Search for Single-Top Production at the Tevatron

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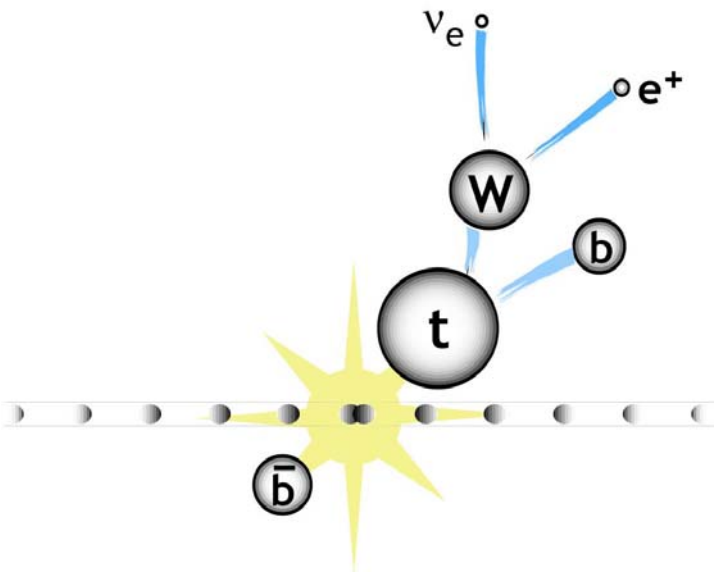
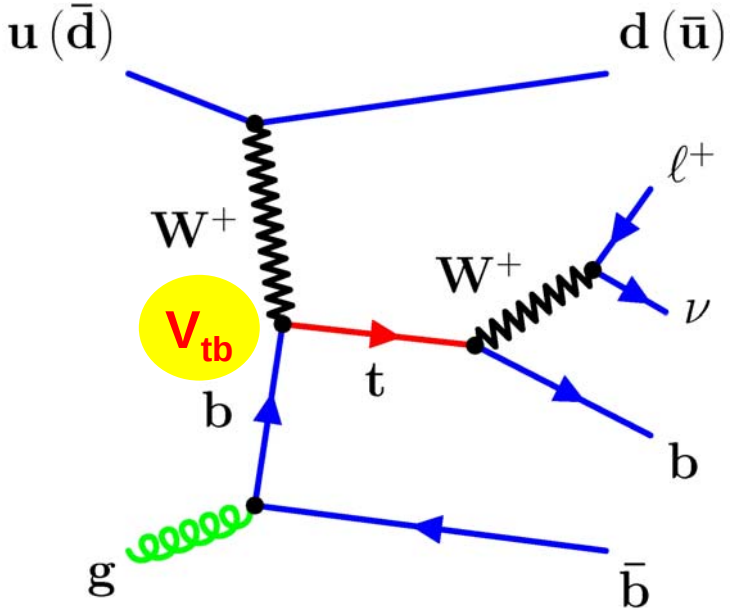


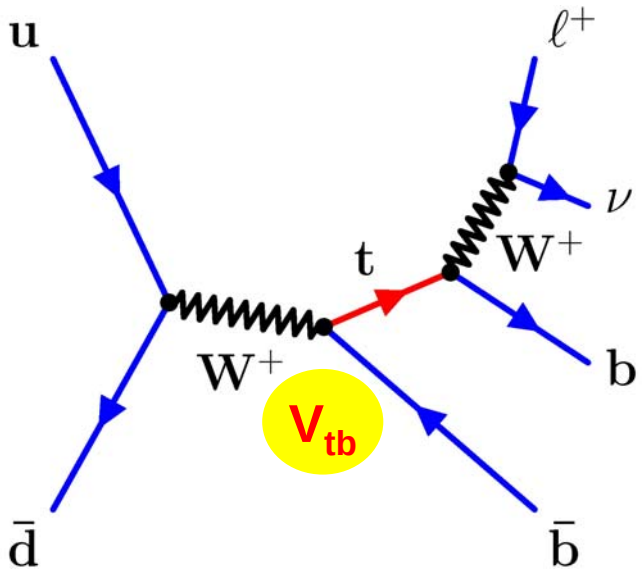
Contents:

Single-Top Quark Production

Top quark production via the weak interaction



t-channel



s-channel

Theoretical cross section predictions at $\sqrt{s}$ = 1.96 TeV

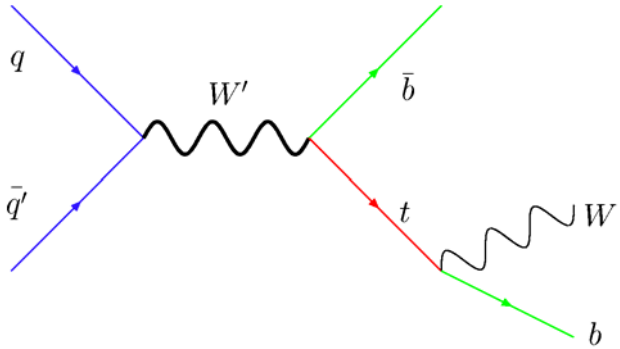
1.98 ± 0.25 pb **0.88 ± 0.11 pb**

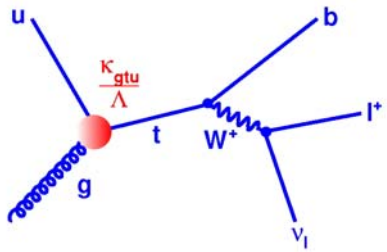
B.W. Harris et al. Phys. Rev. D 66:054024 (2002)

compatible results: Campbell/Ellis/Tramontano, Phys. Rev. D 70:094012 (2004)

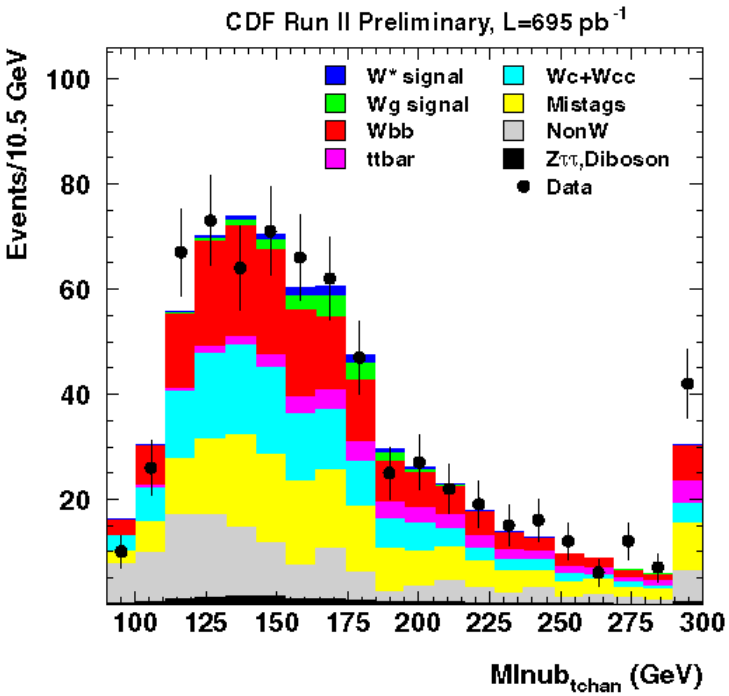
Why look for Single-Top ?

1. Test of the SM prediction. Does it exist?
   - Cross section $\propto |V_{tb}|^2$
     Test unitarity of the CKM matrix, .e.g. $V_{ub}^2 + V_{cb}^2 + V_{tb}^2 \stackrel{?}{=} 1$
     Hints for existence of a 4th generation ?
   - Test of *b* quark structure function: DGLAP evolution
2. Same final state signature as Higgs: WH, H $\rightarrow$ bbbar.
   Understanding single-top backgrounds is prerequisite for Higgs searches at the Tevatron.
3. Test non-SM phenomena
   - Search W' or H^+ (s-channel signature)
   - Search for FCNC, e.g. ug $\rightarrow$ t
   - ...





Single-Top Sample at CDF



- **1 isolated high-P_T lepton (e,μ)**
  p_T > 20 GeV, $|\eta_e| < 2.0$ and $|\eta_\mu| < 1.0$
- **MET > 20 GeV**
- **Jets: N_{jets}= 2, E_T > 15 GeV, $|\eta| < 2.8$**
  ≥ 1 b tag (secondary vertex)

Backgrounds are the challenge

Main Backgrounds:

W + jets, $b\bar{b}$, $t\bar{t}$, Z + jets, diboson

After event selection: S/B = 1/20

Total predicted Background	646 ± 96
Predicted SingleTop	28.2 ± 2.6
Observation	689

using CDF II data with L_{int} = 695 pb^{-1}

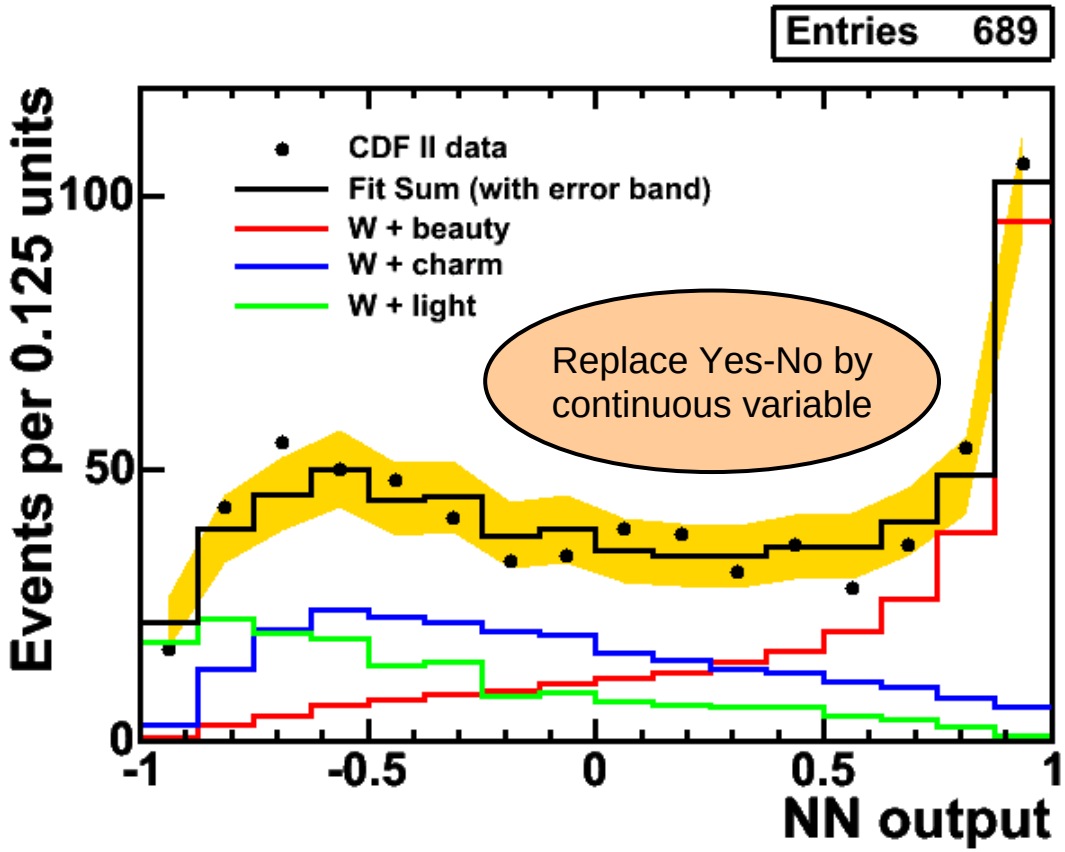
Improved *b* Jet Identification

About 50% of the background in the W+2 jets sample do NOT contain b quarks !

Combine jet and track variables to one powerful discriminant using a neural network.
e.g. vertex mass, decay length, track multiplicity

New possibility:
In situ measurement of the flavor composition in the W + 2 jets sample

Fit to NN output for W + 2 jets events with one secondary vertex (695 pb^{-1})



c-like / mistags …… b-like

Search Strategies

Follow two search strategies:

1. „Combined Search“
   t-channel and s-channel single-top regarded as one single-top signal.
   Cross section ratio is fixed to SM value.
   Important for „discovery“ and test $|V_{tb}| << 1$
2. „Separate Search“
   t-channel and s-channel are regarded as separate processes
   2D fit in $\sigma(s)$ vs. $\sigma(t)$ plane
   important to be sensitive to new physics processes

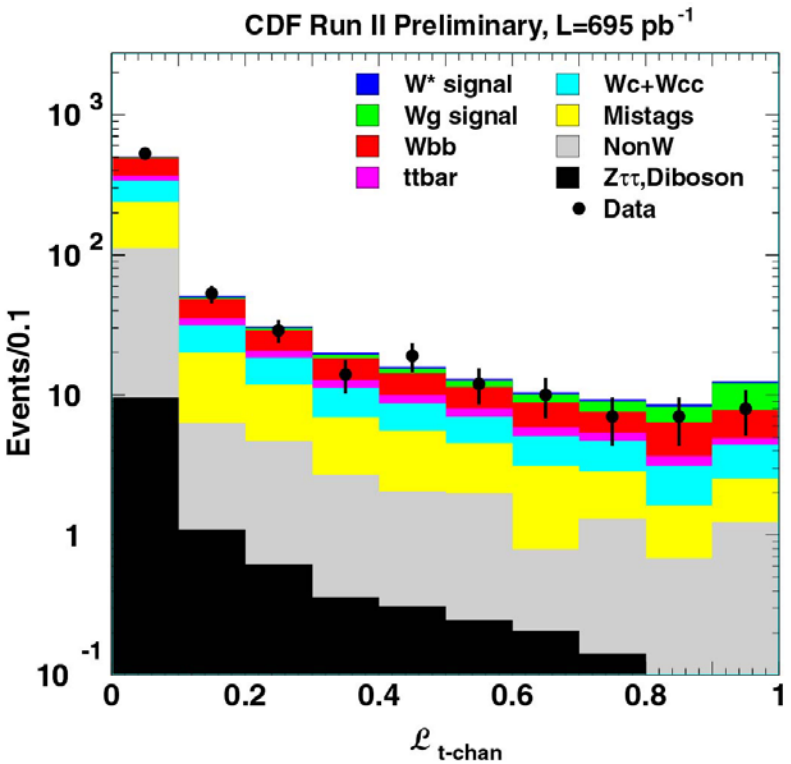
Currently two methods to combine many discriminating variables:

1. Likelihood functions (including kinematic fit)
2. Neural networks (take advantage of correlations)

Matrix element analysis will become public shortly.

Likelihood Function Results

t-channel likelihood function



Observe deficit in the signal region!

Use t- and s-channel likelihood function

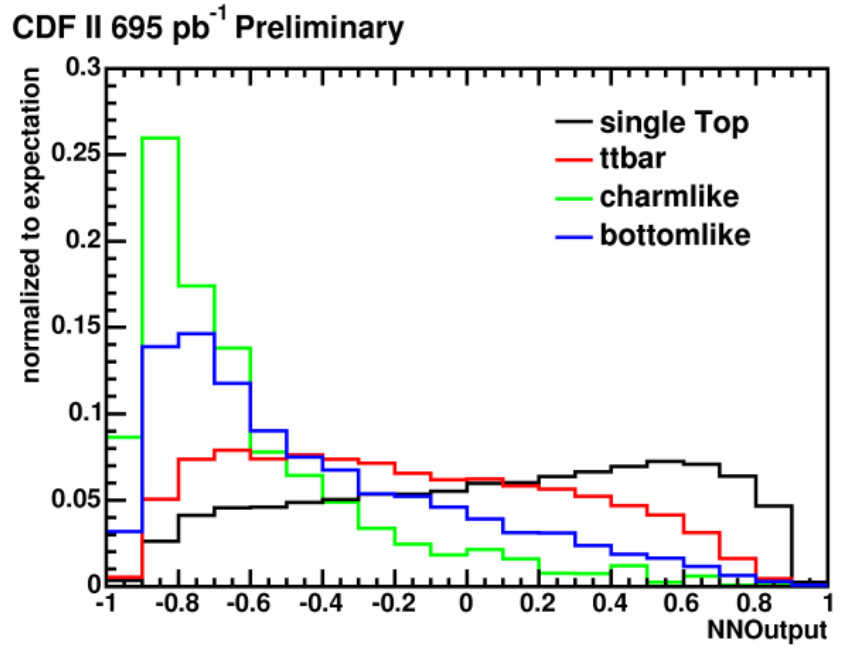
	1 - CL_b	95% C.L. limit
t-channel	39.4%	2.9 pb
s-channel	37.5%	5.1 pb
combined (expected)	25.6% (3.9%)	4.3 pb (3.4 pb)

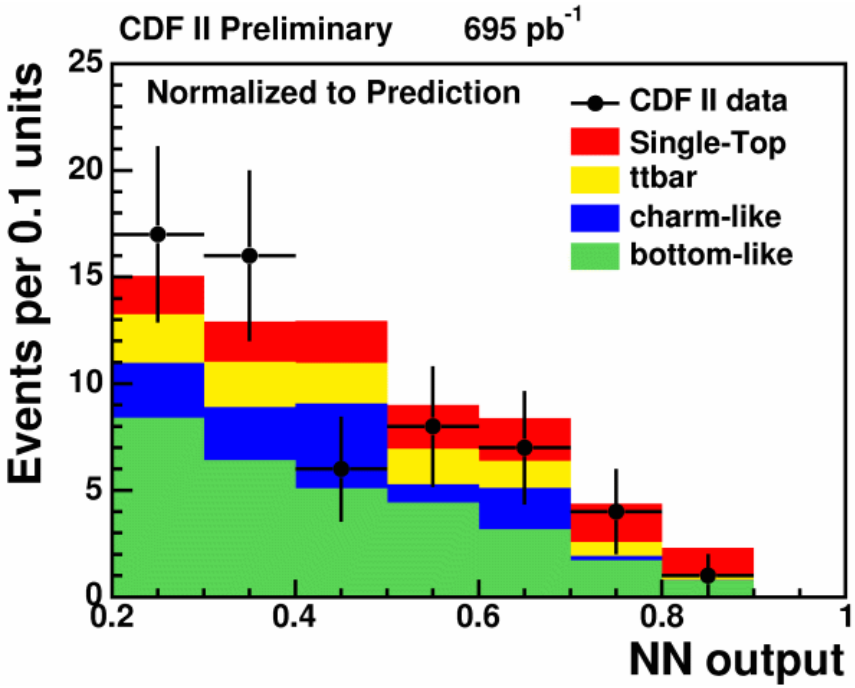
1-CL_b = probability that observation is due to background fluctuation alone

Expected limits: assume no single-top present in ensemble tests

Combined s+t Neural Network Search

signal- and background templates





(only signal region shown, fit perfomed on entire output domain)

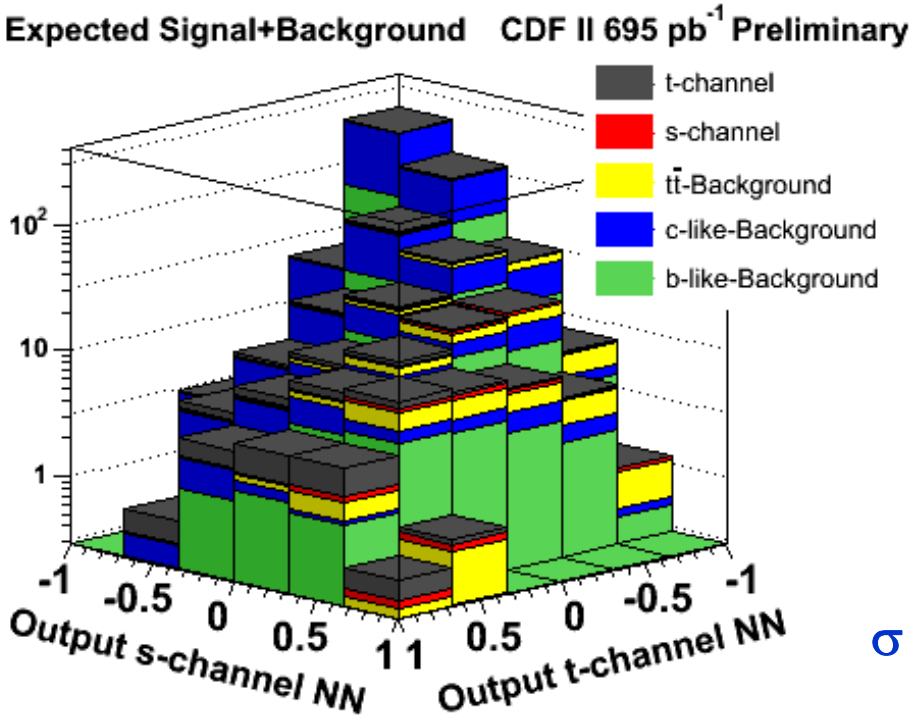
14 variables are used: $Q \cdot \eta$, $M_{l\nu b}$, $\cos\theta_{lb}$, Jet E_T and η, NN b tag, η_W, …

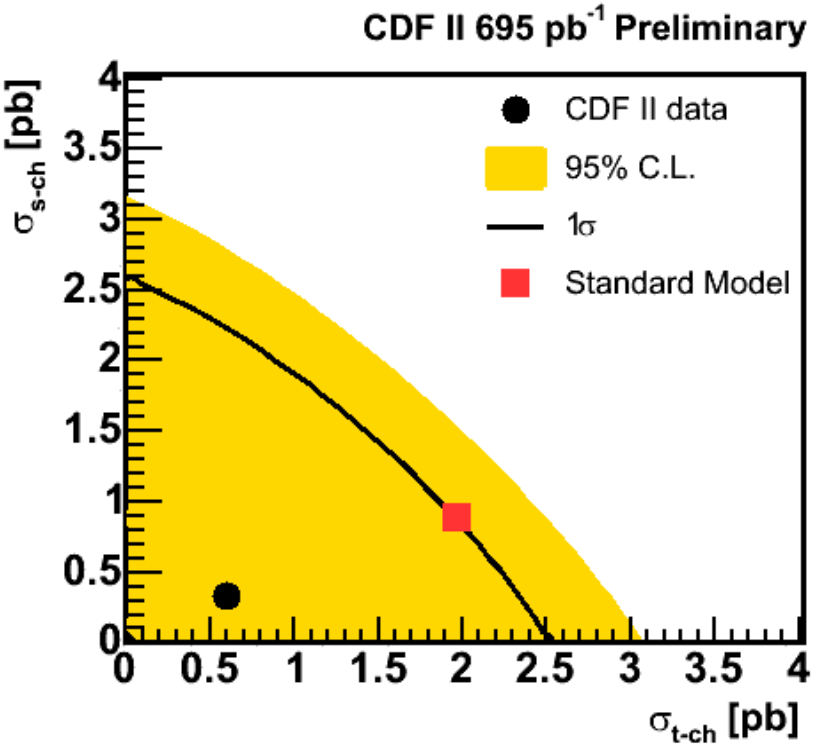
$\sigma_{Fit} = 0.8\ ^{+1.3}_{-0.8}\ (stat)\ ^{+0.2}_{-0.3}\ (syst)$ pb

$\sigma_{SM} = 2.9 \pm 0.4$ pb (Prediction)

Separate Neural Net Search

Use two networks to separate
t- and s-channel



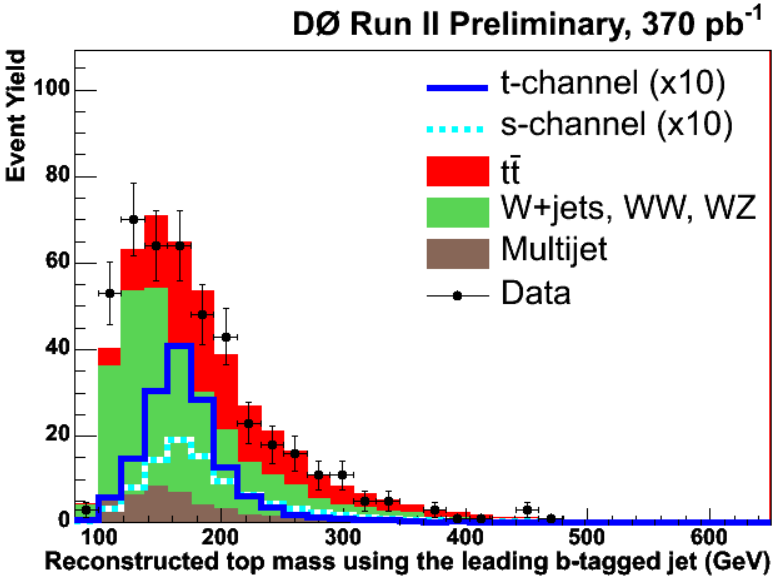


σ (t-channel) < 3.1 pb (SM: 1.98 pb)

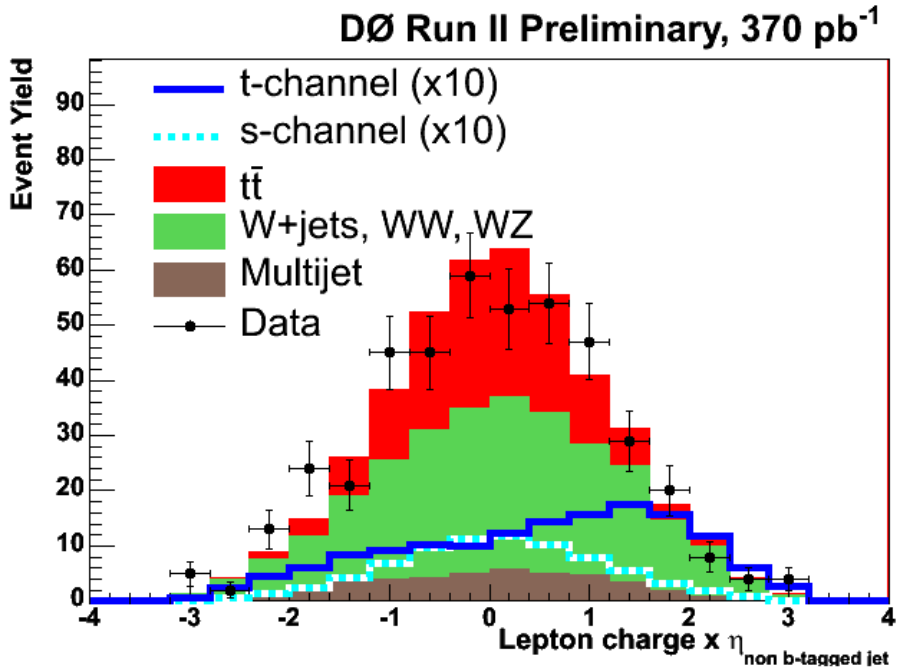
σ (s-channel) < 3.2 pb (SM: 0.88 pb)

Single-Top Sample at D0

t-channel	15.0
s-channel	9.5
expected background	452
observed data	443
= 1 b-tag	367
≥ 2 b-tags	76

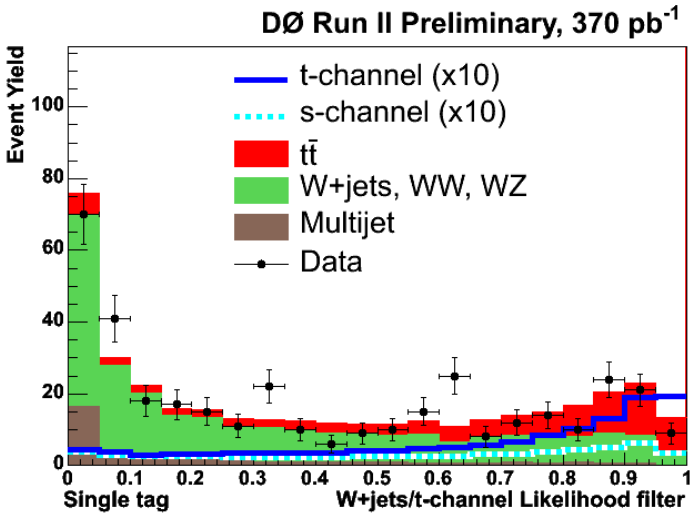


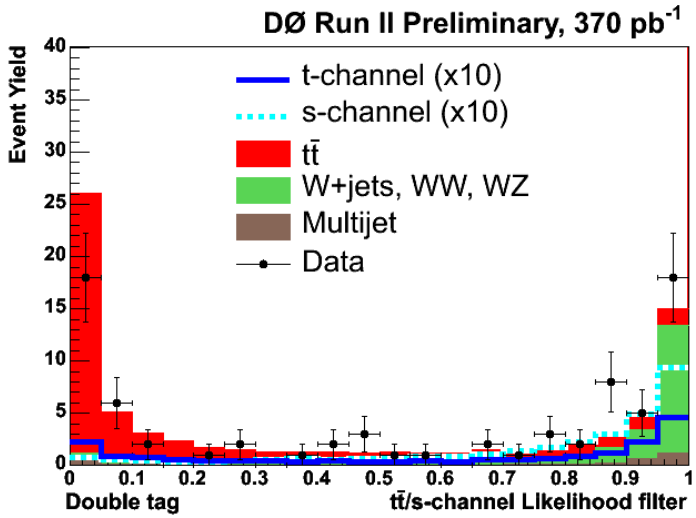
Likelihood Discriminant Analysis with 370 pb^{-1}



- **1 isolated lepton (e,μ)**
  p_T > 15 GeV, $|\eta_e| < 1.1$ and $|\eta_\mu| < 2.0$
- **MET > 15 GeV**
- **Jets: $2 \leq N_{jets} \leq 4$, E_T > 15 GeV, $|\eta| < 3.4$**
  Jet 1: E_T > 25 GeV
  ≥ 1 b tag

Likelihood Discriminant Results





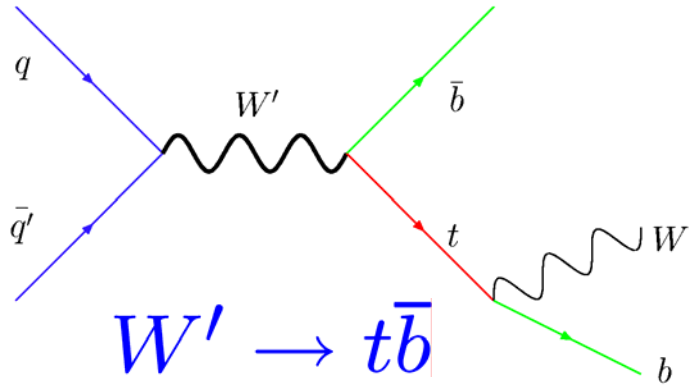
σ (t-channel) < 4.4 pb (SM: 1.98 pb; expected limit: 4.3 pb)

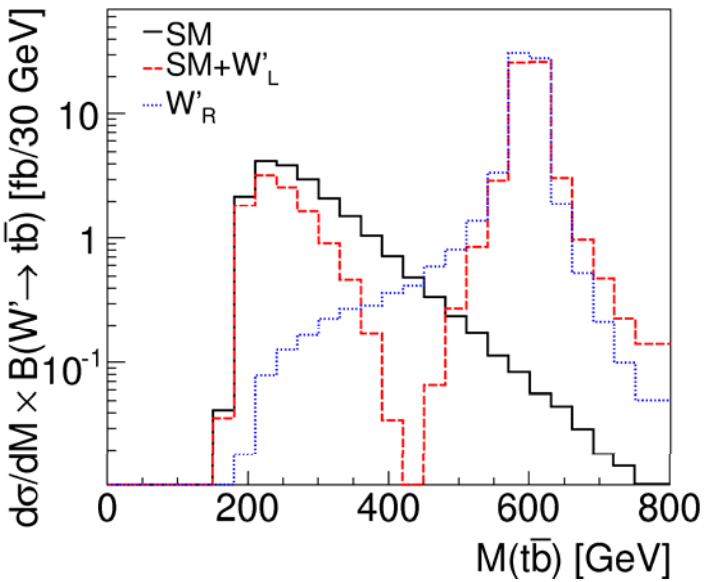
σ (s-channel) < 5.0 pb (SM: 0.88 pb; expected limit: 3.3 pb)

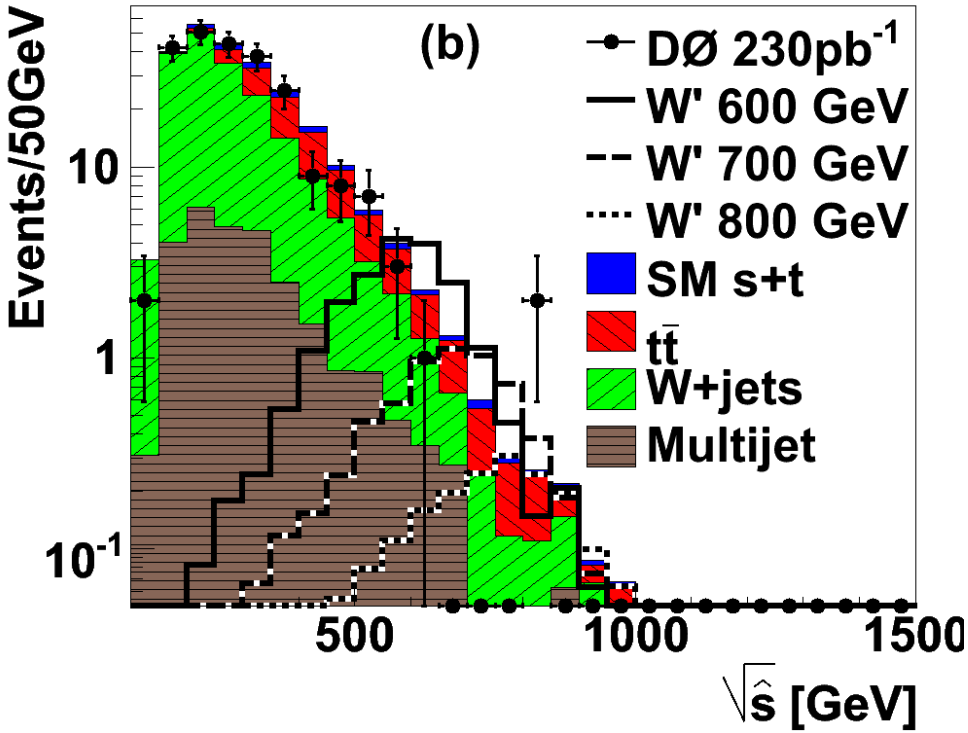
- Dataset is subdivided:
  electron/muon channels $\otimes$ 1-tag / $\geq$ 2-tags
- Likelihood discriminants for:
  s-channel / t-channel vs. ttbar / W+jets
- Total of 16 likelihood discriminants: combined fit to 4 2D distributions

Search for W` → tbbar events

- New: take W` and SM s-channel interference into account (CompHEP)
- distinguish W`$_L$ and W`$_R$
- Use M(lνbj) as discriminant

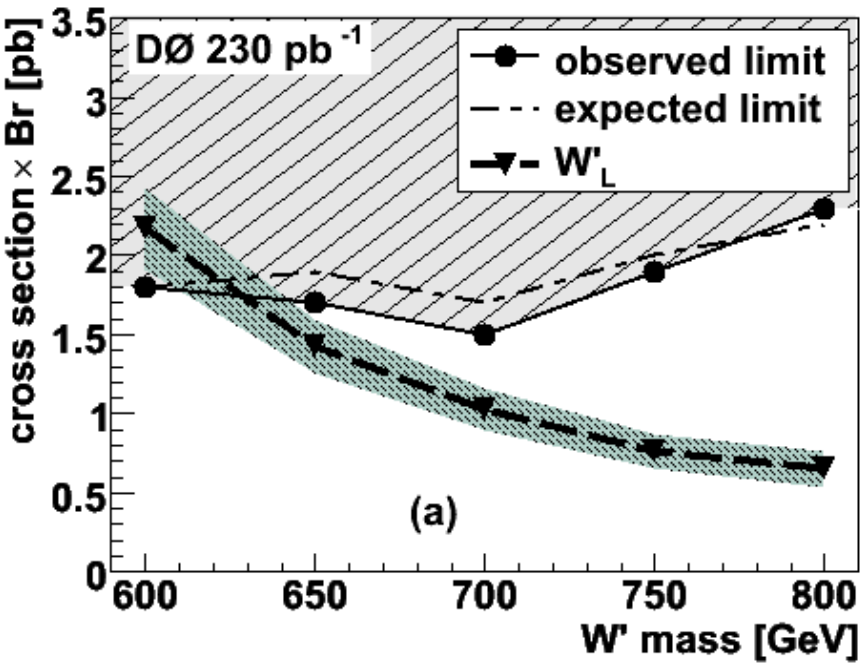


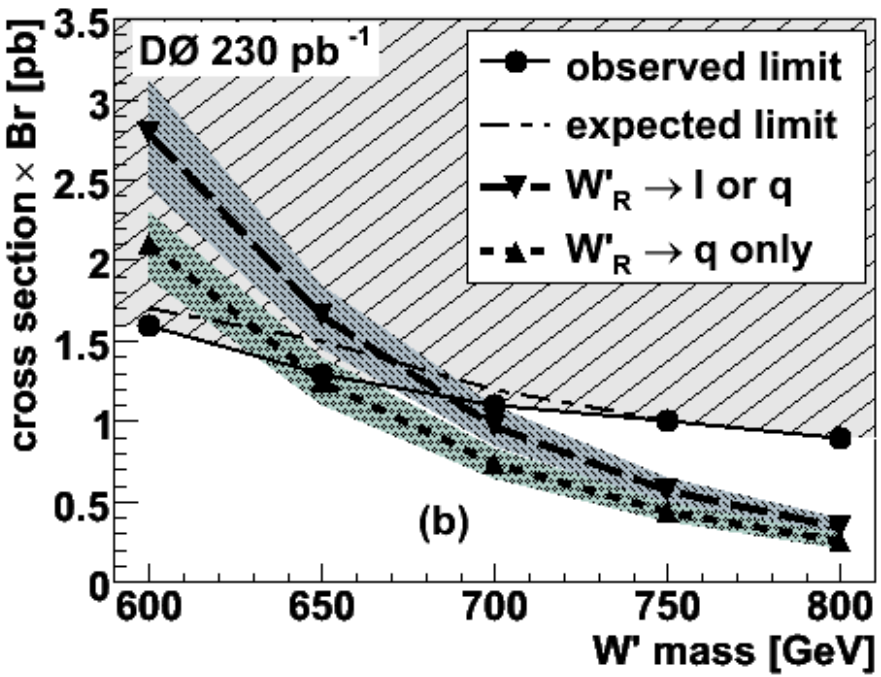




Mass Limits on W`

- New mass limits: $M(W`_L) > 610$ GeV, $M(W`_R) > 630$ GeV
- Best previous limit in $W`_R \rightarrow$ tbbar: $M(W`_R) > 566$ GeV,
  CDF Run I, PRL 90:081802 (2003)
  Complementary searches: $W` \rightarrow e\nu$ / $\mu\nu$
- Submitted to Phys. Lett. B





Conclusions / Plans

- Searches for single-top production enter interesting phase.
- Upper limits approach predicted cross section values:
  CDF (695 pb^{-1}): σ (s+t) < 3.4 pb
  σ (t) < 2.9 pb σ (s) < 3.2 pb
  (CDF observes a deficit; expected a 2 σ excess in 50% of ensemble tests)
  D0 (370 pb^{-1}): σ (t) < 4.4 pb σ (s) < 5.0 pb
- Updates and new analyses with 1 fb^{-1} are underway.
  Expected sensitivity of individual analyses: $\approx$ 2.5 σ
  Individual analyses will be combined !
- Stay tuned for new results in fall !