some clarifications about anomalous VVH couplings in Ogawa-san's study, compared those in literatures

1. formalism

2. current constraints at LHC

formalism

Ogawa

$$\mathcal{L}_{ZZH} = M_Z^2\left(\frac{1}{v} + \frac{a_Z}{\Lambda}\right) Z_\mu Z^\mu H + \frac{b_Z}{2\Lambda}\hat{Z}_{\mu\nu}\hat{Z}^{\mu\nu} H + \frac{\tilde{b}_Z}{2\Lambda}\hat{Z}_{\mu\nu}\tilde{\hat{Z}}^{\mu\nu} H$$

Hagiwara

$$\mathcal{L}_{eff} = a_Z\,\phi Z^\mu Z_\mu + \sum_V \Big\{ b_V\,\phi Z^{\mu\nu} V_{\mu\nu} + c_V\,[(\partial_\mu\phi)Z_\nu - (\partial_\nu\phi)Z_\mu]\,V^{\mu\nu} + \tilde{b}_V\,\phi Z^{\mu\nu}\tilde{V}_{\mu\nu} \Big\},$$

CMS

$$L(\mathrm{HVV}) \sim a_1 \frac{m_Z^2}{2} \mathrm{HZ}^\mu \mathrm{Z}_\mu - \frac{\kappa_1}{(\Lambda_1)^2} m_Z^2 \mathrm{HZ}_\mu \Box \mathrm{Z}^\mu - \frac{1}{2} a_2 \mathrm{HZ}^{\mu\nu}\mathrm{Z}_{\mu\nu} - \frac{1}{2} a_3 \mathrm{HZ}^{\mu\nu}\tilde{\mathrm{Z}}_{\mu\nu}$$

ATLAS

$$\begin{aligned}\mathcal{L}_0^V = \Big\{ & \kappa_{\mathrm{SM}}\left[\frac{1}{2} g_{HZZ} Z_\mu Z^\mu + g_{HWW} W_\mu^+ W^{-\mu}\right] \\ & - \frac{1}{4}\left[\kappa_{Hgg} g_{Hgg} G_{\mu\nu}^a G^{a,\mu\nu} + \tan\alpha\,\kappa_{Agg} g_{Agg} G_{\mu\nu}^a \tilde{G}^{a,\mu\nu}\right] \\ & - \frac{1}{4}\frac{1}{\Lambda}\left[\kappa_{HZZ} Z_{\mu\nu} Z^{\mu\nu} + \tan\alpha\,\kappa_{AZZ} Z_{\mu\nu}\tilde{Z}^{\mu\nu}\right] \\ & - \frac{1}{2}\frac{1}{\Lambda}\left[\kappa_{HWW} W_{\mu\nu}^+ W^{-\mu\nu} + \tan\alpha\,\kappa_{AWW} W_{\mu\nu}^+ \tilde{W}^{-\mu\nu}\right]\Big\} X_0.\end{aligned}$$

difference can be removed by using EOM + contact interaction current constraints at LHC

ATLAS: 13 TeV, 36 fb-1

Table 10: Expected and observed confidence intervals at 95% CL on the κ_{Agg}, κ_{HVV} and κ_{AVV} coupling parameters, their best-fit values and corresponding compatibility with the SM expectation, as obtained from the negative log-likelihood scans performed with 36.1 fb^{-1} of data at $\sqrt{s}$ = 13 TeV. The coupling κ_{Hgg} is fixed to the SM value of one in the fit, while the coupling κ_{SM} is either fixed to the SM value of one or left as a free parameter of the fit.

BSM coupling κ_{BSM}	Fit configuration	Expected conf. inter.	Observed conf. inter.	Best-fit $\hat{\kappa}_{BSM}$	Best-fit $\hat{\kappa}_{SM}$	Deviation from SM
κ_{Agg}	(κ_{Hgg} = 1, κ_{SM} = 1)	[−0.47, 0.47]	[−0.68, 0.68]	±0.43	-	1.8σ
κ_{HVV}	(κ_{Hgg} = 1, κ_{SM} = 1)	[−2.9, 3.2]	[0.8, 4.5]	2.9	-	2.3σ
κ_{HVV}	(κ_{Hgg} = 1, κ_{SM} free)	[−3.1, 4.0]	[−0.6, 4.2]	2.2	1.2	1.7σ
κ_{AVV}	(κ_{Hgg} = 1, κ_{SM} = 1)	[−3.5, 3.5]	[−5.2, 5.2]	±2.9	-	1.4σ
κ_{AVV}	(κ_{Hgg} = 1, κ_{SM} free)	[−4.0, 4.0]	[−4.4, 4.4]	±1.5	1.2	0.5σ

translate to 95% C.L.:

b [-30%, 200%]

b-tilde [-200%, 200%]

compared to ILC by Ogawa: ~a few%

current constraints at LHC

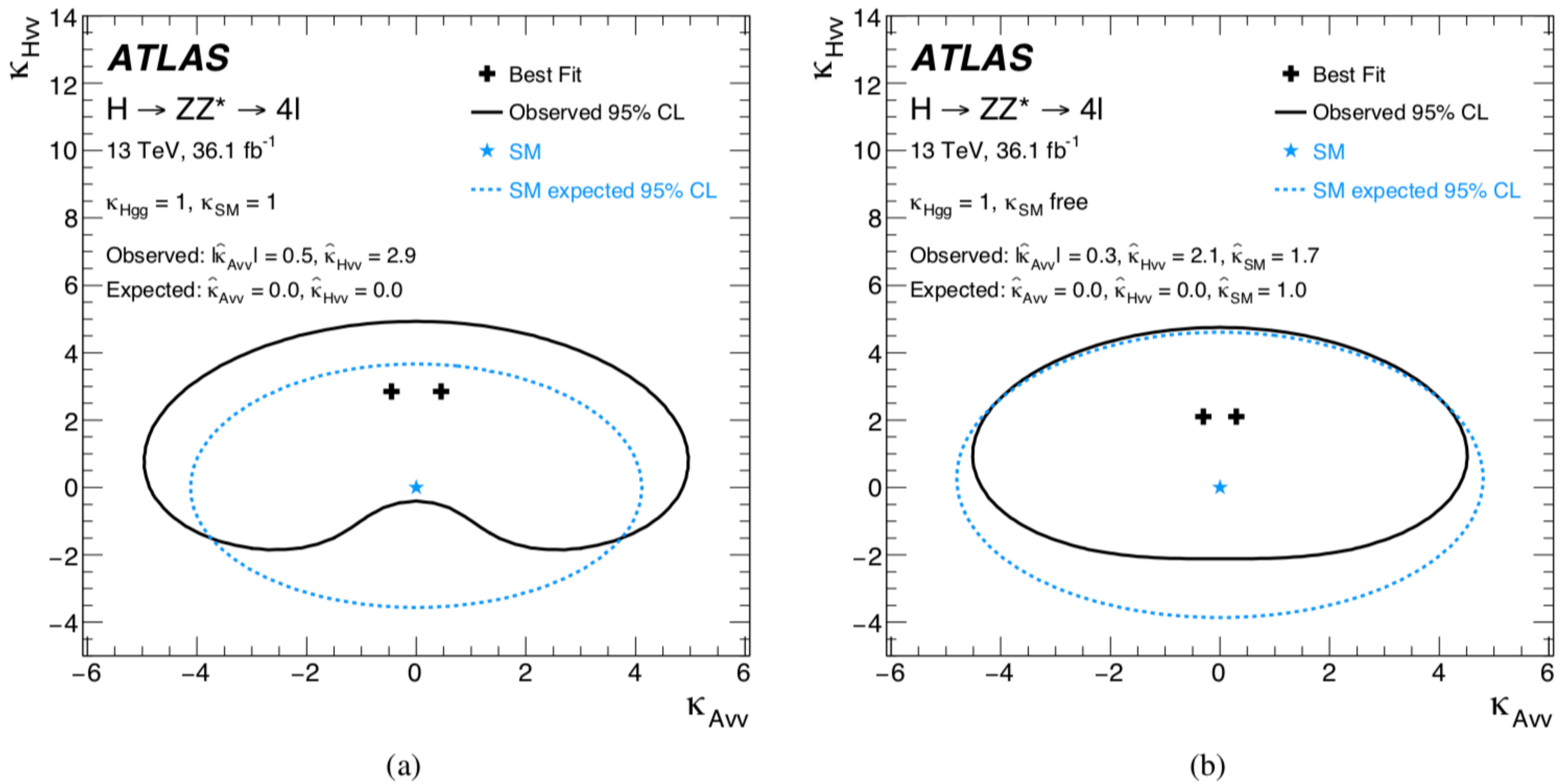

Figure 10: Observed (black) and SM expected (blue) contours of the two-dimensional negative log-likelihood at 95% CL for the κ_{HVV} and κ_{AVV} coupling parameters with 36.1 fb^{-1} of data at $\sqrt{s}$ = 13 TeV. The coupling κ_{Hgg} is fixed to the SM value of one in the fit. The coupling $\kappa_{\rm SM}$ is (a) fixed to the SM value of one or (b) left as a free parameter of the fit (b).

current constraints at LHC

$$L(\mathrm{HVV}) \sim a_1 \frac{m_Z^2}{2} \mathrm{HZ}^\mu \mathrm{Z}_\mu - \frac{\kappa_1}{(\Lambda_1)^2} m_Z^2 \mathrm{HZ}_\mu \Box \mathrm{Z}^\mu - \frac{1}{2} a_2 \mathrm{HZ}^{\mu\nu} \mathrm{Z}_{\mu\nu} - \frac{1}{2} a_3 \mathrm{HZ}^{\mu\nu} \tilde{\mathrm{Z}}_{\mu\nu}$$

Table 5: Summary of allowed 68% CL (central values with uncertainties) and 95% CL (ranges in square brackets) intervals on anomalous coupling parameters in HVV interactions under the assumption that all the coupling ratios are real ($\phi_{ai}^{\mathrm{VV}} = 0$ or π). The expected results are quoted for the SM signal production cross section ($f_{an} = 0$ and $\mu_V = \mu_f = 1$).

Parameter	Observed	Expected
$f_{a3} \cos(\phi_{a3})$	$0.30^{+0.19}_{-0.21}$ $[-0.45, 0.66]$	$0.000^{+0.017}_{-0.017}$ $[-0.32, 0.32]$
$f_{a2} \cos(\phi_{a2})$	$0.04^{+0.19}_{-0.04}$ $[-0.69, -0.64] \cup [-0.04, 0.64]$	$0.000^{+0.015}_{-0.014}$ $[-0.08, 0.29]$
$f_{\Lambda 1} \cos(\phi_{\Lambda 1})$	$0.00^{+0.06}_{-0.33}$ $[-0.92, 0.15]$	$0.000^{+0.014}_{-0.014}$ $[-0.79, 0.15]$
$f_{\Lambda 1}^{Z\gamma} \cos(\phi_{\Lambda 1}^{Z\gamma})$	$0.16^{+0.36}_{-0.25}$ $[-0.43, 0.80]$	$0.000^{+0.020}_{-0.024}$ $[-0.49, 0.80]$

$$\frac{|a_i|}{|a_1|} = \sqrt{f_{ai}/f_{a1}} \times \sqrt{\sigma_1/\sigma_i},$$

translate to: similar sensitivity as by ATLAS