PROCEEDINGS OF SCIENCE

Tau-lepton Fake-Rate determination for the $t\bar{t}H$ coupling measurement using the ATLAS detector at the LHC

Santu Mondal[1,*]

Institute of Experimental and Applied Physics, Czech Technical University (CZ)
Silesian University in Opava (CZ)

E-mail: santu.mondal@cern.ch

A search for the associated production of a top-quark pair with the Higgs boson ($t\bar{t}H$) in multilepton final states is presented. The search is based on a dataset of proton–proton collisions at $\sqrt{s}$ = 13 TeV and an integrated luminosity of 80 fb^{-1} recorded with the ATLAS detector at the CERN Large Hadron Collider.

A synopsis of the final state with two same-charge light leptons (e or μ) and one hadronically-decaying τ is described in more detail. Non-prompt light leptons background is estimated from simulation, with data-driven corrections and fake τ_{had} backgrounds are estimated using data-driven techniques.

An excess of events consistent with $t\bar{t}H$ production, over the expected background from Standard Model processes, is found with an observed significance of 1.8 standard deviations, compared to an expectation of 3.1 standard deviations. Assuming Standard Model branching fractions, the best-fit value of the $t\bar{t}H$ production cross section is $\sigma_{t\bar{t}H} = 294^{+182}_{-162}$ fb, which is consistent with the Standard Model prediction.

40th International Conference on High Energy physics - ICHEP2020
July 28 - August 6, 2020
Prague, Czech Republic (virtual meeting)

[1]On behalf of the ATLAS Collaboration
*Speaker

https://pos.sissa.it/

PoS(ICHEP2020)100

ATL-PHYS-PROC-2020-089
09/11/2020

1. Introduction

In the Standard Model, the Higgs boson is predicted to couple most strongly to the top quark. The top-quark Yukawa coupling, expected to be of order unity, can be probed directly by measuring the cross section for associated production of a Higgs boson with a top-quark pair ($t\bar{t}H$).

The search of $t\bar{t}H$ production is performed in multilepton final states. It is sensitive to the decays $H \rightarrow WW^{*}$, $H \rightarrow \tau^{+}\tau^{-}$, and $H \rightarrow ZZ^{*}$. A search based on 80 fb^{-1} recorded with the ATLAS detector [1] during 2015-2017 at $\sqrt{s}$ = 13 TeV for $t\bar{t}H$ in multilepton final state is presented.

2. Event Selection

In $t\bar{t}H$ to multilepton analysis, six final states, termed channels, are categorised by the number and flavour of charged lepton candidates. The selection criteria are mutually exclusive such that each event only contributes to a single channel. The requirements of $2l\tau_{\text{had}}$ channel are two same-charge light leptons and one hadronically decaying τ-lepton candidate. Events must have at least four jets, of which at least one b-tagged. The selection requirements for each channel are summarised in Ref. [2]. The separation of the $t\bar{t}H$ signal from the background is achieved using multivariate techniques.

3. Background estimation

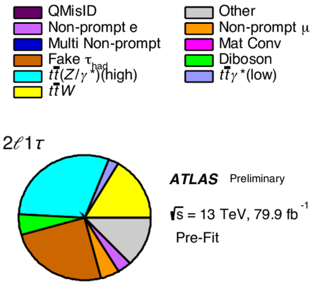
The main backgrounds to the $t\bar{t}H$ signal arise from $t\bar{t}W$, $t\bar{t}$(Z/γ^{*}), and diboson (VV) production, as well as from $t\bar{t}$ production with additional light leptons from heavy-flavour hadron decays, misidentified jets, or photon conversions (collectively referred to as “non-prompt leptons"). The other contributions are from the incorrect assignment of electron charge and misidentification of jets as τ_{had} candidates. The relative fractions in $2l\tau_{\text{had}}$ channel are shown in Figure 1.

In the $2l\tau_{\text{had}}$ channel, the fake τ_{had} background mainly arises from $t\bar{t}$ and $t\bar{t}V$ events with a jet misidentified as a τ_{had} candidate. A control region enriched in dileptonic $t\bar{t}$ event is used to determine the normalisation factor to correct a possible mismodelling of the fake τ_{had} rate in the simulation. The normalisation factor is measured as a function of $(p_T)_{\tau_{\text{had}}}$ is close to unity within the uncertainties [2]. The fraction of fake τ_{had} background with an electron misidentified as a τ_{had} candidate is 10% and it is estimated with the simulation. The total systematic uncertainty depends on $(p_T)_{\tau_{\text{had}}}$ and is on average about 13% (60%) for one-prong (three-prong) τ_{had} candidates.

4. Results

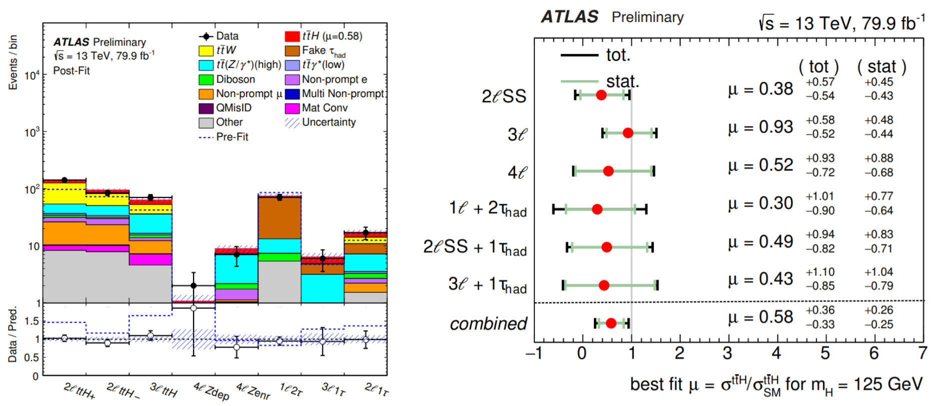
The significance of the observed (expected) excess above the background-only expectation (μ = 0) is 1.8 (3.1) standard deviations. The best-fit value of μ is $0.58^{+0.26}_{-0.25}$. The event yields and best-fit value of μ for each individual channel and the combination of all channels are shown in Figure 2 . The individual channel results are extracted from the full fit using a separate parameter of interest for each channel.

An extrapolation to the inclusive phase space, assuming Standard Model $t\bar{t}H$ kinematics, is made and the measured production cross section is $\sigma_{t\bar{t}H} = 294^{+182}_{-162}$ fb.



(a)

Figure 1: (a) Fractional contributions of the various backgrounds to the total predicted background in $2l\tau_{\text{had}}$ channel. Backgrounds with prompt leptons with misassigned charge are labeled as QMisID. Non prompt leptons originate from material conversions refer to "Mat Conv". The “Other" represents the rare processes ($tZ, tW, WtZ, t\bar{t}WW, VVV, t\bar{t}t, t\bar{t}t\bar{t}$, and tH). ATLAS preliminary [2]



(a) (b)

Figure 2: (a) Comparison between data and prediction for the event yields in eight $t\bar{t}H$ categories. (b) The observed best-fit value of the $t\bar{t}H$ signal strength μ and their uncertainties by analysis channel and combined. The Standard Model prediction corresponds to $\mu = 1$. ATLAS preliminary [2].

5. Conclusion

The expected ATLAS $t\bar{t}H$ significance for a Standard Model Higgs boson is 3.1 standard deviations. The best-fit result of the observed production cross section is $\sigma(t\bar{t}H) = 294^{+182}_{-162}$ fb, in agreement with the Standard Model prediction of 507^{+35}_{-50} fb.

References

[1] ATLAS Collaboration, 2008 JINST 3 S08003.

[2] ATLAS Collaboration, ATLAS-CONF-2019-045, http://cds.cern.ch/record/2693930.