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Search for the Standard Model Higgs boson produced in association with top quarks and decaying into a $b\bar{b}$-pair at $\sqrt{s}$ = 8 TeV with the ATLAS detector at the LHC

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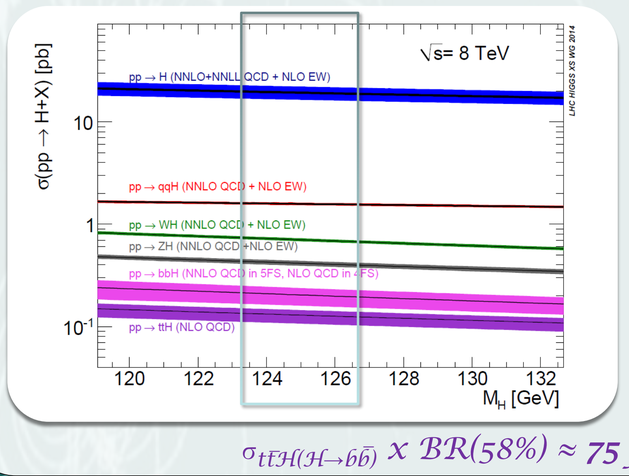
1. Motivation

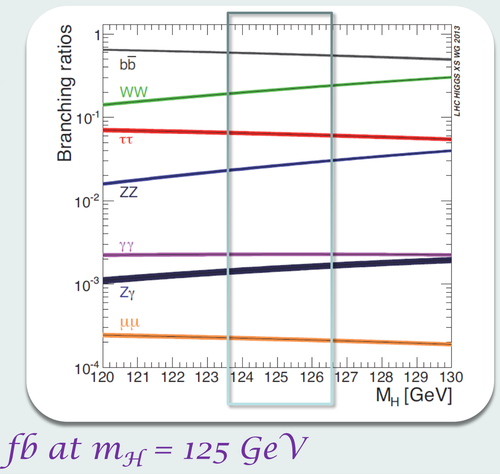
- Convincing evidence of SM Higgs boson [1]

→ presented here: associated top-Higgs production

→ decay studied: $t\bar{t}H \rightarrow l^{\pm}\nu q\bar{q}b\bar{b}(H\rightarrow b\bar{b})$, with l=e,μ

→ gives access to top-Higgs and H-b Yukawa couplings

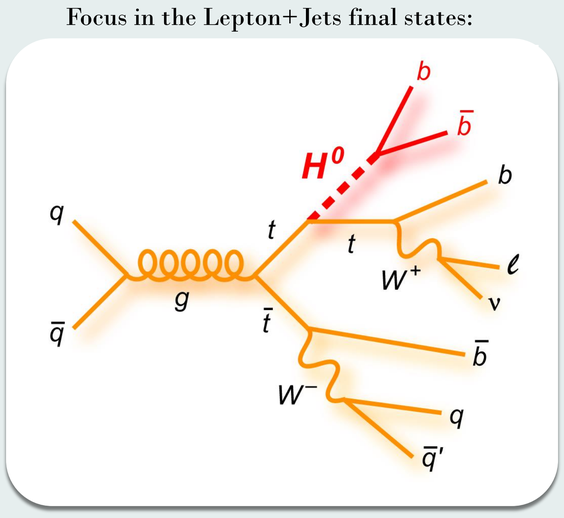




$\sigma_{t\bar{t}\mathcal{H}(\mathcal{H}\rightarrow b\bar{b})}$ x $BR(58\%) \approx$ **75** *fb at* $m_{\mathcal{H}}$ = 125 GeV

2. Signal and Backgrounds

Focus in the Lepton+Jets final states:



- Signatures

→ High p_T isolated lepton

→ E_T^{miss}

→ ≥ 4 jets (≥ 2 b-jets)

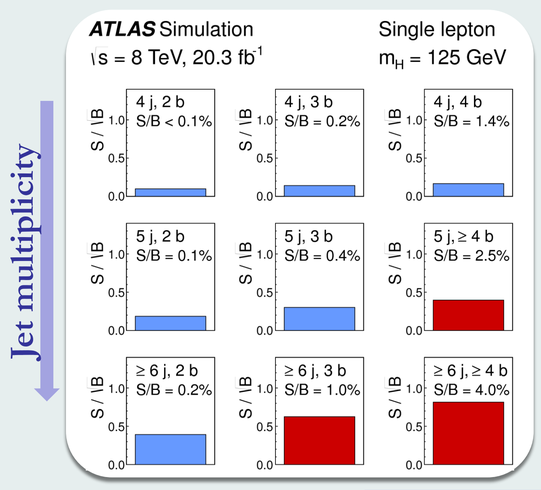
- Backgrounds

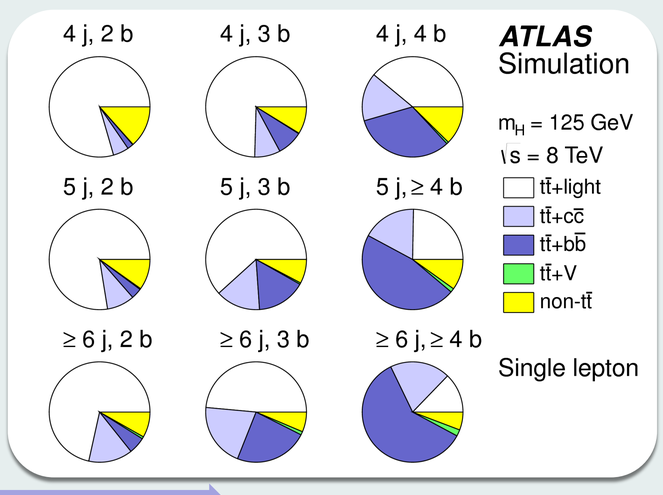
→ irreducible: $t\bar{t}$ + $b\bar{b}$ (~30x)

→ irreducible: $t\bar{t}$ + W/Z (~1x)

→ reducible: $t\bar{t}$ + light jets (450x)

→ other: W+jets, Multijet





- Categorization in 9 independent topologies

→ simultaneous template fit to multiple regions

	2 b-tags	3 b-tags	≥ 4 b-tags
4 jets	H_T	H_T	H_T
5 jets	H_T	NN-HF	NN
≥ 6 jets	H_T	$NN_{with\ MEM}$	$NN_{with\ MEM}$

H_T = scalar sum of jet transverse momenta

3. Multivariate approach

- Neural Network (NN) discriminant for signal extraction

→ Dedicated Bayesian Neural Network per signal region [2]

→ 7 – 12 variables/region: compromise of complexity *vs* separation

- Different topologies/set of variables

→ Object kinematics: Scalar sum of jet p_T, ...

→ Di-jet pairs: mass of the closest jet pair, ...

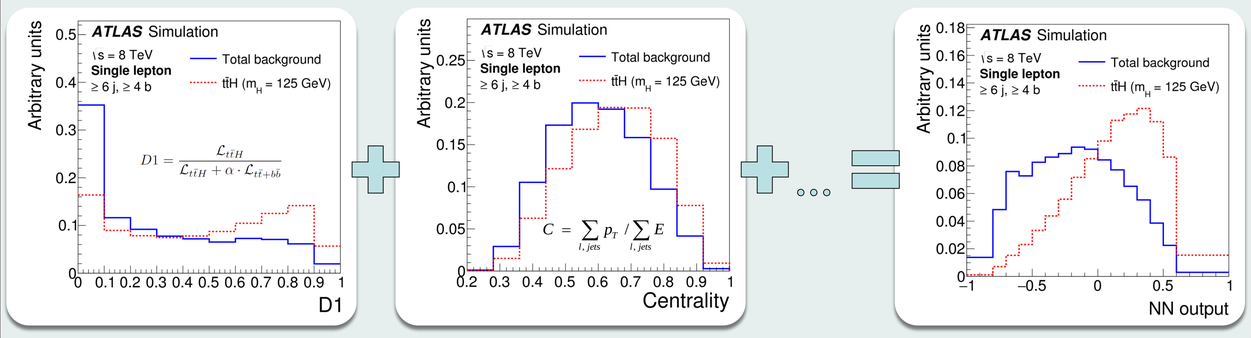
→ Global event variables: Centrality, ...

→ 2 Matrix Element Method (MEM) variables used as input to the NN in the most signal-like regions

Variable	NN rank ≥ 6j, ≥ 4b	≥ 6j, 3b	5j, ≥ 4b	5j, 3b
$D1$	1	10	-	-
Centrality	2	2	1	-
p_T^{jet5}	3	7	-	-
$H1$	4	3	2	-
ΔR_{bb}^{avg}	5	6	5	-
SSLL	6	4	-	-
$m_{bb}^{min\ \Delta R}$	7	12	4	4
$m_{bj}^{max\ p_T}$	8	8	-	-
$\Delta R_{bb}^{max\ p_T}$	9	-	-	-
$\Delta R_{lep-bb}^{min\ \Delta R}$	10	11	10	-
$m_{uu}^{min\ \Delta R}$	11	9	-	2
$Aplan_{b-jet}$	12	-	8	-
N_{40}^{jet}	-	1	3	-
$m_{bj}^{min\ \Delta R}$	-	5	-	-
$m_{jj}^{max\ p_T}$	-	-	6	-
H_T^{had}	-	-	7	-
$m_{jj}^{min\ \Delta R}$	-	-	9	-
$m_{bb}^{max\ p_T}$	-	-	-	1
$p_{T,uu}^{min\ \Delta R}$	-	-	-	3
$m_{bb}^{max\ m}$	-	-	-	5
$\Delta R_{uu}^{min\ \Delta R}$	-	-	-	6
m_{jjj}	-	-	-	7

- Achieving good signal/bkg separation

→ Using NLO MCs for both predictions



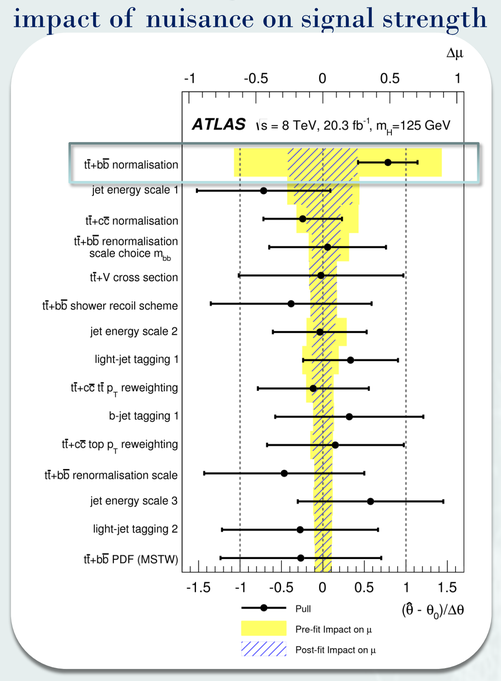
Quite low separation in single-variables — Good discrimination with NN

4. Systematic uncertainties

- N ≡ normalization
- SN ≡ shape and normalization

	Systematic uncertainty	Type	Comp.
	Luminosity	N	1
	Physics Objects		
Detector-oriented	Electron	SN	5
	Muon	SN	6
	Jet energy scale	SN	22
	Jet vertex fraction	SN	1
	Jet energy resolution	SN	1
	Jet reconstruction	SN	1
	b-tagging efficiency	SN	6
	c-tagging efficiency	SN	4
	Light-jet tagging efficiency	SN	12
	High-p_T tagging efficiency	SN	1
	Background Model		
Top-pair modeling	$t\bar{t}$ cross section	N	1
	$t\bar{t}$ modelling: p_T reweighting	SN	9
	$t\bar{t}$ modelling: parton shower	SN	3
	$t\bar{t}$+heavy-flavour: normalisation	N	2
	$t\bar{t}+c\bar{c}$: p_T reweighting	SN	2
	$t\bar{t}+c\bar{c}$: generator	SN	4
	$t\bar{t}+b\bar{b}$: NLO Shape	SN	8
Small bkg uncert.	W+jets normalisation	N	3
	W p_T reweighting	SN	1
	Z+jets normalisation	N	3
	Z p_T reweighting	SN	1
	Lepton misID normalisation	N	3
	Lepton misID shape	S	3
	Single top cross section	N	1
	Single top model	SN	1
	Diboson+jets normalisation	N	3
	$t\bar{t}+V$ cross section	N	1
	$t\bar{t}+V$ model	SN	1
Signal modeling	**Signal Model**		
	$t\bar{t}H$ scale	SN	2
	$t\bar{t}H$ generator	SN	1
	$t\bar{t}H$ hadronisation	SN	1
	$t\bar{t}H$ PDF	SN	1

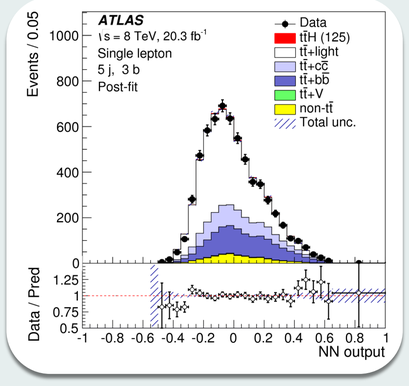
Profiling in action:
impact of nuisance on signal strength

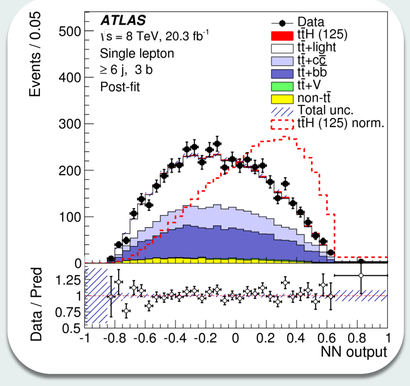


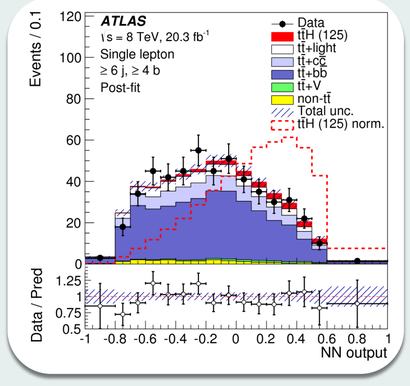
Significant reduction in overall background uncertainty

5. Results

After fitting of the nuisance parameters to data under the signal-plus-background hypothesis (assuming m_H=125 GeV)

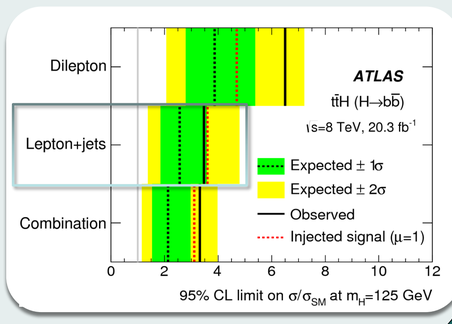






- No significant excess of events observed [arXiv:1503.05066]

→ Obs (exp) 95% CL upper limit of 3.6 (2.6) times SM cross-section for m_H of 125 GeV in the single lepton final state [3]



6. Prospects for the future

- Ratio of $\sigma_{t\bar{t}H}$(13 TeV / 8 TeV) ≈ 3.9 will hugely increase the potential of $t\bar{t}H$ bremsstrahlung measurement at the LHC

References

[1] ATLAS Collaboration: arXiv:1408.7084, arXiv:1408.5191, arXiv:1409.6212 [hep-ex], ATLAS-CONF-2014-060, ATLAS-CONF-2014-061 (2014).

[2] Phi-T GmbH, NeuroBayes package.

[3] **ATLAS Collaboration, arXiv:1503.05066 [hep-ex]**