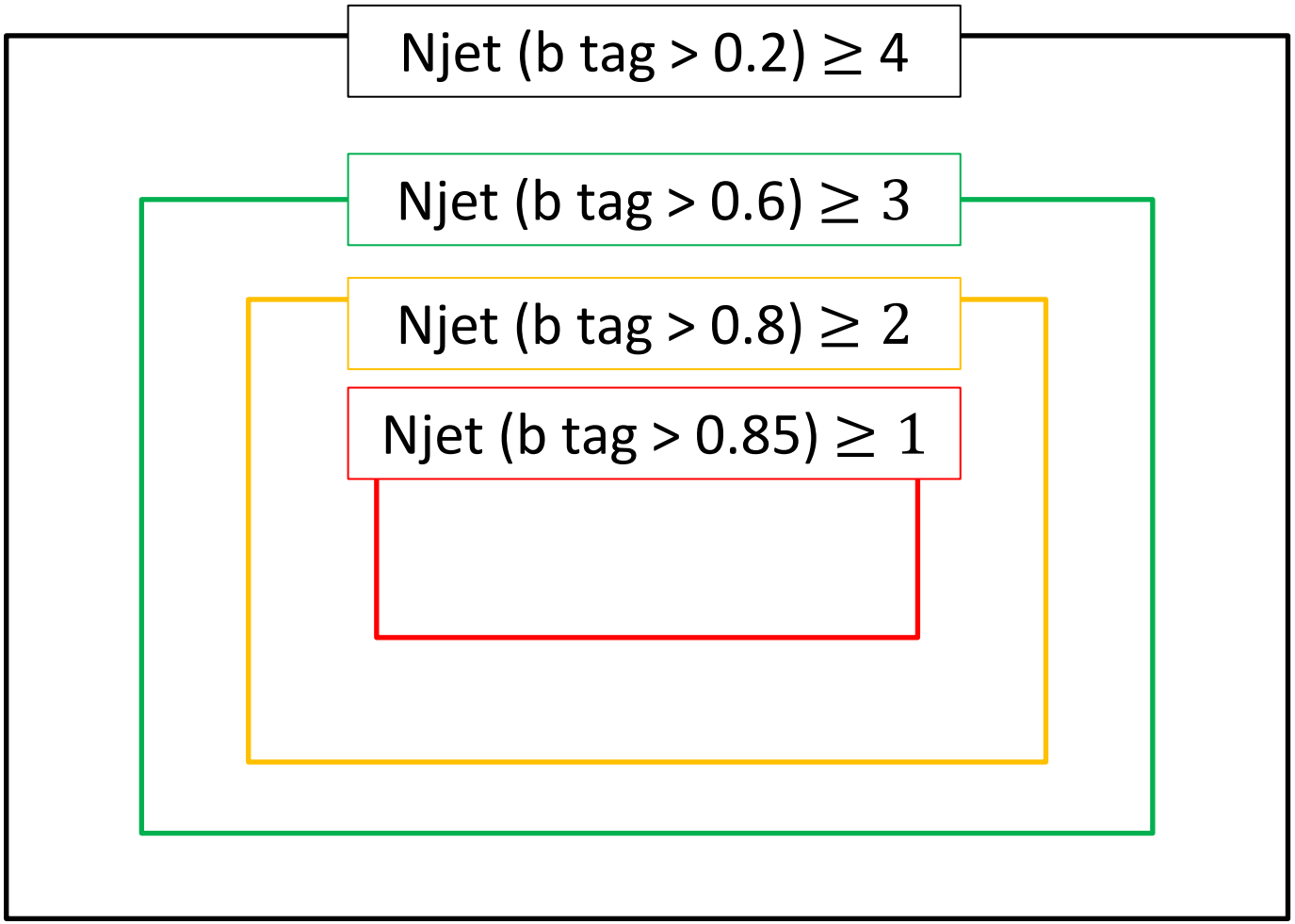
Definition

$$\cos\theta_{\rm cone} = 0.98$$

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

- ✓ Require No Isolated Lepton

✓ B jet candidate ≥ 4



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

reject events which include very forward jet(s)

χ2 Cut

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

$M_{top} = 171.9$ GeV
$\sigma_{M_{top}} = 15.5$ GeV
$M_W = 80.385$ GeV (PDG)
$\sigma_{M_W} = 9.8$ GeV
$\Delta angle(jj) = \sqrt{(\Delta\cos\theta_{jj})^2 + (\Delta\phi_{jj})^2}$
$\Delta angle(higgs\ jj) = 2.714$
$\sigma_{\Delta angle(higgs\ jj)} = 0.369$

- b tag value of j_1, j_2, j_3, $j_6 \geq 0.2$

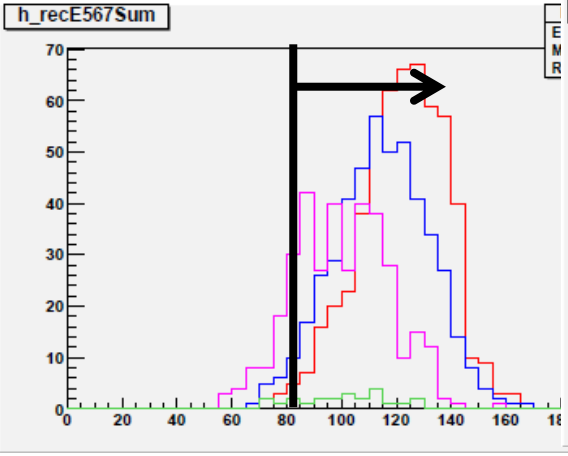
- $\sqrt{s}$ = 500 is almost tth threshold
- $\vec{P}_{\text{higgs}}$ should be small
- Large angle between 2jets

✓ Require χ2 ≤ 9.5

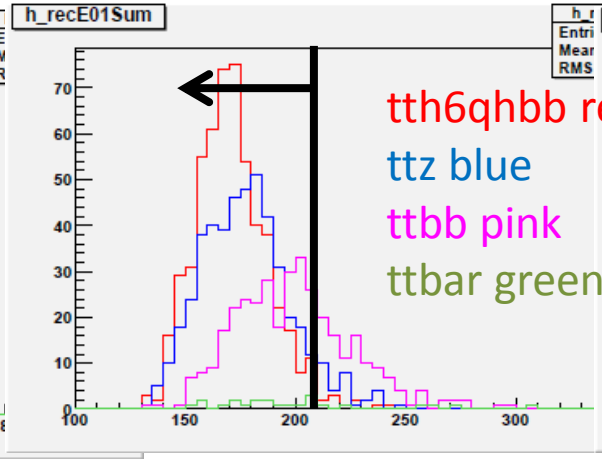
Jet Energy and M_{top} range

- ✓ Leading 2 Jet Energy Sum < 207.5 GeV
- ✓ Lowest 3 Jet Energy Sum > 86.65 GeV
- ✓ top candidate Mjjj ≥ 140 GeV

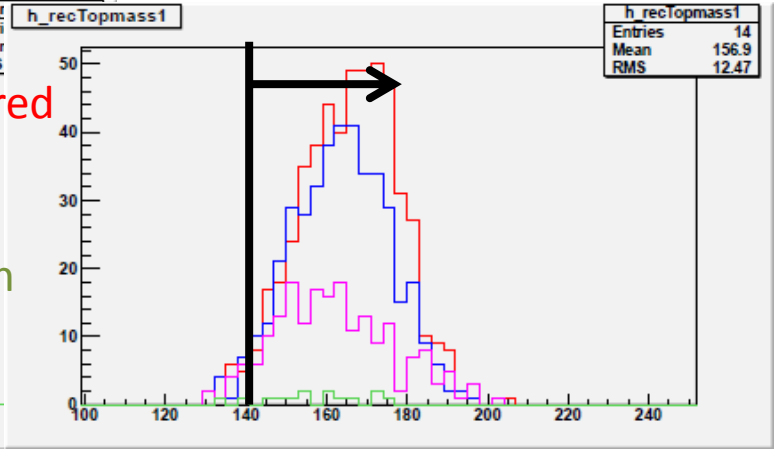
Lowest 3 Jet Energy Sum



Leading 2 Jet Energy Sum



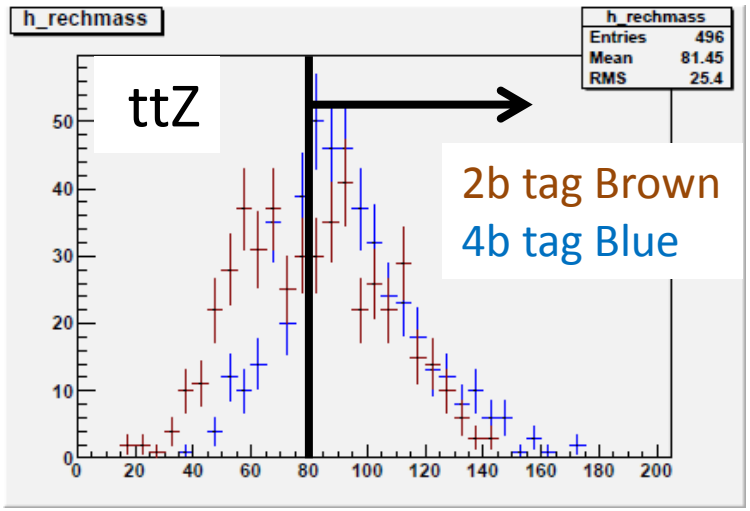
top candidate Mjjj

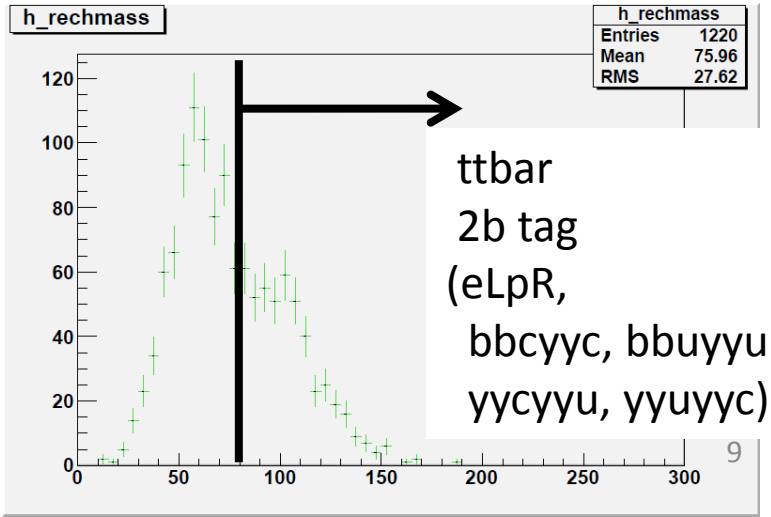


Shape of ttbar background and h candidate Mjj range

- check ttz event shape of
  2 b tag + Y8→7 < 0.008 category and
  4 b tag category
- ttZ event of these categories has similar shape in Mjj > 80 GeV

✓ Use ttbar event shape of 2 b tag + Y8→7 < 0.008 category
✓ Scale factor is calculated from # of event in Mjj≥80 GeV
✓ Apply higgs candidate Mjj ≥ 80 GeV





event selection table

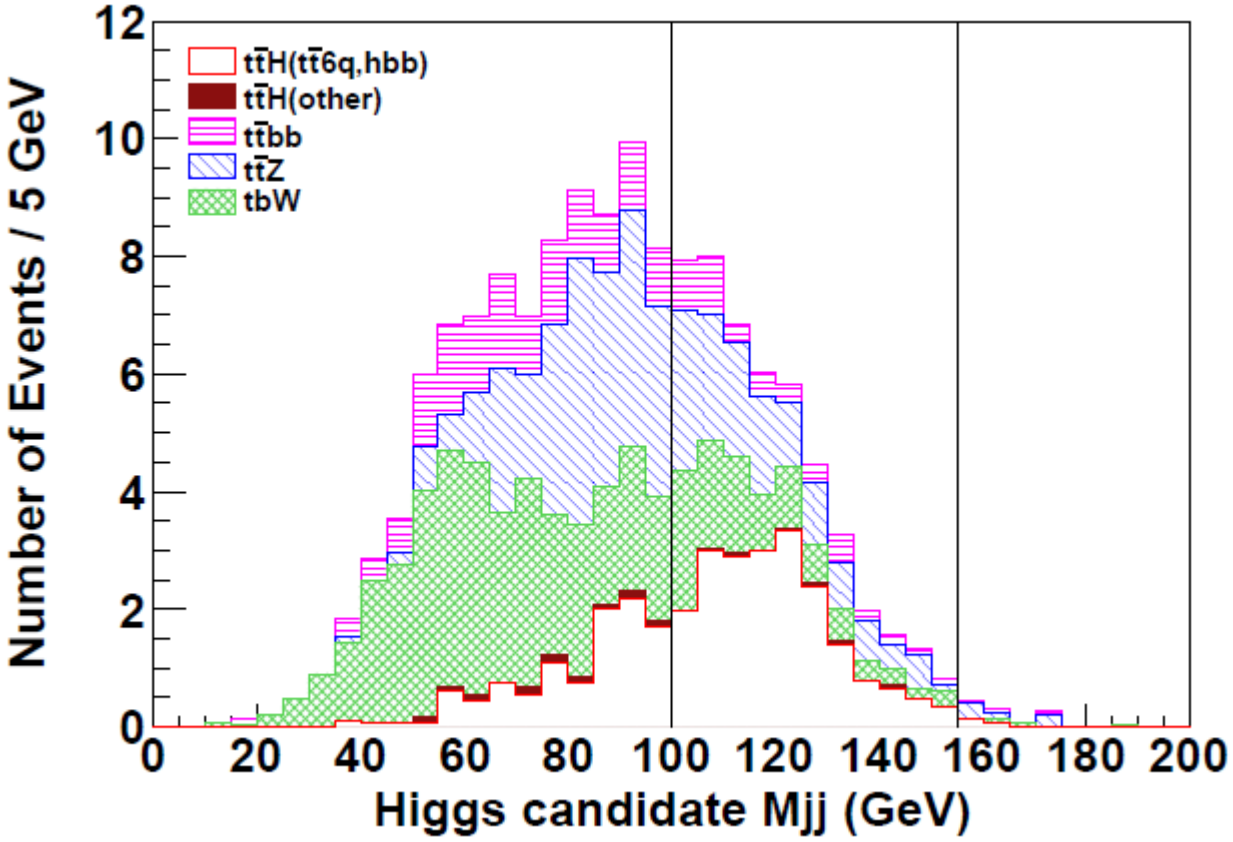
At last, select a Mjj range which maximizes $S/\sqrt{S+B}$

✓ 100 GeV $\leq$ h candidate Mjj $\leq$ 155 GeV

Selection	$t\bar{t}h(t\bar{t}6j\ hbb)$	$t\bar{t}h(t\bar{t}all\ hnobb)$	$t\bar{t}h(t\bar{t}ln4j\ hbb)$	$t\bar{t}h(t\bar{t}2l2n2j\ hbb)$	$t\bar{t}Z$	$t\bar{t}g^*(bb)$	tbW
No Cut	127.9	205.2	122.6	29.3	2409.6	1159.1	979807.7
$Y_{8\to7}$ (8 jets)	87.0	105.2	18.4	0.4	698.4	231.7	60394.6
No Isolated Lepton	81.6	71.3	3.6	0	582.0	201.6	53871.2
b jet candidate ≥ 4	47.3	1.9	1.7	0	71.3	87.6	1106.3
$\mid$ Jet $\cos\theta \mid \leq 0.99$	45.1	1.8	1.6	0	67.3	82.8	491.5
$\chi^2 \leq 9.5$	33.2	1.1	0.6	0	46.5	33.7	148.8
Leading 2 JetEnergySum < 207.5 GeV	32.1	1.1	0.6	0	42.7	22.2	75.8
Lowest 3 JetEnergySum > 86.65 GeV	31.6	1.0	0.4	0	41.0	19.0	67.4
$M_{\text{top}} \geq 140$ (GeV)	30.7	1.0	0.3	0	39.6	17.9	49.5
h Candidate $M_{jj} \geq 80$ (GeV)	27.0	0.7	0.05	0	29.2	8.5	19.3
$100 \leq h$ Candidate $M_{jj} \leq 155$ (GeV)	20.2	0.3	0	0	13.2	4.1	10.0

- Count Number of tth and background events
- Ntth = 20.2
- Nbackground = 27.7

significance



- $S/\sqrt{S+B}$ = 2.92, $|\Delta g_y/g_y \sim 17\%|$

$\sqrt{s}$ = 500 → $\sqrt{s}$ = 550
tth (eLpR) 0.809 → 2.907 fb
ttZ (eLpR) 4.04 → 6.382 fb
ttbb(eLpR) 1.93 → 2.14 fb

→ $S/\sqrt{S+B}$: 2.92 → ~ 7

Summary

- ttbar shape : 2 b tag category (very low stat 4b category)
- Ntth = 20.2
- Nbackground = 27.7
- $S/\sqrt{S+B}$ = 2.92, $|\Delta g_y/g_y \sim 17\%|$ (stat only)

issues

- Lack of MC stat. will make large systematic uncertainty
- ttbar shape

To do

- Estimate systematic uncertainties
- need large stat. MC samples
- ttg→ttqq sample