



Perspectives for studies of Higgs + single top quark associated production at LHC

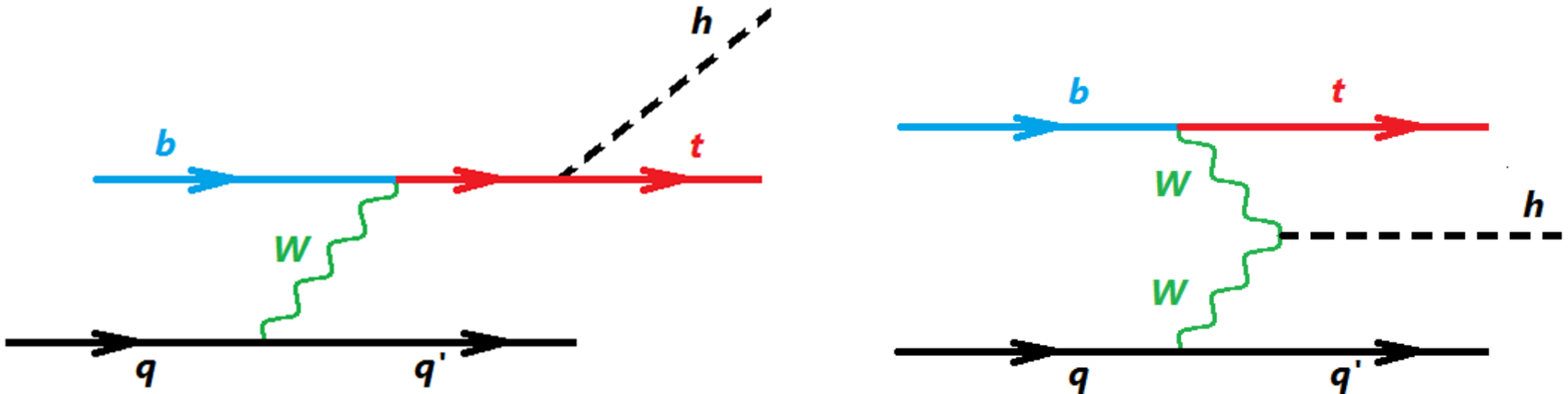
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1. Why is the $h+t$ study interesting? Theoretical highlights: SM and BSM scenarios;
2. Latest experimental results;
3. Perspectives for further studies and BSM searches;

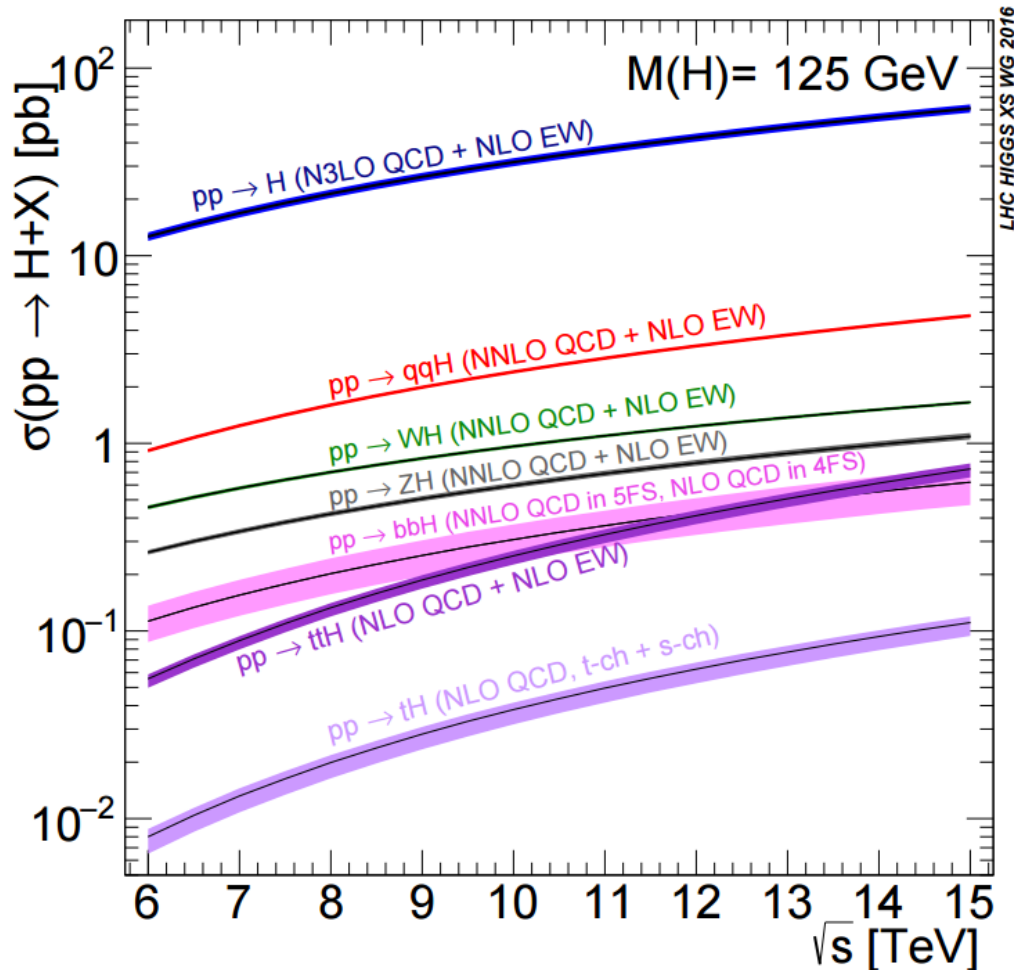
What is interesting about Higgs+top? Theoretical highlights

This final state is produced with the Higgs boson coupled either to t -quark (left) or to W boson (right).



The observable cross-section is thus strongly sensitive to interference between h - t and h - W interactions.

What is interesting about Higgs+top? Theoretical highlights

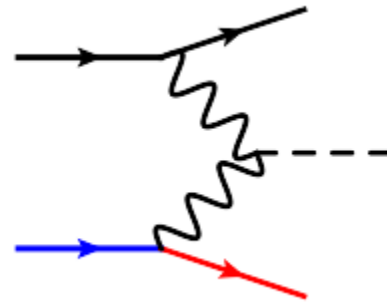
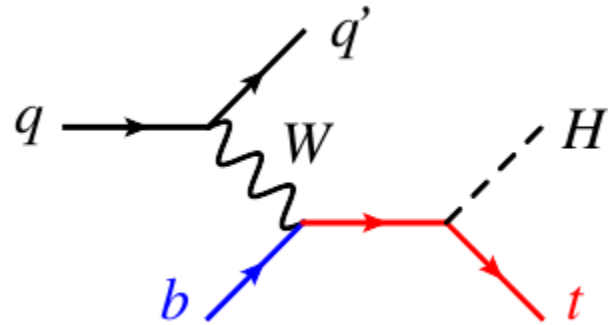


Plot from LHC Higgs XS WG

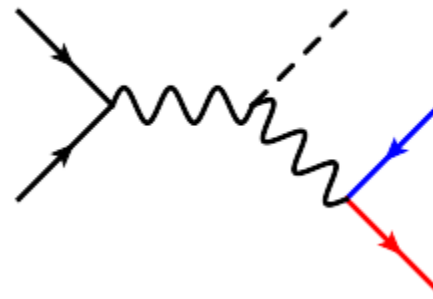
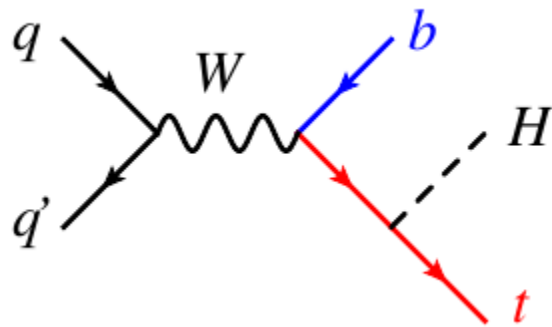
The th production cross section is ~ 5 times smaller compared to that of tth channel.

... due to destructive interference between ht and hW couplings, both contributing to $pp \rightarrow h+t$ process.

What is interesting about Higgs+top? Theoretical highlights

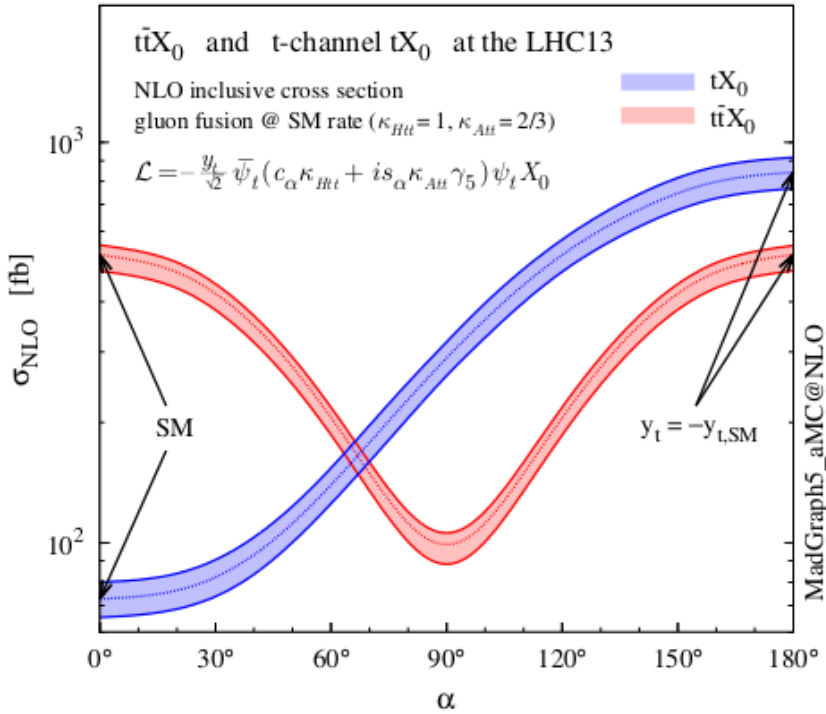


t-channel production

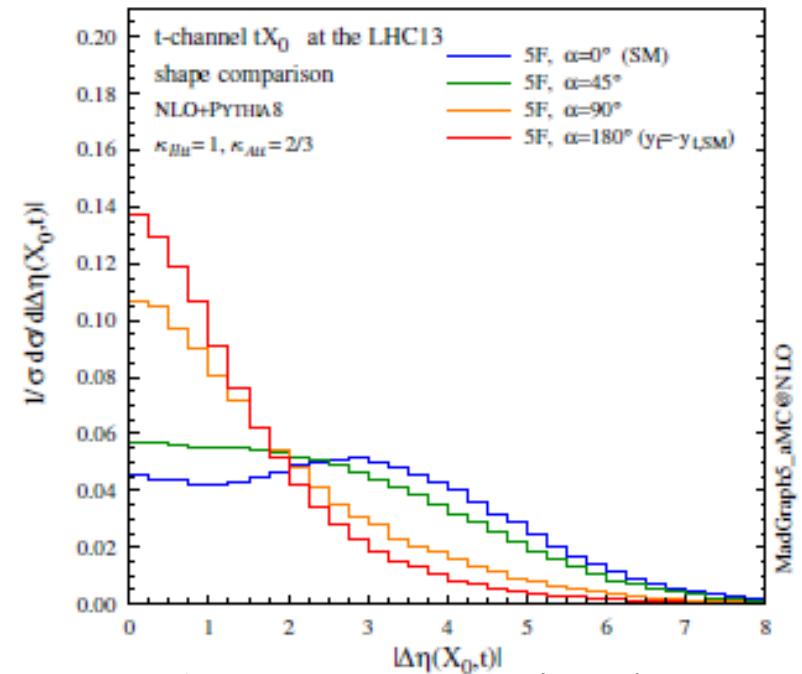


s-channel production has less than 5% σ compared to t-channel: suppressed by high virtuality of W

What is interesting about Higgs+top? BSM scenarios



Through the th - Wh couplings interference, the th production channel is sensitive to the sign of th coupling and thus to BSM physics. Presence of BSM will alternate also the angular distributions:

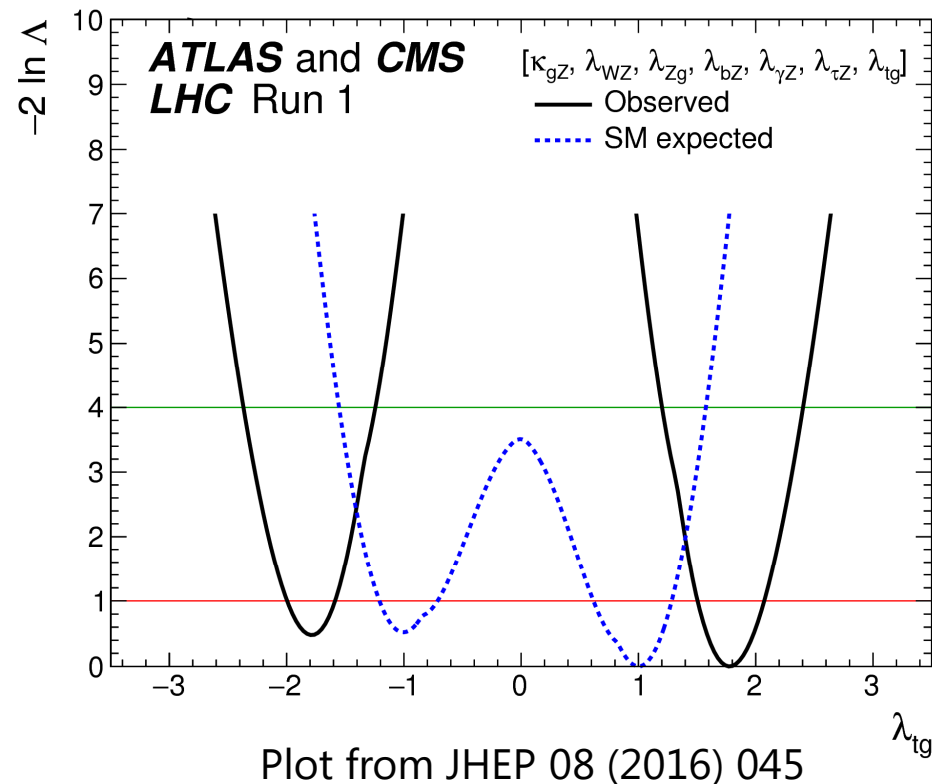


Plots from Eur.Phys.J. C75 (2015) no.6, 267

In case phase differs from SM expected value, the ratio between th and tth production can vary between ~ 0.2 (in SM scenario) to ~ 2.5 (in the so-called ITC scenario);

Experimental results

With respect to the sign of th coupling, the current experimental results are in favor of the SM. However, the separation between positive and negative th coupling hypotheses is not significant enough ($< 1\sigma$, red line).



Experimental results

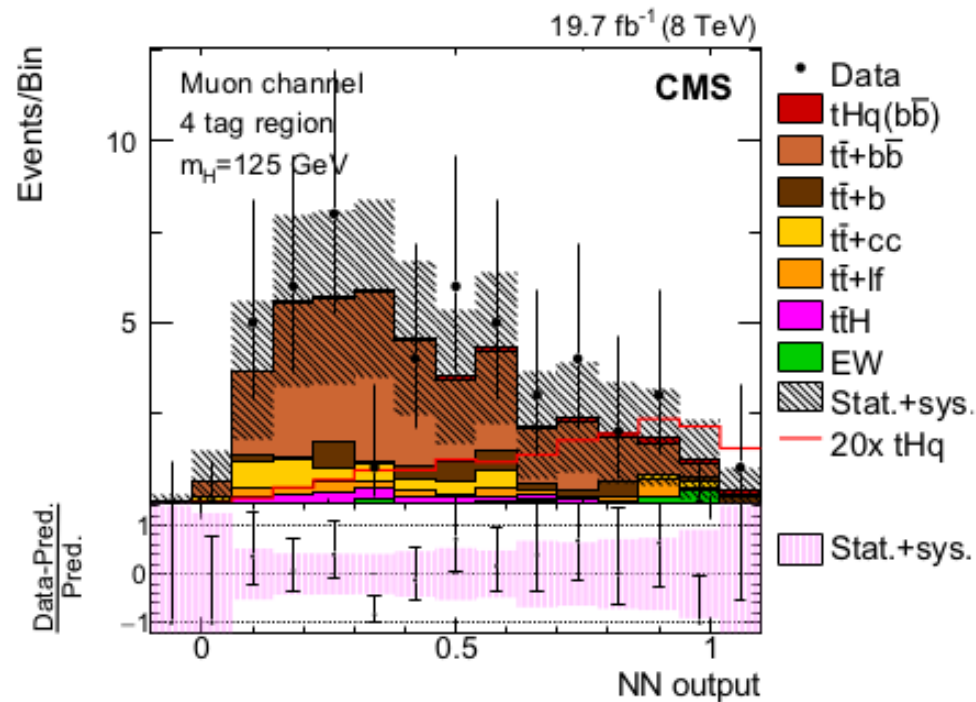
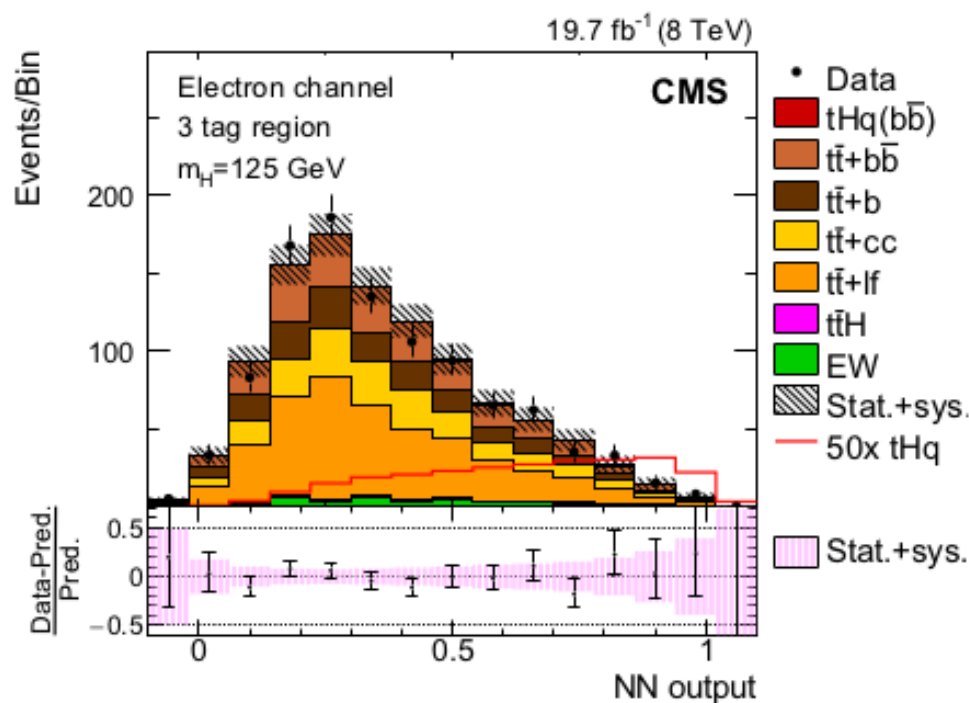
The first search of the Higgs boson production in association of the *Higgs + single top* production has been performed by the CMS experiment using 7,8,13TeV *pp* data.

The current sensitivity is limited by exp. data statistics. To maximize it, it is important to gather all Higgs decay channels: $h \rightarrow bb$, $h \rightarrow WW$, $h \rightarrow \gamma\gamma$, $h \rightarrow \tau\tau$;

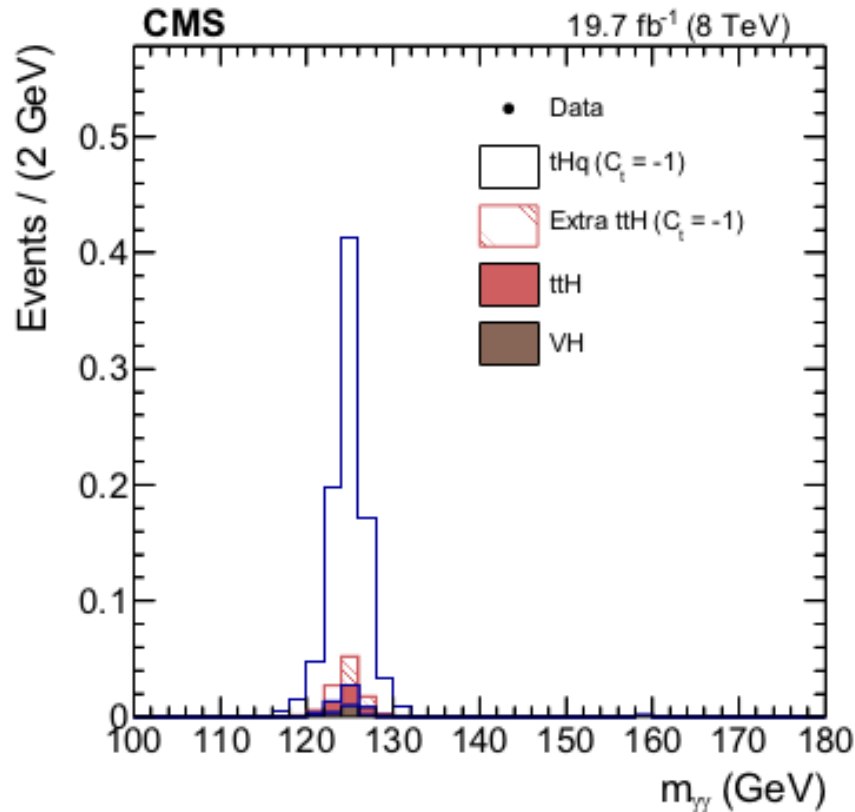
The main backgrounds in these channels are coming from the processes of *tt* production in association with light, heavy flavor jets, as well as *W, Z* bosons. Analysis is most sensitive to the quality of jet measurements and *b*-tagging efficiency, as well as theoretical calculation of multijets processes cross sections.

Experimental results: CMS experiment

The Higgs + single top signal on top of the backgrounds in the ICT scenario.
 $h \rightarrow bb$ channel, neural network outputs.



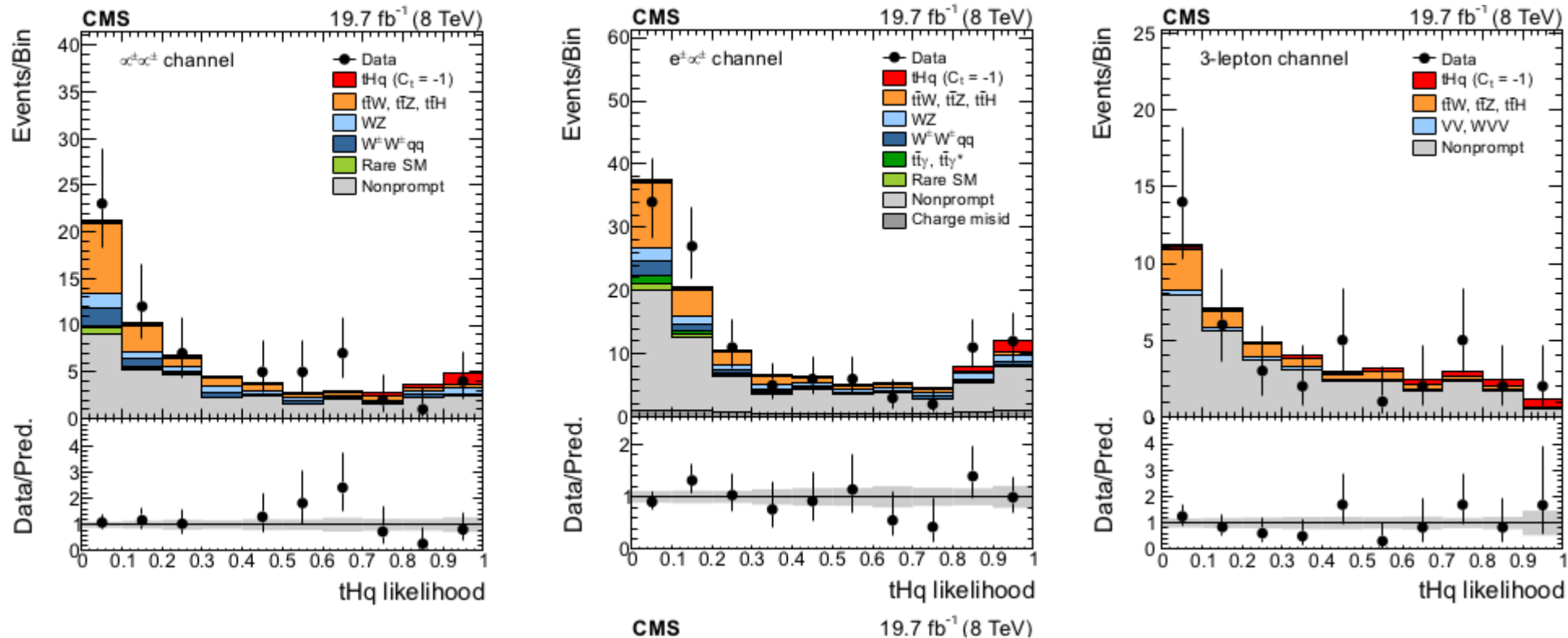
Experimental results: CMS experiment



The Higgs + single top signal on top of the backgrounds in the ICT scenario. $h \rightarrow \gamma\gamma$ channel, invariant mass of the 2 photons.

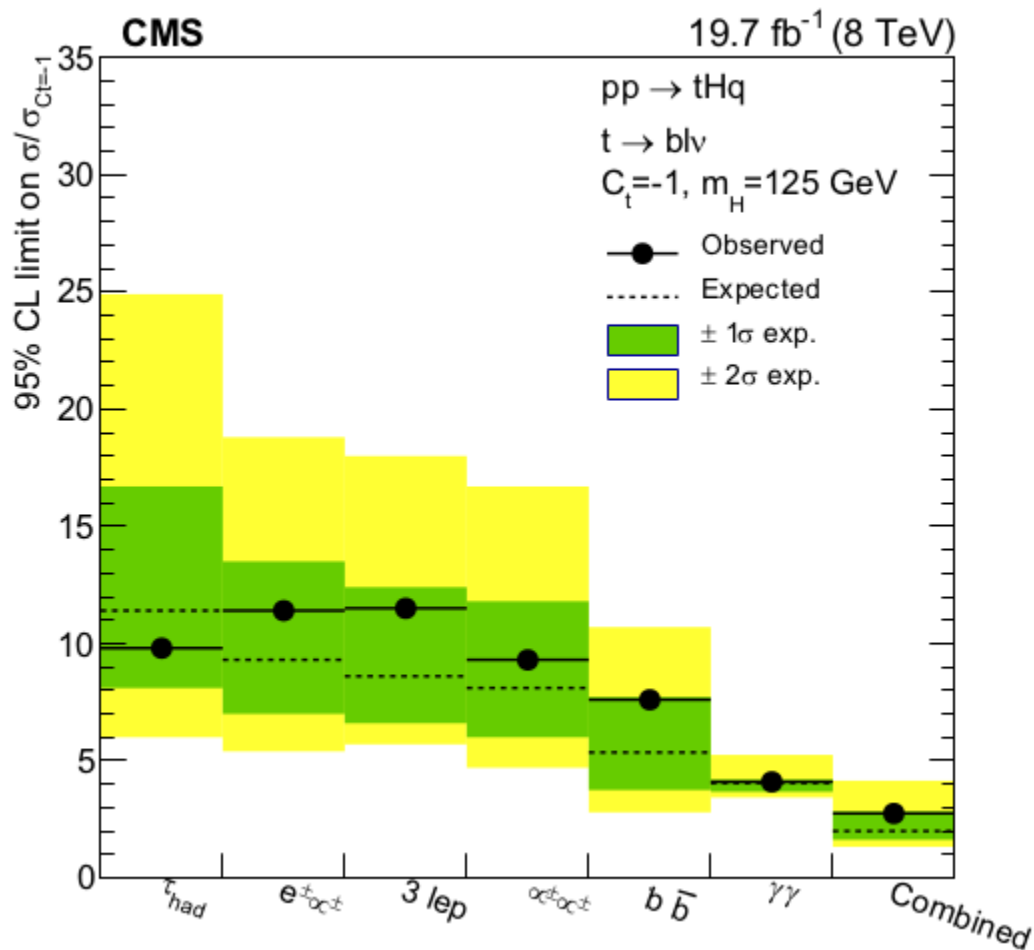
0 events in data are observed.

Experimental results: CMS experiment



The Higgs + single top signal on top of the backgrounds in the ICT scenario. Multilepton channels, likelihood discriminator.

Experimental results: limits



The limit on the $h+t$ cross section in different channels + combination of all channels based on 8TeV pp collisions;

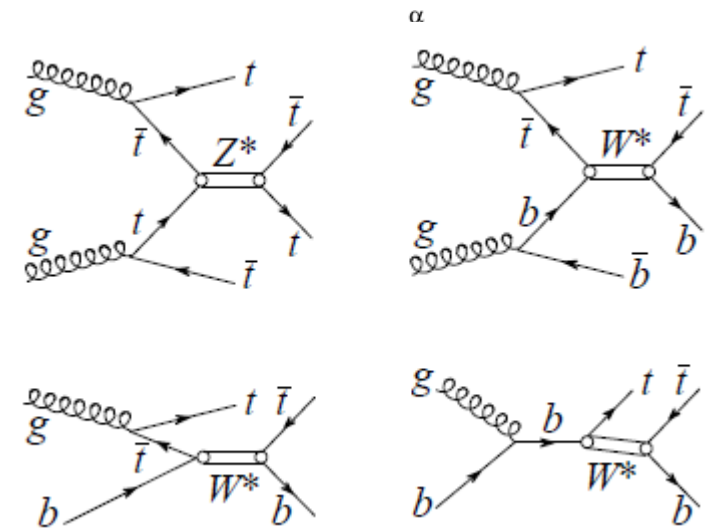
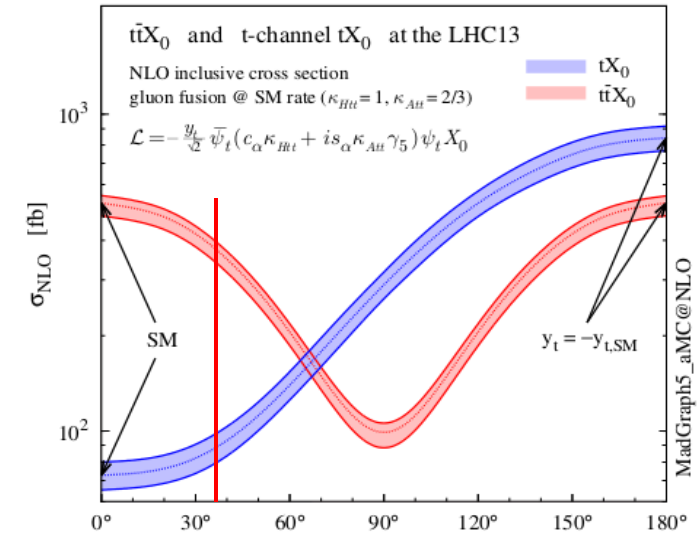
Limit is presented in units of $h+t$ cross section in the ICT scenario.

The expected limit is $2.0 \times \sigma_{Ct = -1}$
the observed limit is $2.8 \times \sigma_{Ct = -1}$ at 95% C.L.

We expect to be sensitive to ICT scenario with Run II data... while to confirm the SM scenario, few times more statistics needed.

Conclusions and plans

1. The ICT is not the only possible BSM scenario: any BSM physics can contribute to th - tW relative phase, so it can be observed somewhere between 0 and 180, not contradicting the current measurements;
2. 4 - top and 3 - top quark channels are perspective w.r.t. their potential to reveal BSM in heavy higgs, Z' , Z^* , etc., models;
3. The ICT scenario can reveal itself with the full Run II data, and the SM measurement can be done with 4-5 times more data statistics.



Plot from Phys. Atom. Nuclei (2016) 79: 721.