

# Measurements of the top quark mass using the ATLAS detector at the LHC

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on behalf of the ATLAS collaboration

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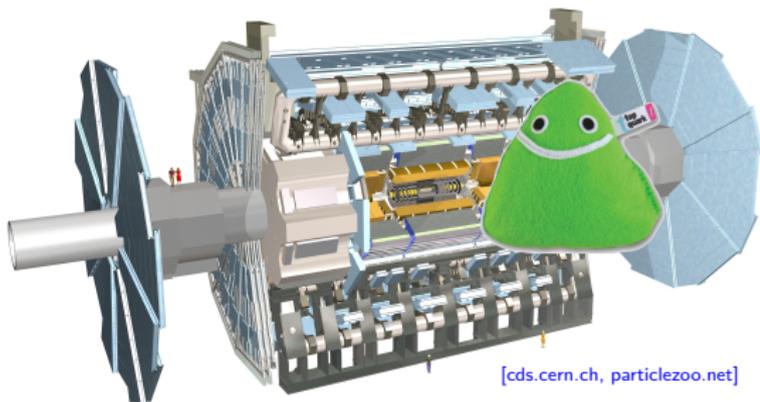
Federal Ministry  
of Education  
and Research

- top quarks produced via strong and electroweak interactions
  - comparatively large cross sections (\*)
- @13TeV:  $\sigma_{t\bar{t}} = 803 \text{ pb}$ ,  $\sigma_{t\text{-chan}} = 229 \text{ pb}$
- ⇒ millions of top quarks produced

data recorded by ATLAS

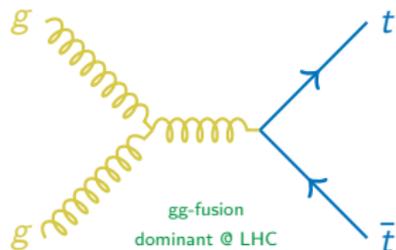
2011:	$4.6 \text{ fb}^{-1}$	7 TeV
2012:	$20.3 \text{ fb}^{-1}$	8 TeV
2015:	$3.2 \text{ fb}^{-1}$	13 TeV

(\*) talks by [A. Hasib](#), [P. Rieck](#)

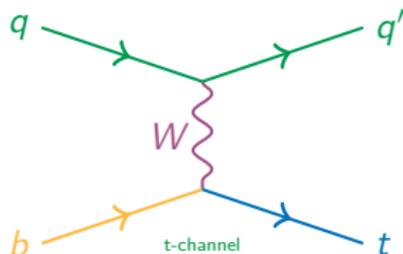


[[cds.cern.ch](http://cds.cern.ch), [particlezoo.net](http://particlezoo.net)]

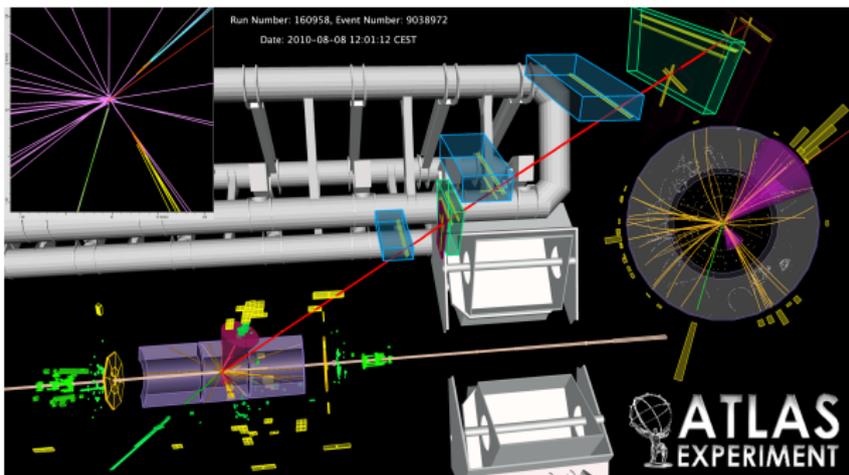
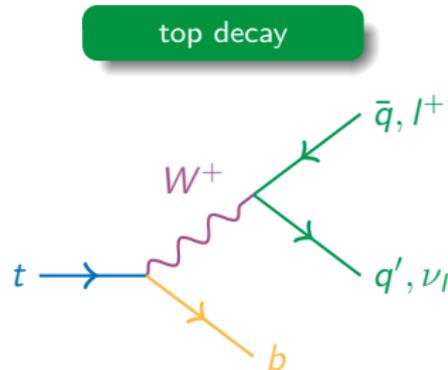
## top pair production



## single top production

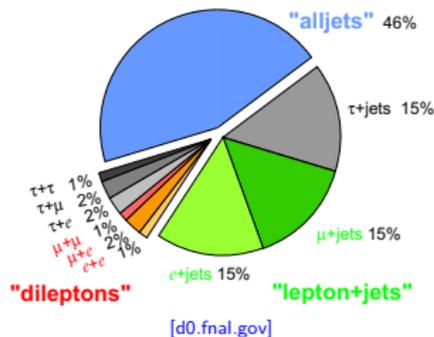


- top quarks decay electroweakly
- lifetime shorter than hadronization timescale  
⇒ study 'bare' quark properties
- decay proportional to  $|V_{CKM}|^2$   
⇒  $t \rightarrow Wb$  ( $\approx 100\%$ )  
⇒ use b-tagging to select top events



[AtlasPublic]

## Top Pair Branching Fractions

(only considering  $e/\mu$  in leptonic channels)

## top quark event topologies

## fully hadronic

- 6 jets (2 bjets)
- no leptons
- no  $E_{\text{T}}^{\text{miss}}$  ( $0 \nu$ )

## dileptonic

- 2 bjets
- 2 leptons
- $E_{\text{T}}^{\text{miss}}$  ( $2 \nu$ )

## lepton+jets

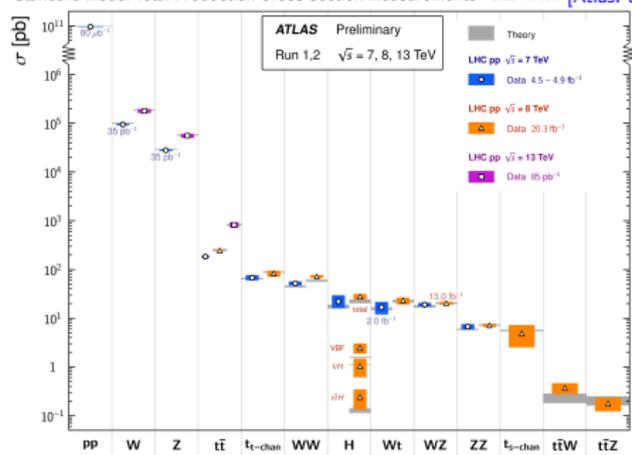
- 4 jets (2 bjets)
- 1 lepton
- $E_{\text{T}}^{\text{miss}}$  ( $1 \nu$ )

## t-channel

- 2 jets (1 bjet)
- 1 lepton
- $E_{\text{T}}^{\text{miss}}$  ( $1 \nu$ )

## Template measurements

- measure top quark mass as defined in MC
  - choose observable sensitive to  $m_{\text{top}}$
  - fit signal distribution(s) for different simulated values of  $m_{\text{top}}$
  - establish linear dependence of fit parameters on  $m_{\text{top}}$  ( $\hat{=}$  template)
- $\Rightarrow$  fit template(s) to data and extract  $m_{\text{top}}$

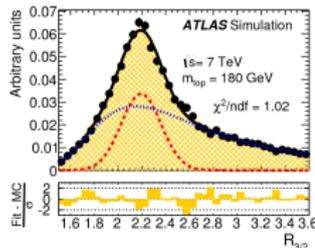
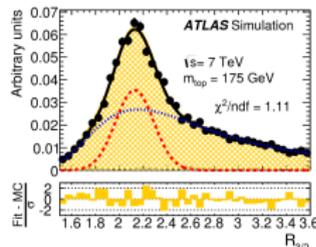
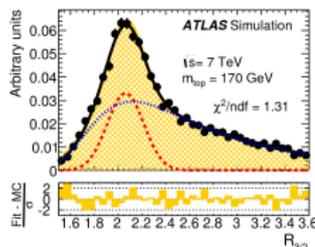
Standard Model Total Production Cross Section Measurements Status: Nov 2015 [AtlasPublic]

## Cross section measurements

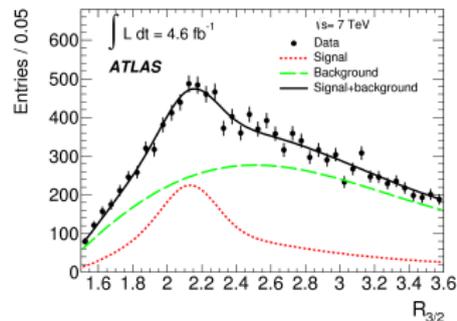
- exploit dependence of cross section on the top quark mass
  - measure the inclusive cross section of  $t\bar{t}$  production
  - measure differential  $t\bar{t} + 1\text{-jet}$  cross section
- $\Rightarrow$  extract  $m_{\text{top}}^{\text{pole}}$  from  $\sigma_{\text{top}}^{\text{meas}}$

Fully hadronic channel @ 7 TeV [Eur. Phys. J. C (2015) 75:158]

- large QCD multijet background
  - ⇒ high jet  $p_T$  requirements and b-tagging to select fully-hadronic  $t\bar{t}$ -events
- estimate background from data (ABCD method)
- reconstruct  $t\bar{t}$ -pair with kinematic fit
  - ⇒  $m_{\text{top}} = 175.1 \pm 1.4$  (stat)  $\pm 1.2$  (syst) GeV



- $t\bar{t}$  Simulation
- Gaussian
- Landau
- Gaussian + Landau (Separate fit)
- Combined fit

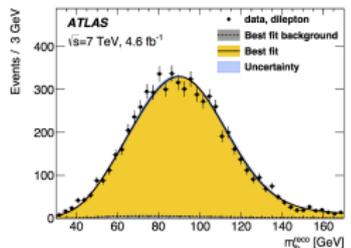
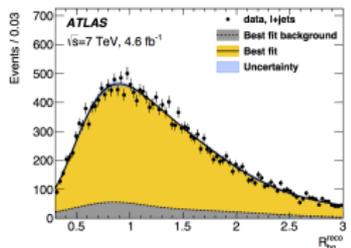
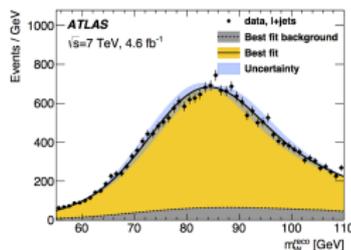
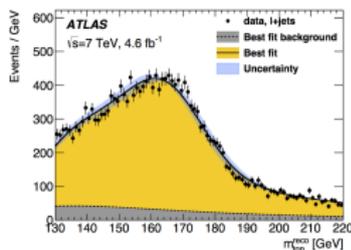


Signal modelling	$\Delta m_t$ (GeV)
Method calibration	0.42
Trigger	0.01
Signal MC generator	0.30
<b>Hadronisation</b>	<b>0.50</b>
Fast simulation	0.24
Colour reconnection	0.22
Underlying event	0.08
ISR and FSR	0.22
Proton PDF	0.09
Pile-up	0.02
Background modelling	$\Delta m_t$ (GeV)
Multijet background	0.35
Jet measurements	$\Delta m_t$ (GeV)
Jet energy scale (see Table 4)	0.51
<b>b-jet energy scale</b>	<b>0.62</b>
Jet energy resolution	0.01
Jet reconstruction efficiency	0.01
b-tag efficiency and mistag rate	0.17
Soft contributions to missing energy	0.02
JVF scale factors	0.02
Total systematic uncertainty	1.22

## Lepton+jets & dilepton channel @ 7 TeV

[Eur. Phys. J. C (2015) 75:330]

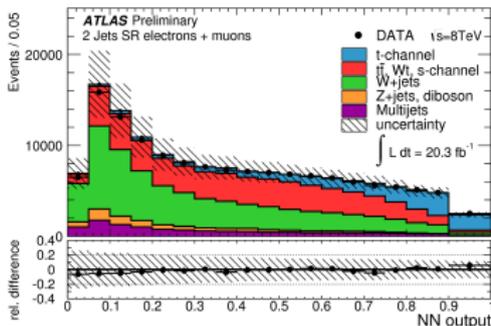
- 3d method in lepton+jets channel
    - kinematic reconstruction of the  $t\bar{t}$ -pair
    - fit simultaneously  $m_{\text{top}}^{\text{reco}}$ ,  $m_W^{\text{reco}}$  and  $R_{\text{bq}}^{\text{reco}}$
  - 1d fit to  $m_{\text{lb}}^{\text{reco}}$  in dilepton channel
  - combine the two channels
- ⇒  $m_{\text{top}} = 173.0 \pm 0.5$  (stat)  $\pm 0.8$  (syst) GeV



	$t\bar{t} \rightarrow$ lepton+jets $m_{\text{top}}^{\ell+\text{jets}}$ [GeV]	$t\bar{t} \rightarrow$ dilepton $m_{\text{top}}^{\text{dl}}$ [GeV]	Combination $m_{\text{top}}^{\text{comb}}$ [GeV]
Results	172.33	173.79	172.99
Statistics	0.75	0.54	0.48
Stat. comp. ( $m_{\text{top}}$ )	0.23	0.54	
Stat. comp. (JSF)	0.25	n/a	
Stat. comp. (bJSF)	0.67	n/a	
Method	$0.11 \pm 0.10$	$0.09 \pm 0.07$	0.07
Signal MC	$0.22 \pm 0.21$	$0.26 \pm 0.16$	0.24
Hadronisation	$0.18 \pm 0.12$	$0.53 \pm 0.09$	0.34
ISR/FSR	$0.32 \pm 0.06$	$0.47 \pm 0.05$	0.04
Underlying event	$0.15 \pm 0.07$	$0.05 \pm 0.05$	0.06
Colour reconnection	$0.11 \pm 0.07$	$0.14 \pm 0.05$	0.01
PDF	$0.25 \pm 0.00$	$0.11 \pm 0.00$	0.17
W/Z+jets norm	$0.02 \pm 0.00$	$0.01 \pm 0.00$	0.02
W/Z+jets shape	$0.29 \pm 0.00$	$0.00 \pm 0.00$	0.16
NP/fake-lepton norm.	$0.10 \pm 0.00$	$0.04 \pm 0.00$	0.07
NP/fake-lepton shape	$0.05 \pm 0.00$	$0.01 \pm 0.00$	0.03
Jet energy scale	$0.58 \pm 0.11$	$0.75 \pm 0.08$	0.41
b-Jet energy scale	$0.06 \pm 0.03$	$0.68 \pm 0.02$	0.34
Jet resolution	$0.22 \pm 0.11$	$0.19 \pm 0.04$	0.03
Jet efficiency	$0.12 \pm 0.00$	$0.07 \pm 0.00$	0.10
Jet vertex fraction	$0.01 \pm 0.00$	$0.00 \pm 0.00$	0.00
b-tagging	$0.50 \pm 0.00$	$0.07 \pm 0.00$	0.25
$E_{\text{T}}^{\text{miss}}$	$0.15 \pm 0.04$	$0.04 \pm 0.03$	0.08
Leptons	$0.04 \pm 0.00$	$0.13 \pm 0.00$	0.05
Pile-up	$0.02 \pm 0.01$	$0.01 \pm 0.00$	0.01
Total	$1.27 \pm 0.33$	$1.41 \pm 0.24$	0.91

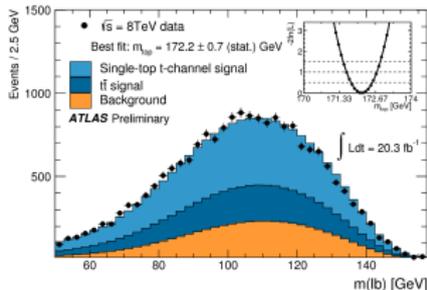
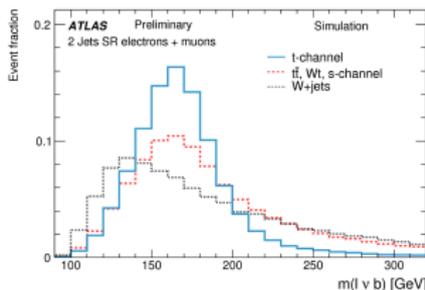
t-channel enhanced analysis @ 8 TeV [ATLAS-CONF-2014-055]

- measure  $m_{\text{top}}$  with electroweakly produced tops
  - signal region dominated by  $t\bar{t}$  and  $W$ +jets
  - using neural network to enhance t-channel fraction
- ⇒  $m_{\text{top}} = 172.2 \pm 0.7$  (stat)  $\pm 2.0$  (syst) GeV



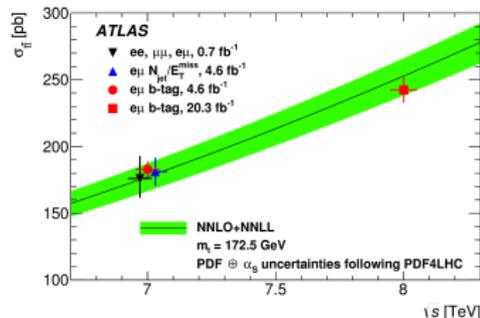
Process	SR	SR ( $NN > 0.75$ )
$t$ -channel	$18100 \pm 1800$	$9100 \pm 1300$
$t\bar{t}, Wt, s$ -channel	$54200 \pm 4300$	$4940 \pm 600$
$W$ +jets	$51000 \pm 28000$	$4090 \pm 2200$
$Z$ +jets, diboson	$6900 \pm 1700$	$360 \pm 90$
Multijet	$12200 \pm 6100$	$950 \pm 480$
Total expectation	$142000 \pm 29000$	$19470 \pm 2700$
Data	143332	19833

	Value [GeV]
Measured value	172.2
Statistical uncertainty	0.7
<b>Jet energy scale</b>	<b>1.5</b>
Jet energy resolution	<0.1
Jet vertex fraction	<0.1
Flavour tagging efficiency	0.3
Electron uncertainties	0.3
Muon uncertainties	0.1
Missing transverse momentum	0.2
$W$ +jets normalisation	0.4
$W$ +jets shape	0.3
$Z$ +jets/diboson normalisation	0.2
Multijet normalisation	0.2
Multijet shape	0.3
Top normalisation	0.2
$t$ -channel generator	<0.1
<b><math>t</math>-channel hadronisation</b>	<b>0.7</b>
$t$ -channel colour reconnection	0.3
$t$ -channel underlying event	<0.1
$t\bar{t}, Wt$ , and $s$ -channel generator	0.2
$t\bar{t}$ hadronisation	<0.1
$t\bar{t}$ colour reconnection	0.2
$t\bar{t}$ underlying event	0.1
$t\bar{t}$ ISR/FSR	0.2
Proton PDF	<0.1
Simulation sample statistics	0.3
Total systematic uncertainty	2.0
Total uncertainty	2.1

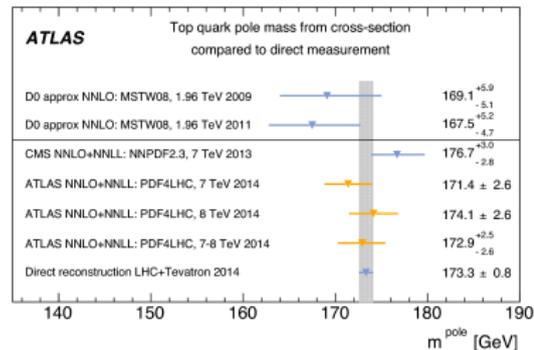
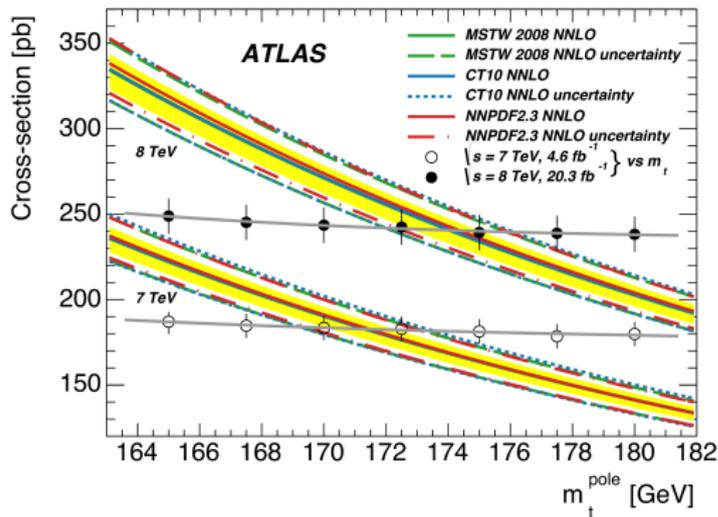


$\sigma_{t\bar{t}}$  analysis @ 7 & 8 TeV [Eur.Phys.J. C74 (2014) 3109]

- select dileptonic  $e\mu$  top pair events
- measurement of  $\sigma_{t\bar{t}}$  gives
  - $\Rightarrow \sigma_{t\bar{t}} = 182.9 \pm 7.1 \text{ pb} \quad (\sqrt{s} = 7 \text{ TeV})$
  - $\Rightarrow \sigma_{t\bar{t}} = 242.4 \pm 10.3 \text{ pb} \quad (\sqrt{s} = 8 \text{ TeV})$
- extract  $m_{\text{top}}^{\text{pole}}$  and combine results
  - $\Rightarrow m_{\text{top}}^{\text{pole}} = 172.9^{+2.5}_{-2.6} \text{ GeV}$



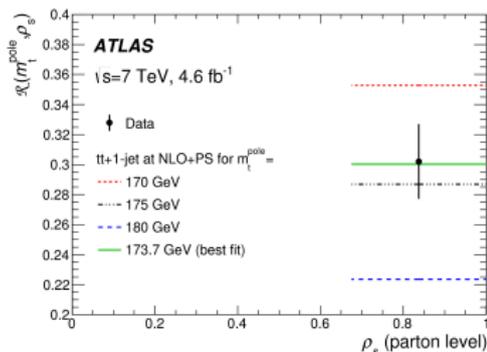
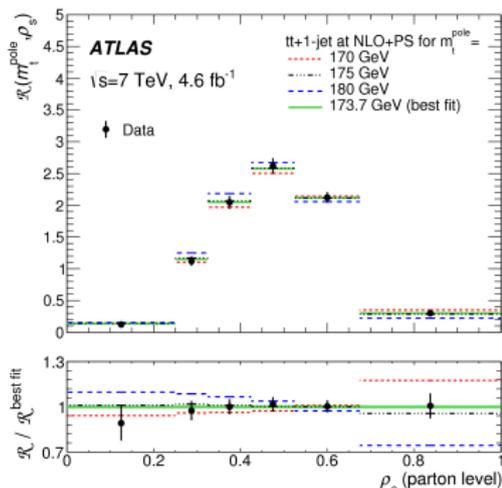
$\Delta m_t^{\text{pole}}$ (GeV)	$\sqrt{s} = 7 \text{ TeV}$	$\sqrt{s} = 8 \text{ TeV}$
Data statistics	0.6	0.3
Analysis systematics	0.8	0.9
Integrated luminosity	0.7	1.2
LHC beam energy	0.7	0.6
PDF+ $\alpha_s$	1.8	1.7
QCD scale choice	+0.9 -1.2	+0.9 -1.3



$t\bar{t} + 1\text{-jet}$  events @ 7 TeV [JHEP 10 (2015) 121]

- $m_{\text{top}}^{\text{pole}}$  from differential cross section observable:
  - estimator  $\mathcal{R} \propto \frac{d\sigma_{t\bar{t}+1\text{-jet}}}{d\rho_s}$ , with  $\rho_s = \frac{2m_0}{\sqrt{s_{t\bar{t}+1\text{-jet}}}}$
  - correct distribution to parton level
  - compare theoretical calculations to measurement
- $\Rightarrow m_{\text{top}} = 173.7 \pm 1.5$  (stat)  $\pm 1.4$  (syst)  $^{+1.0}_{-0.5}$  (theo) GeV

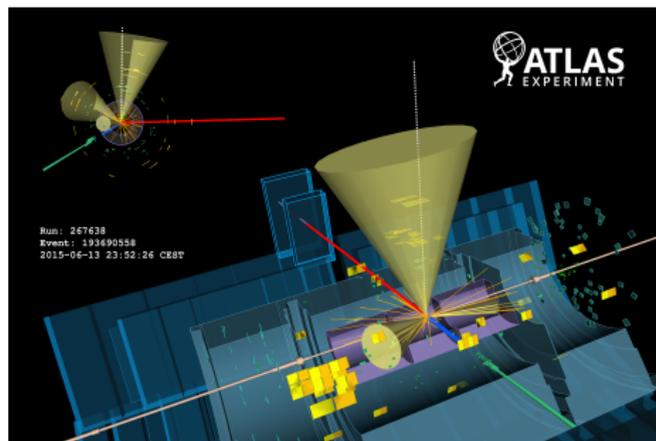
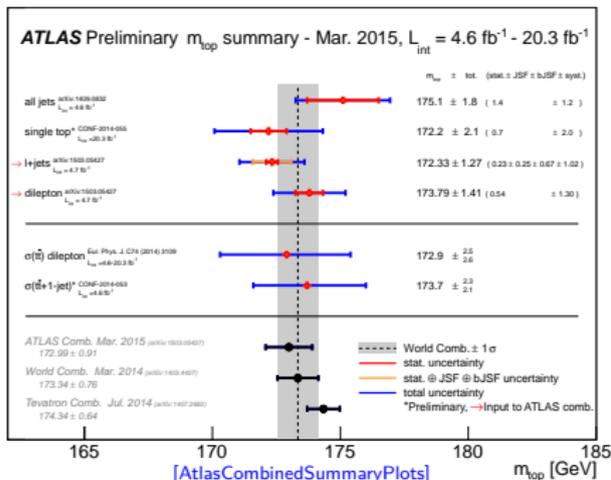
Description	Value
	[ GeV ]
$m_t^{\text{pole}}$	173.71
Statistical uncertainty	1.50
Scale variations	(+0.93, -0.44)
Proton PDF (theory) and $\alpha_s$	0.21
Total theory systematic uncertainty	(+0.95, -0.49)
Jet energy scale (including b-jet energy scale)	0.94
Jet energy resolution	0.02
Jet reconstruction efficiency	0.05
b-tagging efficiency and mistag rate	0.17
Lepton uncertainties	0.07
Missing transverse momentum	0.02
MC statistics	0.13
Signal MC generator	0.28
Hadronization	0.33
ISR/FSR	0.72
Colour reconnection	0.14
Underlying event	0.25
Proton PDF (experimental)	0.54
Background	0.20
Total experimental systematic uncertainty	1.44
Total uncertainty	(+2.29, -2.14)



## Summary &amp; outlook

- measurements of  $m_{\text{top}}$  in different topologies with different methods
- finalizing run I top quark mass measurements  
 $\Rightarrow$  8 TeV  $t\bar{t}$  template results will be published soon
- looking forward to first 13 TeV  $m_{\text{top}}$  results


[\[particlezoo.net\]](http://particlezoo.net)

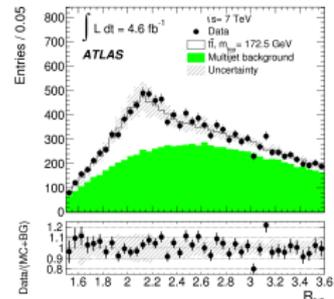
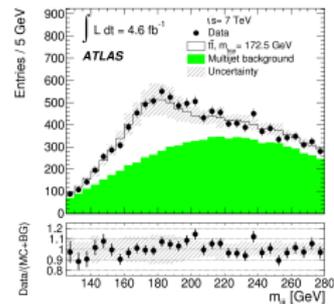
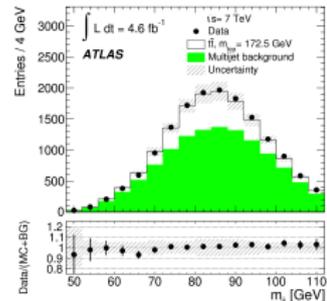
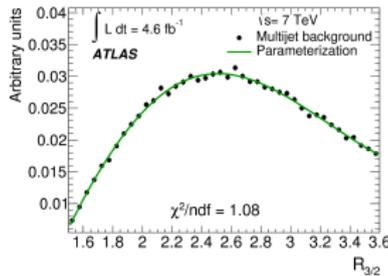
[\[particlezoo.net\]](http://particlezoo.net)


# Backup

- Jet-based trigger
- $\geq 6$  jets with  $p_{\text{T}} > 30$  GeV and  $|\eta| < 2.5$
- $\geq 5$  jets with  $p_{\text{T}} > 55$  GeV and  $|\eta| < 2.5$
- $\Delta R > 0.6$  between pairs of jets with  $p_{\text{T}} > 30$  GeV
- Jet vertex fraction JVF  $> 0.75$
- Reject events w. isolated electrons with  $E_{\text{T}} > 25$  GeV
- Reject events w. isolated muons with  $p_{\text{T}} > 20$  GeV
- Exactly 2  $b$ -tagged jets among the four leading jets
- Missing transverse momentum significance  $E_{\text{T}}^{\text{miss}} / \sqrt{H_{\text{T}}} < 3 \text{ GeV}^{1/2}$
- Centrality  $\mathcal{C} > 0.6$

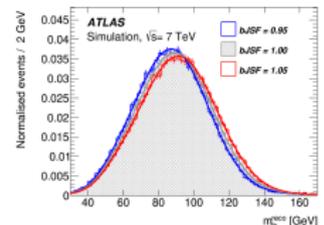
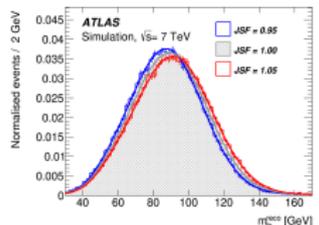
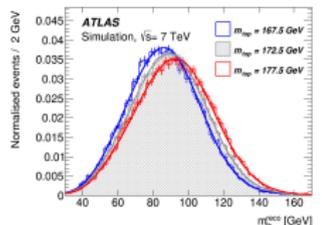
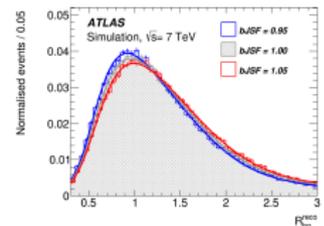
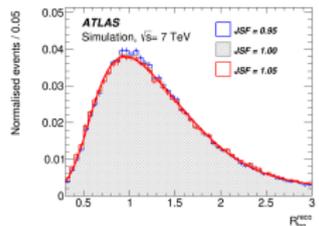
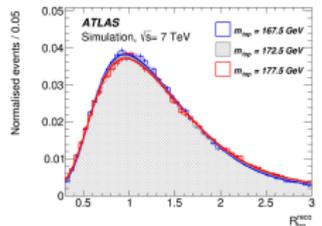
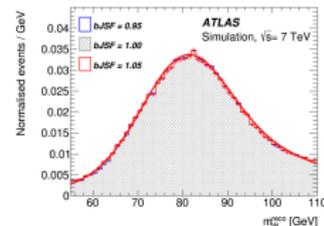
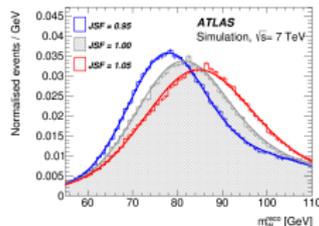
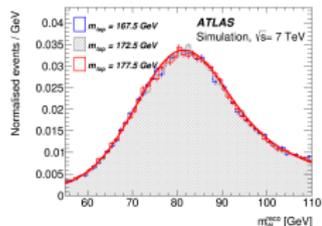
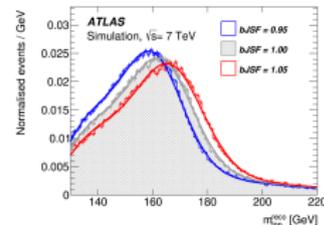
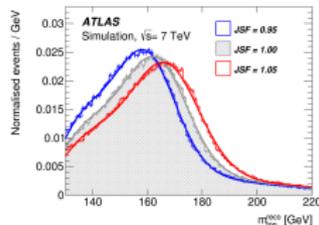
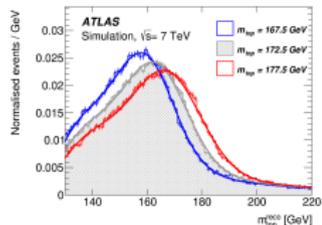
$$N_F^{\text{bkg}}(x) = \frac{N_E^{\text{bkg}}}{2} \cdot \left( \frac{N_B^{\text{bkg}}(x)}{N_A^{\text{bkg}}} + \frac{N_D^{\text{bkg}}(x)}{N_C^{\text{bkg}}} \right)$$

$b$ -tagged jets	Region $R$	$p_{\text{T}}^{\text{6th jet}} \leq 30 \text{ GeV}$		$p_{\text{T}}^{\text{6th jet}} > 30 \text{ GeV}$	
		Data events $N_R^{\text{obs}}$	Signal MC events $N_R^{\text{sig}}$	Data events $N_R^{\text{obs}}$	Signal MC events $N_R^{\text{sig}}$
0	A	93,732	$306 \pm 4$	B	$286,416$
		signal fraction: $0.33 \pm 0.01\%$			
1	C	23,536	$678 \pm 5$	D	$77,301$
		signal fraction: $2.88 \pm 0.04\%$			
2	E	4,532	$399 \pm 5$	F	$15,551$
		signal fraction: $8.80 \pm 0.29\%$			



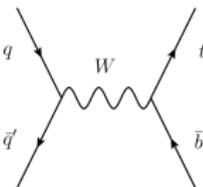
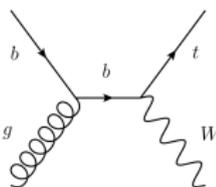
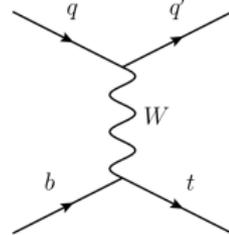
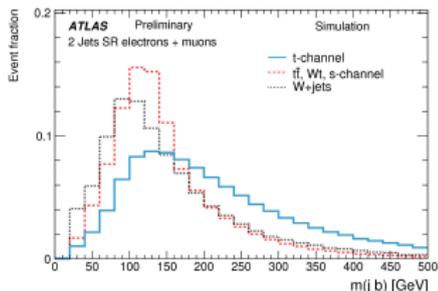
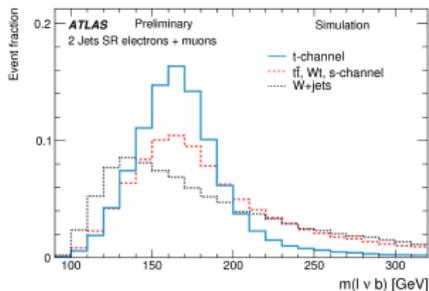
lepton+jets	
e channel	$\mu$ channel
lepton trigger	
one charged lepton	
$E_{\text{T}}^{\text{miss}} > 30 \text{ GeV}$	$E_{\text{T}}^{\text{miss}} > 20 \text{ GeV}$
$m_{\text{T}}^{\text{W}} > 30 \text{ GeV}$	$E_{\text{T}}^{\text{miss}} + m_{\text{T}}^{\text{W}} > 60 \text{ GeV}$
$\geq 4$ jets, $p_{\text{T}} > 25 \text{ GeV}$ , $ \eta  < 2.5$	
$\geq 1$ b-tagged jet	
dilepton	
$ee/\mu\mu$ channel	$e/\mu$ channel
lepton trigger	
two oppositely charged leptons	
$E_{\text{T}}^{\text{miss}} > 60 \text{ GeV}$	$H_{\text{T}} > 130 \text{ GeV}$
$m_{\parallel} > 15 \text{ GeV}$	
$ m_{\parallel} - m_{\perp}  > 10 \text{ GeV}$	
$\geq 2$ jets, $p_{\text{T}} > 25 \text{ GeV}$ , $ \eta  < 2.5$	
1 or 2 b-tagged jet(s)	

Results	$t\bar{t} \rightarrow \text{lepton}+\text{jets}$			$t\bar{t} \rightarrow \text{dilepton}$	Combination	
	$m_{\text{top}}^{\text{JES}}$ [GeV]	JSF	bJSF	$m_{\text{top}}^{\text{dil}}$ [GeV]	$m_{\text{top}}^{\text{comb}}$ [GeV]	$\rho$
Statistics	172.33	1.019	1.003	173.79	172.99	0
- Stat. comp. ( $m_{\text{top}}$ )	0.75	0.003	0.008	0.54	0.48	0
- Stat. comp. (JSF)	0.23	n/a	n/a	0.54		
- Stat. comp. (bJSF)	0.25	0.003	n/a	n/a		
Method	0.67	0.000	0.008	n/a		
	$0.11 \pm 0.10$	0.001	0.001	$0.09 \pm 0.07$	0.07	0
Signal MC	$0.22 \pm 0.21$	0.004	0.002	$0.26 \pm 0.16$	0.24	+1.00
Hadronisation	$0.18 \pm 0.12$	0.007	0.013	$0.53 \pm 0.09$	0.34	+1.00
ISR/FSR	$0.32 \pm 0.06$	0.017	0.007	$0.47 \pm 0.05$	0.04	-1.00
Underlying event	$0.15 \pm 0.07$	0.001	0.003	$0.05 \pm 0.05$	0.06	-1.00
Colour reconnection	$0.11 \pm 0.07$	0.001	0.002	$0.14 \pm 0.05$	0.01	-1.00
PDF	$0.25 \pm 0.00$	0.001	0.002	$0.11 \pm 0.00$	0.17	+0.57
W/Z+jets norm	$0.02 \pm 0.00$	0.000	0.000	$0.01 \pm 0.00$	0.02	+1.00
W/Z+jets shape	$0.29 \pm 0.00$	0.000	0.004	$0.00 \pm 0.00$	0.16	0
NP/fake-lepton norm.	$0.10 \pm 0.00$	0.000	0.001	$0.04 \pm 0.00$	0.07	+1.00
NP/fake-lepton shape	$0.05 \pm 0.00$	0.000	0.001	$0.01 \pm 0.00$	0.03	+0.23
Jet energy scale	$0.58 \pm 0.11$	0.018	0.009	$0.75 \pm 0.08$	0.41	-0.23
b-jet energy scale	$0.06 \pm 0.03$	0.000	0.010	$0.68 \pm 0.02$	0.34	+1.00
Jet resolution	$0.22 \pm 0.11$	0.007	0.001	$0.19 \pm 0.04$	0.03	-1.00
Jet efficiency	$0.12 \pm 0.00$	0.000	0.002	$0.07 \pm 0.00$	0.10	+1.00
Jet vertex fraction	$0.01 \pm 0.00$	0.000	0.000	$0.00 \pm 0.00$	0.00	-1.00
b-tagging	$0.50 \pm 0.00$	0.001	0.007	$0.07 \pm 0.00$	0.25	-0.77
$E_{\text{T}}^{\text{miss}}$	$0.15 \pm 0.04$	0.000	0.001	$0.04 \pm 0.03$	0.08	-0.15
Leptons	$0.04 \pm 0.00$	0.001	0.001	$0.13 \pm 0.00$	0.05	-0.34
Pile-up	$0.02 \pm 0.01$	0.000	0.000	$0.01 \pm 0.00$	0.01	0
Total	$1.27 \pm 0.33$	0.027	0.024	$1.41 \pm 0.24$	0.91	-0.07



### Event selection

- lepton trigger
- one charged lepton ( $e/\mu$ )
- $E_T^{\text{miss}} > 30 \text{ GeV}$
- $m_T^W > 50 \text{ GeV}$
- two jets,  $p_T > 30 \text{ GeV}$ ,  $|\eta| < 4.5$
- one b-tagged jet
- $p_T(l) > 40 \text{ GeV} \cdot \left(1 - \frac{\pi - |\Delta\phi(j_1, l)|}{\pi - 1}\right)$
- NN output  $> 0.75$

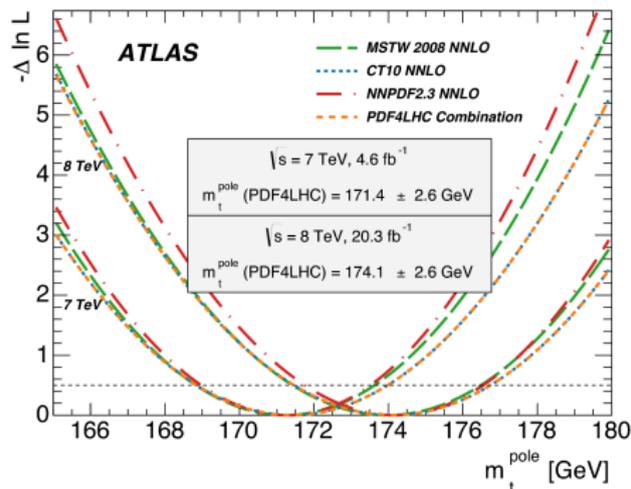


Variable	loss of total correlation (%)	Variable	loss of total correlation (%)
$m(\ell\nu b)$	38	$E_T^{\text{miss}}$	7
$m(jb)$	31	$m_T(W)$	7
$m(\ell b)$	18	$\cos\Theta(\ell, j)$ in the top quark rest frame	6
$ \eta(j) $	14	$p_T(W)$	3
$\eta(\ell\nu)$	13	$\eta(\ell\nu b)$	2
$H_T(\ell, \text{jets}, E_T^{\text{miss}})$	10	$\Delta R(\ell, \ell\nu b)$	1

### Event selection

- lepton trigger
- oppositely charged pair of e and  $\mu$
- one b-tagged or two b-tagged jet(s) with  $p_{\text{T}} > 25$  GeV,  $|\eta| < 2.5$

$$\sigma_{t\bar{t}}^{\text{theo}}(m_t^{\text{pole}}) = \sigma(m_t^{\text{ref}}) \left( \frac{m_t^{\text{ref}}}{m_t^{\text{pole}}} \right) (1 + a_1 x + a_2 x^2)$$



Event counts	$\sqrt{s} = 7$ TeV		$\sqrt{s} = 8$ TeV	
	$N_1$	$N_2$	$N_1$	$N_2$
Data	3527	2073	21666	11739
$Wt$ single top	$326 \pm 36$	$53 \pm 14$	$2050 \pm 210$	$360 \pm 120$
Dibosons	$19 \pm 5$	$0.5 \pm 0.1$	$120 \pm 30$	$3 \pm 1$
$Z(\rightarrow \tau\tau \rightarrow e\mu) + \text{jets}$	$28 \pm 2$	$1.8 \pm 0.5$	$210 \pm 5$	$7 \pm 1$
Misidentified leptons	$27 \pm 13$	$15 \pm 8$	$210 \pm 66$	$95 \pm 29$
Total background	$400 \pm 40$	$70 \pm 16$	$2590 \pm 230$	$460 \pm 130$

Uncertainty	$\Delta\sigma_{t\bar{t}}/\sigma_{t\bar{t}}$ (%)		
	$\sqrt{s}$	7 TeV	8 TeV
Data statistics		1.69	0.71
$t\bar{t}$ modelling and QCD scale		1.46	1.26
Parton distribution functions		1.04	1.13
Background modelling		0.83	0.83
Lepton efficiencies		0.87	0.88
Jets and $b$ -tagging		0.58	0.82
Misidentified leptons		0.41	0.34
Analysis systematics ( $\sigma_{t\bar{t}}$ )		2.27	2.26
Integrated luminosity		1.98	3.10
LHC beam energy		1.79	1.72
Total uncertainty		3.89	4.27

### Event selection

- lepton trigger
- one lepton ( $e/\mu$ )
- $\geq 5$  jets,  $p_T > 25$  GeV,  $|\eta| < 2.5$
- 5<sup>th</sup> jet  $p_T > 50$  GeV
- two b-tagged jets
- $E_T^{\text{miss}} > 30$  GeV &  $m_T^{\text{W}} > 30$  GeV
- $0.9 < \frac{m_{\text{W}}}{m_{\text{jj}}} < 1.25$  &  $\frac{m_{\text{top}}^{\text{leptonic}}}{m_{\text{top}}^{\text{hadronic}}} > 0.9$

	Events	Uncertainty
Signal ( $t\bar{t}$ , $m_t = 172.5$ GeV)	2050 $\pm$	320
W+jets	31 $\pm$	16
Z+jets	6 $\pm$	4
Single top ( $m_t = 172.5$ GeV)	62 $\pm$	34
WW, ZZ, WZ	1 $\pm$	1
Misidentified and non-prompt leptons	22 $\pm$	13
Total Background	121 $\pm$	40
Total Predicted	2170 $\pm$	320
Data	2256	

$$\mathfrak{R} \left( m_{\text{top}}^{\text{pole}}, \rho_s \right) = \frac{1}{\sigma_{t\bar{t}+1\text{-jet}}} \frac{d\sigma_{t\bar{t}+1\text{-jet}}}{d\rho_s} \left( m_{\text{top}}^{\text{pole}}, \rho_s \right)$$

with  $\rho_s = \frac{2m_0}{\sqrt{s_{t\bar{t}+1\text{-jet}}}}$

