~~World combination of~~

m_{top}

combinations from around the world

Pedro Ferreira da Silva (CERN/LIP)

on behalf of the ATLAS, CMS, CDF and D0 collaboration

Top 2013

6th International Workshop on Top Quark Physics

Outline

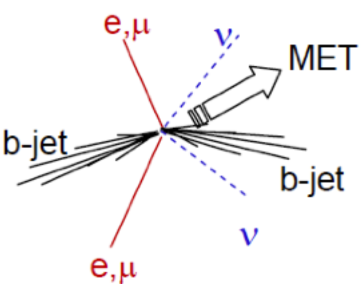
Main **uncertainties** affecting the experimental measurement of m_{top}.

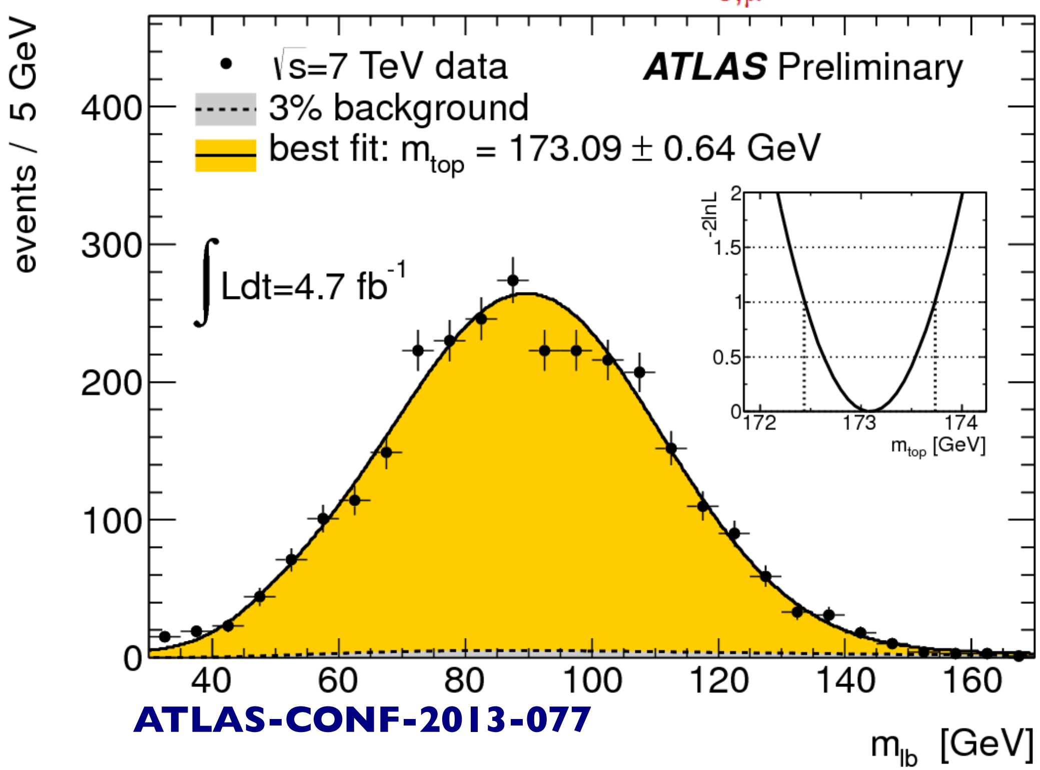
Correlations between uncertainties.

Combination **results**.

Building up a m_{top} measurement

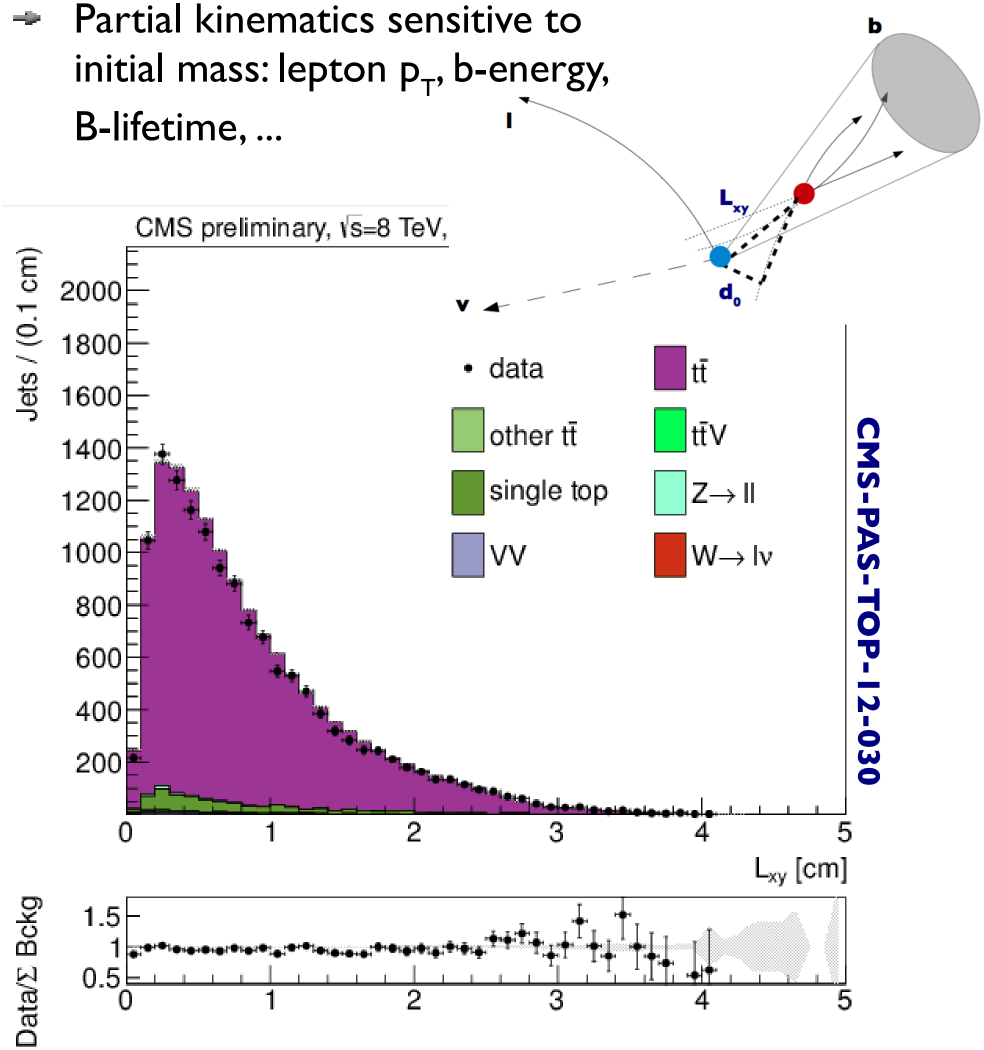
- **m_{top} is usually measured from the invariant mass of decay products**
  - Reconstructed 3-body mass, lepton-jet invariant mass, lepton-J/ψ mass, MT2, ...
  - Combinatorics can all be taken into account: matrix-element weighting, ideogram technique, kinematical fitter…





ATLAS-CONF-2013-077

- **Decay product kinematics convey, as well, information on m_{top}**
  - Full kinematics may be used to to construct event probability based on matrix elements
  - Partial kinematics sensitive to initial mass: lepton p_T, b-energy, B-lifetime, ...



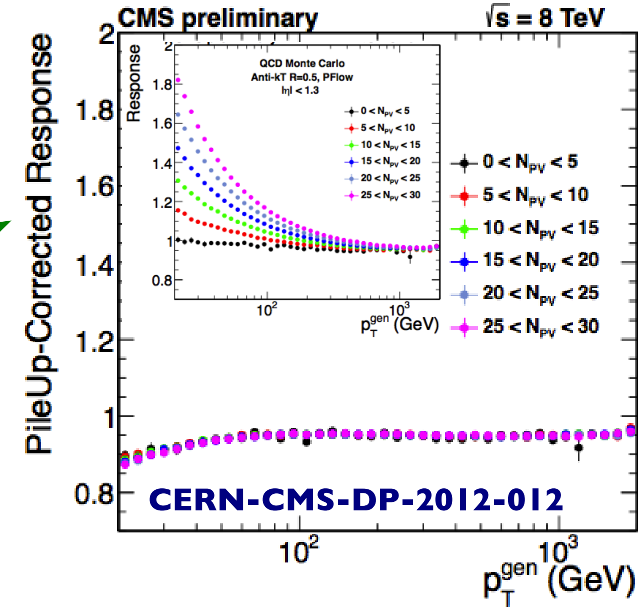
CMS-PAS-TOP-12-030

Main uncertainties: JES (I)

- **Jet energy scale** is amongst the leading systematic uncertainties

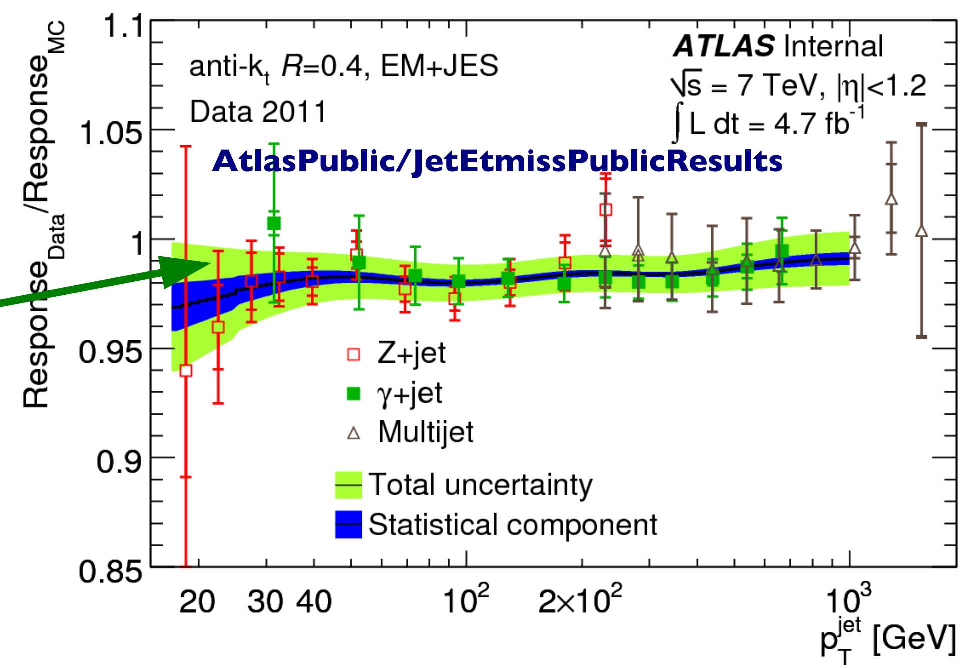
dJES

uncorr	in-situ γ/Z	intercalib



- ***Detector specific uncertainties***
  - statistics in calibration sample, pile-up suppression (ATLAS, CMS)
  - nearby jet (ATLAS), calorimeter stability (CMS)
  - Offset (UN/MI) for uranium noise in calorimeter and multiple interactions in D0
  - MI model – model used for multiple interactions in Tevatron experiments

separate in TEV combination



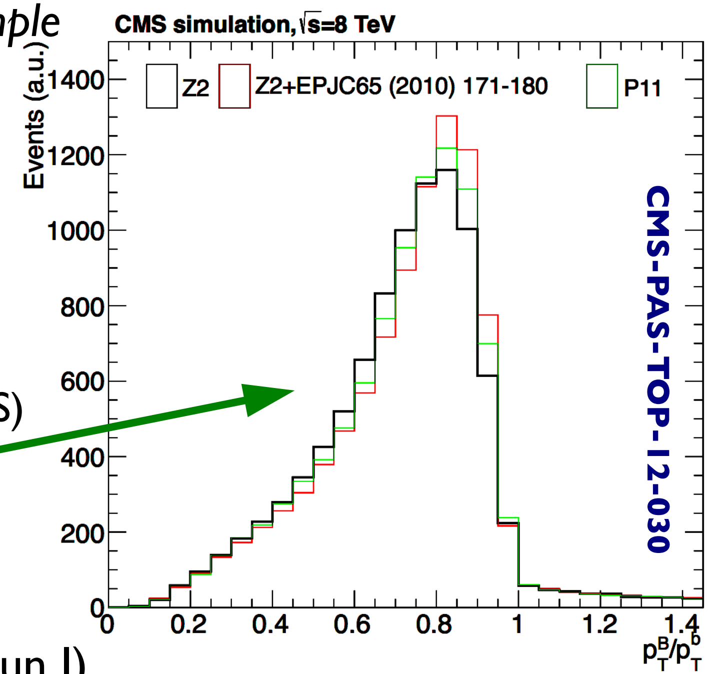
- ***Residual calibration*** derived from γ/Z+jet
- **p_T, η inter-calibration**, including modeling of extra radiation and extrapolation to 0

Main uncertainties: JES (II)

- **Jet energy scale** is amongst the leading systematic uncertainties

dJES			aJES	bJES	cJES	rJES
uncorr	in-situ γ/Z	intercalib	flavour	b-specific	out-of-cone	remainder

- ***Difference in flavor response*** *with respect to calibration sample*
  - Quarks versus gluons, QCD multijets flavour mixture
- ***Separate uncertainties in b-jet modeling***
  - Fragmentation, hadronization, soft radiation in UE model (ATLAS)
  - Full difference in flavor response between quarks and gluons (CMS)
  - Semi-leptonic branching ratio variations, fragmentation, color flow between *b* and *light* jets (CDF, D0)



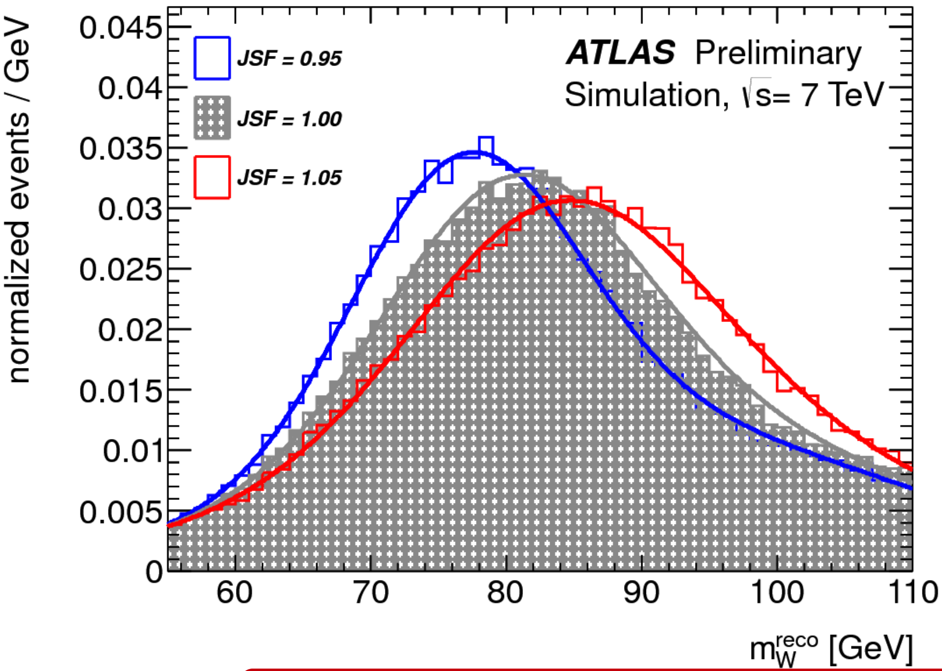
- ***Modeling of out-of-cone corrections from MC*** (TEV Run I)
- ***Remainders*** of absolute calibration, MPI and UE corrections (CDF)

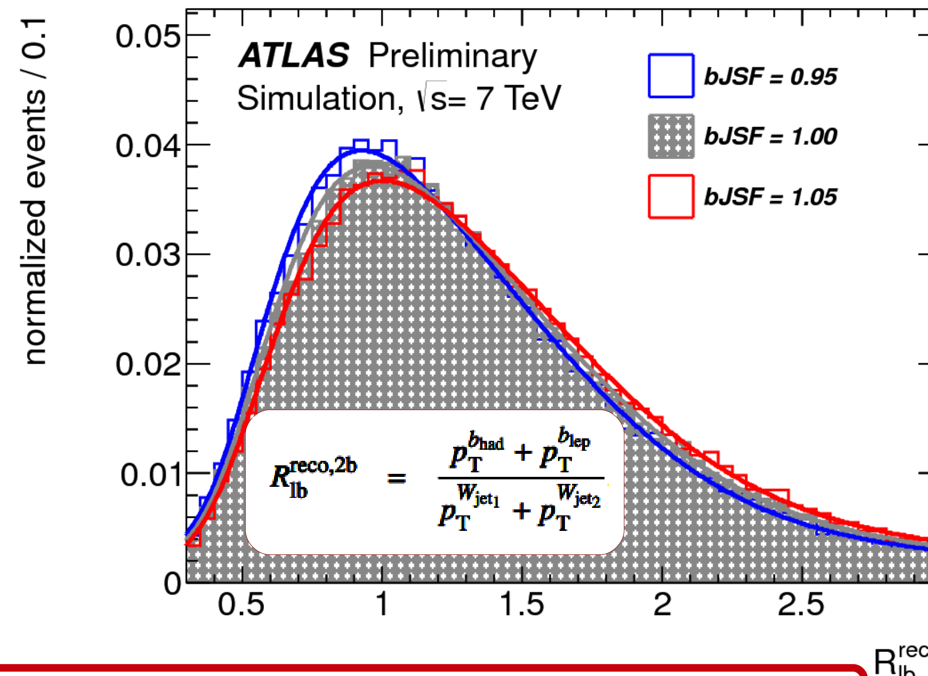
Main uncertainties: JES (III)

- **Jet energy scale** is amongst the leading systematic uncertainties

dJES			aJES	bJES	cJES	rJES	+	iJES
uncorr	in-situ γ/Z	intercalib	flavour	b-specific	out-of-cone	remainder		in-situ

- ***Calibrating in-situ light + b-jet energy scales strengthens individual measurement***
- Use final state topology to constraint partially global JES in the measurement
  - W → qq' used to constraint light jet energy scale
  - relative b-to-light jet energy scale factor from ratio R_{lb}





ATLAS-CONF-2013-046

iJES has a statistical nature: may expect it to be reduced with more data

Main uncertainties: signal model

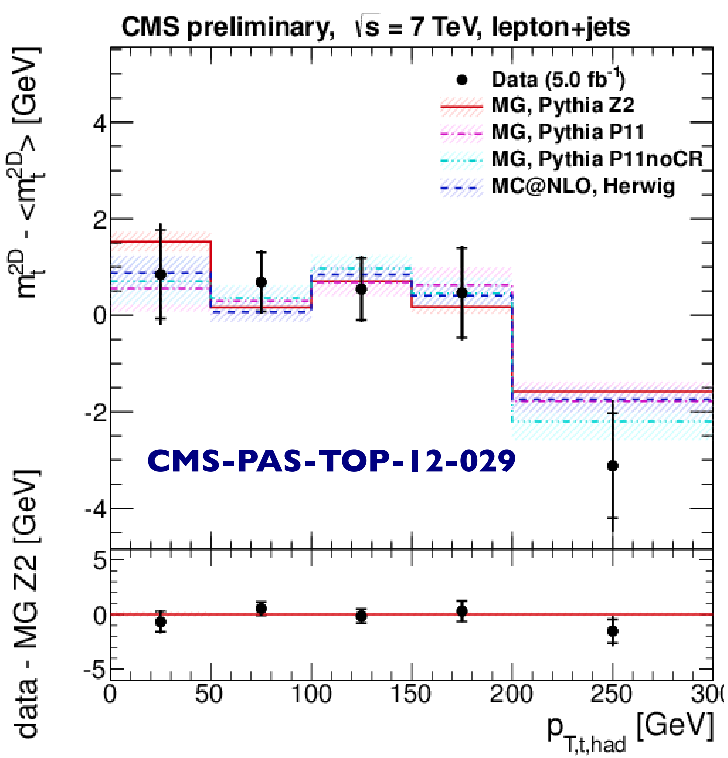
- **Signal modeling is crucial for most methods and may include**

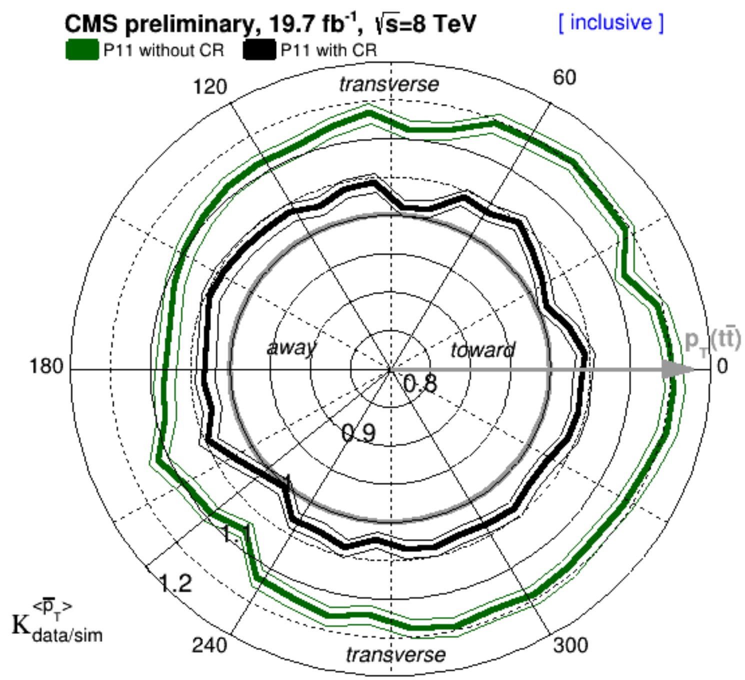
  - **top pair kinematics description** compare diff. generators, qq/gg fractions
  - interplay with the underlying event: **color reconnection**, UE tune, ISR/FSR model, PDFs
  - tt-specific **hadronization model** uncertainties (ATLAS)

Main uncertainties: signal model

- **Signal modeling is crucial for most methods and may include**

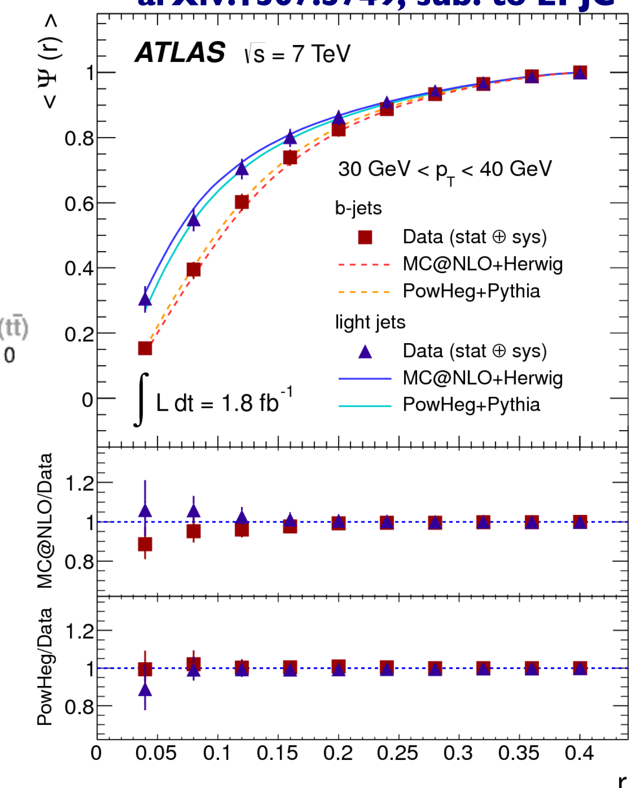
  - **top pair kinematics description** compare diff. generators, qq/gg fractions
  - interplay with the underlying event: **color reconnection**, UE tune, ISR/FSR model, PDFs
  - tt-specific **hadronization model** uncertainties (ATLAS)





CMS-PAS-TOP-13-007

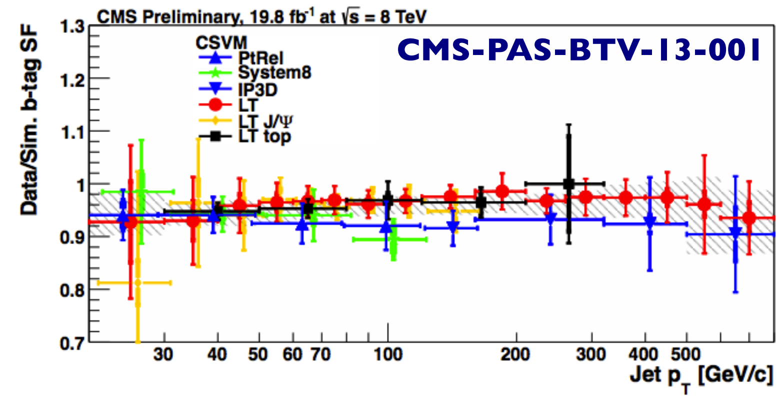
arXiv:1307.5749, sub. to EPJC



Large statistics samples can be used to start constraining some uncertainties

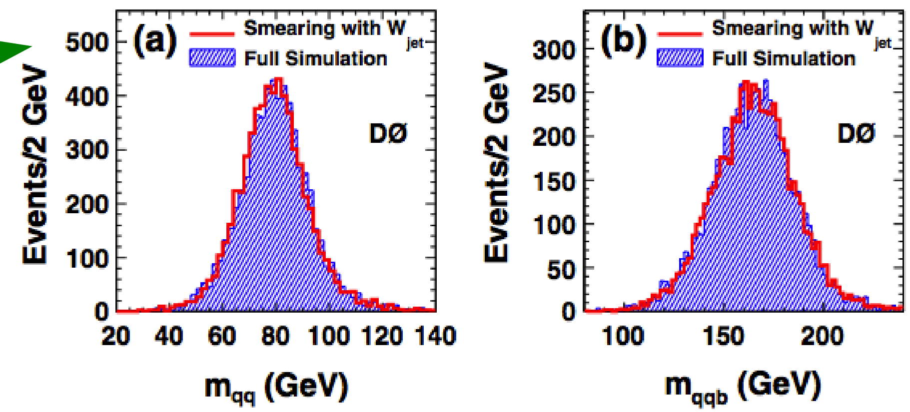
Other uncertainties

- **b-tag systematic uncertainty** may depend on
  - specificity of the method, e.g. 3D-fit exhibits a large sensitivity
  - purity required in selection



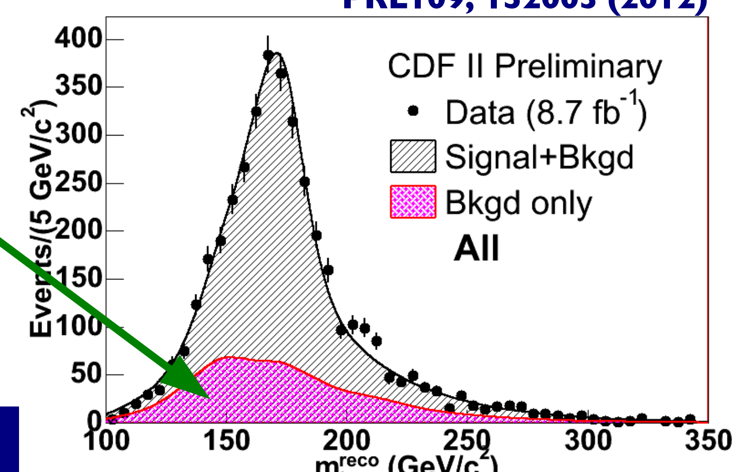
- **Detector modeling systematics may comprise**
  - Lepton energy scale and resolution
  - jet resolution (relevant for ME-based measurements)
  - Missing transverse energy (E_T^{miss})
  - jet reconstruction

PRD 84, 032004 (2011)



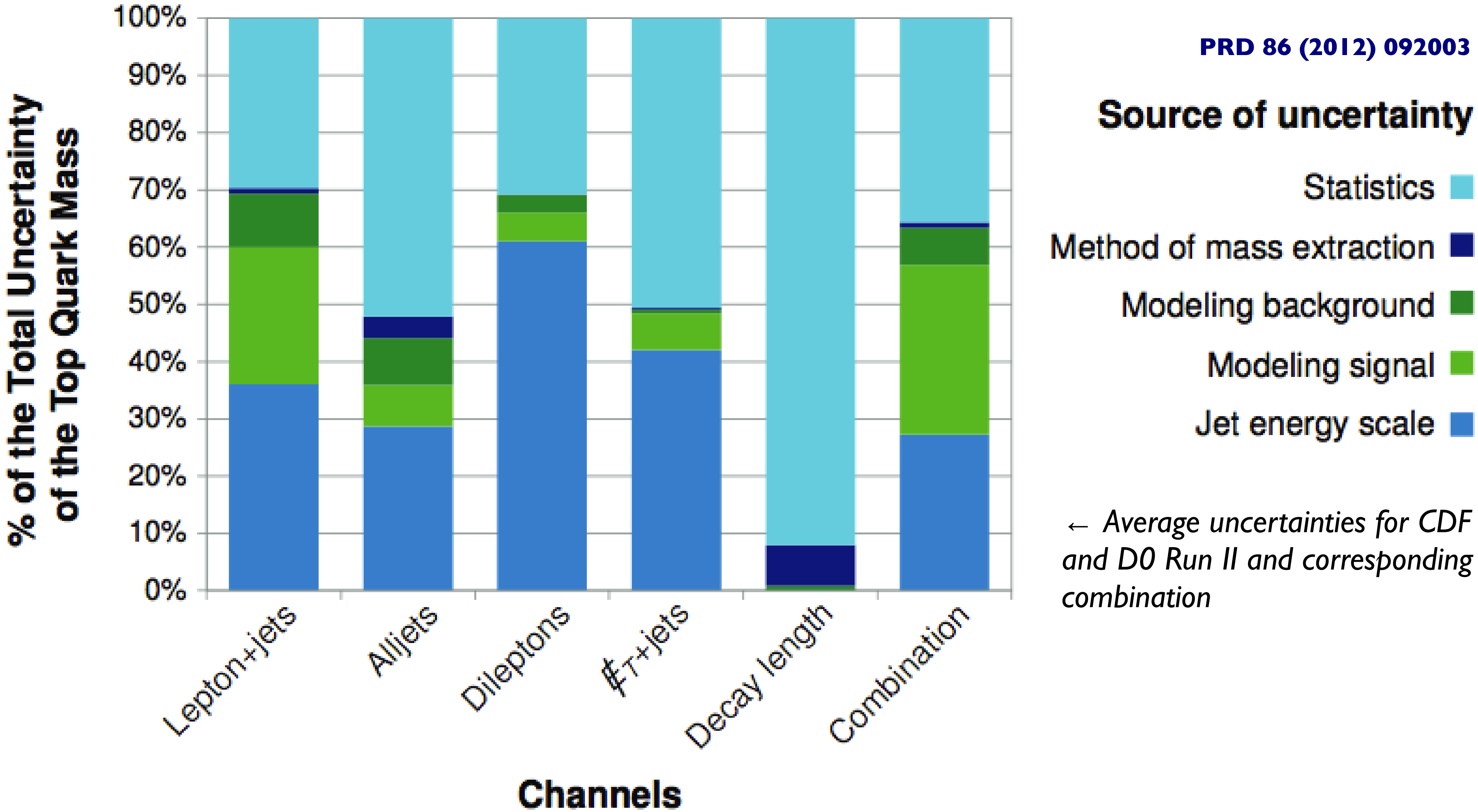
- **Background and analysis method systematic terms**
  - Dilepton channels less affected by background
  - Heavy flavor + fact./ren. scales in describing W+jets background
  - Pileup contamination (MHI) is particularly relevant at the LHC
  - Most methods rely as well on a specific calibration procedure

PRL109, 152003 (2012)



Making best use of individual measurements

- **No single measurement holds the ultimate precision → combine results**



PRD 86 (2012) 092003

← *Average uncertainties for CDF and D0 Run II and corresponding combination*

Inputs for the combination(s)

ATLAS

- Dileptons ATLAS-CONF-2013-077

  $173.09 \pm 0.64_{stat} \pm 1.50_{syst}$ GeV

- Lepton+jets ATLAS-CONF-2013-046

  $172.31 \pm 0.23_{stat} \pm 1.53_{syst}$ GeV

CMS

- Dileptons EPJC 72 (2012) 2202

  $172.50 \pm 0.43_{stat} \pm 1.46_{syst}$ GeV

- Lepton+jets JHEP 12 (2012) 105

  $173.49 \pm 0.27_{stat} \pm 1.03_{syst}$ GeV

- All jets arXiv:1307.4617, *sub. to EPJC*

  $173.49 \pm 0.69_{stat} \pm 1.30_{syst}$ GeV

Only quoting results used in grand combinations

CDF

- Dileptons
  - Run I PRL 82 , 271 (1999): $167.4 \pm 10.3_{stat} \pm 4.9_{syst}$
  - Run II PRD 83 , 111101 (2011): $170.28 \pm 1.95_{stat} \pm 3.09_{syst}$
- Lepton+jets
  - Run I PRD 63, 032003 (2001): $176.1 \pm 5.1_{stat} \pm 5.3_{syst}$
  - Run II PRL 109 152003: $172.85 \pm 0.52_{stat} \pm 0.98_{syst}$
- All jets
  - Run I PRL 79, 1992–1997 (1997): $186.0 \pm 10.0_{stat} \pm 5.7_{syst}$
  - Run II PLB 714, 24 (2012): $172.47 \pm 1.43_{stat} \pm 1.49_{syst}$
- Lxy
  - Run II PRD 81, 032002 (2010): $166.90 \pm 9.0_{stat} \pm 2.90_{syst}$
- MEt
  - Run II PRD 88, 011101(R) (2013): $173.95 \pm 1.26_{stat} \pm 1.35_{syst}$

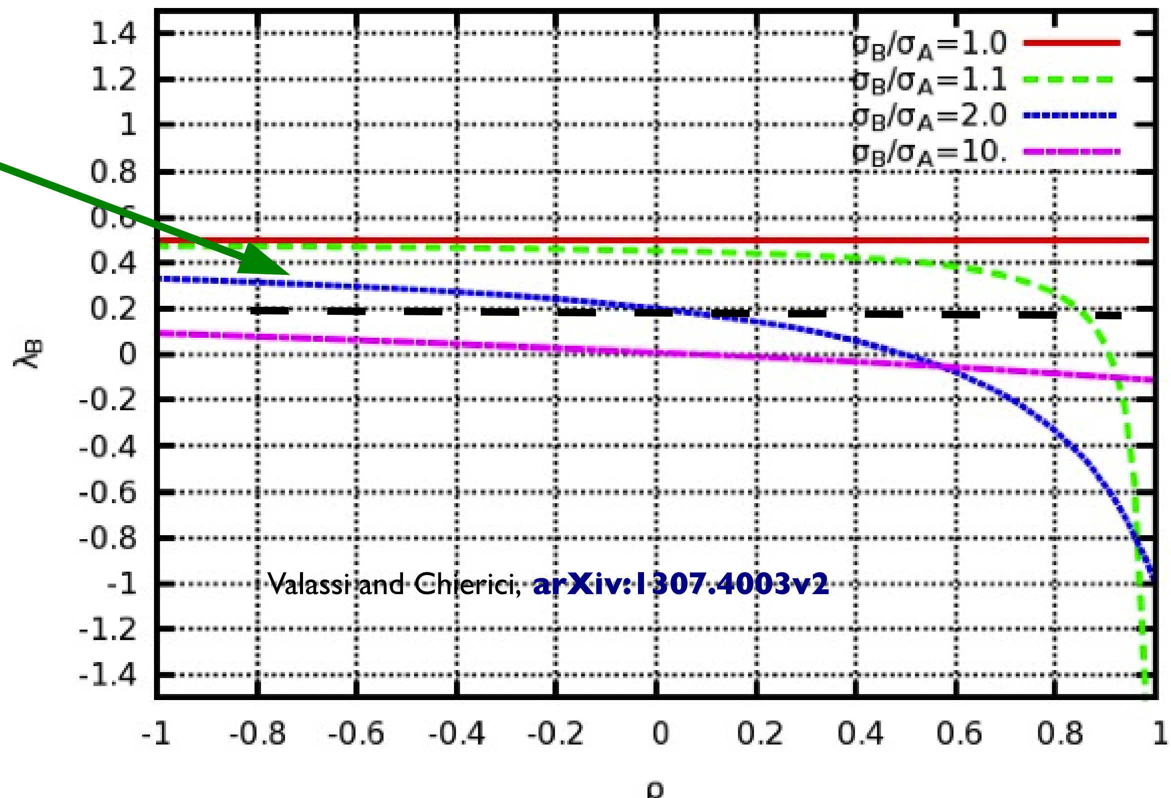
D0

- Dileptons
  - Run I PRD 60 , 052001: $168.4 \pm 12.3_{stat} \pm 3.6_{syst}$
  - Run II PRD 86 , 051103 (2012): $174.00 \pm 2.36_{stat} \pm 1.44_{syst}$
- Lepton+jets
  - Run I Nature 429 , 638 (2004): $180.1 \pm 3.6_{stat} \pm 3.9_{syst}$
  - Run II PRD 84, 032004 (2011): $174.94 \pm 0.83_{stat} \pm 1.24_{syst}$

Combination method

- **Best linear unbiased method** (BLUE) NIM A270 (1988) 110, NIM A500 (2003) 391
  - Linear combination of input measurements (y_i) : $\hat{Y} = \sum_{i=1}^{n} \lambda_i y_i$
  - Set of coefficients (weights) minimizes final uncertainty (optimal): $\lambda_i = \frac{(\mathcal{M}^{-1}\mathbf{U})_i}{\tilde{\mathbf{U}}\mathcal{M}^{-1}\mathbf{U}}$
  - Individual uncertainties and correlations are into account for the final uncertainty: $\sigma_{\hat{Y}}^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} \lambda_i \mathcal{M}_{ij} \lambda_j$

- **Correlations** are the key to the "success" of the combination
  - For correlated measurements may yield negative weights for less precise measurements
  - Sometimes based on a guess estimate: evaluate hypothesis dependency (next slides)
  - Alternatively minimize on Fisher information varying the correlation factors (globally, by source or for off-diagonal elements)

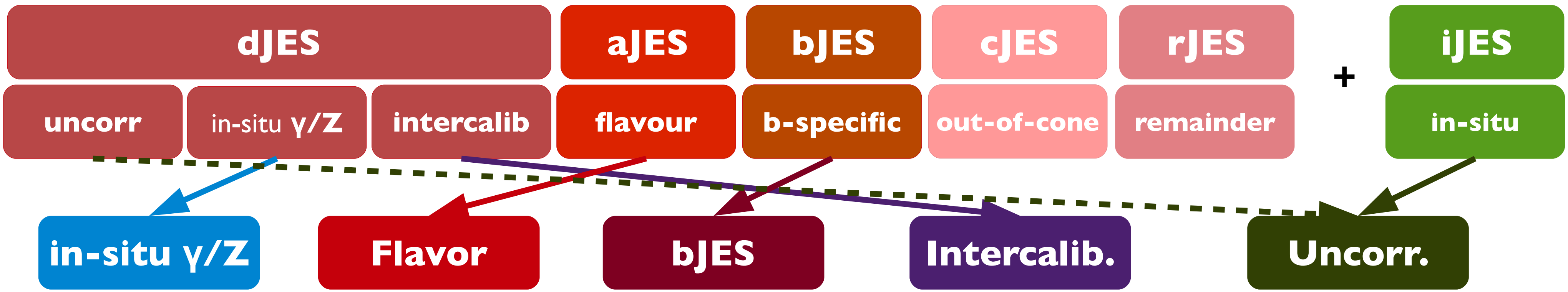


Correlations between systematic uncertainties

Not all the systematics can be matched exactly 1:1.
TeVEWWG: years of discussion between CDF and D0 lead to well established list of systematics.
TOPLHCWG: second round of combination, harmonization between ATLAS and CMS in good progress, some systematics handled differently.

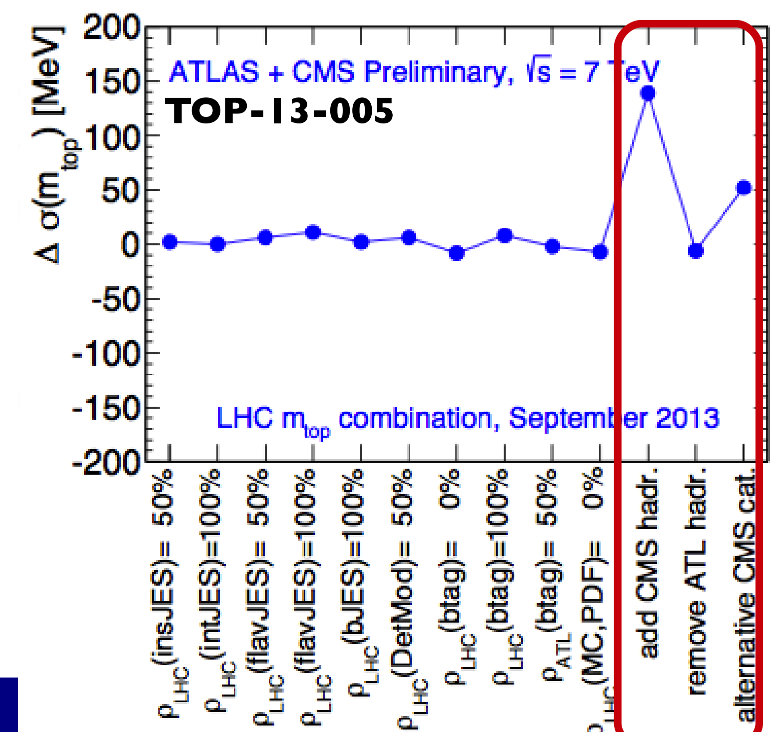
Most relevant correlations: JES

- **Correlation of JES between ATLAS and CMS is split into four groups:**



in-situ γ/Z	Flavor	bJES	Intercalib.	Uncorr.
$\rho_{exp}=1$, $\boldsymbol{\rho_{LHC}=0}$	$\rho_{exp}=1$, $\boldsymbol{\rho_{LHC}=0}$	$\rho_{exp}=1$, $\boldsymbol{\rho_{LHC}=0.5}$	$\rho_{exp}=1$, $\boldsymbol{\rho_{LHC}=0.5}$	$\rho_{exp}=0$ or 1, $\boldsymbol{\rho_{LHC}=0}$
vary 0 → 0.5	vary 0 → 1	vary 0.5 → 1.0	vary 0.5 → 1	

- Robust combination with respect to most variations ►
- **Three additional cross-checks:**
  - add ttbar-specific hadronization uncertainty in CMS measurements comparing Powheg Pythia vs Herwig
  - remove ATLAS tt-specific hadronization
  - re-categorize CMS bJES uncertainty varying b-fragmentation, semi-leptonic BR, hadronization model



Other correlations

- **Signal:** assume ρ_{LHC}=1, even if assessment is different between experiments
  - **Monte Carlo setup**

    ATLAS NLO level+shower model comparison Powheg vs MC@NLO + Pythia vs Herwig

    CMS Born level Madgraph to NLO Powheg comparison
  - **Radiation modeling systematics**

    ATLAS ISR/FSR variations in Pythia constrained by data

    CMS consistent within same Madgraph+Pythia6 setup: ME-PS and $Q=\mu_R=\mu_F$ variations by ½ and 2

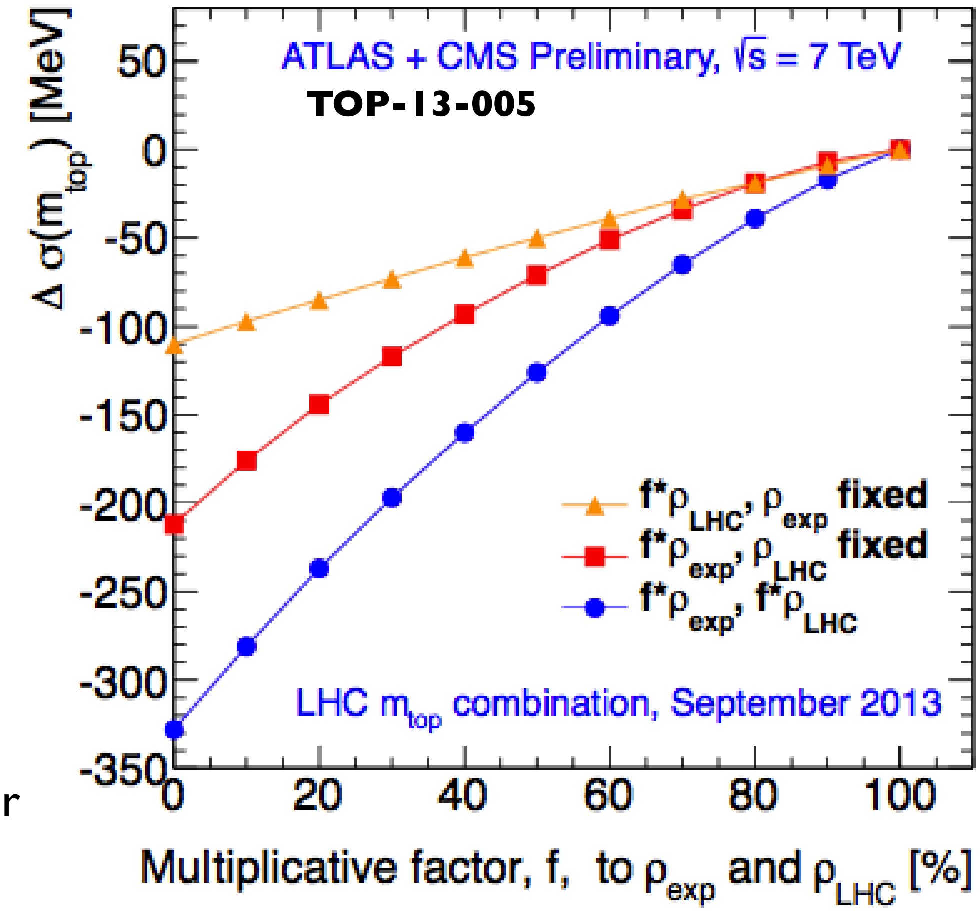
- **Background modeling from MC and analysis method systematic terms**
  - assumed to be uncorrelated between the experiments

- **Underlying event, pileup (MHI), PDFs**
  - assumed to be fully correlated between the experiments
  - For Tevatron MHI modeling is uncorrelated between CDF and D0

Stability checks

- **Can be made a posteriori on the assumed correlations. Some examples:**

- Rescale correlations in the LHC measurements
  - experiment-independent and LHC correlations treated independently or commonly
  - **ideal scenario gains extra 328 MeV in final uncertainty** from fully independent methods and experiments
  - main gains expected to come from fully uncorrelated single measurements



- Possible **residual correlation between detector modeling** at the LHC leads to $\Delta\sigma$=6 MeV when increased to 0.5

- Sources of measurements used for **b-tagging** efficiency (μ+jets and tt) may uncorrelate further this uncertainty: lead to a maximum $\Delta\sigma$=8 MeV

- **Combination method:** minimize on Fisher information instead of uncertainty yields similar final uncertainty (using method proposed in arXiv:1307.4003v2)

Results

The individual measurements are used taking into account the correlation hypothesis.
Tevatron, ATLAS, CMS and LHC combinations.

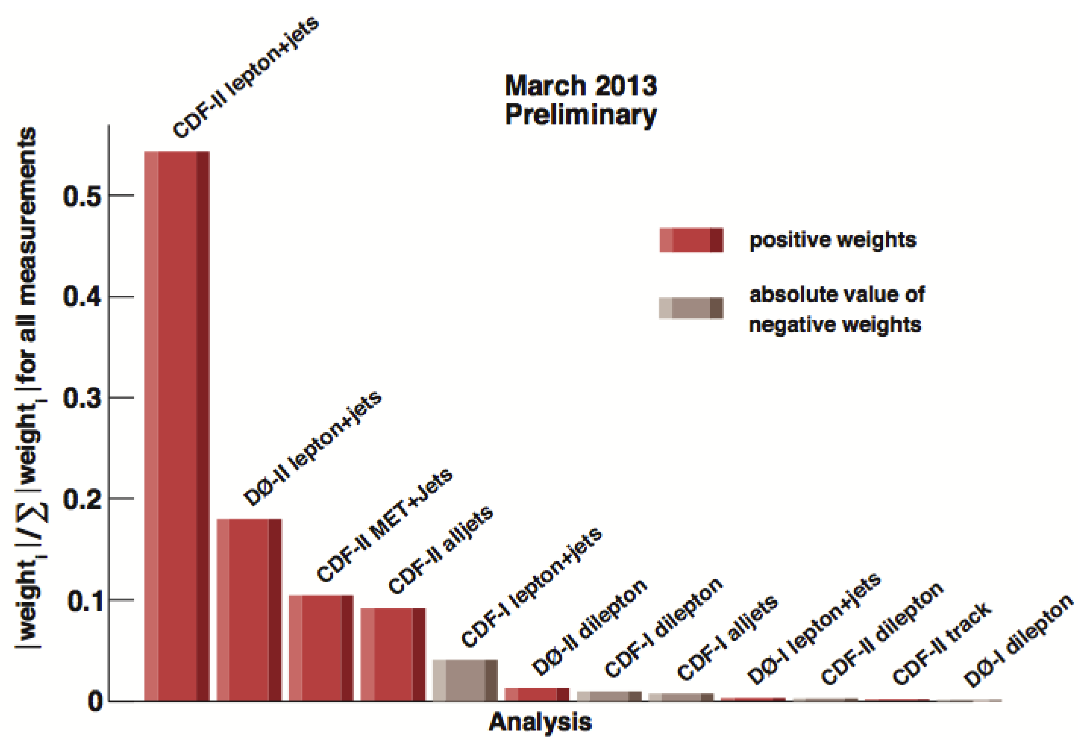
Results: Tevatron

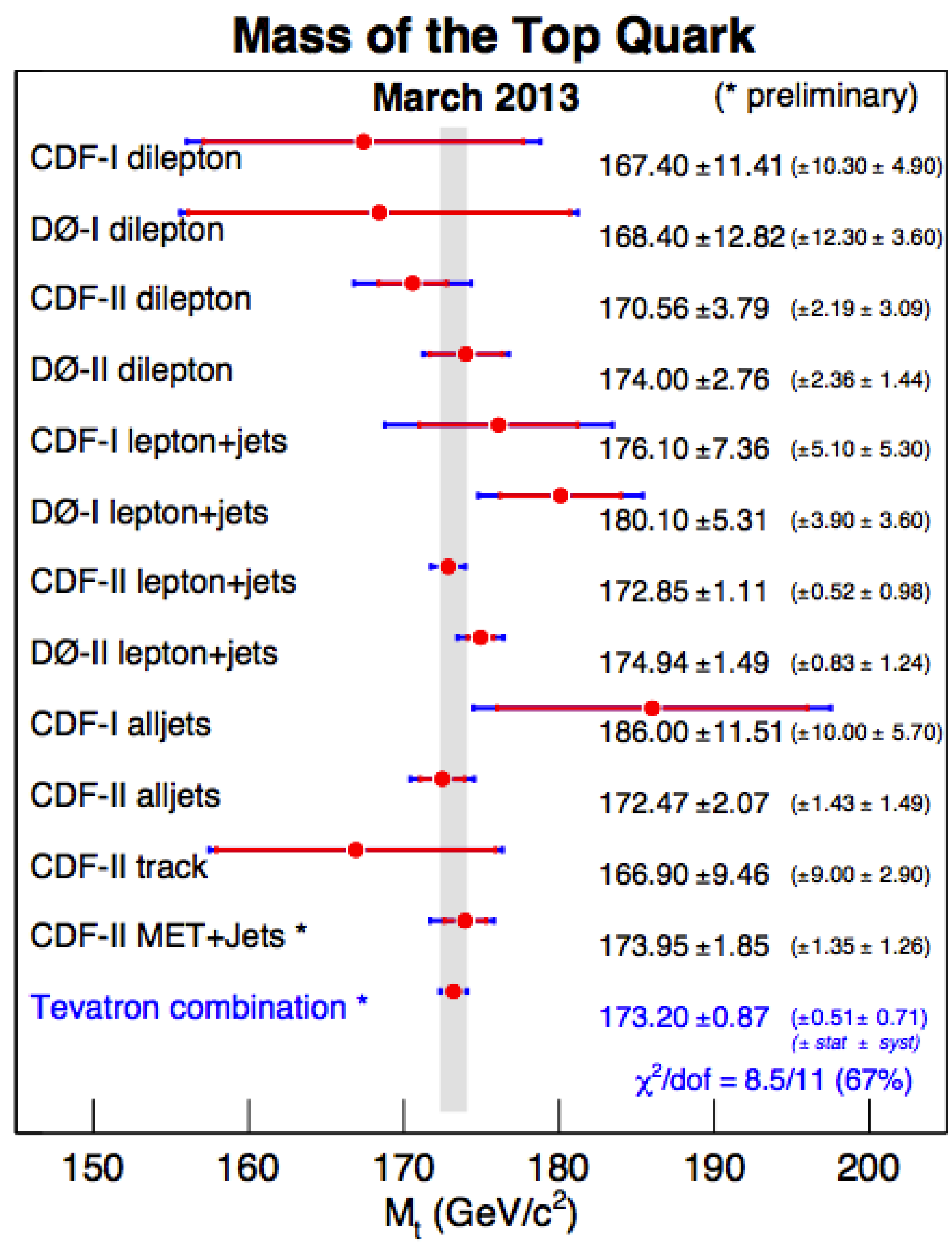
- Measured with 0.5% precision

$$M_t = 173.20 \pm 0.51\,(\mathrm{stat}) \pm 0.71\,(\mathrm{syst})\ \mathrm{GeV}$$

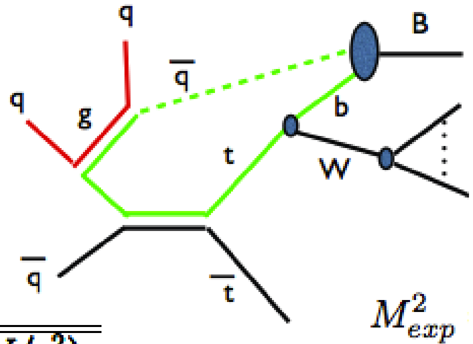
χ^2 /ndf=8.5/11 corresponds to 67% probability

Individual pulls within 1.5σ





- **Combination uncertainty is dominated by:**
  - JES components (iJES, dJES, rJES)
  - signal model (CR) ▶



	Tevatron combined values (GeV/c^2)
M_t	173.20
In situ light-jet calibration (iJES)	0.36
Response to $b/q/g$ jets (aJES)	0.09
Model for b jets (bJES)	0.11
Out-of-cone correction (cJES)	0.01
Light-jet response (2) (dJES)	0.15
Light-jet response (1) (rJES)	0.16
Lepton modeling (LepPt)	0.05
Signal modeling (Signal)	0.52
Jet modeling (DetMod)	0.08
Offset (UN/MI)	0.00
Background from theory (BGMC)	0.06
Background based on data (BGData)	0.13
Calibration method (Method)	0.06
Multiple interactions model (MHI)	0.07
Systematic uncertainty (syst)	0.71
Statistical uncertainty (stat)	0.51
Total uncertainty	0.87

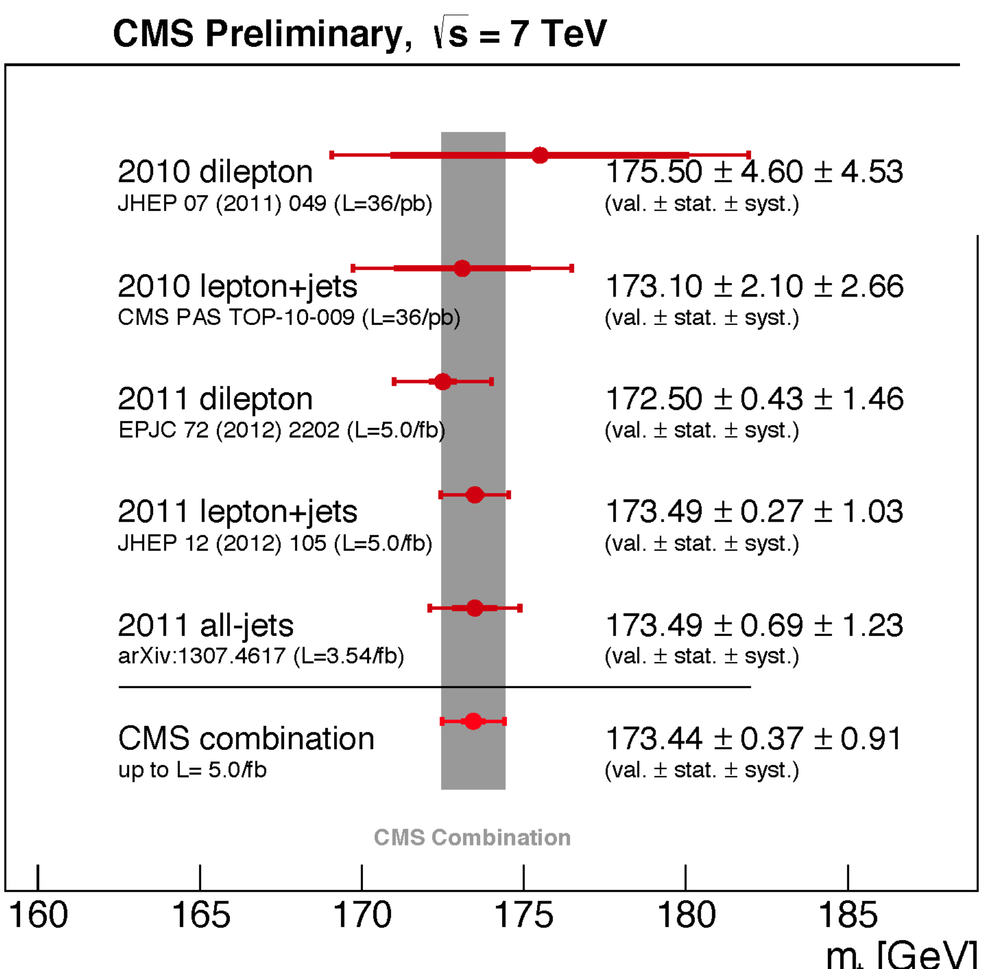
Results: ATLAS and CMS

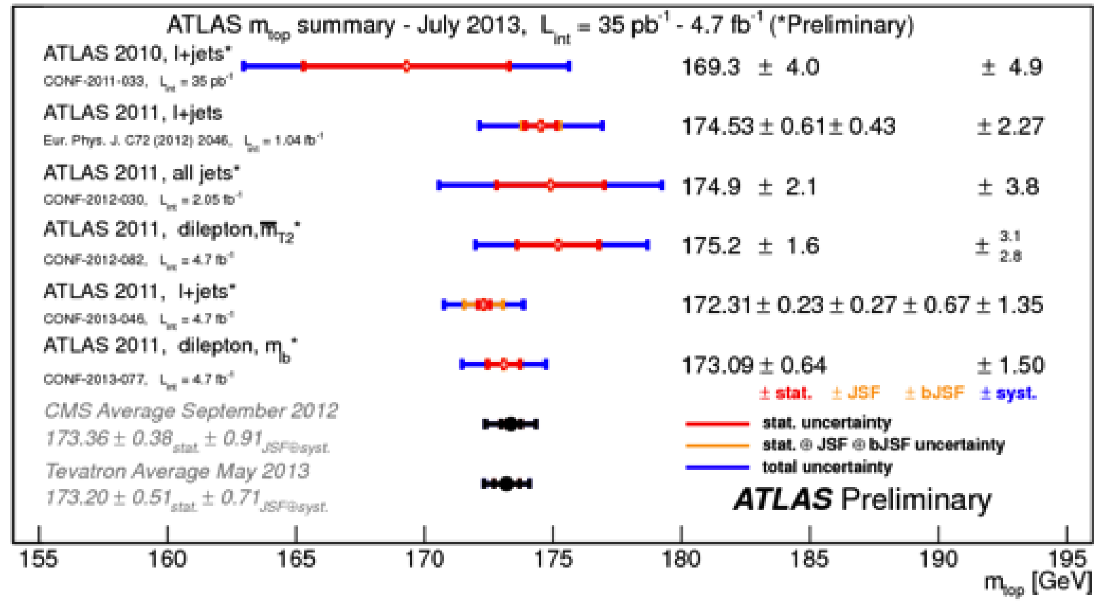
TOP-13-002, TOP-13-005

- **ATLAS** measures m_{top} with 0.83% uncertainty

$$\boxed{m_{\text{top}} = 172.65 \pm 0.31_{\text{stat}} \pm 1.40_{\text{syst}}}$$

cf. TOP-13-005





- **CMS** measures m_{top} with 0.56% uncertainty

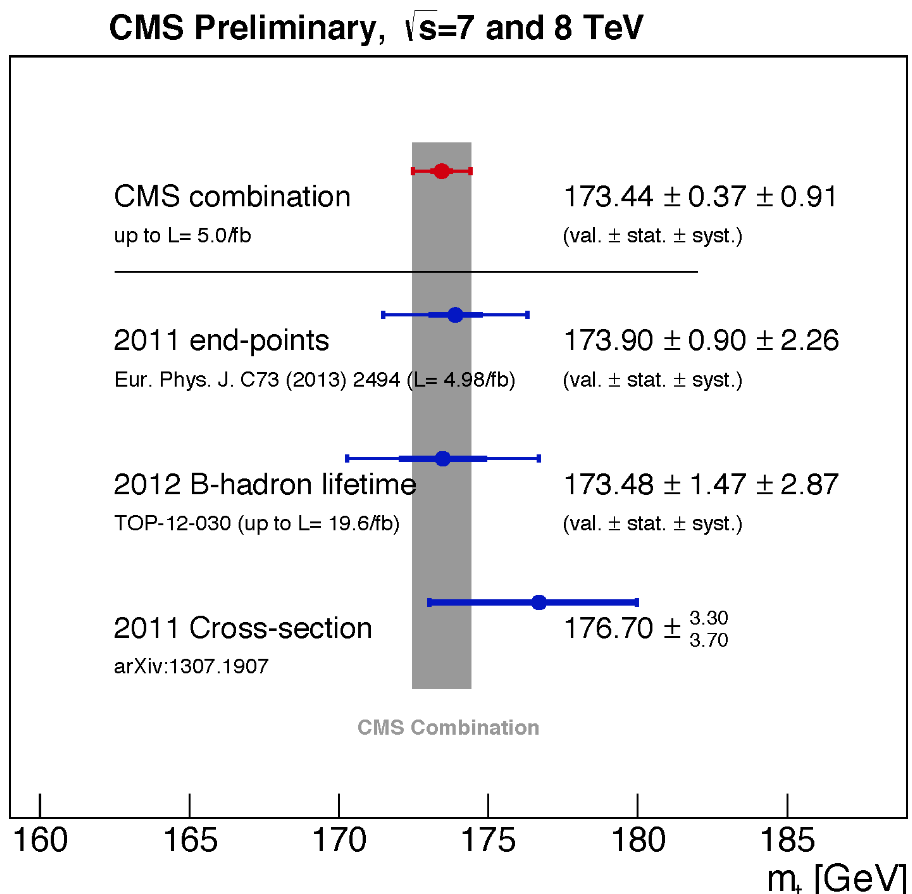
$$\boxed{m_{\text{top}} = 173.44 \pm 0.37_{\text{stat}} \pm 0.91_{\text{syst}}}$$

χ^2/ndf=1.4/4 corresponds to 85% probability

- Combination is dominated by the l+jets (76.5%) and all jets (31.5%) measurements

- **Pole mass from cross section**
  - theoretically well defined quantity
  - Expected to differ by ~1 GeV from other measurements
  - Can't be combined with MC-based top mass definitions used in "classic" measurements
- **Lepton-jet endpoints analysis**
  - although no iJES performed, JES is distinct from other measurements
  - no calibration from simulation
- **B-hadron lifetime**
  - Virtually no JES systematic but hadronization, fragmentation mapped to bJES
  - Depending on theory model for $p_T(t)$

for more details on alternative methods see talk by F. Deliot



$$m_t = 173.49 \pm 0.36\,(\text{stat.}) \pm 0.91\,(\text{syst.})\,\text{GeV}$$

χ^2/ndf=1.6/6 corresponds to 95% probability

With improved precision endpoints and B-hadron lifetime are expected to play crucial role

Results: LHC

TOP-13-005

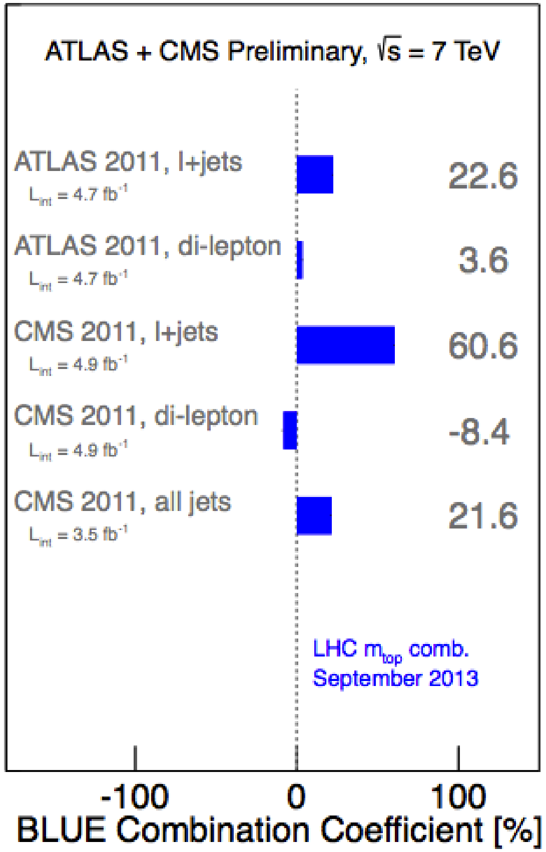
- Measured with 0.55% uncertainty

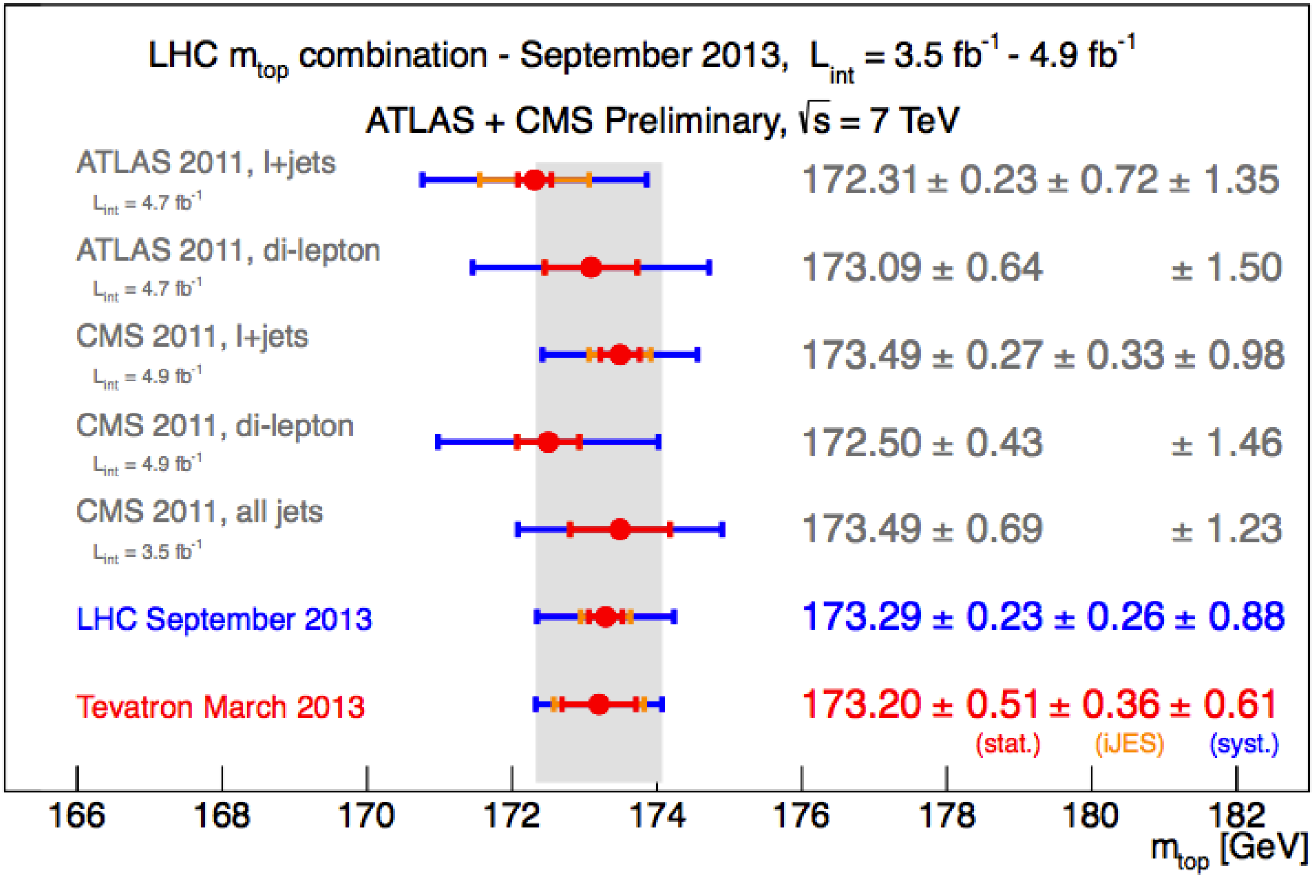
  χ^2 /ndf=1.8/4 corresponds to 77% probability

  $m_{top} = 173.29 \pm 0.23\,(\text{stat}) \pm 0.92\,(\text{syst})\ \text{GeV}$

  Individual pulls within 1σ

  In excellent agreement with the Tevatron combination





Results: uncertainties @ LHC

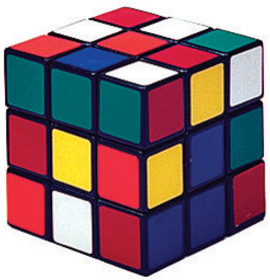
TOP-13-005

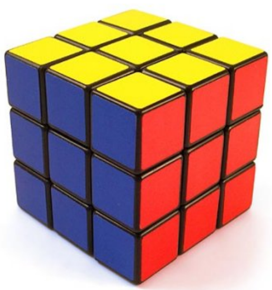
- **Combination uncertainty is dominated by similar sources to the Tevatron**
  - several JES components (iJES, uncorr, bJES)
  - signal model (CR, radiation)
  - b-tagging

	ATLAS comb.	CMS comb.	LHC comb.
Measured m_{top}	172.65	173.59	173.29
iJES	0.41	0.27	0.26
uncorrelated JES comp.	0.66	0.32	0.29
in-situ JES comp.	0.30	0.08	0.10
intercalib. JES comp.	0.28	0.02	0.07
flavour JES comp.	0.21	0.19	0.16
b-jet energy scale	0.35	0.56	0.43
Monte Carlo simulation	0.40	0.06	0.14
Radiation modelling	0.42	0.28	0.32
Colour reconnection	0.31	0.48	0.43
Underlying event	0.25	0.17	0.17
Proton PDF	0.15	0.07	0.09
Detector modelling	0.22	0.25	0.20
b-tagging	0.66	0.11	0.25
Lepton reconstruction	0.07	0.00	0.01
Background from MC	0.06	0.10	0.08
Background from Data	0.06	0.03	0.04
Method	0.08	0.07	0.06
Multiple Hadronic Interactions	0.02	0.06	0.05
Statistics	0.31	0.29	0.23
Systematics	1.40	0.99	0.92
Total Uncertainty	1.43	1.03	0.95

Conclusions

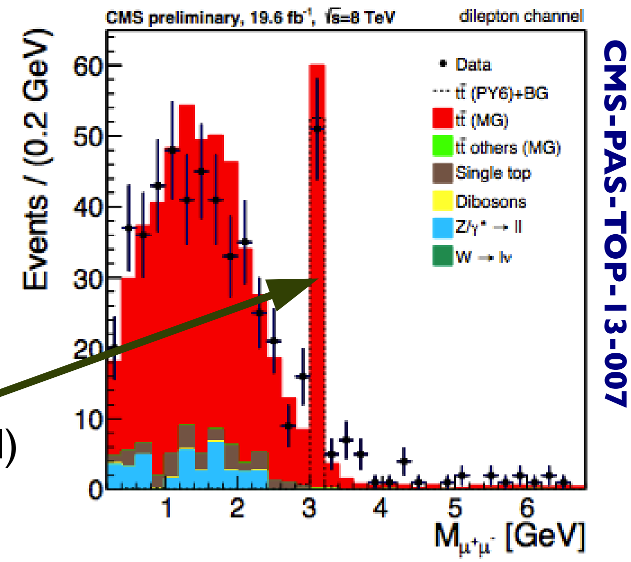
Achieving a final experimental number on m_{top} is not as simple as solving Rubik's cube...





Conclusions

- **Overview of the main uncertainties affecting experimental m_{top} measurements**
  - JES partially constrained in situ for both light jets (both TEV and LHC) and b jets (ATLAS)
  - Colour reconnection, UE and ISR/FSR start to be constrained from data @ the LHC
  - Other uncertainties are smaller and closer to "Λ_{QCD}-limit" at Hadron Colliders



- **Combination of different, outstanding, measurements**
  - Common procedure adopted by both TEV and LHC
  - Harmonization of uncertainties closer worldwide combination needs
  - b-fragmentation/hadronization need further discussion
  - expect to gain in the future with alternative methods (endpoints, L_{xy}, J/ψ+l)
- **We know experimentally (a) top mass with 0.5% (TEV) – 0.54% (LHC) precision**
  - May expect further reduction from worldwide combination
  - May expect reduction of some of the main uncertainties for next round of measurements from LHC
  - Theoretical input is badly needed on the interpretation of this quantity and its relation with m_t^{pole}

Backup

Combination matrix: Tevatron

	Run I published					Run II published						Run II prel.
	CDF			DØ		CDF				DØ		CDF
	ℓ+jets	$\ell\ell$	alljets	ℓ+jets	$\ell\ell$	ℓ+jets	$\ell\ell$	alljets	Lxy	ℓ+jets	$\ell\ell$	MEt
$\int \mathcal{L}\,dt$	0.1	0.1	0.1	0.1	0.1	8.7	5.6	5.8	1.9	3.6	5.3	8.7
Result	176.1	167.4	186.0	180.1	168.4	172.85	170.28	172.47	166.90	174.94	174.00	173.95
In situ light-jet calibration (iJES)	n/a	n/a	n/a	n/a	n/a	0.49	n/a	0.95	n/a	0.53	0.55	1.05
Response to $b/q/g$ jets (aJES)	n/a	n/a	n/a	0.0	0.0	0.09	0.14	0.03	n/a	0.0	0.40	0.10
Model for b jets (bJES)	0.6	0.8	0.6	0.7	0.7	0.16	0.33	0.15	n/a	0.07	0.20	0.17
Out-of-cone correction (cJES)	2.7	2.6	3.0	2.0	2.0	0.21	2.13	0.24	0.36	n/a	n/a	0.18
Light-jet response (2) (dJES)	0.7	0.6	0.3	2.5	1.1	0.07	0.58	0.04	0.06	0.63	0.56	0.04
Light-jet response (1) (rJES)	3.4	2.7	4.0	n/a	n/a	0.48	2.01	0.38	0.24	n/a	n/a	0.40
Lepton modeling (LepPt)	n/e	n/e	n/e	n/e	n/e	0.03	0.27	n/a	n/a	0.17	0.35	n/a
Signal modeling (Signal)	2.6	2.9	2.0	1.1	1.8	0.61	0.73	0.62	0.90	0.77	0.86	0.64
Jet modeling (DetMod)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.36	0.50	0.0
Offset (UN/MI)	n/a	n/a	n/a	1.3	1.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Background from theory (BGMC)	1.3	0.3	1.7	1.0	1.1	0.12	0.24	0.0	0.80	0.18	0.0	0.0
Background based on data (BGData)	0.0	0.0	0.0	0.0	0.0	0.16	0.14	0.56	0.20	0.23	0.20	0.12
Calibration method (Method)	0.0	0.7	0.6	0.6	1.1	0.00	0.12	0.38	2.50	0.16	0.51	0.31
Multiple interactions model (MHI)	n/e	n/e	n/e	n/e	n/e	0.07	0.23	0.08	0.0	0.05	0.0	0.18
Systematic uncertainty (Syst)	5.3	4.9	5.7	3.9	3.6	0.98	3.09	1.49	2.90	1.24	1.44	1.35
Statistical uncertainty (Stat)	5.1	10.3	10.0	3.6	12.3	0.52	1.95	1.43	9.00	0.83	2.36	1.26
Total uncertainty	7.3	11.4	11.5	5.3	12.8	1.11	3.79	2.06	9.46	1.50	2.76	1.85

Combination matrix : CMS

	di-l 2010	$l+$Jets 2010	di-l 2011	$l+$jets 2011	all-jets 2011	Correlations ρ_{chan}	ρ_{year}	CMS 2013
Measured m_t	175.50	173.10	172.50	173.49	173.49			173.44
iJES: *in-situ* JES factor	n/a	n/a	n/a	0.33	n/a	0	0	0.25
bJES: relative b-jet scale	0.90	0.90	0.76	0.61	0.49	1	1	0.54
dJES1: flavor JES comp.	1.21	0.87	0.58	0.11	0.58	1	1	0.18
dJES2: inter-calib. JES comp.	0.17	0.08	0.08	0.01	0.08	1	1	0.02
dJES3: MPF in-situ JES comp.	0.76	0.16	0.35	0.02	0.35	1	1	0.11
dJES4: uncorrelated JES comp.	1.48	1.90	0.69	0.24	0.69	1	1	0.22
rJES: other JES uncertainties	3.28	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	0.01
MC generator	0.50	n/e	0.04	0.02	0.19			0.07
ISR/FSR	0.20	0.20	n/a	n/a	n/a			0.02
Parton distribution functions	0.50	0.10	0.09	0.07	0.06			0.06
Factorization scale	0.60	1.10	0.55	0.24	0.22			0.16
ME-PS matching threshold	0.70	0.40	0.19	0.18	0.24			0.17
Signal						1	1	
Jet energy resolution	0.50	0.10	0.14	0.23	0.15			0.21
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	0.20	1	1	0.13
Background MC	0.10	0.20	0.05	0.13	n/a	1	1	0.08
Background Data	n/a	0.40	n/a	n/a	0.13	0	0	0.05
Fit calib. and MC stat.	0.20	0.10	0.40	0.06	0.13	0	0	0.06
Pileup	1.00	0.10	0.11	0.07	0.06	1	0	0.06
Color reconnection	n/e	n/e	0.13	0.54	0.15	1	1	0.46
Trigger	n/a	n/a	n/a	n/a	0.24	1	0	0.08
Statistical Uncertainty	4.60	2.10	0.43	0.27	0.69			0.37
Total Systematic Uncertainty	4.53	2.66	1.46	1.03	1.23			0.91
Total Uncertainty	6.45	3.39	1.52	1.06	1.41			0.98
Combination Coefficient (%)	- 2.2	- 9.3	3.8	76.2	31.5	χ^2 / ndf = 1.4 / 4		
Pull	0.32	-0.11	-0.82	0.11	0.05	χ^2 prob. = 85 %		

Combination matrix : CMS alternative methods

	Endpoint 2011	Lxy 2012	Correlations ρ_{chan}	Correlations ρ_{year}	CMS 2013	CMS* 2013
Measured m_t	173.90	173.48			173.49	173.45
iJES: *in-situ* JES factor	n/a	n/a	0	0	0.23	0.19
bJES: relative b-jet scale	0.71	0.75	1	1	0.55	0.56
dJES1: flavor JES component	n/a	n/a	1	1	0.17	0.20
dJES2: inter-calib. JES comp.	n/a	n/a	1	1	0.02	0.03
dJES3: MPF in-situ JES comp.	n/a	n/a	1	1	0.10	0.11
dJES4: uncorrelated JES comp.	n/a	n/a	1	1	0.20	0.30
rJES: other JES uncertainties	1.86	0.30	0	0	0.11	0.10
Lepton energy scale	0.40	n/a	1	1	0.03	0.03
MC generator	n/a	n/a			0.06	0.05
ISR/FSR	n/a	n/a			0.02	0.01
Parton distribution functions	n/a	0.26			0.06	0.06
Factorization scale	0.16	0.15			0.15	0.22
ME-PS matching threshold	0.11	0.55			0.17	0.18
B-hadron composition	n/a	0.39			0.01	0.01
B-hadron lifetime	n/a	0.29			0.01	0.01
Top quark p_T modeling	n/a	2.57			0.06	0.10
Signal			1	1		
Jet energy resolution	n/a	n/a			0.19	0.17
b-tagging	n/a	n/a			0.09	0.08
E_T^{miss} scale	n/a	n/a			0.01	0.04
Detector Modeling			1	1		
Underlying event	n/a	0.21	1	1	0.13	0.14
Background MC	0.15	0.36	1	1	0.09	0.09
Background Data	0.50	0.28	0	0	0.06	0.04
Fit calibration and MC statistics	0.58	0.19	0	0	0.07	0.06
Pileup	0.10	n/a	1	0	0.08	0.06
Color reconnection	0.57	0.28	1	1	0.46	0.37
Trigger	n/a	n/a	1	0	0.08	0.06
Statistical Uncertainty	0.90	1.47			0.36	0.25
Total Syst. Uncertainty	2.26	2.87			0.91	0.91
Total Uncertainty	2.43	3.23			0.98	0.94

Combination matrix: LHC

Uncertainty Categories			Size [GeV]						Correlation	
			ATLAS		CMS			LHC	ρ_{exp}	ρ_{LHC}
Tevatron	ATLAS	CMS	2011 l+jets	2011 di-l	2011 l+jets	2011 di-l	2011 all jets	comb		
Measured m_{top}			172.31	173.09	173.49	172.50	173.49	173.29		
	Jet Scale Factor	Jet Scale Factor	0.27		0.33					
	bJet Scale Factor		0.67							
iJES	Sum	Sum	0.72		0.33			0.26	0	0
dJES	uncorrelated JES comp.		0.61	0.73	0.24	0.69	0.69	0.29	1	0
	in-situ γ/Z JES comp.		0.29	0.31	0.02	0.35	0.35	0.10	1	0
	intercalib. JES comp.		0.19	0.39	0.01	0.08	0.08	0.07	1	0.5
aJES	flavour JES comp.		0.36	0.02	0.11	0.58	0.58	0.16	1	0.0
bJES	b-jet energy scale		0.08	0.71	0.61	0.76	0.49	0.43	1	0.5
	MC Generator	MC Generator	0.19	0.20	0.02	0.04	0.19			
	Hadronisation		0.27	0.44						
MC	Sum	Sum	0.33	0.48	0.02	0.04	0.19	0.14	1	1
Rad	ISR/FSR	ISR/FSR	0.45	0.37						
		Q^2-scale			0.24	0.55	0.22			
		Jet-Parton scale			0.18	0.19	0.24			
	Sum	Sum	0.45	0.37	0.30	0.58	0.33	0.32	1	1
Colour reconnection			0.32	0.29	0.54	0.13	0.15	0.43	1	1
Underlying event			0.12	0.42	0.15	0.05	0.20	0.17	1	1
Proton PDF			0.17	0.12	0.07	0.09	0.06	0.09	1	1
	Jet Resolution		0.22	0.21	0.23	0.14	0.15			
	Jet Reco Efficiency		0.05							
	E_T^{miss}		0.03	0.05	0.06	0.12				
DetMod	Sum	Sum	0.23	0.22	0.24	0.18	0.28	0.20	1	0
b-tagging			0.81	0.46	0.12	0.09	0.06	0.25	1	0.5
LepPt	Lepton reconstruction		0.04	0.12	0.02	0.14		0.01	1	0
Background from MC				0.14	0.13	0.05		0.08	1	1
Background from Data			0.10				0.13	0.04	0	0
Method			0.13	0.07	0.06	0.40	0.13	0.06	0	0
Multiple Hadronic Interactions			0.03	0.01	0.07	0.11	0.06	0.05	1	1
		Statistics	0.23	0.64	0.27	0.43	0.69	0.23		
		Systematics	1.53	1.50	1.03	1.46	1.23	0.92		
		Total Uncertainty	1.55	1.63	1.06	1.52	1.41	0.95		
		Comb. Coeff.[%]	22.6	3.6	60.6	-8.4	21.6	χ^2/ndf = 1.8/4		
		Pull	-0.80	-0.15	0.41	-0.67	0.19	χ^2 prob = 77%		