Studying the top quark-Higgs boson coupling at ATLAS

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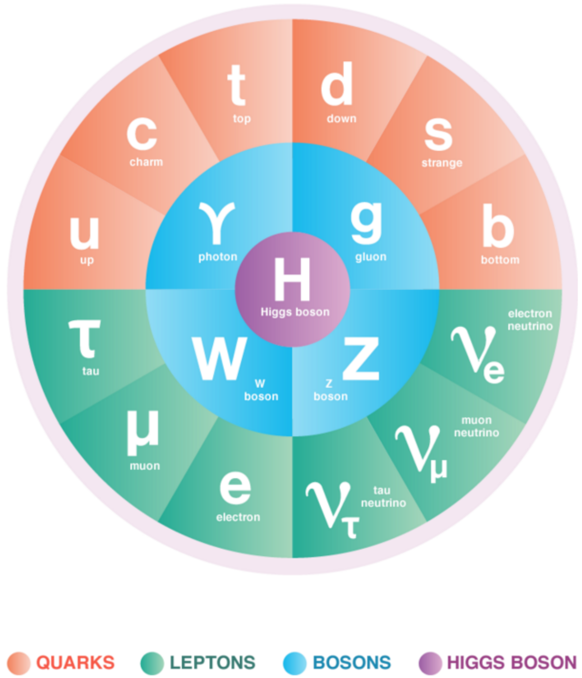
TEXAS
The University of Texas at Austin

ATLAS
EXPERIMENT

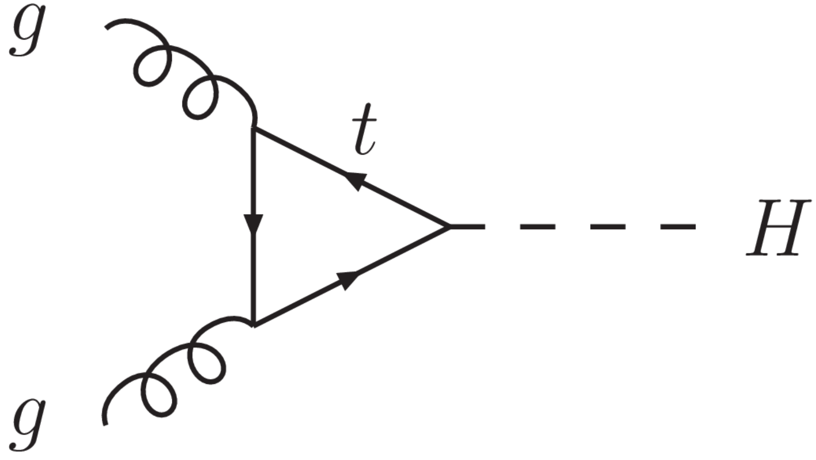
Fermion Masses

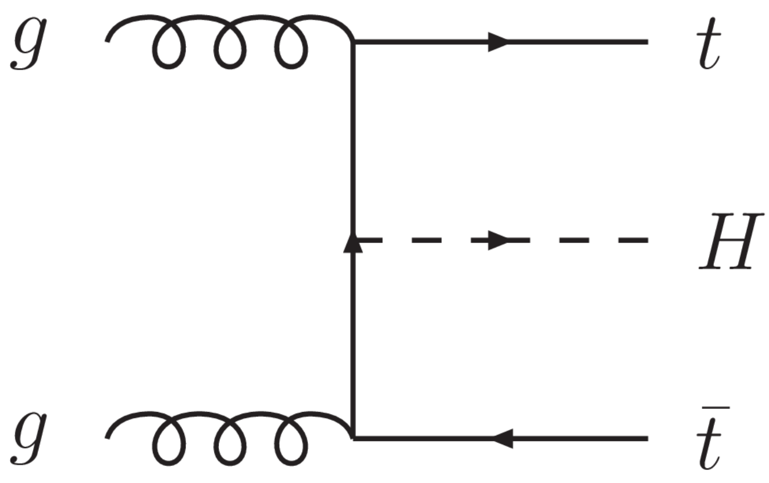
- Want to check whether fermion mass generation mechanism is that of SM
  - a priori EWSB is a *different* problem
- SM Higgs couples ∝ to fermion mass, decay rate ∝ mass^2
  - only interactions with the heaviest fermions are observable
- Assuming generation independence … need to constrain
  - H → leptons: H → ττ
  - H → down-type fermions: H → bb, H → ττ
  - H → up-type fermions: pp → ttH, pp → H (gluon-gluon fusion)
- Higgs boson may have other couplings to the top quark than the SM ones



How to measure the ttH Coupling?

- Highest rate way: gg ⟶ H through top loop
- However effects of top are not distinguishable from new physics in gg ⟶ H or qq ⟶ H
- A tree-level measurement is possible: pp ⟶ $t\bar{t}H$



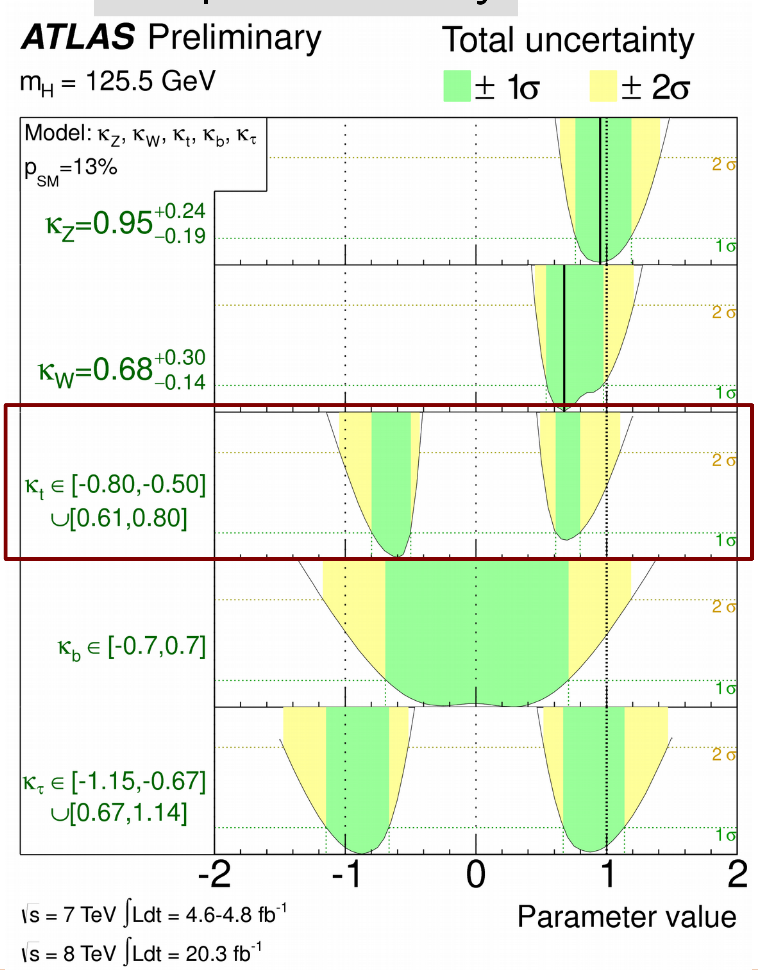


Constraints on Higgs Couplings

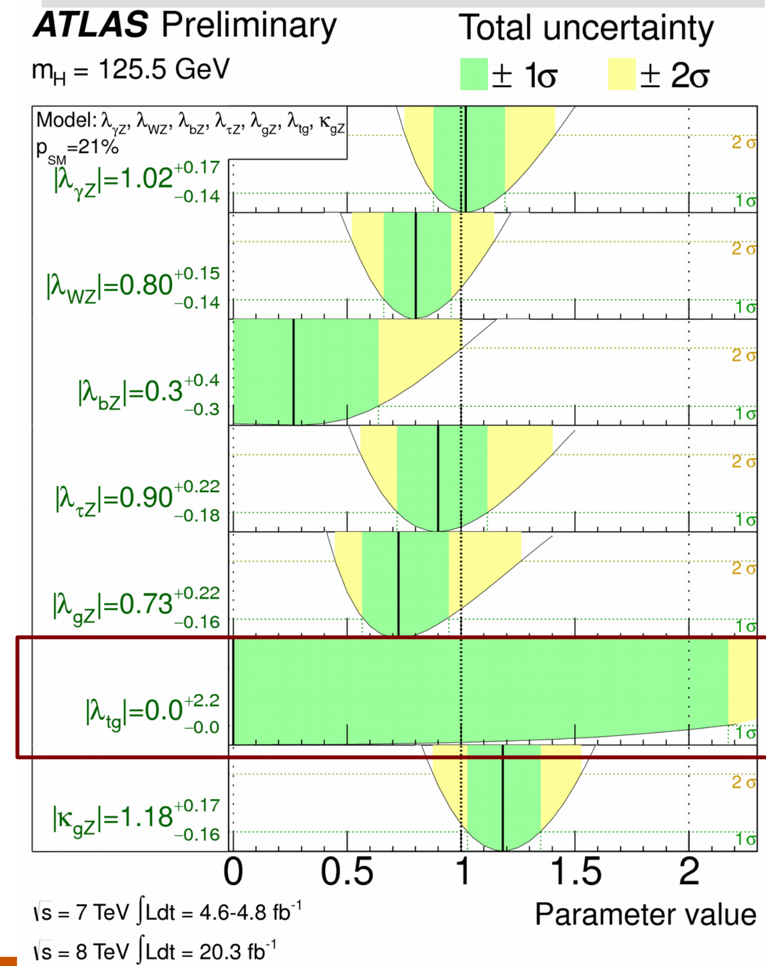
- Need ttH to simultaneously constrain top coupling and new physics in ggF loop

ATLAS-CONF-2014-009
outdated – for illustration…

SM particles only



Allowing new particles in loops



ttH + EFT

- Explicit example of degeneracy between dim-6 operators affecting pp → H and pp → ttH

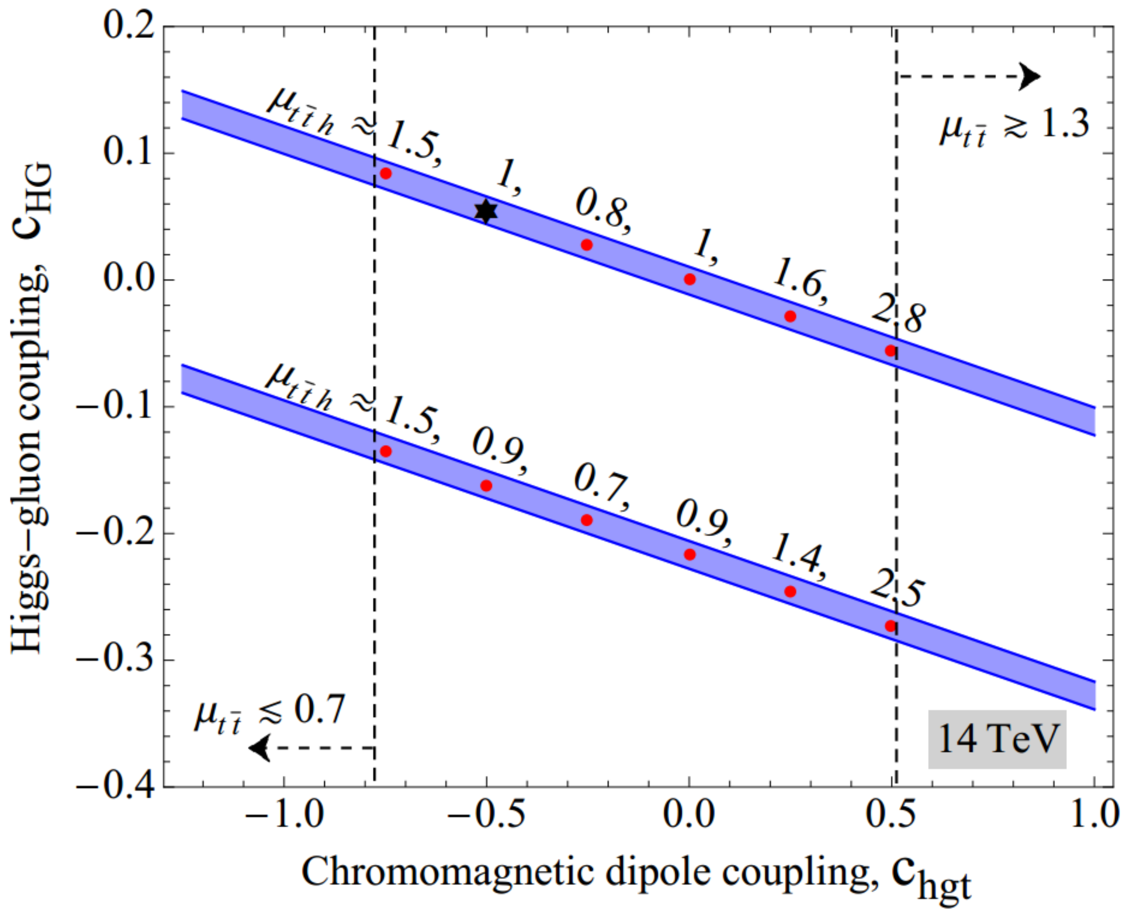
Higgs-gluon coupling:

$$\mathcal{O}_{HG} = \frac{c_{HG}}{2\Lambda^2}(H^\dagger H)G_a^{\mu\nu}G^a_{\mu\nu}$$

Top chromomagnetic dipole:

$$\mathcal{O}_{hgt} = \frac{c_{hgt}}{\Lambda^2}(\bar{Q}_L H)\sigma^{\mu\nu}T^a t_R G^a_{\mu\nu}$$

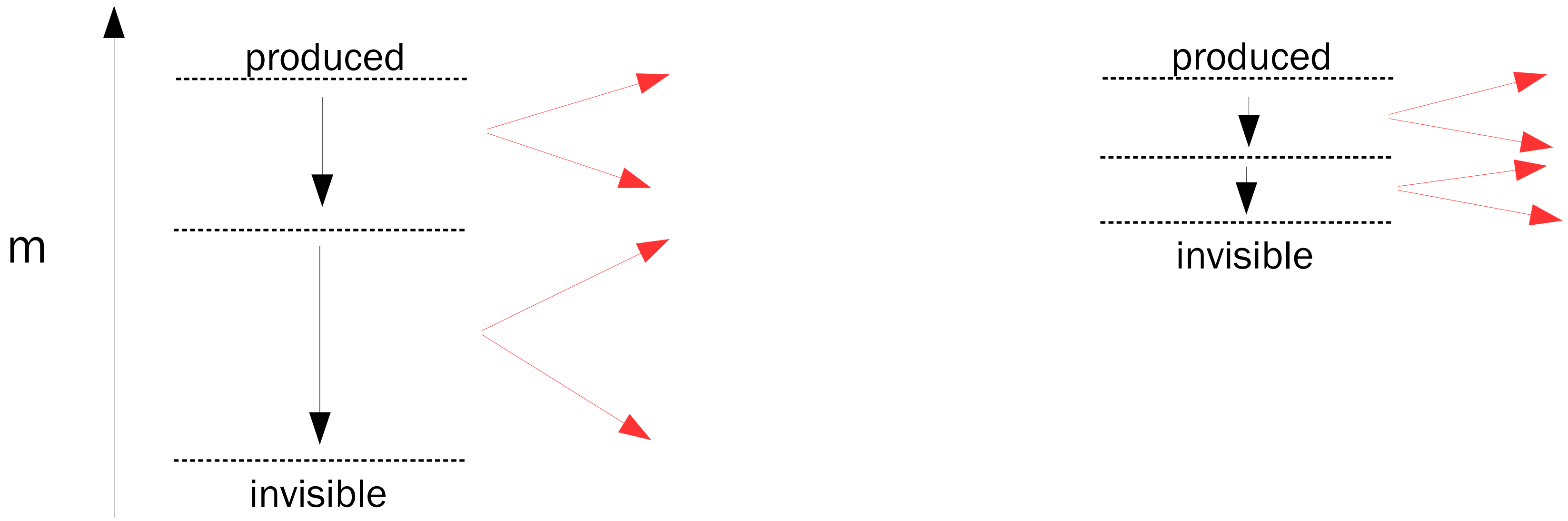
Blue band shows constraint from ggF



Bramante, Delgado,Martin PRD 89, 093006 (2014)

And other new physics …

- We do a very careful study of phase space rarely covered by new physics searches
  - high multiplicity but not super-high energy/missing transverse energy events
- Potential sensitivity to scenarios like compressed spectra

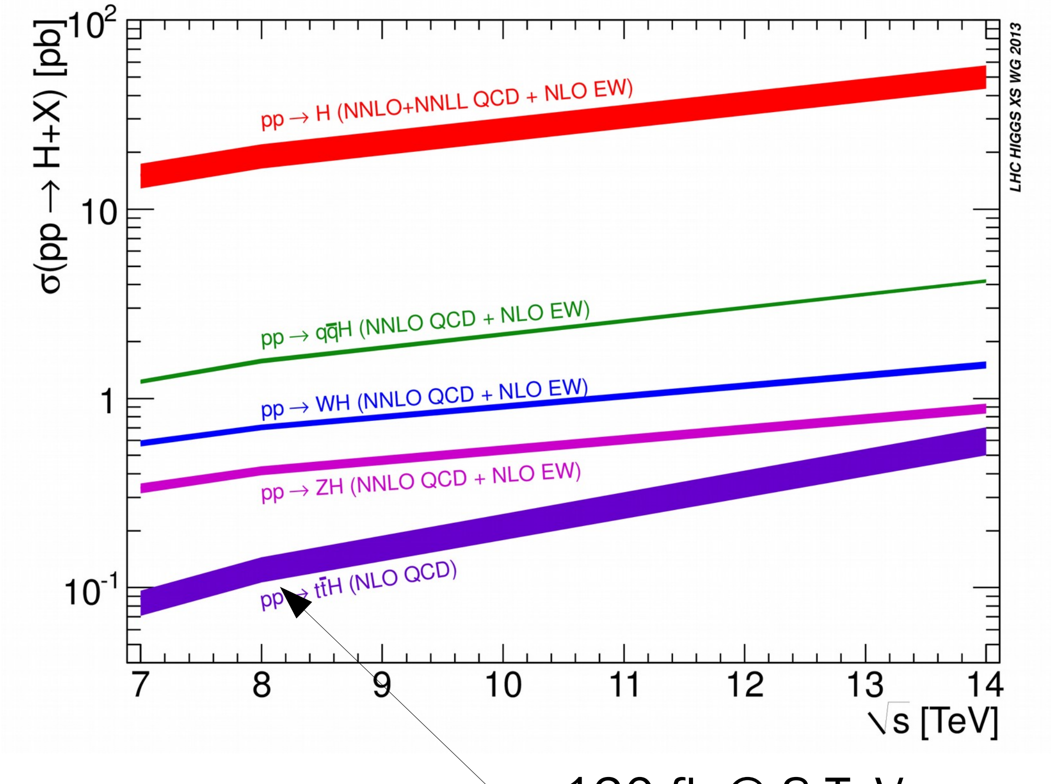


“traditional” cascade
high momentum visible particles
large MET

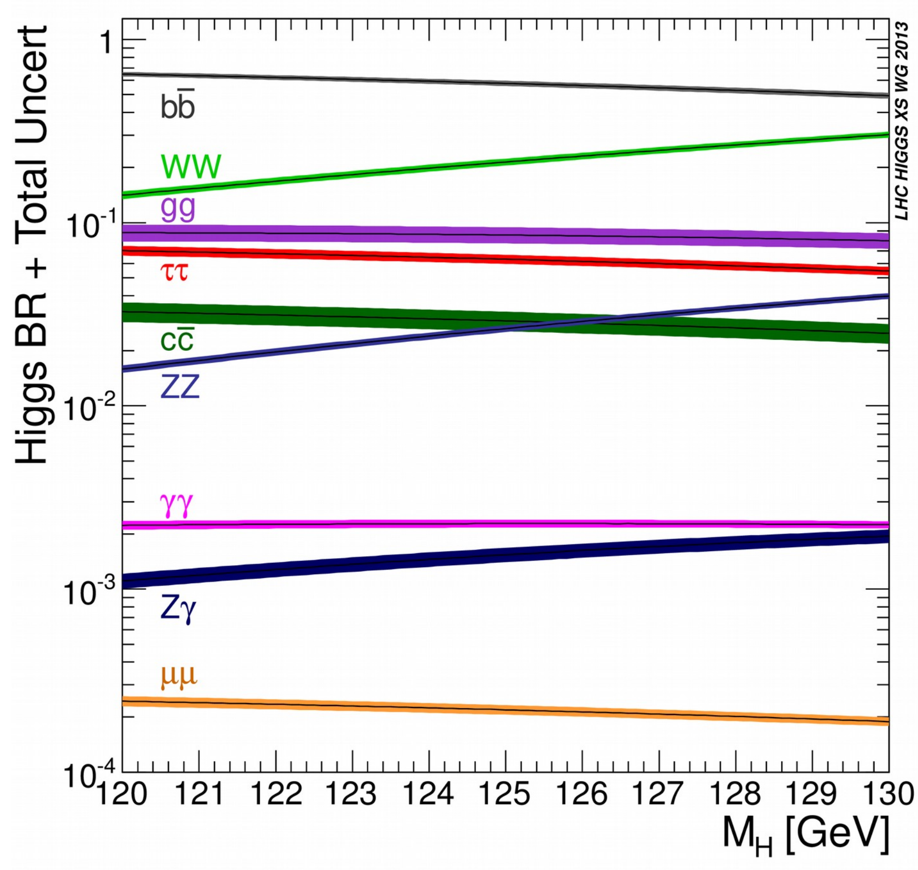
“compressed” cascade
low momentum visible particles
small MET

Process xsec

- Rarest "major" production process – but distinct signature

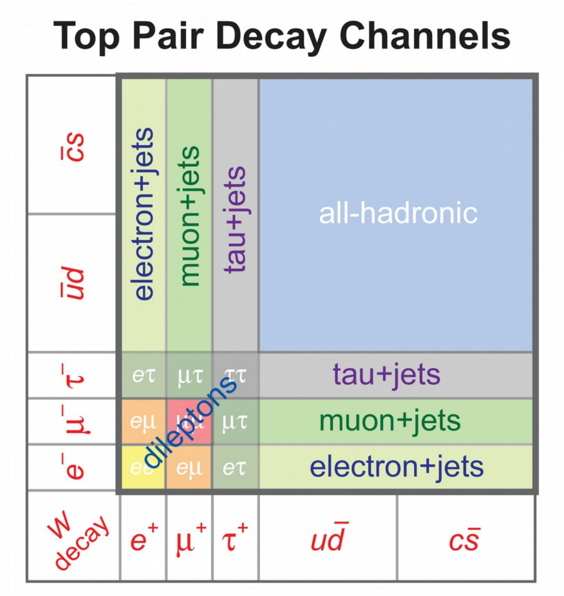


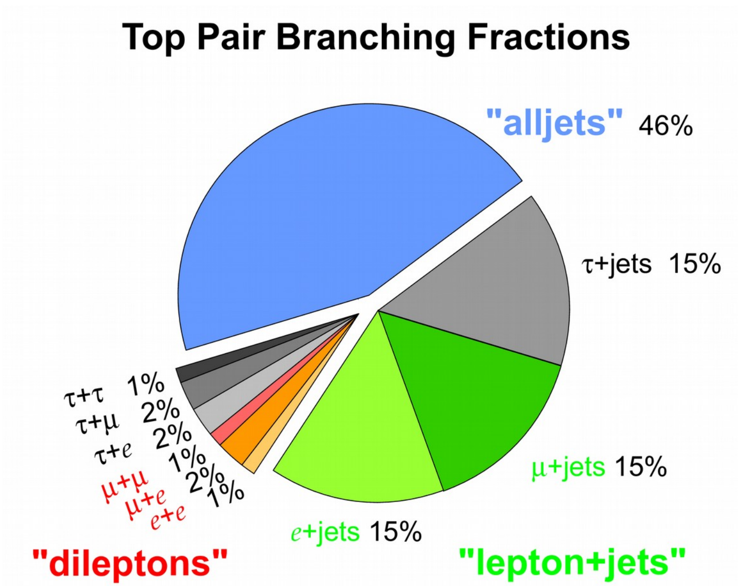
~ 130 fb @ 8 TeV



Finding ttH

- Signature is top pair decay + Higgs decay
- Top quarks decay ~ 100% via t ⟶ W b
  - W decays 68% of the time to quarks, ~ 11% to each of e, μ, τ
- Top quark pair can be dileptonic, semileptonic ("lepton+jets"), or all hadronic
  - dileptonic with e and μ ~ 4% of $t\bar{t}$ decays
  - all hadronic must be separated from pure QCD multijet events





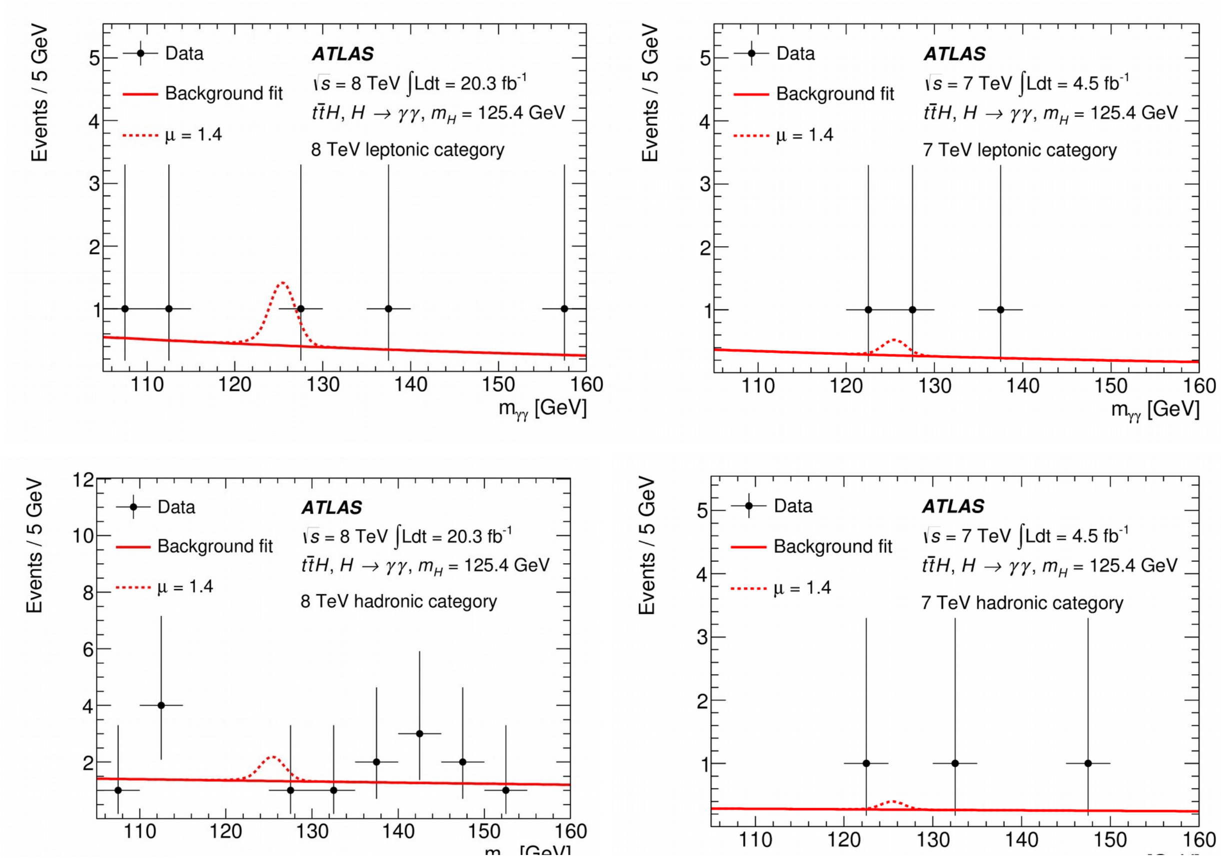
H ⟶ γγ

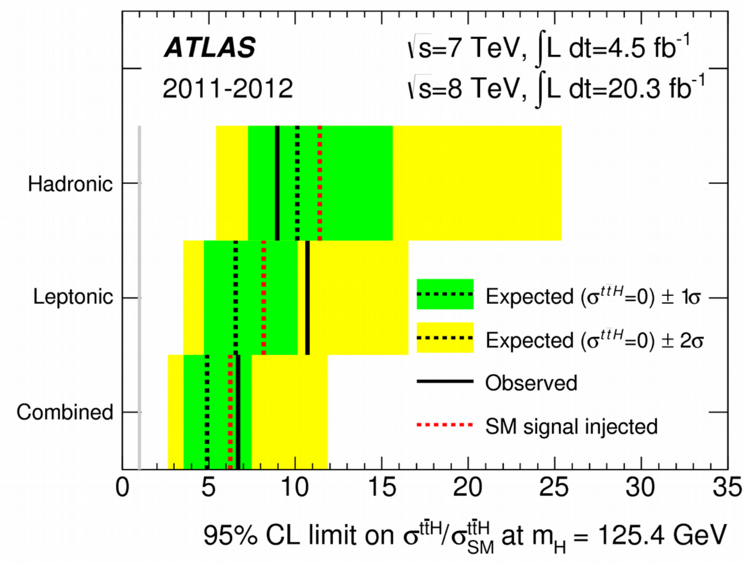
- H ⟶ γγ gives clean Higgs tag, can use mass sidebands. Channel so clean that main challenge is contamination from other Higgs production modes
  - A bump at 125 GeV is a Higgs: but is it ttH?
- Split by top pair decays:
  - lepton + jets: lepton and b-tag requirement enough to remove all other major Higgs production mechanisms
  - all hadronic: contaminated by gluon-gluon fusion. Strict cuts applied to improve purity of observed signal

PLB 740 222 (2015)

Category	N_H	ggF	VBF	WH	ZH	$t\bar{t}H$	$tHqb$	WtH	N_B
7 TeV leptonic selection	0.10	0.6	0.1	14.9	4.0	72.6	5.3	2.5	$0.5^{+0.5}_{-0.3}$
7 TeV hadronic selection	0.07	10.5	1.3	1.3	1.4	80.9	2.6	1.9	$0.5^{+0.5}_{-0.3}$
8 TeV leptonic selection	0.58	1.0	0.2	8.1	2.3	80.3	5.6	2.6	$0.9^{+0.6}_{-0.4}$
8 TeV hadronic selection	0.49	7.3	1.0	0.7	1.3	84.2	3.4	2.1	$2.7^{+0.9}_{-0.7}$

Diphoton Results



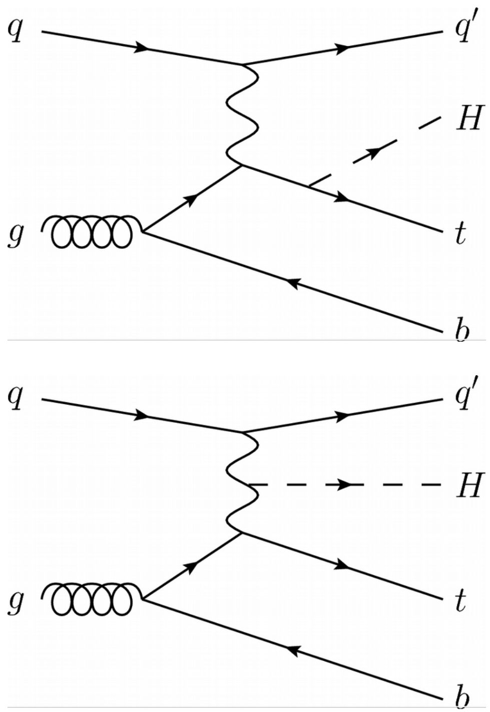


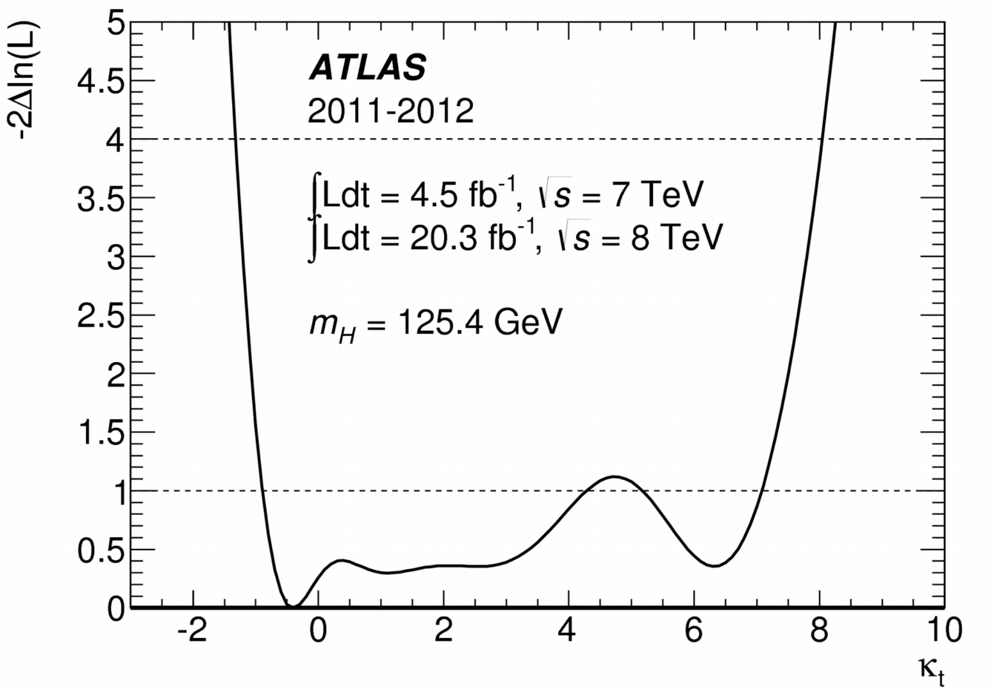
Set $\mu_{non\text{-}ttH} = 1$

	Observed limit	Expected limit	$+2\sigma$	$+1\sigma$	-1σ	-2σ
Combined (with systematics)	6.7	4.9	11.9	7.5	3.5	2.6
Combined (statistics only)	6.3	4.7	10.5	7.0	3.4	2.5
Leptonic (with systematics)	10.7	6.6	16.5	10.1	4.7	3.5
Leptonic (statistics only)	10.2	6.4	15.1	9.6	4.6	3.4
Hadronic (with systematics)	9.0	10.1	25.4	15.6	7.3	5.4
Hadronic (statistics only)	8.5	9.5	21.4	14.1	6.8	5.1

tH

- SM has destructive interference between H emission from top and from W: if relative sign of top coupling flips, have large constructive interference
- Can resolve relative sign of fermionic and bosonic Higgs couplings
  - interplay with Br(H → γγ), which also depends on HWW/Ht$\bar{t}$ interference



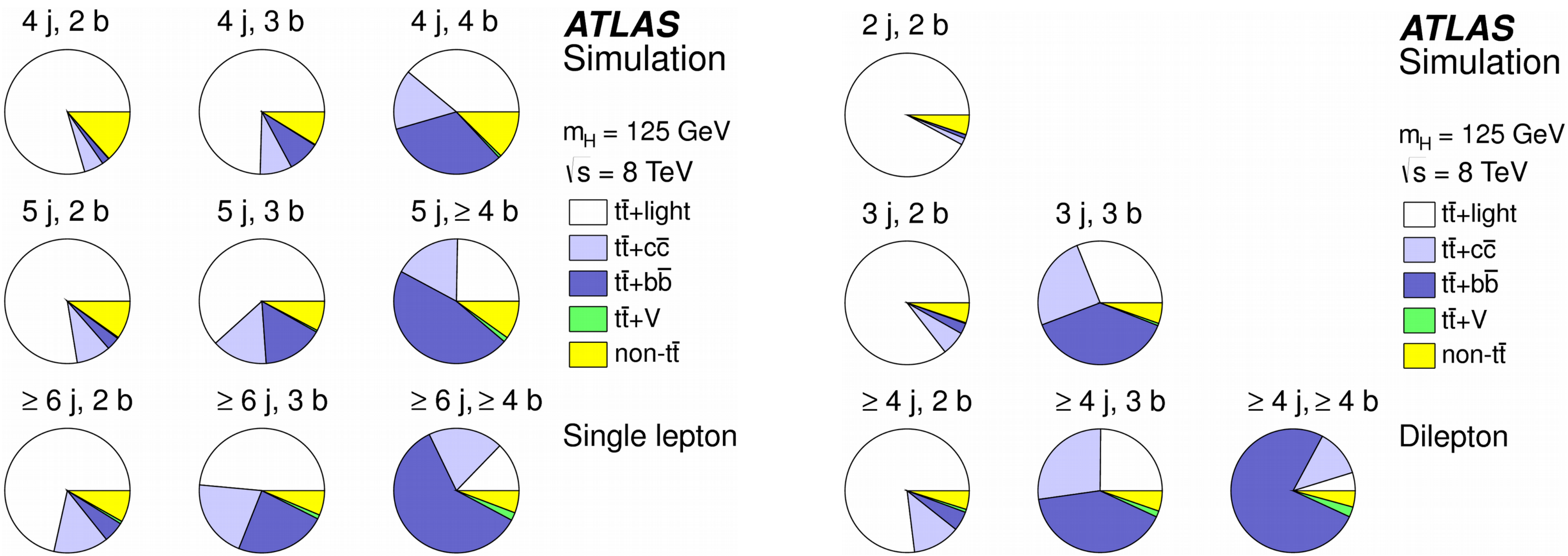


$H \rightarrow bb$

- $H \rightarrow bb$ is 58% of the SM Higgs width @ 125 GeV
  - Mass resolution is much worse than for γγ
  - Background (tt + heavy flavor jets) tricky to model
- Strategy: sort events by number of jets and b-tags, then in each channel use a multivariate discriminant
  - use background-rich channels to constrain background and detector systematics
- Have used lepton+jets, dilepton, and **all-hadronic** channels (*new!*)
  - talk about the leptonic channels first, then allhad

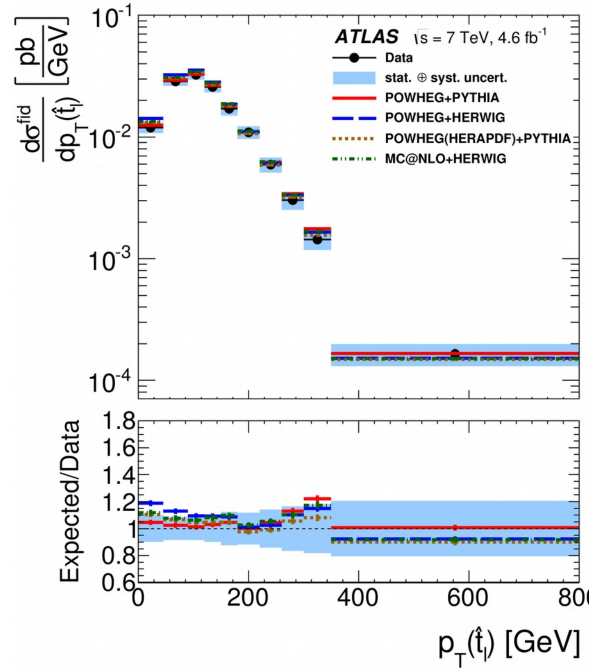
EPJ C 75, 349 (2015) (l+jets, dilep)
arxiv:1604.03812 (allhad)

- leptonic channels: dominated by tt + heavy flavor jets in all signal-rich regions

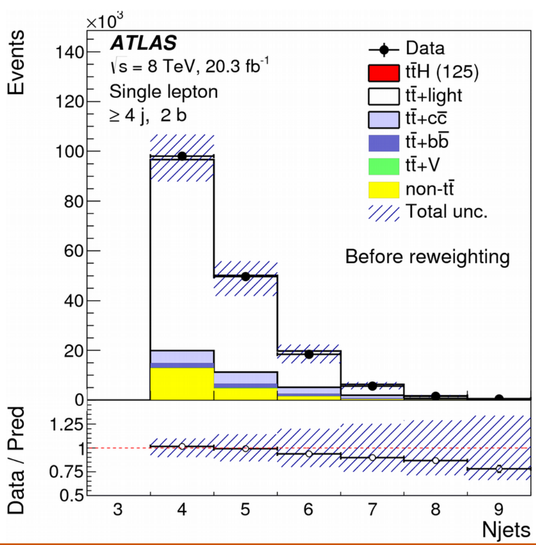


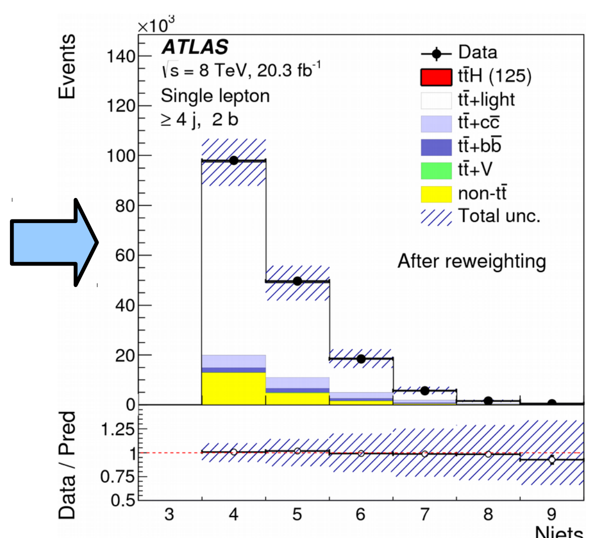
Top Reweighting

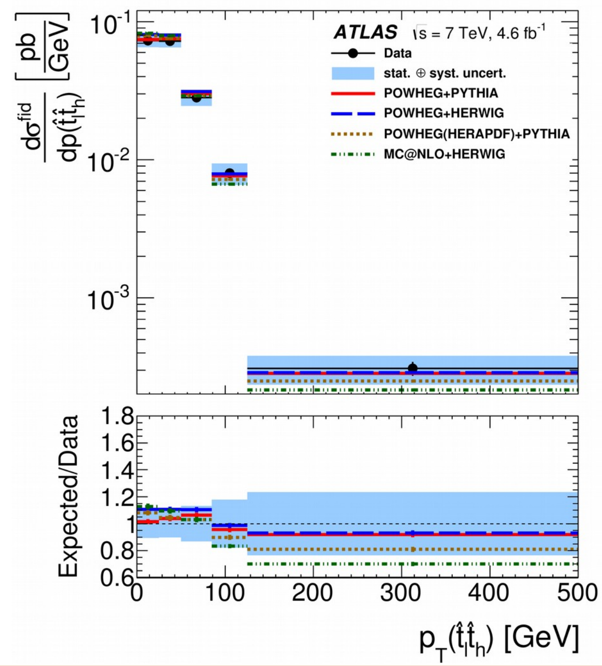
- To improve agreement of MC and data, **reweight** the $t\bar{t}$ pair p_T and the top quark p_T with scalings derived from 7 TeV data
  - Powheg+Pythia spectra generally too hard
  - tt+light, tt+cc events only; tt+bb handled differently



top kinematics: JHEP 06(2015) 100



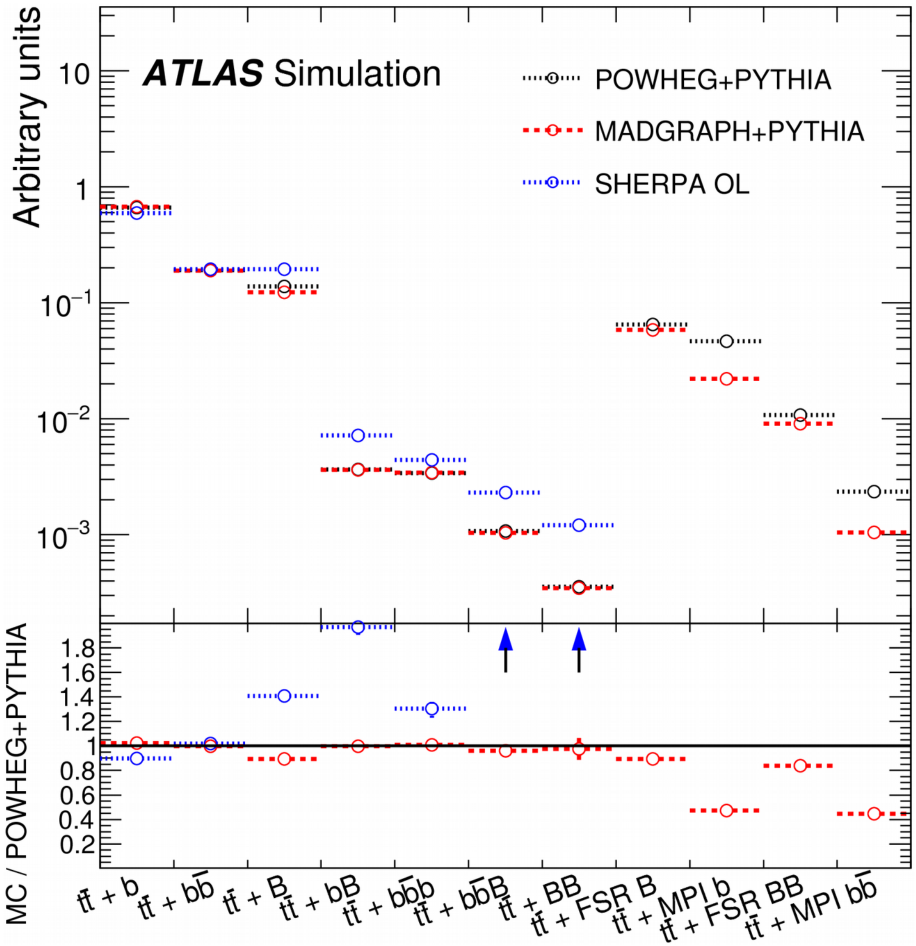




tt+bb Reweighting

- Powheg+Pythia tt+bb reweighted to shower-matched NLO calculation of Sherpa+OpenLoops
  - particular attention paid to separation of b quarks
- Provides theoretically-motivated systematics (Sherpa scale, PDF, shower variations)

b = b-matched jet in acceptance
B = bb-matched jet in acceptance



NN construction

- Variables that are well modeled in background-dominated channels are used to construct neural network discriminants (with NeuroBayes)
  - even in signal-rich channels, checked modeling after applying anti-NN cut ("partial unblinding")
- lepton+jets 6-jet channels also have matrix element discriminant

lepton + jets

	2b	3b	4b
4j	H_T^{had}	H_T^{had}	H_T^{had}
5j	H_T^{had}	NN †	NN
6j	H_T^{had}	NN[ME]	NN[ME]

† trained for tt+HF vs tt+LF

dilepton

	2b	3b	4b
2j	H_T		
3j	H_T	NN	
4j	H_T	NN	NN

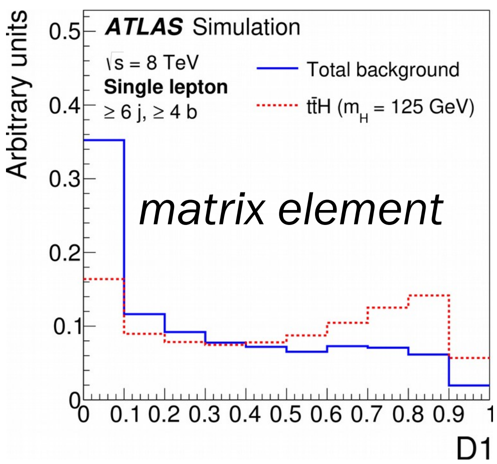
NN Variable Separation

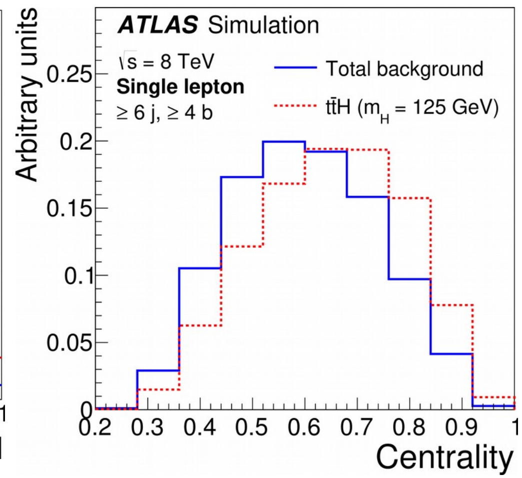
- Four highest ranked variables shown

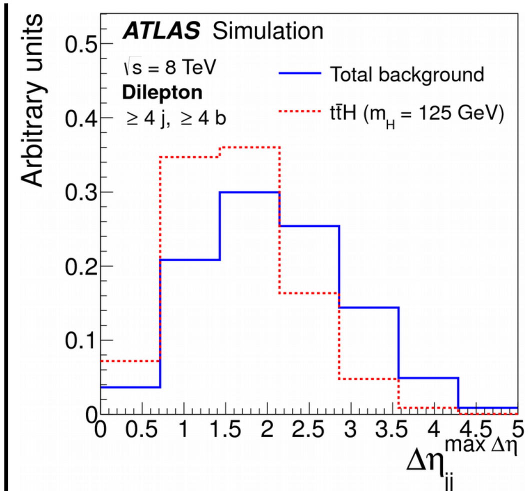
$$D1 = \frac{\mathcal{L}_{t\bar{t}H}}{\mathcal{L}_{t\bar{t}H} + 0.23 \cdot \mathcal{L}_{t\bar{t}+b\bar{b}}}$$

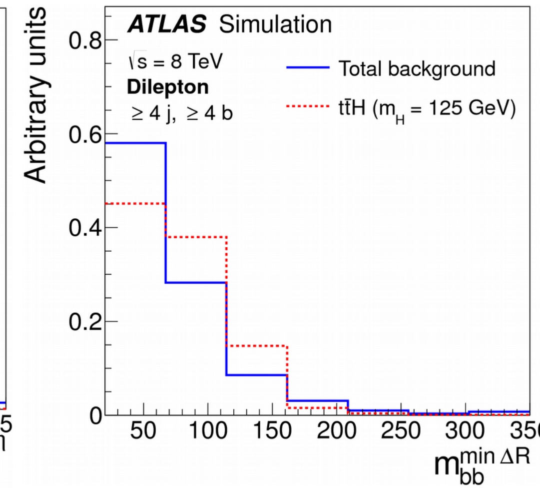
l+jets ≥6j ≥4b

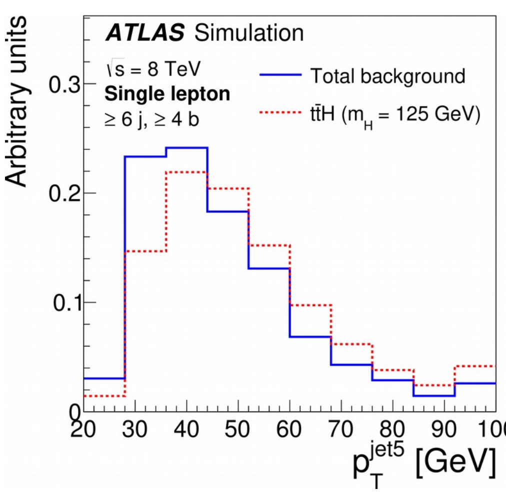
dilepton ≥4j ≥4b

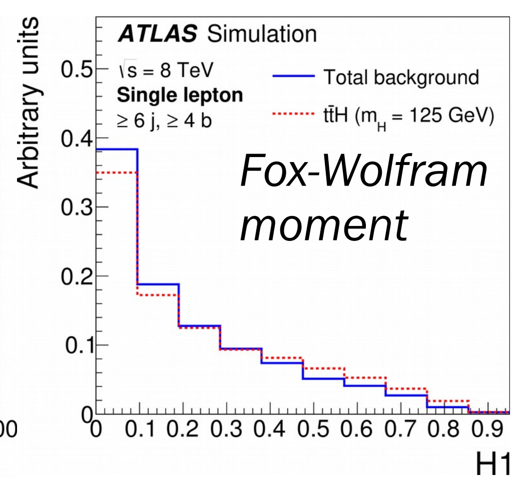


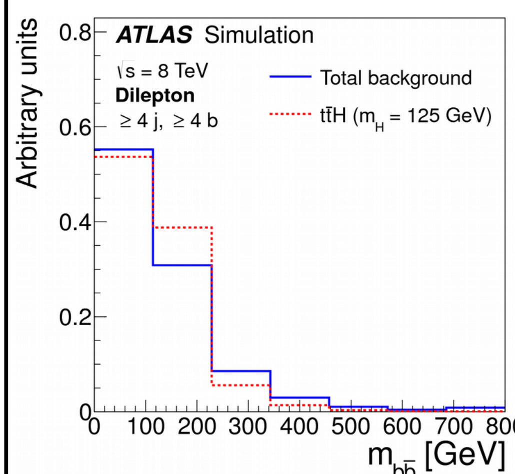


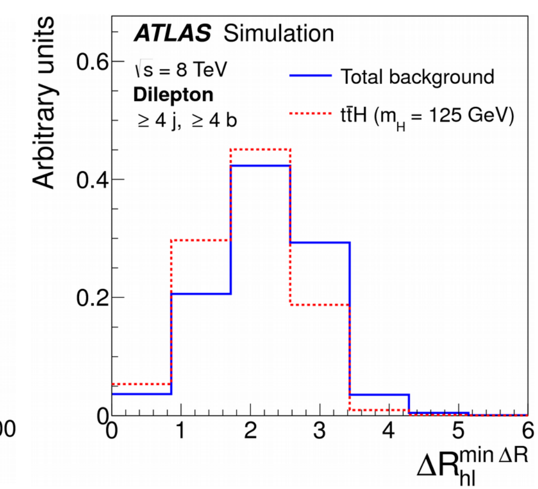








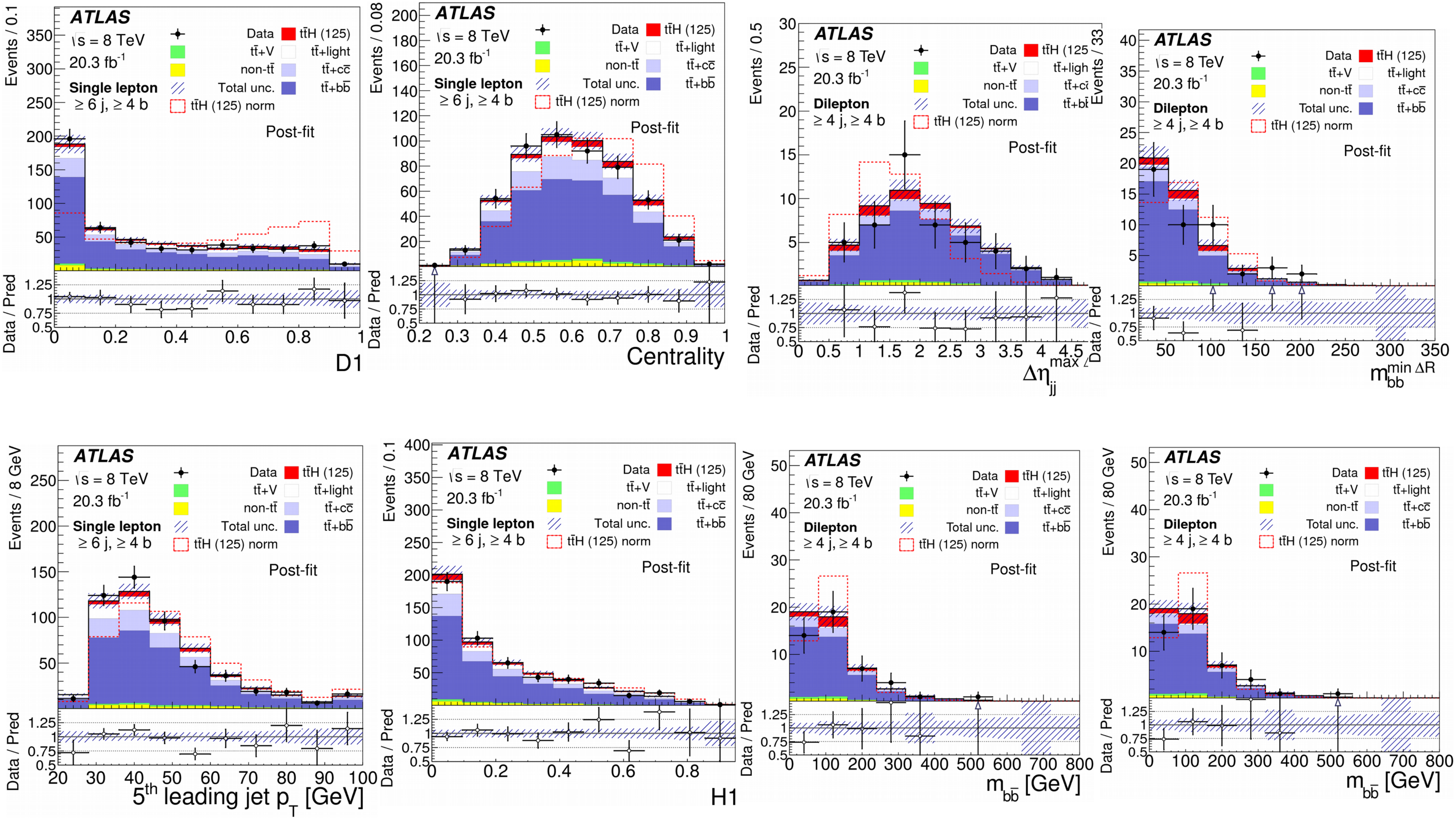




Variable Modeling

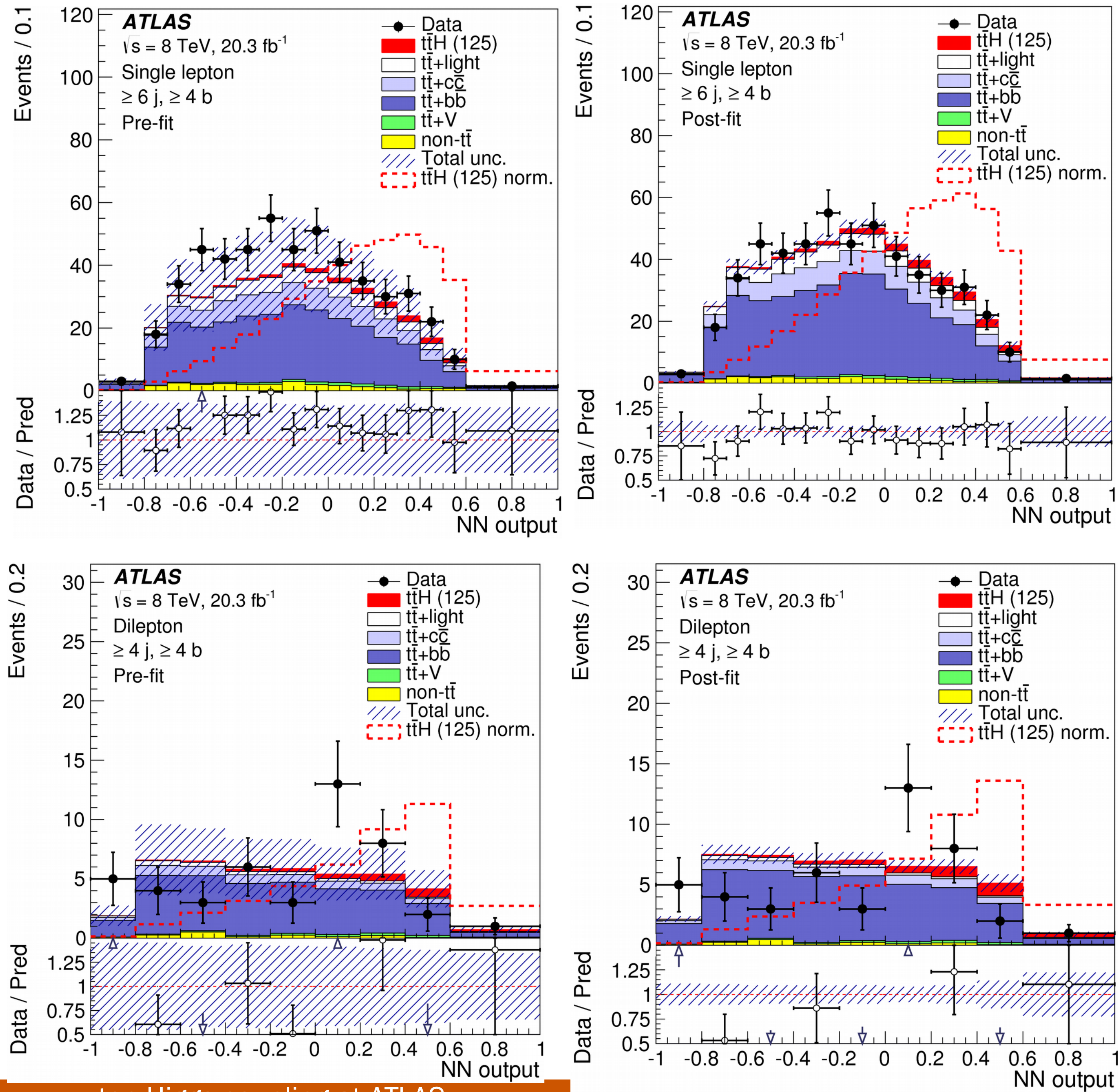
l+jets ≥6j ≥4b

dilepton ≥4j ≥4b

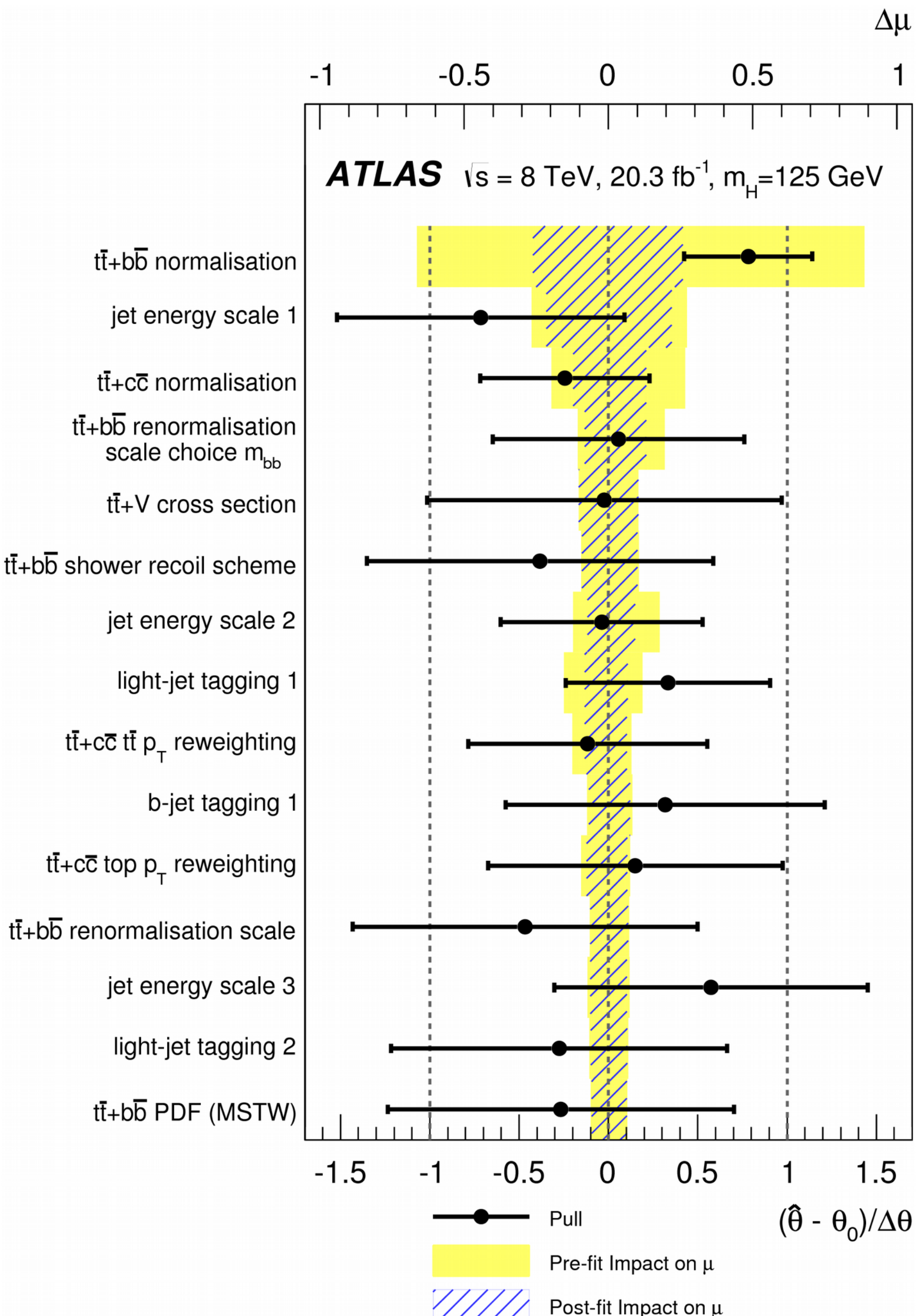


Fit effect on Signal-Rich Regions

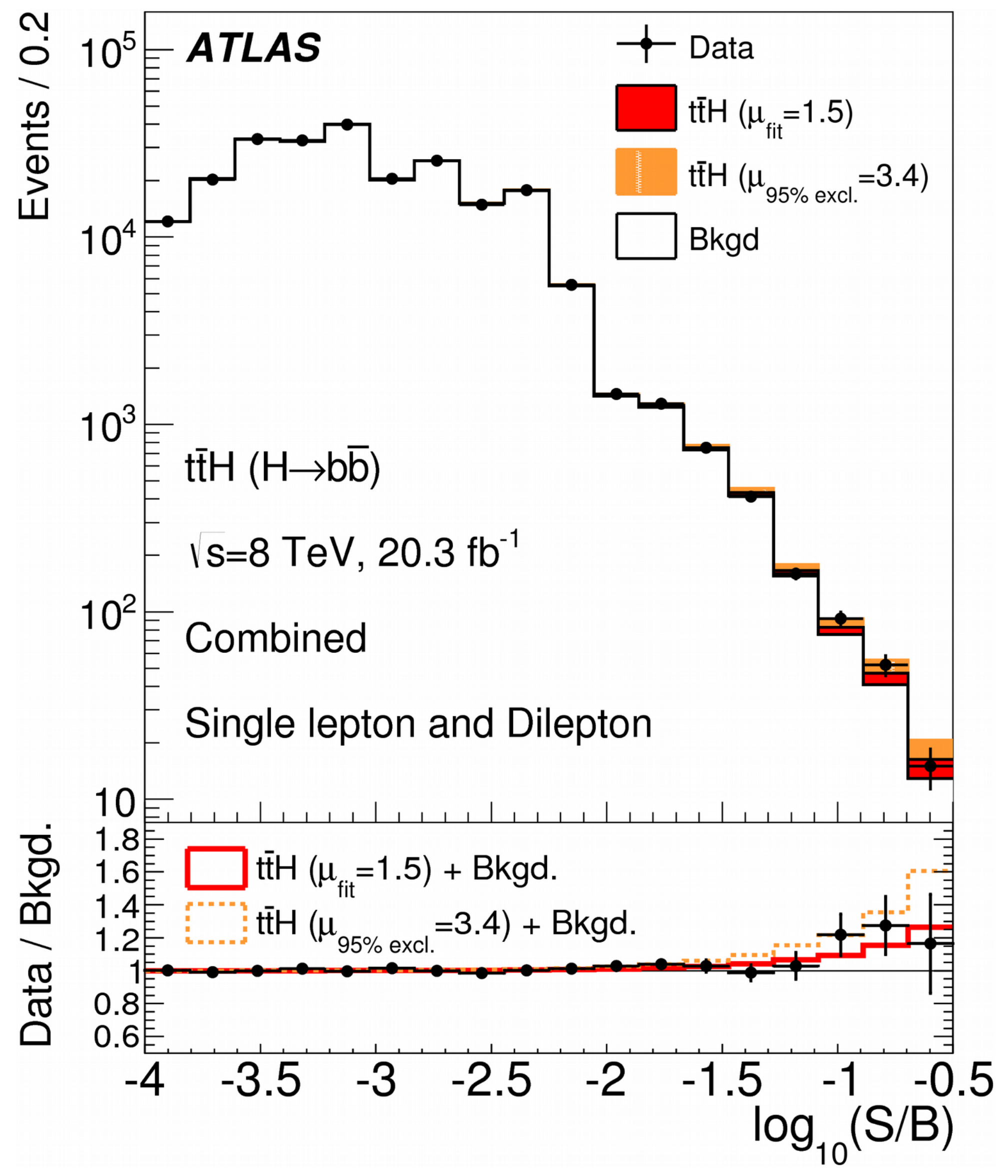
Profile fit collapses systematics – large correlations



Fit Results



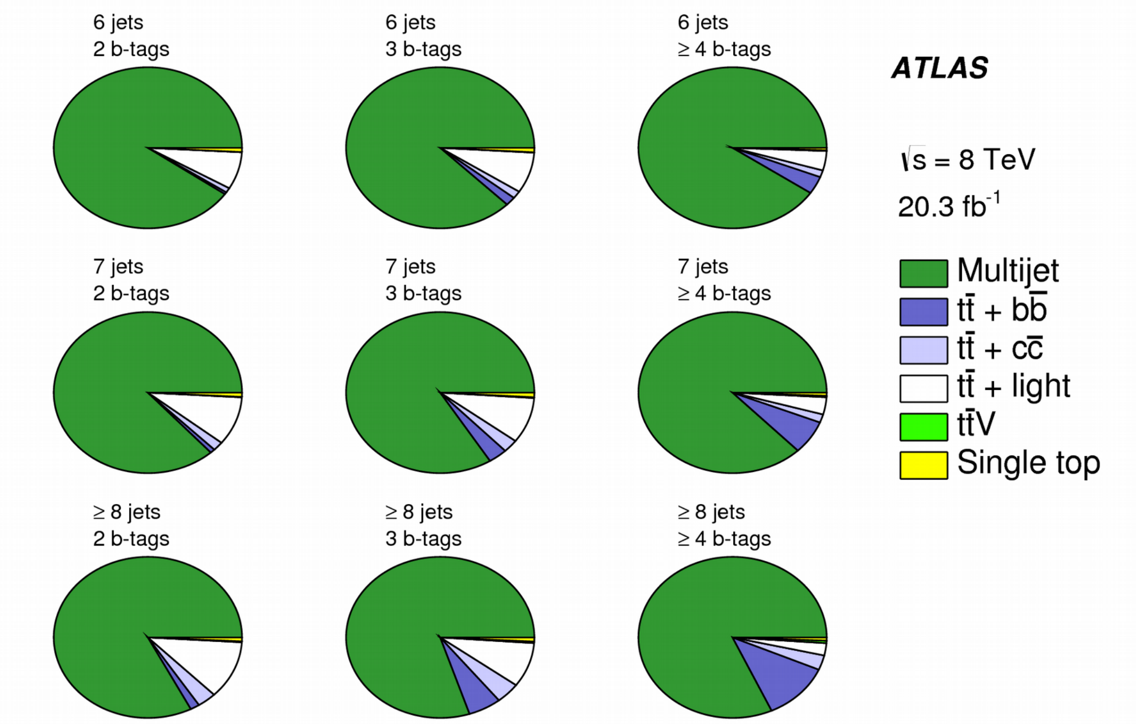
ATLAS √s = 8 TeV, 20.3 fb-1, mH=125 GeV
Δμ
tt̄+bb̄ normalisation
jet energy scale 1
tt̄+cc̄ normalisation
tt̄+bb̄ renormalisation scale choice mbb
tt̄+V cross section
tt̄+bb̄ shower recoil scheme
jet energy scale 2
light-jet tagging 1
tt̄+cc̄ tt̄ pT reweighting
b-jet tagging 1
tt̄+cc̄ top pT reweighting
tt̄+bb̄ renormalisation scale
jet energy scale 3
light-jet tagging 2
tt̄+bb̄ PDF (MSTW)
(θ̂ - θ0)/Δθ
Pull
Pre-fit Impact on μ
Post-fit Impact on μ



ATLAS
Data
tt̄H (μfit=1.5)
tt̄H (μ95% excl.=3.4)
Bkgd
tt̄H (H→bb̄)
√s=8 TeV, 20.3 fb-1
Combined
Single lepton and Dilepton
Events / 0.2
Data / Bkgd.
tt̄H (μfit=1.5) + Bkgd.
tt̄H (μ95% excl.=3.4) + Bkgd.
log10(S/B)

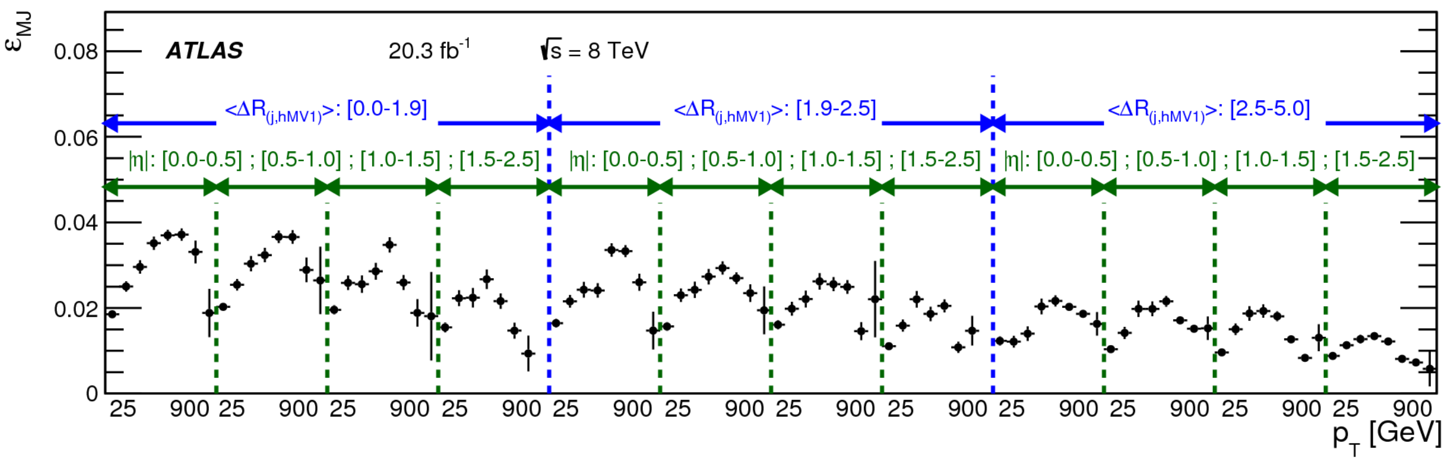
ttH[bb] all-hadronic

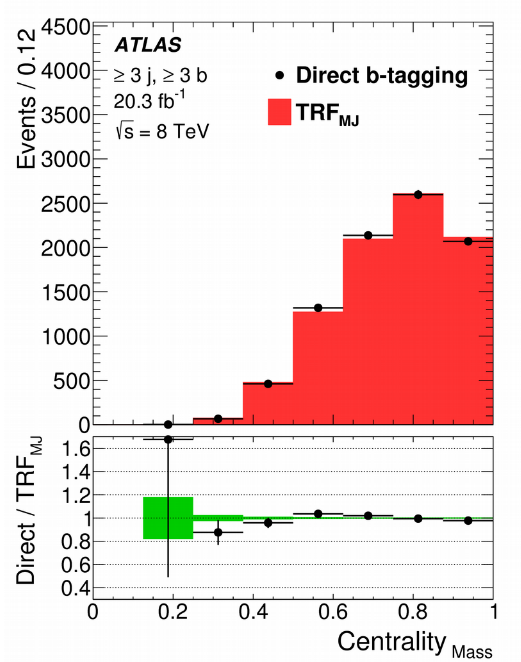
- Expect events with ≥ 8 jets, of which ≥ 4 b-tagged
  - acquire events with multijet triggers
- Multijet backgrounds critical in all categories
  - need data-driven model for MJ properties
- Proceed as per leptonic channels: coupled fit of BDT distributions in each category, same systematic treatment



allhad ttH: multijet TRF

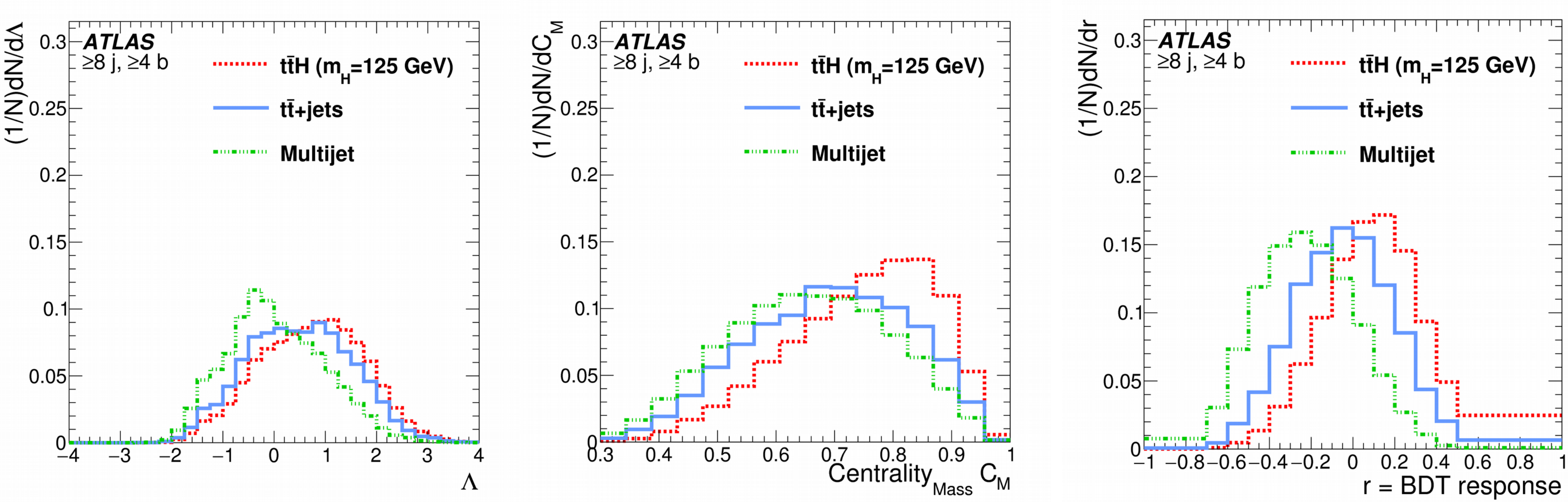
- Bootstrap multijet distributions with high # b-jets from regions with low # b-jets
- Take low #b-jet events and assign b-jet probabilities based on p_T, η, distance from other b-jets
  - e.g. more likely to be a b-jet if near another b-jet



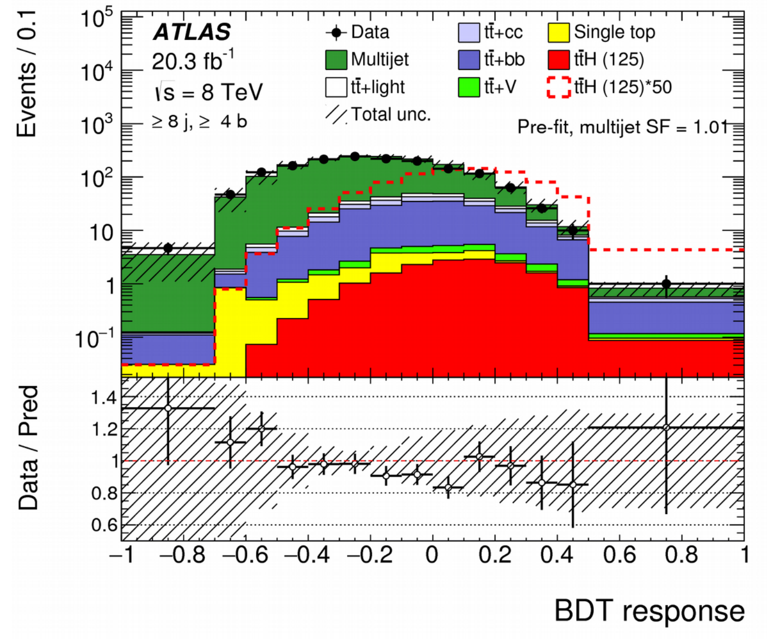


BDTs

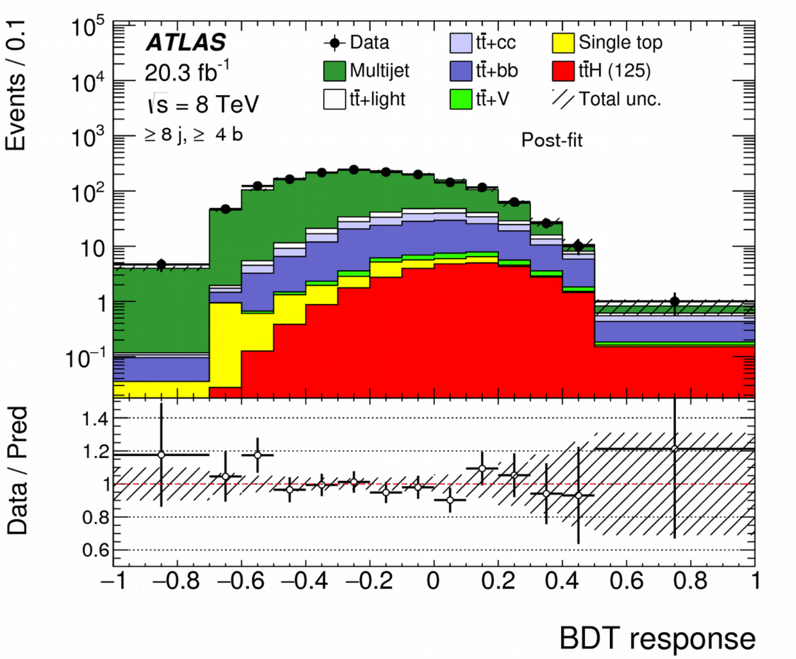
- A number of event shape and object variables are used (e.g. centrality, M(bb) for closest b-jet pair, …)
- Also a simple "likelihood" variable Λ is used to distinguish events with peaking m_W, m_{top}, m_{Higgs} from combinatorics



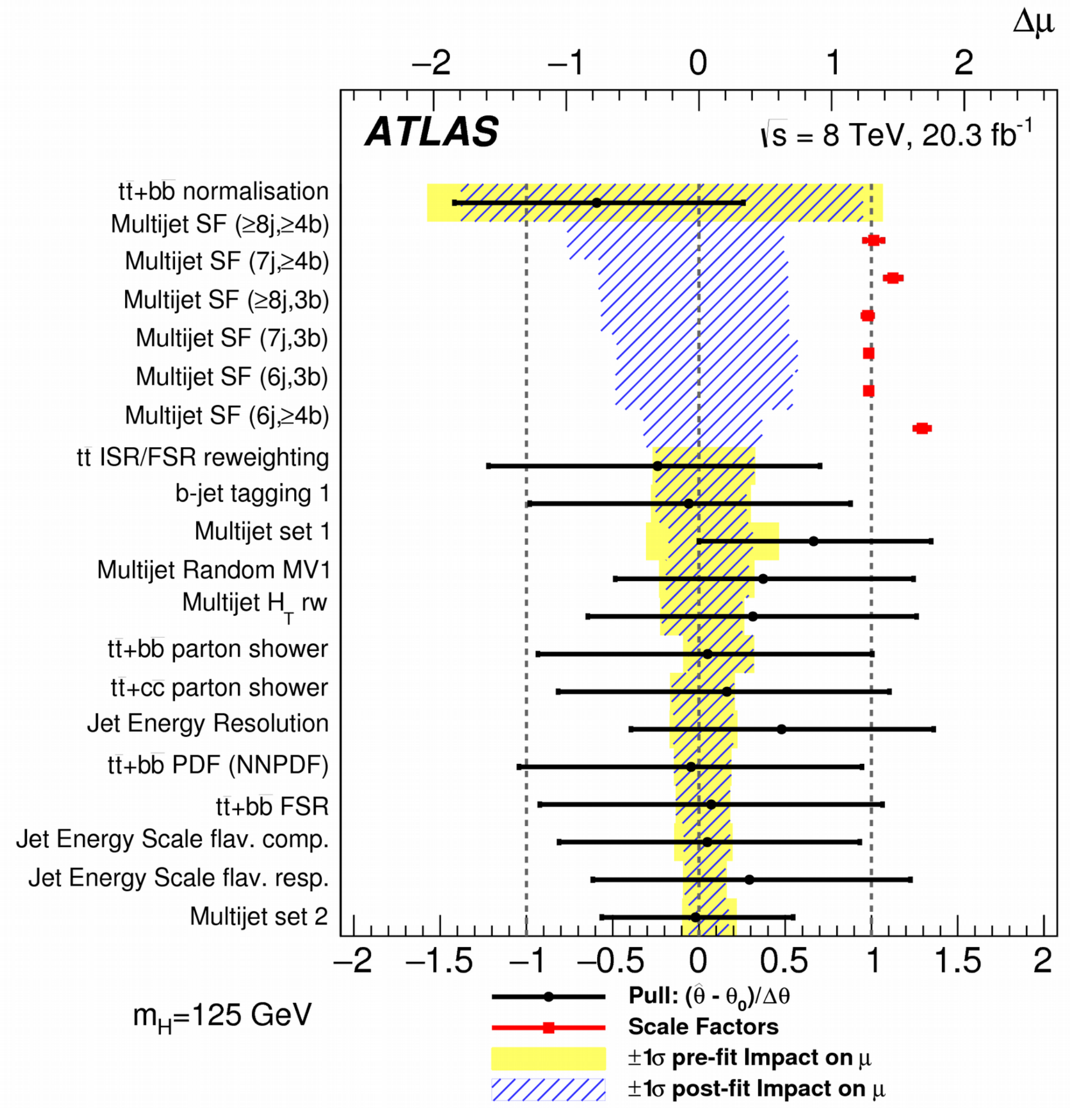
allhad fits



ATLAS
20.3 fb-1
√s = 8 TeV
≥ 8 j, ≥ 4 b
Data
Multijet
tt+light
Total unc.
tt+cc
tt+bb
tt+V
Single top
ttH (125)
ttH (125)*50
Pre-fit, multijet SF = 1.01
Events / 0.1
Data / Pred
BDT response



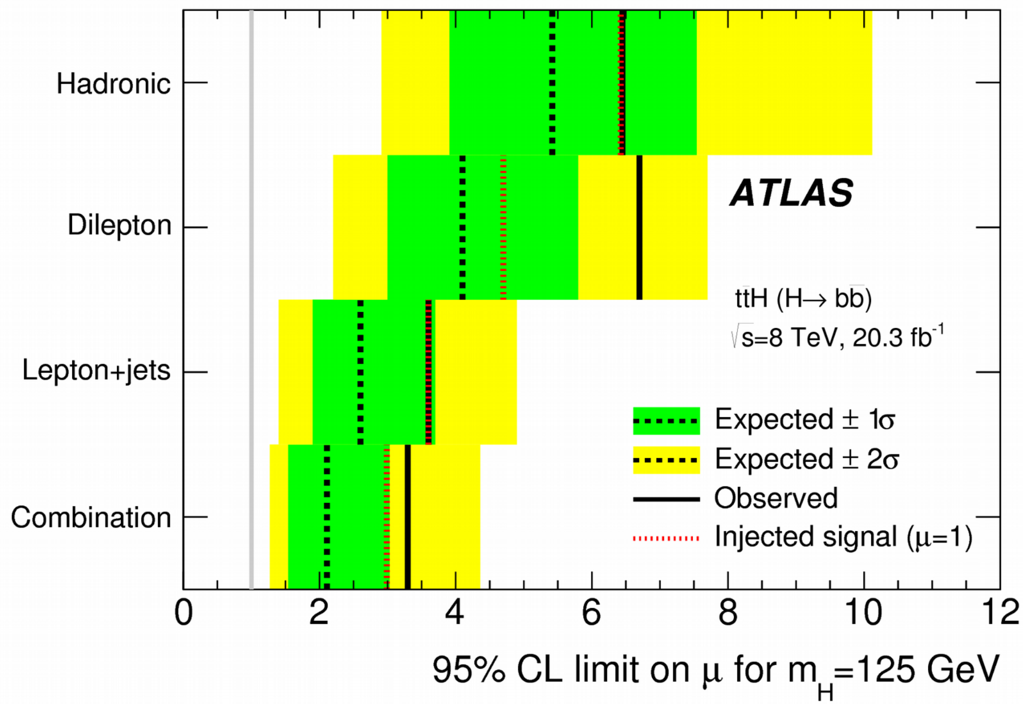
ATLAS
20.3 fb-1
√s = 8 TeV
≥ 8 j, ≥ 4 b
Data
Multijet
tt+light
tt+cc
tt+bb
tt+V
Single top
ttH (125)
Total unc.
Post-fit
Events / 0.1
Data / Pred
BDT response

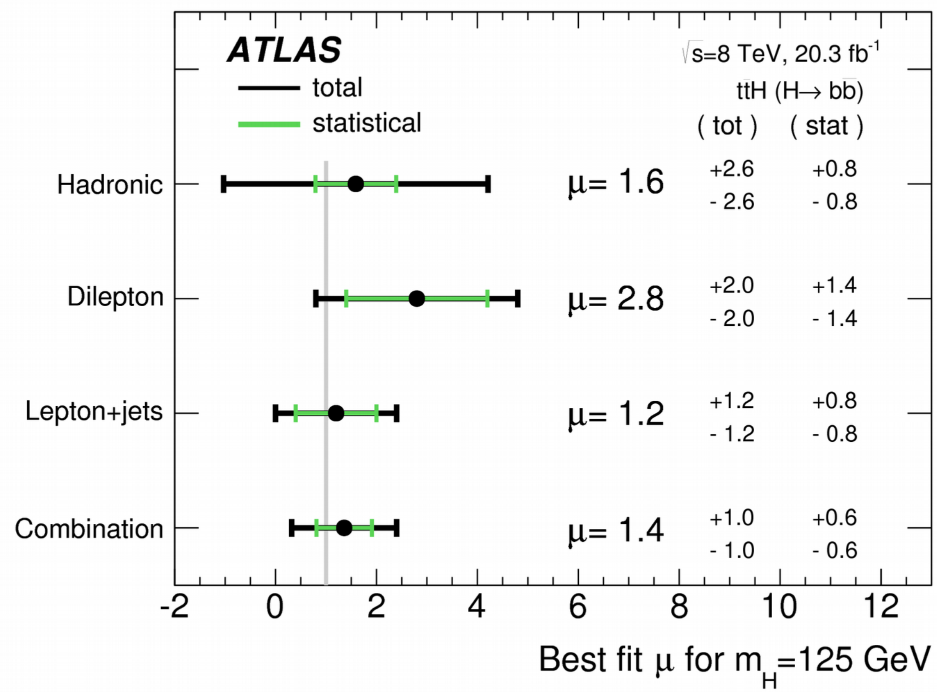


Δμ
ATLAS
√s = 8 TeV, 20.3 fb-1
tt+bb normalisation
Multijet SF (≥8j,≥4b)
Multijet SF (7j,≥4b)
Multijet SF (≥8j,3b)
Multijet SF (7j,3b)
Multijet SF (6j,3b)
Multijet SF (6j,≥4b)
tt ISR/FSR reweighting
b-jet tagging 1
Multijet set 1
Multijet Random MV1
Multijet HT rw
tt+bb parton shower
tt+cc parton shower
Jet Energy Resolution
tt+bb PDF (NNPDF)
tt+bb FSR
Jet Energy Scale flav. comp.
Jet Energy Scale flav. resp.
Multijet set 2
mH=125 GeV
Pull: (θ̂ - θ0)/Δθ
Scale Factors
±1σ pre-fit Impact on μ
±1σ post-fit Impact on μ

ttH[bb] Results

- Combined obs (exp) limit 3.3 (2.1) x SM
  - median limit with SM signal = 3.0 x SM
- Best fit rate (1.4 ± 1.0) x SM
- Many systematics (e.g. tt+HF normalization) will be reduced with more data





ttH, H → WW/ττ

- Complex topologies: WWWWbb or ττWWbb
  - rich set of final states with high multiplicities
  - backgrounds mostly tt + EWK, not tt + QCD
- Take advantage of final states not reachable from tt production
  - ≥ 3 leptons, or 2 same sign leptons
- H → ττ worth exploiting
  - σ(ttZ) and σ(ttH) similar: no overwhelming Z bkg to H → ττ

	Higgs boson decay mode			
	WW*	ττ	ZZ*	other
2ℓ same sign 0τ	80%	15%	3%	2%
3ℓ	74%	15%	7%	4%
2ℓ same sign 1τ	35%	62%	2%	1%
4ℓ	69%	14%	14%	4%
1ℓ 2τ	4%	93%	0%	3%

PLB 749, 519 (2015)

ttH multilepton decays

Signal

Higgs decay	$t\bar{t}$ decay: $\ell\nu\ell\nu$ bb	$t\bar{t}$ decay: $\ell\nu$jj bb
$H \rightarrow WW \rightarrow \ell\nu\ell\nu$	4ℓ	3ℓ
$H \rightarrow WW \rightarrow \ell\nu jj$	3ℓ	$2\ell 0\tau$
$H \rightarrow \tau_l \tau_l$	(4ℓ)	3ℓ
$H \rightarrow \tau_l \tau_h$	3ℓ	$2\ell 1\tau$
$H \rightarrow \tau_h \tau_h$	---	$1l2\tau$

all-hadronic top not targeted

only accept same sign ℓ (for $2\ell 0\tau$)

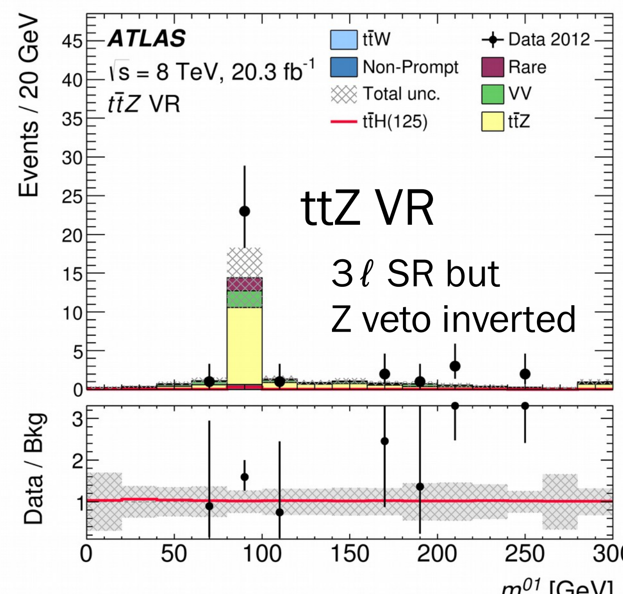
+ require ≥1 b-jet,
high (≥2-5) jet multiplicity

$H \rightarrow ZZ$ not very important due to low BF and Z vetoes

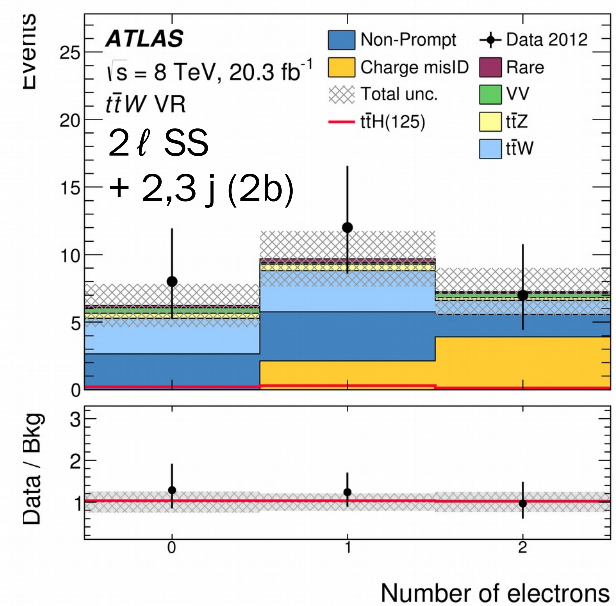
Backgrounds

Main bkg: non-prompt leptons, ttZ, ttW, diboson + jets, fake τ

- non-prompt lepton bkg estimated from extrapolation in isolation, ID variables, p_T
- other backgrounds estimated from Monte Carlo, checked in various validation regions

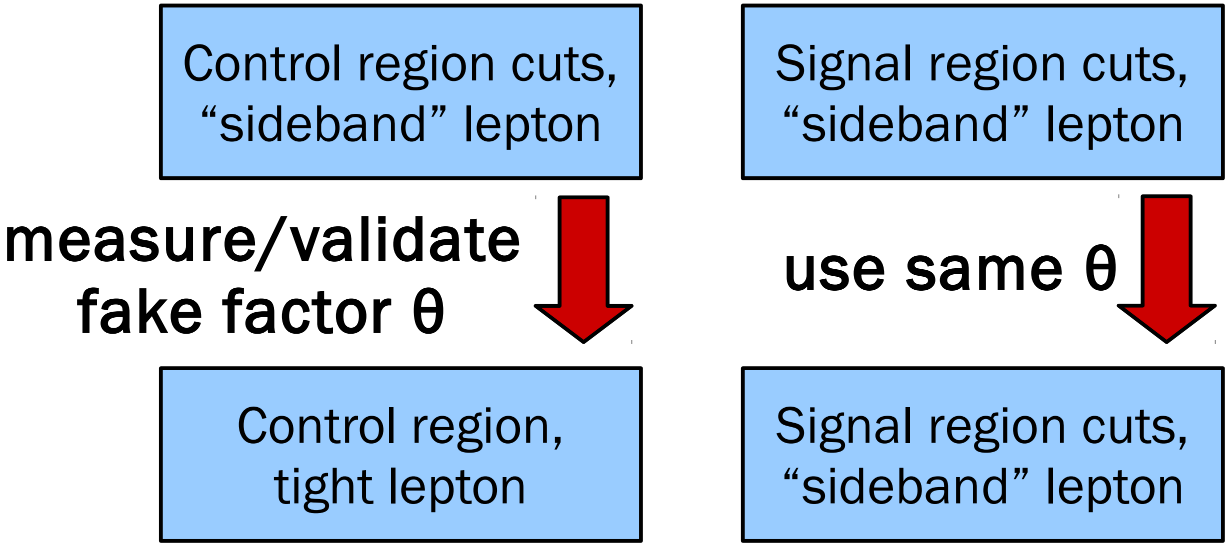


inv mass, smallest ΔR OS lepton pair



Fake Lepton Backgrounds

- Slightly different techniques in each channel.
  - $2\ell 0\tau$, 3ℓ, $2\ell 1\tau$: variants on “fake factor” methods
  - 4ℓ: limit from MC
  - $1\ell 2\tau$: predict fake τ bkg from MC (well modeled with looser event cuts)

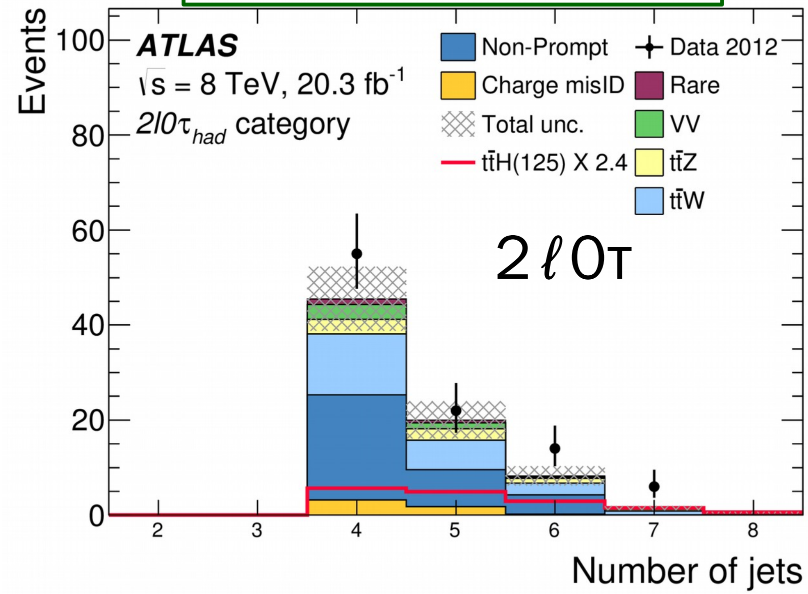


e.g. $2\ell 0\tau$: control region cuts: lower # jets than SR
sideband leptons: non-isolated electrons, low-p_T muons

Fake predictions cross checked with other ATLAS methods

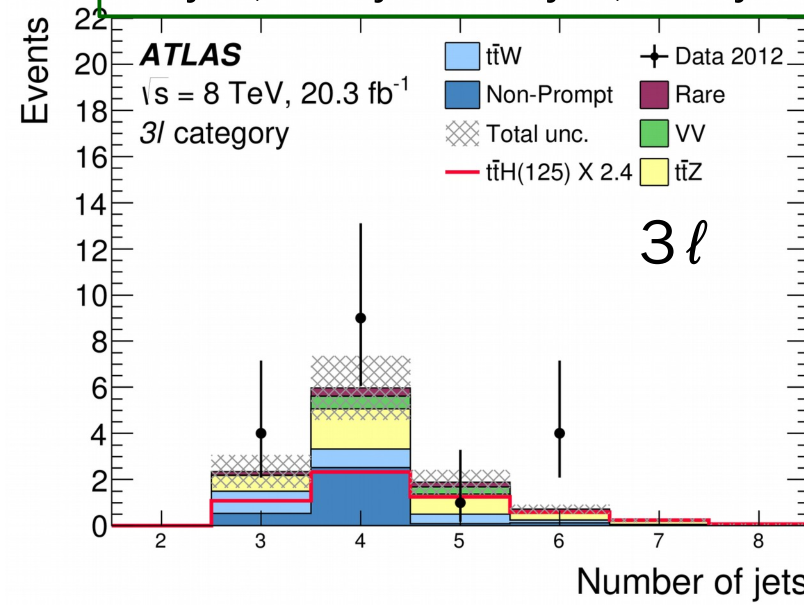
ttH, H → WW/ττ

2 same sign leptons, no tau
≥ 4 jets, ≥ 1 b-jet



Total bkg	77 ± 13
SM H(125)	6.6 ± 1.4
Observed	98

3 leptons
≥ 4 jets, ≥ 1 b-jet or = 3 jets, ≥ 2 b-jets



Total bkg	11.4 ± 3.1
SM H(125)	2.34 ± 0.32
Observed	18

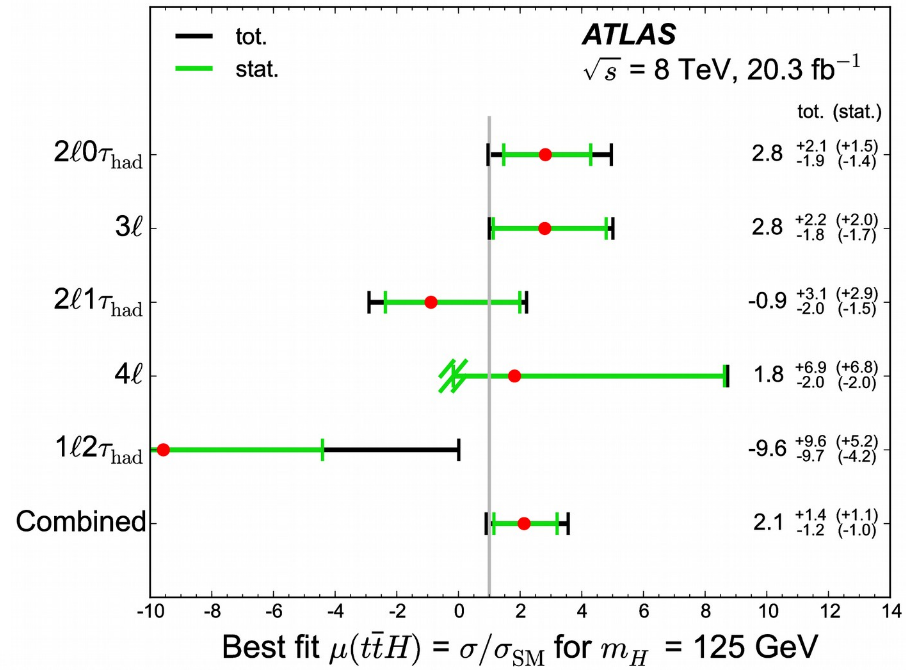
	2ℓ 1τ	4ℓ	1ℓ 2τ
Total bkg	1.4 ± 0.6	0.55 ± 0.17	16 ± 6
SM H(125)	0.47 ± 0.02	0.20 ± 0.01	0.68 ± 0.07
Observed	1	1	10

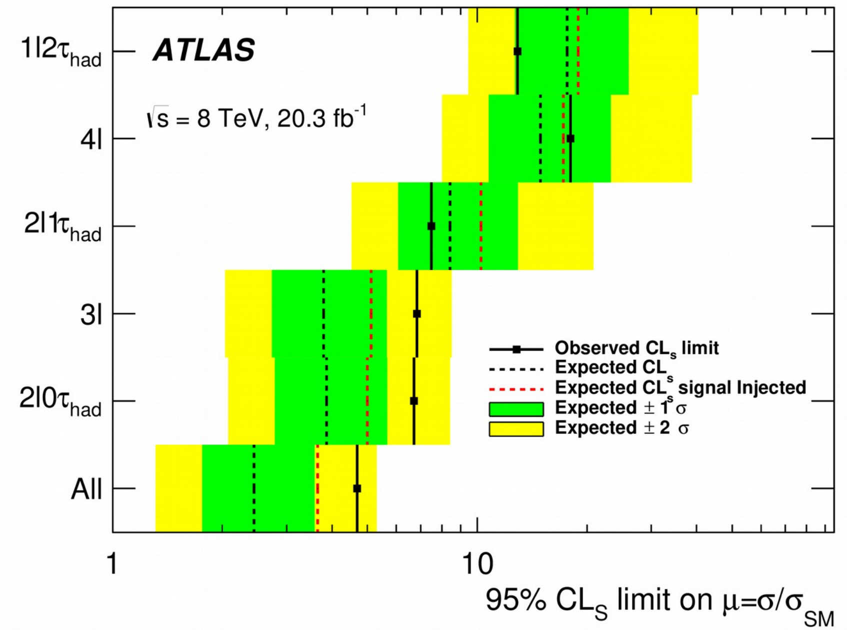
Combined multilepton channels:

$$\mu = 2.1^{+1.4}_{-1.2}$$

$$\mu < 4.7 \text{ obs } (2.4 \text{ exp}) \text{ @ } 95\% \text{ CL}$$

Consistent with SM





Leading systematics:

non-prompt lepton rate in 2ℓ0τ

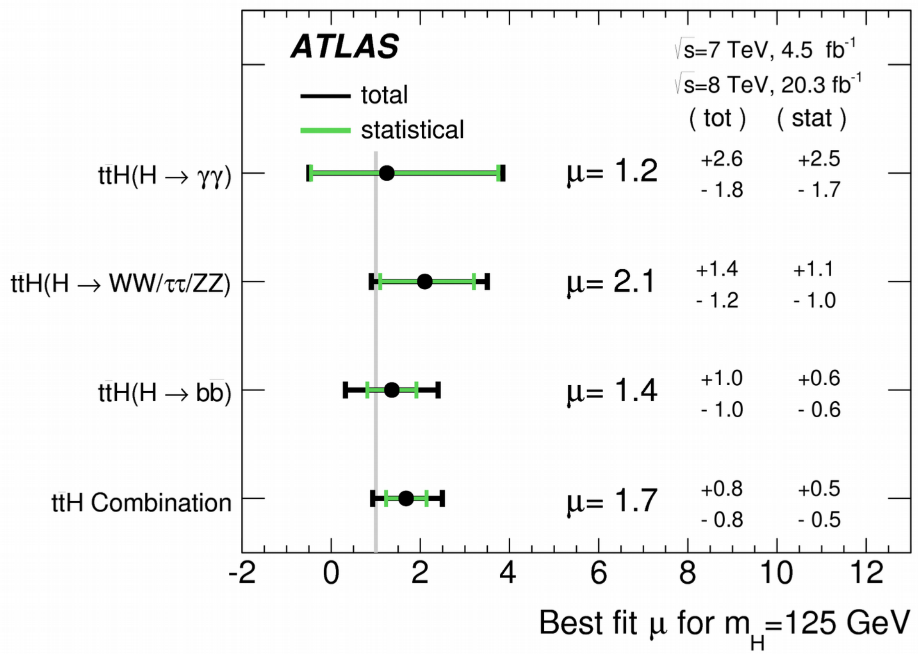
acceptance for ttW+jets

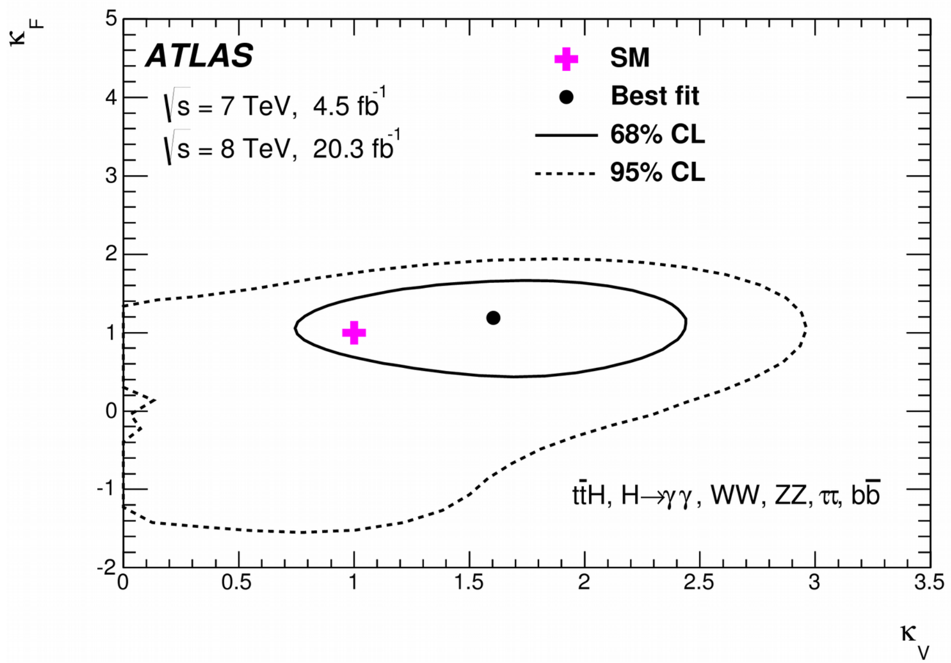
cross sections for ttW, ttZ

Full ttH Combination

- Best fit μ = 1.7 ± 0.8 (all analyses)
  - μ < 3.1 (1.4 exp) @ 95% CL
- Can perform coupling analysis entirely using ttH channels
  - assume fermions share common Higgs coupling strength modifier κ_F, bosons share modifier κ_V
  - compatible with SM

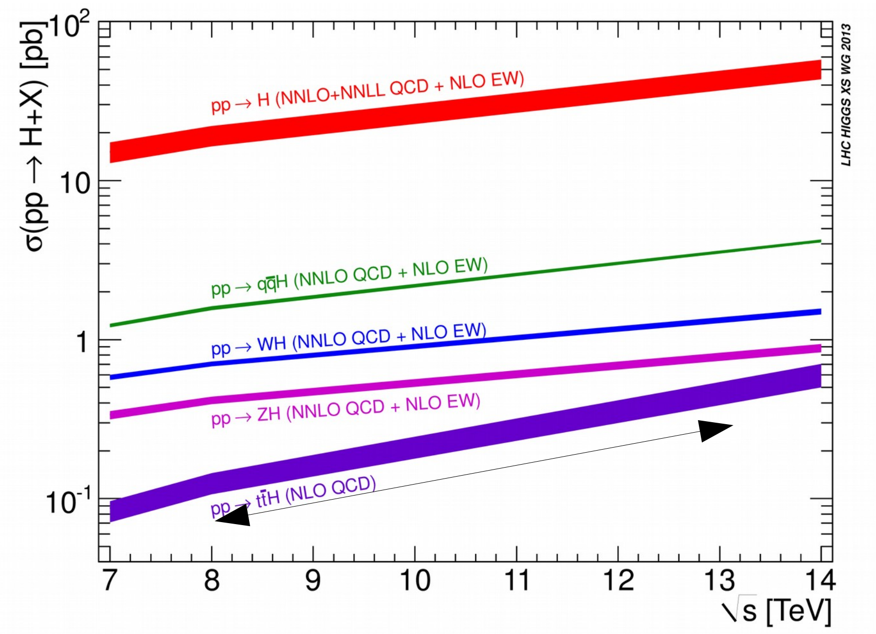
arxiv:1604.03812



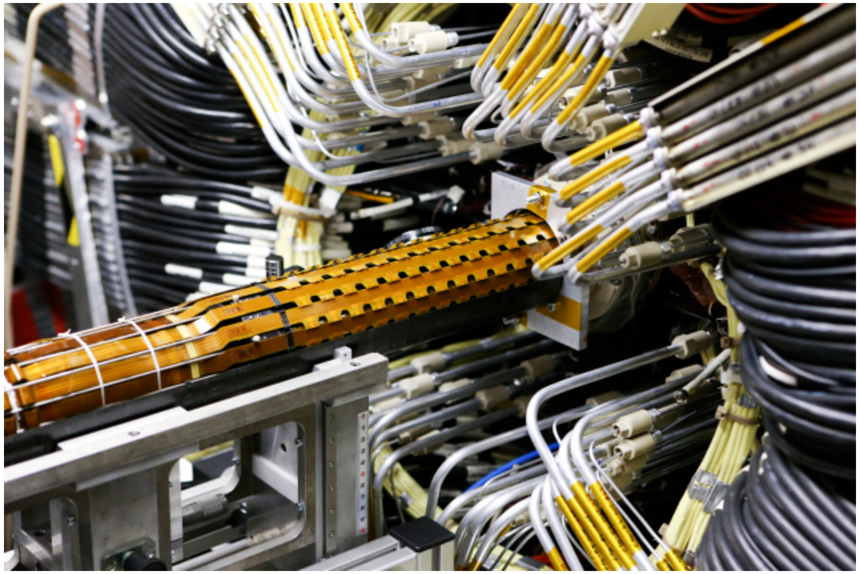


ttH Prospects in Run 2

- Each fb^{-1} worth more @ 13 TeV
  - σ(ttH) up a factor ~ 4
- new pixel layer, b-tagging algorithm improvements give better mistag rate
- Analysis improvements



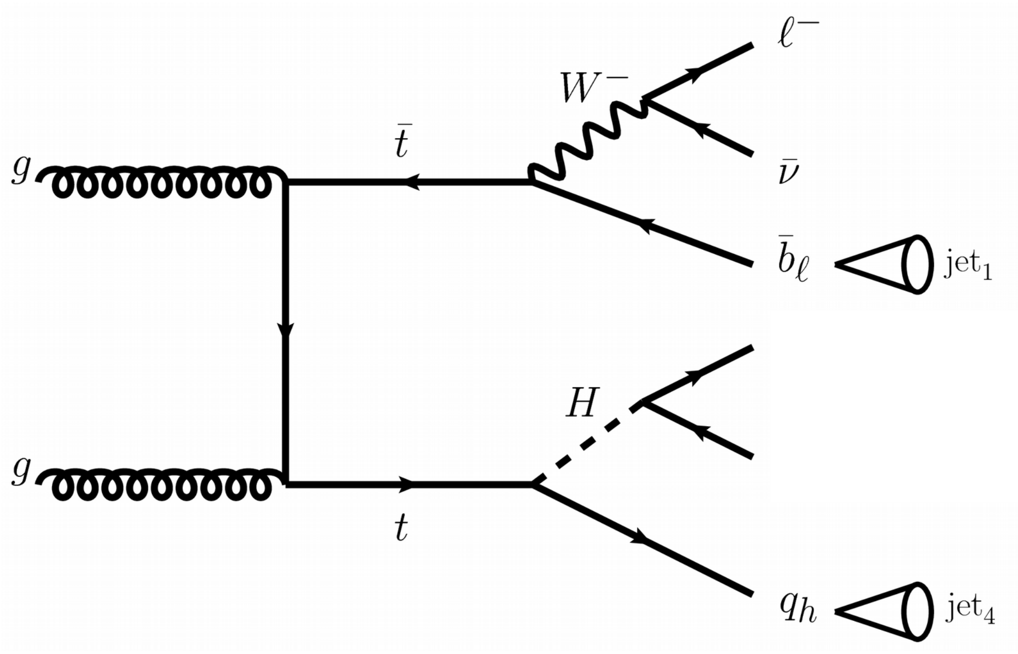
IBL insertion



ttH observation at 5σ is very likely in Run 2 after combination of channels

Flavor-Changing Neutral Currents

- In the SM, there are no vertices involving the Higgs and two different fermions
  - such interactions generally strongly constrained by low energy precision measurements … except for the third generation
- A detectable tqH (q=u, c) coupling is still allowed
  - if one assumes the tqH coupling is the geometric mean of the ttH and qqH couplings, BR(t → Hc) ~ 0.2% !



Fritzsch-like ansatz:

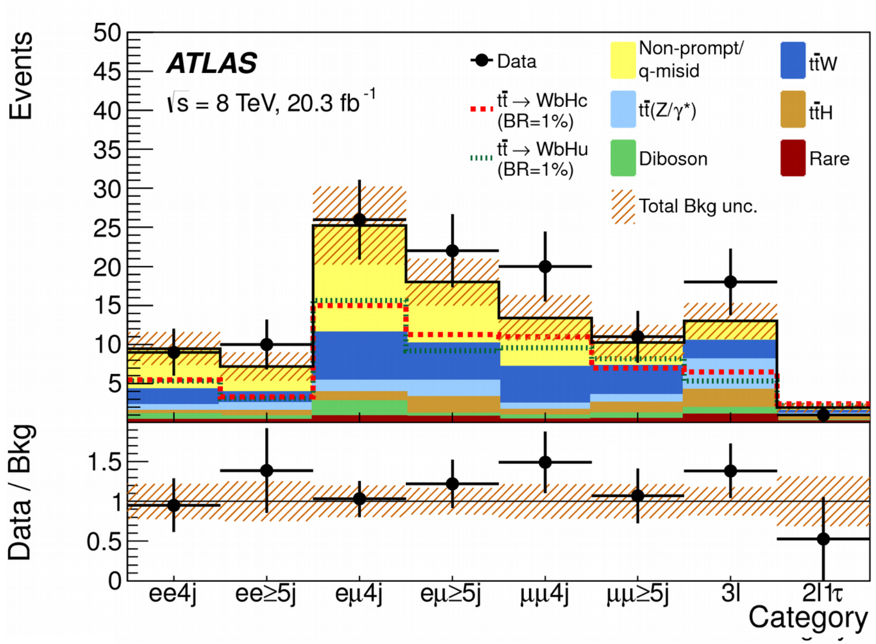
$$\lambda_{tc} = \frac{\sqrt{m_t m_c}}{v} \sim 0.063$$

Kao, Cheng, Hou, Sayre PLB 716, 225 (2012)

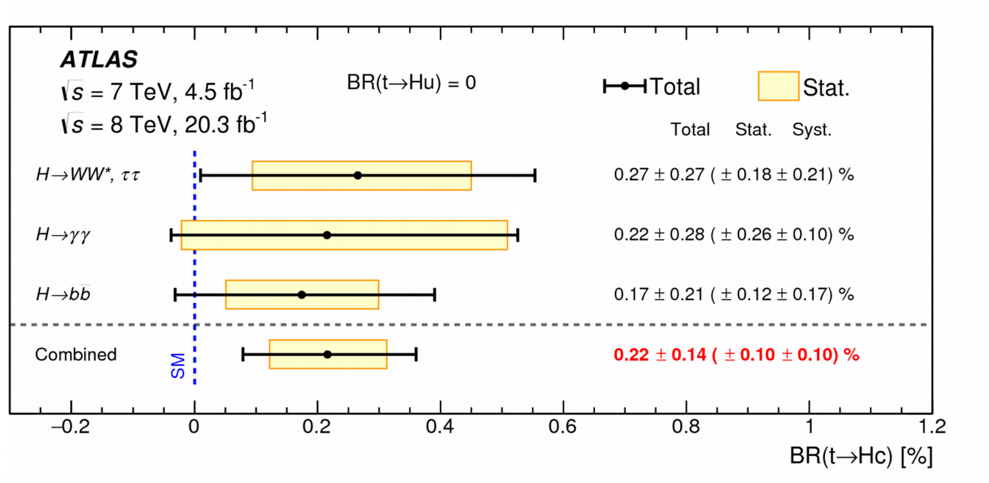
FCNC t → Hq

- Dedicated ATLAS studies done in H → γγ, H → bb; we also repurposed the ttH[WW/ττ] search
  - challenge: FCNC signal contaminates regions used for non-prompt lepton estimation
  - lesson: new physics will not necessarily restrict itself to search regions

JHEP 12(2015) 061



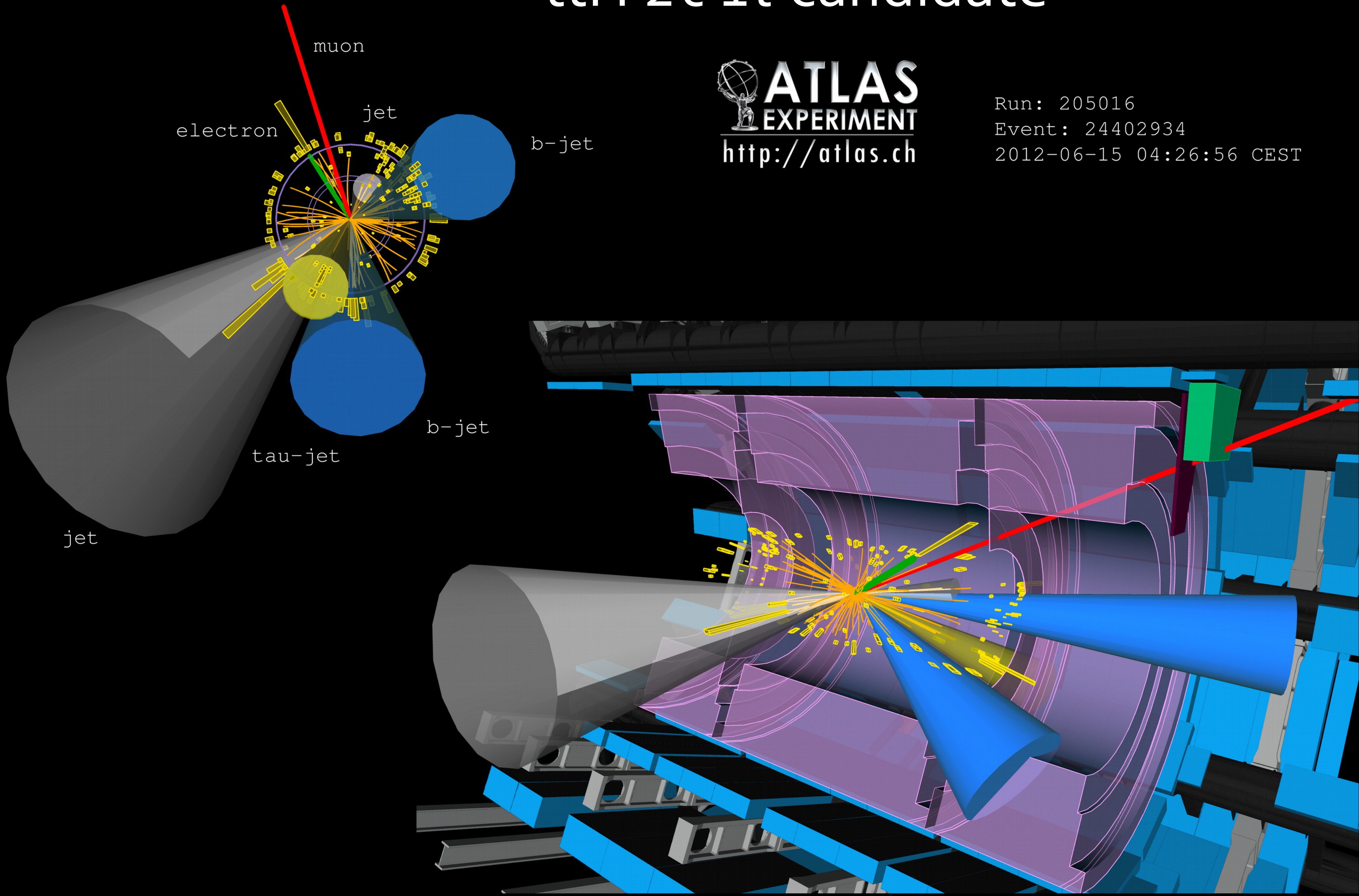
Combination of channels:
Limit BR(t → Hc) < 0.46% (0.25% exp) @ 95% CL
Best-fit BR(t → Hc) = (0.22 ± 0.14)%



Summary

- ttH is a key channel to measure the top Yukawa coupling and constrain new physics
  - Multiple channels are available to search for the signal
  - discovery will be from combination, not from a single channel
  - Run 1 analyses done, look forward to increased statistics of Run 2!
- Can also look for non-SM-like couplings
  - $t \rightarrow Hc$ search entering interesting region and is very exciting for Run 2

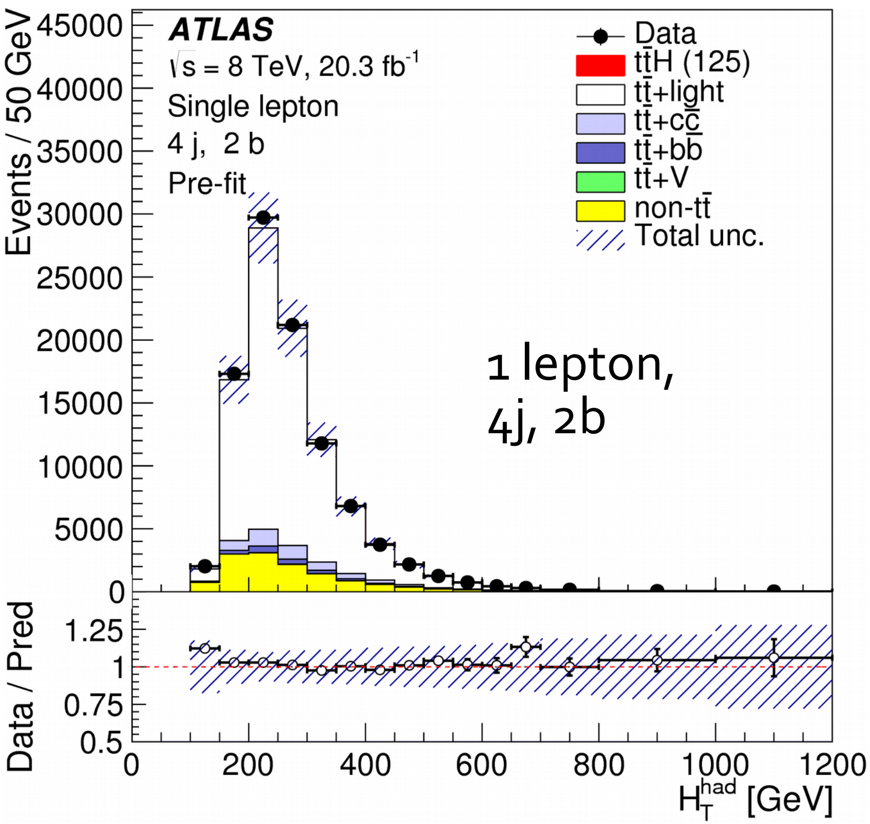
ttH 2ℓ 1τ candidate



Extra

How to look for ttH?

- Generic signature is top pair + a Higgs decay
  - H → γγ has a narrow bump
  - H → bb has a large rate
  - H → WW, H → ττ produce multilepton events
  - H → ZZ → 4ℓ has too low a rate
- Top pairs have a characteristic signatures of leptons, jets, and b-tagged jets

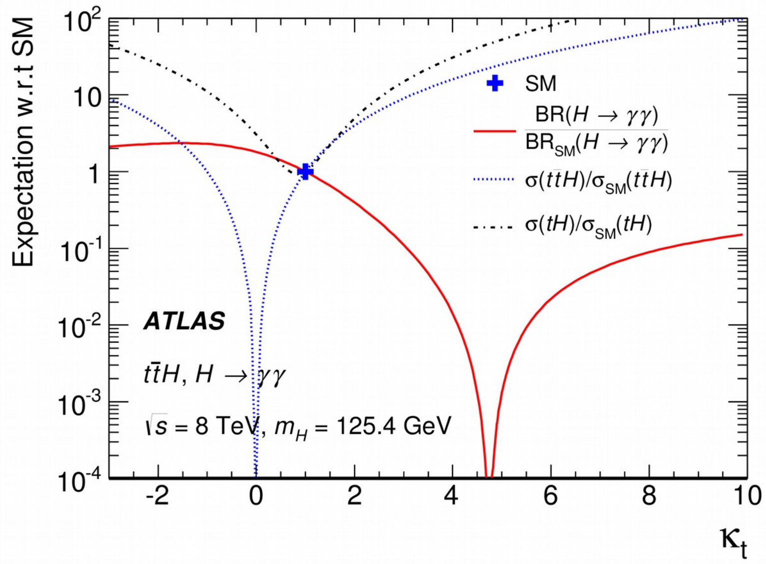


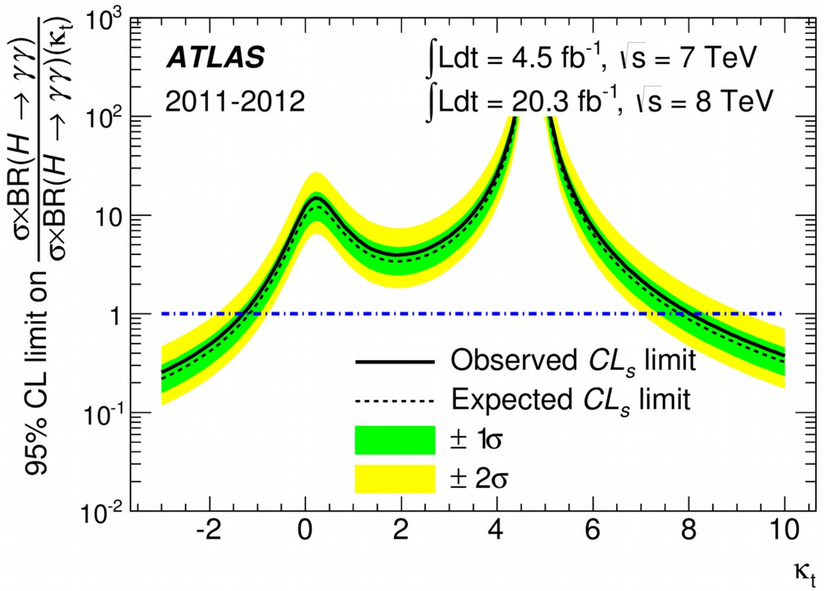
[8 TeV] Diphoton Selection

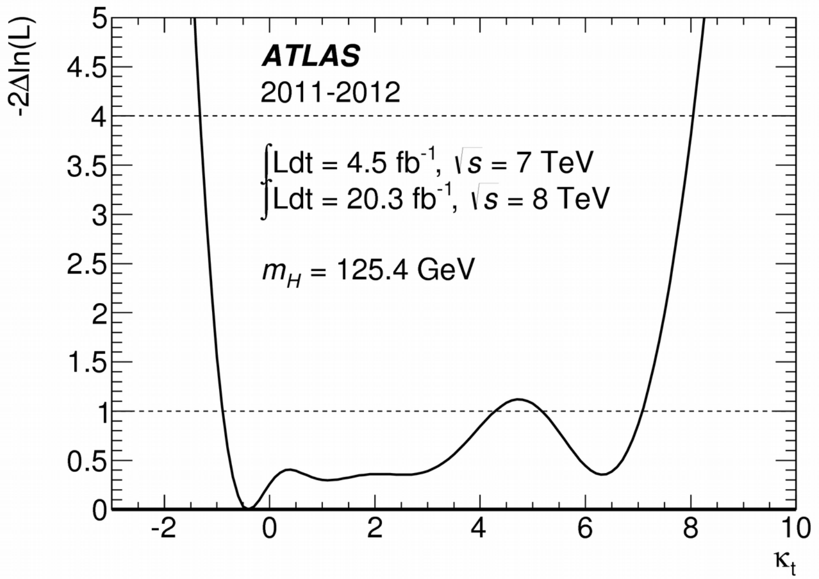
- trigger: diphoton, p_T > (35, 25) GeV
- photons: leading (subleading) p_T > 0.35 (0.25) x $m_{\gamma\gamma}$; require == 2 photons
- leptons: e p_T > 15 GeV; μ p_T > 10 GeV
- leptonic channel: ≥1 lepton, M(eγ) not in [84, 94] GeV, ≥ 1j @ 25 GeV, ≥ 1b @ 80% WP, ETmiss > 20 GeV if only one b-jet
- hadronic channel: no leptons
  - ≥ 6j @ 25 GeV, ≥ 2b @ 80% OR
  - ≥ 5j @30 GeV, ≥ 2b @ 70% OR
  - ≥ 6j @30 GeV, ≥ 1b @ 60%

Category	N_H	ggF	VBF	WH	ZH	$t\bar{t}H$	$tHqb$	WtH	N_B
7 TeV leptonic selection	0.10	0.6	0.1	14.9	4.0	72.6	5.3	2.5	$0.5^{+0.5}_{-0.3}$
7 TeV hadronic selection	0.07	10.5	1.3	1.3	1.4	80.9	2.6	1.9	$0.5^{+0.5}_{-0.3}$
8 TeV leptonic selection	0.58	1.0	0.2	8.1	2.3	80.3	5.6	2.6	$0.9^{+0.6}_{-0.4}$
8 TeV hadronic selection	0.49	7.3	1.0	0.7	1.3	84.2	3.4	2.1	$2.7^{+0.9}_{-0.7}$

Diphoton Coupling Interpretation

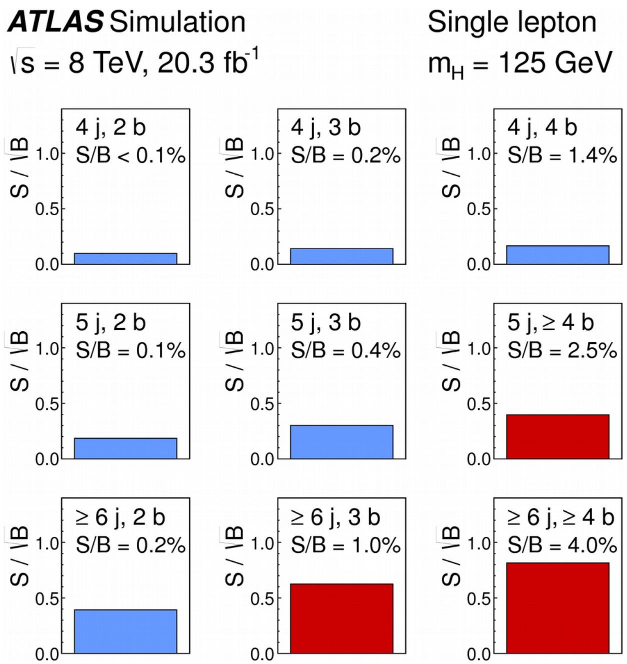


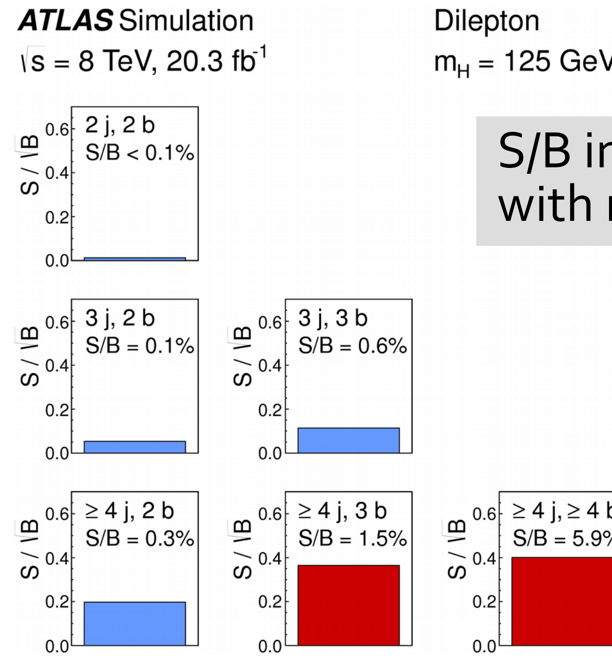




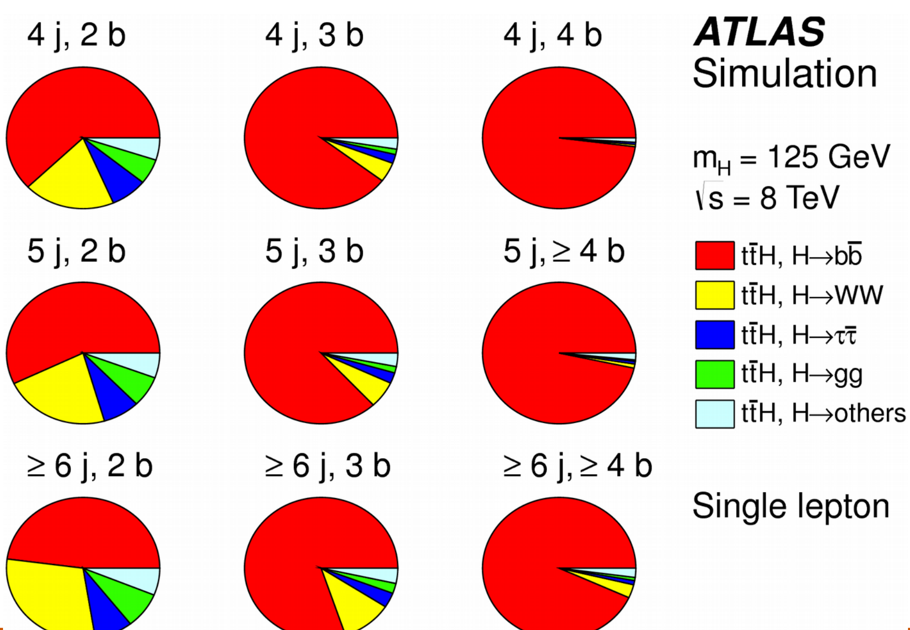
κ_t scales the SM Yukawa coupling (1=SM)

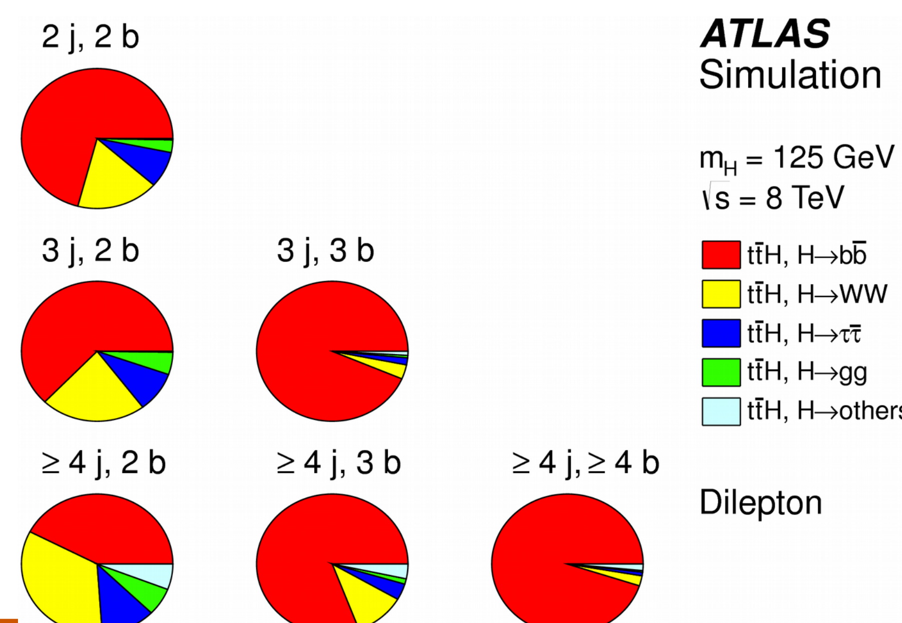
Categories





S/B improved with neural net





Event Selection

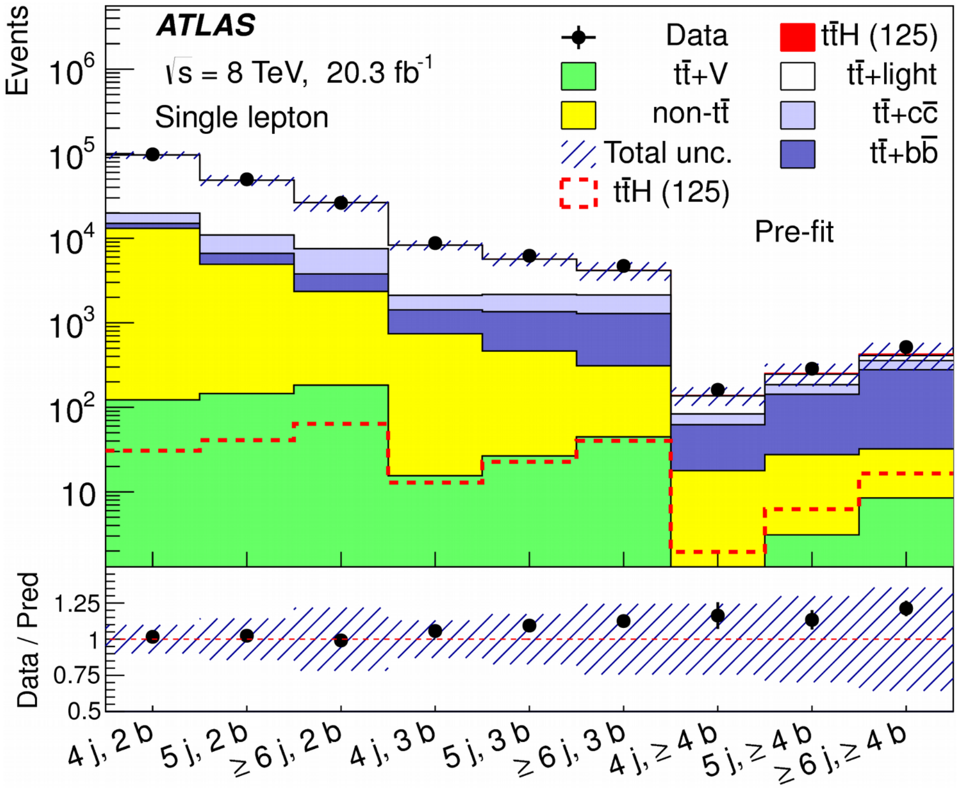
- trigger: single lepton triggers (e or μ); full efficiency @ 25 GeV
- leptons: leading p_T > 25 GeV, subleading p_T > 15 GeV (dilepton channel)
  - 1, 2-lep channels have no overlap
  - dilepton: Mll > 15 GeV, veto events with Mll = $M_Z \pm 8$ GeV for same flavor; H_T > 130 GeV for eμ
- jets: anti-k_T 0.4, p_T > 25 GeV, $|\eta| < 2.5$
- b tagging: 70% efficiency working point

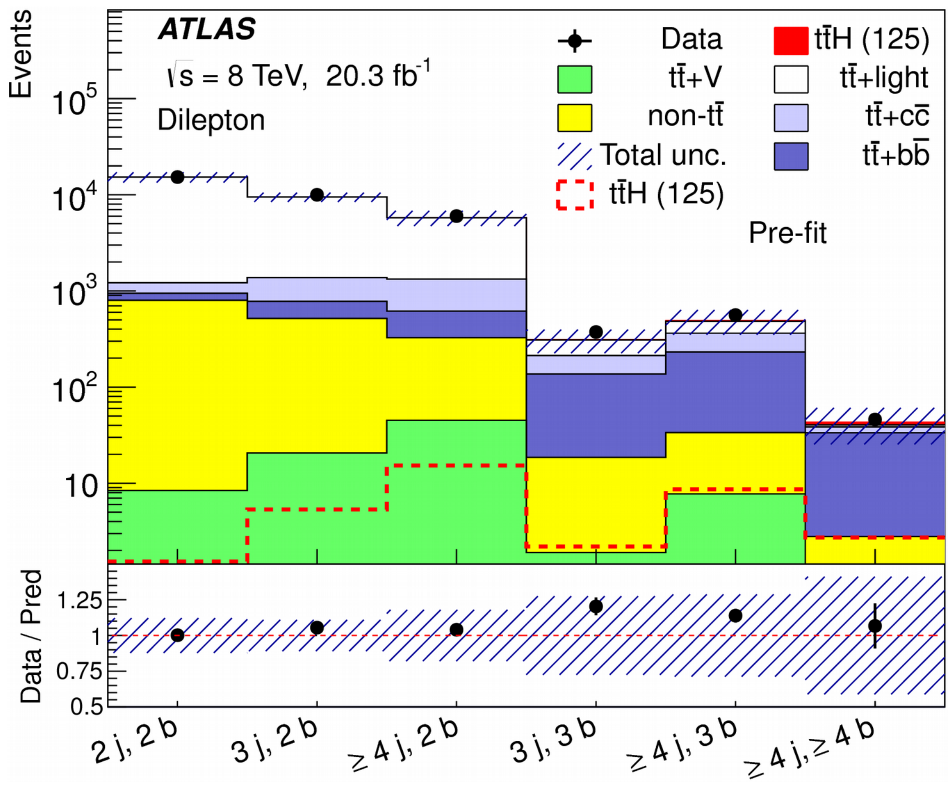
Top Pair Modeling

- Simulations of top quarks + extra jets are still not super-sophisticated
  - Leading order matched simulations (MadGraph/Sherpa) can certainly do a consistent job
  - NLO generation for extra heavy flavor just becoming available, not yet possible to do *full* (light+heavy quark) matched NLO with mass effects
- The vast majority of tt+bb in the relevant kinematic regions comes from parton shower, even in LO matched simulations
  - guessing the kinematic regions where ME and PS are important (which you need to do for Alpgen matching) is a **bad idea**
- We find best agreement in control regions with Powheg+Pythia (NLO) – this is our baseline

Pre-Fit Yields

- Most tt+light in l+jets 3b comes from W ⟶ cs tags
  - no analog in 2l





The Fit

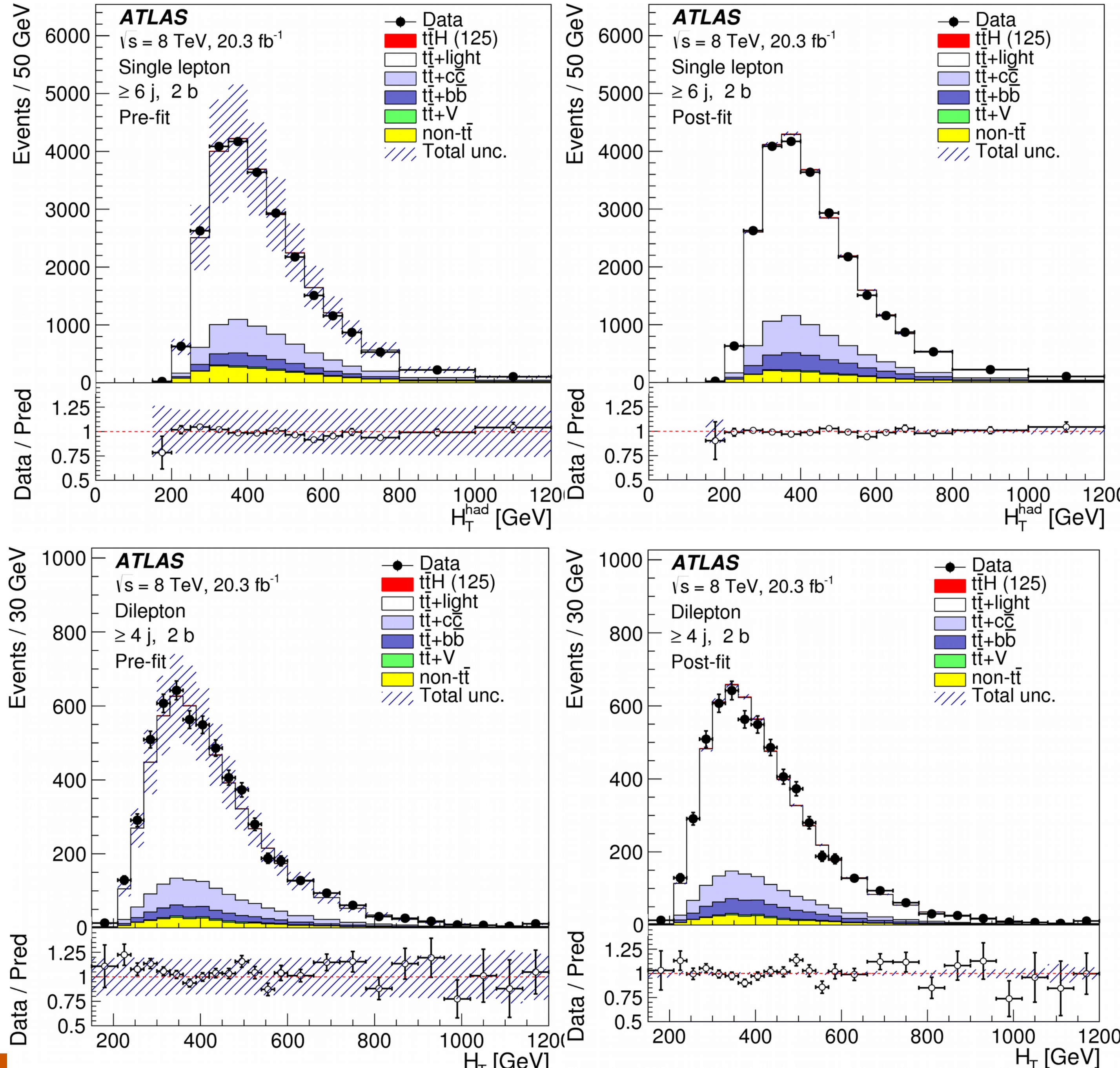
- Systematic uncertainties are "profiled" in the fit: we provide an initial constraint and allow data to update the values & errors
  - in particular this constrains background systematics using bkg-rich regions, and allows in situ charm tagging measurement
- All control and signal regions for lepton + jets and dileptons fit simultaneously
  - of course we can cross check between the channels; excellent agreement seen on central value of systematic nuisance parameters

bb Systematics

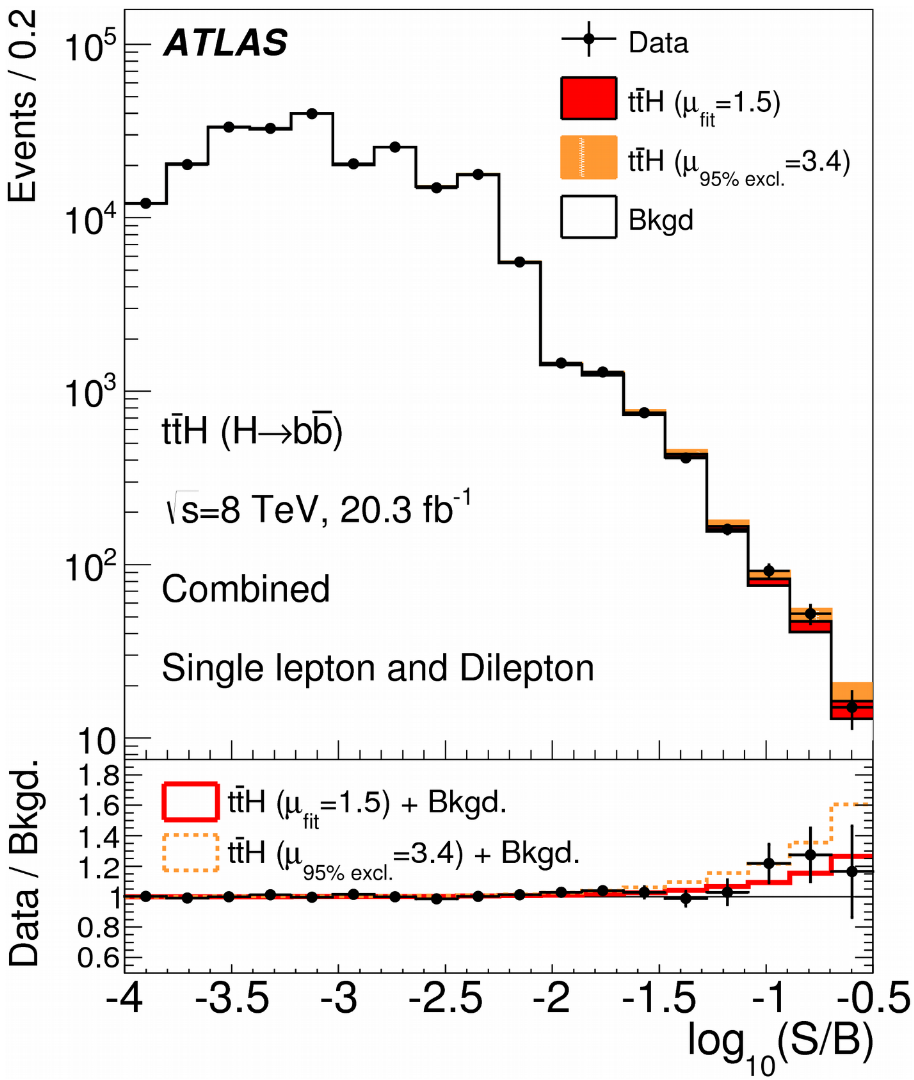
Systematic uncertainty	Type	Comp.
Luminosity	N	1
Physics Objects		
Electron	SN	5
Muon	SN	6
Jet energy scale	SN	22
Jet vertex fraction	SN	1
Jet energy resolution	SN	1
Jet reconstruction	SN	1
b-tagging efficiency	SN	6
c-tagging efficiency	SN	4
Light-jet tagging efficiency	SN	12
High-p_T tagging efficiency	SN	1
Background Model		
$t\bar{t}$ 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
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 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

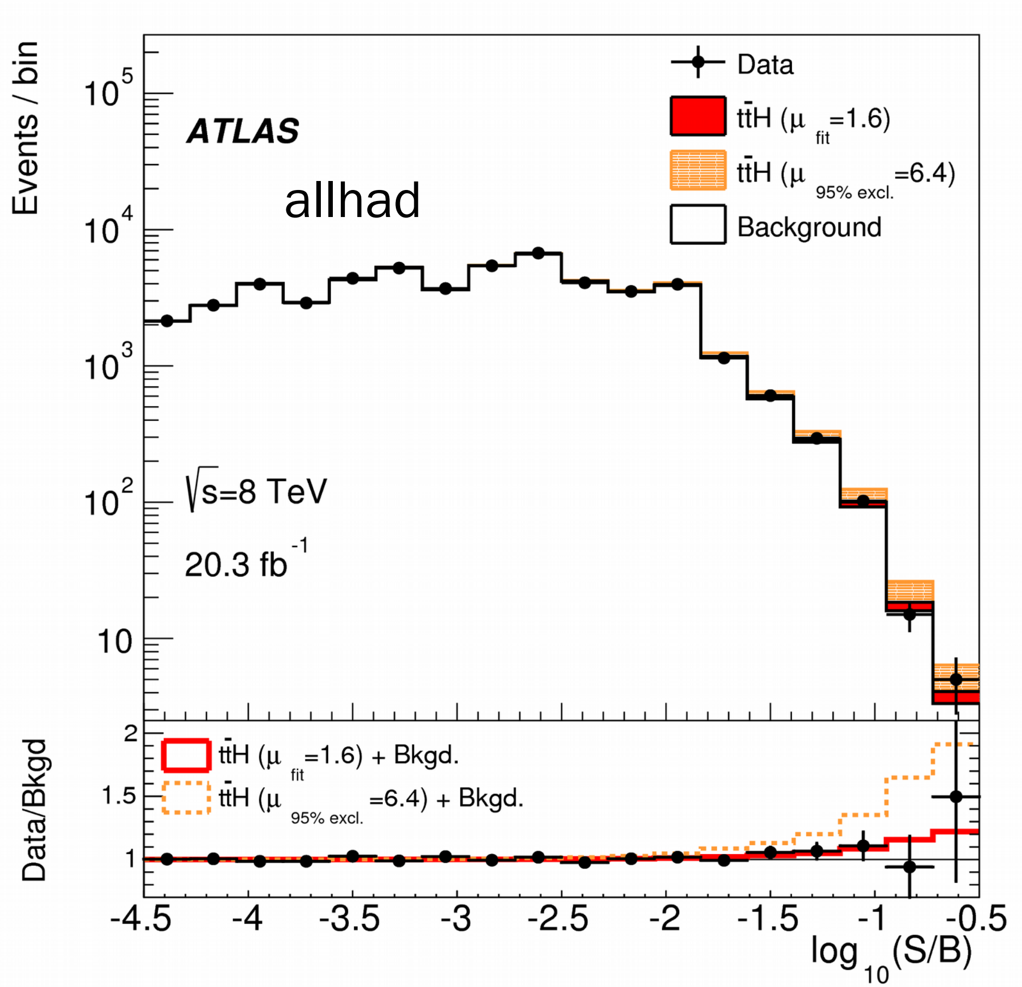
Largest effects come from tt+HF normalization, the tt reweighting, and b-tagging

Fit effect in Background-Rich Regions

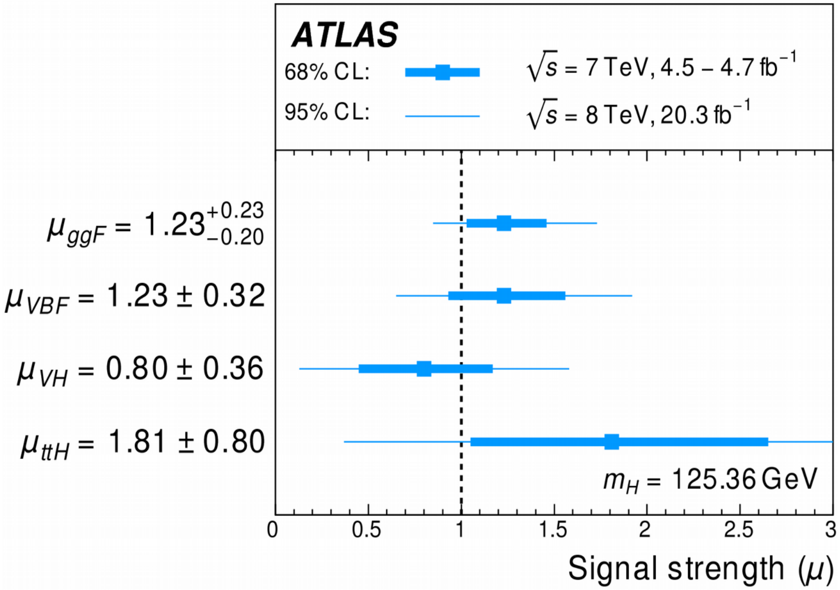


S/B Visualization





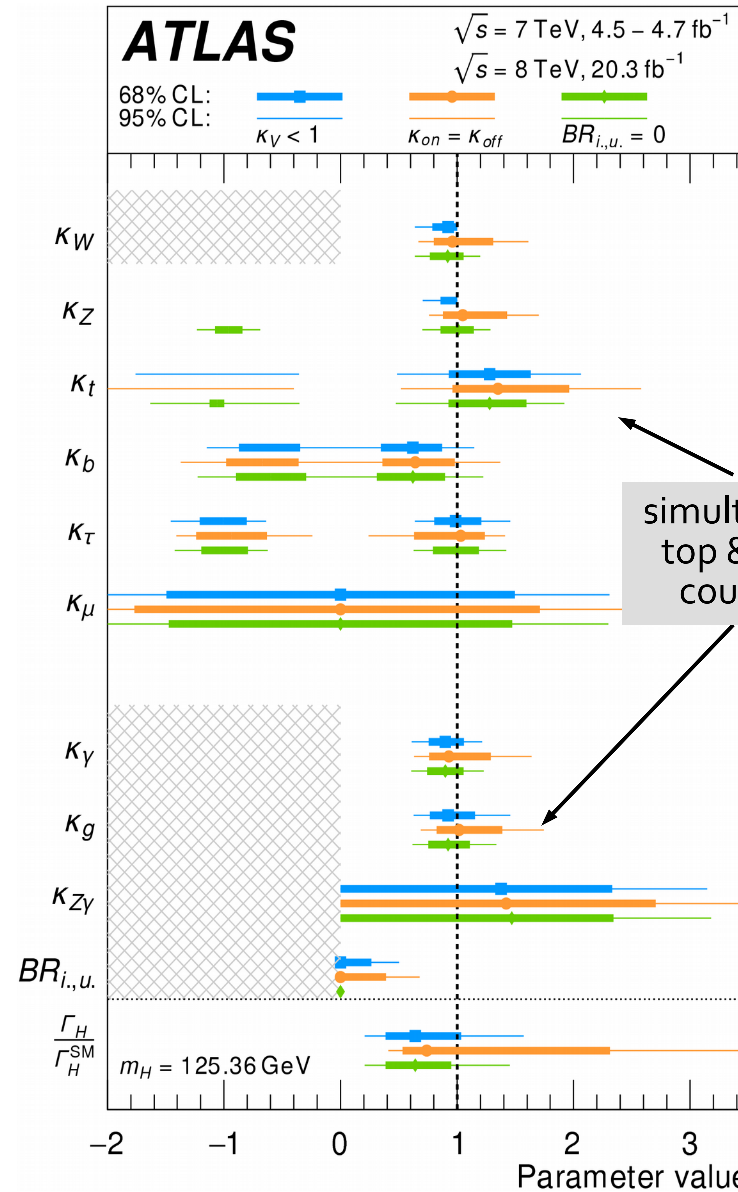
Combination, Couplings



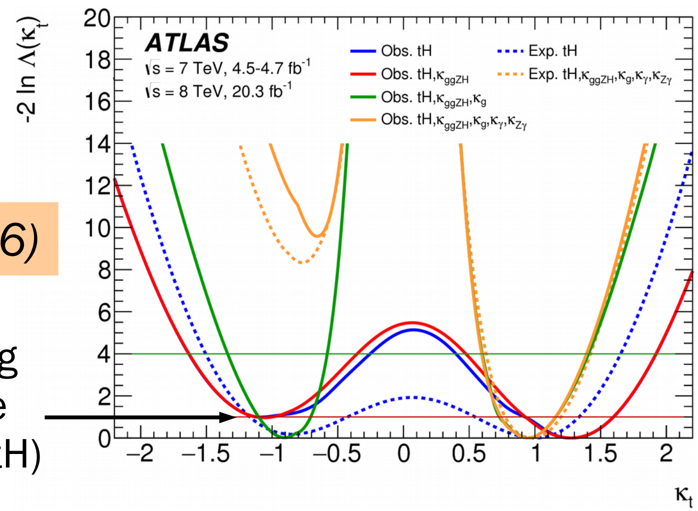
μ_{ttH} < 3.2 (1.4 exp) @ 95% CL

Signal significance: 2.5σ (1.5σ exp)

Start to constrain top coupling independent of gluon, photon loops



simultaneous top & gluon couplings

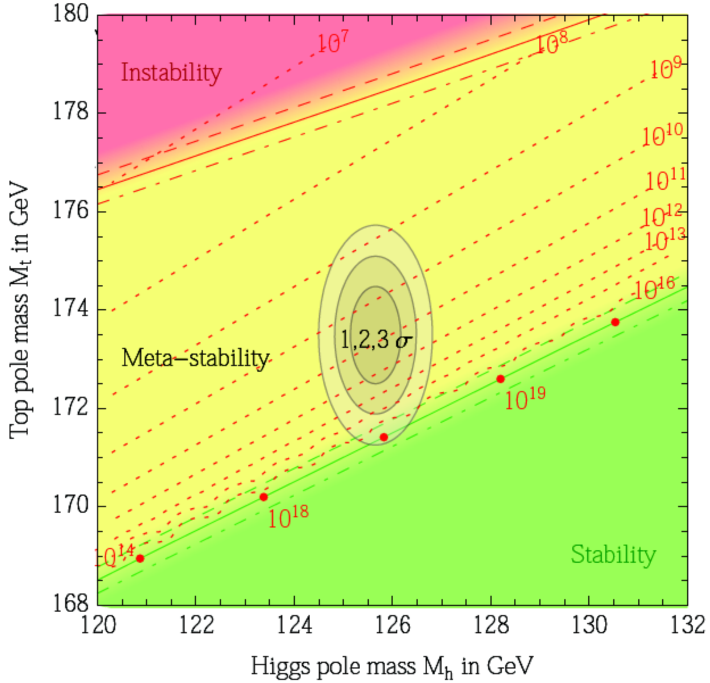


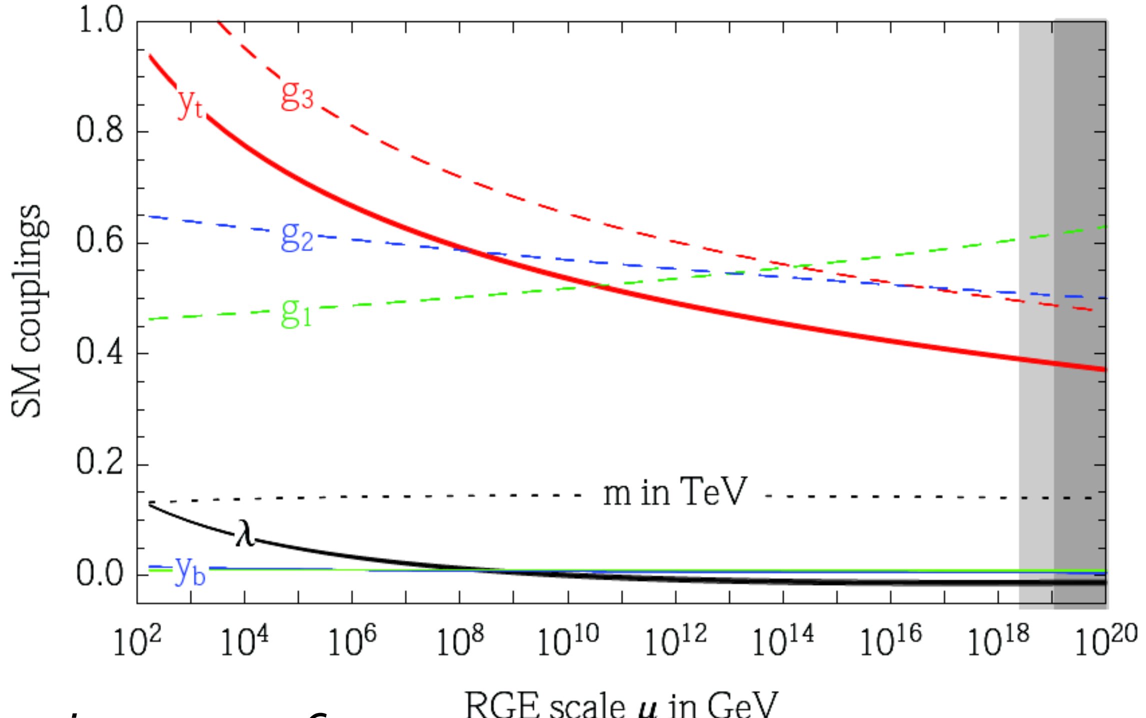
EPJ C 76, 6 (2016)

Sign flip for top coupling disfavored at 1σ by tree measurements alone (tH)

Vacuum Metastability

- Another reason to care about the top Yukawa: SM vacuum apparently metastable given m_H and m_t (aka, y_t). If actual y_t is different from SM, this issue has a different resolution

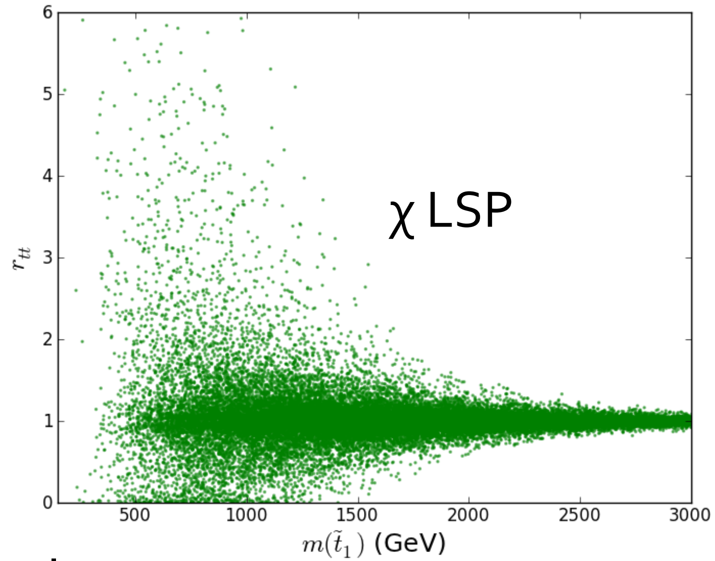




Buttazzo et al., arxiv:1307.3536

ttH in MSSM

- Scans of “pMSSM” models surviving experimental constraints
- Top coupling possibly strongly modified



Cahill-Rowley, Hewett, Ismail, Rizzo
arxiv:1308.0297