Measurement of the ttH production cross-section in multi-lepton final states in pp collisions with the ATLAS detector

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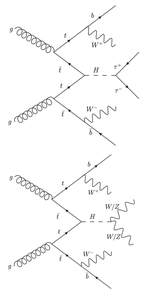
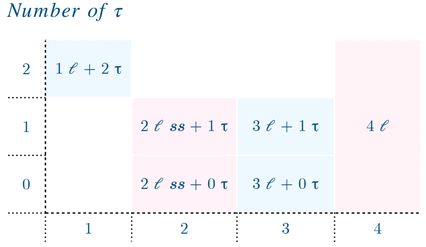
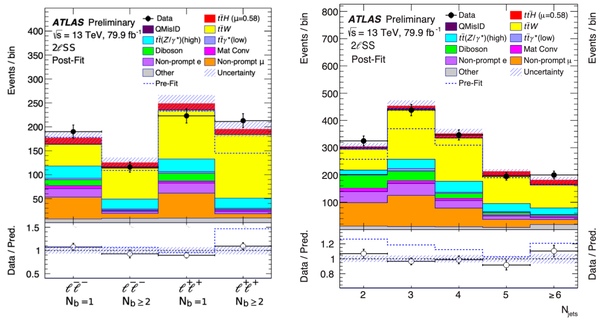
Introduction

- The top-quark Yukawa coupling can be probed directly by measuring the $t\bar{t}H$ production cross-section.
- A search for the production in multilepton final states was performed, based on an integrated luminosity of 80 fb^{-1} [1].
- Six final states were analysed, categorised by the number and flavour of lepton candidates.
- The best-fit value of the observed production cross-section is $\sigma(t\bar{t}H) = 294^{+182}_{-162}\ fb$, in agreement with the SM prediction of $507^{+35}_{-50}\ fb$.





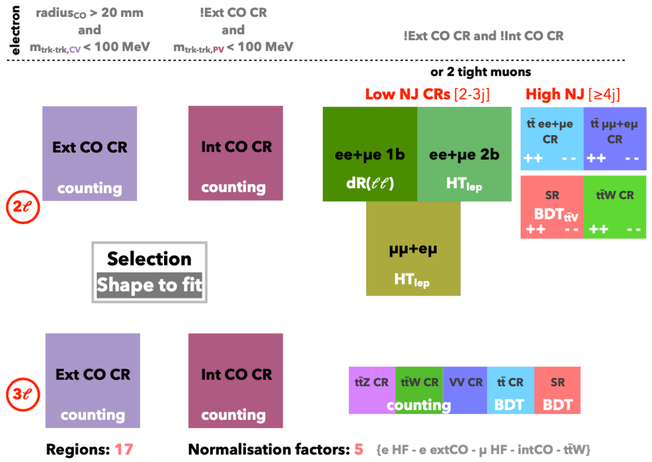
Challenge: ttW bkg



- Significant mismodeling observed of $t\bar{t}W$.
  - Normalisation factor of ttW in different channels, $\lambda^{2lLJ} = 1.56^{0.30}_{-0.28}$, $\lambda^{2lHJ} = 1.26^{0.19}_{-0.18}$ *and* $\lambda^{3l} = 1.68^{0.30}_{-0.28}$ ("LJ" for events with 3,4,5 jets and "HJ" for events with 6 jets)
  - Similar excesses observed in other studies, e.g. in 4tops cross-section measurement [2].
  - Latest CMS ttH multilepton result [3] also suggests a high normalisation factor $\lambda^{ttW} = 1.43 \pm 0.21$.

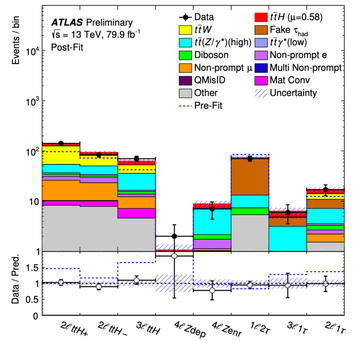
Key component: non-prompt leptons

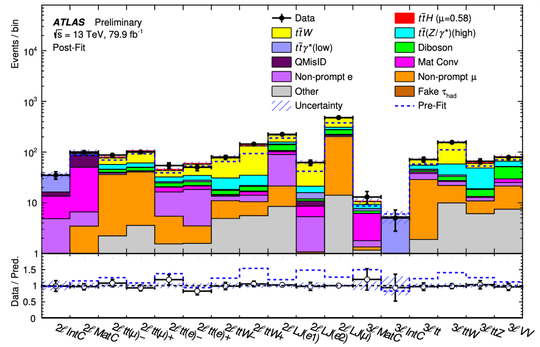
- The non-prompt leptons are from events with the same number of prompt leptons as the $t\bar{t}H$ signal, which includes $t\bar{t}V$, VV and rare processes ($t\bar{t}WW$, tH, tZ, WtZ, VVV, $t\bar{t}t\bar{t}$ and $t\bar{t}$).



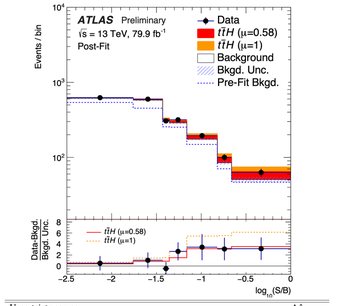
- **Template fit Method**: A semi-data-driven method, relies on the truth information to define different types of fake leptons. The normalisations of the different fakes are left free-floating in the fit to data.

Analysis model and results

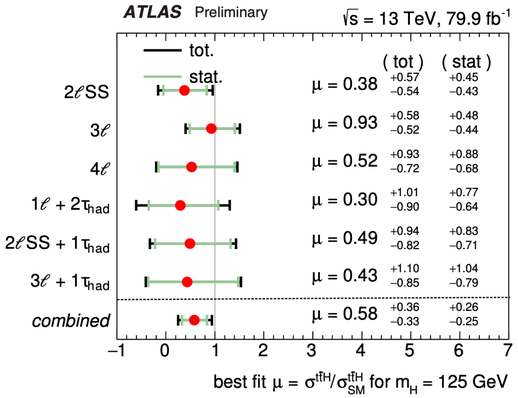




- Multivariate analysis techniques have been developed in all channels, except in $2lSS + 1\tau_{had}$ and $3l + 1\tau_{had}$ given the low statistics.



Uncertainty source	$\Delta\hat{\mu}$	
Jet energy scale and resolution	+0.13	−0.13
$t\bar{t}(Z/\gamma^*)$ (high mass) modelling	+0.09	−0.09
$t\bar{t}W$ modelling (radiation, generator, PDF)	+0.08	−0.08
Fake τ_{had} background estimate	+0.07	−0.07
$t\bar{t}W$ modelling (extrapolation)	+0.05	−0.05
$t\bar{t}H$ cross section	+0.05	−0.05
Simulation sample size	+0.05	−0.05
$t\bar{t}H$ modelling	+0.04	−0.04
Other background modelling	+0.04	−0.04
Jet flavour tagging and τ_{had} identification	+0.04	−0.04
Other experimental uncertainties	+0.03	−0.03
Luminosity	+0.03	−0.03
Diboson modelling	+0.01	−0.01
$t\bar{t}\gamma^*$ (low mass) modelling	+0.01	−0.01
Charge misassignment	+0.01	−0.01
Template fit (non-prompt leptons)	+0.01	−0.01
Total systematic uncertainty	+0.25	−0.22
Intrinsic statistical uncertainty	+0.23	−0.22
$t\bar{t}W$ normalisation factors	+0.10	−0.10
Non-prompt leptons normalisation factors (HF, material conversions)	+0.05	−0.05
Total statistical uncertainty	+0.26	−0.25
Total uncertainty	+0.36	−0.33



- The measured signal strength and cross-section of the $t\bar{t}H$ production:

$\hat{\mu} = 0.58^{+0.26}_{-0.25}\ (\text{stat.})^{+0.19}_{-0.15}\ (\text{exp.})^{+0.13}_{-0.11}\ (\text{bkg. th.})^{+0.08}_{-0.07}\ (\text{sig. th.}) = 0.58^{+0.36}_{-0.33}$

$\hat{\sigma}(t\bar{t}H) = 294^{+132}_{-127}\ (\text{stat.})^{+94}_{-74}\ (\text{exp.})^{+73}_{-56}\ (\text{bkg. th.})^{+41}_{-39}\ (\text{sig. th.})\ \text{fb} = 294^{+182}_{-162}\ \text{fb}$

References

[1] The ATLAS Collaboration, ATLAS-CONF-2019-045 (2019). [2] The ATLAS Collaboration, Eur. Phys. J. C 80, 1085 (2020). [3] The CMS Collaboration, CMS-PAS-HIG-19-008 (2019).