Search for $t\bar{t}H$ production in the 4lepton+Jets channel at $\sqrt{s}$ =13 TeV using 13.2 fb^{-1} data collected by the ATLAS detector at the LHC

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Why search for $t\bar{t}H$ production?

- Powerful probe to measure Yukawa coupling of the Higgs boson to the top quark
- May provide key insights about the underlying mechanisms of Electroweak Symmetry Breaking
- Has potential to identify and disambiguate new physics effects that can modify the $t\bar{t}H$ production cross section relative to the SM expectation

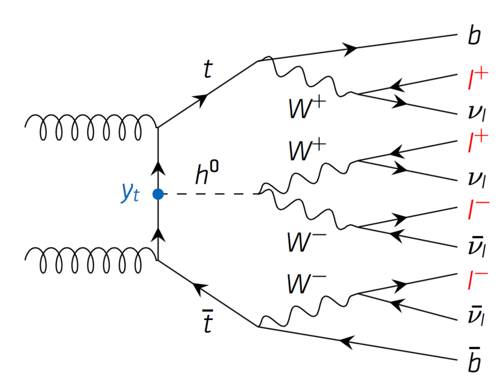

Figure 1: $ttH \to 4l$ Feynman diagram

$t\bar{t}H$ in 4lepton final state

- Good signal/background
- Very pure channel as fraction of non-prompt leptons in 4l channel is very low compared to other channels

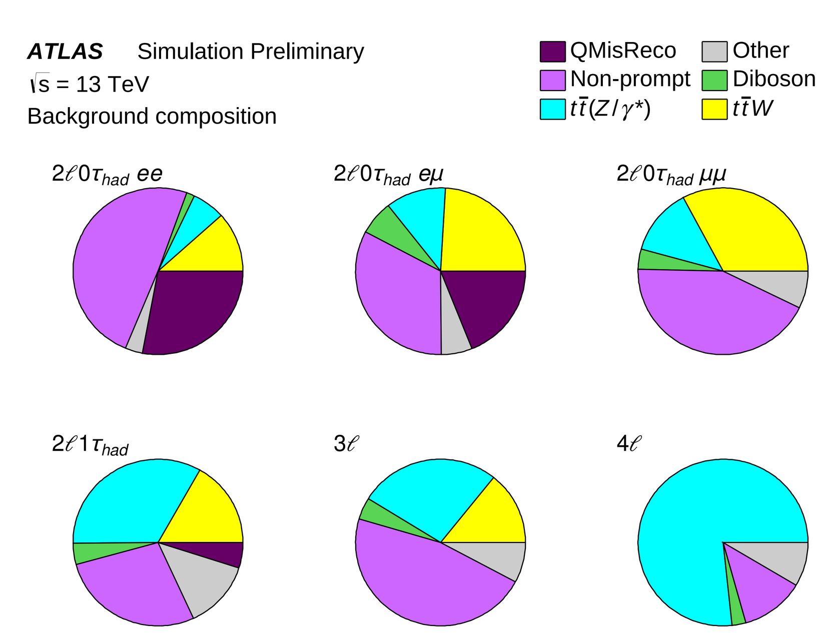

Figure 2: Background composition in the signal region

- Totally statistics limited channel; Has a great potential with more data

Higgs decay mode			
$\tau\tau$	WW^*	ZZ^*	Other
18%	72%	9%	2%

Table 1: Fraction of the expected $t\bar{t}H$ signal arising from different Higgs decay modes in 4lepton final state

Background Rejection

To reduce the background, we applied following selection cuts.

Selection Cut	Reduced Background
Exactly 4 tight isolated leptons $\ni \Sigma_i q_i$=0	$t\bar{t}$ & Non-prompt lepton events
M(l^+l^-,OSSF) $\notin$ [81.2,101.2] GeV	ZZ & $t\bar{t}Z$
M(l^+l^-,OSSF) > 12 GeV	Quarkonium decays
$\geq$ 2-jets with $\geq$ 1-btagged jet	ZZ
M($l_0l_1l_2l_3$) $\in$ [100,350] GeV	ttZ
M($l_0l_1l_2l_3$) $\notin$ [120,130] GeV	$H->ZZ$

Table 2: Signal Region selection cuts; (OSSF = Opposite Sign Same Flavor)

Estimation of fake lepton backgrounds

- Used semi data-driven "Fake Scale Factor" method
- Underlying idea is to correct Monte Carlo predictions according to lepton flavor and nature of environment in which it is produced
- Correction factors λ_l^e, λ_b^e, λ_l^μ, λ_b^μ are extracted from regions enriched in light and heavy flavor (b) fakes.

$$N^{f,\mathrm{CR}}_{\mathrm{Data}} - N^{f,\mathrm{CR}}_{\mathrm{others}} = \lambda_l^f \cdot N^{f,\mathrm{CR}}_{t\bar{t}} + \lambda_b^f \cdot N^{f,\mathrm{CR}}_{Z+\mathrm{jets}} \qquad (1)$$

$t\bar{t}Z$ Validation Region

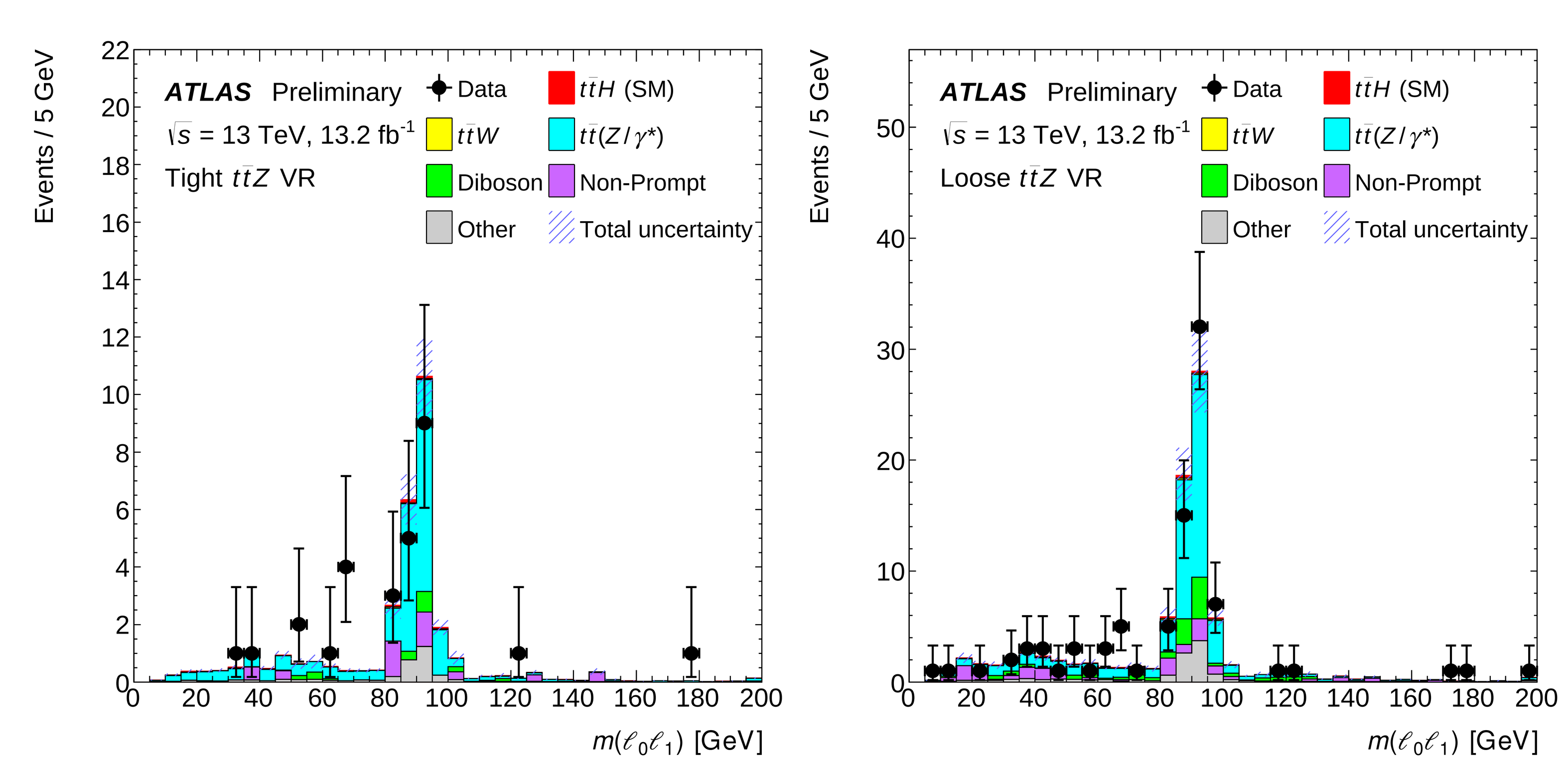

Figure 3: Invariant mass of leptons 0 and 1 for the a) tight and b) loose ttZ validation regions.

Further details: **ATLAS-CONF-2016-058**

Observed Event Yields

Expected signal, background yields and observed data events at $\mathcal{L}$=13.2/fb

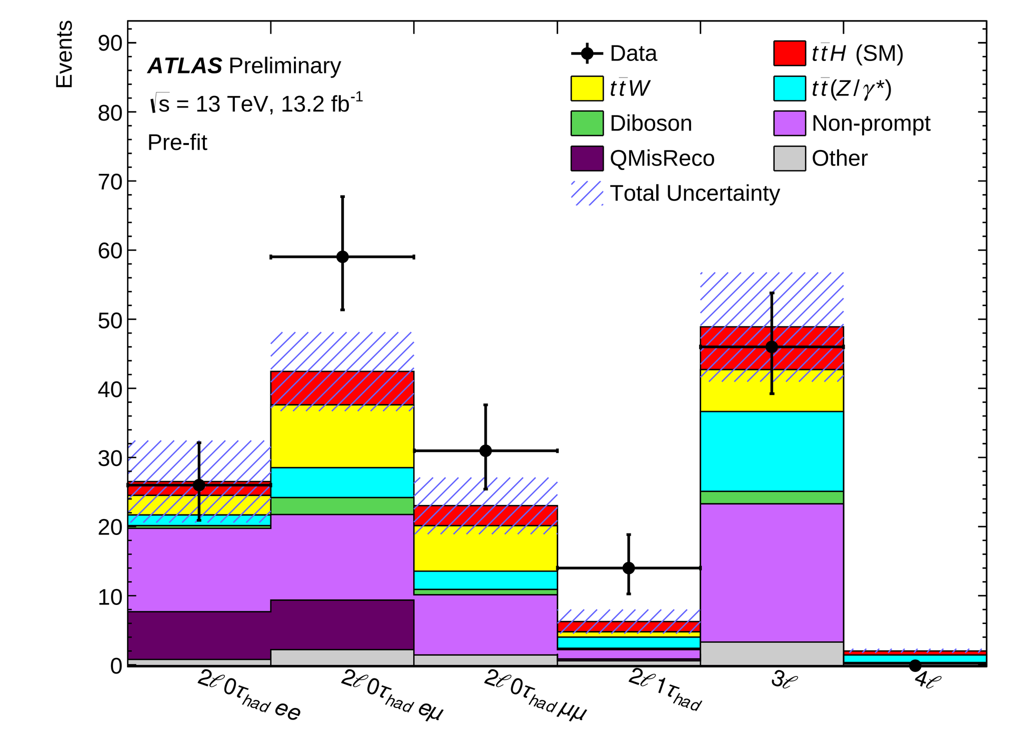

Figure 4: Signal and background predictions and observed data for each final state

$t\bar{t}Z/\gamma^*$	Diboson	Non-prompt leptons	Other
1.12 ± 0.20	0.04 ± 0.04	0.18 ± 0.10	0.12 ± 0.05

ttH	Total background	Data
0.59 ± 0.10	1.46 ± 0.25	0

Table 3: Expected and observed yields in the $t\bar{t}H->4l$ signal region.

Results

- Dominant systematic uncertainties come from $t\bar{t}Z$ theory

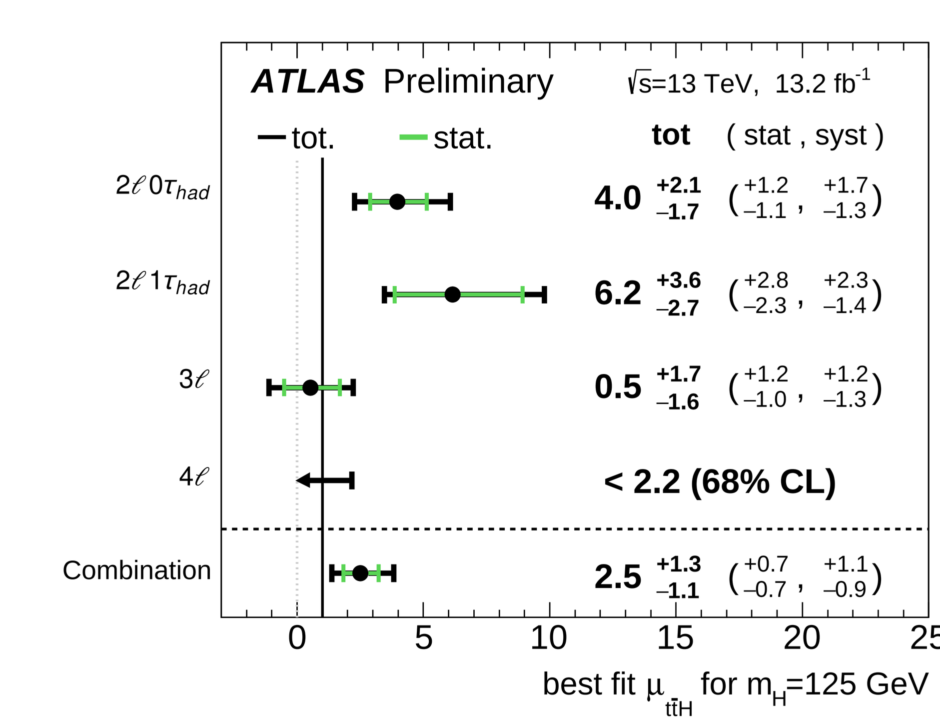

Figure 5: The best-fit value of the $t\bar{t}H$ signal strength is obtained using maximum likelihood fit to observed data yields

$$\text{Best fit } \mu_{t\bar{t}H} = \frac{\sigma^{t\bar{t}H}}{\sigma^{t\bar{t}H}_{SM}} = 2.5^{+1.3}_{-1.1}$$