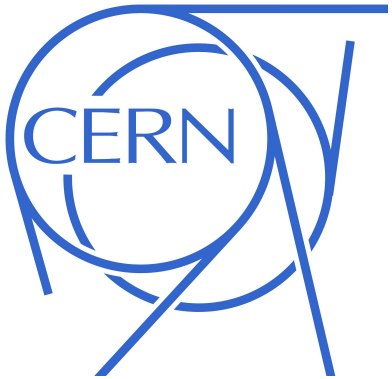


Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Measurement of the Top Quark Mass in the Dileptonic Decay Channel from √s=8 TeV ATLAS Data

Andreas A. Maier (CERN)
on behalf of the ATLAS collaboration

LHCtopWG meeting
May 18th 2016

Introduction

- The top quark mass has been measured in the dileptonic top quark pair decay channel using ATLAS data at √s=8 TeV
- The event selection applied in the 7 TeV analysis (Eur. Phys. J. C 75 (2015) 330) is optimised to obtain the smallest total uncertainty
- The result is combined with the measurements in the lepton+jets and dilepton channels at √s=7 TeV

- This presentation will
  - present the analysis at 8 TeV
  - recap the analyses at 7 TeV
  - present the combination

Motivation

- A precise knowledge of the top quark mass is essential for many applications
- This can be achieved by a) a precise measurement
  b) a combination of sufficiently uncorrelated measurements

→ both are performed in this paper

Dileptonic event selection

$$t\,t \rightarrow W\,W\,b\,b \rightarrow l\,\nu\,l\,\nu\,b\,b$$

- exactly 2 oppositely charged leptons
- ≥ 2 jets and b-tagging requirements
- further requirements to reduce background

→ 36359 data events, 1% background (pre-selection)

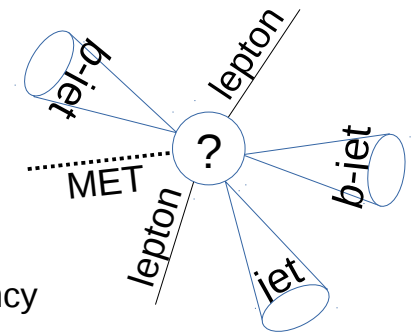
- additional restriction on $p_{T,lb}$*

→ 9426 data events, 1% background (final selection)

*the average transverse momentum of the lepton-*b*-jet systems

***b*-jet to lepton assignment**

- take pairs with minimum sum of pair invariant masses
- Pre-(final) selection:
  - selection purity of 52% (70%)
  - matching efficiency of 78% (95%)

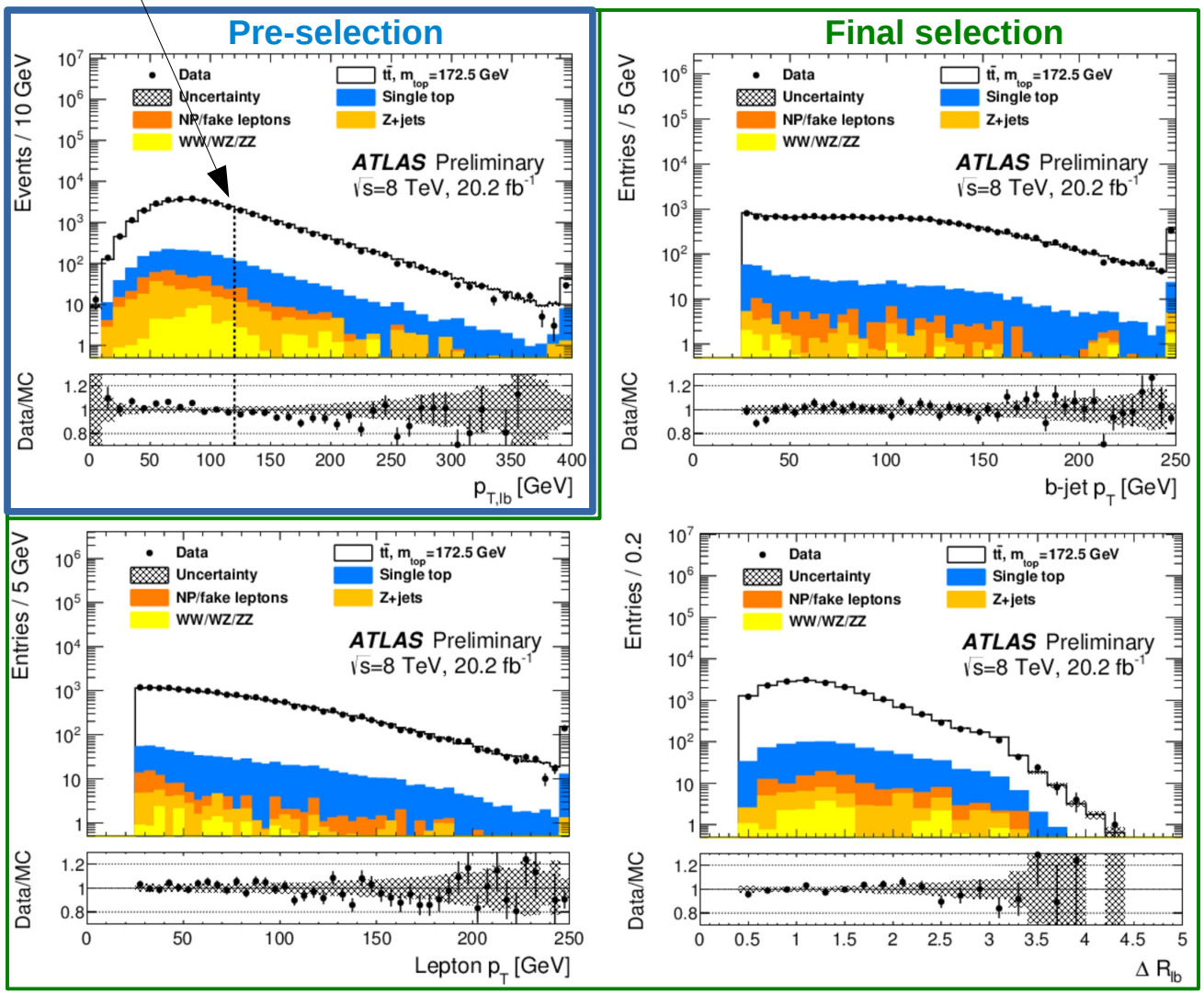


Background
- Fake leptons: data-driven
- Z+jets: Alpgen+Pythia6
- Dibos: Alpgen+Herwig

Signal
(tt+single top)
- Powheg+Pythia6

Data to MC comparison

Cut-off for the final selection



The uncertainty bands are statistical only

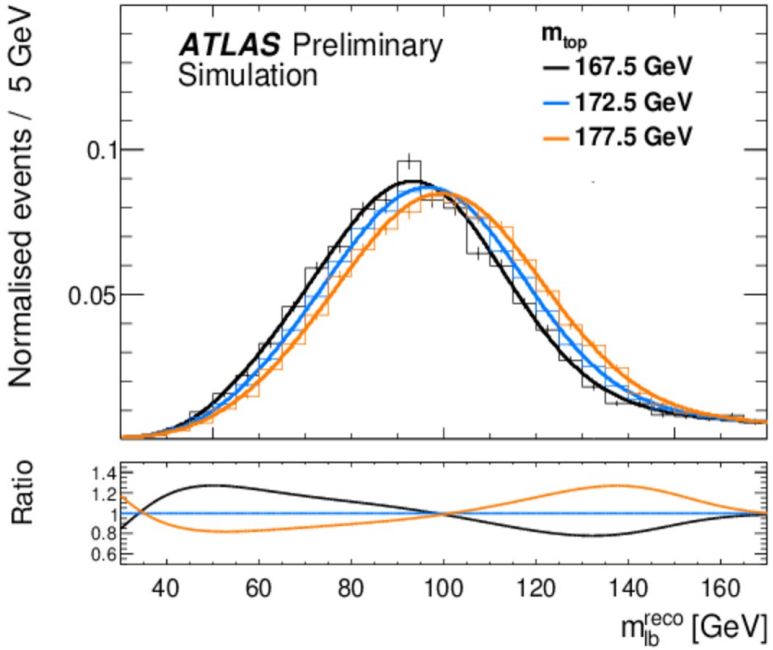
The analysis strategy

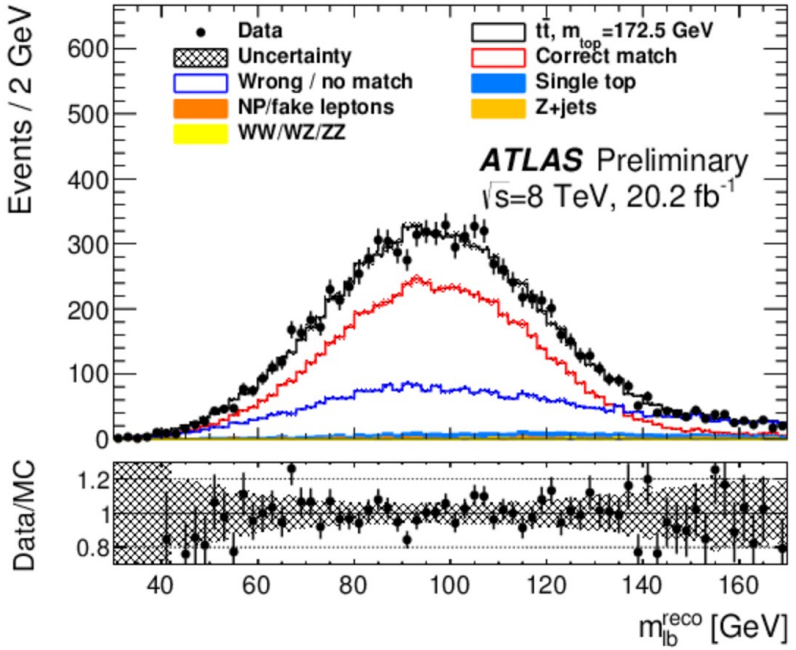
The dilepton channel suffers from underconstrained event kinematics

➔use the minimum average invariant mass of the lepton-*b*-jet systems, $\mathbf{m_{lb}}$

Left: the mass variation templates and the corresponding template fit function

Right: the template for m_{top}=172.5 GeV in comparison to the data





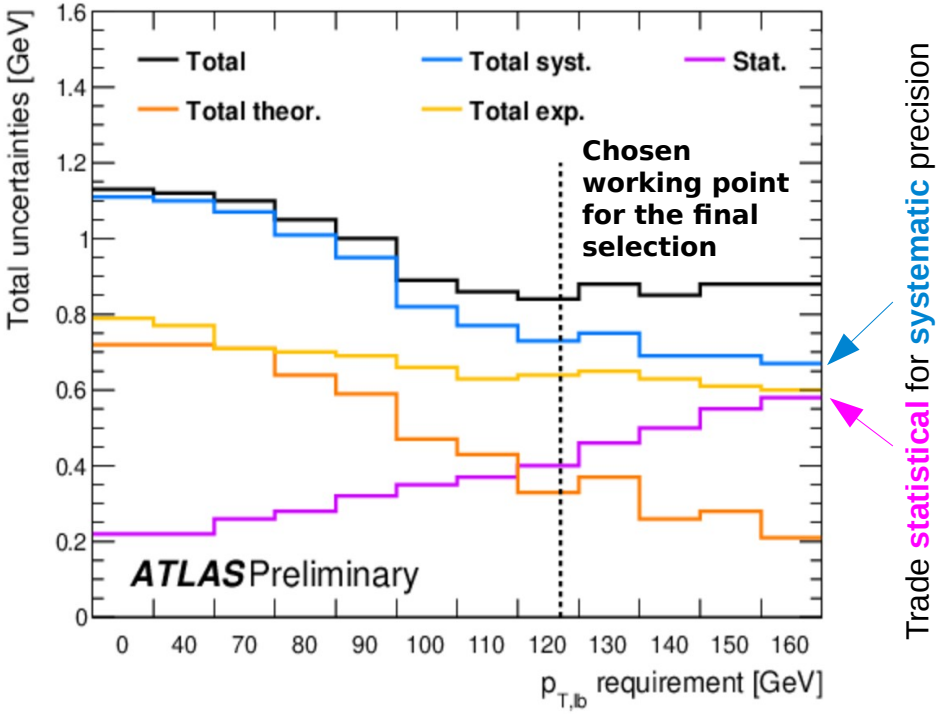
The uncertainty bands are statistical only

The phase space optimisation

- The precision of current m_{top} measurements is limited by
  - **experiment**: jet energy scale uncertainties (more precise for higher p_T)
  - **theory**: modelling uncertainties (sometimes large impact on additional jets)

→ **look for p_T variable with positive correlation to matching efficiency**

- $p_{T,lb}$, the average transverse momentum of the lepton-*b*-jet systems, matches the requirements
- Perform full analysis with various requirements for $p_{T,lb}$
- Significant reduction of the leading uncertainties by cutting on $p_{T,lb}$



The template fit to the data

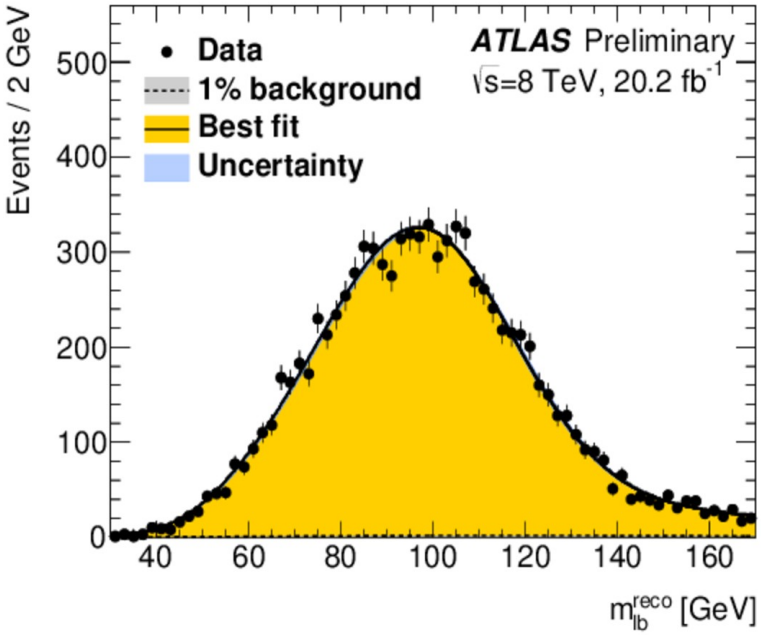
...using a 1-dimensional template method

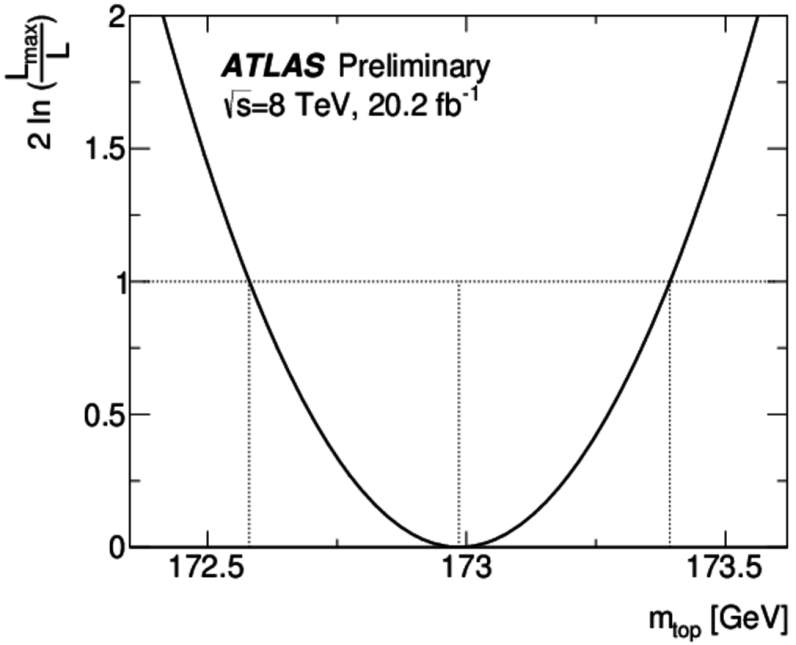
Result: $m_{\text{top}} = 172.99 \pm 0.41\,(\text{stat.}) \pm 0.74\,(\text{syst.})\,\text{GeV} = 172.99 \pm 0.84\,\text{GeV}$

- theor. uncertainties dominated by the hadronisation* and ISR/FSR
- exp. uncertainties dominated by the (*b*)JES uncertainties

Left: the unbinned likelihood fit to the data (1% background hardly visible)

Right: the logarithm of the likelihood around its minimum





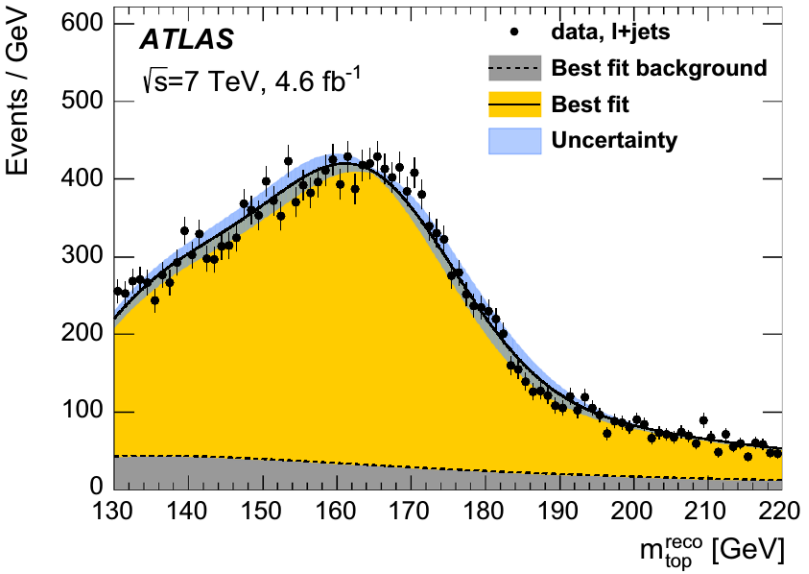
*Pythia vs Herwig comparison

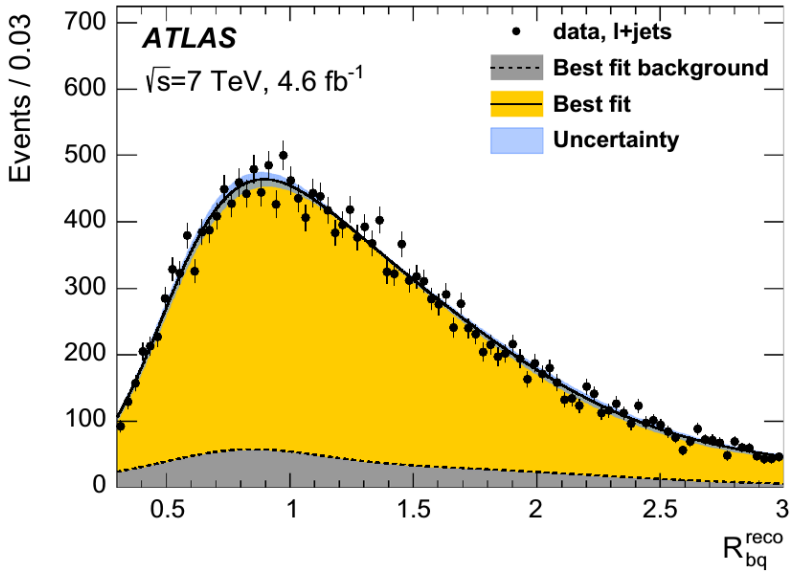
The measurements at 7 TeV

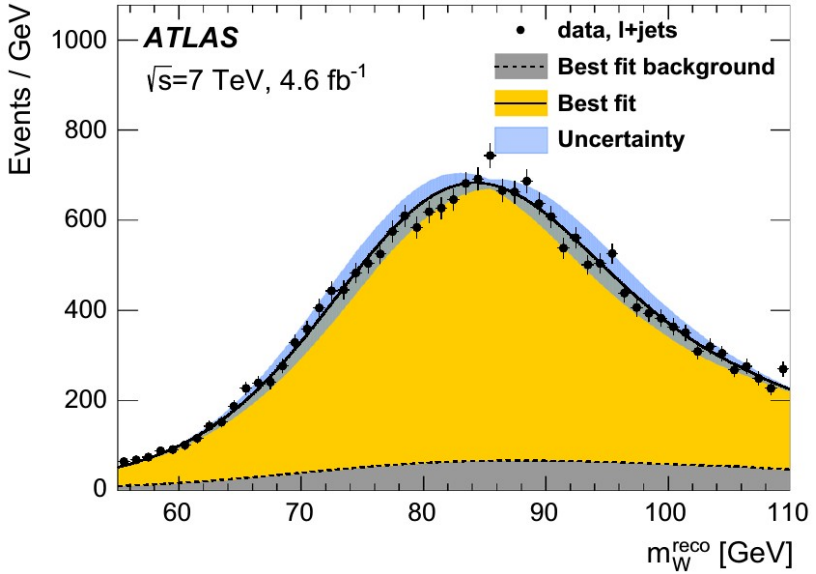
Eur. Phys. J. C 75 (2015) 330

- Dilepton channel: as for 8 TeV but without optimised requirement on $p_{T,lb}$.
- L+jets channel: reconstruction via kin. likelihood fit
  - $\mathbf{m_{top}^{reco}}$, sensitive to m_{top}, JSF* and bJSF**
  - $\mathbf{m_{W}^{reco}}$, sensitive to JSF
  - $\mathbf{R_{bq}^{reco}}$, sensitive to bJSF

  → additional parameters transform scale related systematic into statistical uncertainties







*global Jet energy Scale Factor

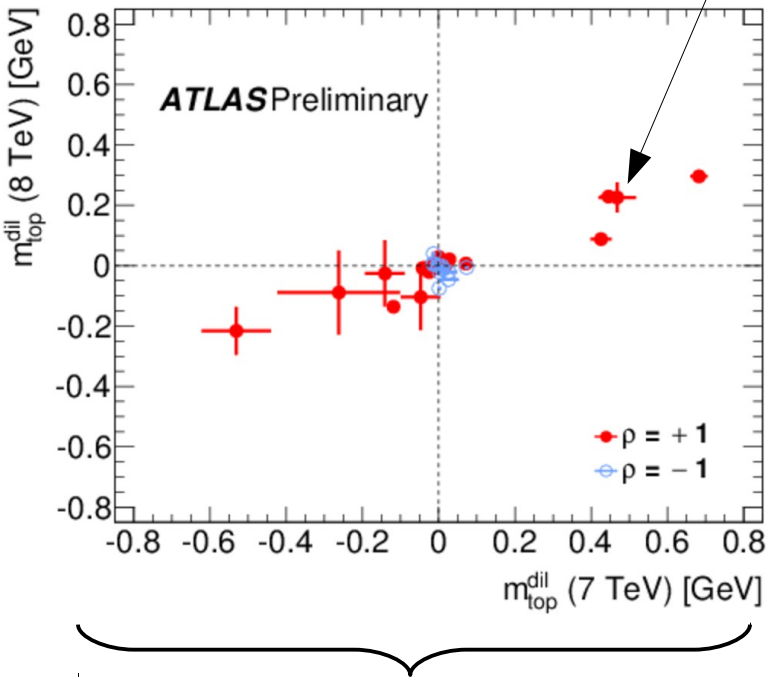
**relative *b*- to light Jet energy Scale Factor

The correlations

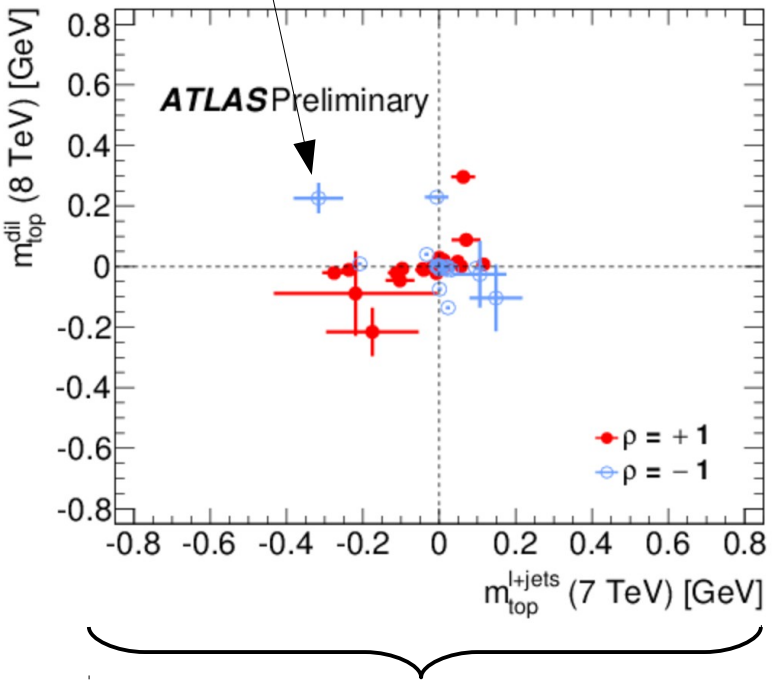
Combination of the measurements using BLUE*

- usage of a dedicated mapping to identify corresponding uncertainty sources at 7 and 8 TeV
- determination of the estimator correlation (±1) for those sources** (see figures below)

e.g. ISR/FSR uncertainty
(lj7: -0.32, dl7: +0.47, dl8: +0.23 GeV)



Dilepton measurements are clearly correlated



Dilepton and l+jets measurements are less correlated

*Best Linear Unbiased Estimator (http://blue.hepfoge.org)

**following the methodology introduced in Eur. Phys. J. C72 (2012) 2046

The combination

Using the determined correlations, the measurements are combined (pairwise compatibilities within 0.75 σ):

Some **uncertainties** of the measurements to be combined

Determined pairwise **correlations**

Results of various **combinations**

	7 TeV l+jets [GeV]	7 TeV dilep [GeV]	8 TeV dilep [GeV]	ρ_{01}	ρ_{02}	ρ_{12}	7 TeV [GeV]	dilep [GeV]	all [GeV]
Statistics	0.75	0.54	0.41	0	0	0	0.48	0.38	0.34
Signal MC gen.	0.22	0.26	0.09	+1	+1	+1	0.24	0.10	0.14
Hadronisation	0.18	0.53	0.22	+1	+1	+1	0.34	0.24	0.23
ISR/FSR	0.32	0.47	0.23	-1	-1	+1	0.04	0.24	0.08
JES	0.58	0.75	0.54	-0.23	+0.06	+0.35	0.41	0.52	0.41
*b*JES	0.06	0.68	0.30	+1	+1	+1	0.34	0.32	0.25
b-tagging	0.50	0.07	0.03	-0.77	0	0	0.25	0.03	0.15
Total	1.27	1.41	0.84	-0.07	0.00	0.51	0.91	0.84	0.70

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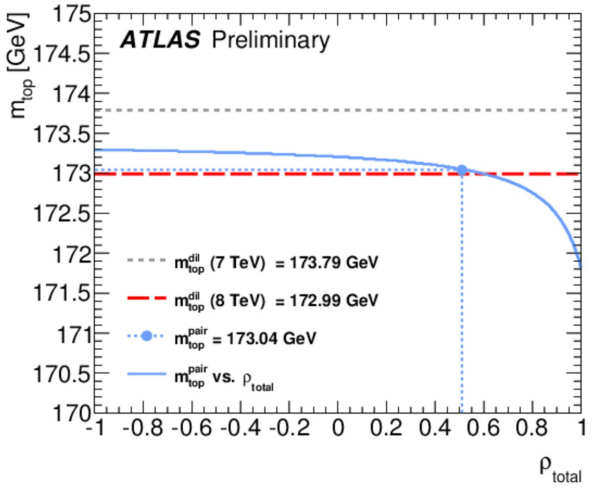
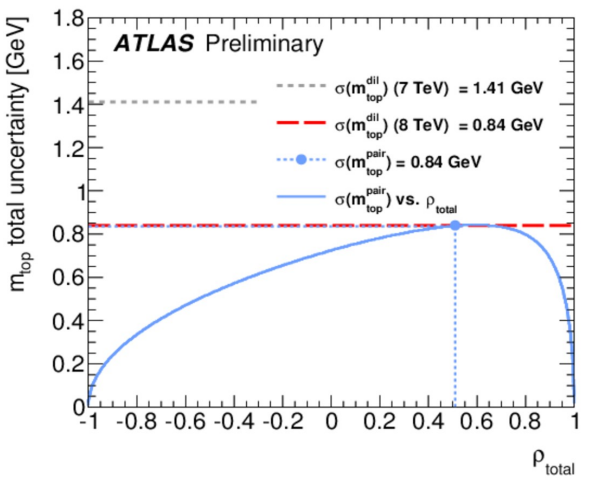
Stability of the combination

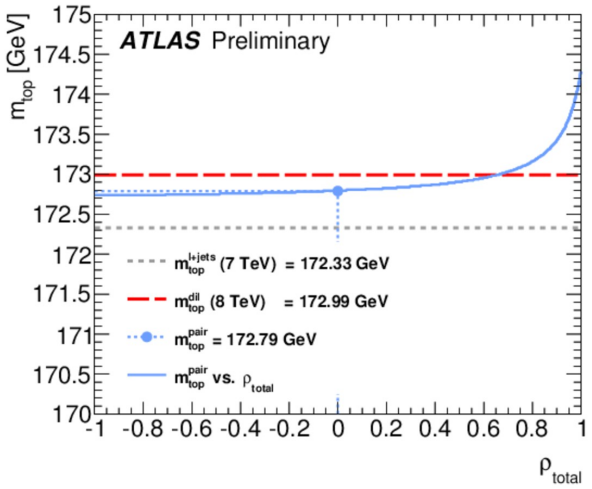
Pairwise combinations

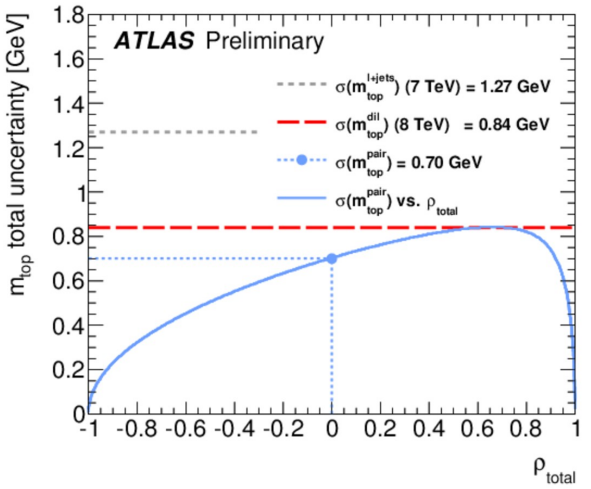
Dilepton measurements



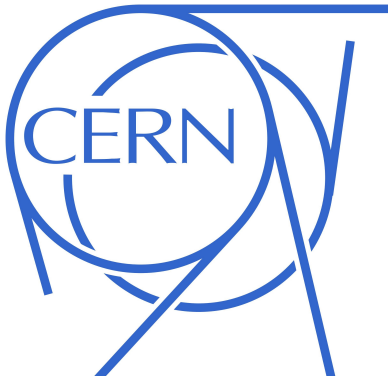


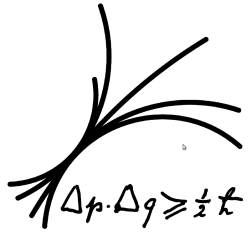
8 TeV dilepton and 7 TeV l+jets measurement





- In pseudo-experiments, varying each uncertainty component within its statistical precision (this also leads to different correlations for the combination), the results are found to be stable at the level of 0.03 GeV
- The combined value and its uncertainty depend on the total correlation ρ_{total}
- The values of the pairwise combinations is shown here as a function of ρ_{total} (the 7 TeV figures are published and not repeated here)
- The combination results lie in regions of small slope and therefore only negligible effects are expected due to correlation changes





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Conclusions

The measured m_{top} in the dilepton channel from pp collisions at 8 TeV is:

$$m_{\text{top}} = 172.99 \pm 0.41\,(\text{stat.}) \pm 0.74\,(\text{syst.})\,\text{GeV} = 172.99 \pm 0.84\,\text{GeV}$$

- improvement of 40% wrt. the corresp. result at 7 TeV (Δm_{top} = 1.41 GeV)
- this represents the most precise m_{top} measurement in the dilepton channel to date

The combination with ATLAS results in the dilepton and l+jets channels at 7 TeV yields:

$$m_{\text{top}}^{\text{comb}} = 172.84 \pm 0.34\,(\text{stat.}) \pm 0.61\,(\text{syst.})\,\text{GeV} = 172.84 \pm 0.70\,\text{GeV}$$

- improvement of 17% wrt. the most precise single input measurement
- improvement of 23% wrt. the old ATLAS combination (Δm_{top} = 0.91 GeV)

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Data vs MC for the $p_{T,lb}$ distribution

- Reweighting the prediction to the data results in Δm_{top}=0.15 GeV
- This is covered by the hadronisation uncertainty (Pythia vs Herwig difference) of 0.22 GeV