Top Quark Mass Measurement at DØ with the Matrix Element Method in the Lepton+Jets Channel

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The precise measurement of the mass of the top quark is one of the central goals of the Fermilab Tevatron. The top quark mass is a fundamental parameter of nature and also serves as an important input to consistency tests of the Standard Model and models beyond it [1,2]. Within the Standard Model it provides indirect contraints on the Higgs boson mass.

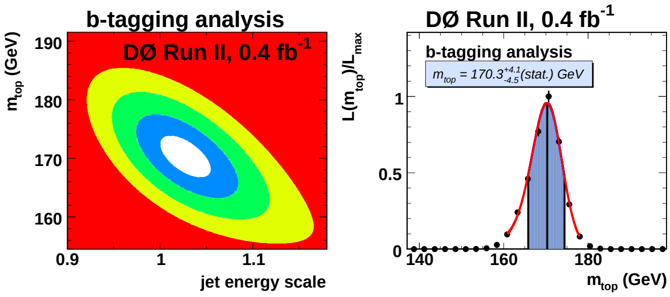

Fig. 1: Published DØ measurement of the top quark mass with the Matrix Element technique. The left plot shows the 1, 2, 3, and 4σ contours around the measurement value in the plane of assumed top quark mass ($m_{\rm top}$) and jet energy scale (JES) values. The right plot shows the projection of the likelihood onto the $m_{\rm top}$ axis, taking correlations into account, together with the measured values.

Our group has extended the so-called Matrix Element technique for the measurement of the top quark mass, including an *in situ* calibration of the calorimeter jet energy scale which reduces the dominant systematic uncertainty [3]. This work resulted in the most precise measurement of the top quark mass by the DØ experiment and has now been published [5]. Figure 1 summarizes the results.

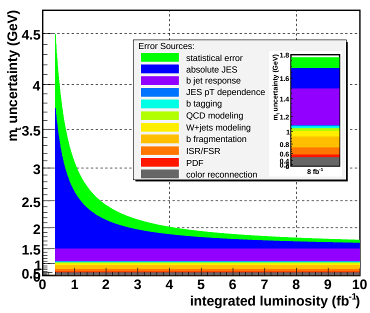

Fig. 2: Expected contributions from the various sources of uncertainty as a function of integrated luminosity if the published DØ measurement of the top quark mass with the Matrix Element technique is applied unchanged to larger datasets. The inset shows the contributions for 8 fb^{-1}.

As shown in Figure 2, the measurement is currently still statistically limited. For the large datasets expected by the end of Run II of the Tevatron, the dominant uncertainty will however come from the largest remaining systematic error, arising from differences between the energy scales for b jets and light-flavour jets. The Munich group addresses both issues. Further improvements of the measurement technique are discussed in [6], while work on the analysis of the larger dataset currently available is described here.

At a hadron collider, the top quark mass is inferred from the properties of the top quark decay products. Simulated events are used to calibrate the measurement and to verify the accuracy of the uncertainty estimate. Consequently, it is crucial to ensure that the simulation correctly reproduces the detector response. The Munich group has worked on the selection of the dataset for the measurement based on an integrated luminosity of 1 fb^{-1} and on the comparison of Monte Carlo simulation with data.

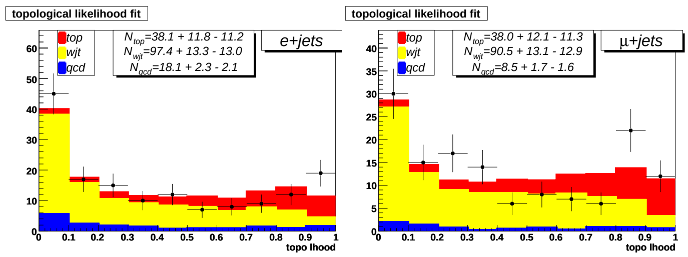

Fig. 3: Distributions of the topological likelihood discriminant for data taken after fall 2004 for e+jets (left) and μ+jets events (right). The data are shown by the points with error bars, while the colored histograms represent the fitted contributions from $t\bar{t}$, W+jets, and multijet events.

To describe the detector response, this large dataset has to be divided into two subsamples with different detector resolution. As an example for comparisons between data and Monte Carlo simulation, Figure 3 shows the distributions of a topological likelihood discriminant designed to separate signal $t\bar{t}$ events from background. Even though not used directly in the mass measurement, the information on the signal fraction in the data sample obtained from this study is needed for tests of the measurement method. The momentum resolution for simulated muons has been adjusted to reproduce that in the data. For the measurement, a transfer function is used, whose parameters have also been determined by the Munich group.

A preliminary measurement of the top quark mass based on the 1 fb^{-1} dataset has been shown [7]. The Munich group works on the publication of this measurement, where the extended technique described in [6] will be applied.

References

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