Combination of searches study for $t\bar{t}t\bar{t}$ produced in proton-proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector

Mohammed Faraj , **Università di Udine / INFN Trieste - Gruppo collegato di Udine and ICTP**

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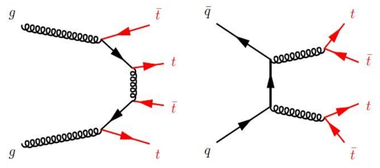
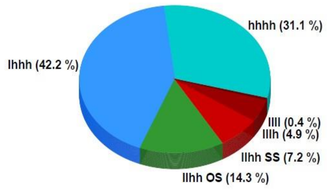
Abstract

The combination of two analyses searching for the production of $t\bar{t}t\bar{t}$ using proton-proton collision data at a center-of-mass energy $\sqrt{s}$ = 13 TeV with an integrated luminosity of 36 fb^{-1} recorded by the ATLAS experiment is presented. The considered final states are events with multiple jets, b-jets, and either: a) one lepton or two leptons with opposite charge, and b) two leptons with same electric charge or three leptons. Constraints are set on the Standard Model (SM) $t\bar{t}t\bar{t}$ production and on an effective field theory inducing four fermions contact interactions.

Four tops in the SM

The SM total cross-section for the production of four top quarks is predicted to be $\sigma_{SM}^{t\bar{t}t\bar{t}} \approx 9.2$ fb at next-to-leading-order in QCD accuracy at a center-of-mass energy $\sqrt{s}$ = 13TeV at the LHC. This process is characterized by several final states: this poster shows results from the single and opposite sign dileptons channels (OS 2l /1l+jets), with BR = 56.5%, and from the same sign dileptons and trilepton channels (SS 2l /3l+jets), with BR = 12.1%. Then, the combined analysis here presented covers 68.5% of all four tops decay channels, since the fully hadronic and fully leptonic decay modes are not included.

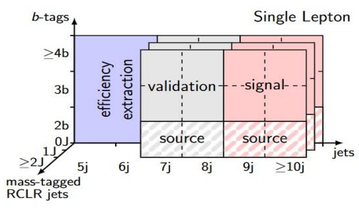


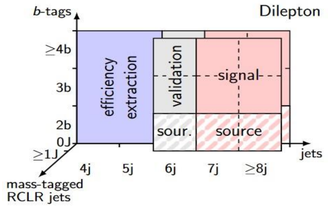


OS 2l /1l+jets

Preselection requirements		
Requirement	Single-lepton	Dilepton
Trigger	Single-lepton triggers	
Leptons	1 isolated	2 isolated, opposite-sign
Jets	≥5 jets	≥4 jets
b-tagged jets	≥2 b-tagged jets	
Other	$E_T^{miss} > 20$ GeV	$m_{\ell\ell} > 50$ GeV
	$E_T^{miss} + m_T^W > 60$ GeV	$\lvert m_{\ell\ell} - 91\text{ GeV}\rvert > 8$ GeV

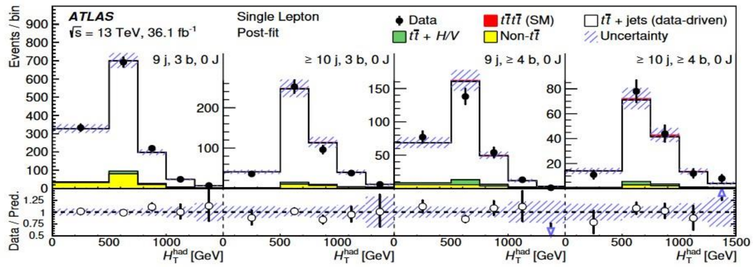
After preselection, events in the single lepton (OS dileptons) channel in the signal regions are required to have at least 10 (8) jets, at least 3 b-tagged jets and are further categorized with respect to the number of reclustered large R jets (RCLR).





Results for OS 2l /1l+jets

- **The main background:** is the $t\bar{t} + jets$.



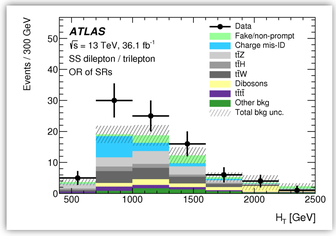
SS 2l /3l+jets

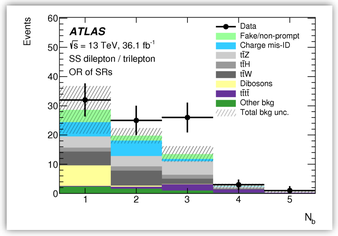
The signal regions for dilepton same sign (three leptons) events are defined as in the following:

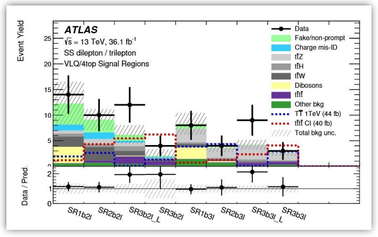
Region name	N_j	N_b	N_ℓ	Lepton charges	Kinematic criteria
SR1b2ℓ	≥ 1	1	2	++ or −−	$H_T > 1000$ GeV and $E_T^{miss} > 180$ GeV
SR2b2ℓ	≥ 2	2	2	++ or −−	$H_T > 1200$ GeV and $E_T^{miss} > 40$ GeV
SR3b2ℓ_L	≥ 7	≥ 3	2	++ or −−	$500 < H_T < 1200$ GeV and $E_T^{miss} > 40$ GeV
SR3b2ℓ	≥ 3	≥ 3	2	++ or −−	$H_T > 1200$ GeV and $E_T^{miss} > 100$ GeV
SR2b3ℓ	≥ 2	2	3	any	$H_T > 1200$ GeV and $E_T^{miss} > 100$ GeV
SR3b3ℓ_L	≥ 5	≥ 3	3	any	$500 < H_T < 1000$ GeV and $E_T^{miss} > 40$ GeV
SR3b3ℓ	≥ 3	≥ 3	3	any	$H_T > 1000$ GeV and $E_T^{miss} > 40$ GeV

Results for SS 2l /3l + jets

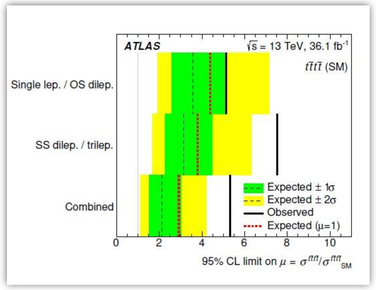
- **The main backgrounds:** are $t\bar{t}H$ **and** $t\bar{t}W/Z$.

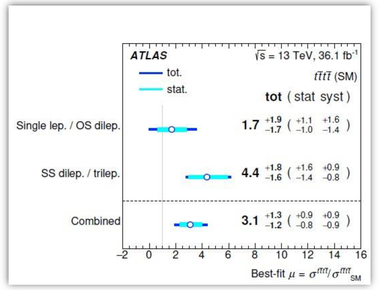






Combined Results





- The expected sensitivity from the combination of the two analysis channels gives an **observed** (**expected**) significance over the expected background, equal to **2.8** (**1.0**) **σ.**
- By assuming no signal, the observed (expected) 95% CL upper limit on the SM four-top-quark production cross section is 49 fb (19 fb).

Conclusion/future work

- No significant excess of events over background expectations was found.
- At present, a new analysis is using the full 13 TeV data set with an integrated luminosity of 140.3 fb^{-1} collected between 2015-2018 to increase statistics in signal regions. In the future, new techniques to increase the sensitivity of this search will be used.

References

- ATLAS Collaboration, Search for four-top-quark production in the single-lepton and opposite-sign dilepton final states using 36.1 fb^{-1} of proton-proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector at the LHC. 2019, Phys. Rev. D 99, 052009 (2019).
- ATLAS Collaboration, *Search for* new phenomena in events with same-charge leptons and b-jets in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector. 2018, JHEP 1812 (2018) 039.