Probing the Higgs-vector coupling with same-sign W bosons

Fady Bishara

Fermilab & University of Cincinnati

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Fermilab

UNIVERSITY OF Cincinnati

In collaboration with Roni Harnik and Felix Yu [arXiv:14XX.YYYY]

Motivation

- ▷ One goal going forward for current and future colliders is to test if the 125 [GeV] Higgs is the one of the SM.
- ▷ Goal of our project: does the 125 [GeV] Higgs couple to the W & Z in the way predicted by the SM.

Parametrization

▷ Higgs effective Lagrangian

$$\mathcal{L}_{\text{eff}} \supset c_V \frac{2m_W^2}{v} hW^{+\mu} W_\mu^- + c_V \frac{m_Z^2}{v} hZ^\mu Z_\mu + c_\gamma \frac{\alpha}{\pi v} hF_{\mu\nu} F^{\mu\nu} + c_{ZZ} \frac{\alpha}{\pi v} hZ^{\mu\nu} Z_{\mu\nu} + \cdots \quad (1)$$

where, in the SM, $c_V = 1$.

▷ We have assumed in Eq. (1) that the custodial symmetry in the Higgs sector is preserved and so $c_W = c_Z = c_V$.

Our goal is to measure or, at least, bound c_V.

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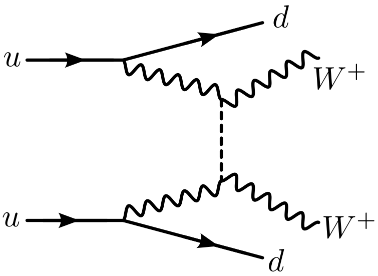
The same-sign W channel

- The Higgs mediated diagram



$$\sigma \propto g_V^4$$

where $g_V \equiv 2m_W/v$.

- The Higgs in the t/u-channel $\Rightarrow$ no dependence on Γ_h
- No Higgs couplings other than g_V enter.

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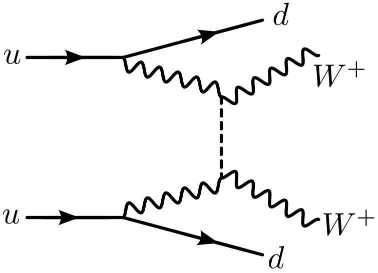

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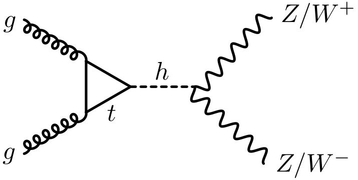
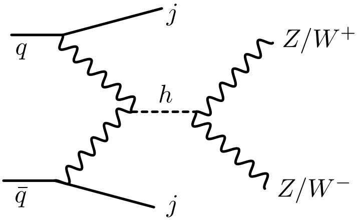
Compare with other channels



$$\sigma \propto \begin{cases} \dfrac{g_t^2\, g_V^2}{\Gamma_h^{\mathrm{TOT}}} & \text{on peak} \\[2ex] g_t^2\, g_V^2 & \text{off peak} \end{cases}$$



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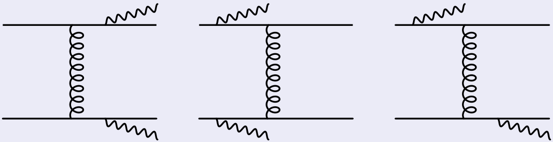
Either g_t enters (golden chan.) or suffer from large $t\bar{t}$ bkgd (VBF).

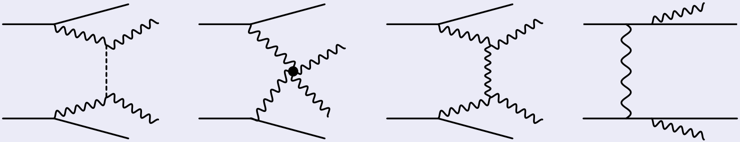
Main contributions

There are two classes of diagrams: strong and electroweak.

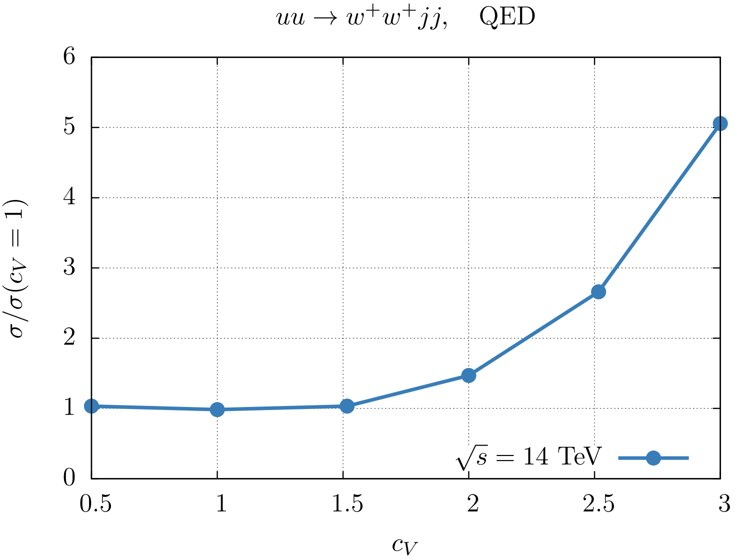
- ▷ Strong production (amplitude $\propto \alpha_W \alpha_s$)



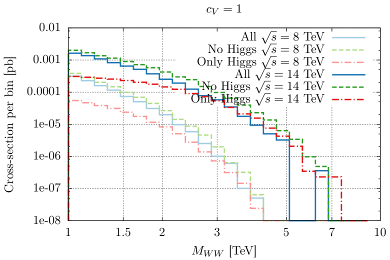
- ▷ Electroweak production (amplitude $\propto \alpha_W^2$)

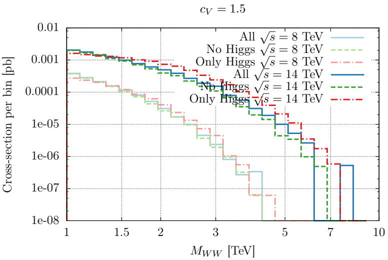


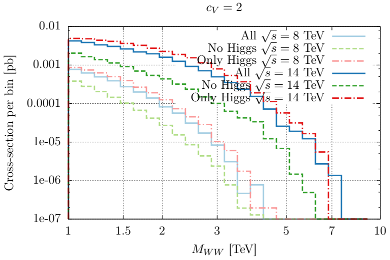
Sensitivity to c_V – total rate

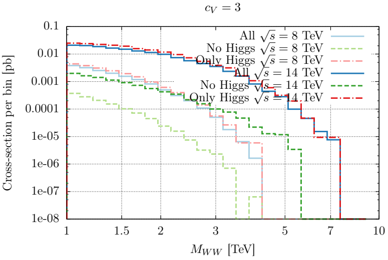


Sensitivity to c_V – distribution of M_{WW}

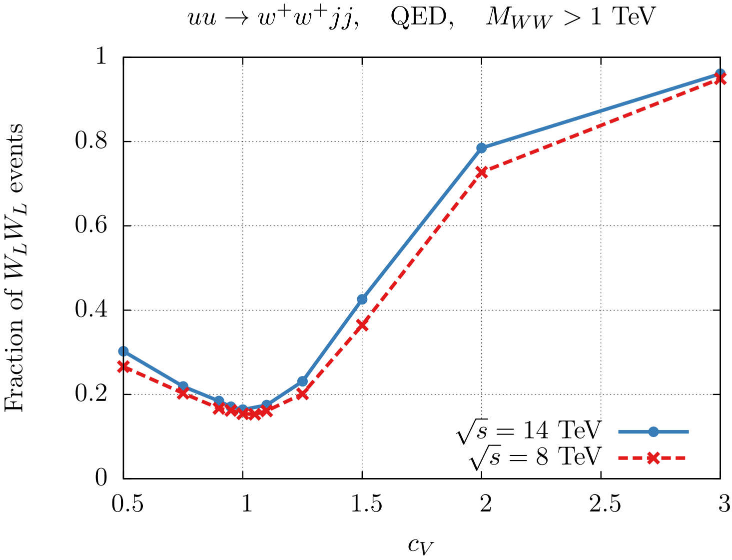








Sensitivity to c_V – fraction of $W_L W_L$



Summary

- We can, in principle, measure or bound c_V with same-sign W boson scattering.
- Need optimized kinematic observables to isolate the longitudinal Ws (work in progress).
- While this may not give the most stringent bound, it is an independent and direct measurement of c_V.
- In the context of a UV model, what are the implications of perturbative unitarity on the masses of the new states? Is the deviation of c_V from 1 still measureable?

Backup Slides

Cuts

As a starting point, used Atlas [ATLAS-CONF-2014-013] cuts.

Pre-selection

Jets	Leptons
$\|\eta\| < 4.5$	$\|\eta\| < 2.5$
$p_T > 30$ GeV	$p_T > 25$ GeV
$\Delta R_{\ell j} > 0.3$	$\Delta R_{\ell\ell} > 0.3$
$m_{j_1 j_2} > 300$ GeV	$m_{\ell\ell} > 20$ GeV
	$E\!\!\!/_T > 40$ GeV

VBS (in addition)
$m_{j_1 j_2} > 500$ GeV
$\|\Delta y_{j_1 j_2}\| > 2.4$

Cross-sections*

$\ell \in \{e, \mu\}$	$\sqrt{s} = 8$ [TeV] Pre	$\sqrt{s} = 8$ [TeV] VBS	$\sqrt{s} = 14$ [TeV] Pre	$\sqrt{s} = 14$ [TeV] VBS
$W^+(\ell\nu)W^+(\ell\nu)jj$ strong	0.63	0.09	1.65	0.30
$W^-(\ell\nu)W^-(\ell\nu)jj$ strong	0.19	0.02	0.64	0.10
$W^+(\ell\nu)W^+(\ell\nu)jj$ electroweak	1.11	0.78	3.64	2.81
$W^-(\ell\nu)W^-(\ell\nu)jj$ electroweak	0.30	0.18	1.22	0.86
$\sum$ Events at 20 [fb^{-1}]	44.5	21.4	143	81.4
$\sum$ Events at 3 [ab^{-1}]	(6665)	(3210)	21425	12210

* All cross sections are in [fb] and do not include acceptance efficiencies.

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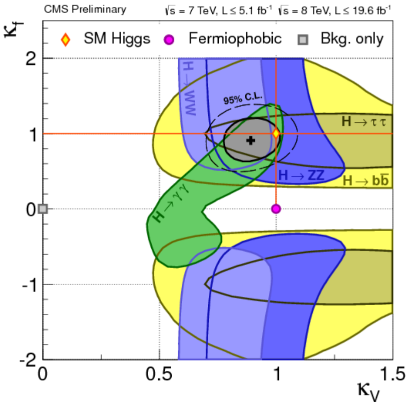
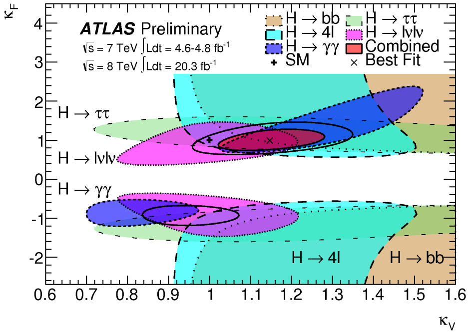
Higgs coupling fits from Atlas & CMS



CMS-PAS-HIG-13-005



ATLAS-CONF-2014-009