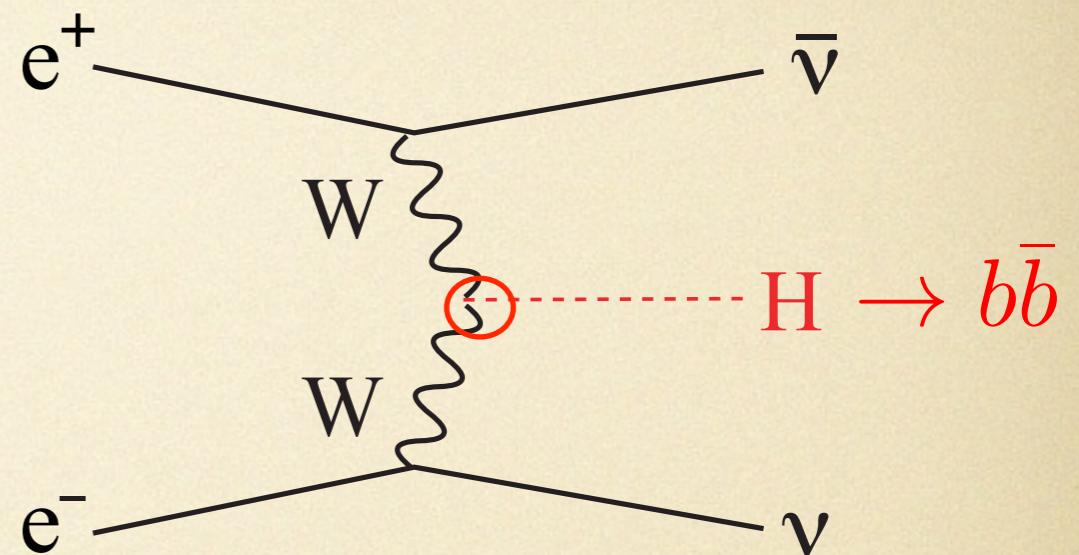


study of HWW coupling using
 $e^+e^- \rightarrow \nu\nu H$ (WW-fusion)

Junping Tian (U' of Tokyo)
ILD software & analysis meeting, June 7, 2017

HWW coupling @ ILC

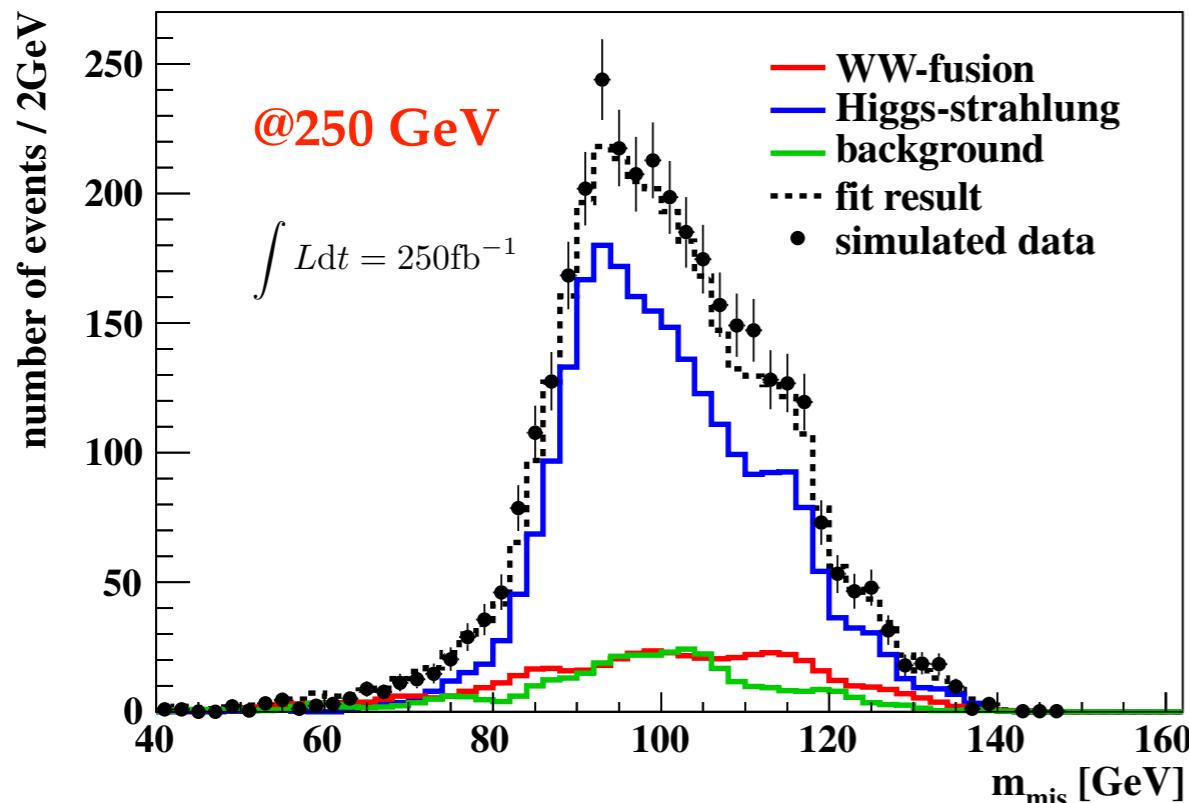
$$\Gamma_H = \frac{\Gamma_{HWW}}{\text{Br}(H \rightarrow WW^*)} \propto \frac{g_{HWW}^2}{\text{Br}(H \rightarrow WW^*)}$$



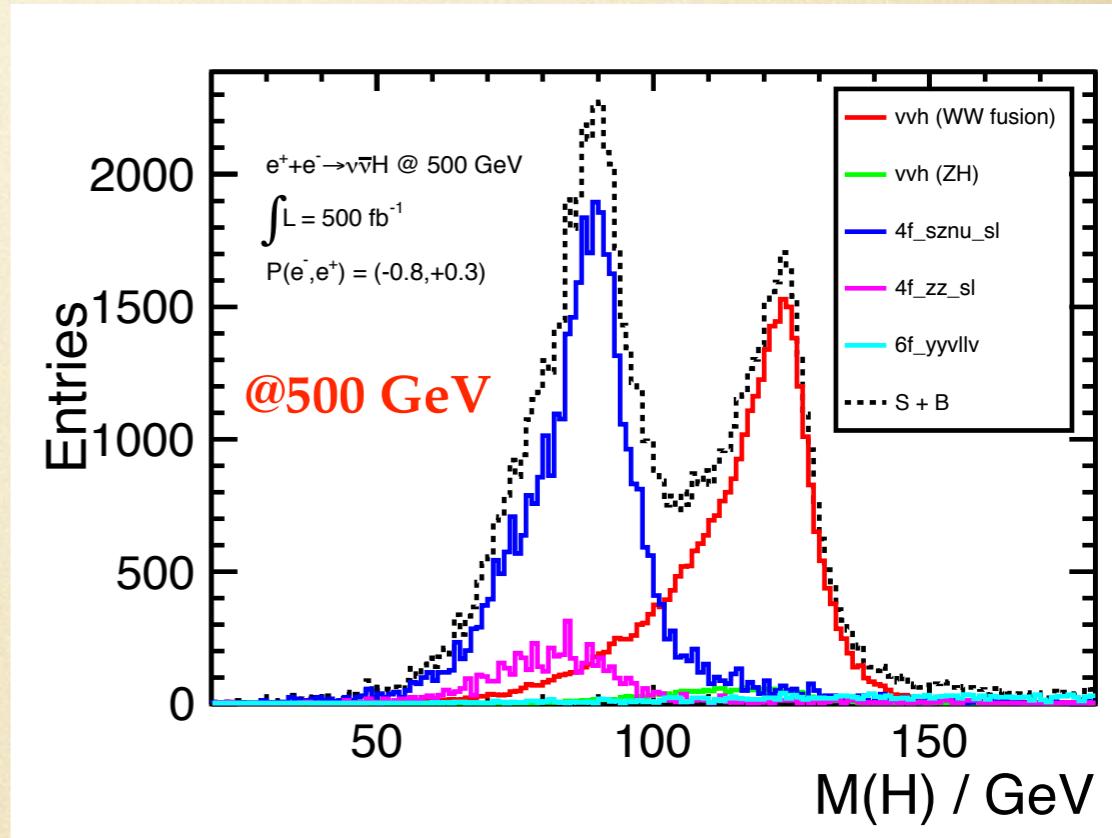
- it has been long advertised that WW-fusion Higgs production is crucial for Higgs total width and Higgs couplings measurement
- at 250 GeV, cross section is x10 smaller than 500 GeV
- recent EFT analysis proves that HWW coupling can be constrained by HZZ coupling based on $SU(2) \times U(1)$ gauge symmetry \rightarrow custodial symmetry
- nevertheless, direct measurement would be still useful \rightarrow purpose of updating this analysis

reminder of old studies

LoI simulation



DBD simulation



$$\frac{\Delta\sigma_{\nu\nu H}}{\sigma_{\nu\nu H}} = 10.5\%$$

$$\frac{\Delta\sigma_{\nu\nu H}}{\sigma_{\nu\nu H}} = 0.66\%$$

Duerig, Tian, et al, arXiv: 1403.7734

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

update today

- 250 GeV analysis using DBD framework
- t-channel and s-channel vvH samples privately generated
- all other SM 2f & 4f samples from DBD

event selection

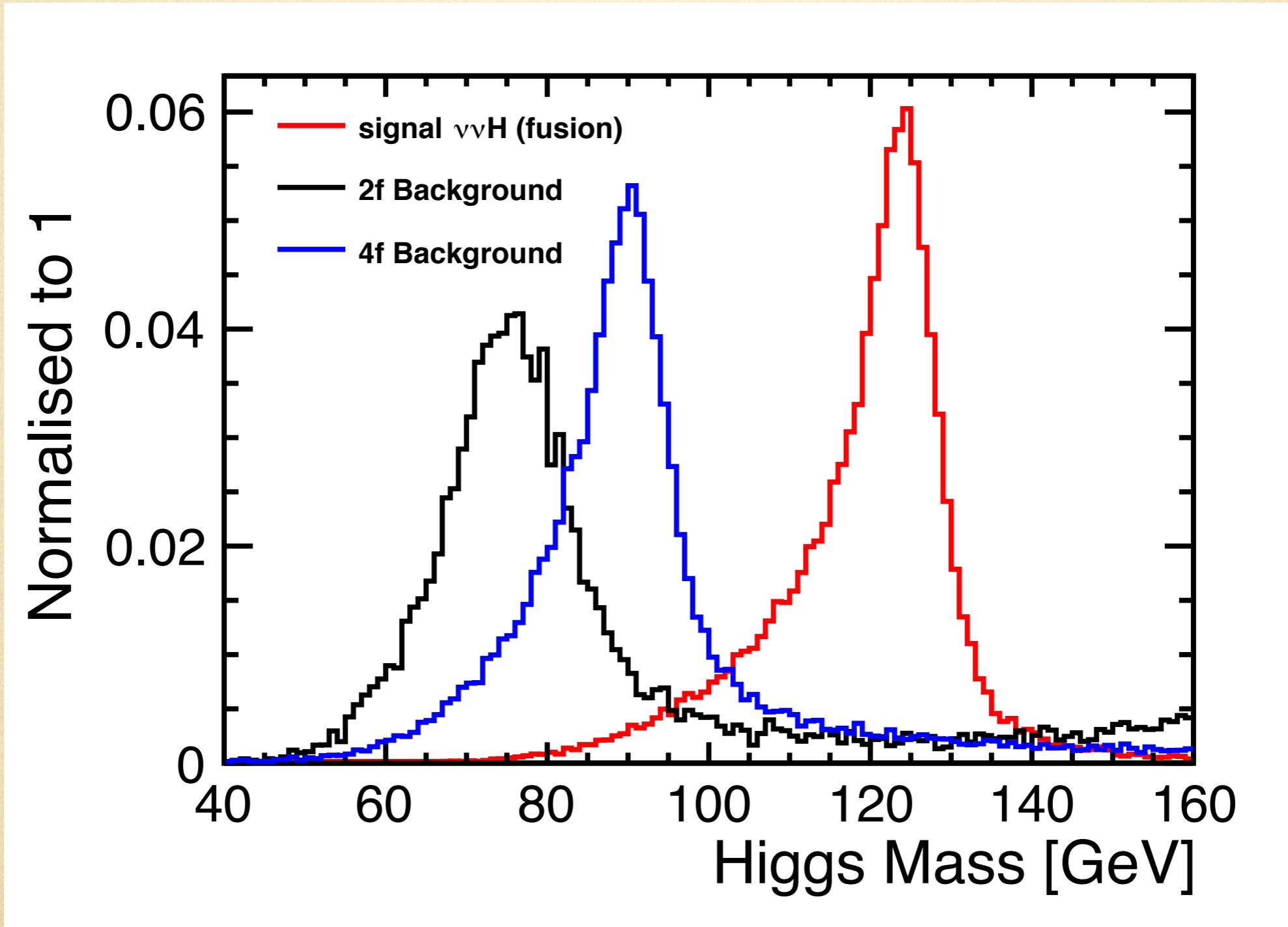
- no overlay removal algorithm applied
- isolated lepton finder
- 2-jet clustering and flavor tagging (LCFIPlus)

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

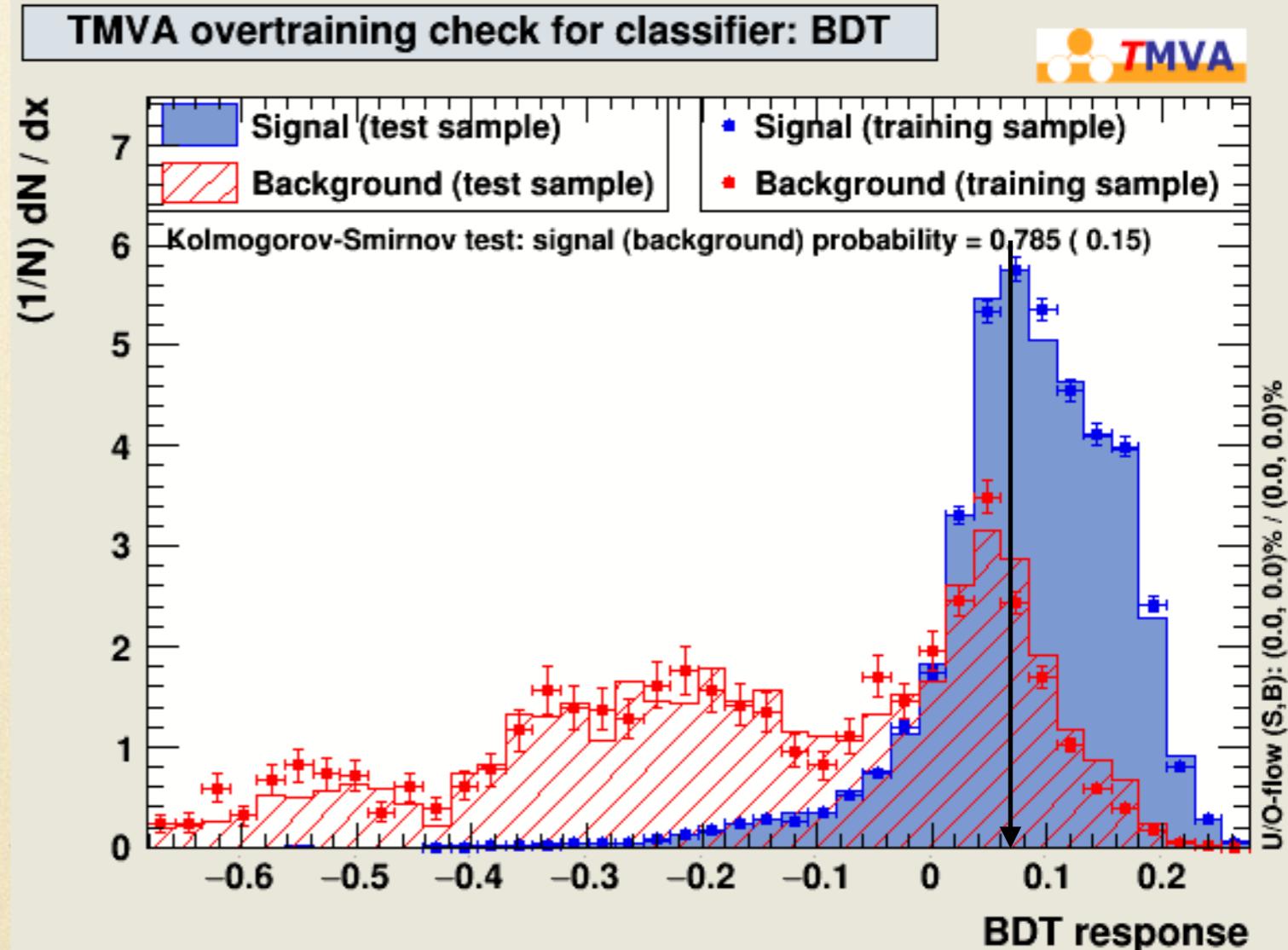
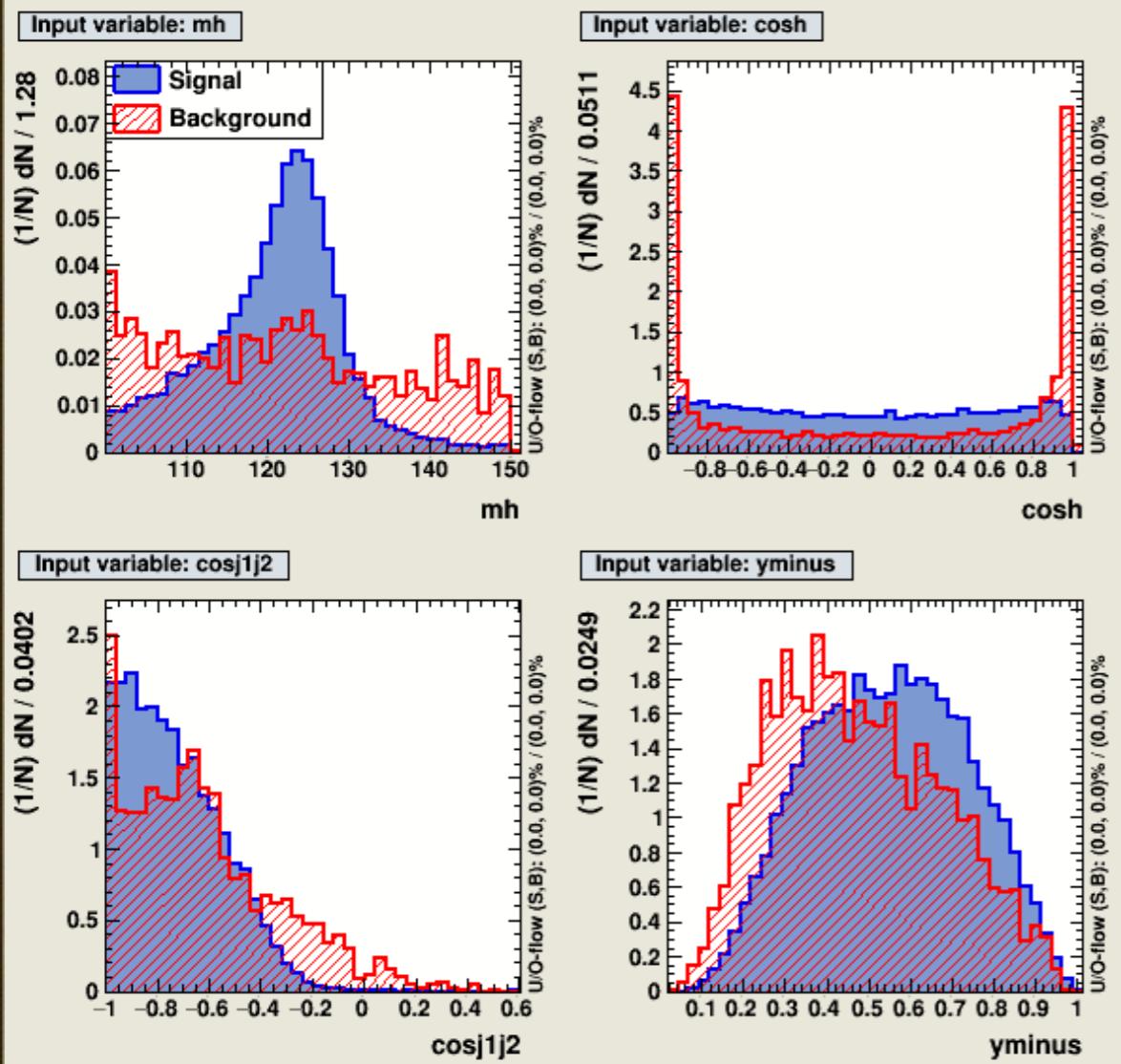
final-selection:

- #isolep = 0 (cut1)
- #pfos >= 6 in each jet; $Y_{3>2} < 0.1$ (cut2)
- missing pt > 10 GeV (cut3)
- btag1 > 0.8; btag2 > 0.2 (cut4)
- Higgs mass: [110, 150] GeV; missing mass > 20 GeV (cut5)
- MVA using $(m_H, \cos\theta_H, \cos\theta_{jj}, Y_{2>1}) > 0.065$ (cut6)

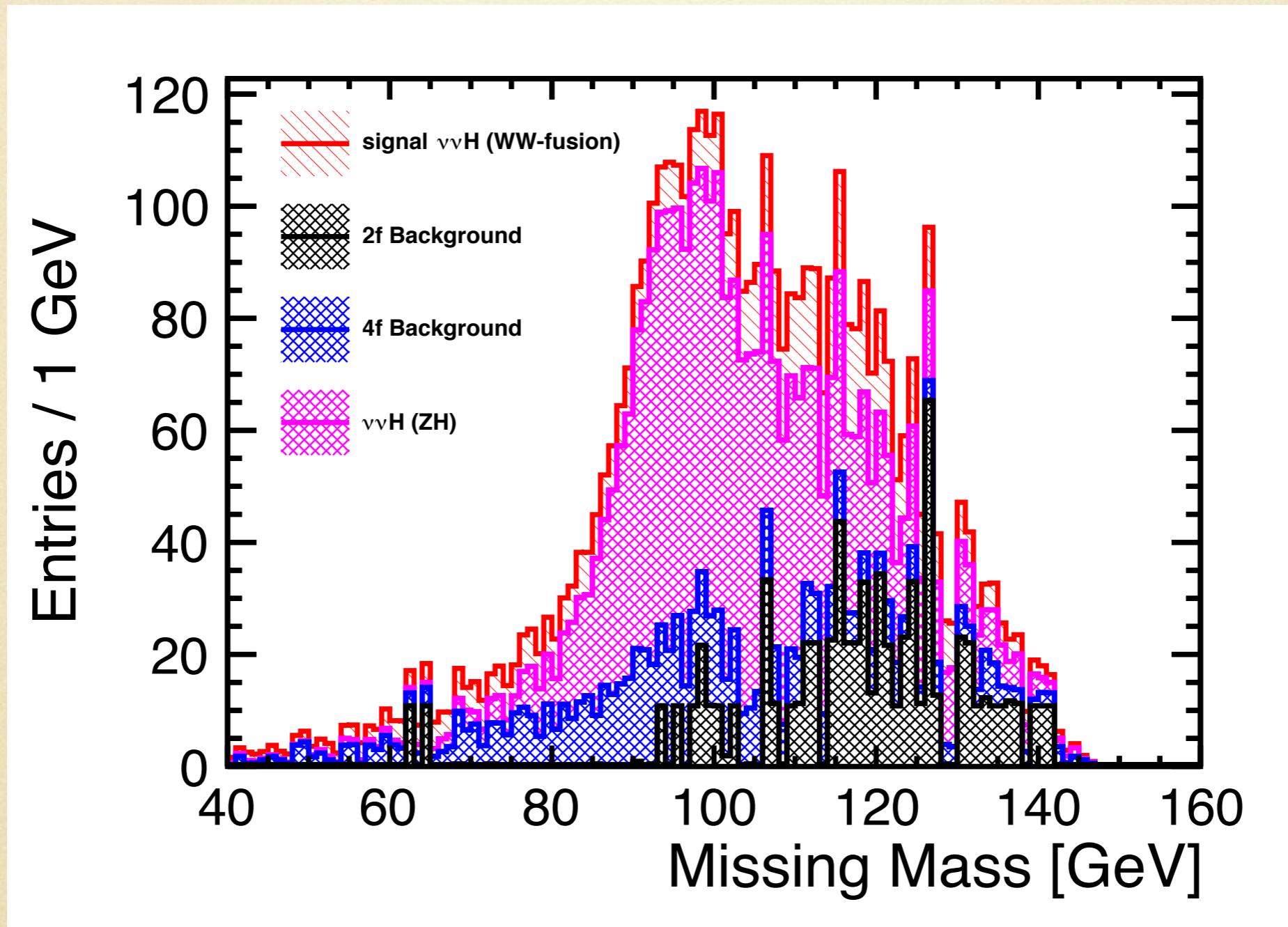
Higgs mass distribution (after cut4)



MVA: inputs and output (after cut5)

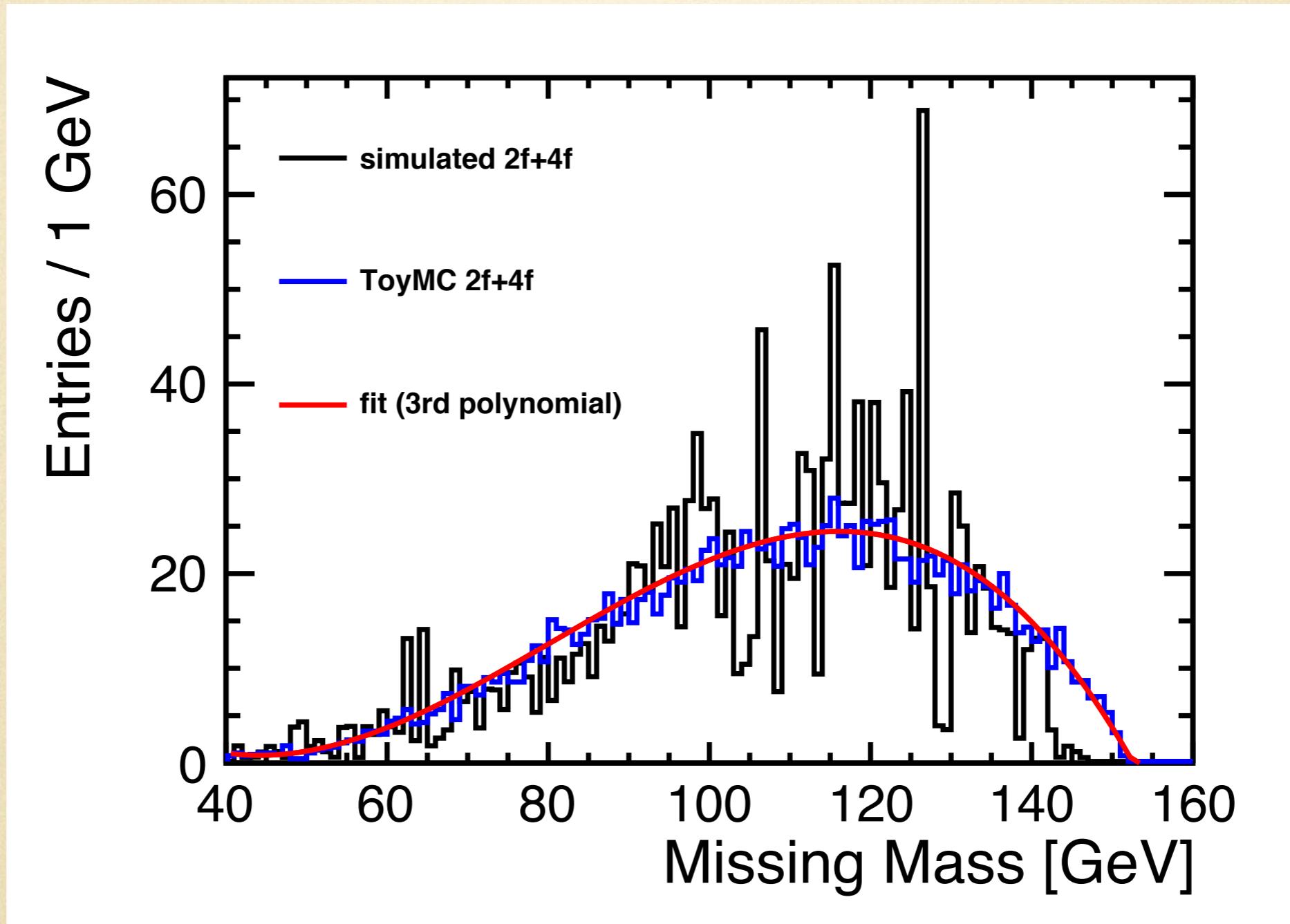


missing mass distribution (after all cuts)



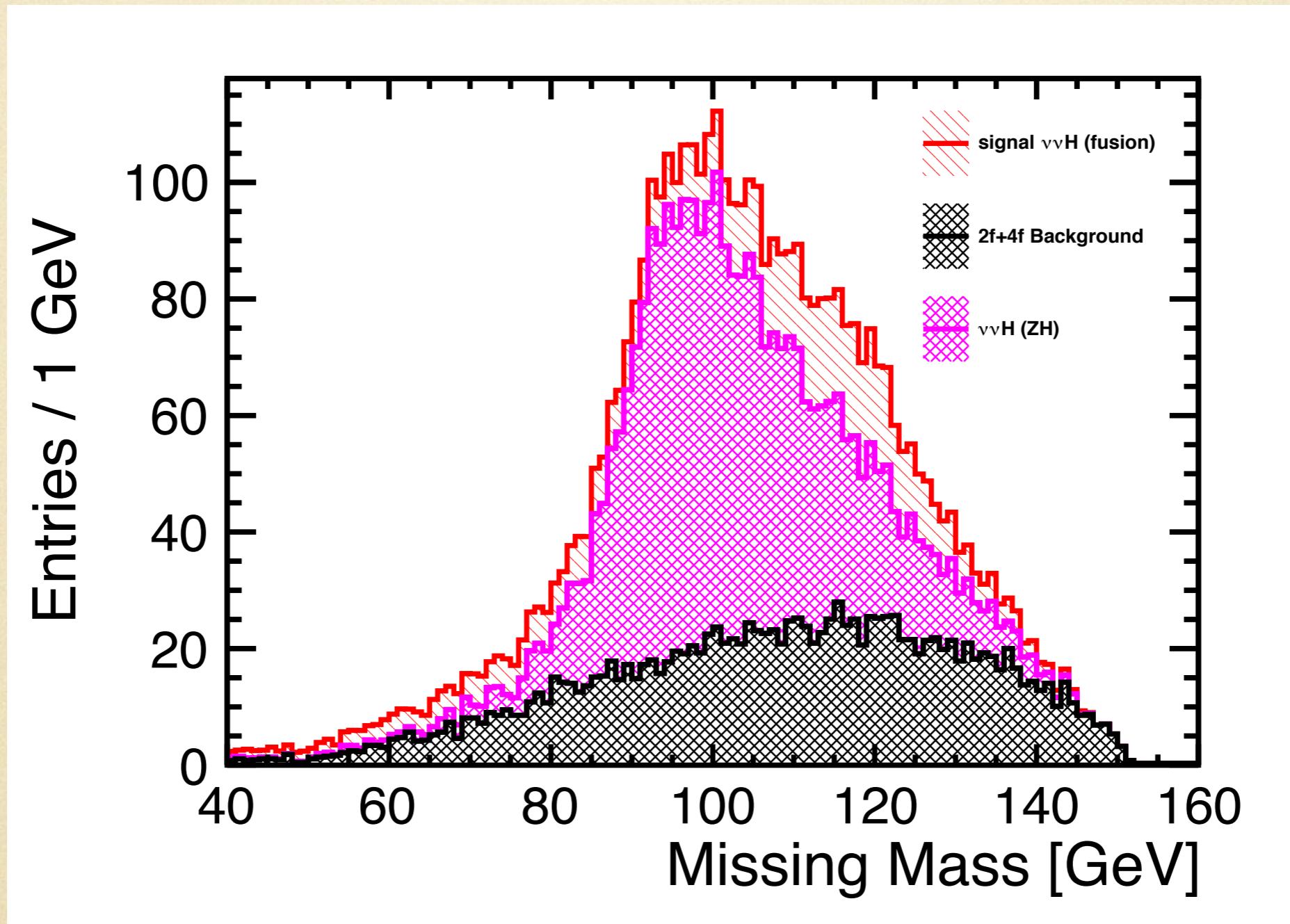
MC statistics again? 2f low mass...

temporary solution (not crucial, so no request now)



my solution: fit 2f+4f background with polynomial, then generated toy MC data

missing mass distribution (after all cuts)

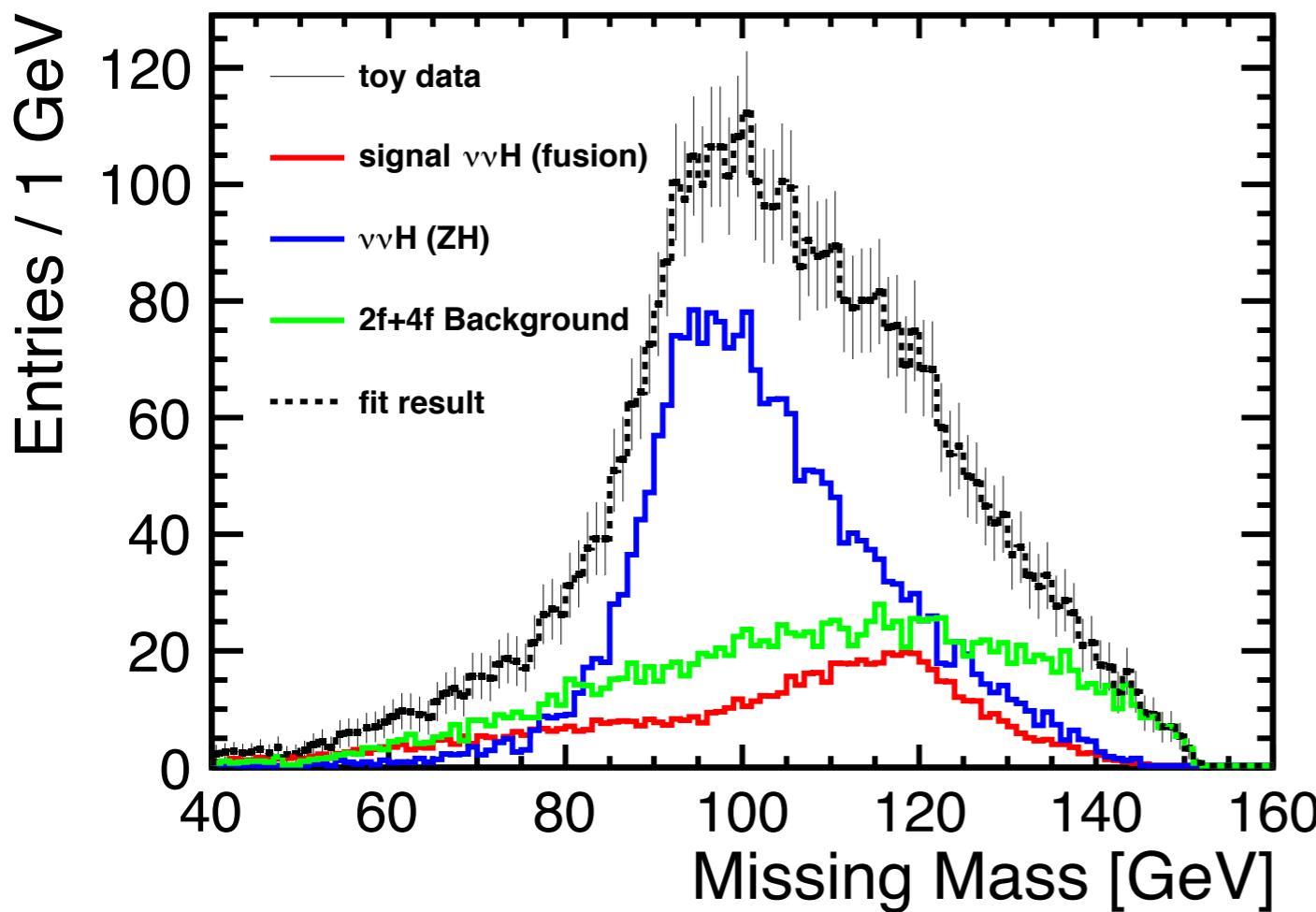


look more comfortable, and OK for evaluating
statistical error of $\sigma(v\nu H)$

new result: $\sigma(vvH)$ from template fit

$$\chi^2 = \sum_i^{N_{\text{bins}}} (N_i^{\text{pred}} - N_i^{\text{data}})^2 / \sigma^2(N_i^{\text{pred}})$$

$$N_i^{\text{pred}} = f_{\text{WW}} N'_{\text{WW},i} + f_{\text{ZH}} N'_{\text{ZH},i} + f_{\text{bgrd}} N'_{\text{bgrd},i}^{\text{tot}}$$

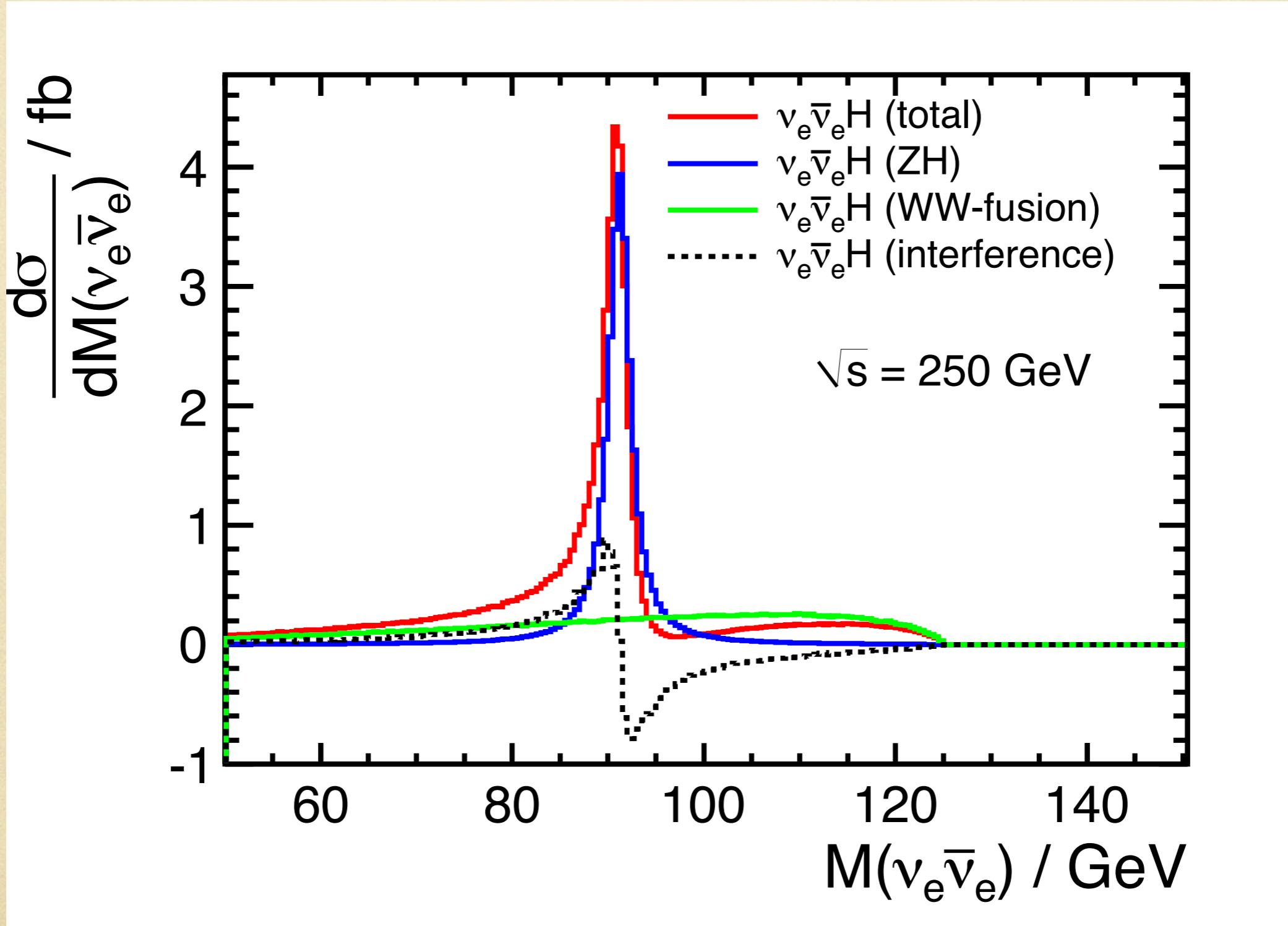


- background 2f/4f normalisation can be almost fixed $\rightarrow 0.1\%$
- vvH (ZH) normalisation can be constrained by qqH and llH measurements $\rightarrow 1.5\%$

$$\frac{\Delta \sigma_{\nu\nu H}}{\sigma_{\nu\nu H}} = \frac{\Delta N'_{WW}}{N'_{WW}} = 8.1\%$$

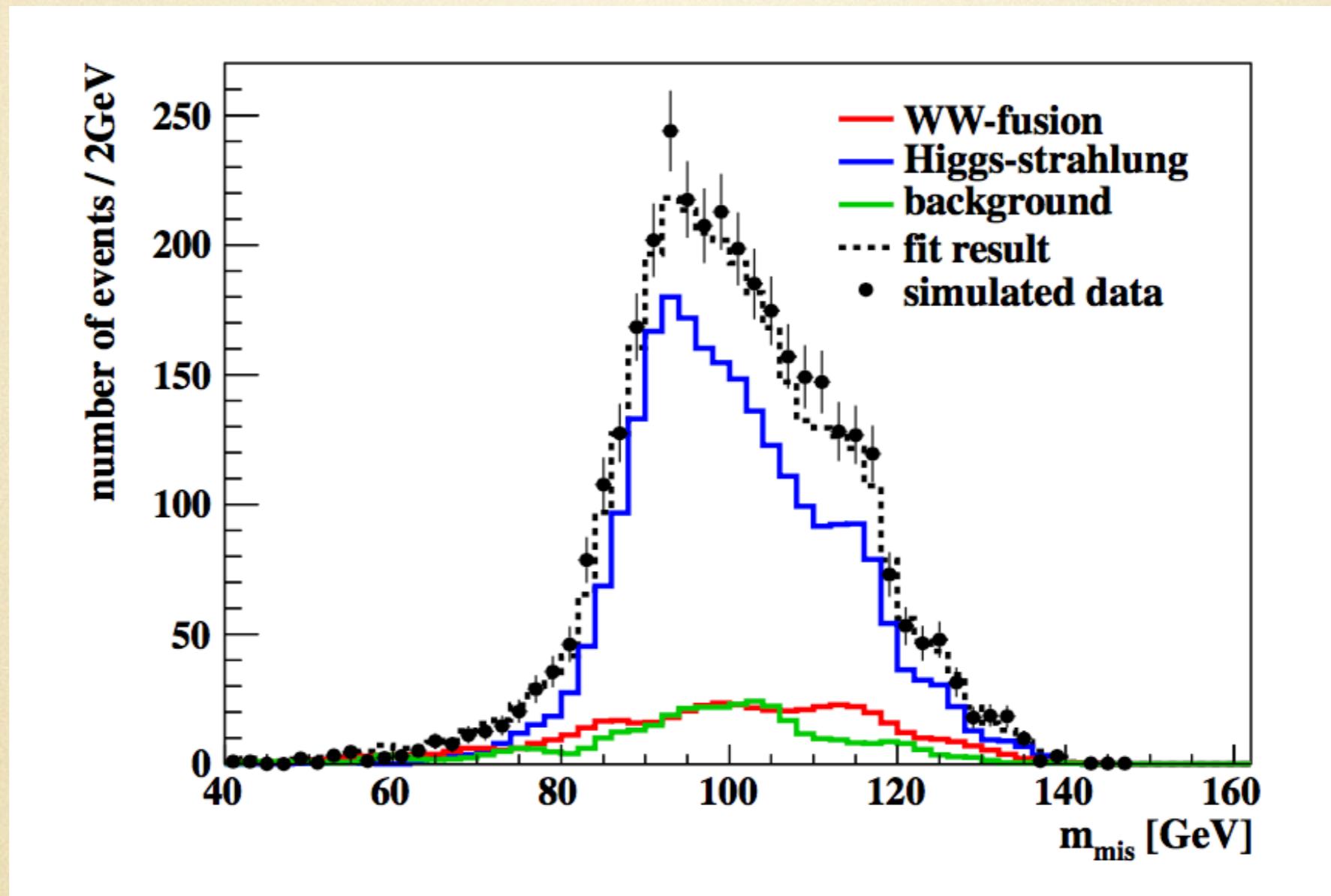
$\sim 20\%$ improvement w.r.t. previous result (10.5%), which is similar with the case that no constraint on vvH (ZH)

the real homework: interference



backup

previous results



reduction table

Polarization: (e-,e+)=(-0.8,+0.3)

$\sqrt{s} = 250\text{GeV}$

$\int L dt = 250\text{fb}^{-1}$

	#Expected	#Generated	cut1	cut2	cut3	cut4	cut5	cut6
vvh (fusion)	3.8×10^3	1.0×10^5	3.4×10^3	2.9×10^3	2.8×10^3	1.4×10^3	1.3×10^3	808
vvh (ZH)	1.4×10^4	2.0×10^5	1.2×10^4	1.1×10^4	5.9×10^3	5.4×10^3	2.3×10^3	2284
2f_1	9.5×10^6	5.8×10^6	1.7×10^6	7.5×10^5	3.6×10^5	499	118	10.6
2f_h	2.0×10^7	3.2×10^6	2.0×10^7	1.6×10^7	1.2×10^6	3.6×10^5	1.6×10^4	740
4f_1	1.4×10^6	3.1×10^6	1.6×10^5	7.3×10^3	5.6×10^3	56.8	10.2	0.3
4f_sl	4.6×10^6	2.7×10^6	1.6×10^6	1.1×10^6	1.0×10^6	2.4×10^4	3.3×10^3	750
4f_h	4.2×10^6	2.7×10^6	4.2×10^6	2.7×10^6	1.7×10^5	6.6×10^3	19.2	0
Total BG	3.9×10^7		2.7×10^7	2.0×10^7	2.4×10^6	4.0×10^5	2.5×10^4	3793
significance	0.35σ		0.43σ	0.46σ	1.3σ	2.2σ	8.0σ	11.8σ

reduction table (Lol analysis)

Polarization: (e-,e+)=(-0.8,+0.3)

$\sqrt{s} = 250\text{GeV}$

$\int L dt = 250\text{fb}^{-1}$

Process	expected	pre-selection	Cut1	Cut2	Cut3	Cut4	Cut5	Cut6	Cut7	Cut8
$\nu\bar{\nu}H(\text{fusion})$	3426	2663	2070	2023	1577	1053	965	547	519	507
$\nu\bar{\nu}H(ZH)$	1.4×10^4	10918	8356	8356	7448	4860	4594	2574	2546	2546
$\nu_l\bar{\nu}_l b\bar{b}$	3.05×10^4	23012	1040	1040	878	421	390	224	193	187
$\nu_l\bar{\nu}_l q\bar{q}$	1.19×10^5	88998	5548	5545	4714	2408	2271	15	9	9
$q\bar{q}l^+l^-$	2.99×10^5	153540	6196	5922	1760	588	508	65	38	36
$q\bar{q}l\nu$	1.73×10^6	1.15×10^6	181973	177193	134047	22654	20533	111	73	65
$q\bar{q}q\bar{q}$	3.91×10^6	1.15×10^6	782	728	3	1	0	0	0	0
$q\bar{q}$	26.02×10^6	17.27×10^6	852321	794892	1507	1199	683	289	152	152
BG	32.104×10^6	19.846×10^6	1.047×10^6	985320	142909	27271	24385	1404	465	449