Status of Higgs Self-Coupling Analysis in $\nu\nu b\bar{b}b\bar{b}$

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The LCD Analysis Meeting

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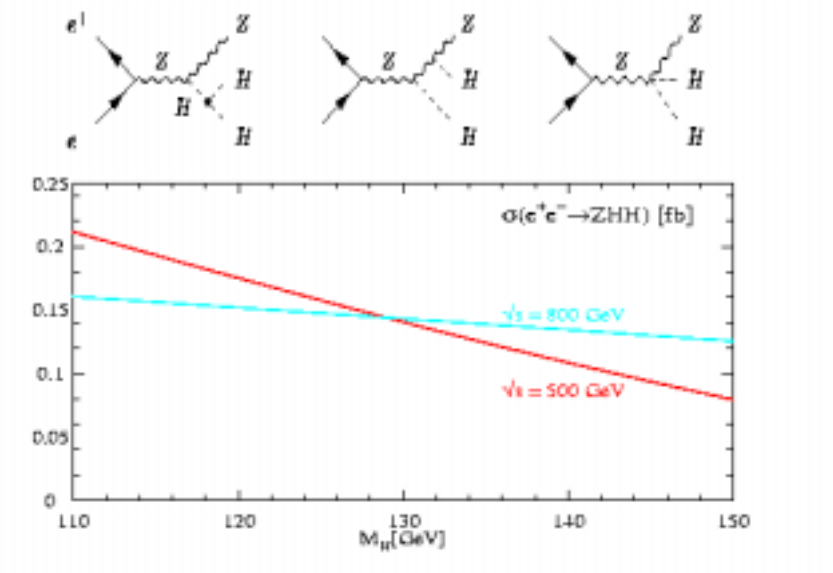
- **Introduction**
- **Analysis Setup**
- **Status of Analysis**
- **To Do list**

Contributions from: M. Battaglia and P. Gay

Introduction

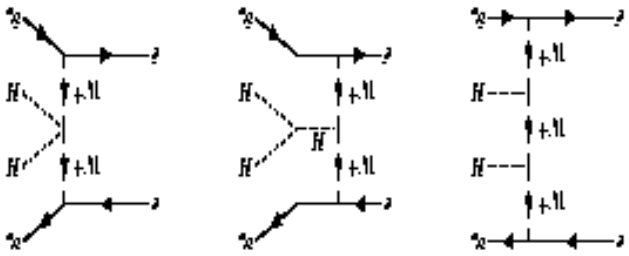
- **One of LC challenges is to measure the Higgs self-coupling precisely**
  $\lambda_{hhh} = 3m_h^2/2v$, **where** $v \approx 246$ **GeV**
- **Experimental establishment of Higgs mechanism. Any Deviation from SM prediction is a sign of new physics**



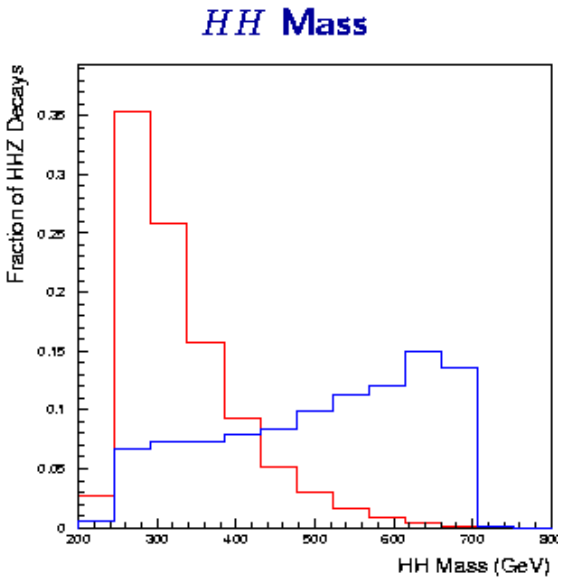
- **TESLA TDR studies indicate** $\Delta\lambda/\lambda \approx 18\%$ **achievable for** $M_H = 120$**GeV for 2000 fb**$^{-1}$ **at 500 GeV.**

Future improvements are feasible

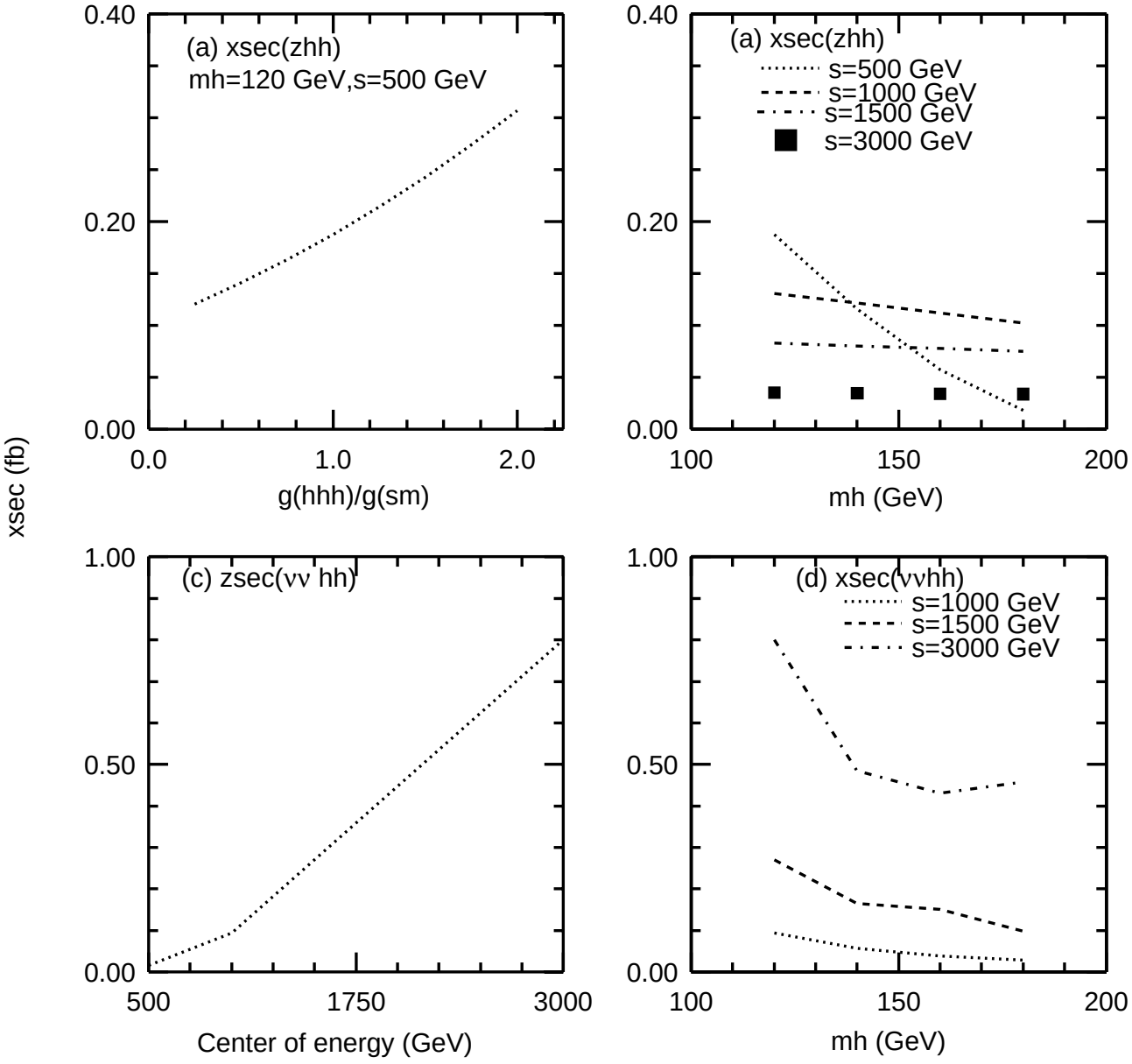
- $e^+e^- \to zHH \to \nu\bar{\nu}b\bar{b}b\bar{b}$
- $e^+e^- \to HH\nu\nu$: **Double WW Fusion at high energy.**



- **Re-examining the M_{HH} kinematic distributions**



- **Explore the high Higgs Masses and higher beam energies**


xsec (fb)
(a) xsec(zhh)
mh=120 GeV,s=500 GeV
0.40
0.20
0.00
0.0
1.0
2.0
g(hhh)/g(sm)
(a) xsec(zhh)
s=500 GeV
s=1000 GeV
s=1500 GeV
s=3000 GeV
100
150
200
mh (GeV)
(c) zsec(νν hh)
1.00
0.50
500
1750
3000
Center of energy (GeV)
(d) xsec(ννhh)
s=1000 GeV
s=1500 GeV
s=3000 GeV

Monte Carlo Setup

Monte Carlo Generators:

- **CompHep(4.1) + Pythia**
- **Pythia(6.158)**

SM Processes at 500 GeV:

Processes	σ (fb)	Generated	Expected 2000 fb^{-1}
$Z(\nu\nu)HH$	0.04	10K	80
$t\bar{t}$	560	50K	1.1M
W^+W^-Z	38	10K	76K
$W^+W^-(tb)$	9.6	10K	19K
$b^+b^-b^+b^-$	7.6	10K	15K
$t^+t^-b^+b^-$	1.0	10K	2K
ZZZ	1.12	10K	2K
ZZH	0.56	10K	1K

Detector Simulations: SimDet 3.1

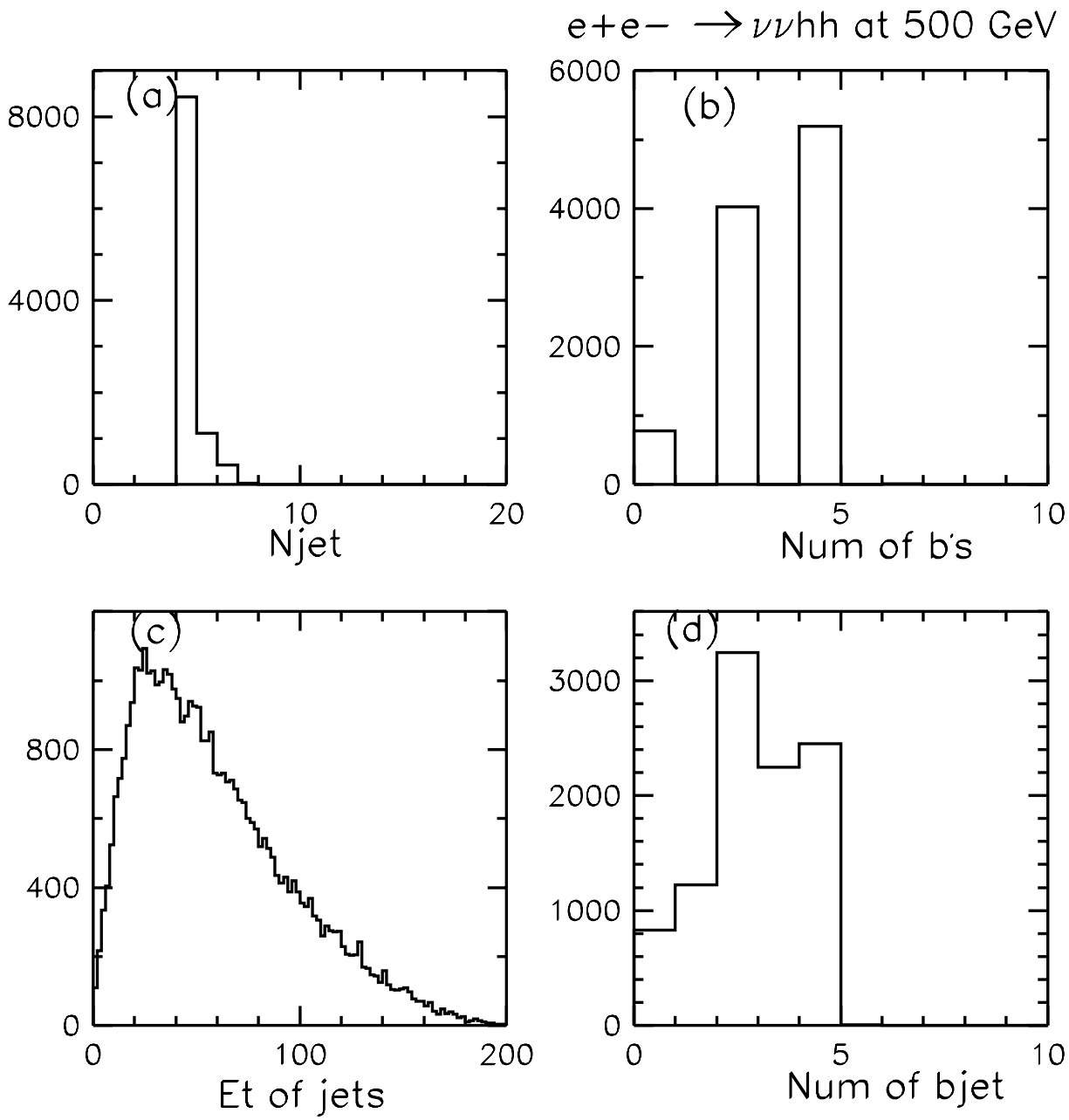
- **Tracking:**
  - **B=4T,**
  - $\Delta P/P \approx 10^{-4} P$,
  - **Eff=0.99,** $Pt_{min} > 30 MeV$
  - **Vertex resolution** $\approx 5 \mu m$
- **EM Calorimeter:**
  $\Delta E/E = 0.102/\sqrt{E} + 0.006$
- **Had Calorimeter:**
  $\Delta E/E = 0.405/\sqrt{E} + 0.042$
- **Will update once the new SimDet is out**

$$e^+e^- \to zhh \to \nu\bar{\nu}b\bar{b}b\bar{b}$$
$$(m_h = 120 \textbf{ GeV at } \sqrt{s} = 500 \textbf{ GeV})$$

Selections:

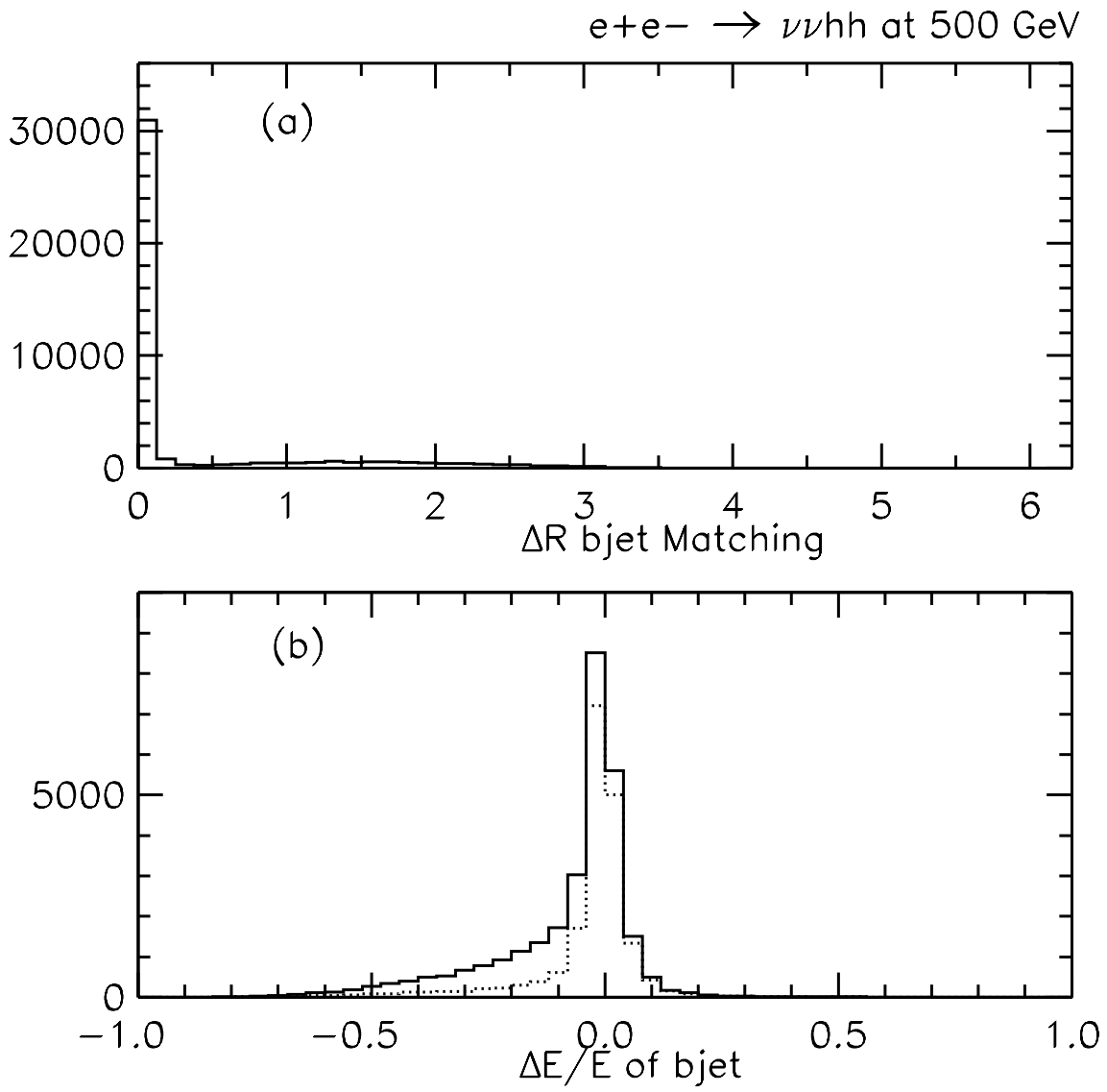
- **Forced 4-jet clustering**
- **≥ 3 btags via matching to b parton**
  - $\epsilon_b = 0.8$
  - $\epsilon_c = 0.05$ **(Important background $W \to cs$)**
- **Large recoil mass>70, miss energy>100 and miss Et>20**
- **No isolated lepton above 25 GeV**
- **Two pairing jets consistent with Higgs vis** $\chi^2 = (m_{12} - mh)^2 + (M_{34} - mh)^2 + (M_{12} - M_{34})^2/2)$
- **Mass Cut:** $100 < m_{12} < 130$, $90 < m_{34} < 130$ **GeV**
- **Higgs mass constrains for improving recoil mass**

Kinematic Distributions

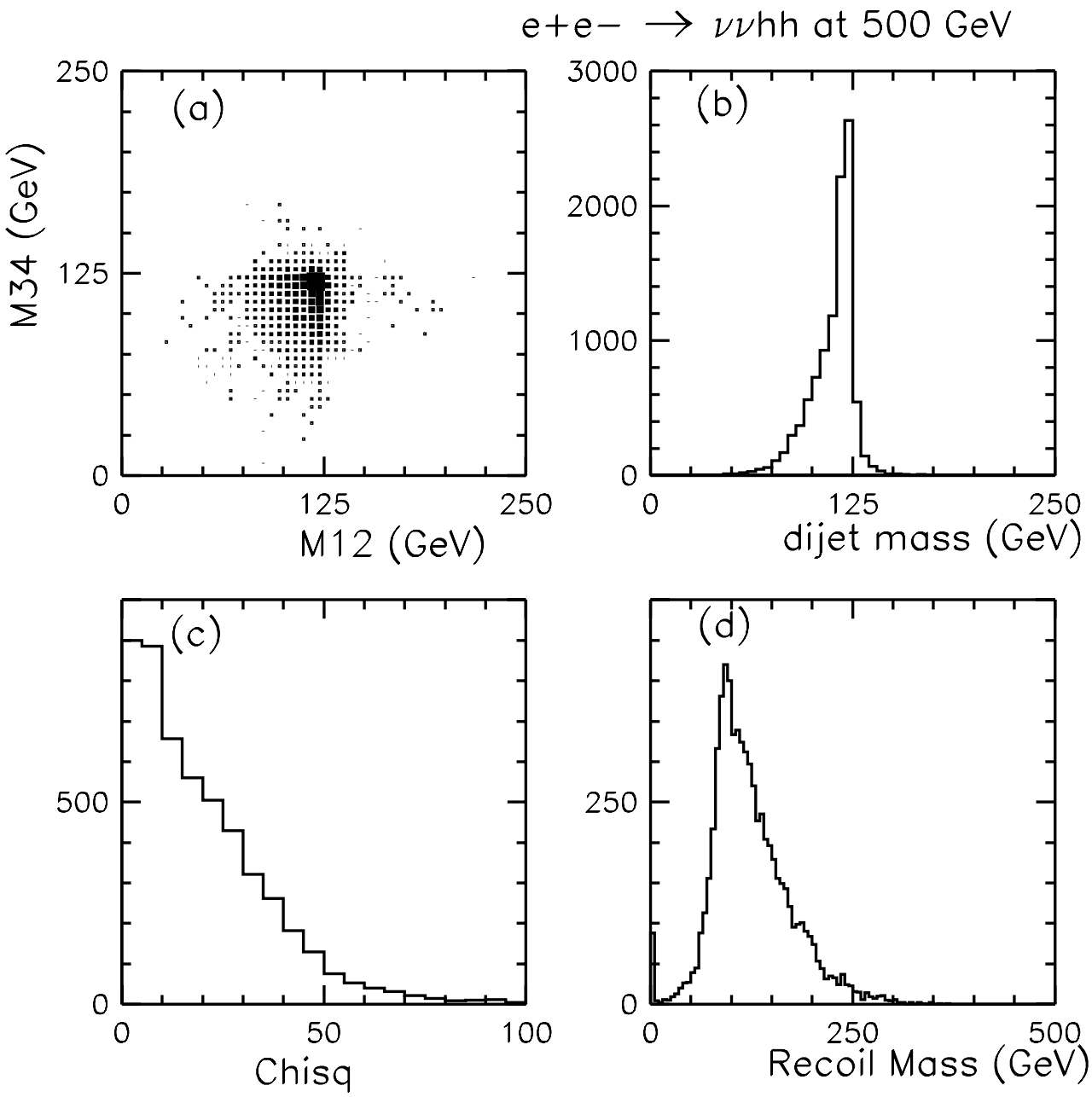


bjet Energy Resolution:

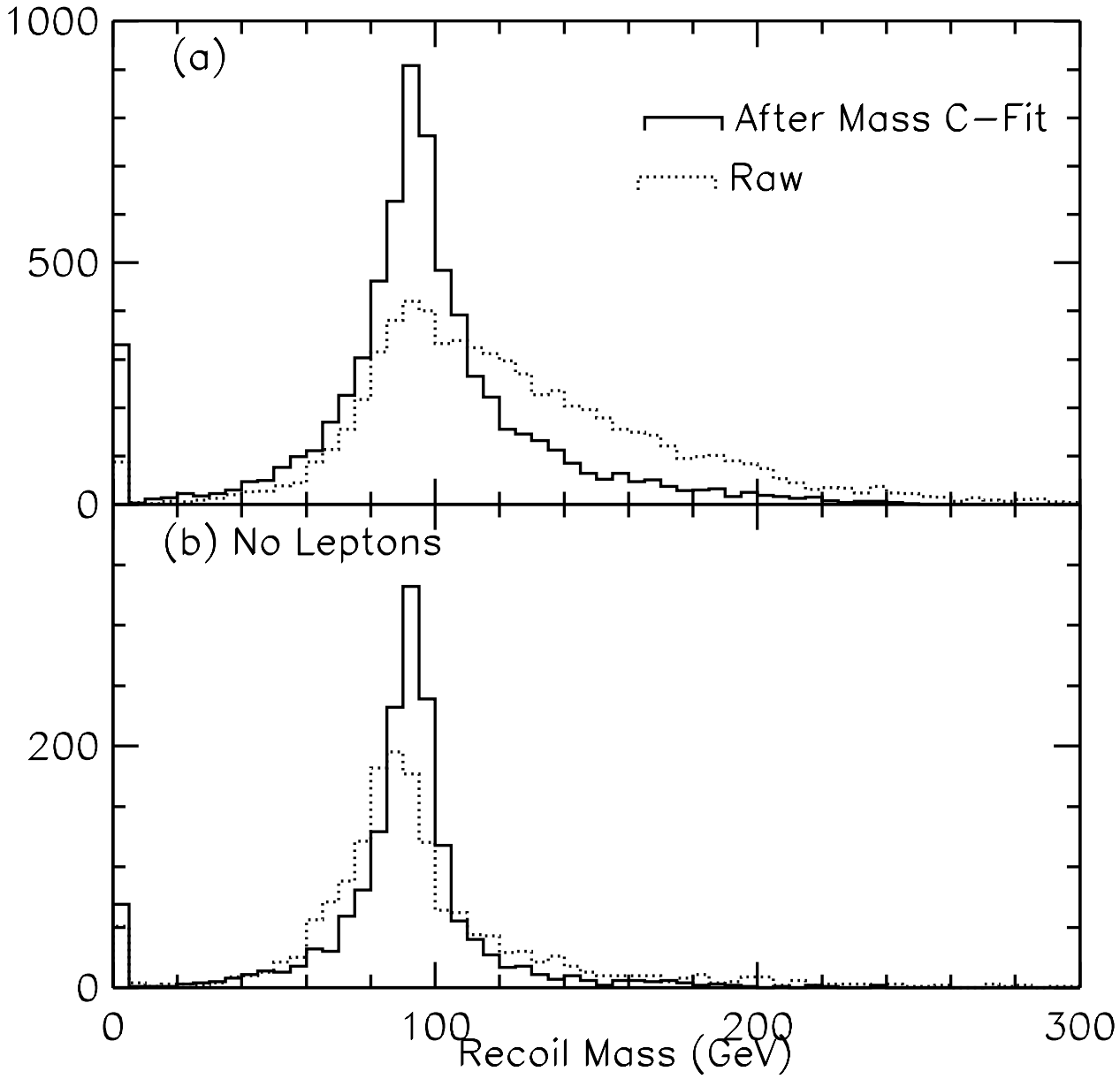
- hist– all bjets
- dash – Hadronic decay



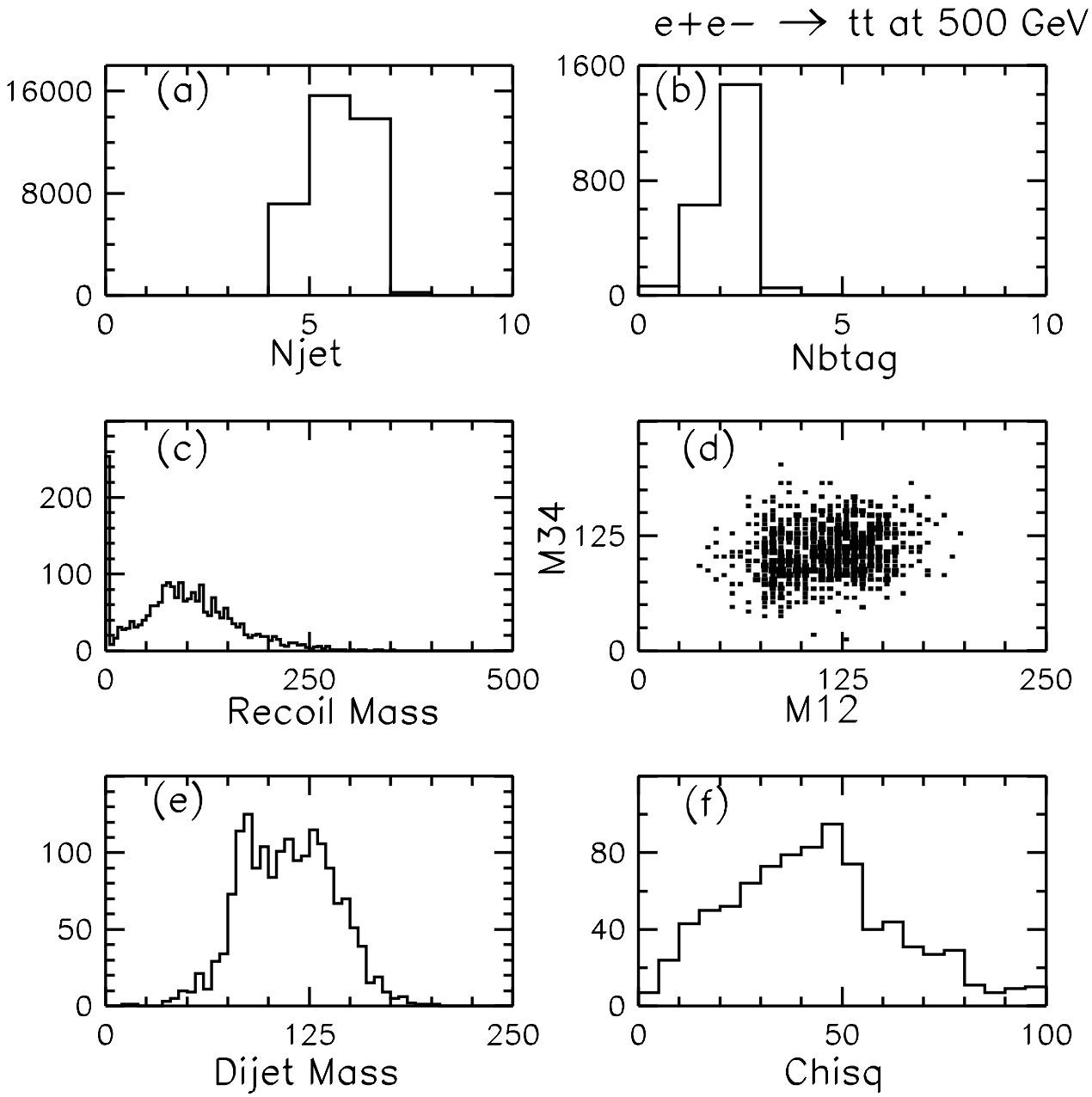
Dijet Masses



Recoil Mass

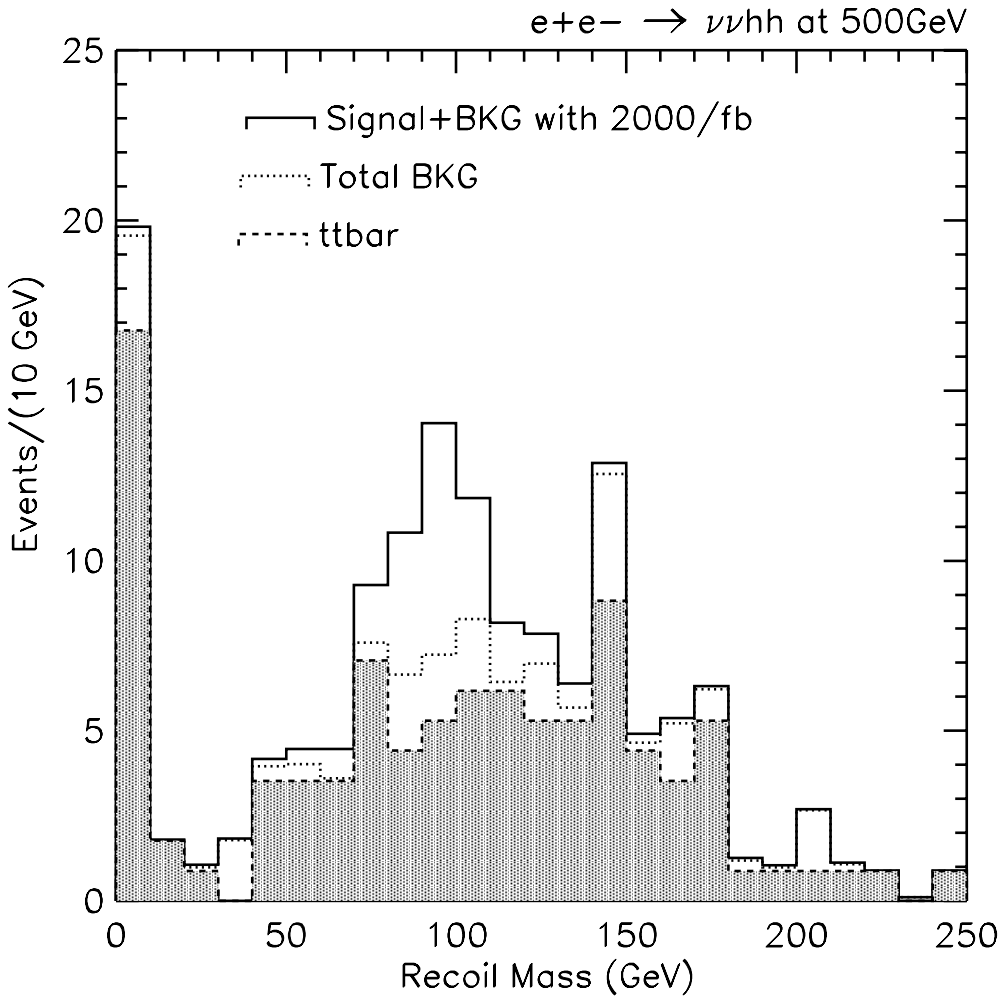

(a)
After Mass C−Fit
Raw
(b) No Leptons
1000
500
0
200
0
0
100
200
300
Recoil Mass (GeV)

$t\bar{t}$ Background

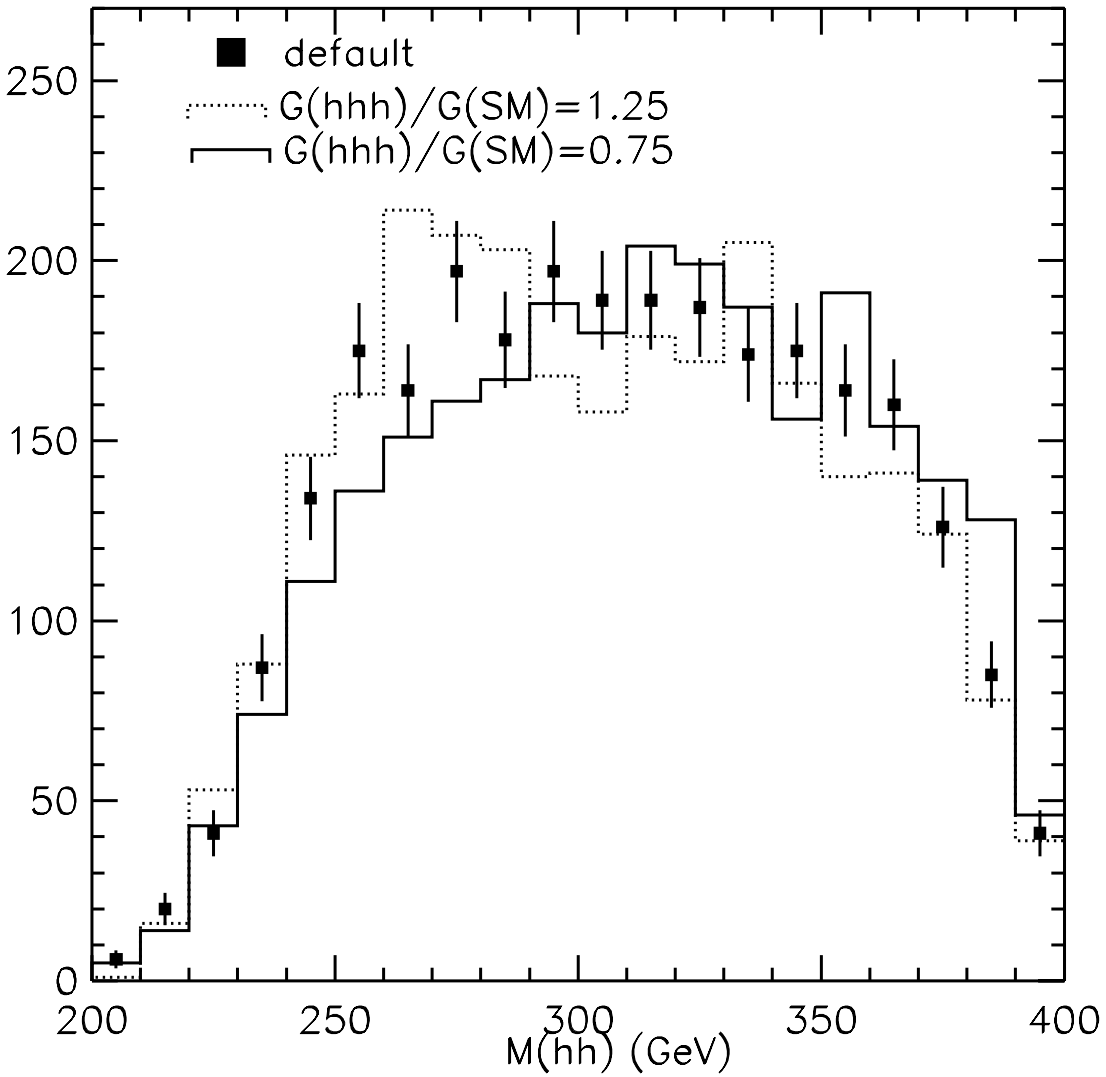


Signal and Backgrounds for 2000 fb^{-1} at 500 GeV

- **N = 18**
- **B = 33**
- $N/\sqrt{B} \approx 3$



M_{hh} Distributions vs Higgs Self-Coupling



To Do List

- **Update Detector Simulations**
- **Understanding the btag on b/c/light flavor jets**
- **Understanding the jet energy flow and the corrections specific for b's**
- **Understanding the ISR effect**
- **Finalize the selection cuts both for signal and backgrounds**
- **Cross checks and combining with the previous results (P. Gay and P. Lutz)**
- **Optimize the results as a function of jet energy resolution**
  - **Detector resolution**
  - **Physical effects**
- **Fitting the hh kinematic distributions to extract higgs coupling directly.**
- **Exploit to WW fusion at higher energies**