

Preface

The top quark is by far the heaviest known fundamental particle with a mass nearing that of a gold atom. Because of this strikingly high mass, the top quark has several unique properties and might play an important role in electroweak symmetry breaking—the mechanism that gives all elementary particles mass. Creating top quarks requires access to very high energy collisions, and at present only the Tevatron collider at Fermilab is capable of reaching these energies.

Until now, top quarks have only been observed produced in pairs via the strong interaction. At hadron colliders, it should also be possible to produce single top quarks via the electroweak interaction. Studies of single top quark production provide opportunities to measure the top quark spin, how top quarks mix with other quarks, and to look for new physics beyond the standard model. Because of these interesting properties, scientists have been looking for single top quarks for more than 15 years.

This thesis presents the first discovery of single top quark production. An analysis is performed using 2.3 fb^{-1} of data recorded by the DØ detector at the Fermilab Tevatron Collider at centre-of-mass energy $\sqrt{s} = 1.96 \text{ TeV}$. Boosted decision trees are used to isolate the single top signal from background, and the single top cross section is measured to be $\sigma(\bar{p}p \rightarrow tb + X, tqb + X) = 3.74^{+0.95}_{-0.74} \text{ pb}$.

Using the same analysis, a measurement of the amplitude of the CKM matrix element V_{tb} , governing how top and b quarks mix, is also performed. The measurement yields: $|V_{tb}f_1^L| = 1.05^{+0.13}_{-0.12}$, where f_1^L is the left-handed Wtb coupling. The separation of signal from background is improved by combining the boosted decision trees with two other multivariate techniques. A new cross section measurement is performed, and the significance for the excess over the predicted background exceeds 5 standard deviations.



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