

# Preparing for the LHC top mass combination - a discussion of options -

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*CMS and ATLAS have agreed to proceed with the combination using a select subset of the most precise published measurements from both experiments.*

*The combination has been 'on hold' until now pending the completion of the ATLAS 8 TeV analyses.*

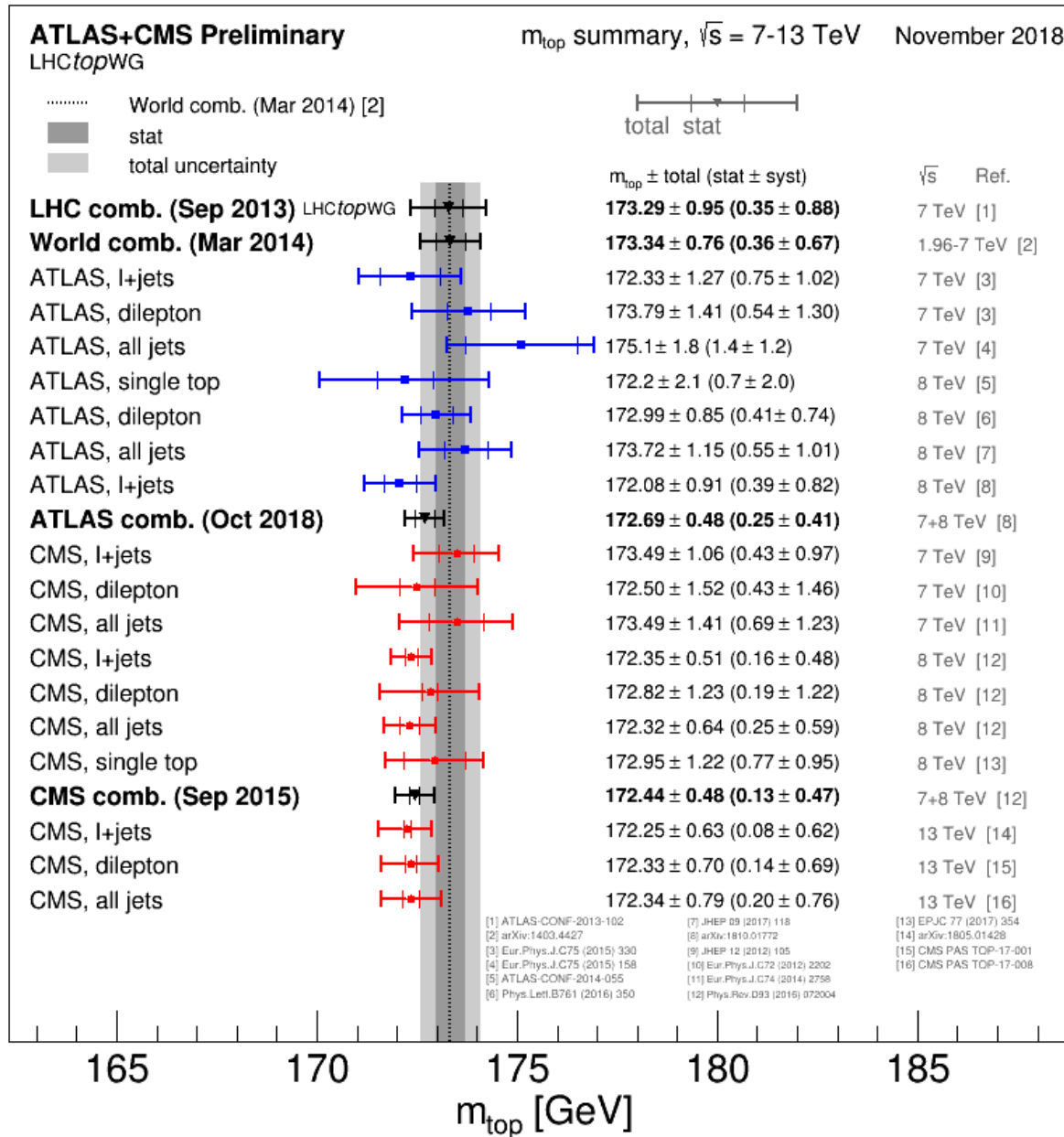
*These were submitted for publication in October  
→ we can now proceed.*

*In this talk I will summarize the issues that lay ahead.*

# Discussion Items

- Which Run I measurements should be included?
- How should we handle the differences in analysis between the two experiments
- What about the Run II measurements?
  - Run I + Run II in the future?
  - Back-porting of the newer treatments of systematics to the Run I measurements?
- Conventional measurements vs pole mass measurements
- .....

# Which Measurements?



Status (11/2018)

CMS and ATLAS

$m_t$

measurements

at

7, 8 and 13 TeV

# Which Measurements?

## CMS Run I Mass Measurements

- 18 Run  $m_t$  measurements that are in the public domain
- 12 of these are published

→ Restrict to only the published results

- 7 'standard' measurements used in the CMS Run 1 legacy analysis
  - 7 TeV (dilepton x 2, lepton+jets, all-jets)
  - 8 TeV (dilepton, lepton+jets, all-jets)

PRD 93 (2016) 072004

- 5 'alternative' measurements
  - 7 TeV (endpoint analysis)
  - 8 TeV lepton+J/ $\Psi$  analysis
  - $M_{T2}$ /MAOS analysis
  - lepton+SecVtx analysis
  - single top enriched analysis

EPJC (2013) 2494

JHEP 12 (2016) 123

PRD 96 (2017) 032002

PRD 93 (2016) 092006

EPJC 77 (2017) 354

# CMS Proposal

Start from the CMS Legacy combination (PRD 93 (2016) 072004)

→ Restrict to only the 2012 analyses (i.e. drop 2010 and 2011)

Test combinations show that this leads to no loss in precision and it has the advantage that all of the corrections and systematic uncertainties are treated fully consistently.

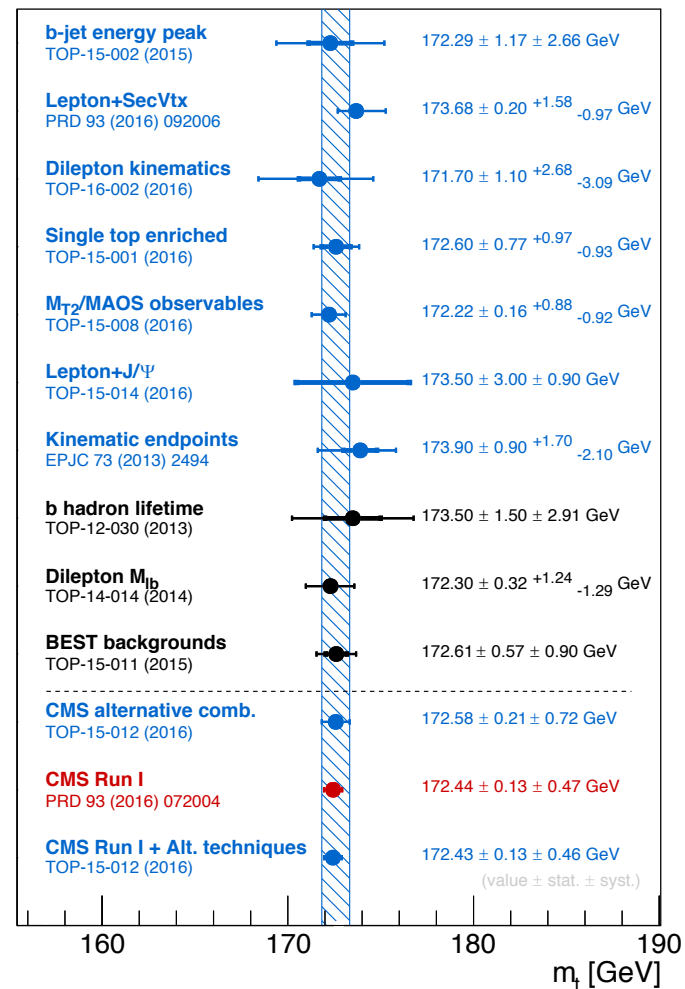
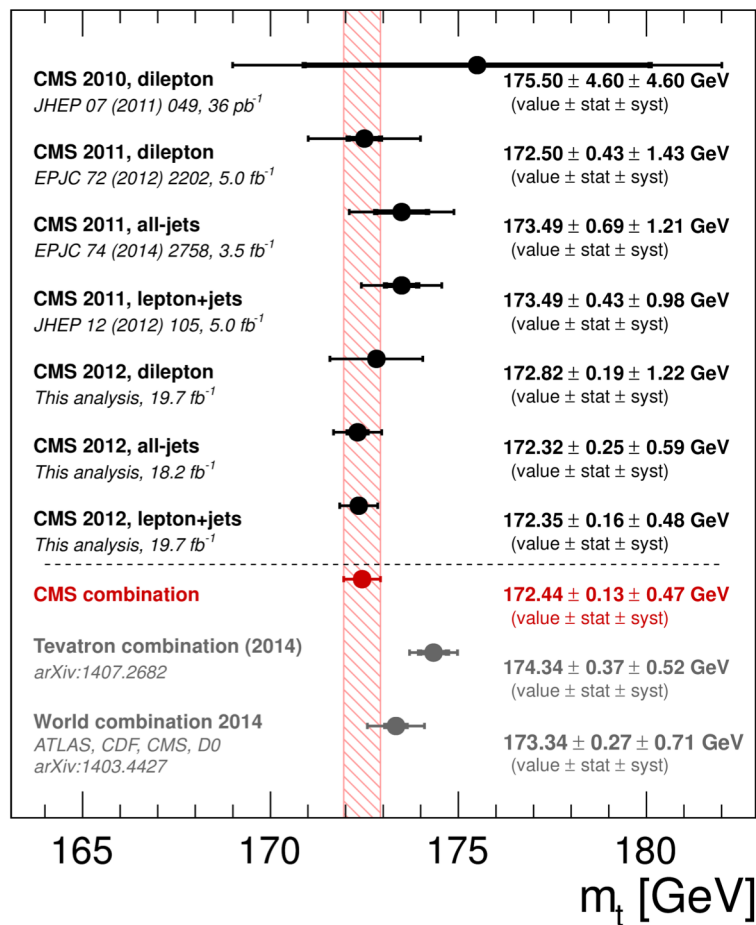
Remove the AMWT dilepton result and replace it with the more accurate MT2/MAOS dilepton measurement.

Add in the single top enriched measurement.

Add in some of the other CMS alternative analysis measurements if they provide any gain in precision/new information.

Studies show that an improvement beyond the precision of the CMS legacy result may be possible by making these choices.

# CMS Run I Measurements



CMS → start with the 4 checked measurements

# ATLAS Measurements

## Run I ATLAS Measurements

- 6 Run  $m_t$  measurements that are in the public domain and are published or submitted for publication
- ‘standard’ measurements in the dilepton, lepton+jets, and all-jets channels

7 TeV all-jets

Eur. Phys. J. C75 (2015) 158

7 TeV lepton+jets and dilepton

Eur. Phys. J. C75 (2015) 380

8 TeV dilepton

Phys. Lett. B761 (2016) 350

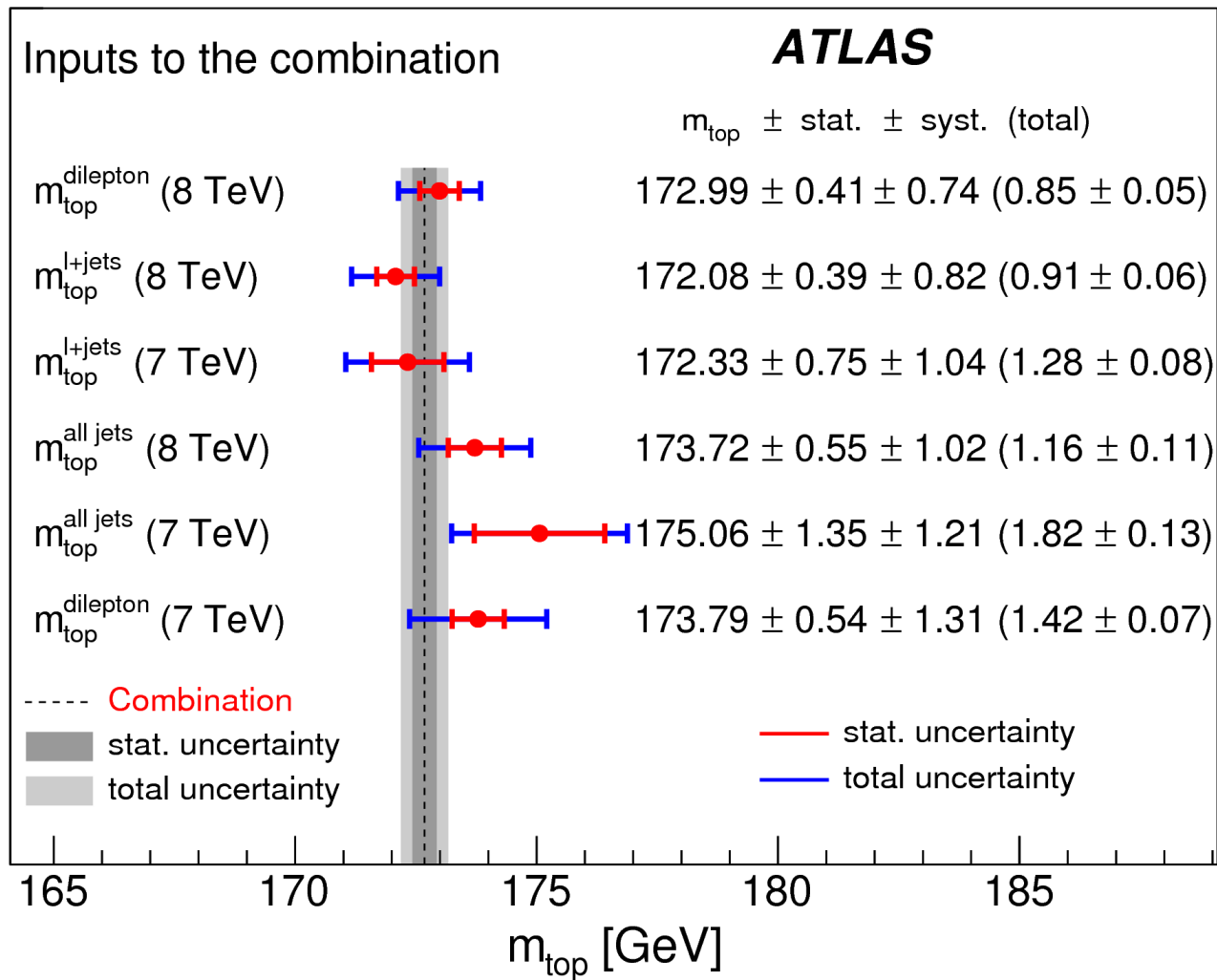
8 TeV all-jets

JHEP 02 (2017) 118

8 TeV lepton+jets

arXiv 1810.01772 (sub to EPJC, Oct. 2018)

# ATLAS Measurements



ATLAS → start with all of these as they contribute to the ATLAS combined result.

# Analysis Differences

CMS uses its hybrid results which absorb a large fraction of the effects of anti-correlations between the systematic terms, whereas ATLAS uses these explicitly.

Q: Is this an issue/area where some gain might be obtained?

C: Test studies with the CMS results show that adding the residual anti-correlations may give a small net gain in precision.

C: Also need to check for any anti-correlations between the ATLAS and CMS systematics.

The sensitivity to these choices will have to be checked.

# Analysis Differences

There are some differences in the way systematics are treated.

C: These are mostly understood and we have agreed on ways to map the two experiments onto each other.

e.g.

The correlations between the JSF terms have been studied and they are fully mapped.

Other differences remain and their effects will need to be checked.

e.g.

fragmentation modelling, top  $p_T$  mismodelling.....



# The Role of the Run II Measurements

## The elephant in the room.....

For Run II CMS and ATLAS tried to harmonize their analysis baselines as much as possible (MC generator etc.) to facilitate easier comparison of the 13TeV measurements.

The ME generators and showering code are different between Run I and Run II for both experiments.

Improved modeling some of the systematic uncertainties → some additional differences from here also.

(e.g. Color reconnection modeling is very different in the CMS case)

Q: Should the techniques and uncertainties used in the Run II analyses be back-ported into the published Run I measurements, so that they can be combined with / compared to the Run II results on an equal footing?

C: This would require taking uncertainties from Run II and changing the Run I results prior to combining them. Initial proposal → not to modify the published results.

## The elephant in the room.....

Q: The first Run II results are available (see earlier slide) and more are coming.  
What should be done with these?

C: It is probably the wrong time to fold these into an LHC combination but we will  
have to facilitate a comparison of them with the Run I results in some manner.  
(see previous question)



# The Top Pole Mass Measurements

The combination that comes from these studies of the mass will be written up and published as a LHCtopWG/CMS/ATLAS paper.

Q: Should this paper also contain the pole mass measurements derived from the production cross-sections?

C: ATLAS: work on the pole mass from the cross sections is in progress  
→ should be kept separate from this paper.

Q: In the longer term, should these be kept as independent measurements or should they also be compared to the 'MC values'?

C: ATLAS and CMS treat the MC mass results as proxies for the pole mass within the current theoretical uncertainties.

C: Maybe its time to start considering how to compare/combine the MC and pole mass results or at least discussing what can be said to map one onto the other or both onto other mass schemes?

# Summary

We have a full set of Run I results and can now proceed with a new LHC combined result.

The precision of the result will depend on the choices of:

- i.) input datasets
- ii.) level of harmonization of the analysis techniques and the systematic uncertainty treatment
- iii.) restriction to published results or back-porting of knowledge gained from Run II

Decisions on these and the effects they have will need to be checked, documented and signed off by the two collaborations.