Update on measurement accuracies of higgs branching fractions in vvh at 350 GeV

Work in progress

Felix Müller
ILD analysis/software
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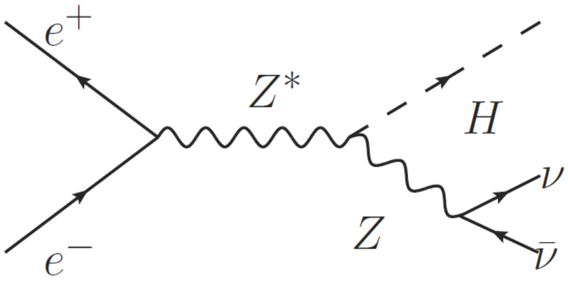
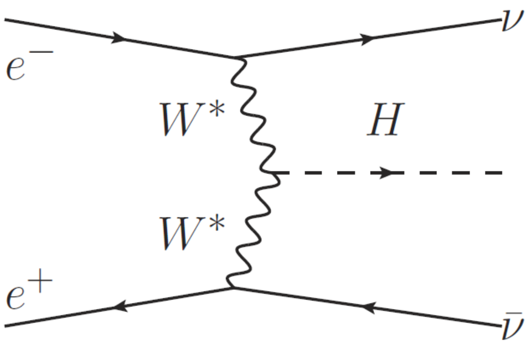
HELMHOLTZ GEMEINSCHAFT

DESY

Reconstruction Strategy

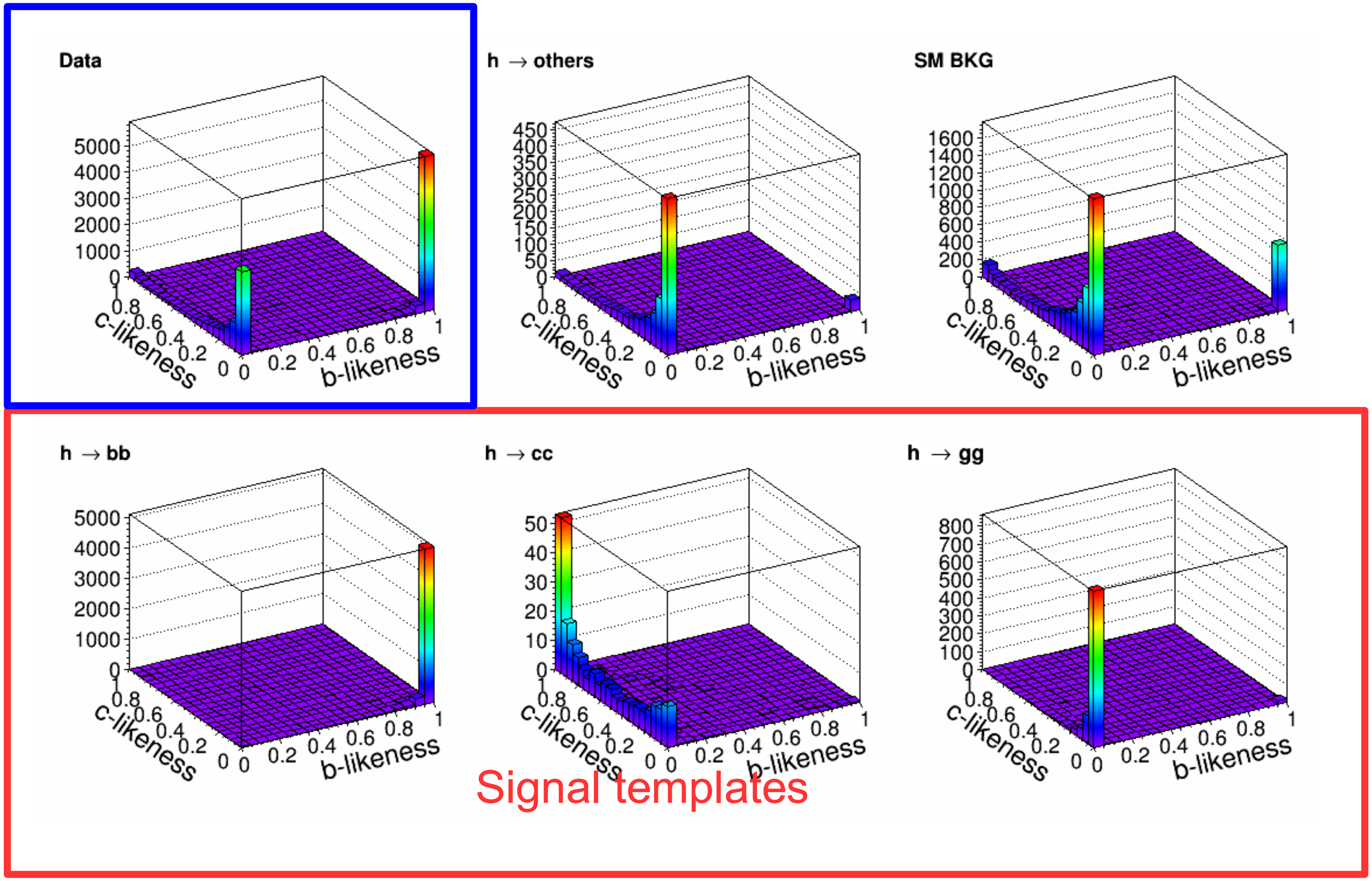
- vvh → 2 Jets + Missing Mass
- γγ-overlay removal (FastJetProcessor)
- Jet clustering and flavor tagging (LCFIPlus)
- Event selection with cut analysis and BDT
- Template fit to the flavor likeness of the Higgs di-jets (b, c, g)





	LOI	DBD
Higgs Mass	120 GeV	125 GeV
Branching Ratio	Pythia	LHC Higgs XSWG
γγ-overlay	not used	used
Detector model	ILD_00	ILC_o1_V05
Software	ilcsoft v01-06	ilcsoft v01-16
Luminosity	250 fb^{-1}	330 fb^{-1}

3-D Template Fit



Fitting the Templates

- Until now the fit function looked like:

$$N_{ijk}^{template} = \sum_{s=b,c,g} r_s \cdot N_{ijk}^{s} + N_{ijk}^{bkg} + N_{ijk}^{h\rightarrow other}$$

- With N_{ijk} being the number of entries in the corresponding bin ijk of the 3D-histogram and the fit parameter r_s being:

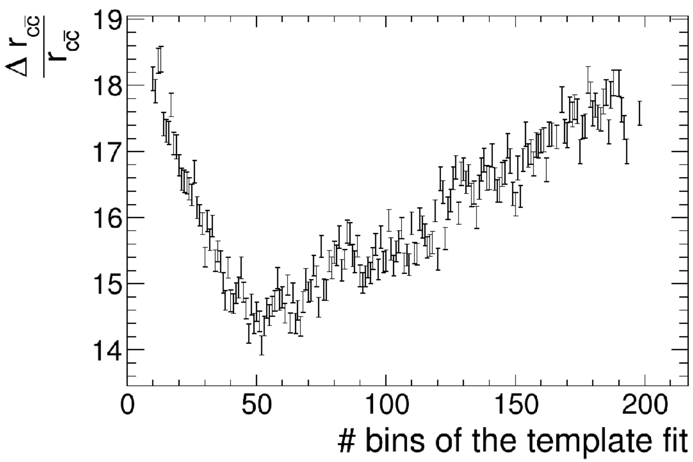
$$r_s = \frac{\sigma \cdot BR(H\rightarrow s)}{(\sigma \cdot BR(H\rightarrow s))^{SM}}$$

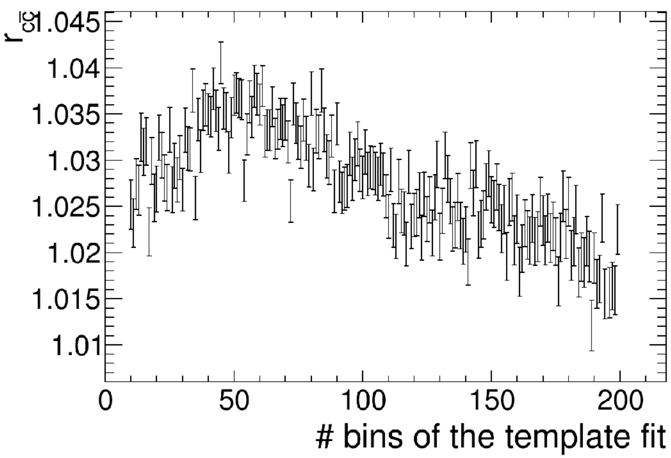
- Observed difficulties:
  - H -> other was fixed. As one wants to measure the Higgs Branching ratios, it seem strange to fix a BR, which also does not really know
  - σ = σ(ZH+WWH) . One needs this to get the BR out of the fit. But σ(WWH) not well known. Can one fit this by using the missing mass as another dimension?
  - Fit values are correlated
  - How to fit the templates? Which binning? Which method (chi^2, log likelihood)? How to treat zero bins?

First Ansatz

- Copy the results from Hiroaki
- Log likelihood fit with rejection of small entry bins (n < 1), BUT small or zero entry bins also carry information

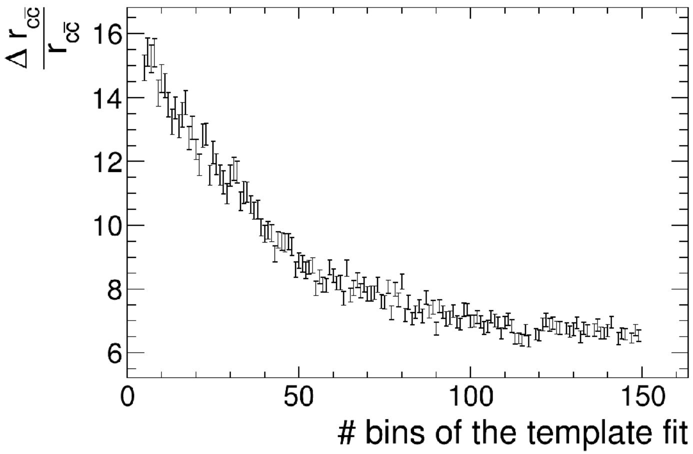
  -> Fit values r_s differ from 1 by several sigma

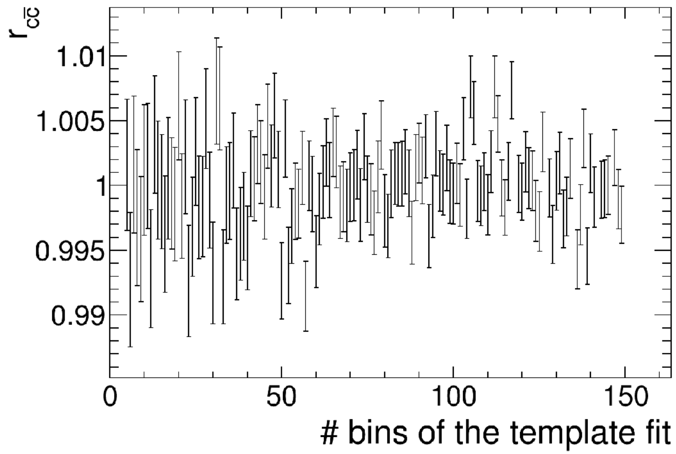




Second Try

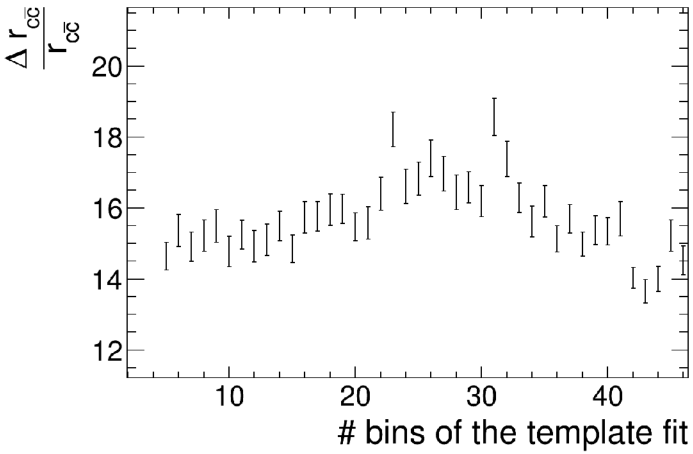
- Log likelihood fit from ROOT
- Fit values r_s are equal to 1
- Higher binning give better results
  - Zeros carry information
  - Convergence for large binning

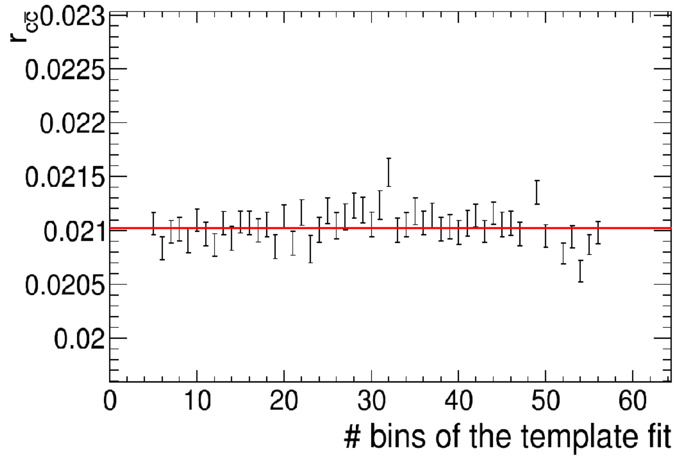




Third Try

- TFractionFitter
  - Log likelihood Fit that considers the error of the sample templates
- Results are rather independent of the number of bins
- But rather bad results
- Maybe the error on the MC samples not negligible? Need higher MC statistics?



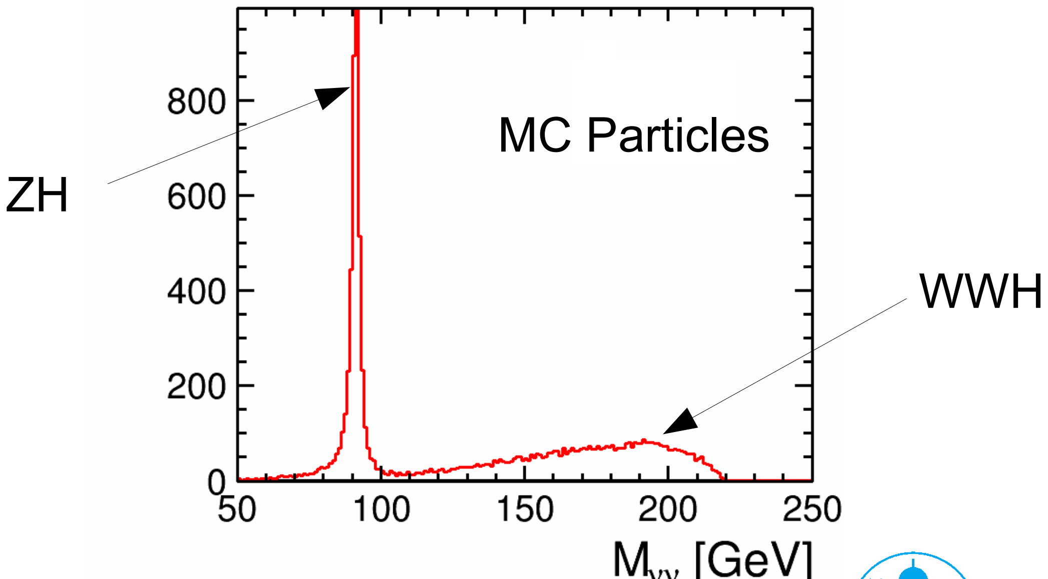


New Fitting Function

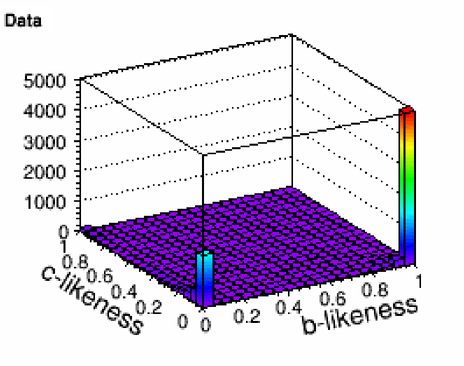
- Change Fit to remove the correlations and to extract the cross sections

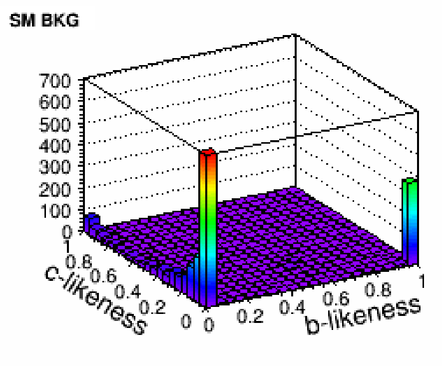
$$N_{ijk}^{template} = \sum_{t=ZH,WWH} \sum_{s=b,c,g,other} \frac{\sigma(t)}{\sigma^{SM}(t)} \cdot \frac{BR(h\rightarrow s)}{BR^{SM}(h\rightarrow s)} \cdot N_{ijk}^{t\rightarrow s} + N_{ijk}^{bkg}$$

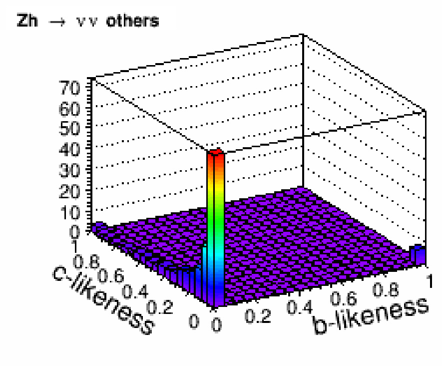
- Need to create a template for each decay times the two production processes
- Differentiate between the production processes by the missing mass of the MC Particles
  - Cuts at M_Z +- 2 $\Gamma(M_Z)$
  - ~ 2% contribution from WWH

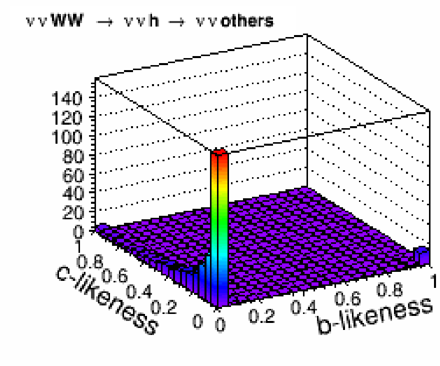


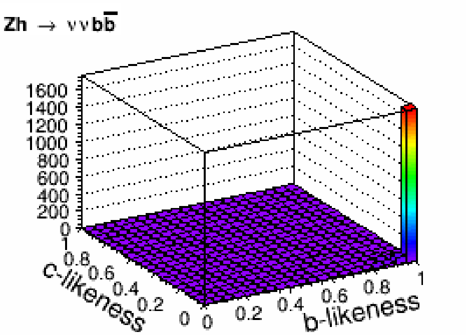
New 3D-Templates

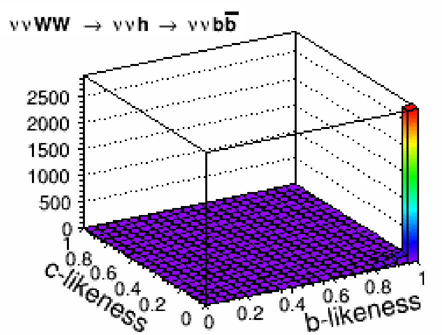


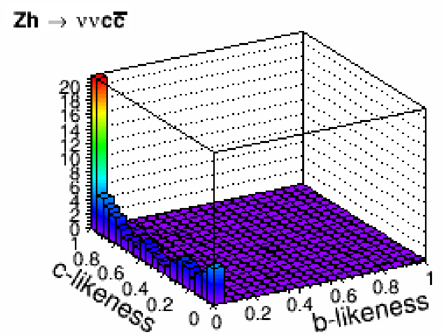


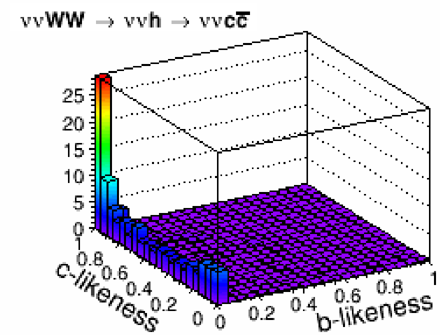


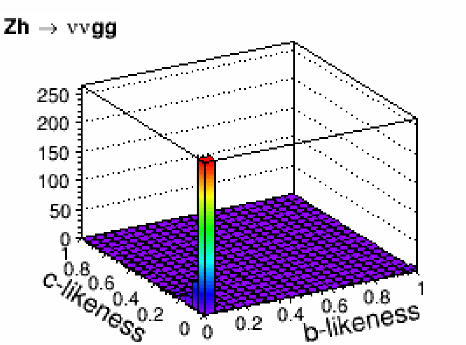


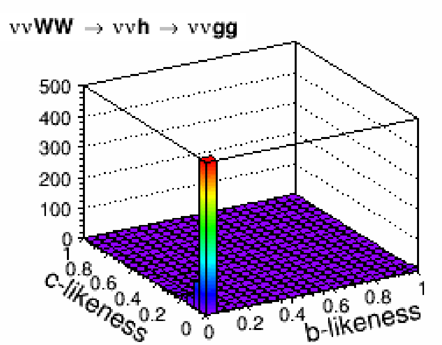




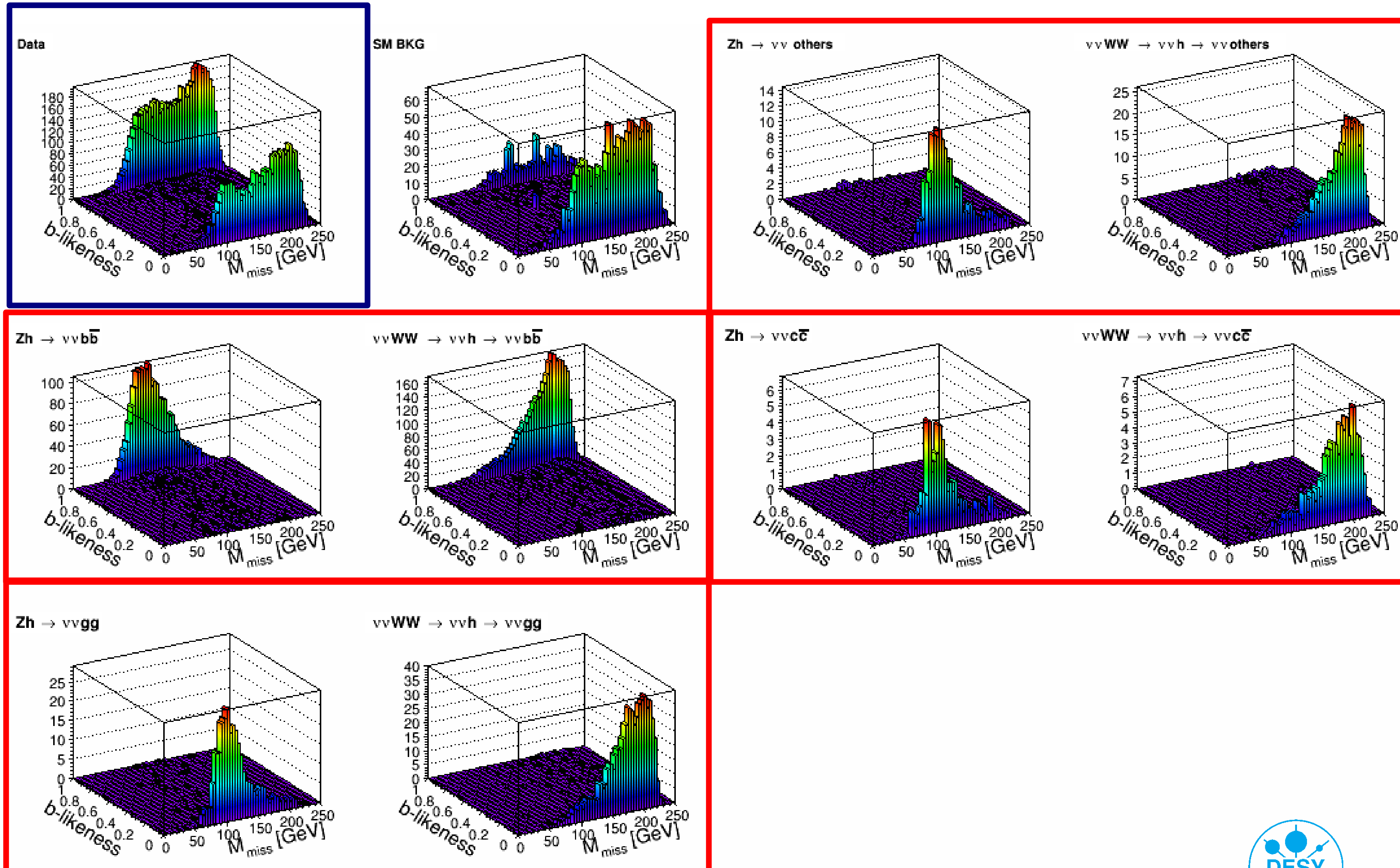






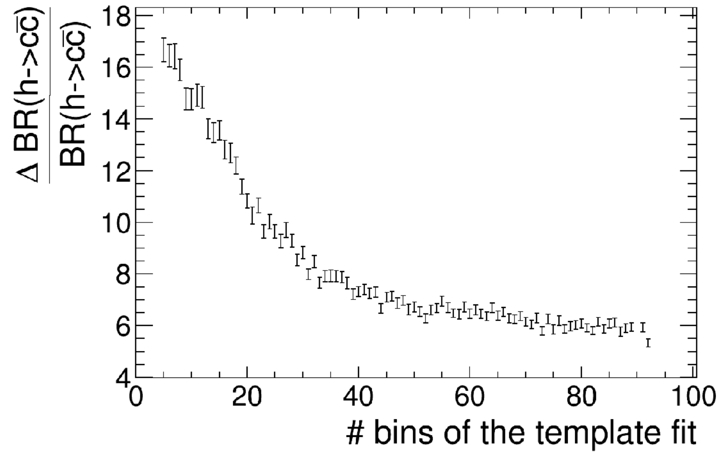


New 3D-Templates

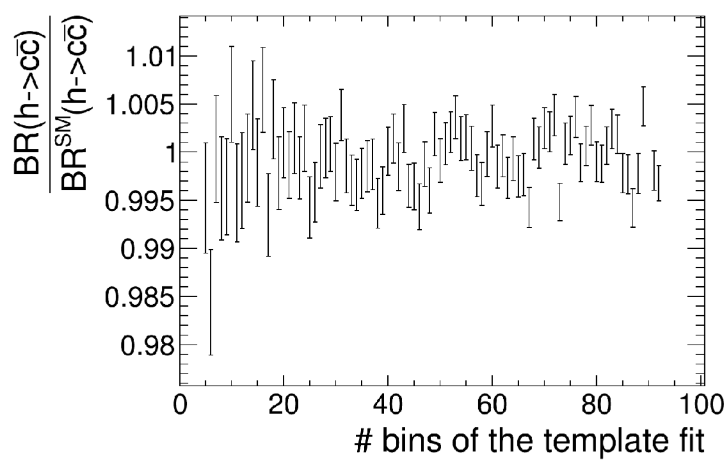


Results

- Fitted values are consistent with 1
- The values start to converge with higher binning of the templates



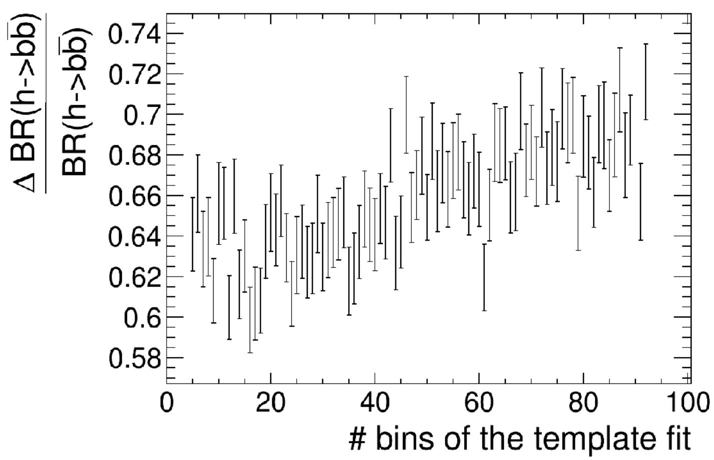
Fit value	relative error [%]
BR(h->bb)	~0.7
BR(h->cc)	~6.5
BR(h->gg)	~3
BR(h->other)	~4
σ(ZH)	~1.8
σ(WWH)	~1.1



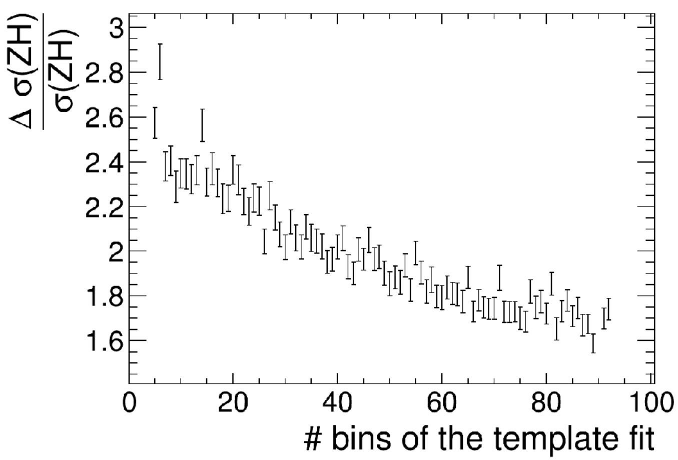
Conclusion

- Neglecting zero entry bins leads to fit values unequal 1 (-> fake non SM coupling)
- Use missing mass and a different fitting function to extract σ(ZH) and σ(WWH)
  - H -> other additional free parameter
  - Reproduce SM coupling
- TFractionFitter indicate worse results due to the finite MC samples. Need more statistic to neglect errors of the MC samples?

Backup

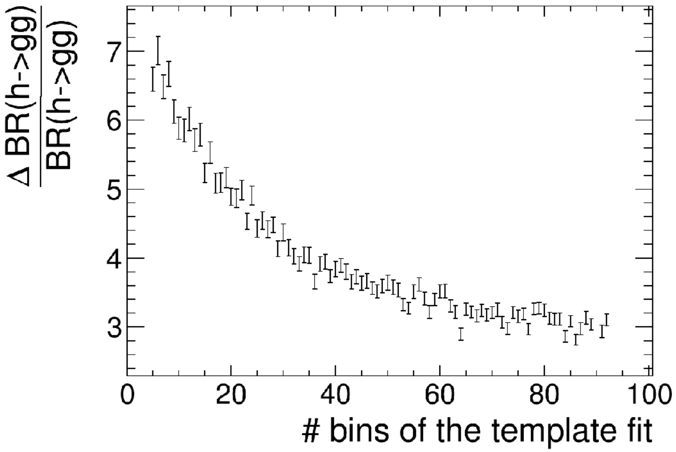


$\frac{\Delta BR(h->b\bar{b})}{BR(h->b\bar{b})}$
0.74
0.72
0.7
0.68
0.66
0.64
0.62
0.6
0.58
0
20
40
60
80
100
bins of the template fit

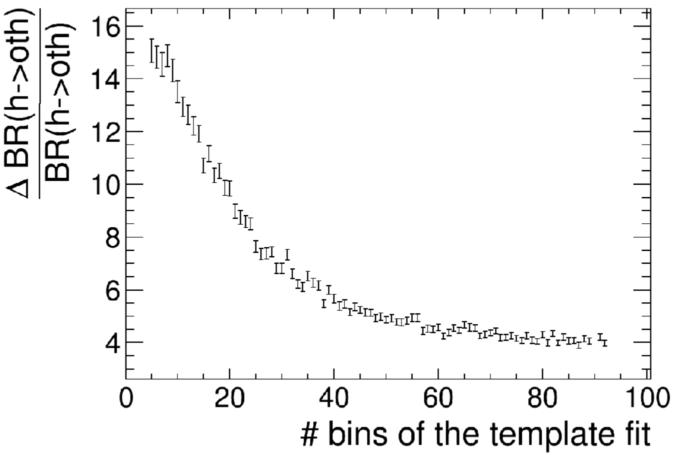


$\frac{\Delta \sigma(ZH)}{\sigma(ZH)}$
3
2.8
2.6
2.4
2.2
2
1.8
1.6
0
20
40
60
80
100
bins of the template fit

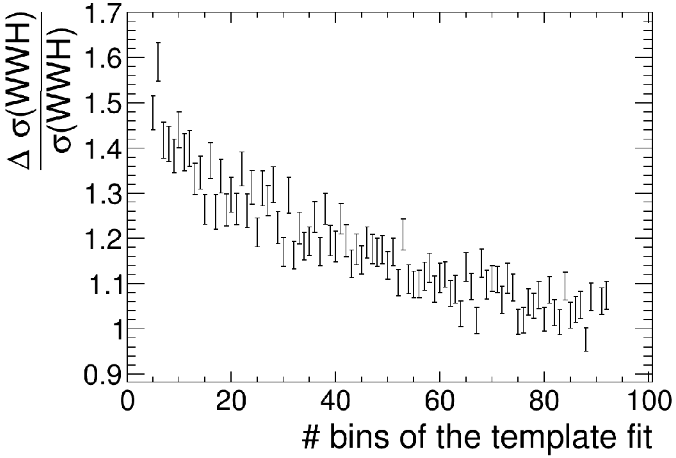
Results



$\frac{\Delta BR(h\text{->}gg)}{BR(h\text{->}gg)}$
3
4
5
6
7
0
20
40
60
80
100
bins of the template fit



$\frac{\Delta BR(h\text{->}oth)}{BR(h\text{->}oth)}$
4
6
8
10
12
14
16
0
20
40
60
80
100
bins of the template fit



$\frac{\Delta \sigma(WWH)}{\sigma(WWH)}$
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
0
20
40
60
80
100
bins of the template fit

$$
\begin{aligned}
N_{ijk}^{template} = & \frac{\sigma(ZH)}{\sigma^{SM}(ZH)} \cdot \frac{BR(h\to bb)}{BR^{SM}(h\to bb)} \cdot N_{ijk}^{Zh\to bb} \\
& + \frac{\sigma(ZH)}{\sigma^{SM}(ZH)} \cdot \frac{BR(h\to cc)}{BR^{SM}(h\to cc)} \cdot N_{ijk}^{Zh\to cc} \\
& + \frac{\sigma(ZH)}{\sigma^{SM}(ZH)} \cdot \frac{BR(h\to gg)}{BR^{SM}(h\to gg)} \cdot N_{ijk}^{Zh\to gg} \\
& + \frac{\sigma(ZH)}{\sigma^{SM}(ZH)} \cdot \frac{BR(h\to oth)}{BR^{SM}(h\to oth)} \cdot N_{ijk}^{Zh\to oth} \\
& + \frac{\sigma(WWH)}{\sigma^{SM}(WWH)} \cdot \frac{BR(h\to bb)}{BR^{SM}(h\to bb)} \cdot N_{ijk}^{WWh\to bb} \\
& + \frac{\sigma(WWH)}{\sigma^{SM}(WWH)} \cdot \frac{BR(h\to cc)}{BR^{SM}(h\to cc)} \cdot N_{ijk}^{WWh\to cc} \\
& + \frac{\sigma(WWH)}{\sigma^{SM}(WWH)} \cdot \frac{BR(h\to gg)}{BR^{SM}(h\to gg)} \cdot N_{ijk}^{WWh\to gg} \\
& + \frac{\sigma(WWH)}{\sigma^{SM}(WWH)} \cdot \frac{BR(h\to oth)}{BR^{SM}(h\to oth)} \cdot N_{ijk}^{WWh\to oth} \\
& + N_{ijk}^{bkg}
\end{aligned}
$$