TOPLHCWG open meeting, May 20–21, 2015

Update on ATLAS m_{top} results

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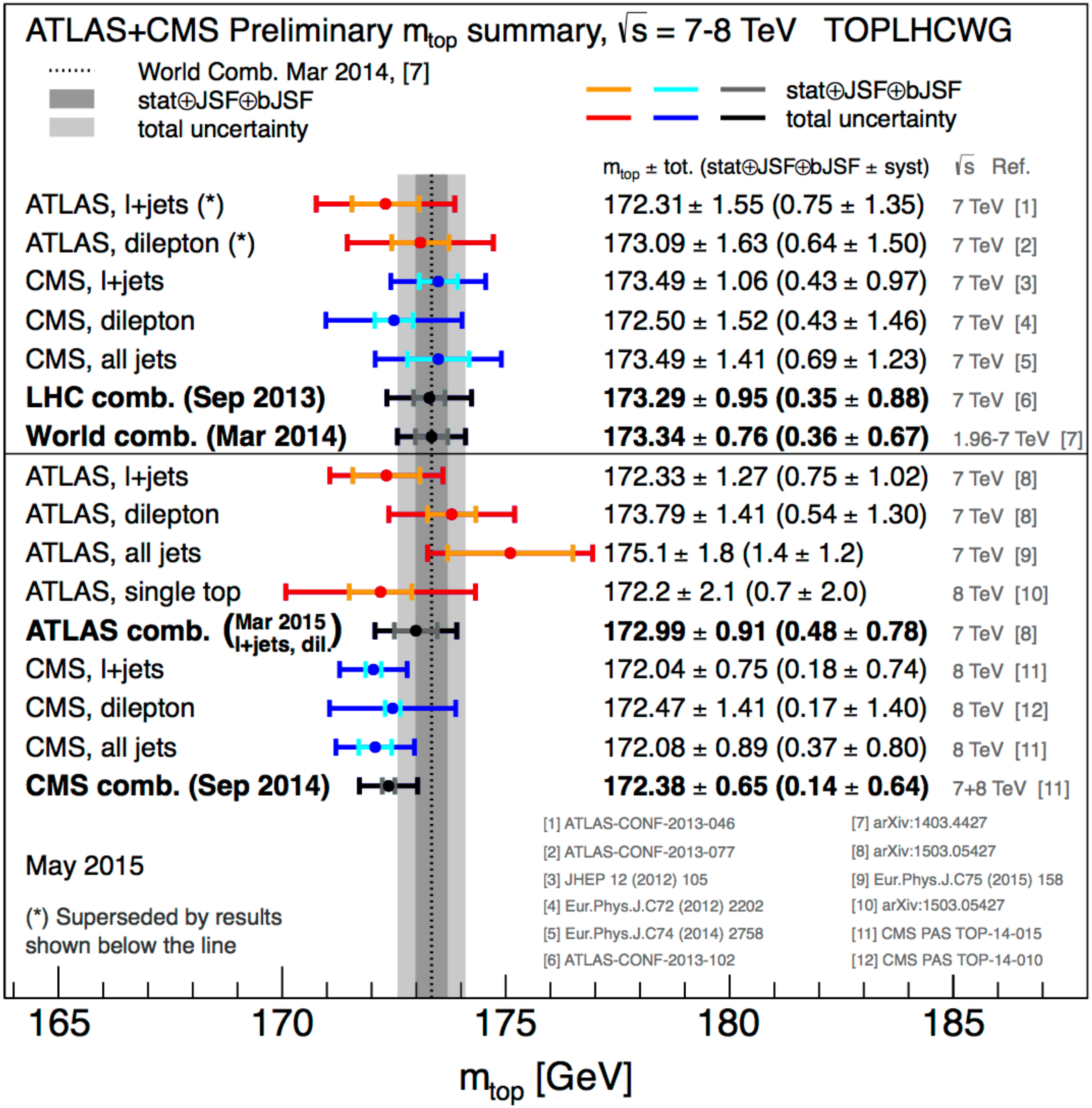
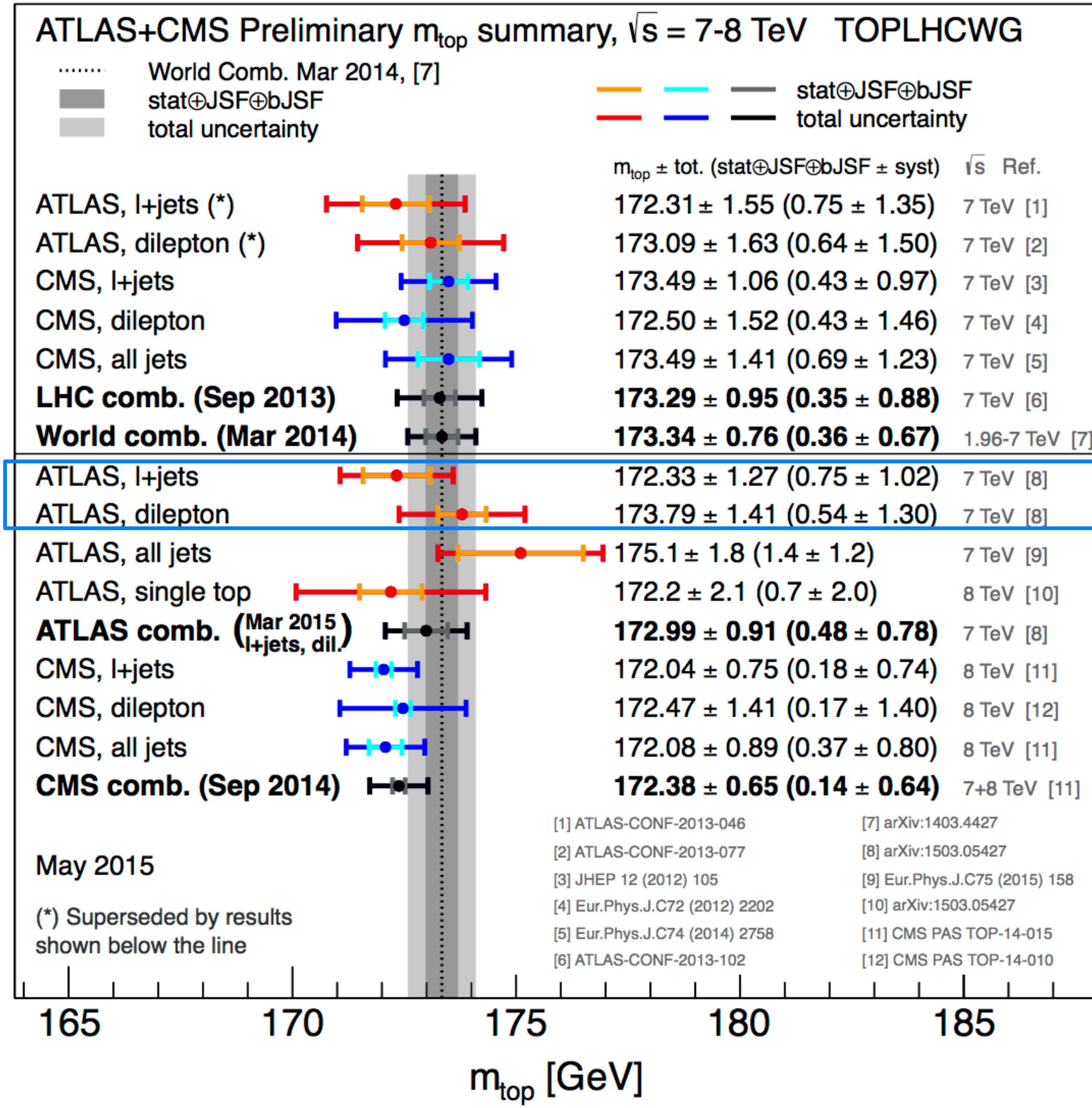
(Werner-Heisenberg-Institut)

Status


ATLAS+CMS Preliminary m_{top} summary, $\sqrt{s}$ = 7-8 TeV TOPLHCWG
World Comb. Mar 2014, [7]
stat⊕JSF⊕bJSF
total uncertainty
stat⊕JSF⊕bJSF
total uncertainty
m_{top} ± tot. (stat⊕JSF⊕bJSF ± syst) $\sqrt{s}$ Ref.
ATLAS, l+jets (*) 172.31 ± 1.55 (0.75 ± 1.35) 7 TeV [1]
ATLAS, dilepton (*) 173.09 ± 1.63 (0.64 ± 1.50) 7 TeV [2]
CMS, l+jets 173.49 ± 1.06 (0.43 ± 0.97) 7 TeV [3]
CMS, dilepton 172.50 ± 1.52 (0.43 ± 1.46) 7 TeV [4]
CMS, all jets 173.49 ± 1.41 (0.69 ± 1.23) 7 TeV [5]
LHC comb. (Sep 2013) 173.29 ± 0.95 (0.35 ± 0.88) 7 TeV [6]
World comb. (Mar 2014) 173.34 ± 0.76 (0.36 ± 0.67) 1.96-7 TeV [7]
ATLAS, l+jets 172.33 ± 1.27 (0.75 ± 1.02) 7 TeV [8]
ATLAS, dilepton 173.79 ± 1.41 (0.54 ± 1.30) 7 TeV [8]
ATLAS, all jets 175.1 ± 1.8 (1.4 ± 1.2) 7 TeV [9]
ATLAS, single top 172.2 ± 2.1 (0.7 ± 2.0) 8 TeV [10]
ATLAS comb. (Mar 2015 l+jets, dil.) 172.99 ± 0.91 (0.48 ± 0.78) 7 TeV [8]
CMS, l+jets 172.04 ± 0.75 (0.18 ± 0.74) 8 TeV [11]
CMS, dilepton 172.47 ± 1.41 (0.17 ± 1.40) 8 TeV [12]
CMS, all jets 172.08 ± 0.89 (0.37 ± 0.80) 8 TeV [11]
CMS comb. (Sep 2014) 172.38 ± 0.65 (0.14 ± 0.64) 7+8 TeV [11]
May 2015
(*) Superseded by results shown below the line
[1] ATLAS-CONF-2013-046
[2] ATLAS-CONF-2013-077
[3] JHEP 12 (2012) 105
[4] Eur.Phys.J.C72 (2012) 2202
[5] Eur.Phys.J.C74 (2014) 2758
[6] ATLAS-CONF-2013-102
[7] arXiv:1403.4427
[8] arXiv:1503.05427
[9] Eur.Phys.J.C75 (2015) 158
[10] arXiv:1503.05427
[11] CMS PAS TOP-14-015
[12] CMS PAS TOP-14-010
165
170
175
180
185
m_{top} [GeV]

Status



- New 7 TeV top quark mass results, submitted to EPJC, arXiv:1503.05427.

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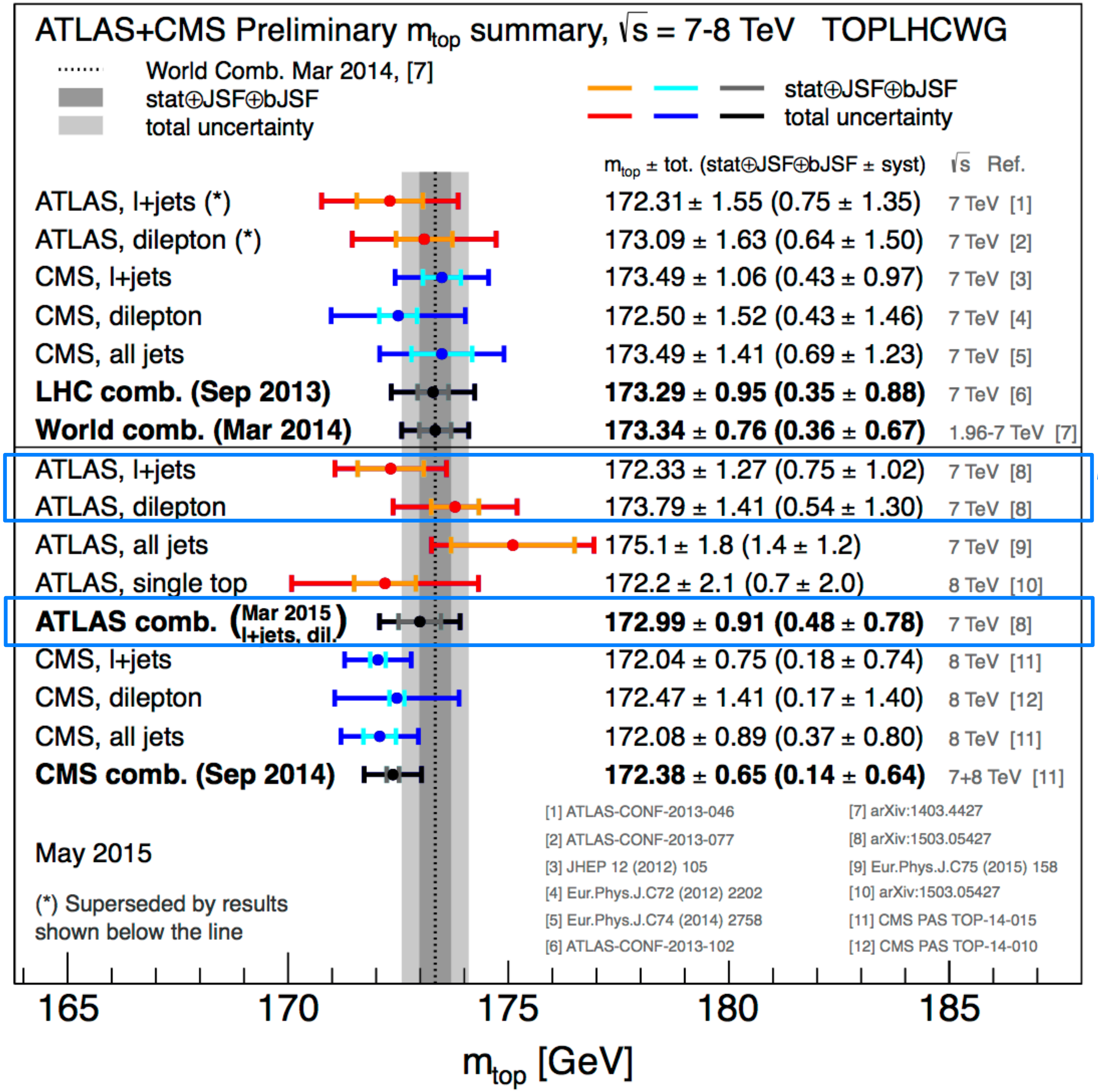

- New 7 TeV top quark mass results, submitted to EPJC, arXiv:1503.05427.
- + improved channel combination (interesting in view of the next LHC, and Tevatron+LHC combination efforts)

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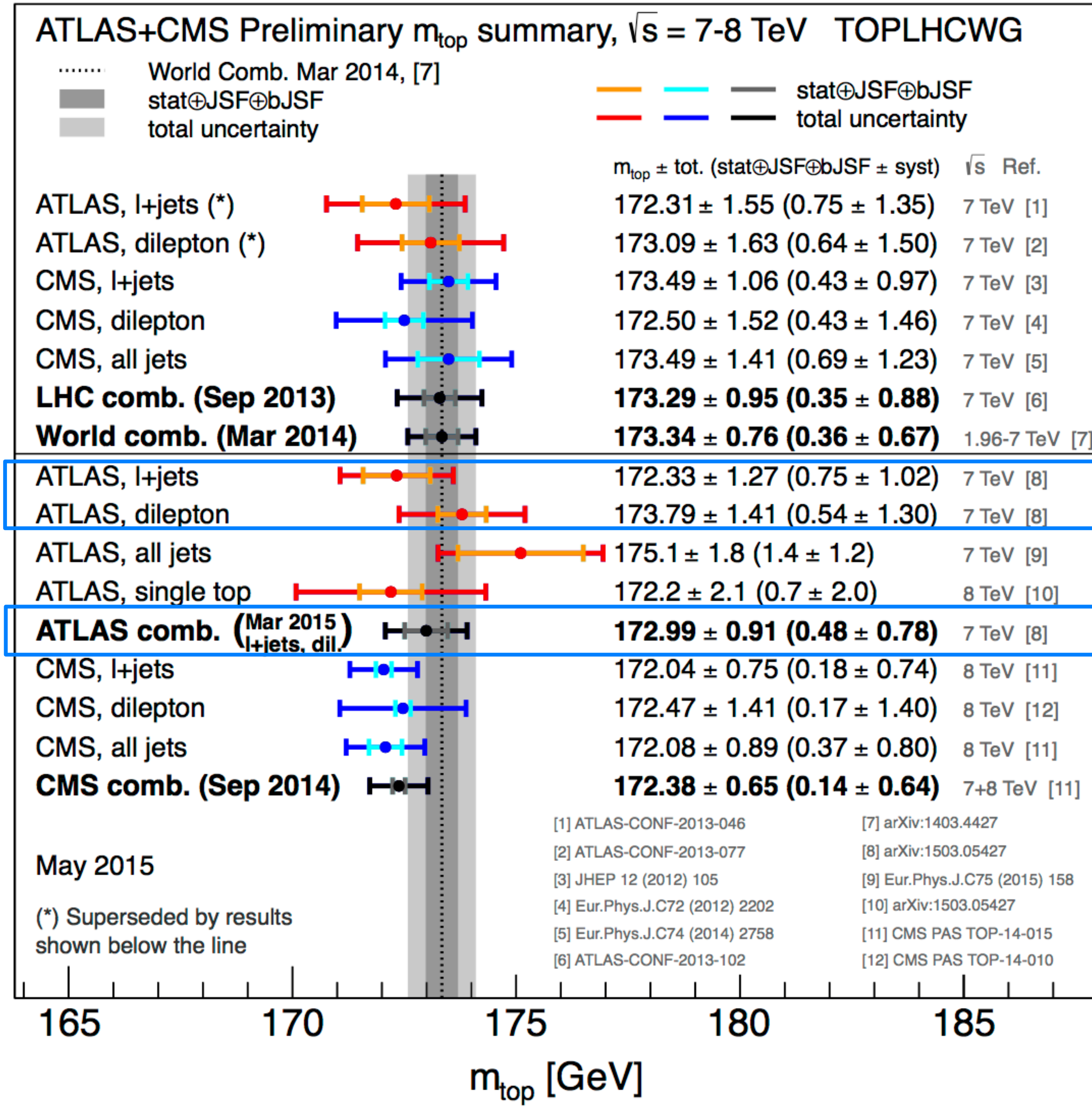
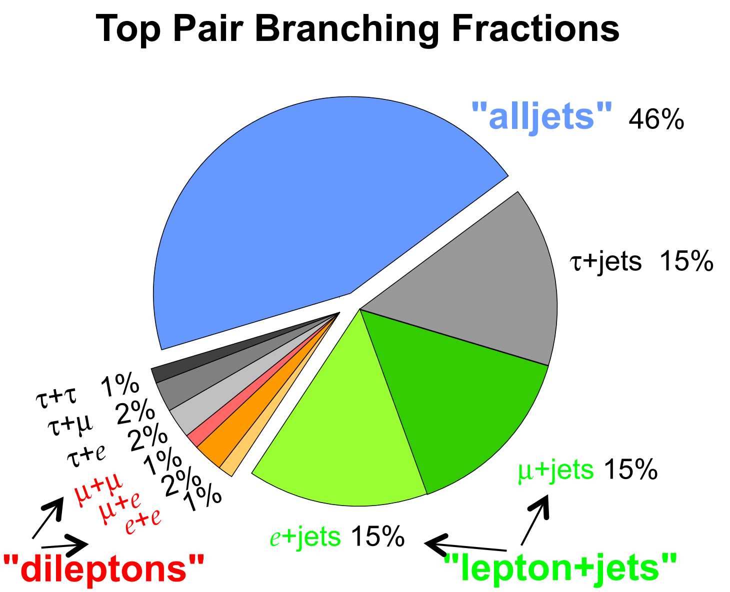


- New 7 TeV top quark mass results, submitted to EPJC, arXiv:1503.05427.
- + improved channel combination (interesting in view of the next LHC, and Tevatron+LHC combination efforts)
- For previously released ATLAS results please refer to Fabrice's talk at the TOPLHCWG open session of January 2015.

Analyses overview

- Use the full 7 TeV ATLAS dataset (4.6 fb^{-1})
- Select events with one or two isolated charged leptons (e/μ) and (b)-jets: l+jets and dilepton channels.
- Apply b-tagging requirements (WP 75%) to reduce background and facilitate event reconstruction
  - Use events with 1 or 2 b-tags (≥2 for the l+jets)
- Expected background fractions are 16% and 2% for l+jets and dilepton channels respectively.



dileptons

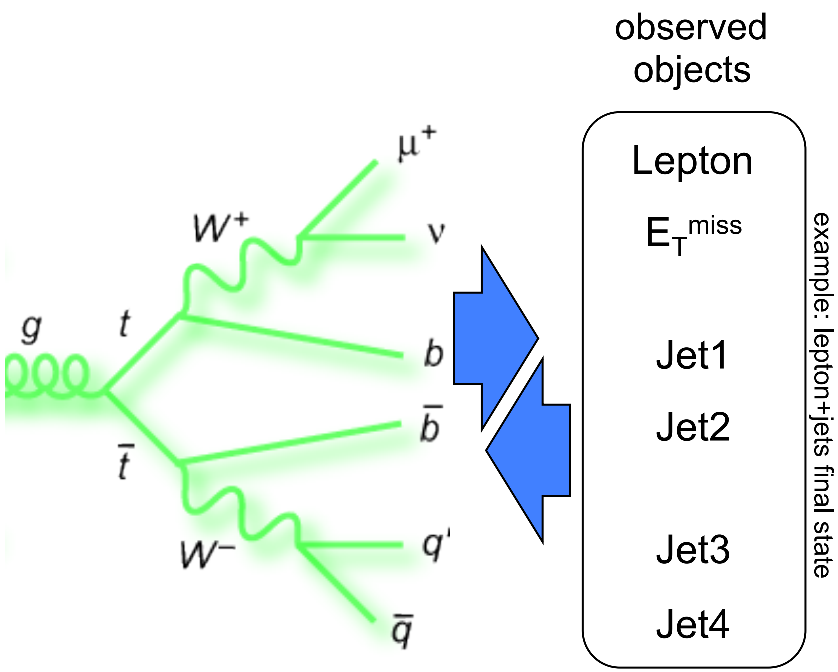
Process	Sum
$t\bar{t}$ signal	5790 ± 360
Single top quark (signal)	264 ± 15
Z+jets	38 ± 12
WW/WZ/ZZ	7.62 ± 0.67
NP/fake-leptons (data)	55 ± 30
Signal+background	6150 ± 360
Data	6476
Exp. Bkg. frac.	0.02 ± 0.00
Data/MC	1.05 ± 0.06

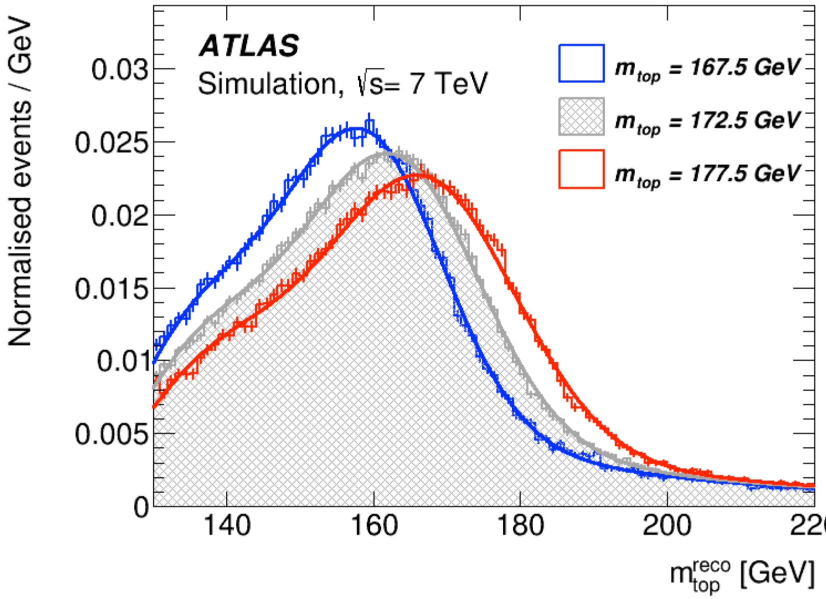
lepton+jets

Process	Sum
$t\bar{t}$ signal	18100 ± 1100
Single top quark (signal)	1052 ± 57
W+jets (data)	2400 ± 730
Z+jets	303 ± 93
WW/WZ/ZZ	48.2 ± 2.6
NP/fake-leptons (data)	780 ± 390
Signal+background	22700 ± 1400
Data	21763
Exp. Bkg. frac.	0.16 ± 0.01
Data/MC	0.96 ± 0.06

Event reconstruction: l+jets

- Estimator sensitive to m_{top}
  - Use a kinematical fit to the decay hypothesis to relate reconstructed objects to the original partons. m_{top}^{reco} can be obtained from the best fit considering all jet permutations and physics object resolutions (via transfer functions)



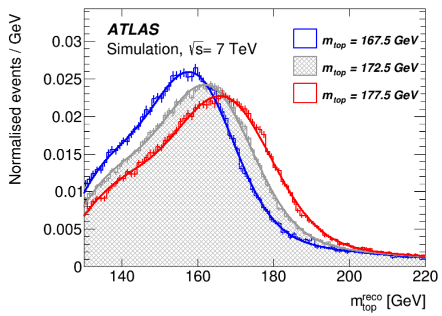


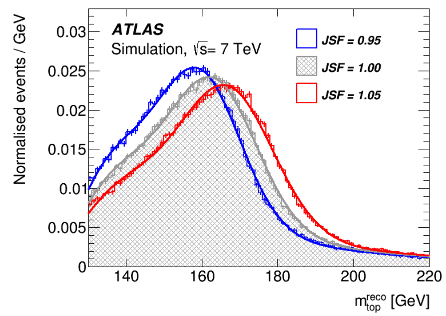
- Template method: fit the data distribution of a given m_{top} estimator (i.e. m_{top}^{reco}) to the sum of signal and background PDFs (probability distribution functions).

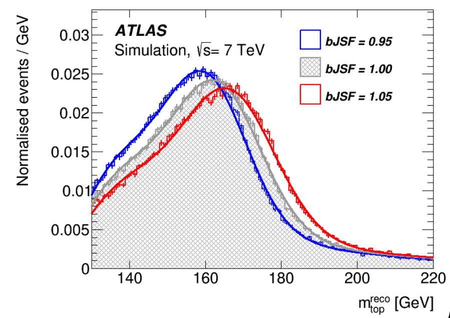
The problem…

Observables main dependences m_{top} JES bJES

Reco m_{top}







Good sensitivity to the underlying top quark mass. The quantity to be measured

Large dependence on the jet energy scale. Large systematics

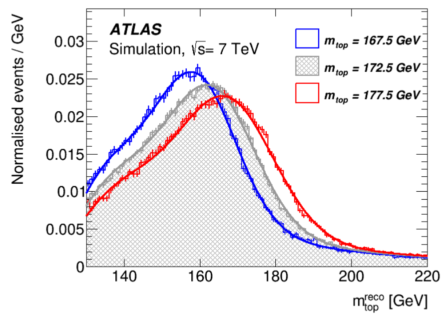
Large dependence on the b-jet energy scale. Large systematics

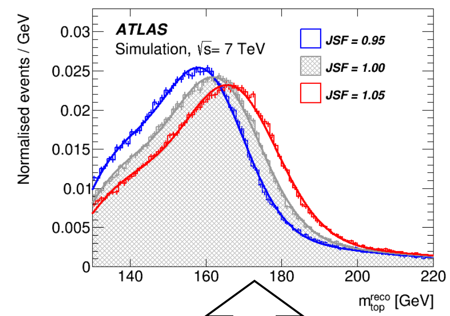
The problem… and its solution

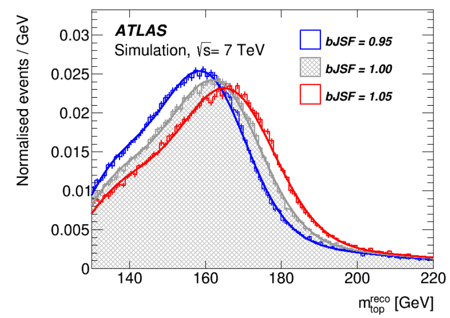
Observables main dependences m_{top} JES bJES

2-dim fits for m_{top}, JSF

Reco m_{top}

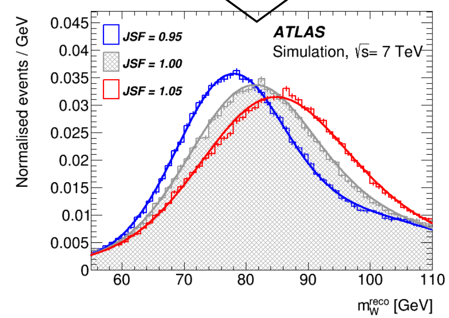






Reco m_W

in the l+jets channel, the light-quark jets from W can be used to determine a global jet energy scale factor (JSF) constraining the light jets JES variations



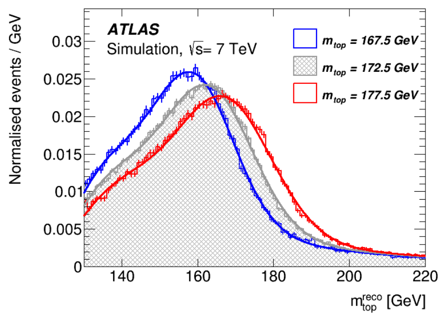
Pioneered by the CDF collaboration in [Phys.Rev.D73:032003,2006]

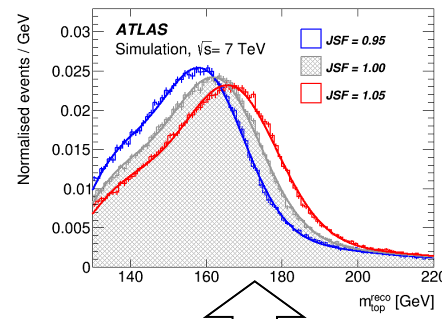
The problem… and its solution

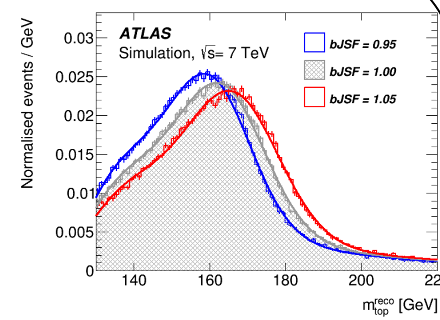
Observables main dependences — m_{top} — JES — bJES

3-dim fits for m_{top}, JSF, bJSF

Reco m_{top}







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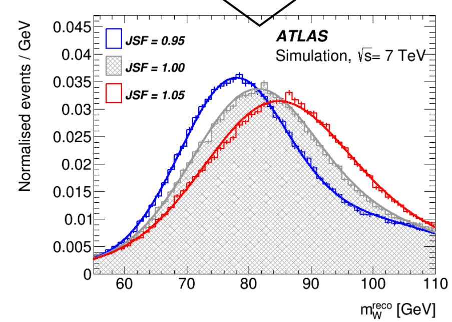
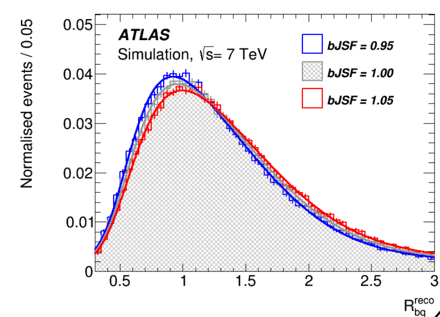


Reco R_{bq}

similarly a variable sensitive to the relative b-to-light jet energy scale (bJSF) can be used to constrain the b-jet JES variations (bJES)



The problem… and its solution

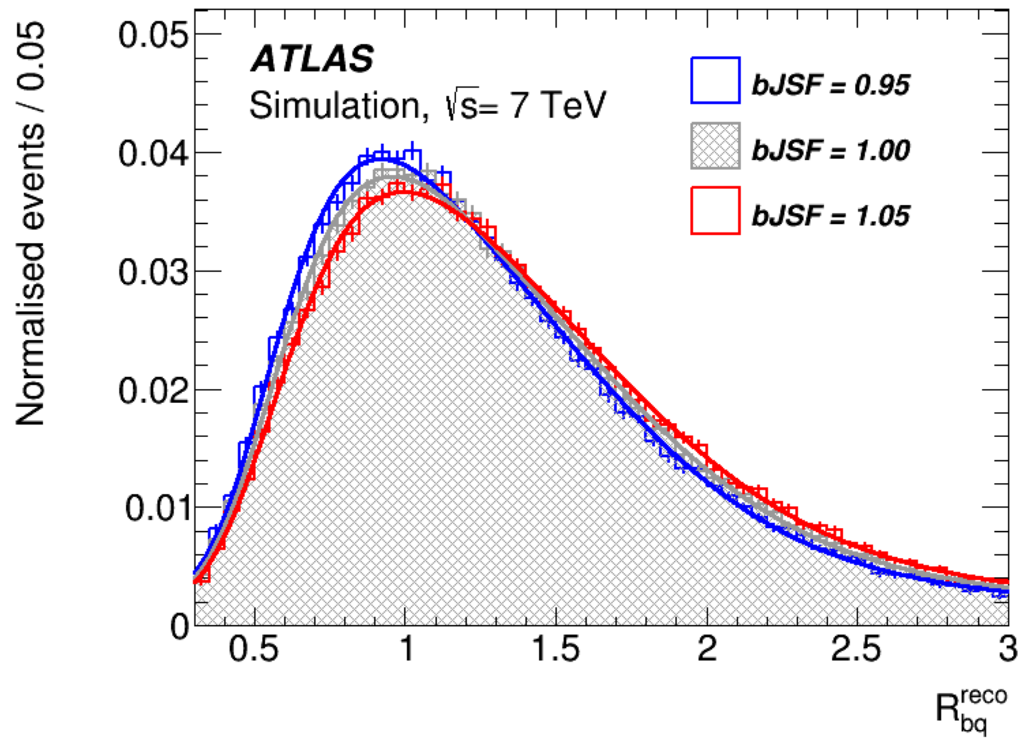
Observables main dependences m_{top} JES bJES

3-dim fits for m_{top}, JSF, bJSF

For events with 2 b-tags:

$$R_{bq}^{reco} = \frac{\sum p_T^{b-\text{tagged jets}}}{\sum p_T^{\text{untagged jets}}}$$

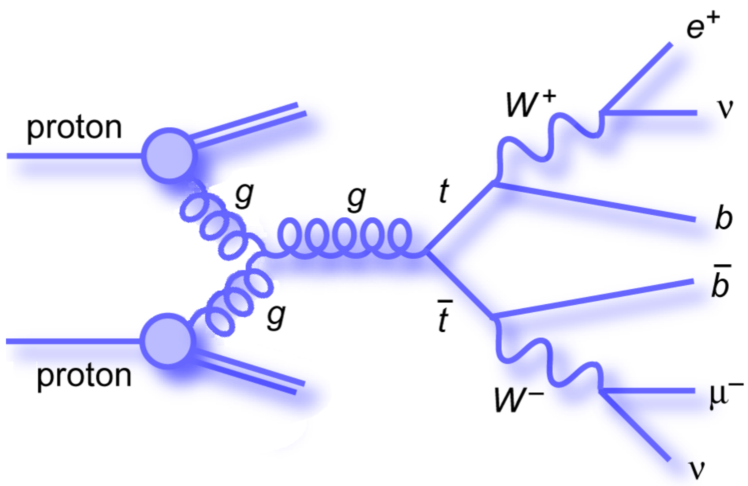
bJSF = the relative b-to-light jet energy scale



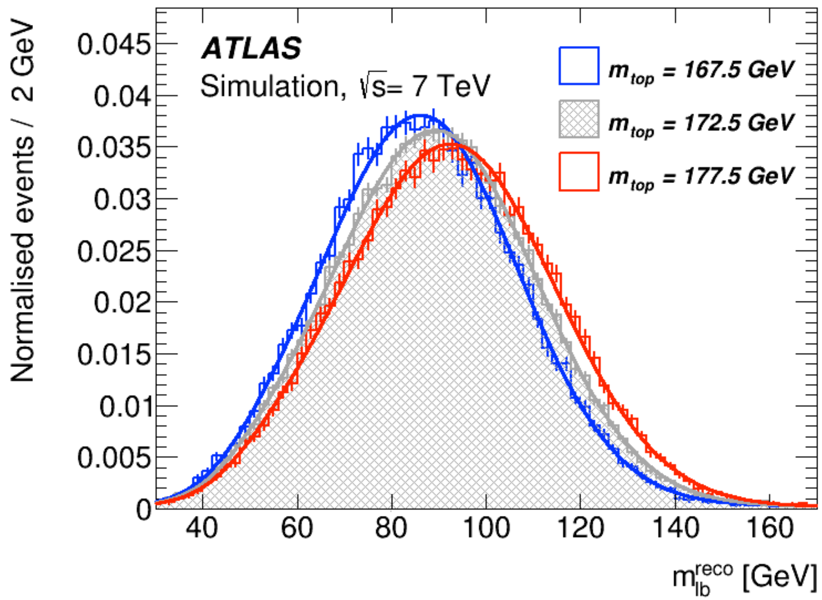
The m_{top}^{reco}, m_W^{reco} and R_{bq}^{reco} templates are used in a 3-dimensional (3dTMT) fit to the data to determine m_{top} along with the JSF and the bJSF

The small dependence of R_{bq} on m_{top}, is taken into account in the templates and the fit to the data.

Event reconstruction: dilepton



m_{lb} signal PDF from top quark pair MC

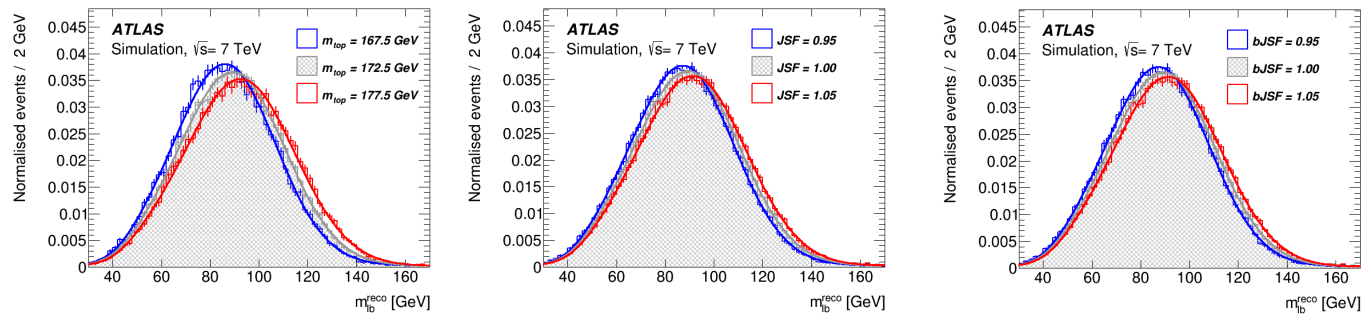


- Select events with
  - exactly 2 oppositely charged *e*, or *μ*
  - E_T^{miss}
  - =1 or =2 b-tagged jets
- Background fraction ≤ 2%
- Under-constrained event kinematics (two escaping neutrinos)
- Use the template method with the m_{lb} observable as an estimator for m_{top}:
  - exploiting a partial reconstruction of the event.

Same problem as for the l+jets…

Observables main dependences m_{top} JES bJES

Reco m_{lb}



Good sensitivity to the underlying top quark mass. The quantity to be measured

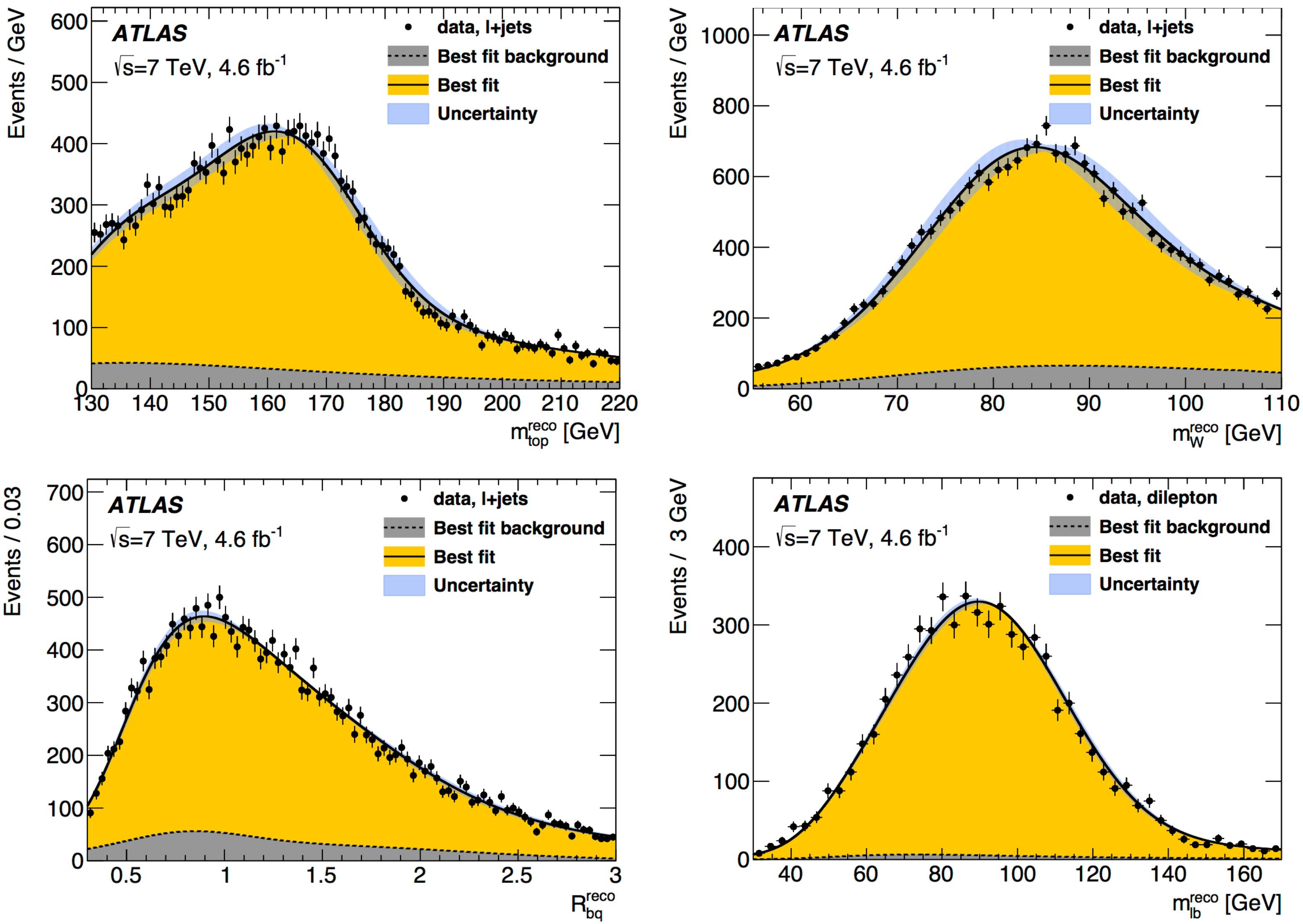
Large dependence on the jet energy scale. Large systematics

Large dependence on the b-jet energy scale. Large systematics

- Why not “transfer” JSF and bJSF from the l+jets?
  - The m_{lb} variable is degenerate in m_{top}, JSF and bJSF. The dilepton events do not further constrain the scales but effectively "copy" them over from the l+jets analysis (no information gain)
  - We could reduce the JES/bJES uncertainties in the dilepton analysis, however this would increase correlations between the estimators used in the two channels, reducing the gain in the combination (see Table VI of PRD 79 (2009) 092005).
    - We are interested in the best possible knowledge of m_{top}, not the best m_{top} per each decay channel!

Fit to the data

$$
\begin{aligned}
m_{\mathrm{top}}^{\ell+\mathrm{jets}} &= 172.33 \pm 0.75\ (\mathrm{stat}+\mathrm{JSF}+\mathrm{bJSF})\ \mathrm{GeV},\\
\mathrm{JSF} &= 1.019 \pm 0.003\ (\mathrm{stat}),\\
\mathrm{bJSF} &= 1.003 \pm 0.008\ (\mathrm{stat}),\\
m_{\mathrm{top}}^{\mathrm{dil}} &= 173.79 \pm 0.54\ (\mathrm{stat})\ \mathrm{GeV}.
\end{aligned}
$$



Measurement uncertainties

	$t\bar{t} \rightarrow$ lepton+jets		
	$m_{\text{top}}^{\ell+\text{jets}}$ [GeV]	JSF	bJSF
Results	172.33	1.019	1.003
Statistics	$\boxed{0.75}$	0.003	0.008
– Stat. comp. (m_{top})	*0.23*	*n/a*	*n/a*
– Stat. comp. (JSF)	*0.25*	*0.003*	*n/a*
– Stat. comp. (bJSF)	*0.67*	*0.000*	*0.008*
Method	0.11 ± 0.10	0.001	0.001
Signal MC	0.22 ± 0.21	0.004	0.002
Hadronisation	0.18 ± 0.12	0.007	0.013
ISR/FSR	0.32 ± 0.06	0.017	0.007
Underlying event	0.15 ± 0.07	0.001	0.003
Colour reconnection	0.11 ± 0.07	0.001	0.002
PDF	0.25 ± 0.00	0.001	0.002
W/Z+jets norm	0.02 ± 0.00	0.000	0.000
W/Z+jets shape	0.29 ± 0.00	0.000	0.004
NP/fake-lepton norm.	0.10 ± 0.00	0.000	0.001
NP/fake-lepton shape	0.05 ± 0.00	0.000	0.001
Jet energy scale	0.58 ± 0.11	0.018	0.009
b-Jet energy scale	0.06 ± 0.03	0.000	0.010
Jet resolution	0.22 ± 0.11	0.007	0.001
Jet efficiency	0.12 ± 0.00	0.000	0.002
Jet vertex fraction	0.01 ± 0.00	0.000	0.000
b-Tagging	0.50 ± 0.00	0.001	0.007
$E_{\text{T}}^{\text{miss}}$	0.15 ± 0.04	0.000	0.001
Leptons	0.04 ± 0.00	0.001	0.001
Pile-up	0.02 ± 0.01	0.000	0.000
Total	1.27 ± 0.33	0.027	0.024

- Statistical components:
  - the extra statistical uncertainties on m_{top} introduced by the simultaneous JSF (bJSF) fits.

Measurement uncertainties

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- reduced bJES uncertainty from 0.88 GeV in a 2-dim fit to 0.06 GeV thanks to the 3rd dimension

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- Statistical components:
  - the extra statistical uncertainties on m_{top} introduced by the simultaneous JSF (bJSF) fits.
- MC modelling
  - dominant uncertainties are reduced due to the simultaneous fit of the JSF/ bJSF, with respect to a 2-dim analysis
- reduced bJES uncertainty from 0.88 GeV in a 2-dim fit to 0.06 GeV thanks to the 3rd dimension

Measurement uncertainties

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- Residual JES uncertainty
  - introduced by the p_T dependence of the JES uncertainty, not recoverable by a global JSF
  - Half of that from a 1-dim analysis (no JSF).
- b-tagging:
  - the 3dTMT has a large sensitivity to b-tag systematics (related to the p_T dependence of the data-to-MC b-tagging scale factors uncertainties, affecting the shape of the R_{bq}^{reco} , the 3rd dimension). Reduced from 0.8 GeV in the preliminary result to 0.5 GeV, by simultaneous variations of the common systematics affecting the b-tagging calibration and the m_{top} analysis

Measurement uncertainties

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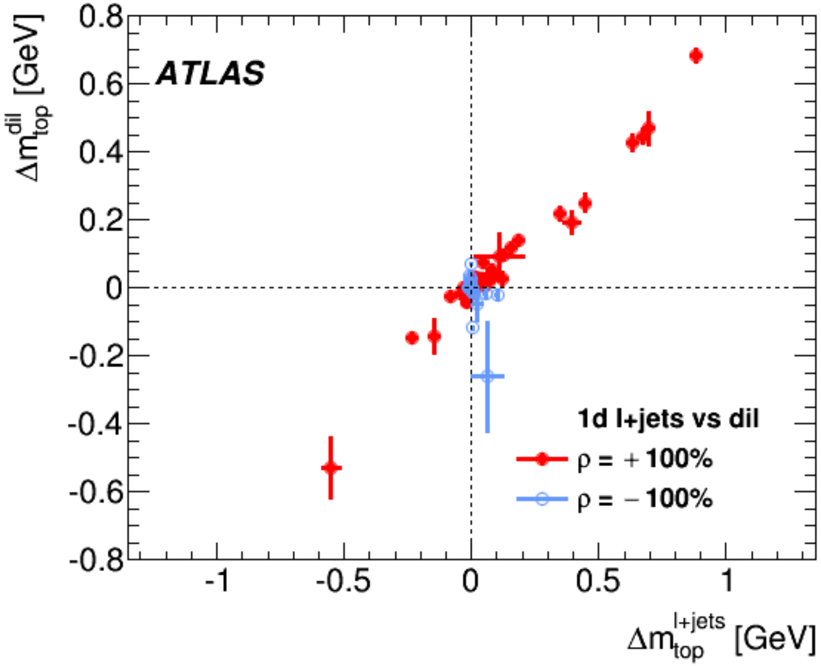
– *Stat. comp. (bJSF)*	*0.67*	*0.000*	*0.008*	*n/a*
Method	0.11 ± 0.10	0.001	0.001	0.09 ± 0.07
Signal MC	0.22 ± 0.21	0.004	0.002	0.26 ± 0.16
Hadronisation	0.18 ± 0.12	0.007	0.013	0.53 ± 0.09
ISR/FSR	0.32 ± 0.06	0.017	0.007	0.47 ± 0.05
Underlying event	0.15 ± 0.07	0.001	0.003	0.05 ± 0.05
Colour reconnection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

- Dilepton:
  - Main systematic uncertainties due to JES/bJES (no in-situ constraint), and MC modelling (ISR/FSR + Hadronisation)

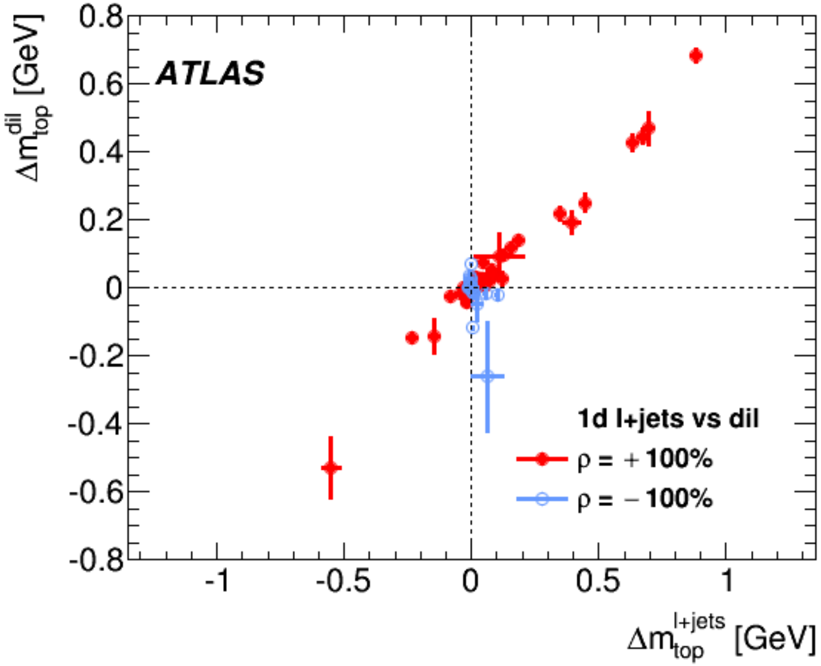
Measurement uncertainties

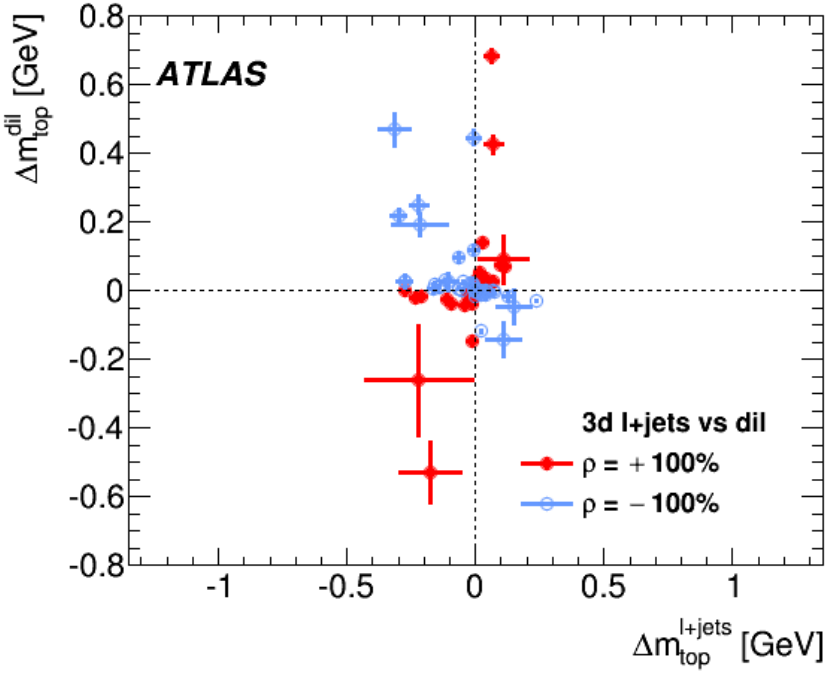
	$t\bar{t} \to$ lepton+jets			$t\bar{t} \to$ dilepton	Combination	
	$m_{\mathrm{top}}^{\ell+\mathrm{jets}}$ [GeV]	JSF	bJSF	$m_{\mathrm{top}}^{\mathrm{dil}}$ [GeV]	$m_{\mathrm{top}}^{\mathrm{comb}}$ [GeV]	ρ
Results	172.33	1.019	1.003	173.79	172.99	
Statistics	0.75	0.003	0.008	0.54	0.48	0
– *Stat. comp.*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

- The combination is performed with BLUE taking into account the signs of the induced m_{top} variations in the two channels under the same systematic effect.

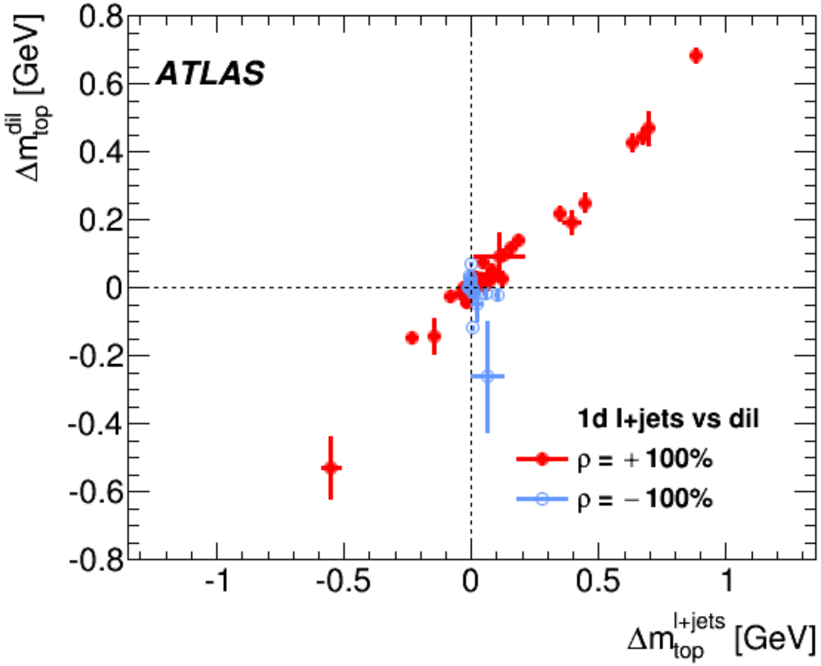


- Size (and sign) of the systematic uncertainties in the two channels:
  - l+jets (1-dim)



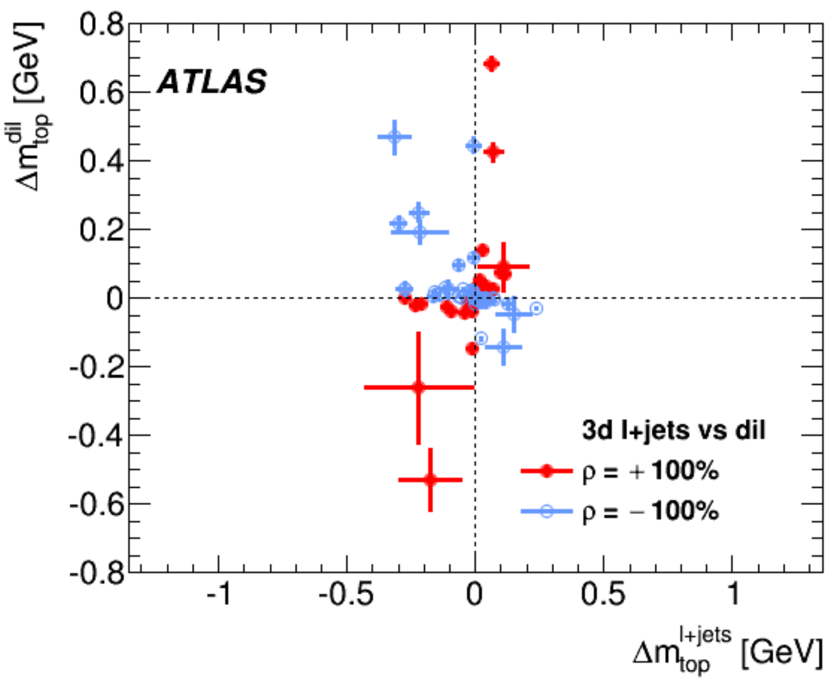


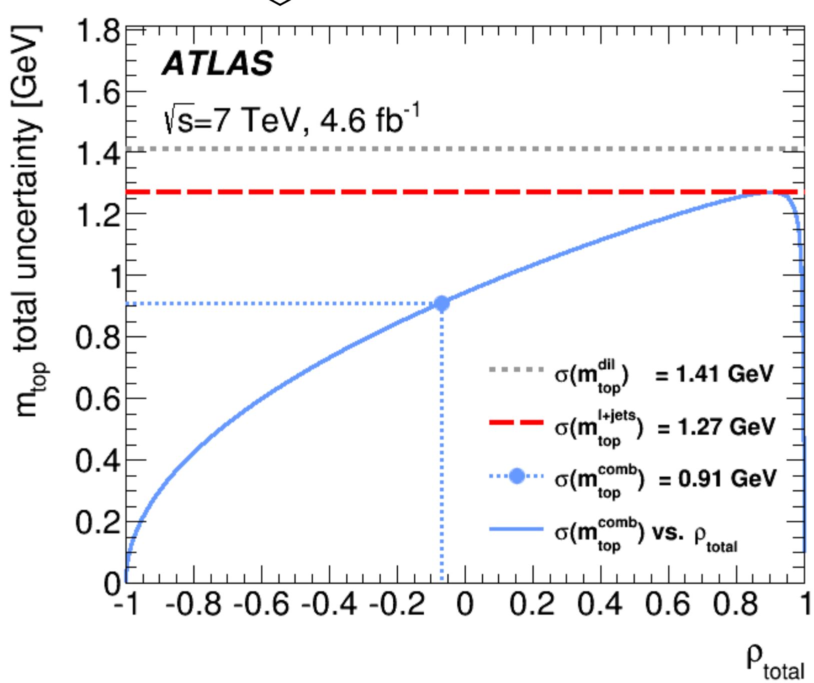
- Size (and sign) of the systematic uncertainties in the two channels:
  - l+jets (1-dim)
  - l+jets (3-dim)
    - Overall syst. reduction
    - De-correlation of the observables

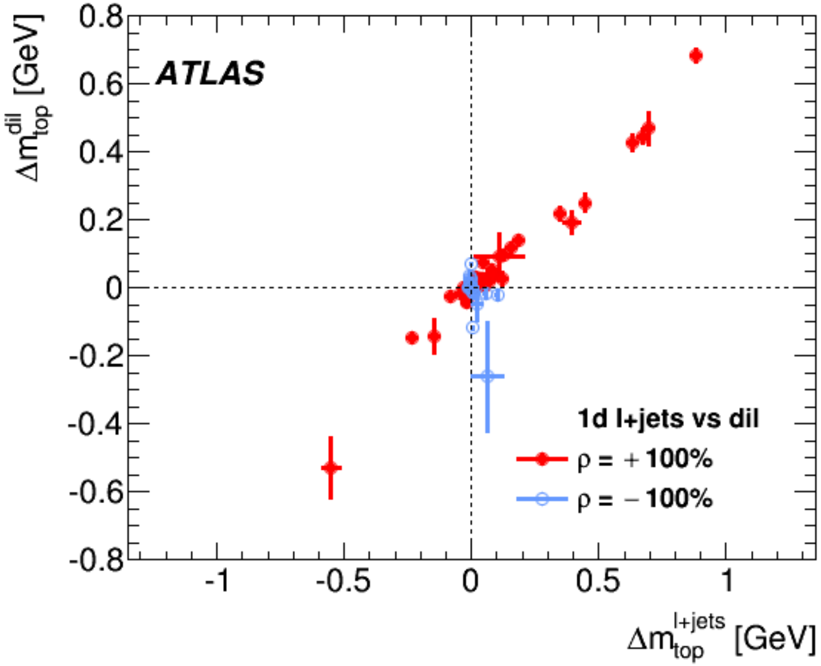


- Size (and sign) of the systematic uncertainties in the two channels:
  - l+jets (1-dim)
  - l+jets (3-dim)
    - Overall syst. reduction
    - De-correlation of the observables

very significant gain
In the combination

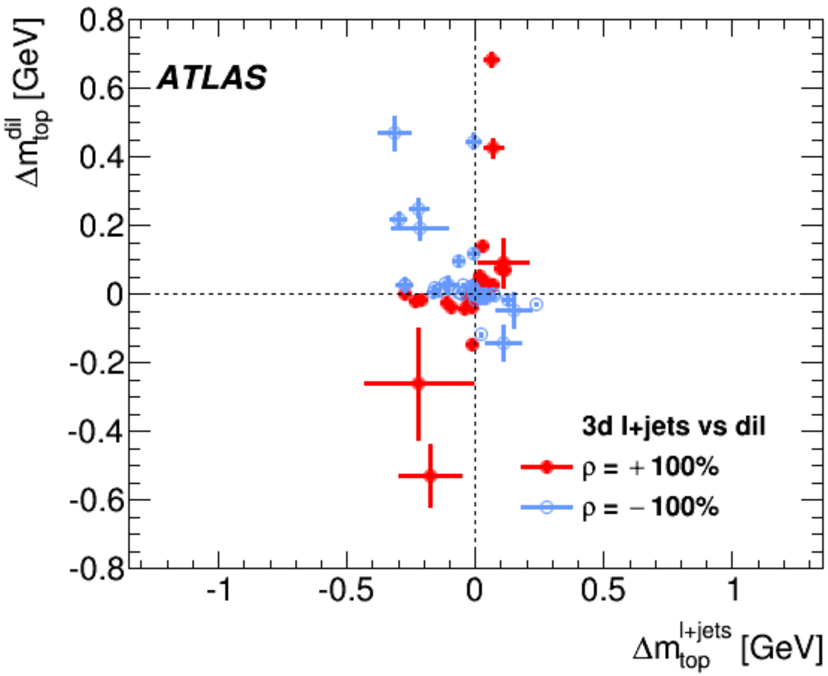


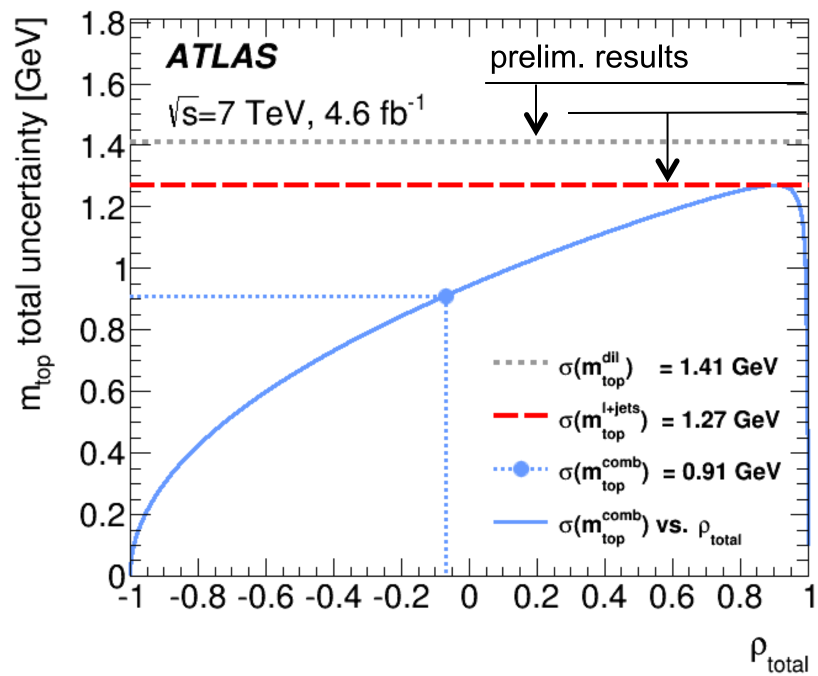




- Size (and sign) of the systematic uncertainties in the two channels:
  - l+jets (1-dim)
  - l+jets (3-dim)
    - Overall syst. reduction
    - De-correlation of the observables

very significant gain
In the combination





In arXiv:1403.4427 the l+jets/dil analysis correlations was estimated to be 0.64

Conclusions

- The new ATLAS top quark mass results in the l+jets and dilepton channels are:

$$
\begin{aligned}
m_{\rm top}^{\ell+\rm jets} &= 172.33 \pm 0.75\,(\text{stat} + \text{JSF} + \text{bJSF}) \pm 1.02\,(\text{syst})\ \text{GeV},\\
\text{JSF} &= 1.019\ \pm 0.003\,(\text{stat})\ \pm 0.027\,(\text{syst}),\\
\text{bJSF} &= 1.003\ \pm 0.008\,(\text{stat})\ \pm 0.023\,(\text{syst}),\\
m_{\rm top}^{\rm dil} &= 173.79 \pm 0.54\,(\text{stat}) \pm 1.30\,(\text{syst})\ \text{GeV}.
\end{aligned}
$$

  - These supersede the preliminary results, and constitute an improvement in precision of 18% and 14% for the l+jets and dilepton channels, respectively.

- Their combination yields:

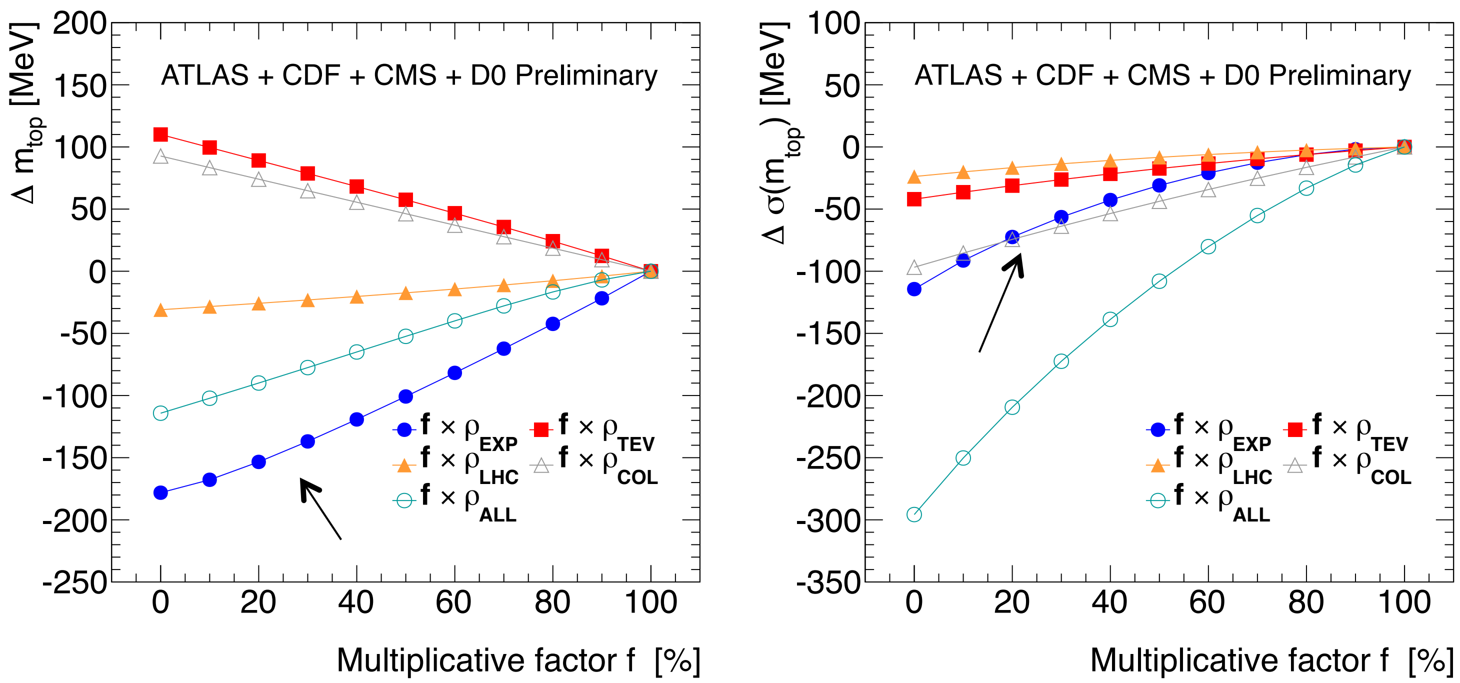
$$m_{\rm top}^{\rm comb} = 172.99 \pm 0.48\,(\text{stat}) \pm 0.78\,(\text{syst})\ \text{GeV} = 172.99 \pm 0.91\ \text{GeV}.$$

  - Improving by 28% the precision of the most precise input measurement.
  - It is more precise than the previous LHC combination (m_{top}^{LHC} = 173.29 ± 0.95 GeV), which included the ATLAS conference note results, based on the same dataset (previous m_{top}^{ATLAS} = 172.65 ± 1.44 GeV).

Outlook

- In view of the next LHC/Tevatron+LHC combination (see Benjamin's talk) an improved treatment of the correlations for analyses from the same experiment could significantly improve our knowledge of m_{top}.
  - Variations of the correlation assumption within the same experiment have proven to be important in the first m_{top} world combination.
  - 1-dim and 2-dim analyses are performed by all experiments, such that sizeable de-correlation effects might be present and could be exploited to improve the final m_{top} precision.

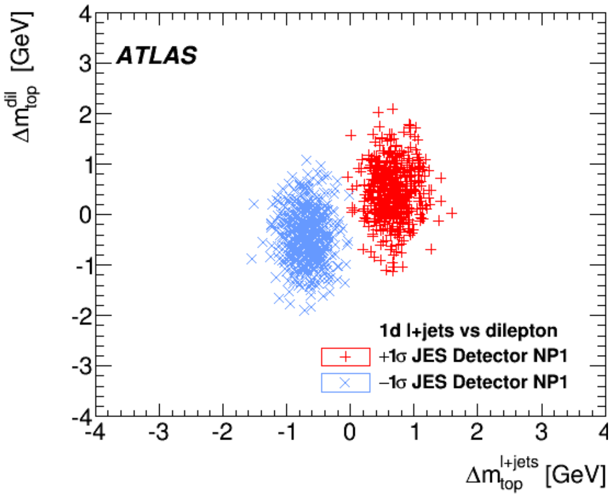
plots from the World m_{top} combination: arXiv:1403.4427

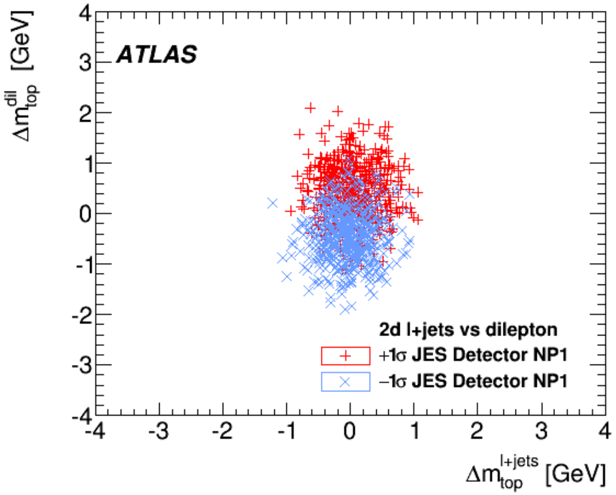


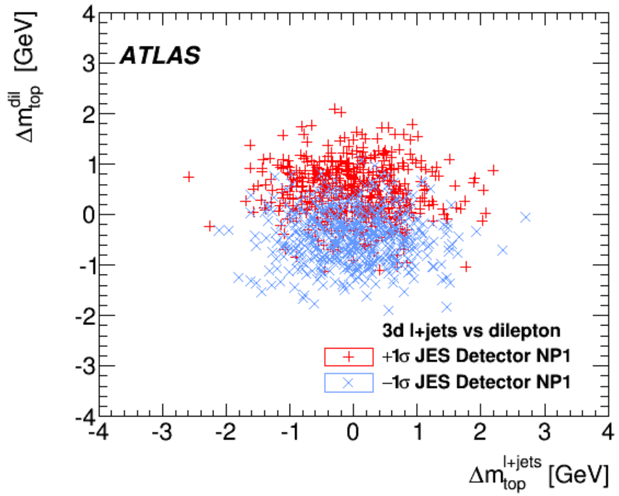
- Backup -

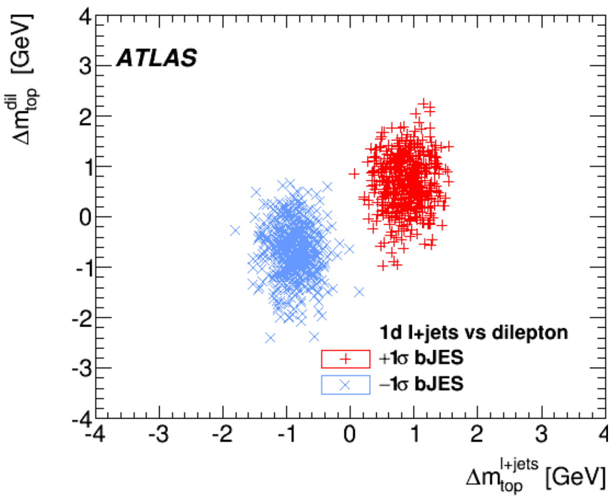
JES uncertainties breakdown

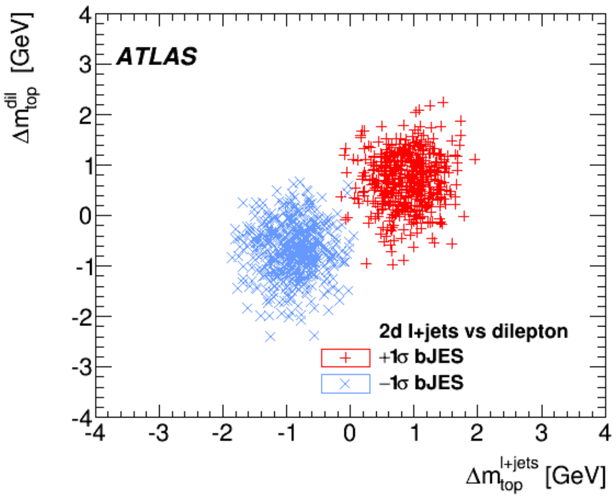
	$t\bar{t} \to$ lepton+jets			$t\bar{t} \to$ dilepton	Combination	
	$\Delta m_{\mathrm{top}}^{\ell+\mathrm{jets}}$ [GeV]	ΔJSF	ΔbJSF	$\Delta m_{\mathrm{top}}^{\mathrm{dil}}$ [GeV]	$\Delta m_{\mathrm{top}}^{\mathrm{comb}}$[GeV]	ρ
Statistical (total)	0.18 ± 0.04	0.003	0.001	0.16 ± 0.03	0.11	−0.25
– Statistical NP1	−0.17 ± 0.02	+0.002	+0.001	+0.01 ± 0.02	0.09	−1.00
– Statistical NP2	+0.02 ± 0.00	+0.001	−0.000	+0.05 ± 0.00	0.03	+1.00
– Statistical NP3	−0.01 ± 0.02	+0.001	+0.001	+0.12 ± 0.02	0.05	−1.00
– η inter-calibration (stat.)	−0.07 ± 0.02	+0.001	+0.001	+0.10 ± 0.02	0.01	−1.00
Modelling (total)	0.31 ± 0.06	0.009	0.002	0.52 ± 0.04	0.26	−0.18
– Modelling NP1	−0.30 ± 0.03	+0.006	+0.001	+0.22 ± 0.02	0.07	−1.00
– Modelling NP2	+0.03 ± 0.02	+0.002	−0.000	+0.14 ± 0.02	0.08	+1.00
– Modelling NP3	−0.01 ± 0.02	−0.002	−0.000	−0.15 ± 0.02	0.07	+1.00
– Modelling NP4	−0.01 ± 0.00	+0.000	+0.000	+0.02 ± 0.00	0.00	−1.00
– η inter-calibration (model)	+0.07 ± 0.04	+0.007	−0.001	+0.43 ± 0.03	0.23	+1.00
Detector (total)	0.05 ± 0.03	0.007	0.001	0.45 ± 0.04	0.20	−0.19
– Detector NP1	−0.01 ± 0.03	+0.007	+0.001	+0.45 ± 0.02	0.20	−1.00
– Detector NP2	−0.05 ± 0.00	+0.000	+0.001	+0.03 ± 0.00	0.02	−1.00
Mixed (total)	0.02 ± 0.02	0.001	0.001	+0.03 ± 0.02	0.01	−0.80
– Mixed NP1	−0.02 ± 0.00	+0.000	+0.001	+0.02 ± 0.00	0.00	−1.00
– Mixed NP2	+0.00 ± 0.02	+0.001	−0.000	+0.02 ± 0.02	0.01	+1.00
Single particle high-p_{T}	+0.00 ± 0.00	+0.000	−0.000	+0.00 ± 0.00	0.00	+1.00
Relative non-closure MC	+0.00 ± 0.02	+0.001	−0.000	+0.03 ± 0.02	0.02	+1.00
Pile-up (total)	0.15 ± 0.04	0.001	0.002	0.04 ± 0.03	0.09	+0.03
– Pile-up: Offset(μ)	−0.11 ± 0.02	−0.001	+0.001	−0.02 ± 0.02	0.07	+1.00
– Pile-up: Offset(n_{vtx})	−0.10 ± 0.04	−0.000	+0.001	+0.03 ± 0.03	0.04	−1.00
Flavour (total)	0.36 ± 0.04	0.012	0.008	0.03 ± 0.03	0.20	−0.17
– Flavour Composition	−0.24 ± 0.02	+0.006	−0.002	−0.02 ± 0.02	0.14	+1.00
– Flavour Response	−0.28 ± 0.03	+0.011	−0.008	+0.03 ± 0.02	0.14	−1.00
Close-by jets	−0.22 ± 0.04	+0.005	+0.002	+0.25 ± 0.03	0.01	−1.00
b-Jet energy scale	+0.06 ± 0.03	+0.000	+0.010	+0.68 ± 0.02	0.34	+1.00
Total (without bJES)	0.58 ± 0.11	0.018	0.009	0.75 ± 0.08	0.41	−0.23

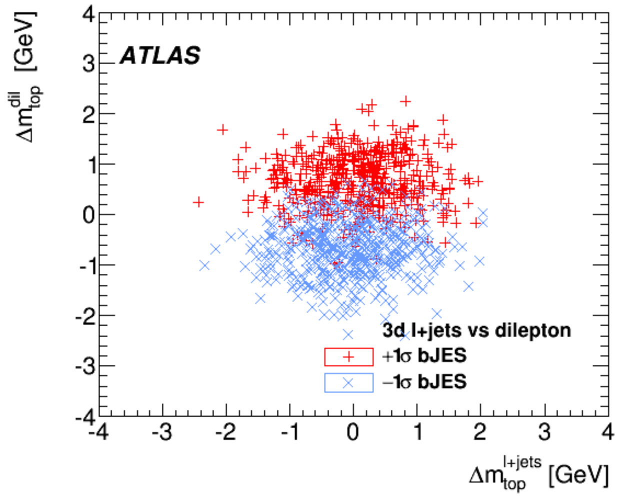

ATLAS
1d l+jets vs dilepton
+1σ JES Detector NP1
−1σ JES Detector NP1
Δm_{top}^{l+jets} [GeV]
Δm_{top}^{dil} [GeV]


ATLAS
2d l+jets vs dilepton
+1σ JES Detector NP1
−1σ JES Detector NP1
Δm_{top}^{l+jets} [GeV]
Δm_{top}^{dil} [GeV]


ATLAS
3d l+jets vs dilepton
+1σ JES Detector NP1
−1σ JES Detector NP1
Δm_{top}^{l+jets} [GeV]
Δm_{top}^{dil} [GeV]


ATLAS
1d l+jets vs dilepton
+1σ bJES
−1σ bJES
Δm_{top}^{l+jets} [GeV]
Δm_{top}^{dil} [GeV]


ATLAS
2d l+jets vs dilepton
+1σ bJES
−1σ bJES
Δm_{top}^{l+jets} [GeV]
Δm_{top}^{dil} [GeV]


ATLAS
3d l+jets vs dilepton
+1σ bJES
−1σ bJES
Δm_{top}^{l+jets} [GeV]
Δm_{top}^{dil} [GeV]

Measurement corr. in the world comb.

		CDF				D0		ATLAS		CMS		
		l+jets	di-l	all jets	$E_{\mathrm{T}}^{\mathrm{miss}}$	l+jets	di-l	l+jets	di-l	l+jets	di-l	all jets
CDF	l+jets	1.00										
	di-l	0.49	1.00									
	all jets	0.28	0.25	1.00								
	$E_{\mathrm{T}}^{\mathrm{miss}}$	0.31	0.27	0.17	1.00							
D0	l+jets	0.29	0.09	0.16	0.18	1.00						
	di-l	0.15	0.07	0.10	0.11	0.38	1.00					
ATLAS	l+jets	0.17	0.07	0.10	0.12	0.17	0.11	1.00				
	di-l	0.30	0.12	0.17	0.19	0.24	0.15	0.64	1.00			
CMS	l+jets	0.23	0.12	0.15	0.16	0.21	0.16	0.24	0.34	1.00		
	di-l	0.09	0.05	0.05	0.08	0.08	0.07	0.16	0.24	0.64	1.00	
	all jets	0.15	0.06	0.09	0.10	0.13	0.08	0.15	0.23	0.57	0.75	1.00

Table 5: Correlations among the eleven input measurements. The elements in the table are labelled according to the experiment and the $t\bar{t}$ final state.

Impact of $\Delta\rho_{exp}$ in the world comb.