

Higgs production in association with single top

Chih-Ting Lu
(NTHU)

National Tsing Hua University, Hsinchu, Taiwan



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- ***Collaborators :***

- Prof. Kingman Cheung

- Prof. Jae Sik Lee

- Dr. Jung Chang

- ***Reference :***

- Probing the top-Yukawa coupling in associated Higgs production with a single top quark (JHEP 1405 (2014) 062)

- Entangling Higgs production associated with a single top and a top-quark pair in the presence of anomalous top-Yukawa coupling (JHEP 1704 (2017) 138)

Wrong Sign Yukawa Couplings is a Clear Signal of BSM !

Status of the CP-conserving 2HDM

Alignment and wrong-sign Yukawa

The **Alignment (SM-like) limit** - all tree-level couplings to fermions and gauge bosons are the SM ones.

$$\sin(b - a) = 1 \quad \text{P} \quad k_D = 1; \quad k_U = 1; \quad k_W = 1$$

Wrong-sign Yukawa coupling - at least one of the couplings of h to down-type and up-type fermion pairs is opposite in sign to the corresponding coupling of h to VV (in contrast with SM).

$$k_D k_W < 0 \quad \text{OR} \quad k_U k_W < 0$$


R. Santos
ISEL & CFTC (U. Lisboa)

The actual sign of each κ_i depends on the chosen range for the angles.

How to detect this kind of **wrong sign Yukawa coupling** signal at the LHC ?

- Directly Probing the Top-Yukawa Coupling in Associated Higgs production with a Single Top Quark
- Study entangling Higgs production associated with a single top and a top-quark pair

$t\bar{t}h$ production at LO

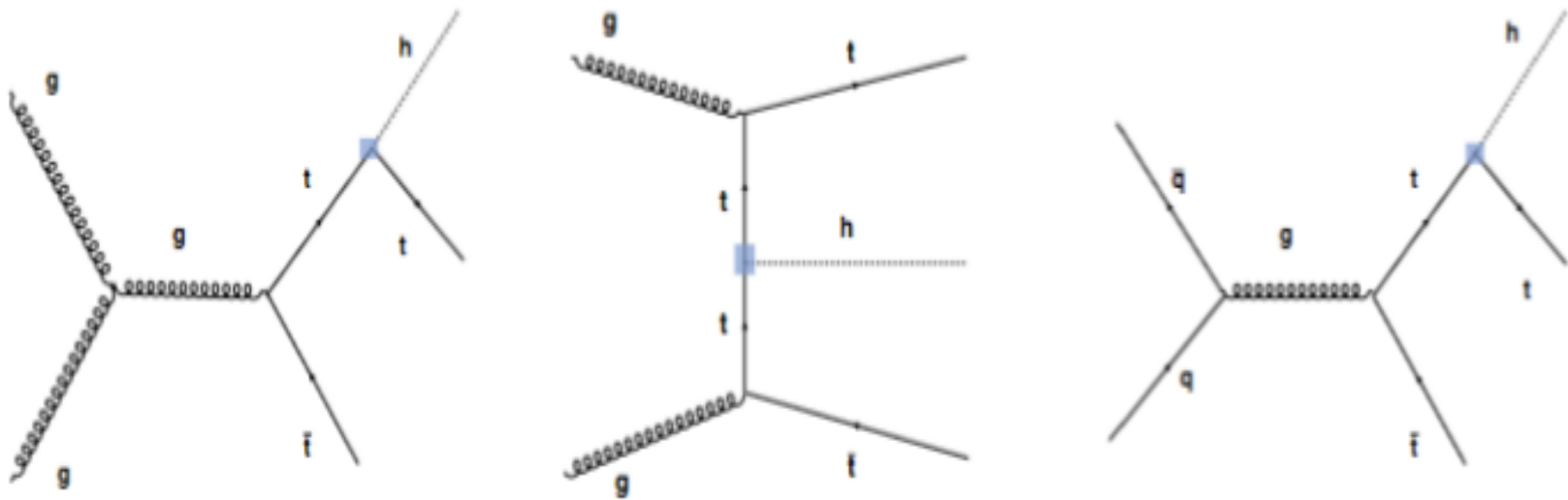


FIG. 1. Feynman diagrams contributing to $t\bar{t}h$ production at LO.

thX production with $X=j$

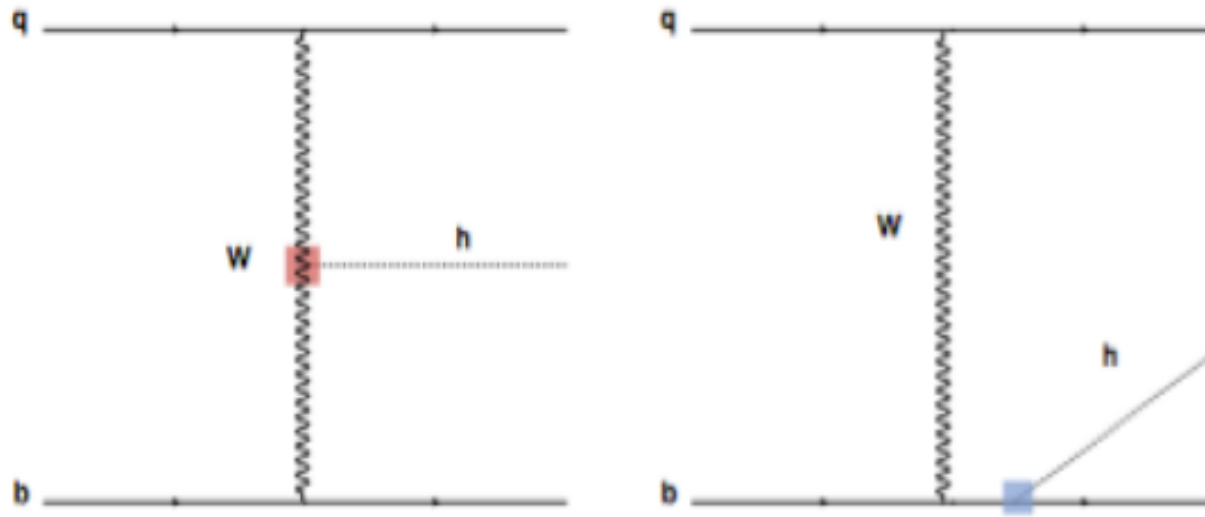


FIG. 2. Feynman diagrams contributing to thX production with $X = j$.

Variation of cross sections for thX production

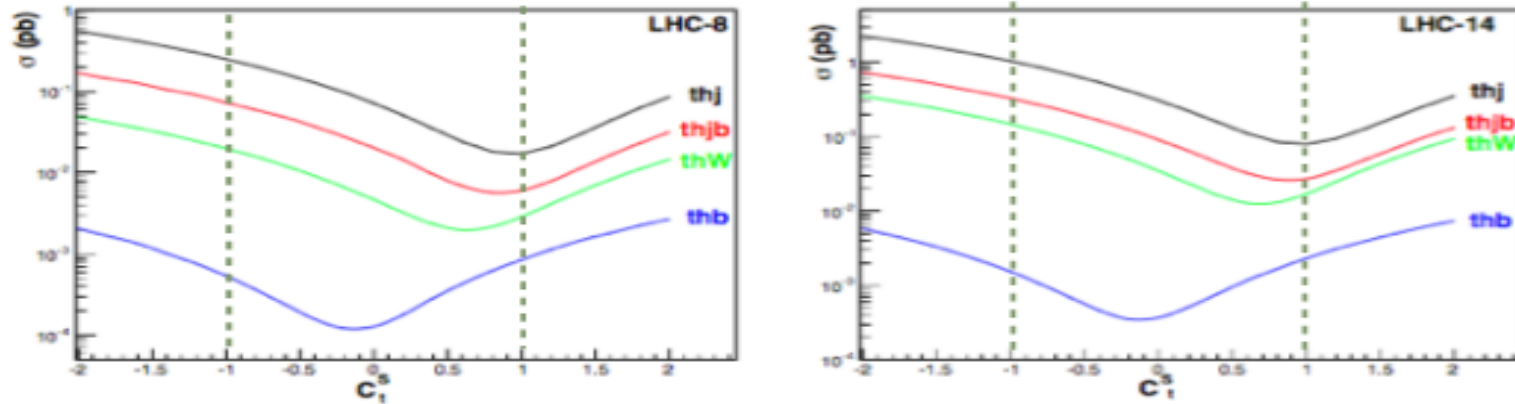
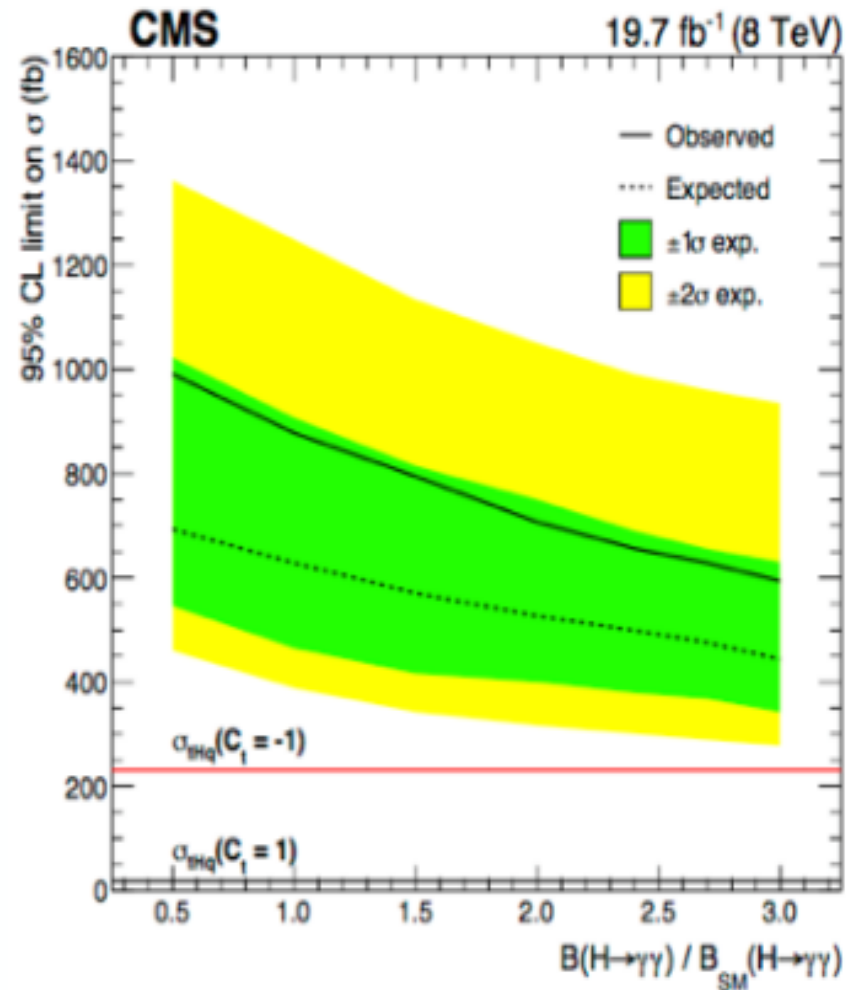
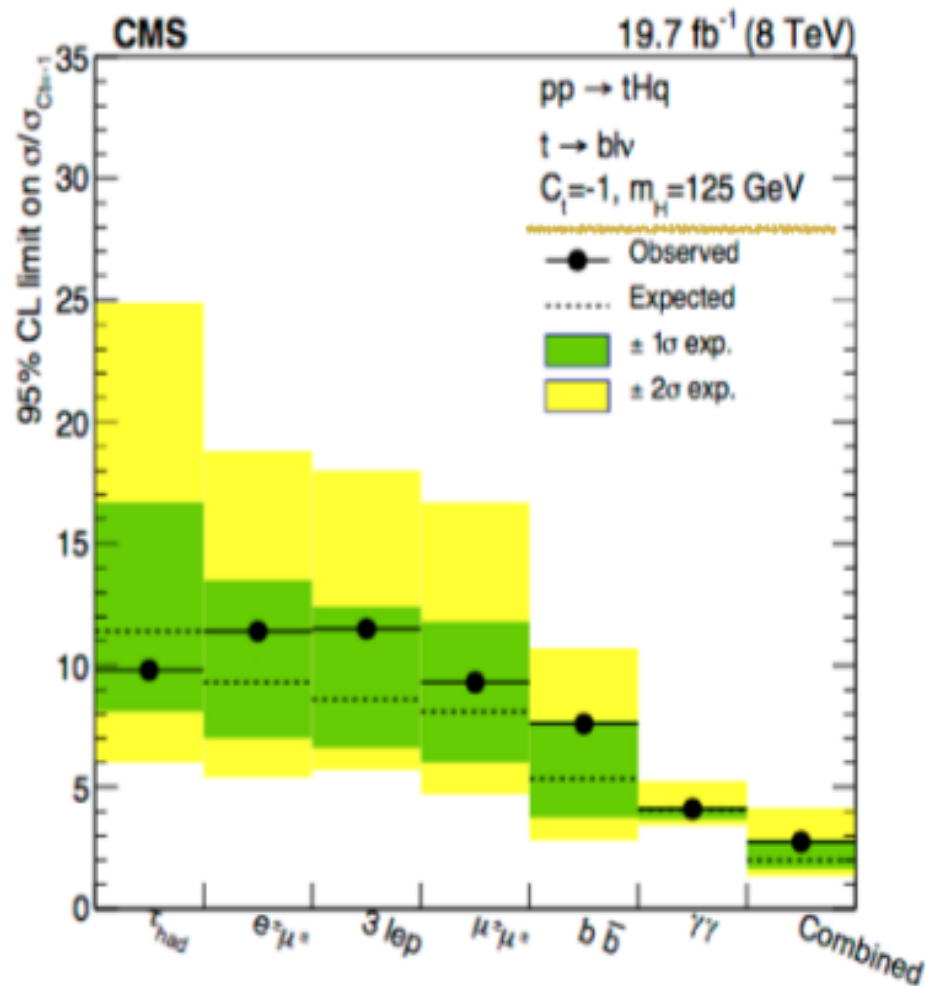


Figure 5. Variation of the total cross sections versus C_t^S for $pp \rightarrow thX$ with $X = j, jb, W, b$ in the order of the size of cross sections at (a) LHC-8 and (b) LHC-14. We have taken $C_v = C_b^S = 1$ and $C_{t,b}^P = 0$. No cuts are imposed except for the second process $pp \rightarrow thjb$ in which we applied the cuts in eq. (3.1) to remove the divergence.

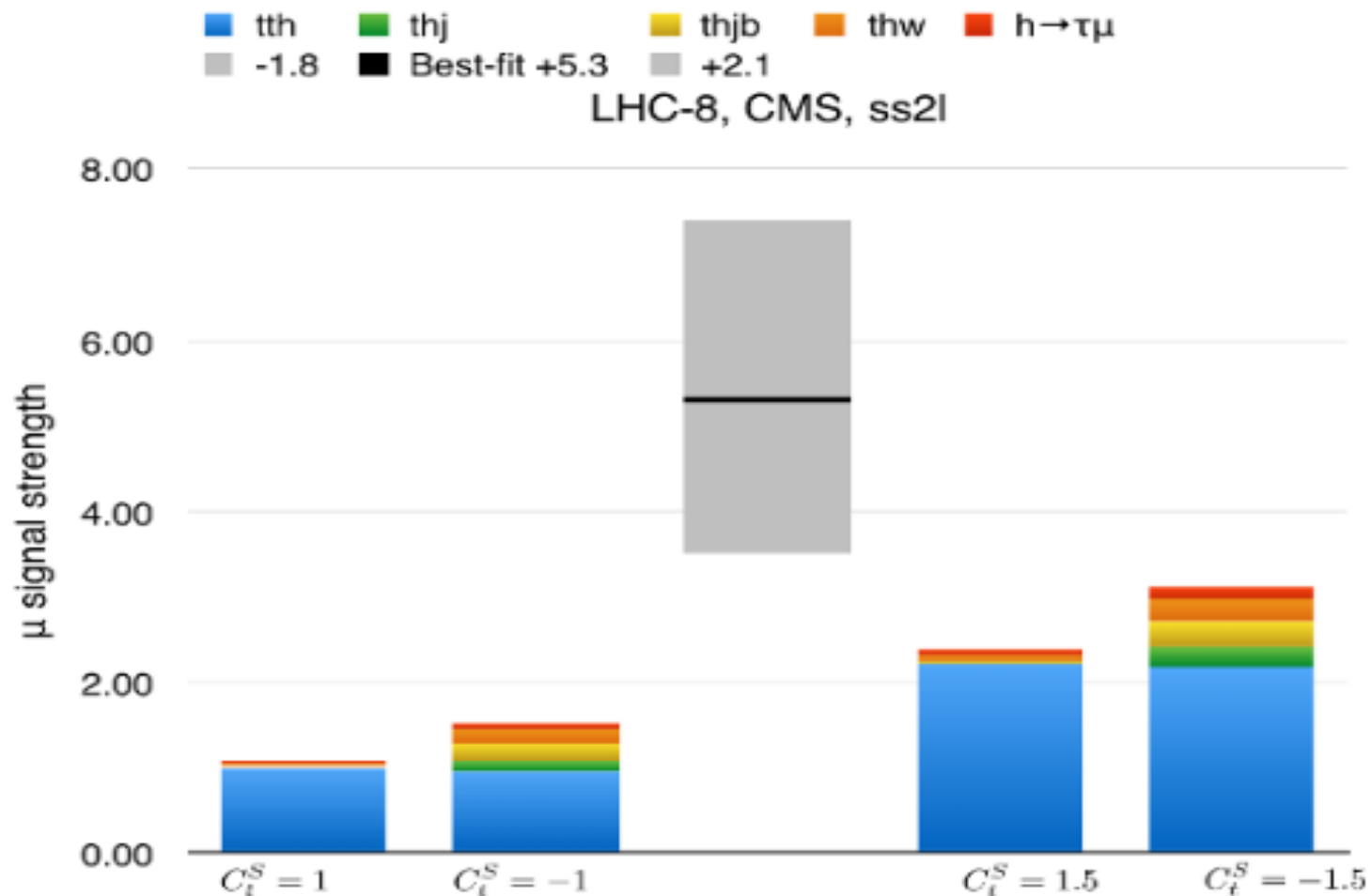
	$\sigma(pp \rightarrow thX)[\text{fb}]$			
	$X = j$	$X = j + b$	$X = W$	$X = b$
$C_t^S = +1$ (SM)	79.4 (17.1)	27.1 (5.95)	17.0 (2.89)	2.32(0.833)
$C_t^S = 0$	305 (71.4)	90.0 (19.8)	34.4 (4.66)	0.368 (0.126)
$C_t^S = -1$	1030 (249)	325 (72.8)	146 (19.8)	1.52 (0.536)

Table 1. The leading-order production cross sections in fb for the processes $pp \rightarrow th + X$ at 14 TeV (8 TeV) LHC, taking $C_v = C_b^S = 1$ and $C_{t,b}^P = 0$. We have not applied any cuts except for the case with $X = j + b$ for which we required $p_{T_b} > 25$ GeV, $|\eta_b| < 2.5$; $p_{T_j} > 10$ GeV, $|\eta_j| < 5$, see text for details.

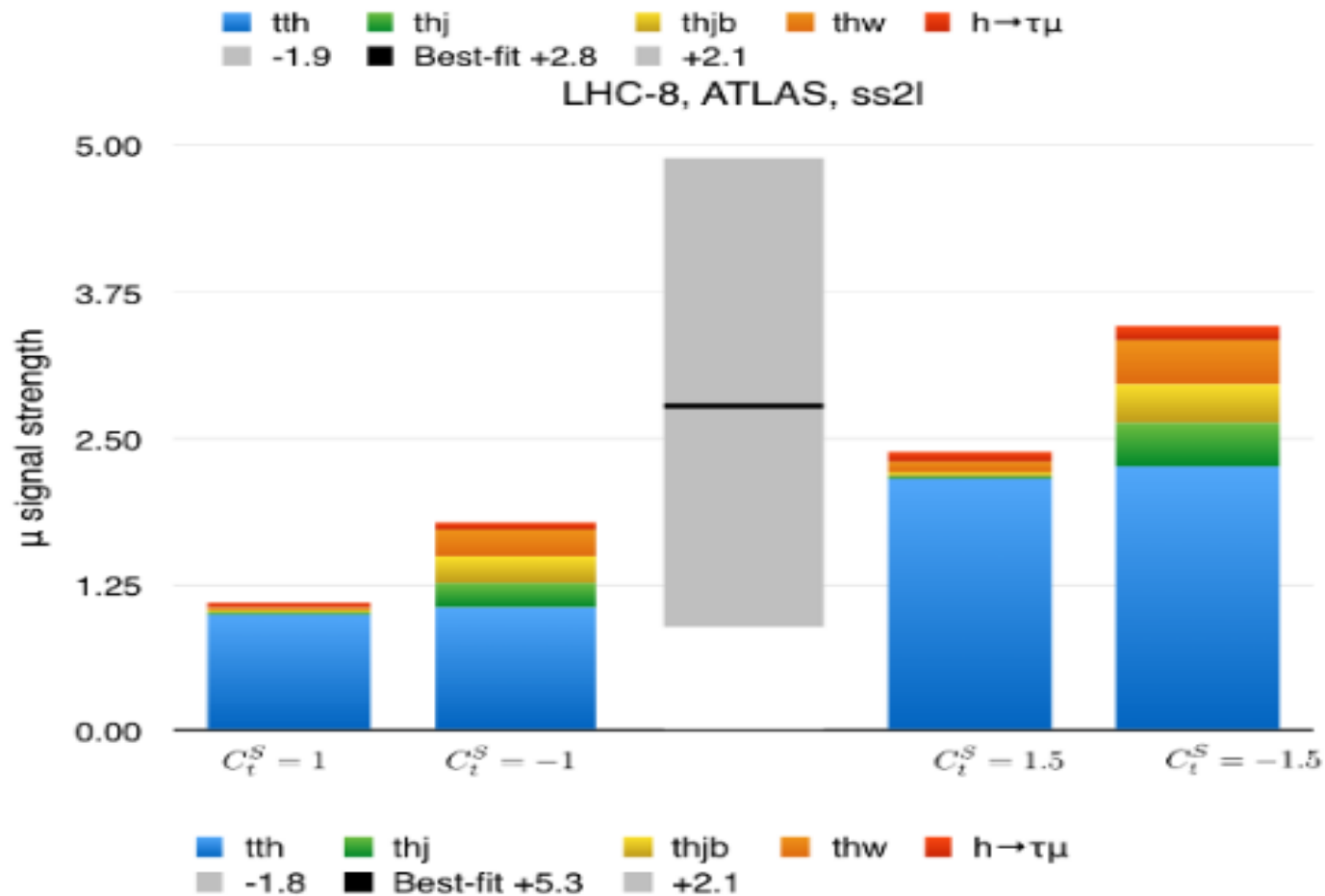
CMS search for the Associated Higgs production with a Single Top Quark



Entangling Higgs production associated with a single top and a top-quark pair

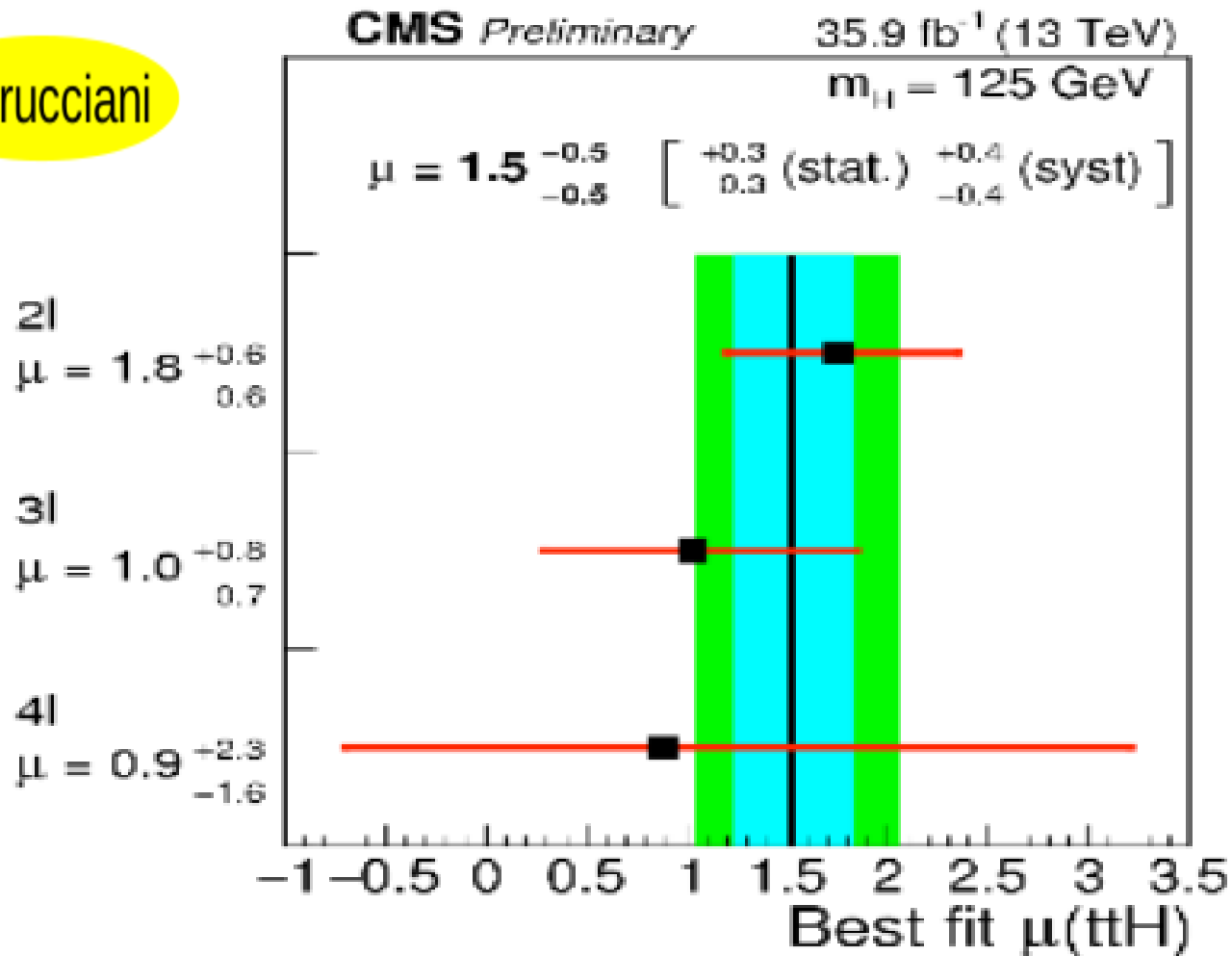


Entangling Higgs production associated with a single top and a top-quark pair



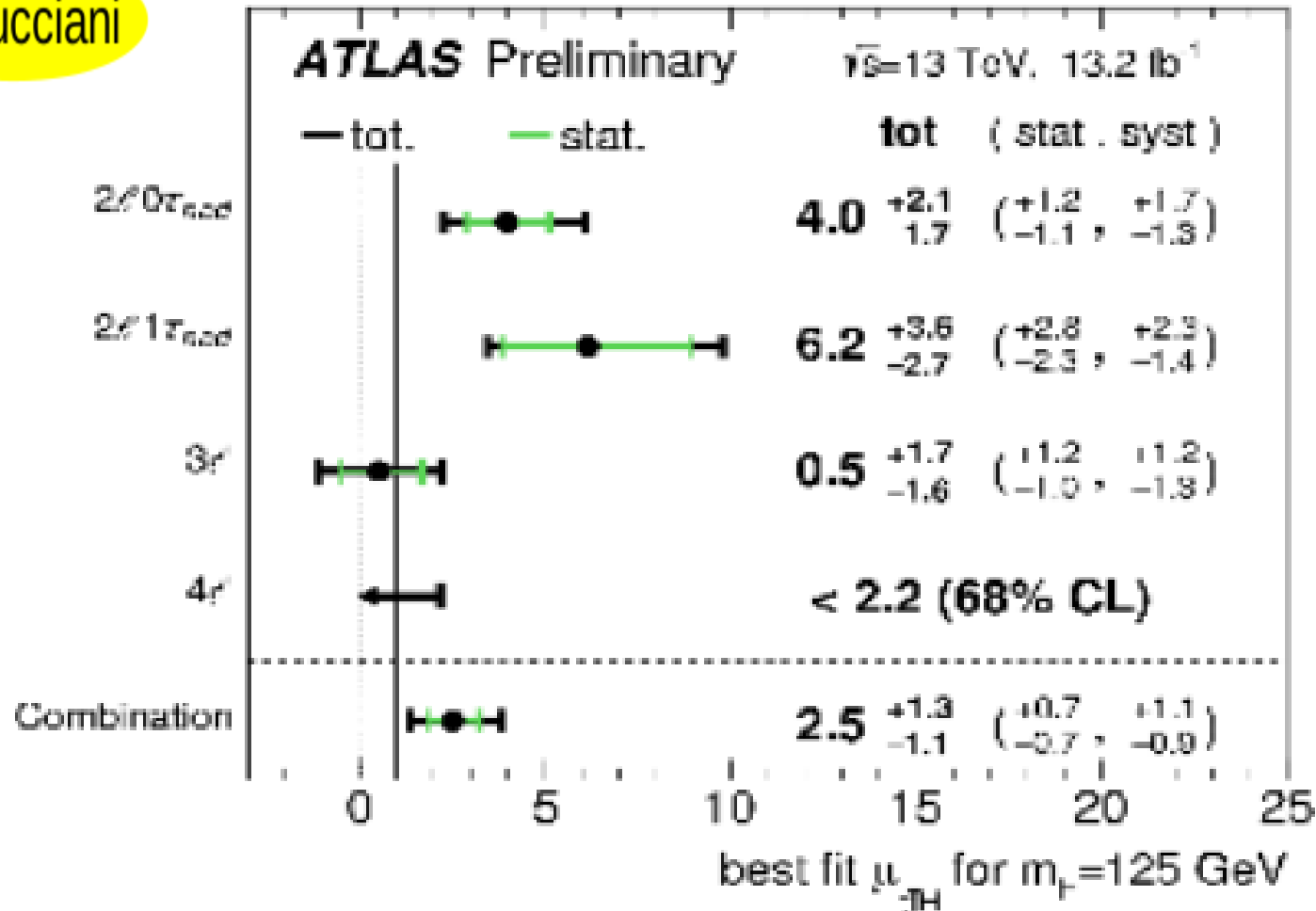
ttH searches at LHC-13

Petrucciani

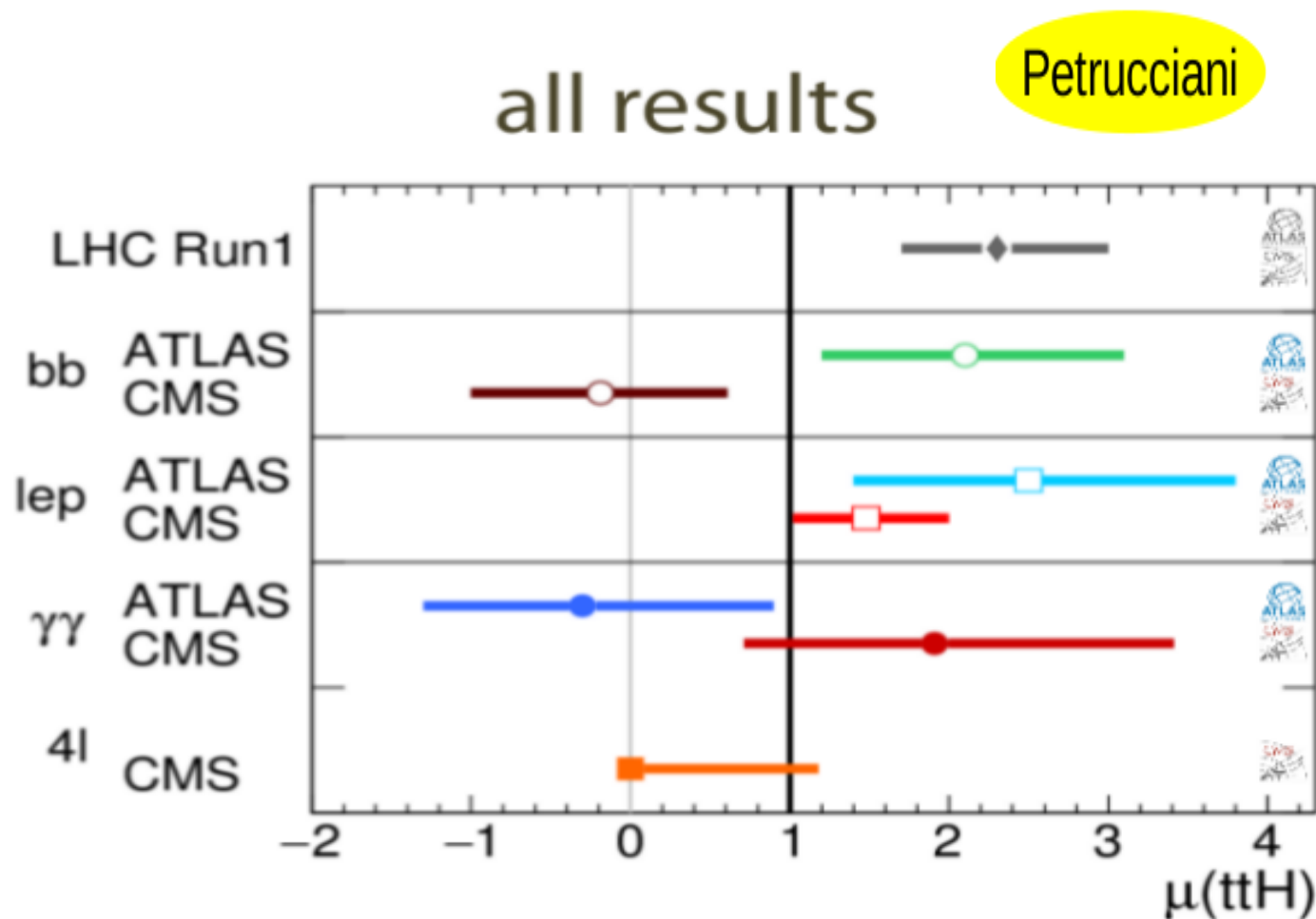


ttH searches at LHC-13

Petrucciani

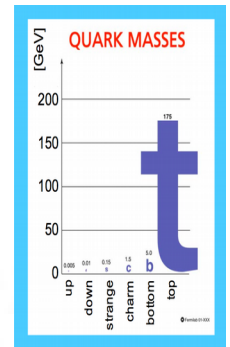
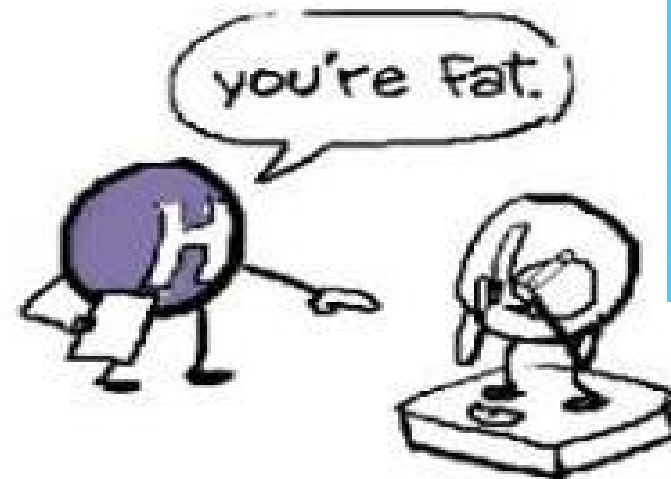


It's time to put our heart and soul into studying both the **sign** and **size** of **Top-Yukawa coupling** NOW !



Thank you for your listening ! !

THE HIGGS IS THE
PARTICLE RESPONSIBLE
FOR GIVING MASS TO
OTHER PARTICLES.



Other thX productions with X=jb, W, b

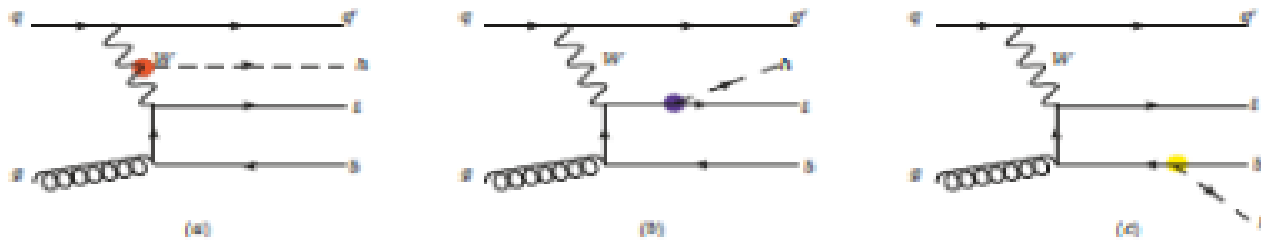


Figure 2. Some of the contributing Feynman diagrams for $qq \rightarrow thq'\bar{b}$.

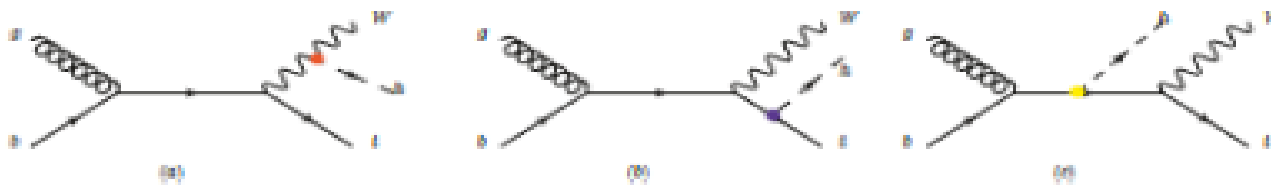


Figure 3. Some of the contributing Feynman diagrams for $gb \rightarrow thW^-$.

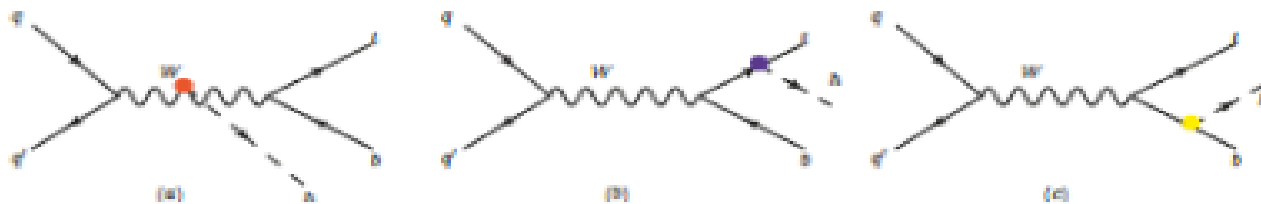
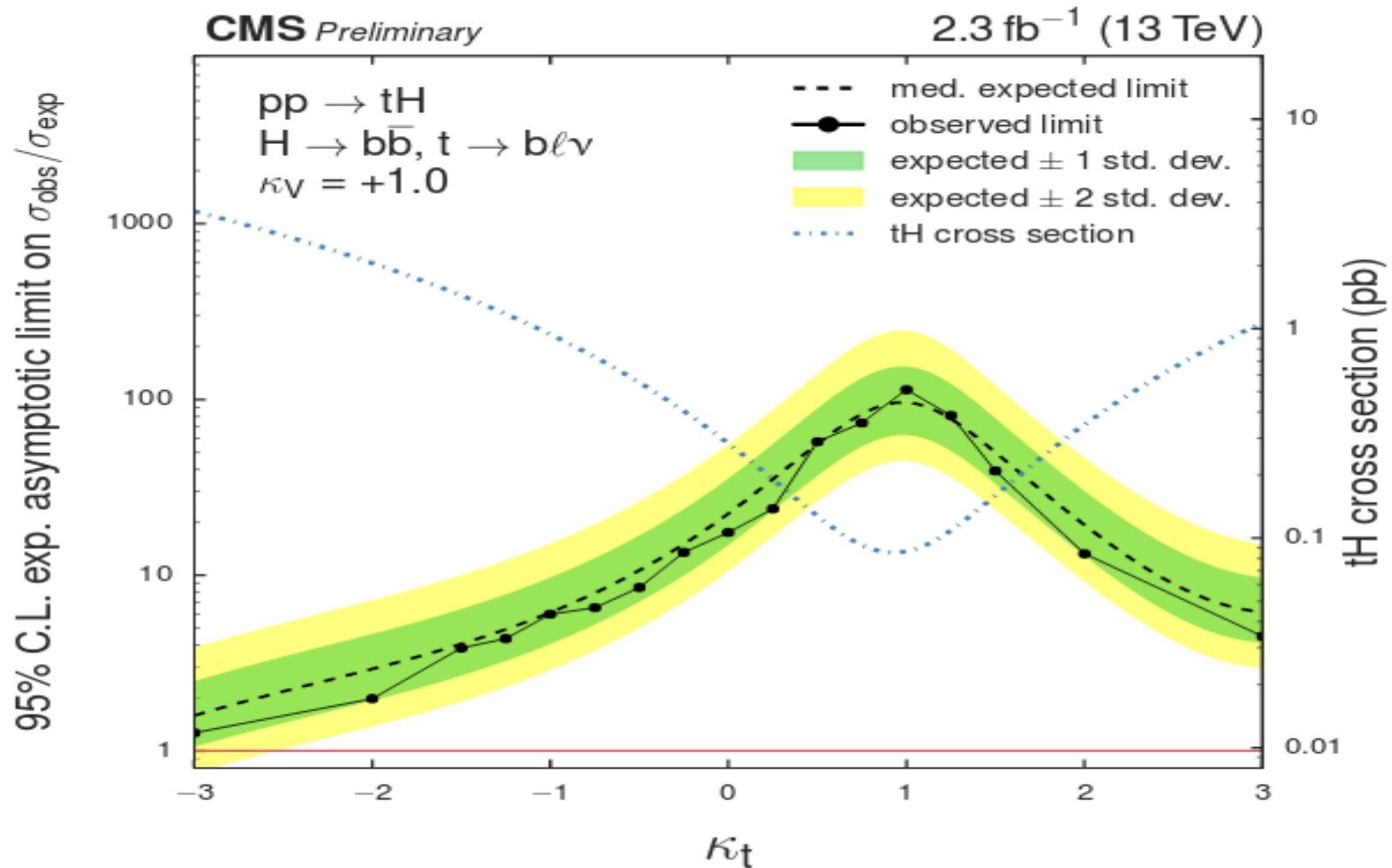


Figure 4. Contributing Feynman diagrams for $qq' \rightarrow th\bar{b}$.

Search for H to bbar in association with a single top quark as a test of Higgs boson couplings at 13 TeV



Entangling Higgs production associated with a single top and a top-quark pair at LHC-13

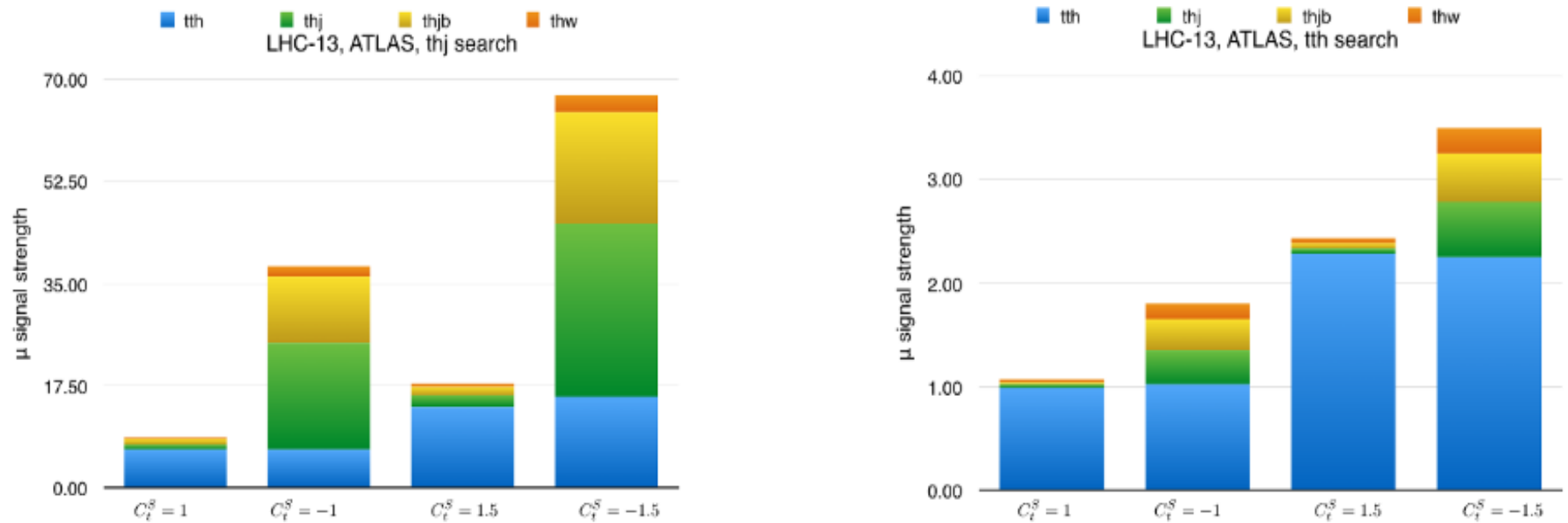


Figure 10. Accumulated signal strengths $\mu(thj)$ (left) and $\mu(tth)$ (right) at LHC-13 obtained by stacking the various thX contributions on the tth one for $C_t^S = +1, -1, +1.5, -1.5$ from left to right. We use the Delphes ATLAS template for detector simulations.