Is Single-Top Higgs a single process?
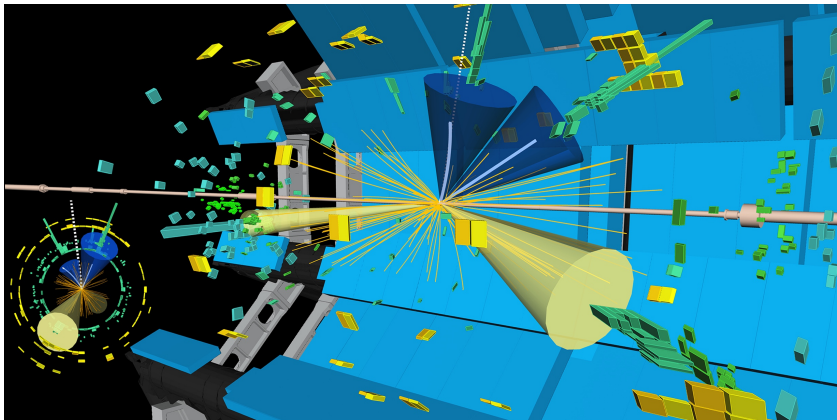
## Chris Young, Karsten Köneke

27th March 2024

Introduction

▶ In the current STXS framework all tH processes are summed and are treated as a single parameter of interest.

▶ Like in Single-Top production there are 3 mechanisms; tHW, t-channel $tHjb$, and s-channel tHb.

▶ All three processes have diagrams with HWW and Htt vertices which interfere.

▶ Experimentally, obviously, the tHW process is significantly different as there can be additional leptons from the W-boson decay.

▶ The cross-section for s-channel is very small compared to the other channels [1];

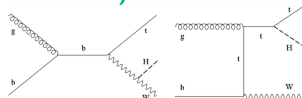| t-channel	s-channel	tHW
0.074 pb	0.0029 pb	0.015 pb

▶ **I propose we have 2 Pols; tHb (both t-channel and s-channel) and tHW**


t-channel   s-channel tHW
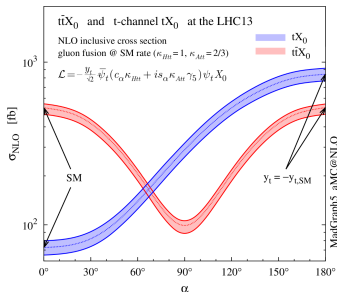
Images from 1504.00611 and 1809.10733
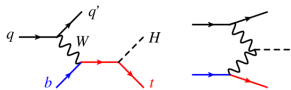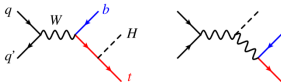
Interference

- All three processes have interference between diagrams where the Higgs couples to the top and where the Higgs couples to the W-boson.

- For t-channel and *tHW* these interfere destructively such that the cross-section is lower than the contributions from each individual diagram.

- For s-channel the interference is constuctive such that the total cross-section is larger than each individual diagram.

- The destructive interference in t-channel is much stronger than in *tHW* so there is different sensitivity from each of these processes to the nature of the couplings.

Images from hep-ph/0106293
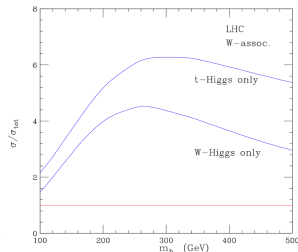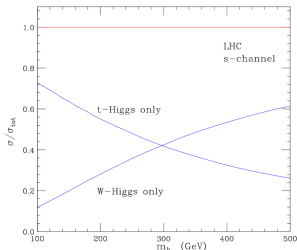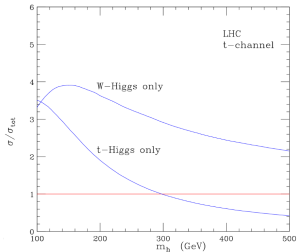
Nature of y_t

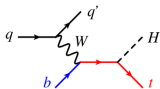- A key property that is probed using single-top-higgs is the sign and nature of y_t.
- The two processes; t-channel and tHW, are both sensitive to new physics in y_t.
- If the two processes have different sensitivity then they should certainly be separated in the STXS framework.
- Using the ATLAS aMcAtNlo + Pythia8 13 TeV setup for the two processes the ratio of the cross-section to that of the SM can be evaluated.
- As seen from the table (which matches 1504.00611) the two processes have different sensitivities so should certainly be separated in the STXS framework!
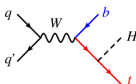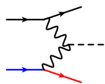

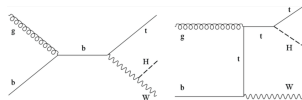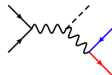|	$\sigma^{\mathrm{t-chan}}/\sigma_{\mathrm{SM}}^{\mathrm{t-chan}}$	$\sigma^{tHW}/\sigma_{\mathrm{SM}}^{tHW}$
$\alpha = 30^o$	1.25	1.38
$\alpha = 60^o$	2.3	2.5
$\alpha = 90^o$	4.5	4.4
$y_t = -1$	11.8	9.0
$y_t = 2$	4.0	5.5

Conclusions

▶ In the current STXS framework all tH processes are summed and are treated as a single parameter of interest.

▶ There are 3 production mechanisms; *tHW*, t-channel *tHjb*, and s-channel *tHb*.

▶ I propose we have 2 PoIs; *tHb* (both t-channel and s-channel) and *tHW*

▶ This is motivated experimentally as these two processes are very different due to the presence of a W-boson in the final state of one but not the other which results in the possibility of additional leptons.

▶ This is also motivated theoretically as these processes have different sensitivity to potential new physics effects.

▶ For s-channel I suggest we place this with t-channel as there is the same final state, modulo jet vs b-jet, and the cross-section is very small such that it will have little impact.

t-channel   s-channel   tHW

Images from 1504.00611 and 1809.10733