# update of e+e- -> vvh analysis

# —towards proper inclusion of $\sigma_{WWF}$xBR(h—>bb) into a global fit

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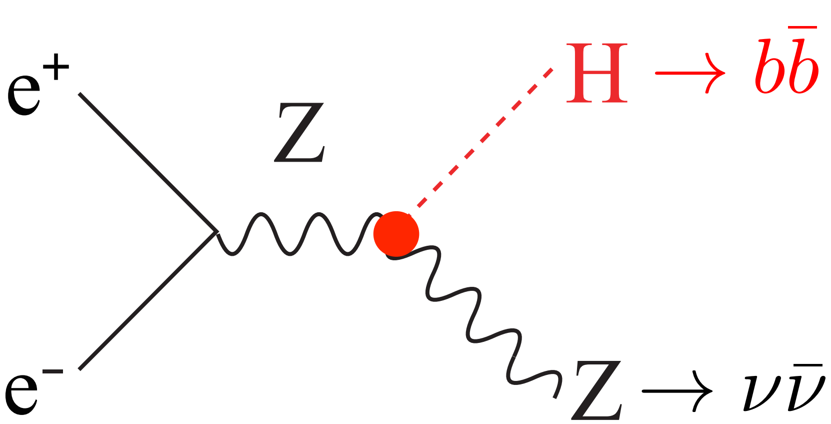
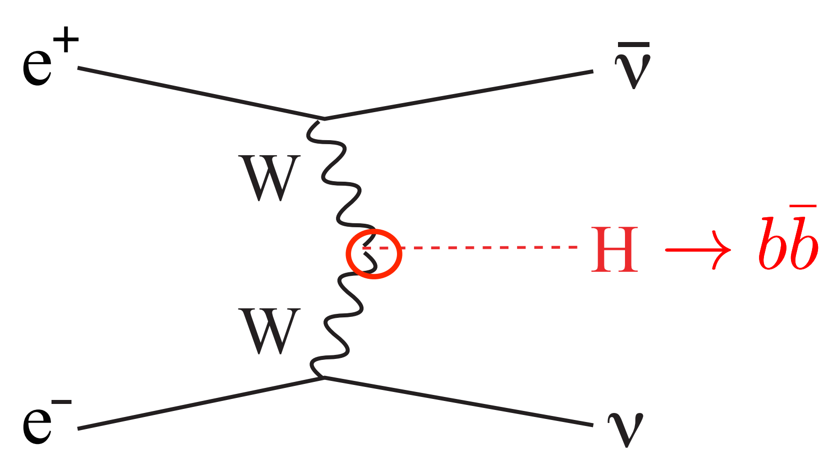
many thanks to discussion with T.Barklow, K.Fujii, J.List

arXiv:1506.07830

| $\int \mathscr{L} dt$ at $\sqrt{s}$ | 250 fb$^{-1}$ at 250 GeV | | 330 fb$^{-1}$ at 350 GeV | | 500 fb$^{-1}$ at 500 GeV | | |
|---|---|---|---|---|---|---|---|
| $P(e^-, e^+)$ | (-80%,+30%) | | | | | | |
| production | $Zh$ | $\nu\bar{\nu}h$ | $Zh$ | $\nu\bar{\nu}h$ | $Zh$ | $\nu\bar{\nu}h$ | $t\bar{t}h$ |
| $\Delta\sigma/\sigma$ | [39] 2.0% | - | [10,40] 1.6% | - | 3.0 | - | - |
| BR(invis.) [41] | $< 0.9\%$ | - | $< 1.2\%$ | - | $< 2.4\%$ | - | - |
| decay | $\Delta(\sigma \cdot BR)/(\sigma \cdot BR)$ | | | | | | |
| $h \to b\bar{b}$ | 1.2% | 10.5% | 1.3% | 1.3% | 1.8% | 0.7% | 28% |
| $h \to c\bar{c}$ | 8.3% | - | 9.9% | 13% | 13% | 6.2% | - |
| $h \to gg$ | 7.0% | - | 7.3% | 8.6% | 11% | 4.1% | - |
| $h \to WW^*$ | 6.4% | - | 6.8% | 5.0% | 9.2% | 2.4% | - |
| $h \to \tau^+\tau^-$ | [42] 3.2% | - | [43] 3.5% | 19% | 5.4% | 9.0% | - |
| $h \to ZZ^*$ | 19% | - | 22% | 17% | 25% | 8.2% | - |
| $h \to \gamma\gamma$ | 34% | - | 34% | [44] 39% | 34% | [44] 19% | - |
| $h \to \mu^+\mu^-$ [45] | 72% | - | 76% | 140% | 88% | 72% | - |

**correlation was not taken into account (neither interference) in past global fit**



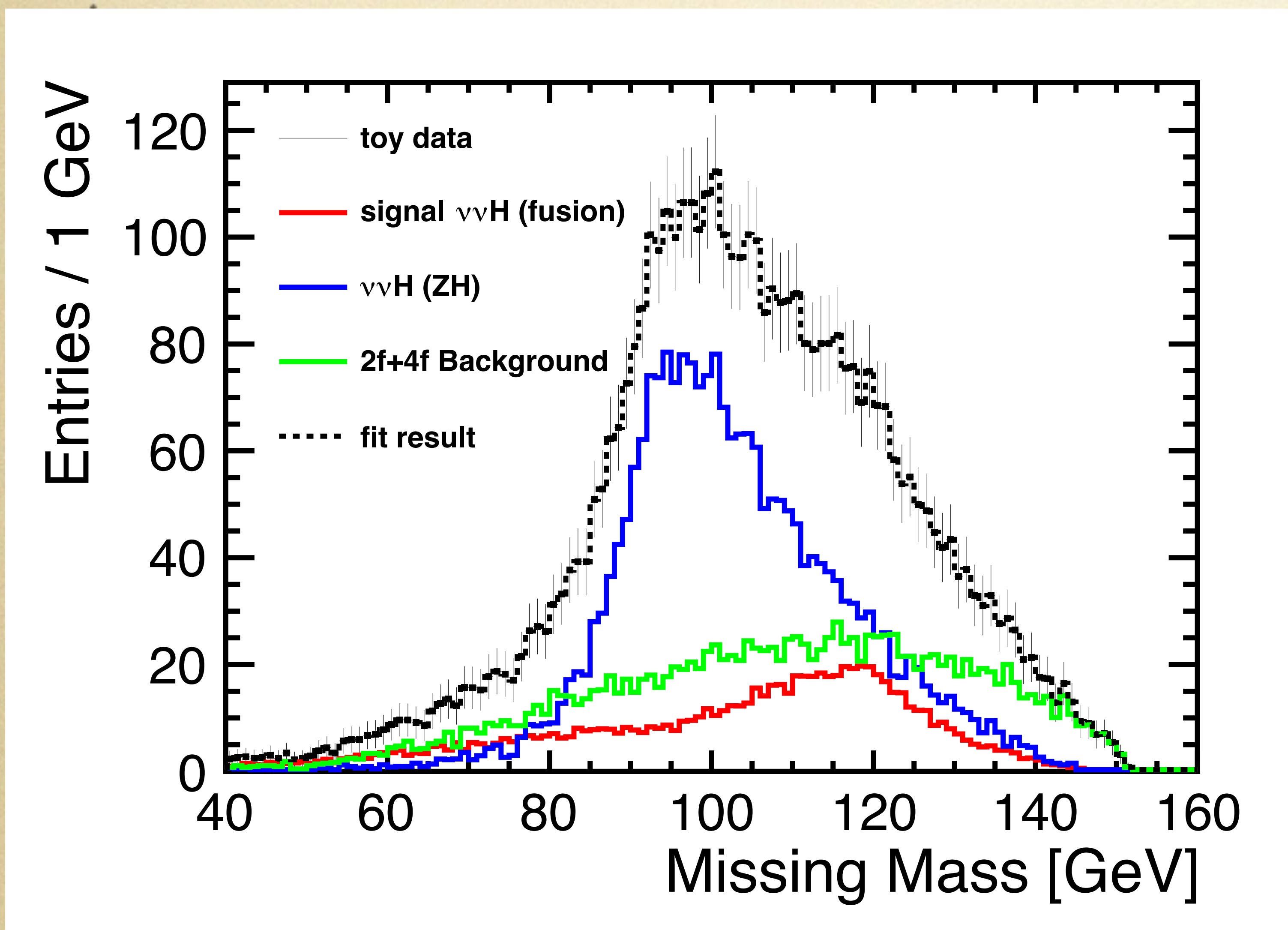



**(reported on June 7)**

## new result: σ(vvH) from template fit

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

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




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

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

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

# real relevant observables

$$O_1 = \sigma_{Zh} \times \mathrm{BR}(h \to bb) \times \mathrm{BR}(Z \to ll)$$

$$O_2 = \sigma_{Zh} \times \mathrm{BR}(h \to bb) \times \mathrm{BR}(Z \to qq)$$

$$O_3 = \sigma_{Zh} \times \mathrm{BR}(h \to bb) \times \mathrm{BR}(Z \to \nu\nu)$$

$$O_4 = \sigma_{WWF} \times \mathrm{BR}(h \to bb)$$

# approach A

**$\Delta O_3$, $\Delta O_4$, together with correlation $\rho_{34}$ are obtained simultaneously from one analysis for final state ννbb**

**put them together with independent observables $O_1$, $O_2$ into a global fit**

# comments on approach A

**technically already feasible in current program**

**but we have to expand the input tables with more observables, and in principle treat properly parametrization of Z decay**

# approach A'

**assume branching ratios of Z decay are perfectly known (meaning, uncertainties are much smaller than Higgs related observables, e.g. O1, O2, O3, O4 here, which is probably true)**

**then observables O1, O2, O3 are just independent measurements of one same observable, let's call it O0 = σZh x BR(h->bb)**

# observables in approach A'

$$O_{1'} = \sigma_{Zh} \times \mathrm{BR}(h \to bb)$$

$$O_{2'} = \sigma_{Zh} \times \mathrm{BR}(h \to bb)$$

$$O_{3'} = \sigma_{Zh} \times \mathrm{BR}(h \to bb)$$

$$O_4 = \sigma_{WWF} \times \mathrm{BR}(h \to bb)$$

# comments on approach A’

**again, technically already feasible in current program; we add measurement simultaneously O3’ (O0) and O4 together with their correlation, and repeat adding measurements O1’, O2’ as same observable O0,**

**again, we have to expand the input tables for σZh x BR(h->bb)**

# approach B

**try to combine O1’, O2’, O3’ and O4 into two observables O0, O4, + correlation ρ04**

**(identical to approach A’, see next slides)**

# approach B (what I adopted now)

$$\chi^2 = \chi^2(O_3', O_4) + (\frac{O_1' - O_0^{pre}}{\Delta O_1'})^2 + (\frac{O_2' - O_0^{pre}}{\Delta O_2'})^2$$

$$= \chi^2(O_0, O_4) + (\frac{O_0 - O_0^{pre}}{\Delta O_1'})^2 + (\frac{O_0 - O_0^{pre}}{\Delta O_2'})^2$$

**χ2(O3’, O4) is obtained in analysis for final state vvbb (by missing mass distribution); ΔO1’, ΔO2’ are obtained in other two analyses.**

**minimizing χ2 gives ΔO0, ΔO4, $\rho_{04}$ (side remark, $\rho_{04} \ll \rho_{34}$)**

**O0, O4 are exactly the ones in current input table, what we need add is $\rho_{04}$ (a minimum change of formalism/code)**

**at ECM >= 350, $\rho_{04}$ can be neglected (missing masses are sufficiently separated for two channels)**

# full simulation results

**(input results from other analyses)**

Ono, et al, Eur. Phys. J. C (2013) **73**: 2343

**for mh = 120 GeV**

$$\Delta O'_1/O'_1 = 2.5\% \quad \Delta O'_2/O'_2 = 1.5\%$$

**extrapolated to mh = 125 GeV**

$$\Delta O'_1/O'_1 = 2.7\% \quad \Delta O'_2/O'_2 = 1.9\%$$

Polarization: (e-,e+)=(-0.8,+0.3) $\sqrt{s} = 250\mathrm{GeV}$ $\int L\mathrm{d}t = 250\mathrm{fb}^{-1}$

# full simulation results

Polarization: (e-,e+)=(-0.8,+0.3) $\sqrt{s} = 250\mathrm{GeV}$ $\int L\mathrm{d}t = 250\mathrm{fb}^{-1}$

**approach A'**

$$\Delta O_3'/O_3' = 4.10\% \quad \Delta O_4/O_4 = 11.3\% \quad \rho_{34} = -74\%$$

**approach B**

$$\Delta O_0/O_0 = 1.34\% \quad \Delta O_4/O_4 = 8.10\% \quad \rho_{04} = -34\%$$