Top mass shift resulting from the recalibration of flavor-dependent jet energy corrections in the DØ lepton+jets top mass measurement

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We review the possible effects of the miscalibration of the flavor-dependent Jet Energy Corrections (F_Corr) on the DØ lepton+jets top mass measurement. The work is based on a previous study, where the DØ F_Corr calibration procedure was repeated based on the release of the internal DØ notes after a 5-year moratorium. The cited study was motivated by the extraordinary precision claimed by DØ in their top mass measurement. Using a Pythia6-based F_Corr recalibration, the $m_t$ result was shifted from 174.95 to 173.16 GeV. Moreover, utilizing a Herwig7-based F_Corr calibration (not accounted for in the DØ studies), a shift down to 171.84 GeV was observed. We find this both convincing and specific evidence for re-reviewing a part of the F_Corr calibration process. However, DØ has been unwilling to open such studies or to provide other convincing counter-evidence.

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1 Introduction

The most notable measurements of the top quark mass ($m_t$) are those performed by the Tevatron collaborations CDF and DØ and those performed by the LHC collaborations ATLAS and CMS. The DØ $m_t$ combination ($174.95 \pm 0.75$ GeV) [1] is a distinct outlier in the $m_t$ world combination [2]. The measurements by CDF, ATLAS and CMS tend to produce values ranging from 172 to 173 GeV. Moreover, the DØ combination is almost completely driven by the lepton+jets measurement ($174.98 \pm 0.76$ GeV) [3]. This gives motivation for studying the calibrations behind this measurement.

The Master’s thesis written by Toni Mäkelä [2] made an in-depth study of the DØ flavor-dependent Jet Energy Corrections ($F_{\text{corr}}$). It was based on the DØ internal notes that were released from their five-year moratorium early in 2018. Some DØ authors were helpfully collaborating with Toni, and provided him with all the necessary material and communication. As a notable detail, the DØ Run IIb $F_{\text{corr}}$'s differ considerably from those of Run IIa. Toni’s most significant finding was that the Run IIb results should have indeed resembled more those of Run IIa.

In the $m_t$ shifting analysis, performed by the main author of this text, we apply the $F_{\text{corr}}$ values produced by Toni into a lepton+jets top mass measurement. The study utilizes a standalone top quark pair simulation and a detailed mathematical framework for propagating the $F_{\text{corr}}$ changes into the $m_t$ measurement [5]. In the TOP2020 poster session, the results obtained with this method were presented.

Figure 1: $F_{\text{corr}}$ values in the four DØ RunII eras. Row 1: DØ histograms (open markers), DØ fits (lines) and our P6 reproduction of the DØ results (closed markers). Row 2: our P6 (continuous line) and H7 (dotted line) fits vs. DØ fits (dashed line).
2 Observations and Interpretation

Toni’s analysis consists of two steps: refitting the 3 Single Particle Response (SPR) parameters and making parametrized $F_{\text{Corr}}$ fits based on these. The analysis was performed both on Pythia6 (P6) and Herwig7 (H7). P6 was run with the exact same settings that DØ used. H7 was used with a reasonable tune, to probe the possible systematic errors. We believe that Herwig or other secondary Monte Carlo (MC) event generators have not been utilized sufficiently in the DØ’s Jet Energy Calibration and error analysis [6].

Toni’s measurements are distilled in Figure 1. On Row 1, we observe DØ’s histogram-data and the fits based on these. The closed markers display histograms based on Toni’s SPR remakes. It is observed that Toni has found the same histogram results as DØ. In contrast, DØ’s histograms and fits agree only for Run IIa, but not for the Run IIb eras. The histograms also show better time-stability than the fits.

On Row 2 of Fig. 1, the histograms are not shown, but the same DØ fits are displayed. In addition, Toni’s fits are given. His P6 fits agree with the histograms and are more stable in time than the DØ ones. Both the fits and histograms for H7 show a great deviation from the P6 results. The H7 histograms are not displayed in the Figure, but these agree with the H7 fits. This motivates a suspicion of the remarkably small $F_{\text{Corr}}$ errors stated by DØ, even if a DØ tune for H7 was not available.

The $m_t$ shifting method presented in Ref. [5] utilizes Toni’s P6 and H7 fits. The method takes DØ’s original fits as a reference and consequently probes the changes in the measured $m_t$ values introduced by Toni’s fits. The results are considered run-by-run (Run IIa and Run IIb{1,2,34}) and separating the electron and muon channels. The $m_t$ analysis is performed purely with P6, utilizing DØ’s tuning. We do not expect similar generator-dependence in the $m_t$ measurement, as in the $F_{\text{Corr}}$ measurement.

The final $m_t$ shifts using the P6 and H7 $F_{\text{Corr}}$ values are given in Fig. 2. It is noteworthy that the P6-shifted $m_t$ result is quite close to that of the CDF collaboration. The generator choices of DØ and CDF are similar, and hence also the related systematic errors should agree. The ATLAS and CMS results agree in a similar fashion as the CDF and the P6-shifted DØ results. Interestingly, a simple linear combination of the P6-shifted and H7-shifted DØ results produces a value close to those of the CMS and ATLAS collaborations. The LHC collaborations utilize more heavily Herwig in their jet calibrations than the Tevatron collaborations. This could indicate that the choice of generators in the jet calibration process sets the rough baseline for results obtained in a precision measurement of the top mass measurement.
Figure 2: The most prominent top mass measurements and the DØ measurements shifted using Toni’s $F_{\text{corr}}$ values. Lepton+jets channel dominates the DØ result.

### 3 Discussion

Toni has presented his results actively during 2018-2019, including a LHC Top WG meeting. After finishing his Master’s thesis, he left our group in mid-2019 to pursue a PhD in Germany. The final $m_t$-shift results were published as an arXiv-preprint in early 2020, to be later included in the main author’s PhD thesis. In the spring of 2020, the results were presented and handled in an LHC Top WG meeting. In this meeting, some of the DØ contacts got active, and were unknowing of Toni’s previous contact efforts. The situation was extraordinary, as Toni had been proactively in contact with the DØ authors. The agreement of the meeting was that the mass shifting method itself seems trustworthy. However, the DØ contacts disagreed on Toni’s results. Toni provided further information about his studies, but the contact from DØ dried up.

The $m_t$ shifting results were submitted as a poster for the TOP2020 conference. We did not hear from DØ sooner than one day before the poster presentation in a short letter [7]. Here, it is addressed that There were no interactions between the authors of Refs. [1, 4] and the primary DØ authors concerning the details in the internal notes. This is not how we observed the process, where Toni has been very active into the direction of DØ. Thanks to his contact with the DØ authors, he received all the material reasonably available, making the former statement false. Furthermore, other inconvenient findings were completely disregarded in the letter, such as the H7-based systematics treatment.

The letter aims for closing the conversation without looking into the $F_{\text{corr}}$ calibra-
The disagreement between DØ fits and histograms is spoken off by mentioning that *the plots in the internal notes could have been misleading*. It is stated that the DØ review process is very thorough, and hence they do not expect any errors. This should not be a valid argument for defending a calibration. The final paper releases are less detailed than the analysis notes. The details ending up in the published paper are usually reviewed with the help of the more detailed analysis notes. If there are internal disagreements within the notes, how can we trust the calibrations of the final paper? To support their arguments, DØ should show that the final fits were indeed corrected from the ones presented in the note. Stating that the fits are probably correct without a visual or numerical reference remains unconvincing.

Even with the tight schedule, the TOP2020 organizers allowed adding a mention of the DØ letter into the poster. Regrettably, a thorough reciprocal discussion of the DØ statements did not enter the poster session. The audience was generally curious, and the most critical voices of the DØ letter were absent.

In short, these $m_t$ studies aimed for a DØ re-review of a specific part of their $F_{Corr}$ calibration. However, DØ has responded to this only with a short letter including controversial statements. This is not consistent with good scientific practice. With the release of DØ’s internal notes, our collaboration with DØ started in a promising manner. Utilizing the available material, we have completed a detailed study of the DØ analysis chain. Going into more detail is infeasible without DØ taking the lead.

We wish that DØ would pick up the issue and truly re-review the $F_{Corr}$ calibration. We have pinpointed the location of the possible issues, so this should not be labor-intensive. With the amount of work and evidence that we have provided, failing to do this serves against the self-corrective ideals of science.

References

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