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MEASUREMENT OF THE TOP QUARK MASS AT DØ

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DØ has measured the top quark mass using a sample of 32 single-lepton events selected from approximately 115 pb^{-1} of $\sqrt{s} = 1.8$ TeV $p\bar{p}$ collisions collected from 1992 - 1996. The result is $m_t = 169 \pm 8(stat) \pm 8(syst)$ GeV/c^2. Using a sample of 3 $e\mu$ events, DØ measures $m_t = 158 \pm 24(stat) \pm 10(syst)$ GeV/c^2.

8 Event Selection

It is assumed that top quarks are pair-produced and decay via $t \rightarrow Wb$, so that every candidate event includes two top quarks and two on-shell W bosons. In the subset of events where one of the Ws decays to $e\nu$ or $\mu\nu$ and the other hadronically, the final state consists of a high-p_T lepton, four high-p_T jets, and significant missing E_T ($\not{E}_T$) due to the fact that the neutrino does not interact in the detector. Hence the initial selection requires four jets with $E_T > 15$ GeV and $|\eta| < 2.0$, $\not{E}_T > 25$ GeV, and a central electron (or muon) with $E_T > 20$ GeV. Additionally, a soft muon tag in a jet or a leptonic W with $|\eta^W| < 2.0$ and $E_T^W \equiv E_T(\ell) + E_T(\nu) > 60$ GeV was required. Ninety-three events survive these cuts from ≈ 115 pb^{-1} collected between 1992 and 1996 and form the *base sample* for the mass analysis.

9 Kinematic Fitting

Each event in the base sample is kinematically fit for the top quark mass. The presence of a final-state neutrino means that three quantities are unmeasured. Four-momentum conservation provides five constraints (total $\vec{p_T} = 0$, $m_{\ell\nu} = m_{jj} = m_W$, $m_t = m_{\bar{t}}$), so a 2C fit is possible. In performing this fit, there are 12 possible assignments of jets to parent partons. All combinations are attempted, and the solution with lowest χ^2 is used to give the *reconstructed mass.* If no solution has $\chi^2 < 7$ the event is rejected, leaving 73 events in the base sample. As this sample is dominated by QCD W + multijet events, a procedure is required to assign the relative probability that each event is top. This is done by forming a *top likelihood discriminant* based on four variables which are nearly uncorrelated with the reconstructed mass: $\not{E}_T$, aplanarity, $H'_{T2} \equiv \left(\sum_{\text{jets}} E_T - E_T(\text{jet1})\right) / \sum_{\text{jets}} |E_z|$, and $K_{T\min} \equiv (\min \Delta R_{jj} \times E_T(\text{lesser jet})) / E_T^W$.

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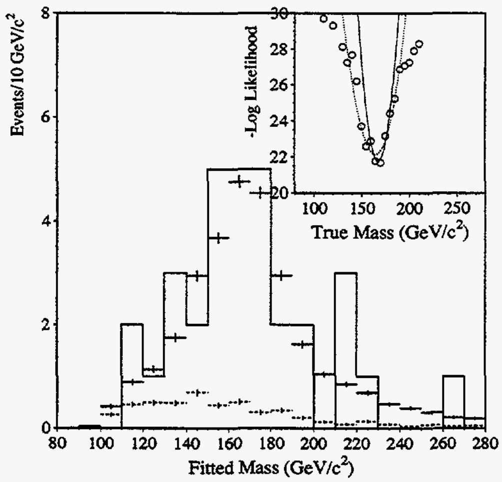

Figure 3: Result of maximum likelihood fit to mass sample, projected onto the reconstructed top mass axis.

10 Maximum Likelihood Fit

In order to extract the top quark mass, a maximum likelihood fit is performed. First, the base sample is binned in two dimensions (reconstructed mass vs. top discriminant), and a binned likelihood fit is made with m_t and the number of signal and background events as unconstrained output parameters. The result is $m_t = 168 \pm 10$ GeV/c^2, $n_s = 27 \pm 7$, and $n_b = 46 \pm 10$, where the errors are statistical. Tests using ensembles of Monte Carlo events show that one expects better resolution on m_t when fitting only those events in the half of the two-dimensional plane which are most likely to be top, with a constraint on the number of signal events provided by the fit to the full base sample. Thirty-two events are in this *mass sample*, and a binned likelihood fit yields $m_t = 168 \pm 8$ (*stat*) GeV/c^2 (see Fig. 1). To account for small differences observed between the input m_t and mean maximum likelihood mass from ensemble tests, the central value is increased by 1 GeV/c^2.

11 Systematic Errors

The dominant error is due to uncertainty in the jet energy scale. Jets are corrected both for calorimeter effects and for gluon radiation that falls outside of the jet cone. Studying the E_T balance in $Z+$ multijet events gives a scale

uncertainty of 4% with a 1 GeV constant term, giving an uncertainty in m_t of ± 7.3 GeV/c^2. Differences in models of top quark production (between ISAJET and HERWIG) and in the W + multijet background add ± 3.3 GeV/c^2 and the limits of the Monte Carlo statistics another ± 2.0 GeV/c^2. Summing these in quadrature gives a systematic uncertainty of ± 8.3 GeV/c^2.

12 Mass Fitting Using Topological Variables

As a cross-check to the kinematic fitting result, mass analyses are also performed using topological variables which are highly correlated with the top quark mass as mass estimators for each event. Three such variables are $H_{T\ell} \equiv \sum_{\text{jets},\ell} E_T$, $M_T \equiv$ transverse mass of ℓ + jets system, and M, the mass of the ℓ + jets system. The event sample fit consists of 34 events with an expected background of 19.6 ± 2.6 events, and an unbinned maximum likelihood fit is performed with background unconstrained. The result for the $H_{T\ell}$ fit is $m_t = 170 \pm 18(stat) \pm 10(syst)$ GeV/c^2, while the M_T and M fits have central values of 171 and 163 GeV/c^2, with similar errors.

13 Dilepton Analysis

DØ has also measured the top quark mass using the sample of three events in the $e\mu$ channel, for which the background is low. The second ν in the final state renders a kinematic fit impossible, so one must consider a range of top quark masses consistent with the event kinematics and assign a probability for each solution. Two methods of assigning this probability are employed. Method 1, which follows the ideas of Dalitz, Goldstein, and Kondo [1], finds $m_t = 158 \pm 24(stat) \pm 10(syst)$ GeV/c^2. Method 2, which integrates over the ν phase space, gives a similar result: $m_t = 157 \pm 23(stat) \pm 9(syst)$ GeV/c^2.

14 Conclusions

DØ has measured the top quark mass using 32 events in the ℓ + jets decay channel, and finds $m_t = 169 \pm 8(stat) \pm 8(syst)$ GeV/c^2. Cross-checks using topological variables rather than constrained kinematic fitting to estimate the mass give consistent results, as do fits using the smaller sample of $e\mu$ events.

References

1. R.H. Dalitz and G.R. Goldstein, *Phys. Rev.* D **45**, 1531 (1992); K. Kondo, *J. Phys. Soc. Japan* **60**, 836 (1991)