# Latest ATLAS results on ttHbb Analysis

**[ATLAS-CONF-2020-058]**





**TOP-LHC-France 2021**

Centre de Physique des Particules de Marseille

Aix-Marseille Université / IN2P3-CNRS

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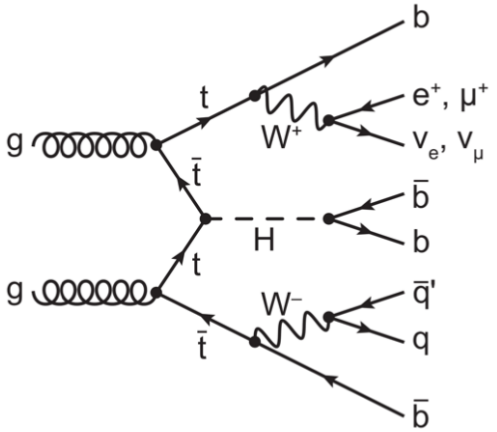
# Introduction

## Top Yukawa coupling

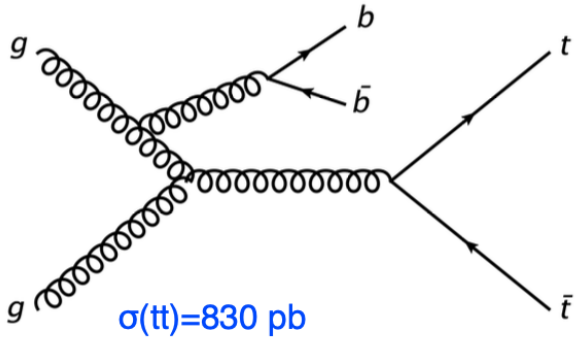
- Probing the **top-Higgs Yukawa** $y_t$: Largest in SM and sensitive to potential New Physics (BSM)
- ttH production provides direct probe of $y_t$
- Higgs measurement explored through **Simplified Template Cross Sections (STXS)** formalism




σ(ttH)xBR(H->bb) = 0.3 pb

## ttH(bb) leptonic channels

- **ttH(bb)** channel exploits the large branching ratio of **H→bb (58%)** and the leptonic decays of top quarks ⇒ distinctive signature
- Two channels based on the number of leptons in the final state: **single-lepton** and **di-lepton**
- **Challenges**: Modeling of tt+HF background due to large **irreducible background** with **big theoretical uncertainty** (from tt+bb)
- Higgs boson reconstruction challenging due to b-jet combinatorics




σ(tt)=830 pb
σ(tt+b-jets) ~ O(10) pb

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**Measurement of the ttH production with ttH(bb) events using full Run-2 (139 fb$^{-1}$) luminosity with 1 or 2 leptons (e/$\mu$) in final state**

**Similar analysis to** 36.1 fb$^{-1}$ Phys.Rev.D 97 (2018) 072016 **with updates:**

## Categorization

- Signal regions defined by #**leptons**, #**jets**, #**b-tagged jets (4 working points)** and **boosted Higgs + top tagging DNNs**
- Splitting the single-lepton channel into **boosted** and **resolved** channels
- Events split into $p_T^H$ bins, matching **STXS** $p_T^H$ bins
- Define **CRs** to constrain **tt+$\geq$1b** and **tt+$\geq$1c**

## Reconstruction

- **BDTs** trained on **signal events** to match reconstructed jets to the partons emitted from **top-quark** and **Higgs-boson decays** in resolved channel
- **DNN** trained to identify boosted Higgs and tops in boosted channel

## Classification

- **BDTs** trained to discriminate signal (**ttH**) from **backgrounds** depending on channel

| Region | Dilepton | | | | Single-lepton | | | |
|---|---|---|---|---|---|---|---|---|
| | $SR^{\geq 4j}_{\geq 4b}$ | $CR^{\geq 4j}_{3b\ hi}$ | $CR^{\geq 4j}_{3b\ lo}$ | $CR^{3j}_{3b\ hi}$ | $SR^{\geq 6j}_{\geq 4b}$ | $CR^{5j}_{\geq 4b\ hi}$ | $CR^{5j}_{\geq 4b\ lo}$ | $SR_{boosted}$ |
| #leptons | = 2 | | | | = 1 | | | |
| #jets | $\geq 4$ | | | = 3 | $\geq 6$ | = 5 | | $\geq 4$ |
| #$b$-tag @85% | – | | | | $\geq 4$ | | | |
| #$b$-tag @77% | – | | | | – | | | $\geq 2^{\dagger}$ |
| #$b$-tag @70% | $\geq 4$ | = 3 | | | $\geq 4$ | | | – |
| #$b$-tag @60% | – | = 3 | < 3 | = 3 | – | $\geq 4$ | < 4 | – |
| #boosted cand. | – | | | | 0 | | | $\geq 1$ |
| Fit input | BDT | Yield | | | BDT/Yield | $\Delta R^{avg}_{bb}$ | | BDT |

- Background estimate: **tt+$\geq$1b** largest background in all regions
- **tt+light** jets is small due to tightened and simplified b-jet requirements

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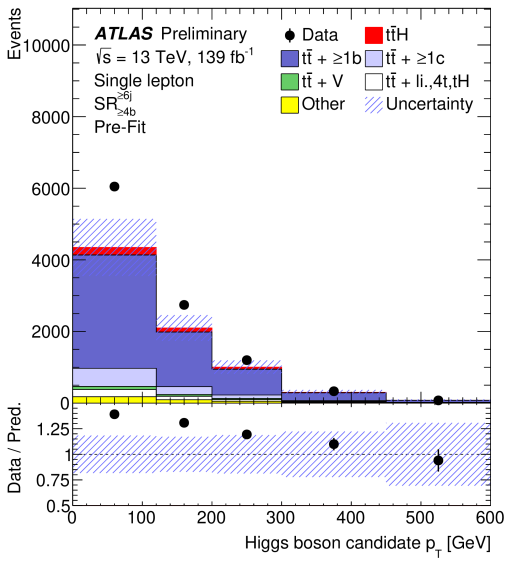
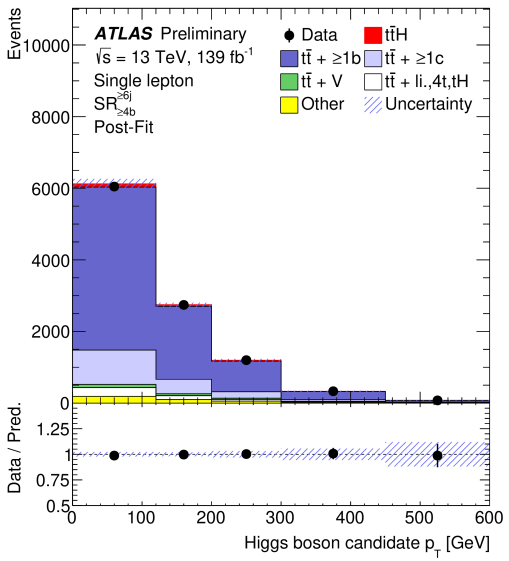
- **tt+bb NLO 4FS** simulation used in this analysis for nominal **tt+≥1b** background estimate

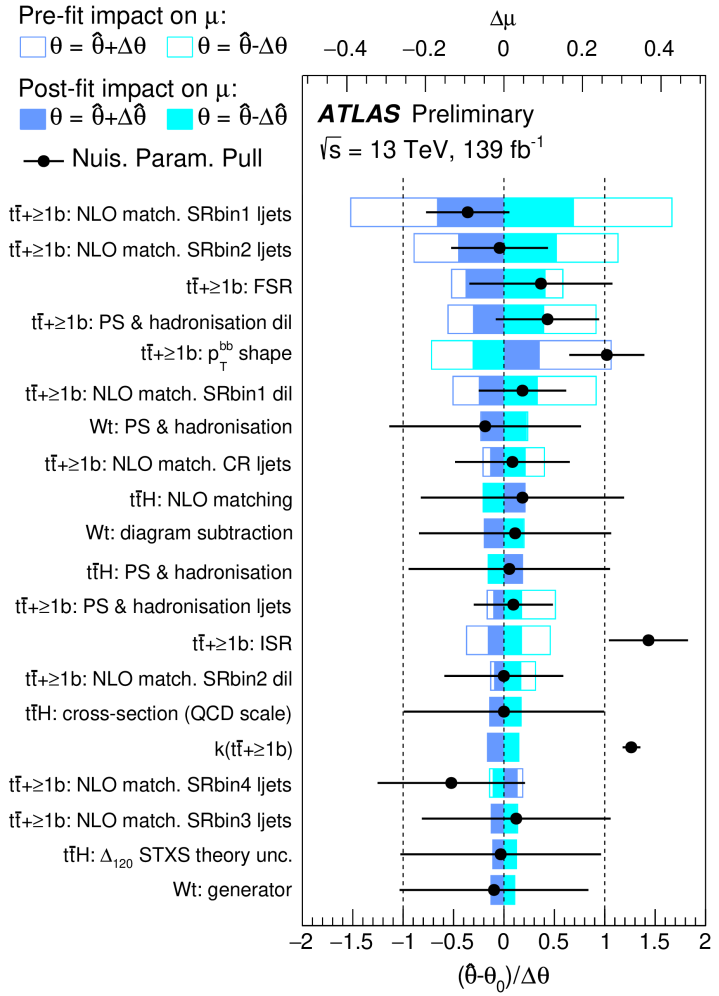
- Different samples are used to model and assign the **uncertainties** from **initial** and **final state radiation**, **parton shower** and also **NLO matching** uncertainties on relative fractions of **tt+bb** sub-components

- To correct the $p_T^H$ **shape in the fit**, data/MC uncertainty was derived from inclusive single-lepton and di-lepton regions

- Normalisation of **tt+≥1b** estimated with free-floating parameter in the signal extraction fit to data ⇒ $\mathbf{1.25^{+0.09}_{-0.08}}$



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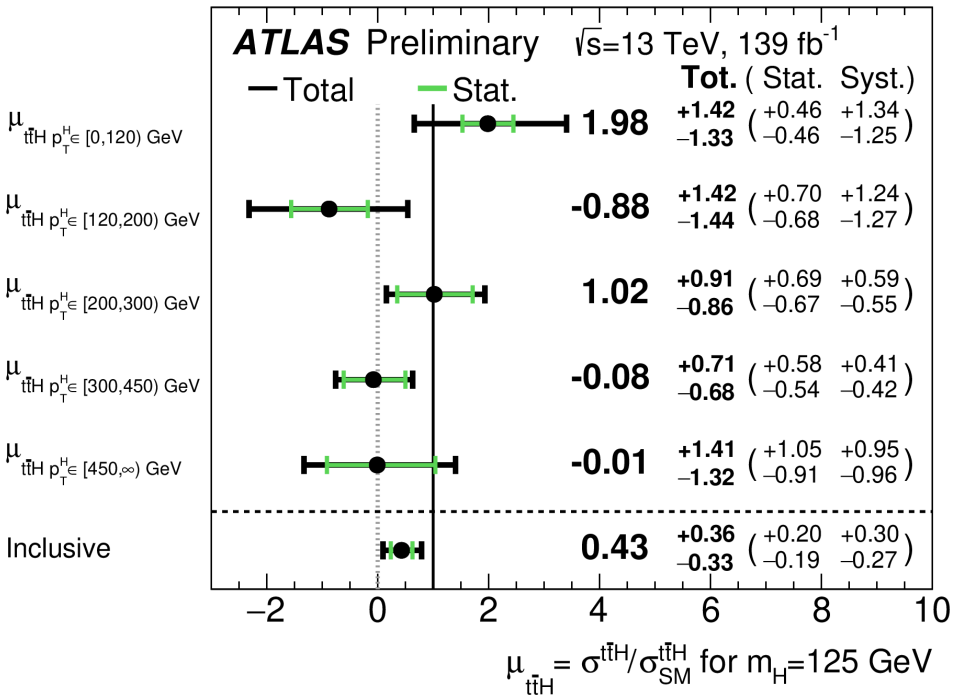
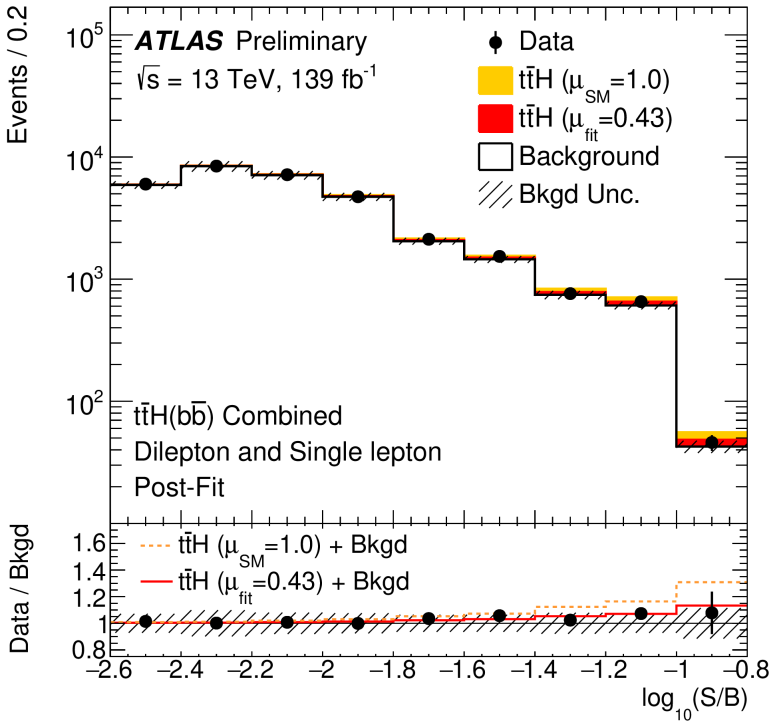
- The measurement **uncertainty** is **dominated** by systematic uncertainties, in particular from **tt+≥1b modeling**
- **Observed significance ⇒ 1.3 and (expected significance ⇒ 3.0)**
  $\left(1.4\ (1.6) \text{ for } 36.1\ \text{fb}^{-1}\right)$
- The first **differential measurement** of the ttH signal strength performed in five $p_{\mathrm{T}}^{H}$ bins in the **STXS** framework
- **Inclusive measurement of ttH signal-strength: $\mu = 0.43^{+0.36}_{-0.33}$**



**Thank you for your attention!**