The top quark has only been observed when produced in pairs of top and antitop by means of the strong interaction. But top quarks may also be produced through the electroweak interaction, and produced alone, along with a bottom quark. The production rate of this “single top quark” process is smaller than that of pairs of top quarks and it poses an experimental problem to disentangle from the large backgrounds, one of which is pair production itself! We expect to observe this new mode of production at the Tevatron and look for deviations from the Standard Model.

**Single Top Quark Production**

According to the Standard Model, at the Tevatron top quarks can be produced via the exchange of a W-boson in two dominant modes: s-channel and t-channel.

\[ q \rightarrow W^+ t \]

30% s-channel

\[ b \rightarrow W^- b \]

70% t-channel

The theoretically expected production rate (cross-section) at the Tevatron’s center of mass energy of 1.96 TeV is 2.9 picobarns (1 pb = 10^{-12} barn = 10^{-26} cm²), 0.88 pb for the s-channel and 1.98 pb for the t-channel. The final state, concentrating only on semileptonic top decays (t\rightarrow bW\rightarrow blν), consists of: one isolated lepton, missing transverse energy (neutrino), and two b-jets or one b-jet and a light (non-b) jet.

By observing the interaction vertex between a W-boson, a top quark and a bottom quark at production, we can measure directly - and for the first time- the strength of the coupling between these particles: the so-called V_{tb} element of the Cabibbo-Kowayashi-Maskawa (CKM) mixing matrix. So far only indirect constraints exist on this parameter.

But the interest of this process goes beyond the Standard Model:

- **New heavy particles** could enhance the production cross section in the s-channel.
- **Anomalous couplings** (like those predicted from a 4th family of quarks or other exotic theories) would enhance the t-channel production.

Thus, top quarks offer a vantage point to study new phenomena beyond the Standard Model given their high mass and their preferred coupling to the Higgs boson that is thought to give mass to all particles.

**Search for Single Top Quarks**

Events are selected loosely, trying to keep a high acceptance since this is a search, with a basic set of cuts: One electron or muon with p_T>15 GeV, Missing Energy >15 GeV, and 2, 3 or 4 jets each with energy >15 GeV, the leading jet with energy >25 GeV.

We apply the Jet Lifetime Probability (JLIP) algorithm to identify a b-jet with ~50% efficiency and ~99.6% purity, greatly reducing the W+jets and multijet backgrounds. The algorithm relies on the fact that tracks from B-hadrons have a large impact parameter with respect to the primary vertex.

At this point we expect around 25 single top events in our data sample of 443 events, where we expect some 451 background events.

**Summary of Results and Projected Sensitivity**

Likelihood discriminant results with 370pb^{-1} of data, 95% CL upper limits:

- s-channel cross section < 5.0 pb
- t-channel cross section < 4.4 pb

Neural networks and likelihoods have similar sensitivity.

Most stringent limits obtained thanks to:

- **Multivariate analysis** (NN and Lhood)
- Use the shape information from the multivariate output to set the limits

- **Exclusion on the plane of s- and t-channel cross sections.** The colored points represent models of physics beyond the Standard Model.

- **Given the current D0 analysis, we would need a few fb^{-1} for an observation.** But of course we are going to improve the analysis, so expect an observation sooner!