

Update of $\nu\nu HH$ @ 1TeV analysis based on full detector simulation

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reminder:

$\nu\nu\text{HH}$ @ 1 TeV based on SGV simulation

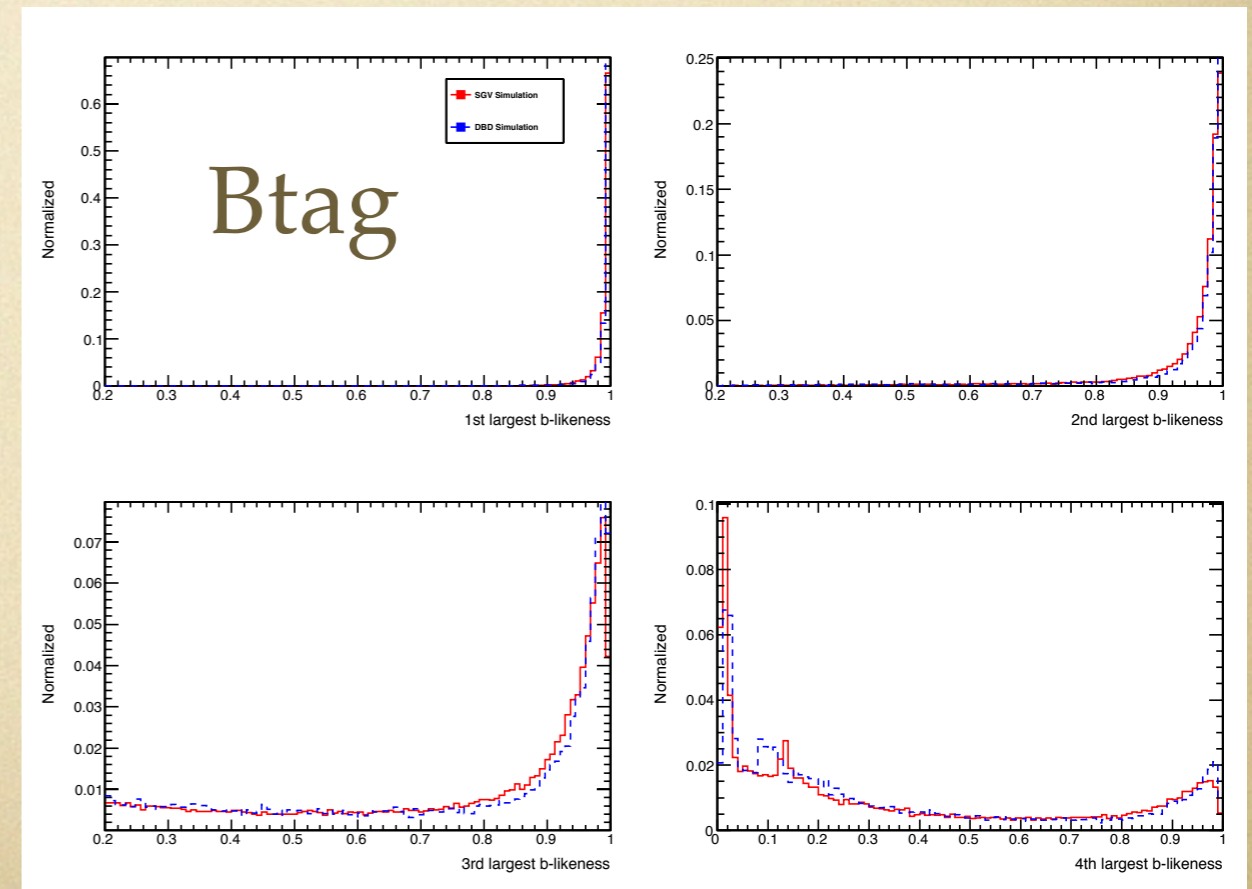
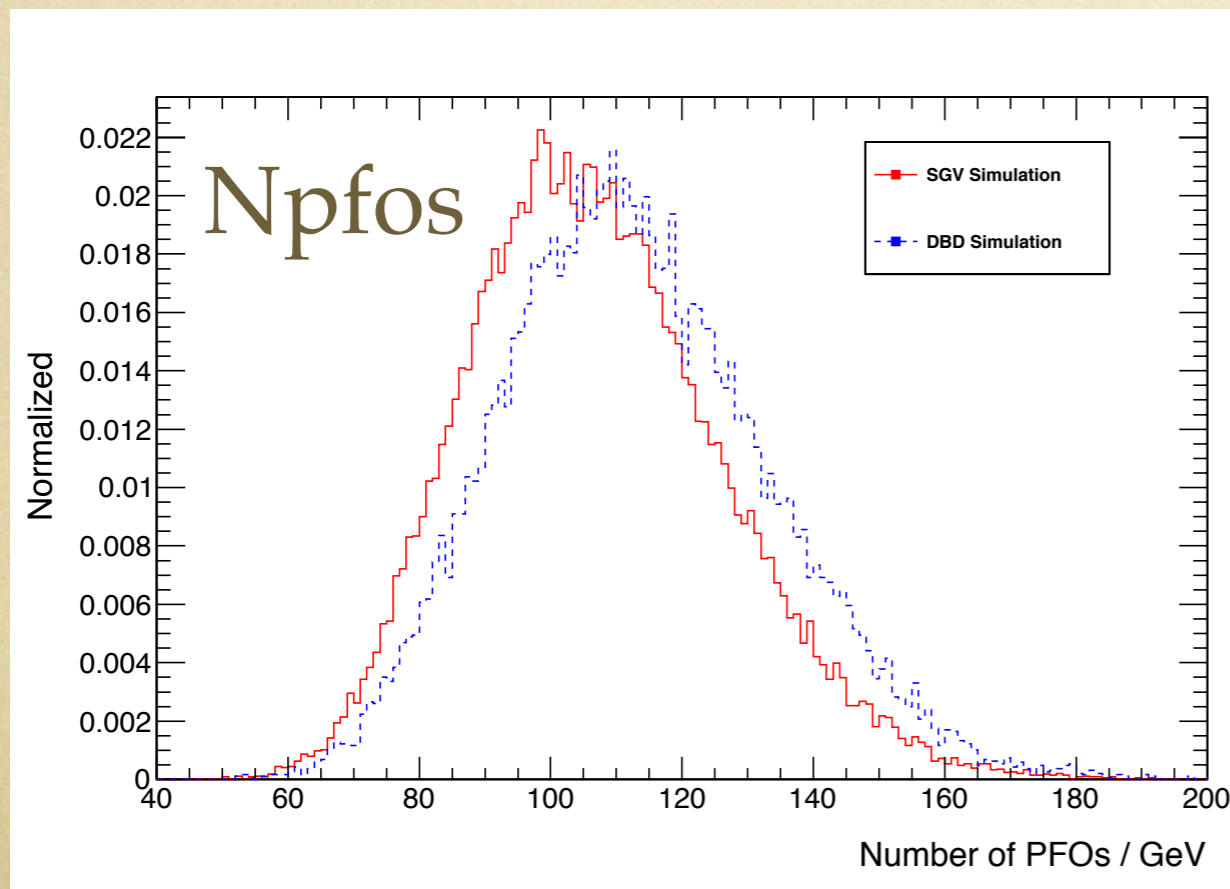
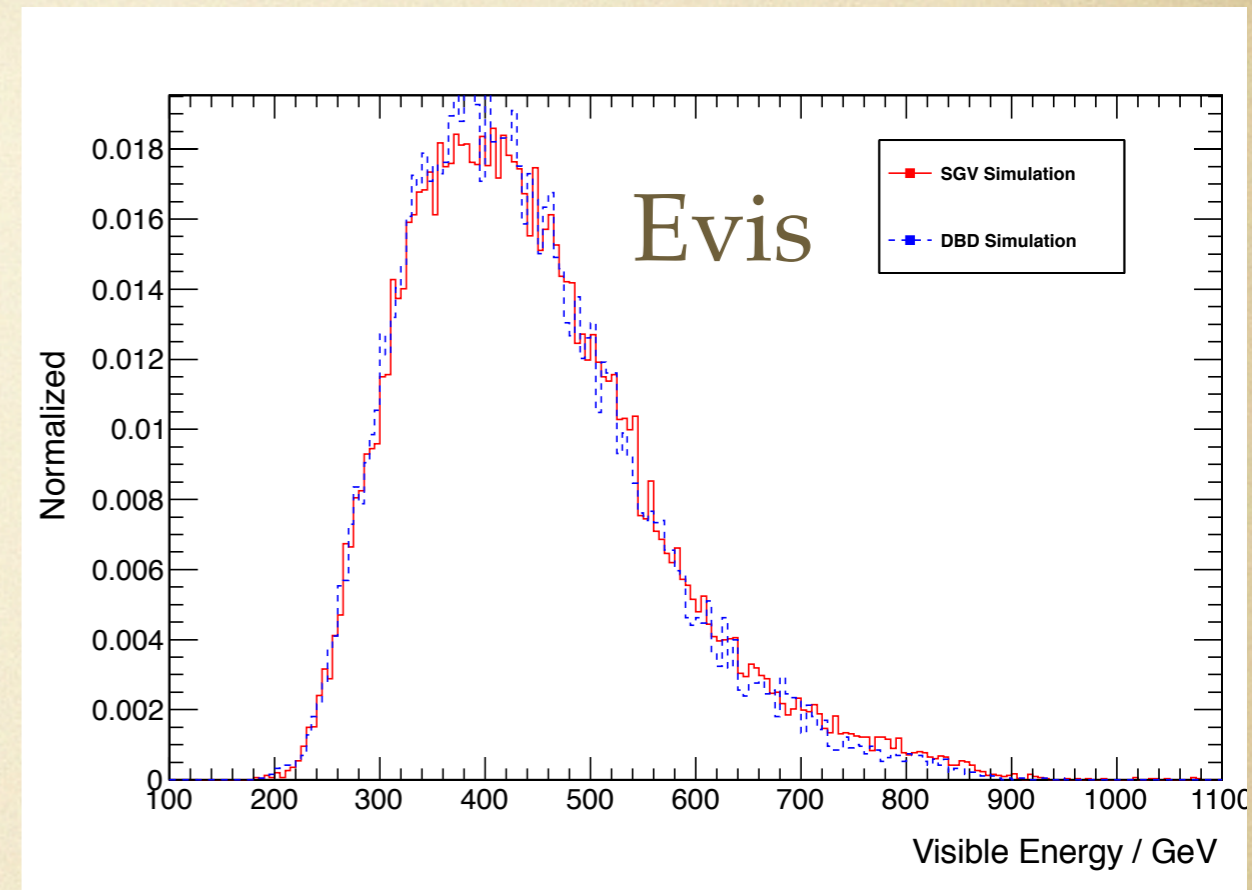
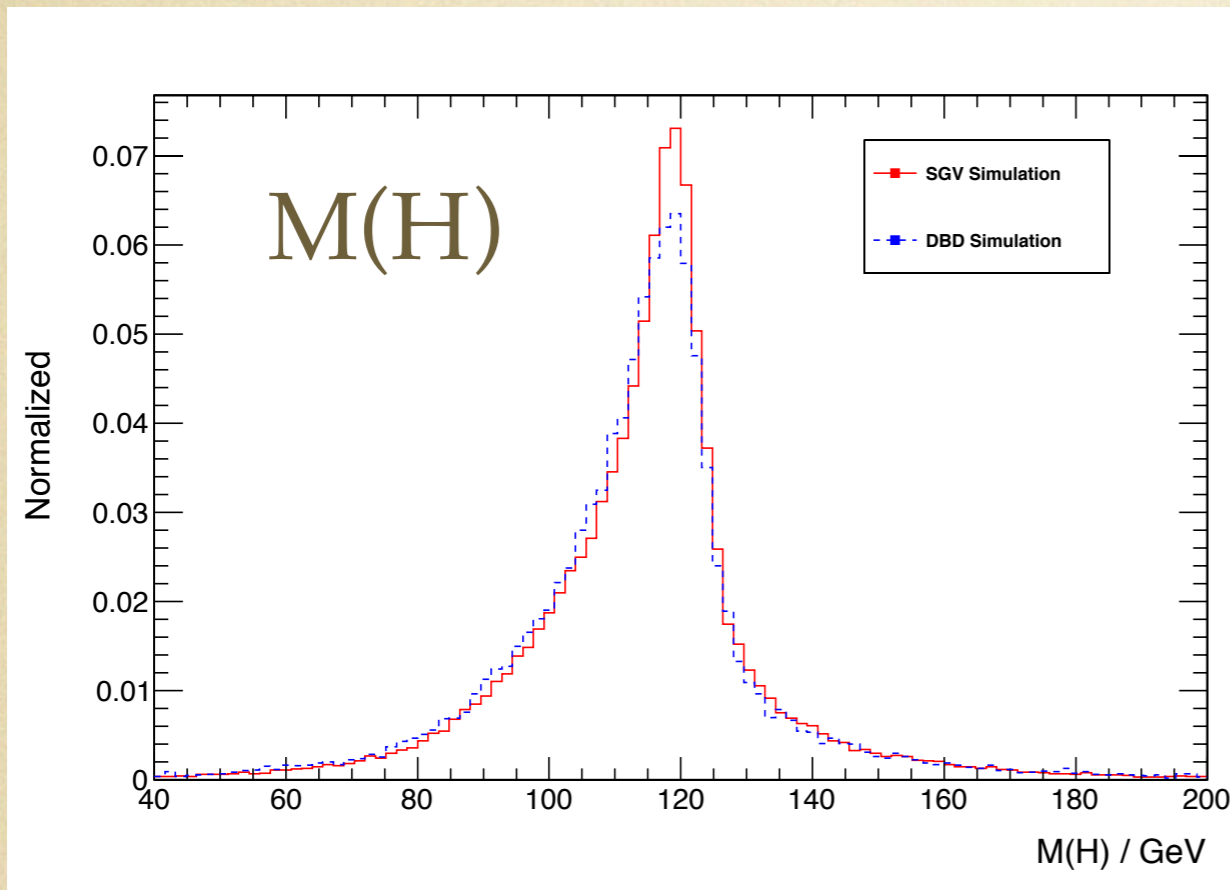
Polarization: $(e^-, e^+) = (-0.8, +0.2)$ $E_{\text{cm}} = 1 \text{ TeV}$, $M_H = 120 \text{ GeV}$ $\int L = 2 \text{ ab}^{-1}$

	Expected	Generated	pre-selction	cut1	cut2	cut3	cut4	cut5
$\nu\nu\text{hh}$ (WW F)	272	9.20×10^4	104	97.9	96.5	75.8	44.8	35.6
$\nu\nu\text{hh}$ (ZHH)	74.0	4.76×10^5	26.8	17.9	14.7	7.15	4.46	3.67
$\nu\nu\text{bbbb}$	650	4.43×10^5	481	466	459	162	4.18	3.28
$\nu\nu\text{ccbb}$	1070	5.10×10^5	200	193.6	189	64.4	1.56	0.22
bbxyyx	2.92×10^5	1.05×10^6	14102	563	530	20.6	12.4	0.91
evbbqq	1.16×10^5	6.22×10^5	620	462	353	34.6	6.42	0.83
$\mu\nu\text{bbqq}$	1.08×10^5	6.39×10^5	366	255	196	10.1	2.25	0.49
$\tau\nu\text{bbqq}$	1.08×10^5	6.37×10^5	3502	2184	1741	104	33.9	4.47
$\nu\nu\text{ZH}$	3125	5.00×10^4	449	441	439	296	21.4	13.1
ttH	6952	1.00×10^5	88.6	59.7	55.1	1.40	0.96	0.68
BG	6.37×10^5		19835	4643	3978	701	87.4	27.6
significance	0.34		0.74	1.42	1.51	2.72	3.90	4.48

$$\frac{\Delta\sigma}{\sigma} \approx 22\%$$

$$\frac{\Delta\lambda}{\lambda} \approx 19\% \quad (17\%)$$

comparison between **SGV** and **DBD** simulation



full simulation @ 1 TeV

$$e^+ + e^- \rightarrow \nu\bar{\nu} H H \rightarrow \nu\bar{\nu} (b\bar{b})(b\bar{b})$$

pre-selection:

- no isolated lepton (neural-net based)
- four jets, each with at least 7 particles, 3rd Btagging > 0.2
- $E_{\text{vis}} < 900 \text{ GeV}$, $\text{MissPt} > 5 \text{ GeV}$, $\text{MissMass} > 0$

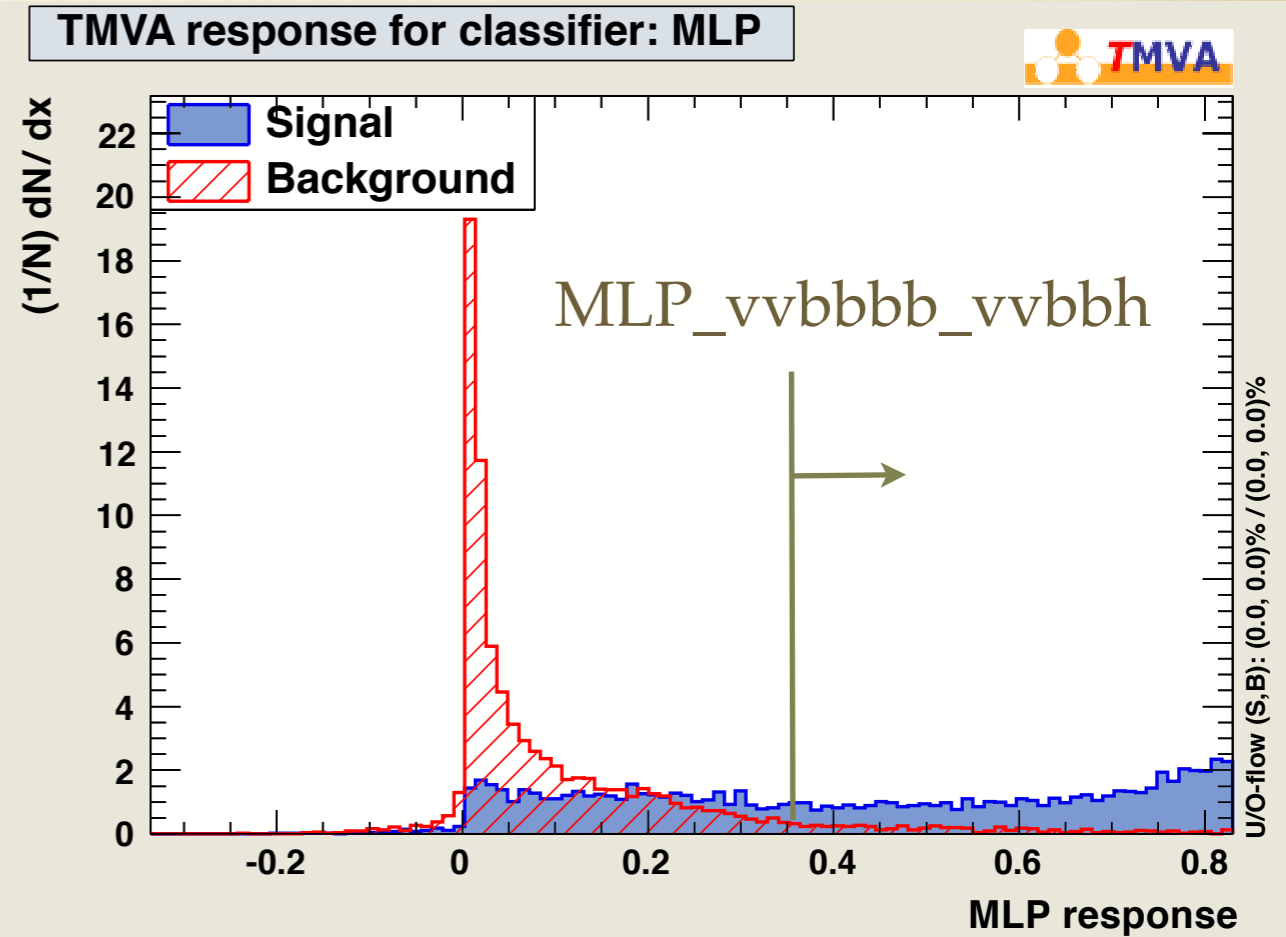
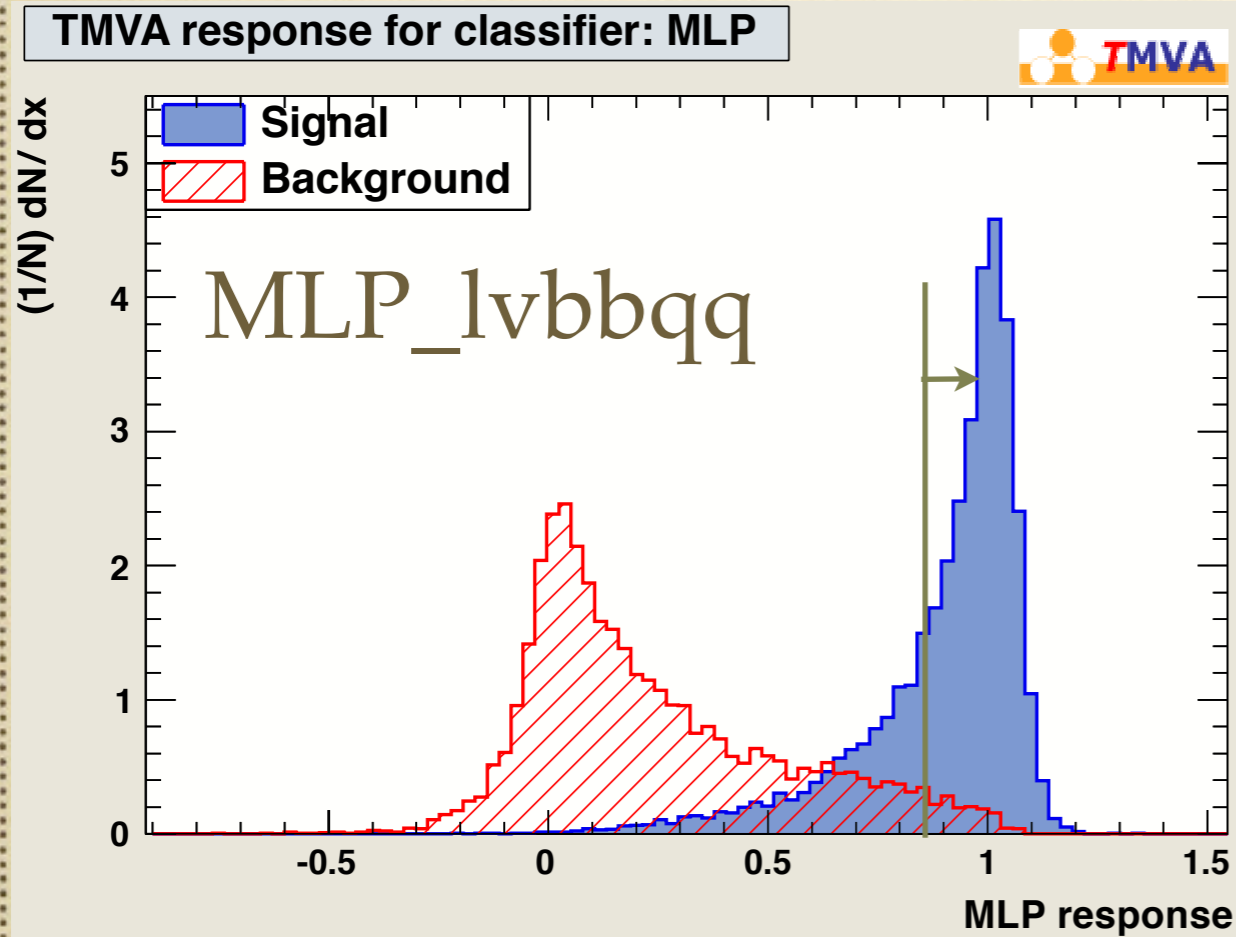
- ♦ generator: Whizard 1.95
- ♦ simulation: ilcsoft-v01-14-01
- ♦ reconstruction: ilcsoft-v01-16
- ♦ flavor tagging: LCFIPlus

final-selection:

- Visible energy: $E_{\text{vis}} < 700 + 5 * \text{MissPt}$ (cut1)
- tt-bar suppression: $\text{MLP}_{lvbbqq} > 0.84$ (cut2)
- vvZZ and vvZH suppression: $\text{MLP}_{vvbbbb} > 0.36$ (cut3)
- B-tagging: $B_{\text{max}3} + B_{\text{max}4} > 0.71$ (cut4)

Great thanks to Jan and Frank for generating most of the background samples

Neural-net output



DBD analysis (no gam-gam overlay):

signal and backgrounds (reduction table)

Polarization: $(e^-, e^+) = (-0.8, +0.2)$ $E_{cm} = 1 \text{ TeV}$, $M_H = 120 \text{ GeV}$

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

	Expected	Generated	pre-selection	cut1	cut2	cut3	cut4
vvhh (WW F)	272	1.05×10^5	127	107	77.2	47.6	35.7
vvhh (ZHH)	74.0	2.85×10^5	32.7	19.7	6.68	4.88	3.88
vvbbbb	650	2.87×10^5	553	505	146	6.21	4.62
vvccbb	1070	1.76×10^5	269	242	63.3	2.69	0.19
yyxyyx	3.74×10^5	1.64×10^6	18951	4422	38.5	26.7	1.83
yyxyev	1.50×10^5	6.21×10^5	812	424	44.4	11.0	0.73
yyxylv	2.57×10^5	1.17×10^6	13457	4975	202	84.5	4.86
vvZH	3125	7.56×10^4	522	467	257	30.6	17.6
BG	7.86×10^5		34597	11054	758	167	33.7
significance	0.30		0.68	1.01	2.67	3.25	4.29

$$\frac{\Delta\sigma}{\sigma} \approx 23\%$$

$$\frac{\Delta\lambda}{\lambda} \approx 20\% \text{ (18%)} \text{ (with weighting)}$$

Double Higgs excess significance: 7.2σ

backup

preliminary

DBD analysis at 500 GeV (combined)

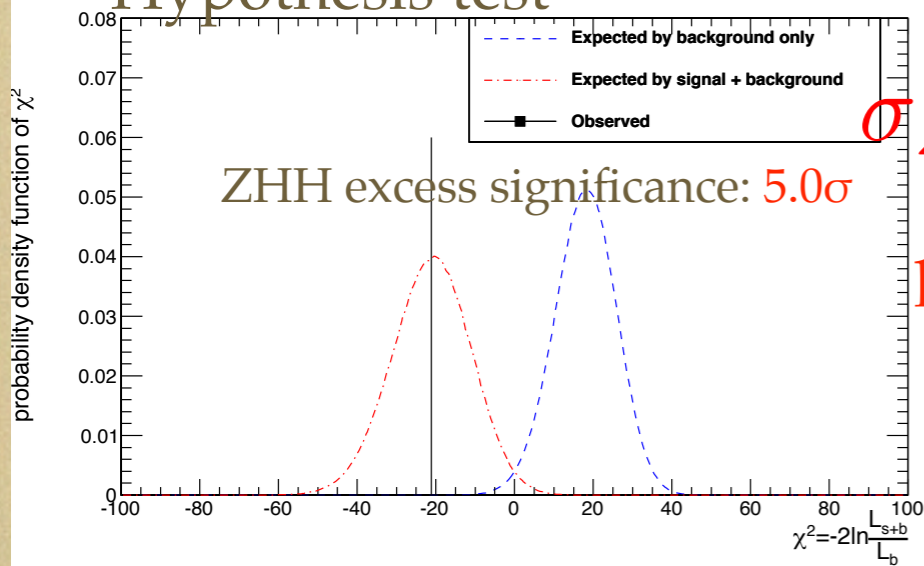
$P(e^-, e^+) = (-0.8, 0.3)$

$$e^+ + e^- \rightarrow ZHH$$

$M(H) = 120\text{GeV}$ $\int Ldt = 2\text{ab}^{-1}$

Energy (GeV)	Modes	signal	background	significance	
				excess (I)	measurement (II)
500	$ZHH \rightarrow (l\bar{l})(b\bar{b})(b\bar{b})$	3.7	4.3	1.5 σ	1.1 σ
		4.5	6.0	1.5 σ	1.2 σ
500	$ZHH \rightarrow (\nu\bar{\nu})(b\bar{b})(b\bar{b})$	8.5	7.9	2.5 σ	2.1 σ
500	$ZHH \rightarrow (q\bar{q})(b\bar{b})(b\bar{b})$	13.6	30.7	2.2 σ	2.0 σ
		18.8	90.6	1.9 σ	1.8 σ

Hypothesis test

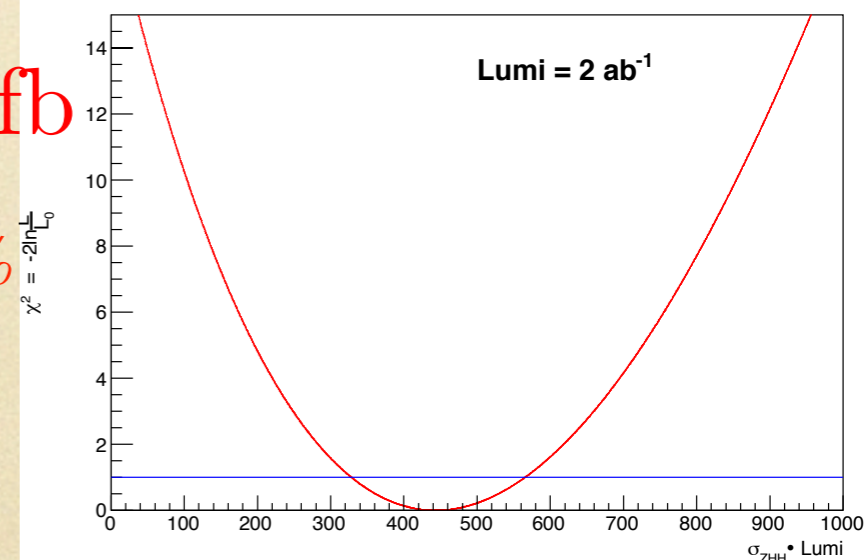


$$\sigma_{ZHH} = 0.22 \pm 0.06 \text{ fb}$$

precision of cross section: 27%

Higgs self-coupling: 48%

χ^2 as a function of cross section

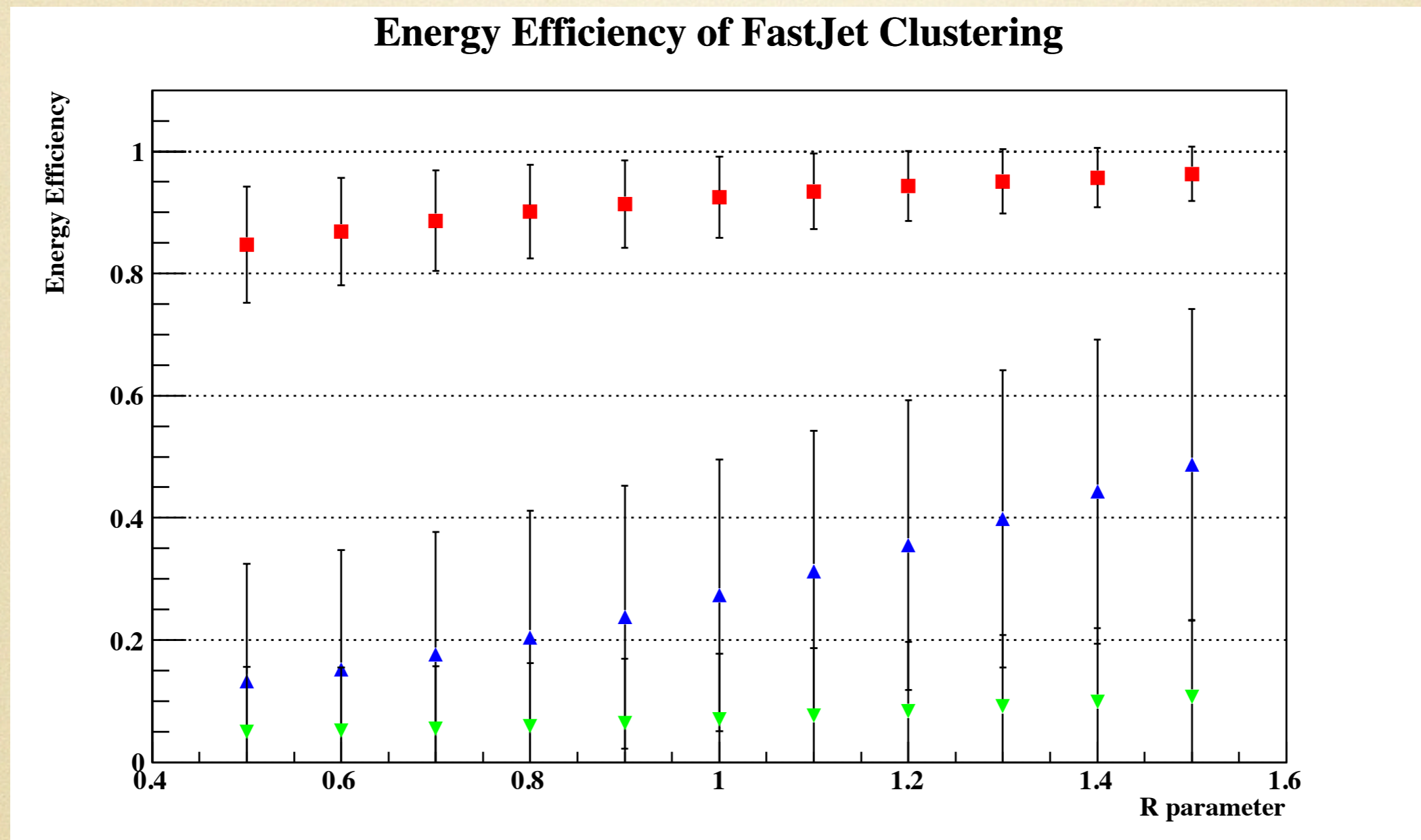


after using weighting, would be:

$$\frac{\delta\lambda}{\lambda} = 44\%$$

gam-gam overlay

red: for PFOs from signal
blue: for PFOs from overlay
green: Eoverlay / Esignal



gam-gam overlay

Higgs Mass

