Overview and combination of CMS results on the mass of the Top quark

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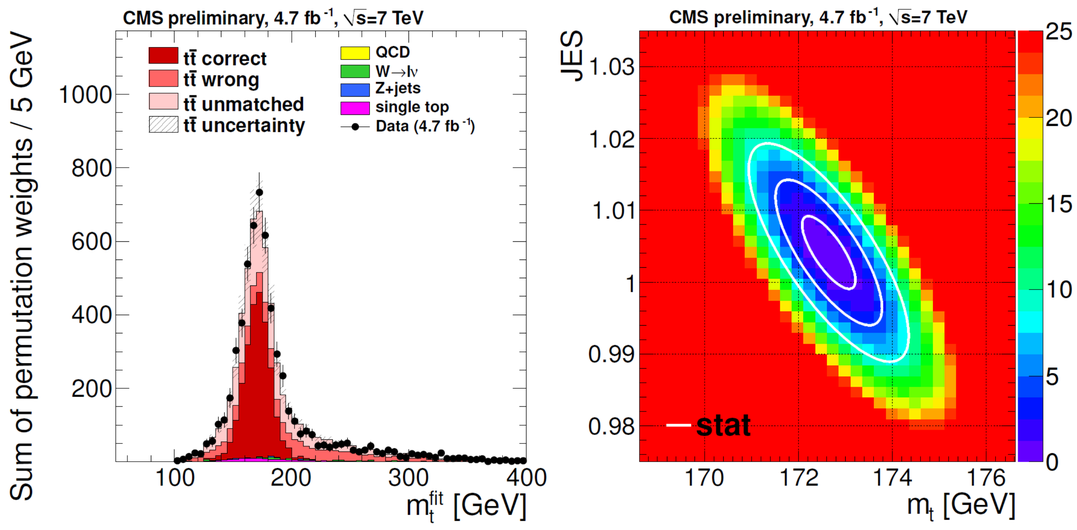
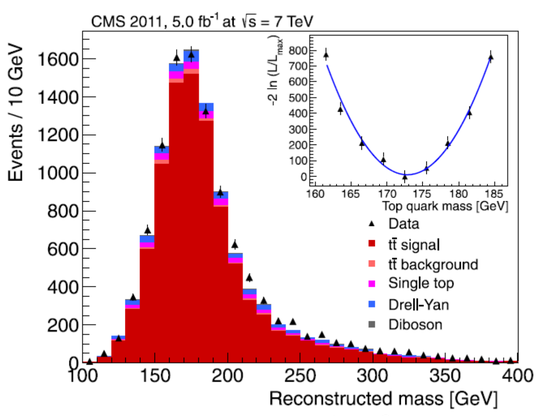
Combination[1]

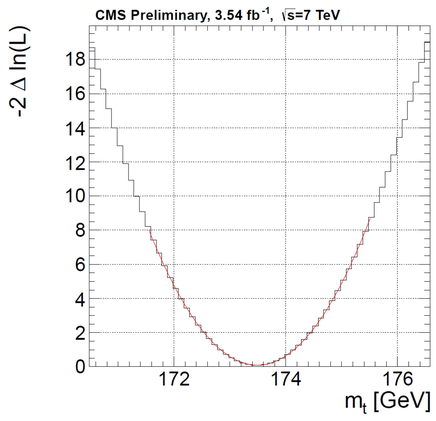
We combine top quark mass results using up to 5.0 fb^{-1} of CMS recorded data of proton-proton collisions at a centre-of-mass energy $\sqrt{s} = 7$ TeV, across the 2010 and 2011 data taking periods.



e, μ +jets analysis[2]



ee, eμ, μμ analysis[3]



All-hadronic analysis[4]

The BLUE method[5]

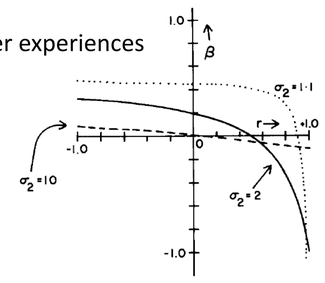
The BLUE (Best Linear Unbiased Estimator) method has been previously used in top quark mass combinations by both Tevatron and LHC experiments.

- ❖ Linear combination of each individual input measurement
- ❖ Relies on splitting and categorising and correlating sources
- ❖ A Fine-grained categorisation allows the use of zero or one values for the correlation coefficients.
- ❖ Categories are chosen based on previous combinations from other experiences

To ensure the robustness of the method, several checks have been made :

- ✓ Variation from 0 to 1 for fully correlated coefficients
- ✓ Limiting correlation to uncertainty values ratios, to avoid negative weights (right plot)

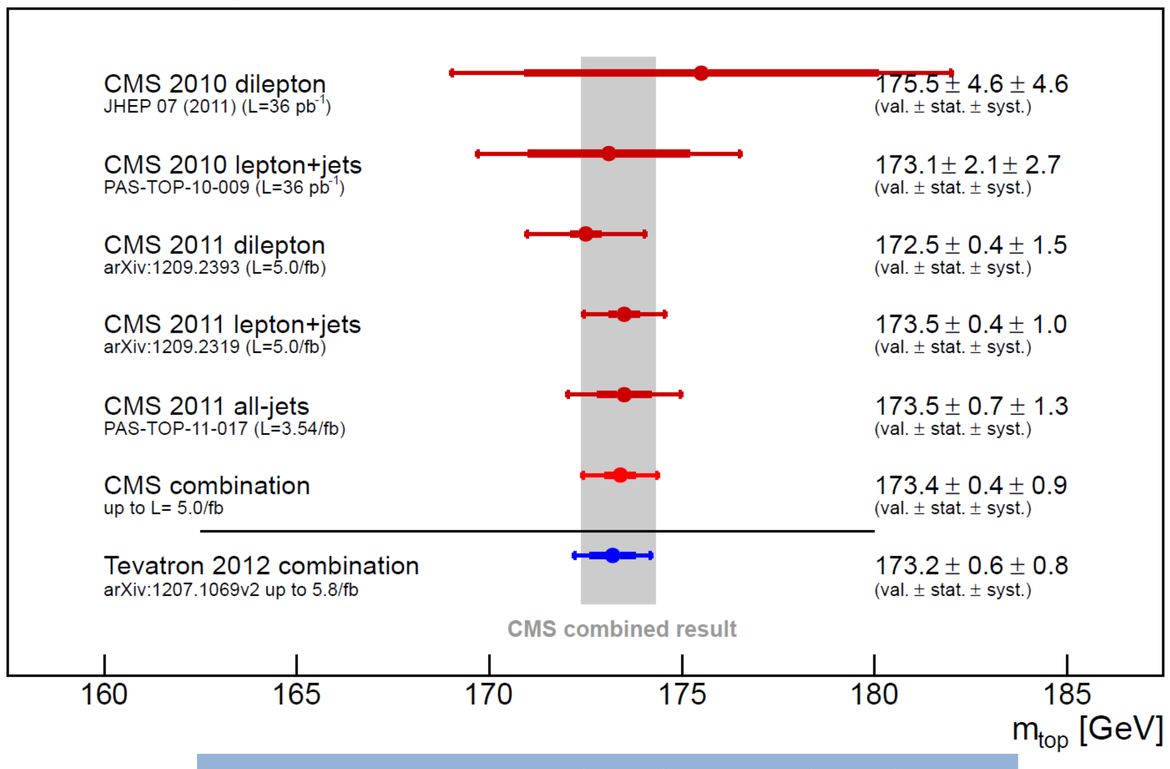
- ➢ The impact on the combined central value, and its associated uncertainty is negligible



Plot showing the evolution of the weight for y_2 value and the correlation with y_1 as a function of the ratio of the uncertainties of these two measurements

Result[1]

CMS Preliminary



$$m_t = 173.36 \pm 0.38(\text{stat.}) \pm 0.91(\text{syst.})\ \text{GeV}$$

- ❖ Total uncertainty of 0.99 GeV (0.57%)
- ❖ 7.4% improvement with respect to the most precise measurement (2011 l+jets)

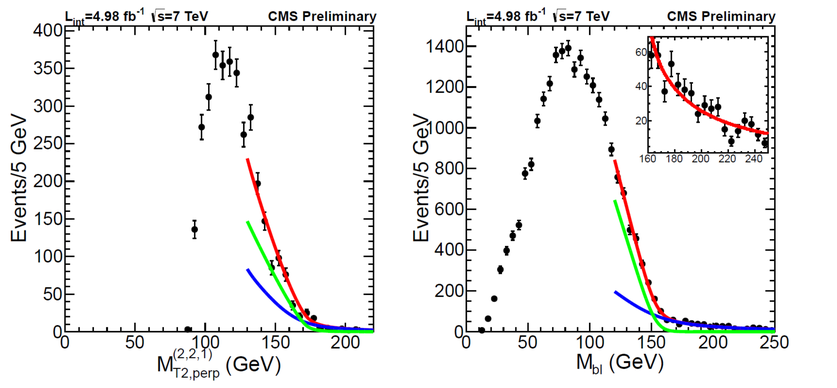
Details on input measurements

	Dileptons 2010	Lepton+jets 2010	Dileptons 2011	Lepton+jets 2011	All jets 2011	Correlation between channels	Correlation between years	Combination
Measured m_t	175.50	173.10	172.50	173.49	173.49			173.36
Statistical Uncertainty	4.60	2.10	0.43	0.27	0.69	0	0	0.38
iJES: *in-situ* JES factor	n/a	n/a	n/a	0.33	n/a	0	0	0.24
bJES: relative b-jet scale	0.90	0.90	0.71	0.61	0.49	1	1	0.55
dJES: η and p_T-dependent JES	2.10	2.10	0.94	0.28	0.97	1	1	0.32
rJES: other uncorrelated JES	3.30	n/a	n/a	n/a	n/a	0	0	0.07
Lepton energy scale	0.30	n/a	0.14	0.02	n/a	1	1	0.03
MC generator	0.50	n/a	0.04	n/a	n/a			0.01
ISR/FSR	0.20	0.20	n/a	n/a	n/a			0.03
PDF	0.50	0.10	0.09	0.07	0.06			0.06
Factorization scale	0.60	1.10	0.55	0.24	0.22			0.17
ME-PS matching threshold	0.70	0.40	0.19	0.18	0.24			0.16
Signal						1	1	
Jet energy resolution	0.50	0.10	0.14	0.23	0.15			0.20
b-tagging	0.40	0.10	0.09	0.12	0.06			0.10
E_T^{miss} scale	0.10	0.40	0.12	0.06	n/a			0.01
Detector Modeling						1	1	
Underlying event	1.30	0.20	0.05	0.15	0.32	1	1	0.15
Background MC	0.10	0.20	0.05	0.13	n/a	1	1	0.07
Background Data	n/a	0.40	n/a	n/a	0.20	0	0	0.07
Fit calibration and MC statistics	0.20	0.10	0.40	0.06	0.13	0	0	0.08
Pile-up	1.00	0.10	0.11	0.07	0.06	1	0	0.09
Color reconnection	n/e	n/e	0.13	0.54	0.15	1	1	0.45
Trigger	n/a	n/a	n/a	n/a	0.24	1	1	0.07
Total Systematic Uncertainty	4.52	2.63	1.41	1.03	1.25			0.91
Total Uncertainty	6.45	3.37	1.46	1.07	1.43			0.99
Combination weight	-0.023	-0.109	0.124	0.733	0.275			

The table lists individual uncertainty sources categories for each of the input measurements used in the combination. The categories are in agreement with the ones used in previous Tevatron and LHC combinations.
The correlation coefficients, the uncertainty values on the combined result, and the combination weights are also shown.

Next steps

Several other measurements would have to be included in the combination, and thus, careful choices on the correlations coefficients are needed.
The study of end-points of several $t\bar{t}$ system kinematics variables, allows to extract simultaneously the top quark, W boson, and neutrino masses. This method has been tested in this particular frame, but will be useful in case of new physics studies in the future.



Top quark mass determination using end-point method[6]

The 2011 l+jets precise determination, along with the large amount of recorded data, has been used to study the top quark mass dependency with respect to event kinematics[7]:

- ❖ First top quark mass measurement binned in event kinematic variables
  - ✓ All dependencies are well understood
- ❖ Additional validation of various Monte-Carlo tunes
  - ✓ No mis-modelling effects due CR, ISR/FSR, b-quark kinematics or mass definition observed

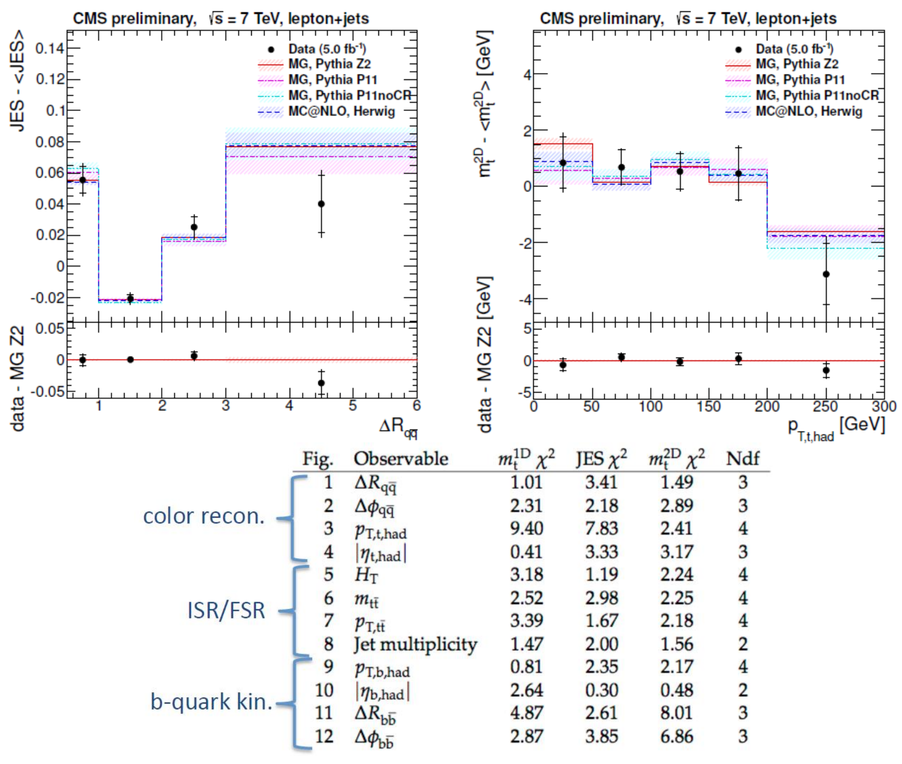


	Fig.	Observable	m_t^{1D} χ^2	JES χ^2	m_t^{2D} χ^2	Ndf
color recon.	1	$\Delta R_{q\bar{q}}$	1.01	3.41	1.49	3
	2	$\Delta\phi_{q\bar{q}}$	2.31	2.18	2.89	3
	3	$p_{T,t,had}$	9.40	7.83	2.41	4
	4	$\lvert\eta_{t,had}\rvert$	0.41	3.33	3.17	3
ISR/FSR	5	H_T	3.18	1.19	2.24	4
	6	$m_{t\bar{t}}$	2.52	2.98	2.25	4
	7	$p_{T,t\bar{t}}$	3.39	1.67	2.18	4
	8	Jet multiplicity	1.47	2.00	1.56	2
b-quark kin.	9	$p_{T,b,had}$	0.81	2.35	2.17	4
	10	$\lvert\eta_{b,had}\rvert$	2.64	0.30	0.48	2
	11	$\Delta R_{b\bar{b}}$	4.87	2.61	8.01	3
	12	$\Delta\phi_{b\bar{b}}$	2.87	3.85	6.86	3

Level of agreement between data and different simulation models
Global χ2/ndf = 0.9 obtained based on independent m_t^{1D} and JES, thus neglecting correlations between observables

References:
1. CMS-PAS-TOP-11-018
2. J. High Energy Phys. 12 (2012) 105
3. Eur. Phys. J. C 72 (2012) 2202
4. CMS-PAS-TOP-11-017
5. Nucl. Instrum. Meth. A270 (1988) 110
6. CMS-PAS-TOP-11-027
7. CMS-PAS-TOP-12-029