Search for the SM Higgs boson produced in association with top quarks (ttH) at $\sqrt{s}$ = 13 TeV with the ATLAS detector at the LHC

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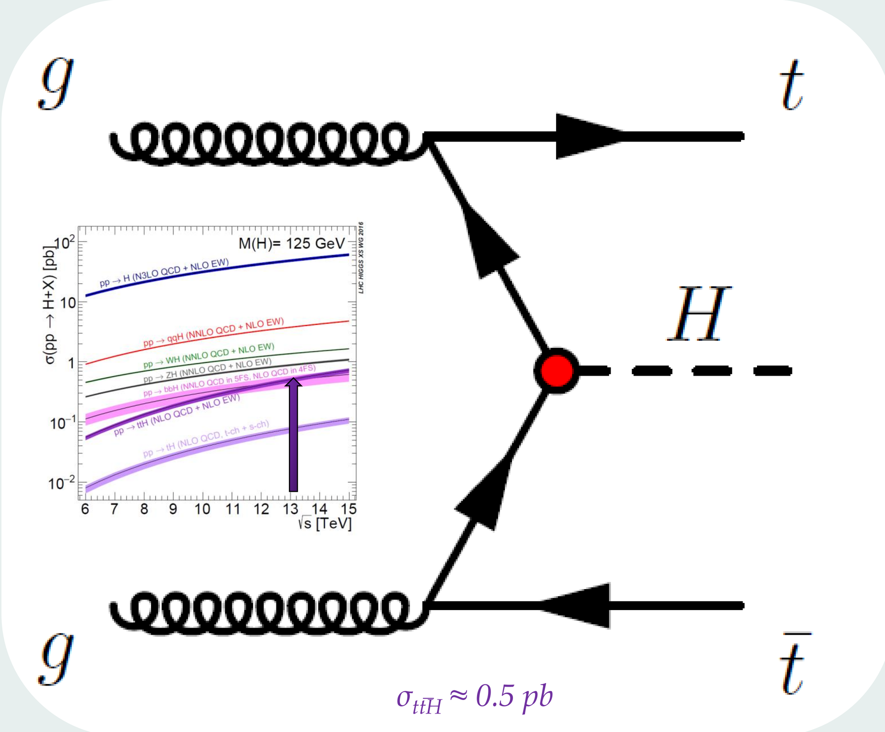
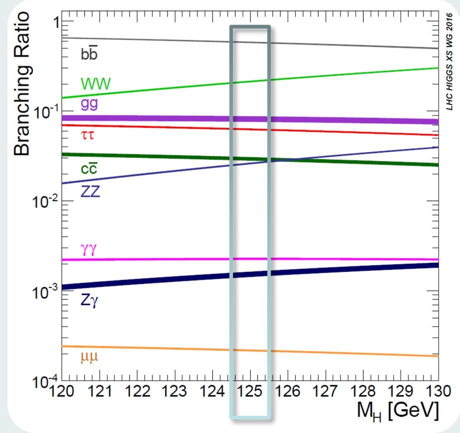
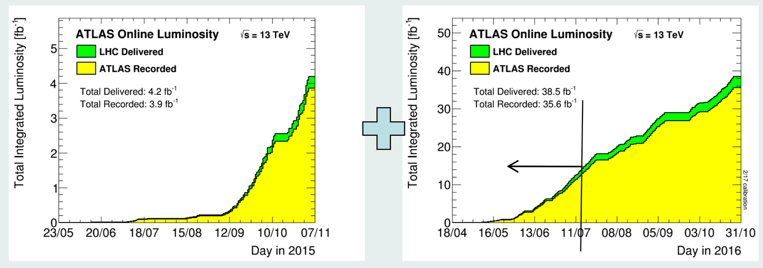
Introduction and motivations

- Presented today: **associated top-Higgs production (ttH)**
- Due to its small production cross-section (~1% of total Higgs boson cross-section), this production mechanism has not been directly observed
- Indirect constraints on the top-Higgs Yukawa coupling come from ggF and H→γγ (through loop)
- ttH production allows direct (tree level) probe of top-Higgs Yukawa coupling
- Any deviation could be a hint of new physics
- ATLAS+CMS Run I result: observation at **4.4σ** (2.0σ exp.) [1]



- Can be studied in a variety of final states/channels, depending on the top quark decay topology and the Higgs boson decay mode: **γγ, WW/ZZ/ττ** (multi-lepton) and **bb**
- Results here based on 2015 + partial 2016 data, 13.2 fb^{-1}

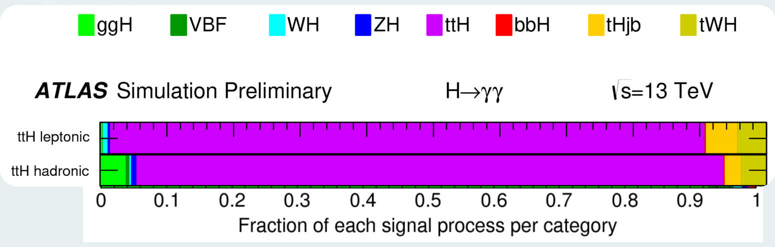




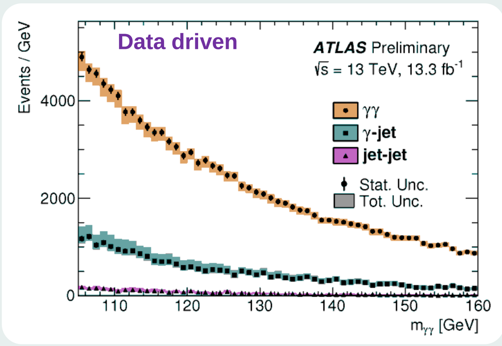
Analyses presented

• ttH, H → γγ [2]

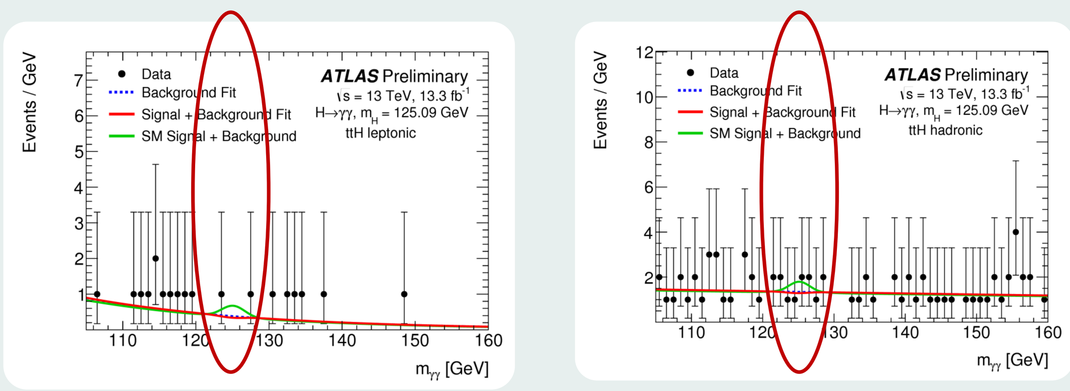
- Clean signature thanks to excellent mass resolution, but small branching ratio (BR ~ 0.23%)
- 2 channels, depending on the top quark pair system decay: all-hadronic and (semi)leptonic
- Events selected and categorised in regions enriched with ttH production mode



- Looking for narrow signal peak in the di-photon invariant mass spectrum on top of a smothly falling background

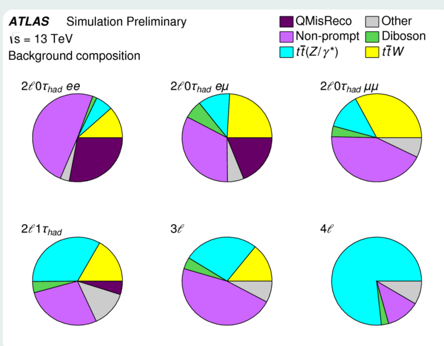


- Control regions with inverted photon identification for background (γγ, γ-jet and jet-jet) estimation
- Search dominated by statistical uncertainties



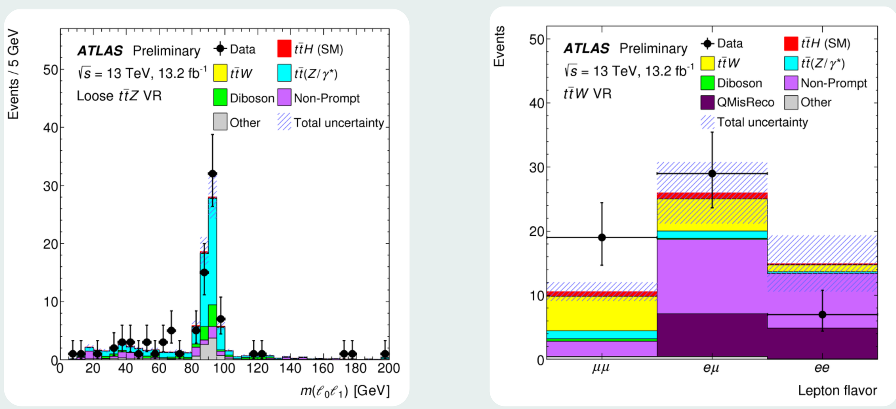
• ttH, H → WW/ZZ/ττ [3]

- (Semi)-leptonic final states with low background, but with additional sensitivity to ttW/ttZ background
- Cut-and-count analysis in 4 categories, depending on the number, charge and flavour of leptons (ℓ): 2 same sign (ss) ℓ+0τ_{had}, 2ssℓ+1τ_{had}, 3ℓ and 4ℓ

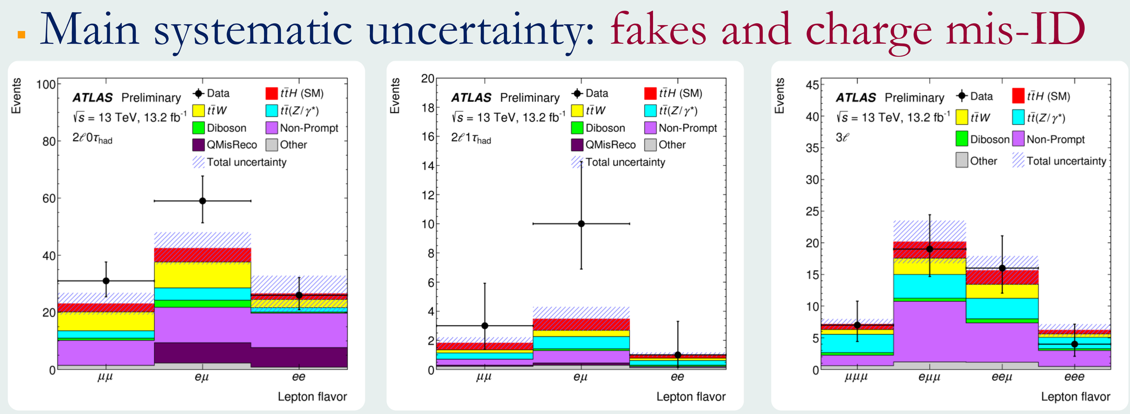


	Higgs boson decay mode				$A\times\epsilon$
Category	WW^*	$\tau\tau$	ZZ^*	Other	$(\times10^{-4})$
$2\ell0\tau_{had}$	77%	17%	3%	3%	14
$2\ell1\tau_{had}$	46%	51%	2%	1%	2.2
3ℓ	74%	20%	4%	2%	9.2
4ℓ	72%	18%	9%	2%	0.88

- 3 validation regions in order to study ttV background, data driven estimations of non-prompt lepton, fake τ, and processes with mis-identified charged lepton

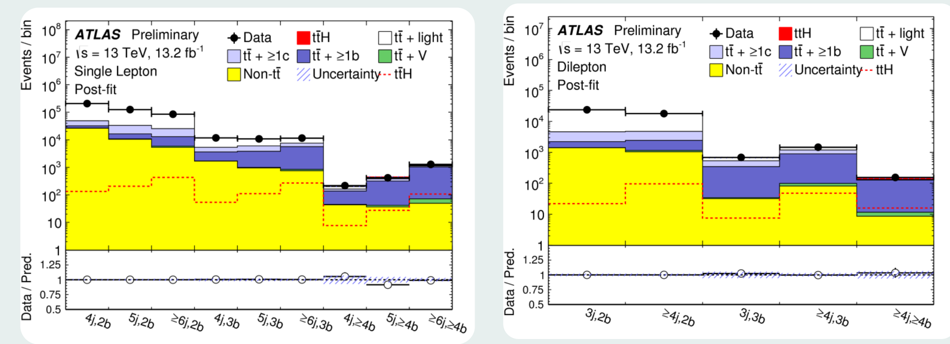


- Main systematic uncertainty: fakes and charge mis-ID

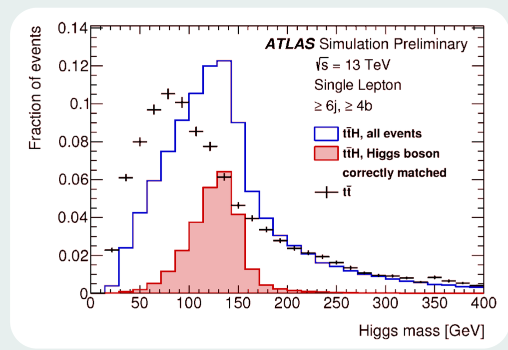


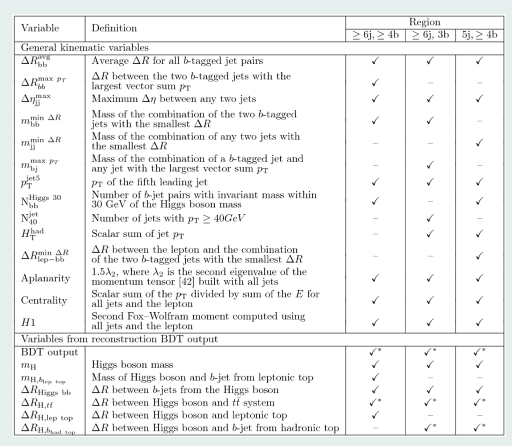
• ttH, H → bb [4]

- Small signal on top of large background dominated by production of tt+heavy flavour (HF) jets
- 2 channels, depending on the top quark pair system decay: single lepton (1ℓ) and opposite-sign dilepton (2ℓ)
- Events categorised according to jet and b-jet multiplicities: 6 control (CR) and 3 signal regions (SR) in 1ℓ and 2 CR and 3 SR in 2ℓ channels

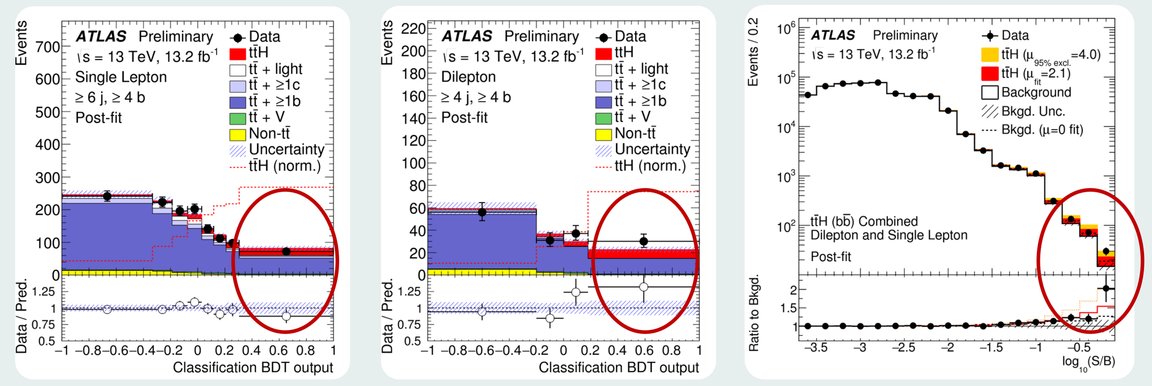


- Analysis strategy uses 2-step multivariate technique: reconstruction BDT (match jets) and discrimination NN/BDT (kinematics)



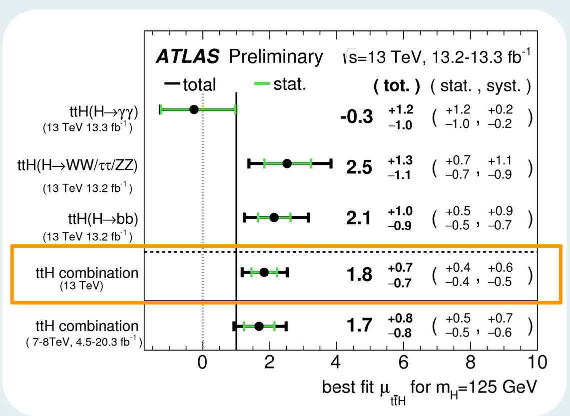


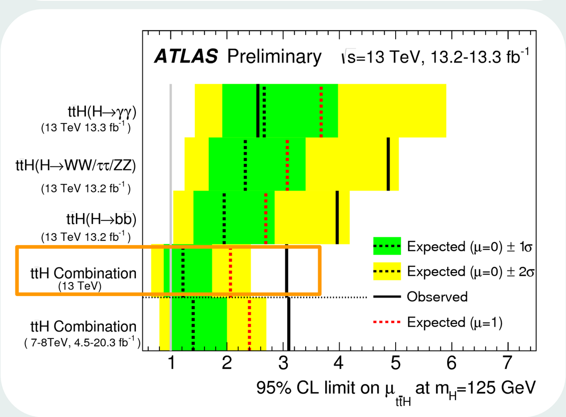
- Theory uncertainty on tt+HF dominates the search



Combination and prospects

- Combination of the three presented ATLAS ttH analyses [5]:
- Measured signal strength **μ = 1.8 ± 0.7**
- Corresponds to an observed (expected) significance of **2.8σ** (**1.8σ**) and exceeds the Run I ATLAS expected significance (1.5σ)
- Observed (expected) 95% C.L. limit on μ is 3.0 (2.1)





- All three analyses are within 1.5σ of the central value
- Largest systematic uncertainty contribution is related tt+b/c modelling uncertainties affecting the ttH(H→bb) analysis

- Projections with full 2015+2016 LHC data
- Optimistic projection with 2015 + full 2016 data (36.5 fb^{-1}), after several optimisations, combination could achieve **3σ**
- Work in progress within ATLAS: updates soon!
- At HL-LHC with L=3000 fb^{-1}, expected precision on ttH signal strength using only **H→γγ** [6]:

	$\Delta\hat{\mu}/\hat{\mu}$ (%)			
Production mode	Total	Statistical	Experimental	Theoretical
$t\bar{t}H$	$^{+21}_{-17}$	$^{+13}_{-12}$	$^{+5}_{-4}$	$^{+17}_{-11}$

References

[1] ATLAS and CMS Collaborations, JHEP 08 (2016) 045
[2] ATLAS Collaboration: ATLAS-CONF-2016-067 (2016)
[3] ATLAS Collaboration: ATLAS-CONF-2016-058 (2016)
[4] ATLAS Collaboration: ATLAS-CONF-2016-080 (2016)
[5] ATLAS Collaboration: ATLAS-CONF-2016-068 (2016)
[6] ATLAS Collaboration: ATL-PUB-2014-012 (2014)