DØ Note 5747-CONF

Combination of the DØ top quark mass measurements

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We present a combination of the top quark mass measurements performed by the DØ experiment in the dilepton and lepton plus jets (ℓ+jets) channels. Combined result yields

$$m_{\rm top} = 172.8 \pm 0.9 \text{ (stat)} \pm 1.3 \text{ (syst) GeV or}$$
$$m_{\rm top} = 172.8 \pm 1.6 \text{ GeV.}$$

Result for summer 2008 conferences

I. INTRODUCTION

The combination of top quark mass measurements presented in this note includes the best DØ measurements from Run I of the Tevatron in the dilepton [1] and ℓ+jets [2] channels, and the most recent Run II measurements in the dilepton [3, 4] and the ℓ+jets [5, 6] channels with up to 2.8 fb^{-1} and 2.2 fb^{-1} data sets, respectively.

II. METHOD AND INPUTS

We use BLUE [7] method to perform the combination of the top quark mass measurements. We follow the same procedure and use the same package as was used to compute the world average top quark mass [8]. Table II summarizes the top quark mass measurements that enter the combination with the corresponding statistical and systematic uncertainties. Definition of uncertainties follows Ref. [8].

The top quark mass measurement in the ℓ+jets channel has been performed separately using Run IIa [5] and Run IIb [6] data yielding

$$\begin{aligned} {m_{\rm top}}^{\ell+\rm jets} &= 171.5 \pm 1.8 \text{ (stat+JES)} \pm 1.1 \text{ (syst) GeV and} \\ {m_{\rm top}}^{\ell+\rm jets} &= 173.0 \pm 1.9 \text{ (stat+JES)} \pm 1.0 \text{ (syst) GeV}, \end{aligned}$$

respectively. Both analyses use Matrix Element method with the in-situ jet energy calibration. In addition, Run IIa measurement takes advantage of the external jet energy scale calibration to achieve the best precision. Therefore, to correcly take into account correlations between different sources of systematic uncertianties, the JES uncertainty for the Run IIa measurement has to be split into two parts: coming from the in-situ calibration and from the external JES. To perform such breakdown we used three Run IIa mass measurements performed under different conditions (systematics uncertainties are not shown):

- with fixed JES: $m_1 = 173.05 \pm 1.45$ (stat),
- with floating JES without a prior: $m_2 = 170.59 \pm 2.15$ (stat+in-situ),
- with floating JES and a prior: $m = 171.50 \pm 1.78$ (stat+in-situ/prior).

The last line corresponds to the actual result.

From the first two measurements we obtain a relative statistical uncertainty (0.84%) and a relative uncertainty due to in-situ calibration (0.94%). These translate into 1.44 GeV statistical uncertainty and 1.61 GeV in-situ uncertainty for the third measurement. The usage of the prior reduces the latter. To extract the uncertainty solely due to prior, i.e., due to external JES, we use BLUE method iteratively and combine the third measurement with the statistical and in-situ uncertainties mentioned above with a pseudo-measurement that has the same central value and statistical uncertainty, zero uncertainty from in-situ calibration and unknown uncertainty from the external JES. We take statistical uncertainties fully correlated in the combination, so that the statistical uncertainty of the combined result is the same as for inputs. We stop the iterative process when the combined in-situ and prior uncertainty on the resulting mass becomes equal to the measured one. We obtain that the uncertainty from the prior, if no in-situ calibration is used, would be 1.37 GeV (see Table I). The output of the BLUE combination code provides a breakdown of the total measured uncertainty of 1.78 GeV into a statistical component (1.44 GeV), uncertainty from in-situ calibration (0.68 GeV) and uncertainty from the prior (0.80 GeV). The latter corresponds to dJES and the former to iJES entries in Table II.

	mean	statistical	in-situ	prior	total
input 1	171.50	1.44	1.61	0	2.16
input 2	171.50	1.44	0	1.37	2.00
output	171.50	1.44	0.68	0.80	1.78

TABLE I: Inputs and output of the BLUE combination code used for splitting of prior and in-situ calibration uncertainties in ℓ+jets channel.

	Run I		Run II		
	ℓ+jets	dilepton	ℓ+jets Run IIa	ℓ+jets Run IIb	dilepton
lumi	130 pb^{-1}	130 pb^{-1}	1.0 fb^{-1}	1.2 fb^{-1}	2.8 fb^{-1}
top quark mass	180.1 GeV	168.4 GeV	171.5 GeV	173.0 GeV	174.4 GeV
aJES	0.0	0.0	0.8	0.8	1.2
bJES	0.7	0.7	0.03	0.1	0.3
cJES	2.0	2.0	0.0	0.0	0.0
dJES	0.0	0.0	0.8	0.03	1.5
iJES	0.0	0.0	0.7	1.4	0.0
rJES	2.5	1.1	0.0	0.0	0.0
signal	1.1	1.8	0.5	0.5	0.5
background	1.0	1.1	0.4	0.4	0.6
fit	0.6	1.1	0.3	0.2	0.2
UE/MI	1.3	1.3	0.0	0.0	0.0
systematic	3.9	3.6	1.5	1.7	2.1
statistical	3.6	12.3	1.5	1.3	3.2
total	5.3	12.8	2.1	2.2	3.8

TABLE II: Inputs to the top quark mass combination. Uncertainties are in GeV.

	Run I		Run II		
	ℓ+jets	dilepton	ℓ+jets Run IIa	ℓ+jets Run IIb	dilepton
aJES	n/a	n/a	×	×	×
bJES	×	×	×	×	×
cJES	×	×	×	×	×
dJES	×	×	o	o	o
iJES					
rJES	×	×	×	×	×
signal	×	×	×	×	×
background	×	o	×	×	o
fit					
UE/MI	×	×	n/a	n/a	n/a
statistical					

TABLE III: Summary of correlations between different sources of uncertainties. Within each category same symbol indicates that uncertainties are taken as 100% correlated.

III. RESULTS

Combining the top quark mass measurements performed using Run IIa [5] and Run IIb data [6] in ℓ+jets channel we obtain

$$\begin{aligned} {m_{\rm top}}^{\ell+\rm jets} &= 172.2 \pm 1.0 \text{ (stat)} \pm 1.4 \text{ (syst) GeV or} \\ {m_{\rm top}}^{\ell+\rm jets} &= 172.2 \pm 1.7 \text{ GeV.} \end{aligned}$$

The χ^2 for combination is 0.3 for 1 degree of freedom. The probability to get this or larger value of the χ^2 is 56.8%.

Combined top quark mass measurement in dilepton channel using up to 2.8 fb^{-1} of data in ee, $e\mu$, $\mu\mu$ and lepton+track channels is

$$\begin{aligned} {m_{\rm top}}^{\ell\ell} &= 174.4 \pm 3.2 \text{ (stat)} \pm 2.1 \text{ (syst) GeV or} \\ {m_{\rm top}}^{\ell\ell} &= 174.4 \pm 3.8 \text{ GeV.} \end{aligned}$$

Combination of all Run I and Run II measurements yields:

$$\begin{aligned} m_{\rm top} &= 172.8 \pm 0.9 \text{ (stat)} \pm 1.3 \text{ (syst) GeV or} \\ m_{\rm top} &= 172.8 \pm 1.6 \text{ GeV.} \end{aligned}$$

Table IV summarizes the pulls and weights of individual measurements. The χ^2 for combination is 3.2 for 4 degree of freedom. The probability to get this or larger value of the χ^2 is 53.0%. Breakdown of uncertainties on the combined result is shown in Tab.V.

	Run I		Run II		
	ℓ+jets	dilepton	ℓ+jets Run IIa	ℓ+jets Run IIb	dilepton
weight	5.97%	0.65 %	45.30%	42.20%	5.89 %

TABLE IV: Summary of weights of the individual measurements.

	ℓ+jets Run II	all channels
top quark mass	172.2 GeV	172.8 GeV
aJES	0.83	0.79
bJES	0.06	0.12
cJES	0.0	0.13
dJES	0.44	0.47
iJES	0.75	0.66
rJES	0.0	0.16
signal	0.47	0.52
background	0.37	0.39
fit	0.18	0.16
UE/MI	0.0	0.09
systematic	1.35	1.34
statistical	0.98	0.90
total	1.67	1.62

TABLE V: Breakdown of systematic uncertainties on the combined Run IIb top quark mass measurement in the ℓ+jets channel and for a complete DØ combination. Uncertainties are in GeV.

Fig.1 shows a suumary of measurements used for DØ combination along with the DØ combination result, the world average and the top quark mass extracted from the cross section measurement [9].

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[2] DØ Collaboration, V. Abazov *et al.*, Nature **429**, 638 (2004).
[3] DØ Collaboration, V. Abazov *et al.*, "Measurement of the Top Quark Mass in the Dilepton Channel via Neutrino Weighting", D0 note 5745-CONF
[4] DØ Collaboration, V. Abazov *et al.*, "Measurement of the top quark mass in the electron-muon channel using the matrix element method with 2.8 fb^{-1}", D0 note 5743-CONF
[5] DØ Collaboration, V. Abazov *et al.*, "Precise measurement of the top quark mass from lepton+jets events at DØ ", arXiv:0807.2141 [hep-ex], FERMILAB-PUB-08/242-E, Submitted to PRL
[6] DØ Collaboration, V. Abazov *et al.*, "Measurement of the top quark mass in the Lepton+Jets Channel using Matrix Element Method on 2.1 fb^{-1} of DØ Run II Data", D0 note 5610-CONF
[7] L. Lyons, D. Gibaut and P. Clifford, Nucl. Instrum. and Methods A **270**, 110 (1988) and A. Valassi, Nucl. Instrum. and Methods A **500**, 391 (2003).
[8] CDF and DØ Collaborations,"Combination of CDF and DØ Results on the Mass of the Top quark", FERMILAB-TM-2403-E, arXiv:0803.1683.
[9] DØ Collaboration, V. Abazov *et al.*, "Top quark mass extraction from $t\bar{t}$cross section measurements", D0 note 5742-CONF

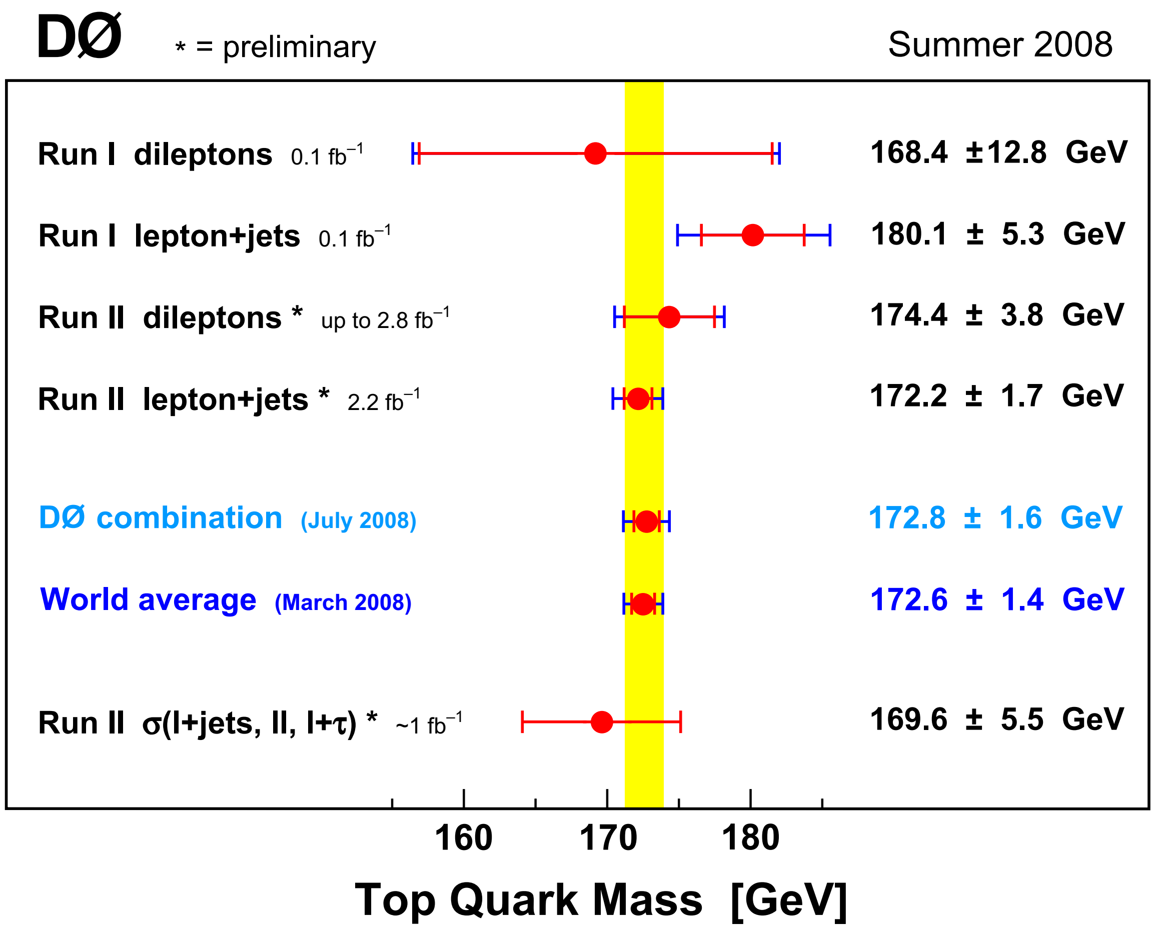

FIG. 1: A summary of the top quark mass measurements used for DØ combination along with the DØ combination result, the world average top quark mass and the top quark mass extracted from the cross section measurement.