# Top Mass Measurement at DØ Run II with the Matrix Element Method

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The mass of the top quark is an important parameter in precision elektroweak fits and provides indirect constraints on the Higgs boson mass. Measurements from Tevatron Run I yield $m_t = 174.3 \pm 5.1$ GeV/c$^2$. The application of the Matrix Element Method in Run I led to significant improvements in both statistical and systematic uncertainties on the top quark mass measurement at DØ [1]. This study describes the steps towards a measurement of the top mass with this technique in Run II.

The reaction $p\bar{p} \to t\bar{t}X$ with $t\bar{t} \to q\bar{q}b\bar{b}l\nu$ is considered ("lepton+jets" final state). For each preselected event, the probability $P_{t\bar{t}}$ of the kinematic state to be produced via the signal process is calculated as a function of the top mass, based on the leading order production matrix element. The probability to obtain a measured jet energy $E'$ if a parton with energy $E$ was produced is taken into account and an integration over all possible parton energies is performed. The transverse momentum of the neutrino is obtained from the $p_T$ imbalance of the lepton and the four jets. The probability $P_{bkg}$ of an event to be produced via the background process (W + 4 jets) is calculated in a similar way, and an event probability is formed:

$$P_{evt}(x; m_{top}) = f_{top} \cdot P_{t\bar{t}}(x; m_{top}) + (1 - f_{top}) \cdot P_{bkg}(x) \quad (1)$$

where $x$ denotes the kinematics of the event and $f_{top}$ the signal fraction in the sample. The event probabilites of the sample are combined to a likelihood $\mathcal{L}$, and the top mass is determined by minimizing

$$-ln\mathcal{L} = -\sum_{i=1}^{k} lnP_{evt}(x_i; m_{top}) \quad (2)$$

The increased statistical sensitivity relative to previous methods can be mostly attributed to all possible jet/parton combinations being taken into account and the signal probability being calculated event-by-event, thus allowing well-measured events to contribute more than poorly-measured events.

Events are selected in which an isolated, high-energetic lepton and significant missing transverse energy indicate the presence of a leptonically decaying W boson. Furthermore, exactly 4 jets with large transverse momentum are required, corresponding to the 4 partons in the $t\bar{t}$ decay. 75 and 76 events remain in the $e$+jets and $\mu$+jets samples respectively, which both correspond to roughly 320 pb$^{-1}$ of integrated luminosity.

For the calibration of the measurement, ensemble tests with Monte Carlo samples of various top pole masses are performed. The number of events in each ensemble is set to the observation in data, and $t\bar{t}$ and W+jets events are added with the signal fractions estimated by a topological likelihood fit: 40% in the $e$+jets, 30% in the $\mu$+jets channel. The resulting calibration curve and the width of the pull distribution for different top pole masses are shown in Figure 1 for the combined lepton+jets sample.

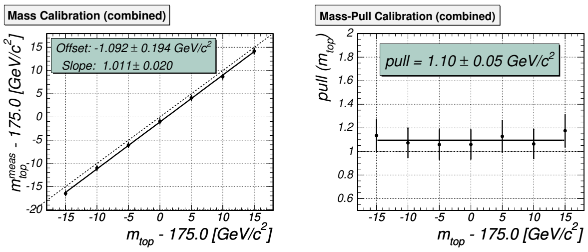


Fig. 1: Mass calibration and pull width for the combined lepton+jets sample.

Figure 2 shows the distributions of mass and mass-error estimators for ensembles at a top pole mass of 175 $GeV/c^2$.

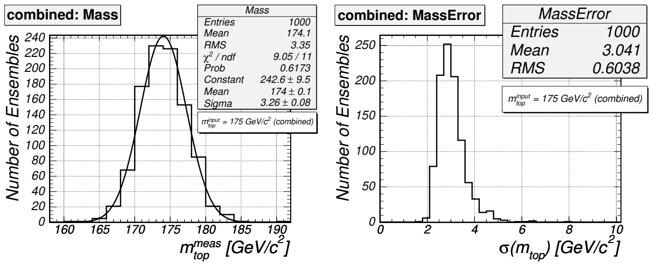


Fig. 2: Distribution of mass- and error estimators for $m_{top} = 175\ GeV/c^2$.

The expected statistical uncertainty is roughly 3 $GeV/c^2$ for the l+jets sample.

The systematic uncertainty on the measurement is expected to be dominated by the Jet Energy Scale. The error band of the correction to be applied to each jet is taken into account and applied to each ensemble. The distributions of deviations from the nominal fit result from scaling jet energies up and down accordingly are shown in Figure 3.

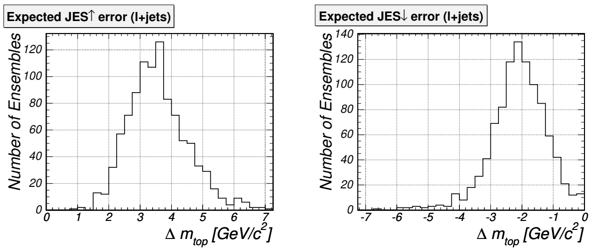


Fig. 3: Expected systematic error originating from Jet Energy Scale uncertainty.

Among other sources expected to contribute significantly to the systematic uncertainty, effects of QCD contamination, signal- and background modeling and the sample composition were studied. The Monte Carlo analysis of the method indicates great performance and the potential to significantly enhance our knowledge of the top quark mass with the current statistics. The application to recent data is currently under collaboration review.

## References

[1] V.M. Abazov *et al.*, Nature **429** (2004) 638-642