

# Study of Higgs Self-couplings at ILC

**J. Tian** (Tsinghua U.)

Y. Takubo (Tohuko U.)

K. Fujii (KEK)

Y. Gao (Tsinghua U.)

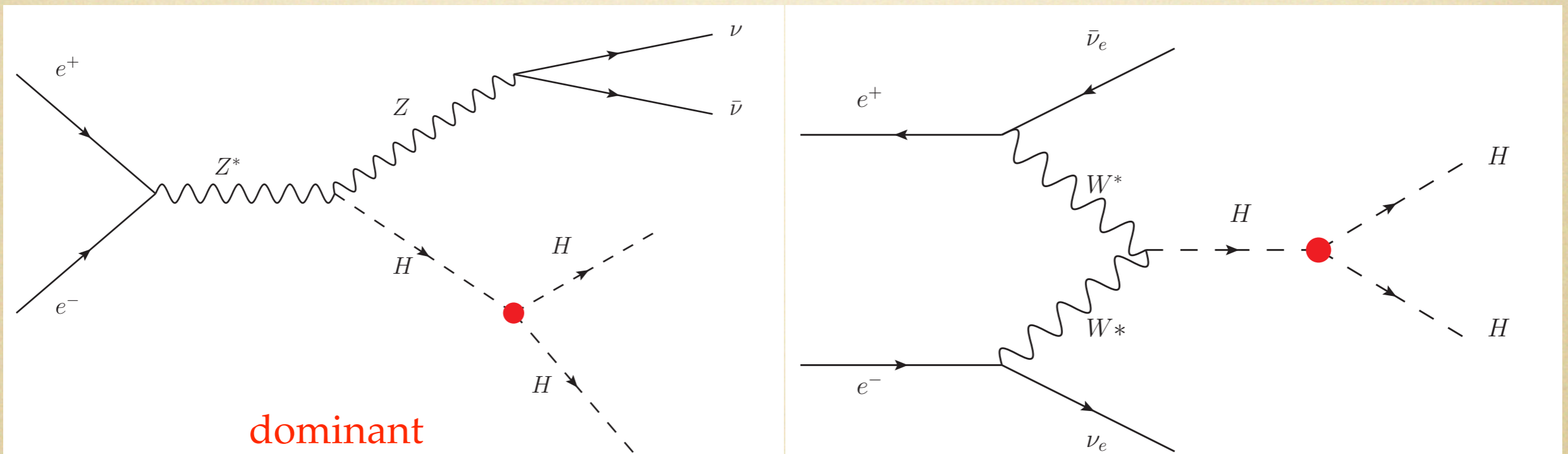
$$e^+ + e^- \rightarrow ZHH \rightarrow (\nu\bar{\nu})HH$$

$$\sigma = 33.9\text{ab} \quad @E_{\text{cm}} = 500\text{GeV}, M_H = 120\text{GeV}$$

full simulation

Marlin framework

(v01-07)



$$e^+ + e^- \rightarrow ZHH \rightarrow (\nu\bar{\nu})(b\bar{b})(b\bar{b}) \rightarrow \nu\bar{\nu} + 4 \text{ bjets}$$

## pre-selection:

- no isolated charged leptons
- force the particles(PFOs) to four jets
- combine the four jets by minimizing

$$\chi^2 = \frac{(M(b, \bar{b}) - M_H)^2}{\sigma_{H_1}^2} + \frac{(M(b, \bar{b}) - M_H)^2}{\sigma_{H_2}^2}$$

## requirement implied in the pre-selection:

- $|M(jj)-M(H)| < 80 \text{ GeV}$

# isolated lepton selection

similar with the method used in  $e^+ + e^- \rightarrow ZHH \rightarrow (l\bar{l})(b\bar{b})(b\bar{b})$

$$e : \begin{cases} \frac{E_{ecal}}{E_{total}} > 0.9 \\ 0.8 < \frac{E_{total}}{P} < 1.2 \\ P > 25.5 + 0.25E_{cone} \end{cases} \quad \mu : \begin{cases} \frac{E_{ecal}}{E_{total}} < 0.5 \\ \frac{E_{total}}{P} < 0.3 \\ P > 28.3 + 0.1E_{cone} \end{cases}$$

- Eecal: energy deposited in the ECal
- Etotal: energy deposited in ECal and HCal
- P: momentum
- Econe: charged cone energy with  $\text{Cos}\theta_{cone} = 0.98$

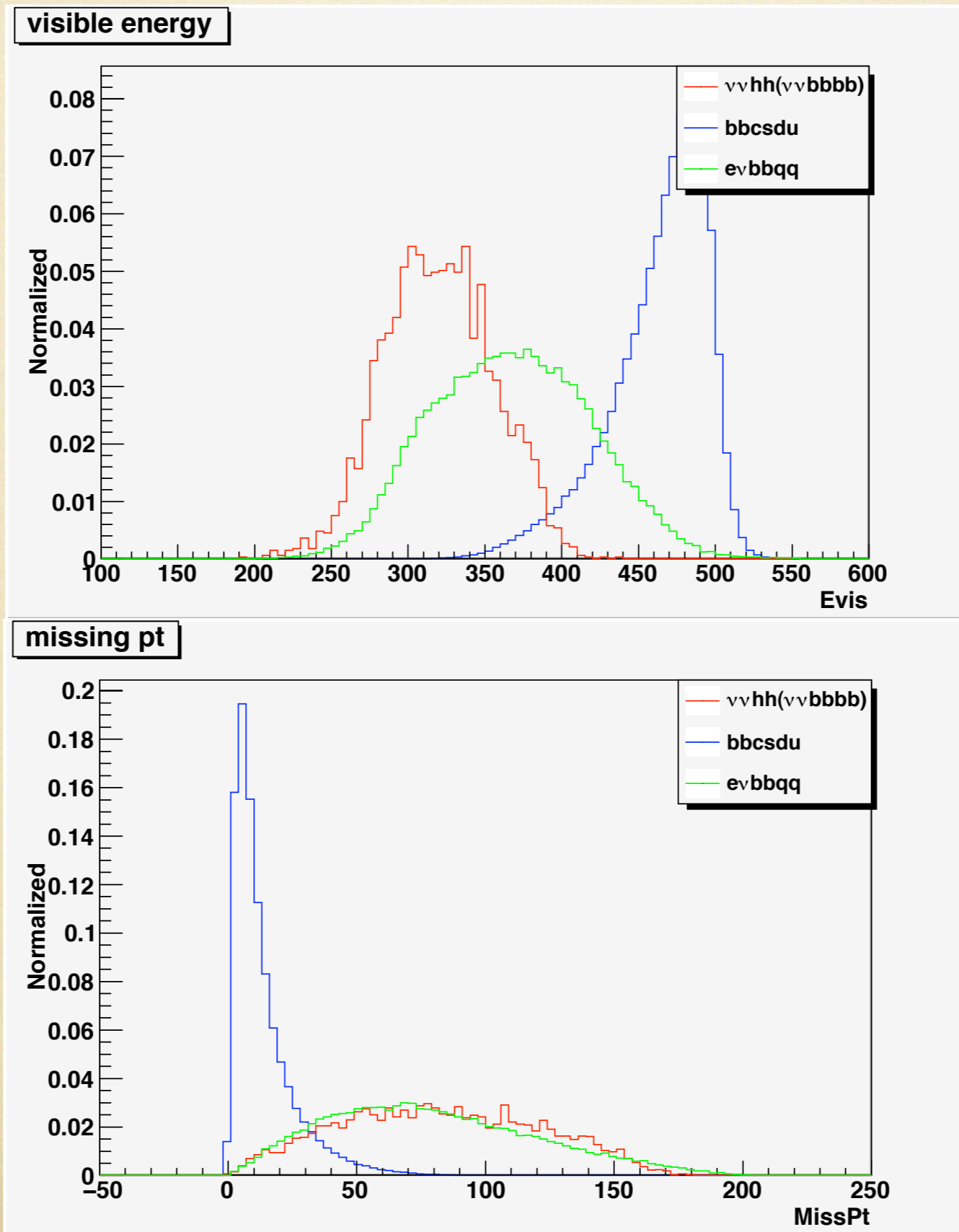
# signal and backgrounds

$$E_{\text{cm}} = 500\text{GeV}, M_H = 120\text{GeV}$$

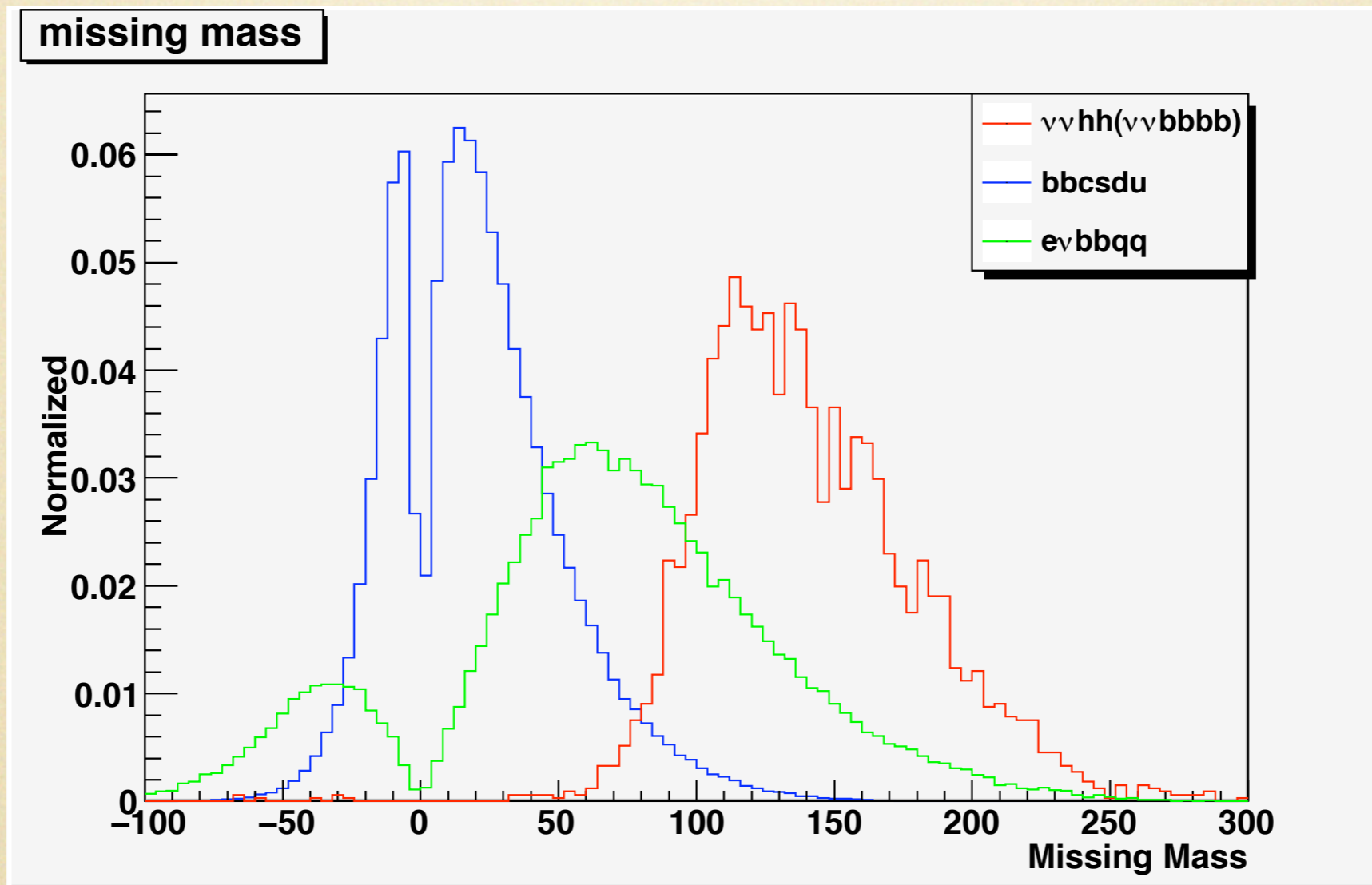
$$\int L dt = 2\text{ab}^{-1}$$

normalized	MC	expected	pre-selection
<b>vvhh(vvbbbb)</b>	<b>8087</b>	<b>67.9(30.3)</b>	<b>55.5(27.8)</b>
vvbbbb		50.4	
vvbbH		160	
bbcsdu	405727	230600	145542
bbuddu	231600	116200	72125
qqbb	29637	207600	170174
llbb	31585	316000	82497
evbbqq	318926	159200	31566
$\mu$ vbbqq	318926	159200	32194
$\tau$ vbbqq	159175	159200	129633

# visible energy and missing pt



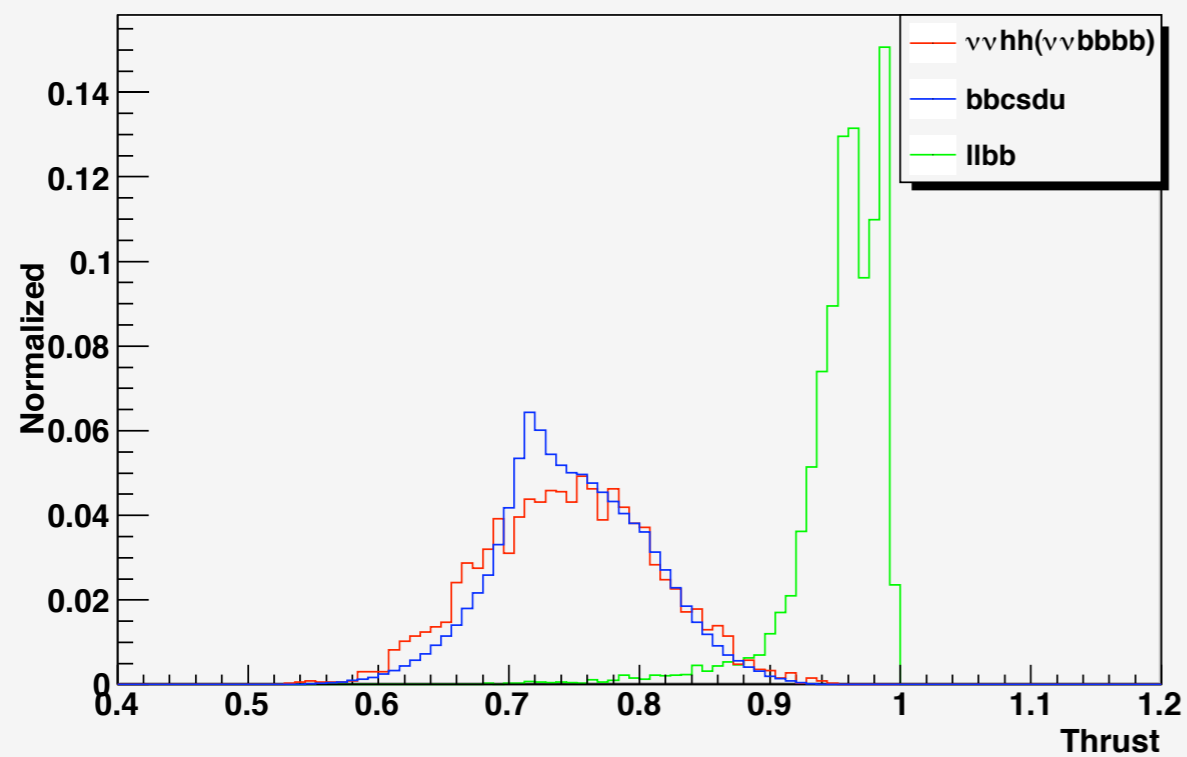
# missing mass



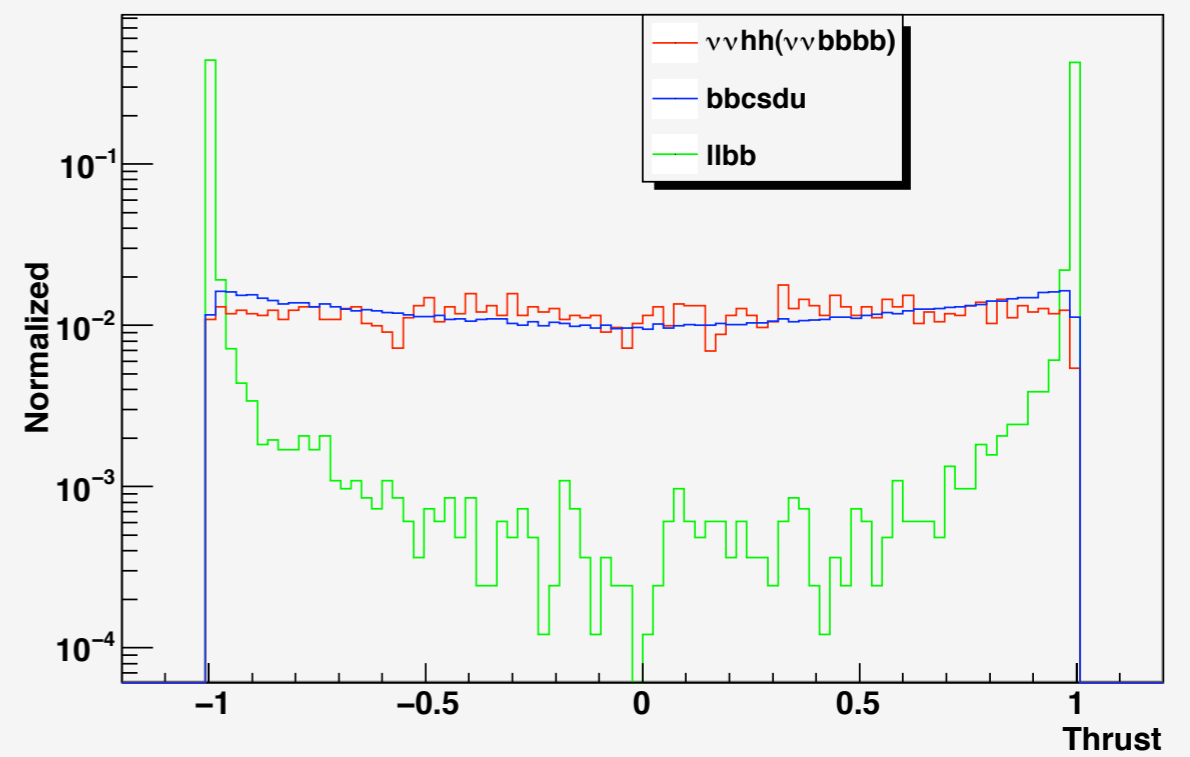
# Thrust and Axis of thrust

## ThrustReconstruction Processor

thrust



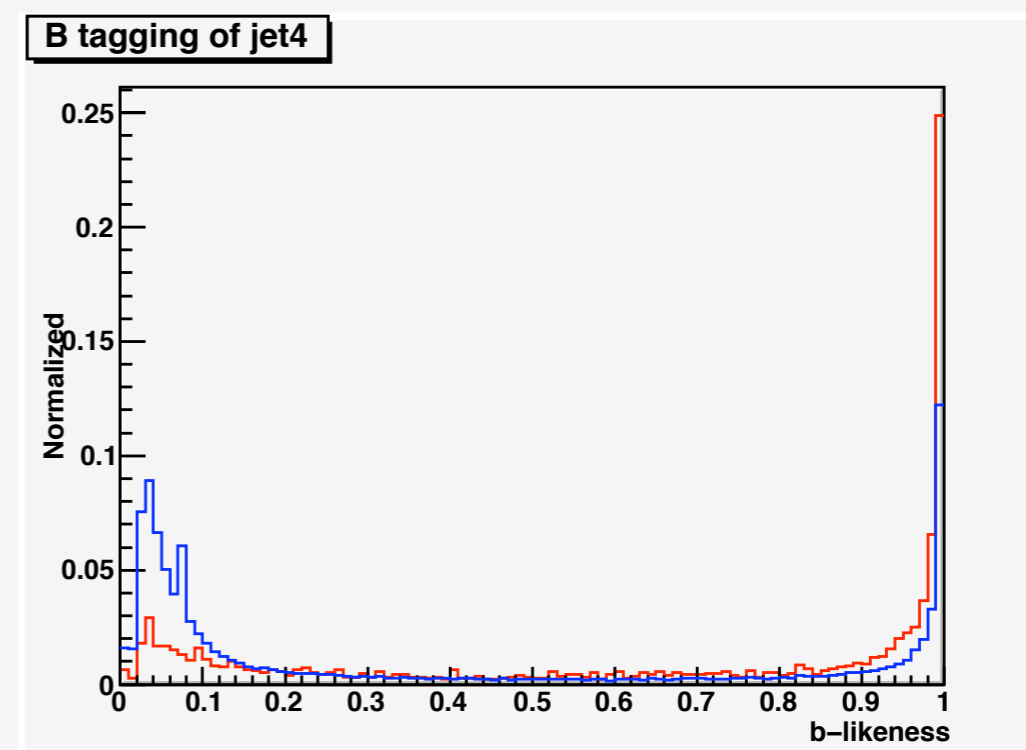
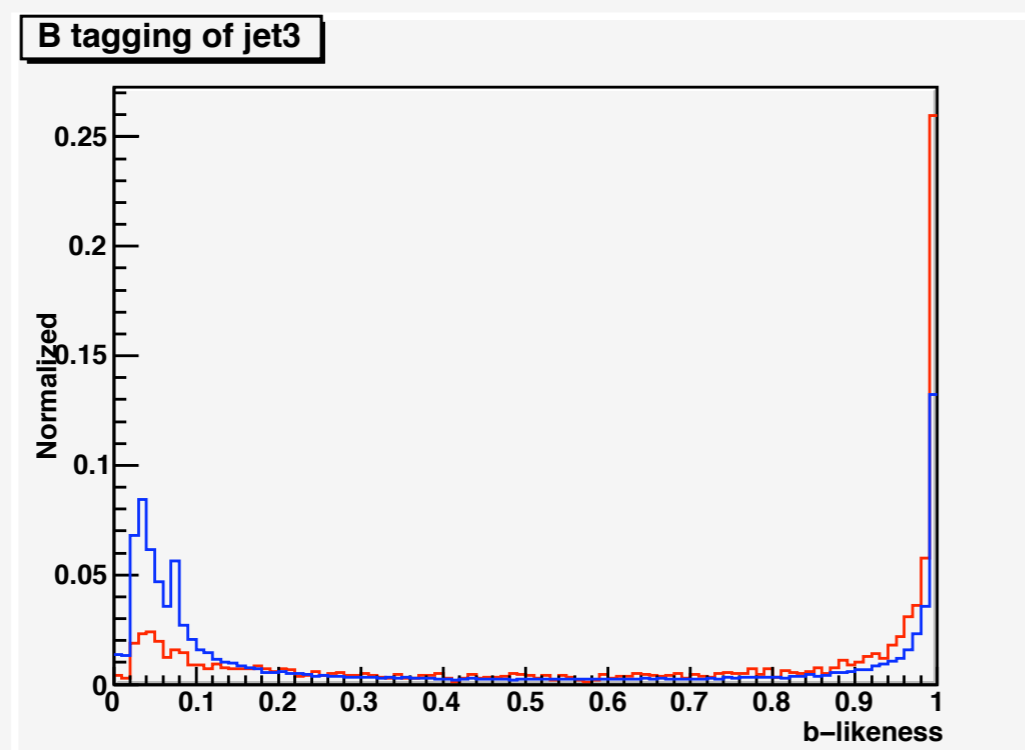
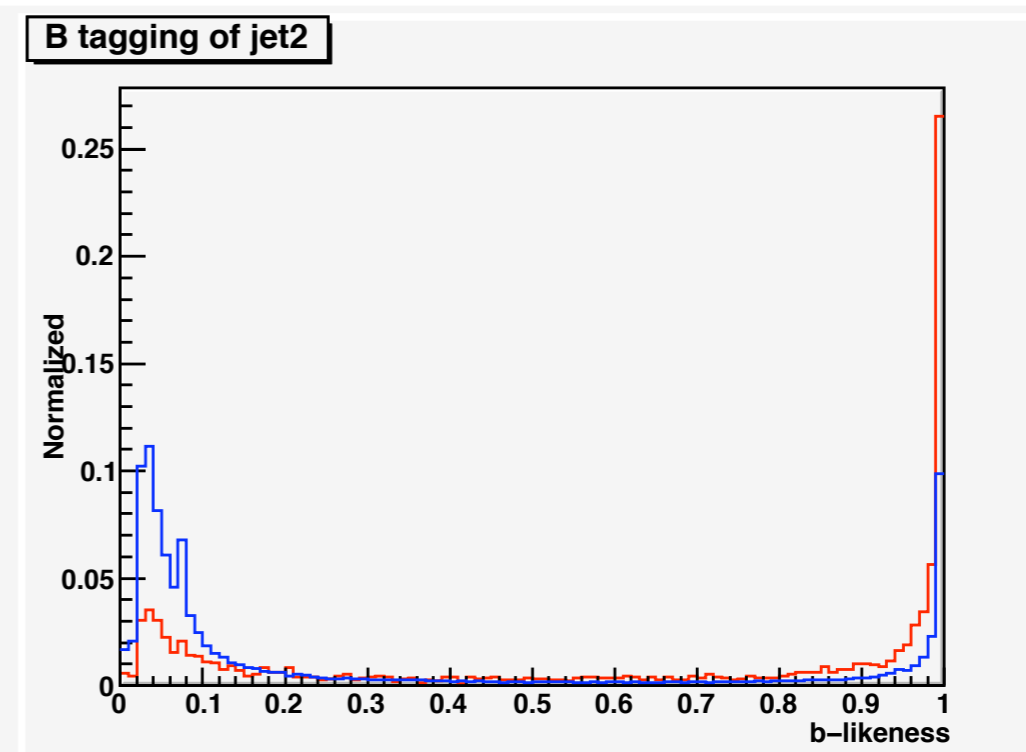
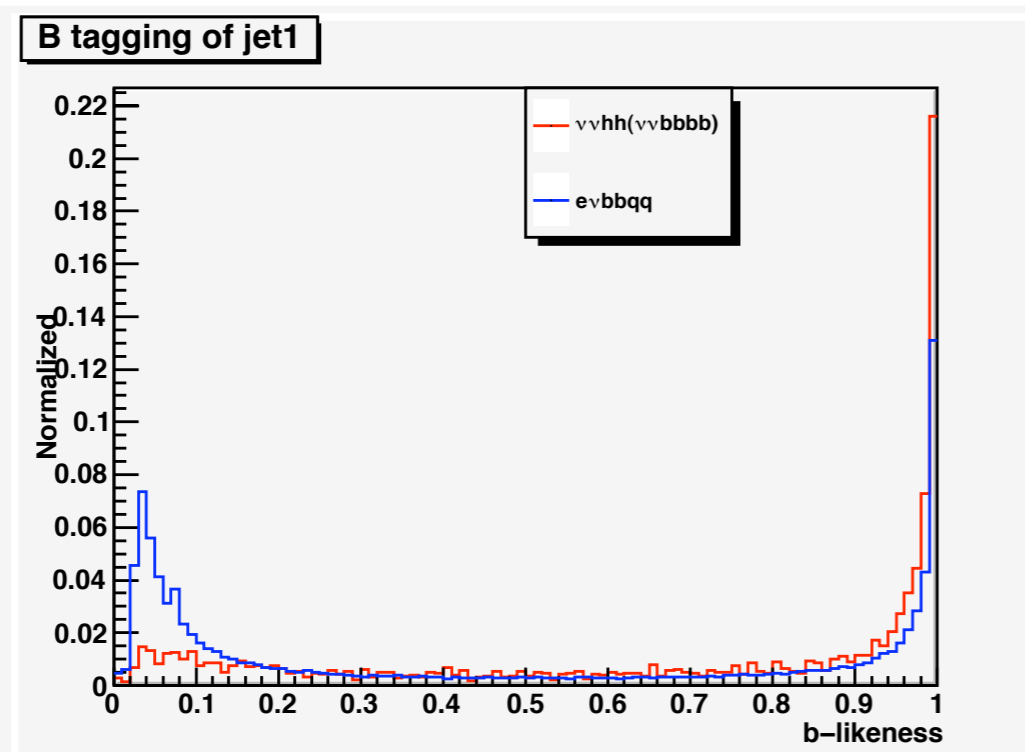
axis of thrust



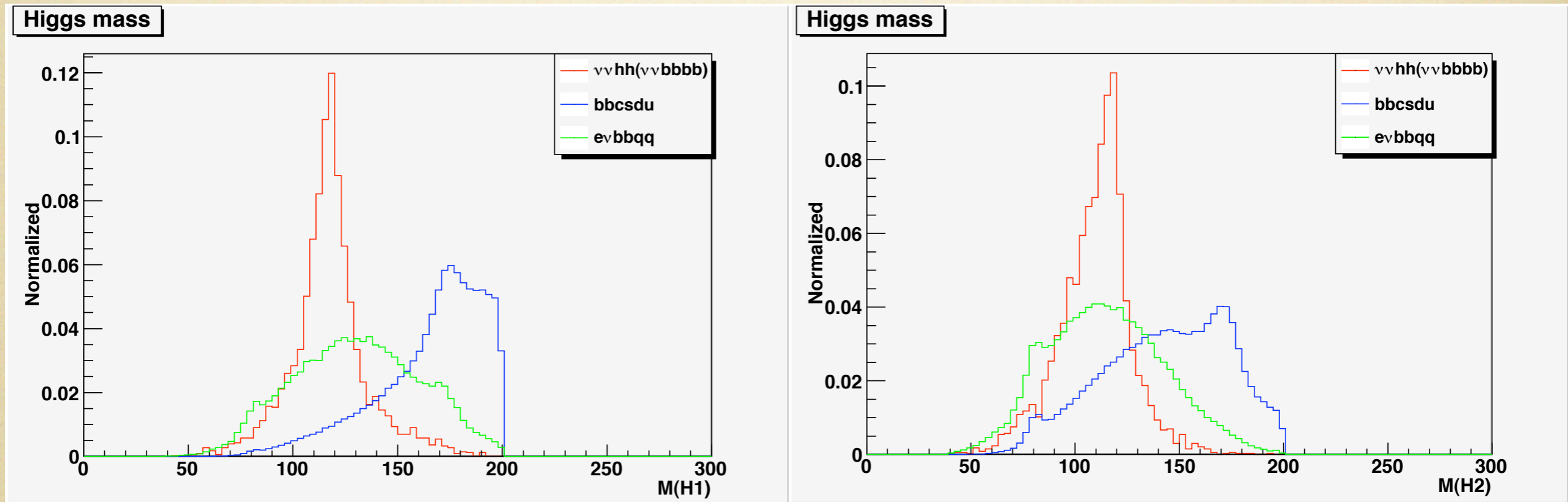


# B tagging for the four jets

LCFIVertex Processor



# invariant mass of the higgs



# preliminary results

no beam polarization

$$E_{\text{cm}} = 500\text{GeV}, M_H = 120\text{GeV}$$

$$\int L dt = 2\text{ab}^{-1}$$

normalized	MC	expected	pre-selection	Evis<380	MissPt>40	80<MissM<200	Npfos>60	Thrust<0.85  Cos >0.8	Btagging
vvhh(llbbbb)	8087	67.9(30.3)	55.5(27.8)	53.2(26.5)	46.0(22.9)	37.3(20.6)	31.9(19.1)	24.8(14.5)	5.58(5.46)
vvbbbb		50.4							
vvbbH		160							
bbcsdu	405727	230600	145542	3134	369	335	305	255	0.57
bbuddu	231600	116200	72125	1410	144	133	118	99.8	0
qqbb	29637	207600	170174	29392	2647	1688	784	168	21
llbb	31585	316000	82497	12155	2531	1610	10.0	0	0
evbbqq	318926	159200	31566	18746	17168	10075	6588	4719	18.5
$\mu$ vbbqq	318926	159200	32194	21162	19165	11660	7832	5644	28.0
$\tau$ vbbqq	159175	159200	129633	84272	72247	55033	35603	25602	254

# summary

- tau mode of  $t\bar{t}$  events became the dominant background.
- $v\bar{v}b\bar{b}b\bar{b}$  and  $v\bar{v}b\bar{b}H$  samples are needed to generate.
- increase statistics of signal and then do neural-net training.

backup