Search for Single-Top Production at CDF

New Results with 695 pb^{-1}

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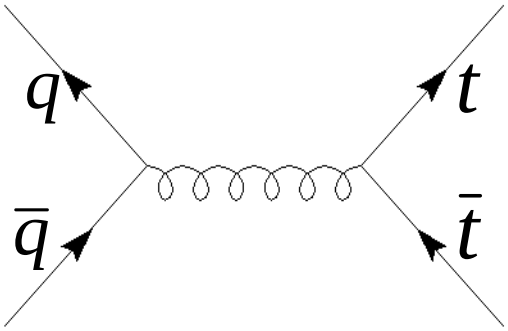
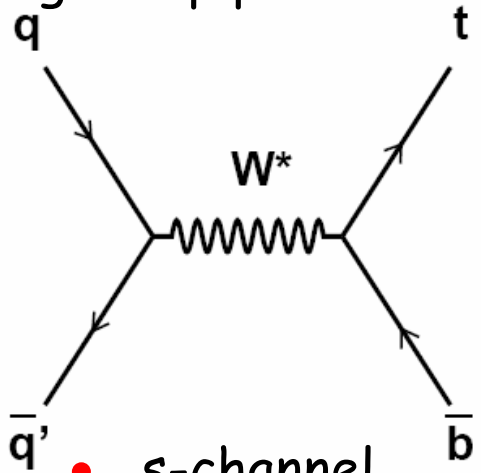
for the CDF Collaboration

Production and Decay at Tevatron

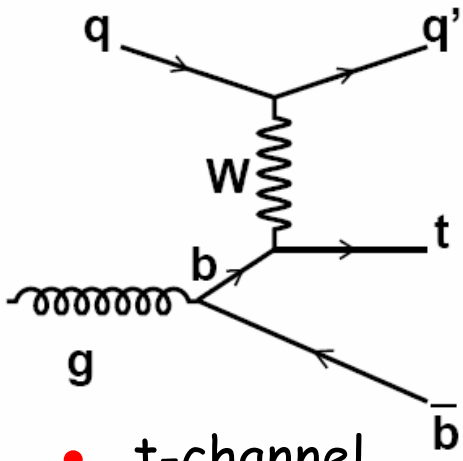


- Pair production
  - Strong interaction
  - σ_{NLO} = 6.7 pb

Single-top production: Electroweak interaction

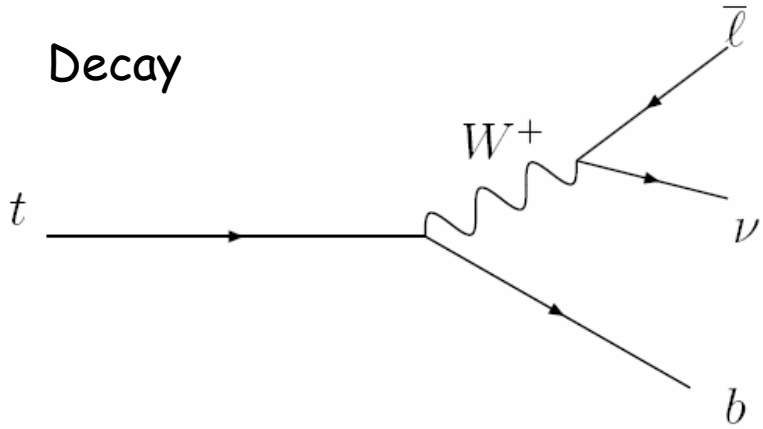


- s-channel
  - σ_{NLO} = 0.88 pb



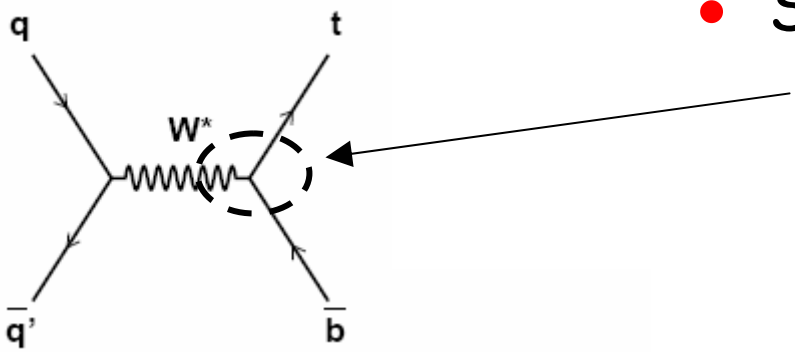
- t-channel
  - σ_{NLO} = 1.98 pb

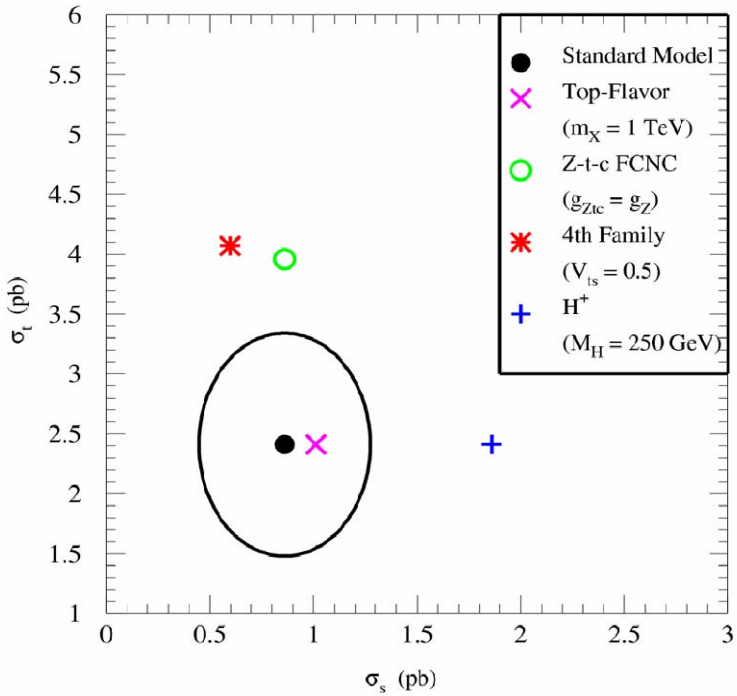
Decay



- Single-top
  - Lepton + MET + 2 jets
- Pair production
  - 2 leptons + MET + 2 jets
  - Lepton + MET + 4 jets

Standard Model and Beyond

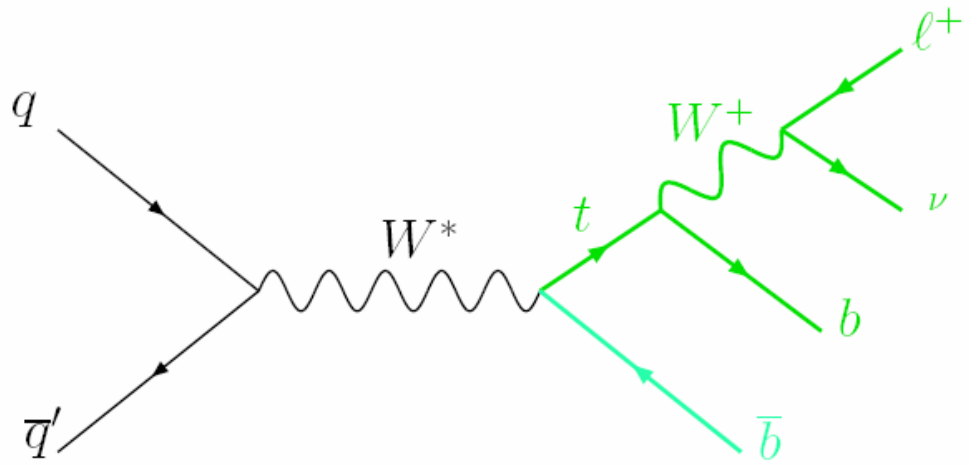




Tait, Yuan PRD63, 014018(2001)

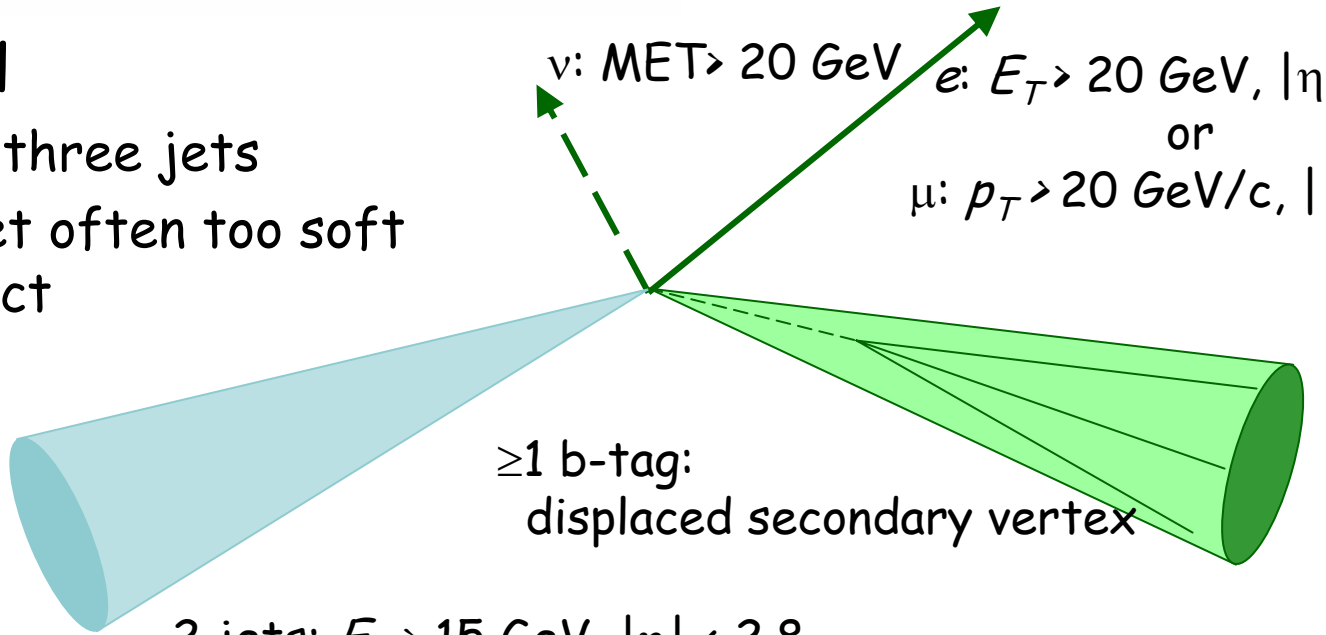
- Standard Model
  - Rate $\propto |V_{tb}|^2$
  - Spin polarization probes V-A structure
  - Background for other searches (Higgs)
- Beyond the Standard Model
  - Sensitive to a 4th generation
  - Flavor changing neutral currents
  - Additional heavy charged bosons
    - W′ or H^+
- New physics can affect s-channel and t-channel differently

Single-Top Signature at CDF



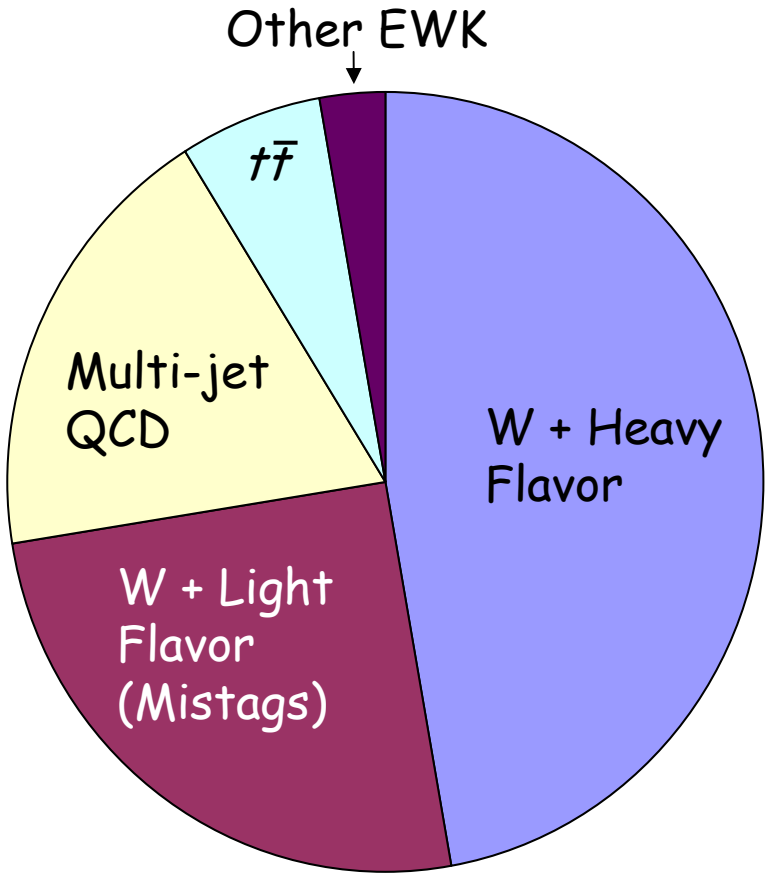
- s-channel
  - Two jets
  - One from top decay
  - 2nd jet also a *b*-jet

- t-channel
  - Two or three jets
  - 2nd *b*-jet often too soft to detect



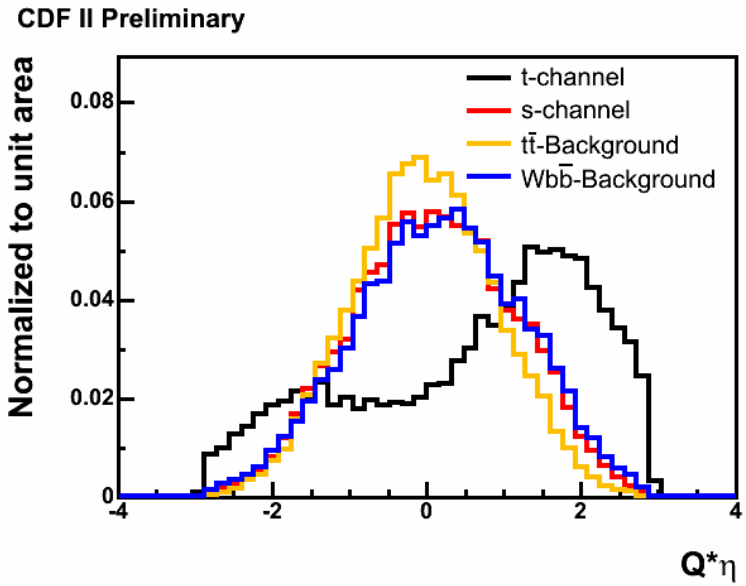
Backgrounds

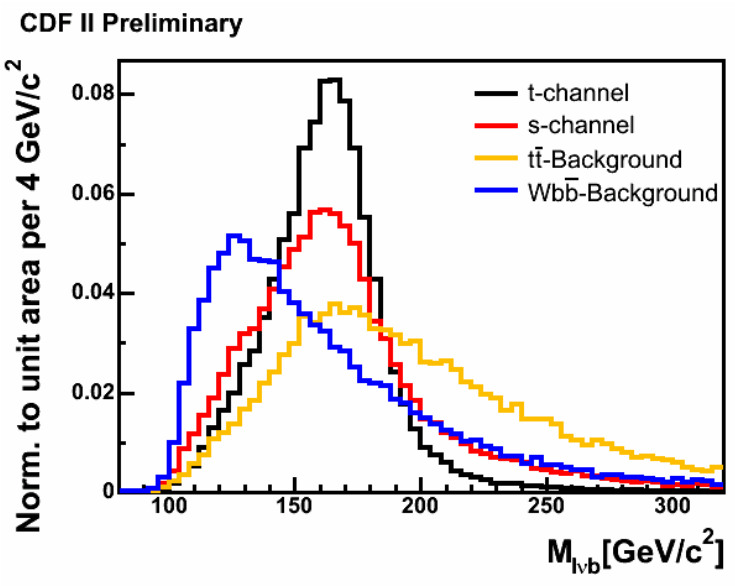
- *W* + Heavy Flavor
  - W + $b\bar{b}$
  - W + $c\bar{c}$
  - W + *c*
- *W* + jets production (mistags)
  - Light flavor jet tagged because of poorly reconstructed tracks
- Multi-jet QCD
  - Jet faking lepton
  - *bb* production with semileptonic decay
- Top pair production
  - Mainly dilepton channel where one lepton is not reconstructed
- Other EWK backgrounds
  - WW, WZ, Z→ττ, etc.
- Signal / Background ~ 1/20



Total Background: 646±96 events
Expected Single-Top: 28 ± 3 events

Multivariate Methods



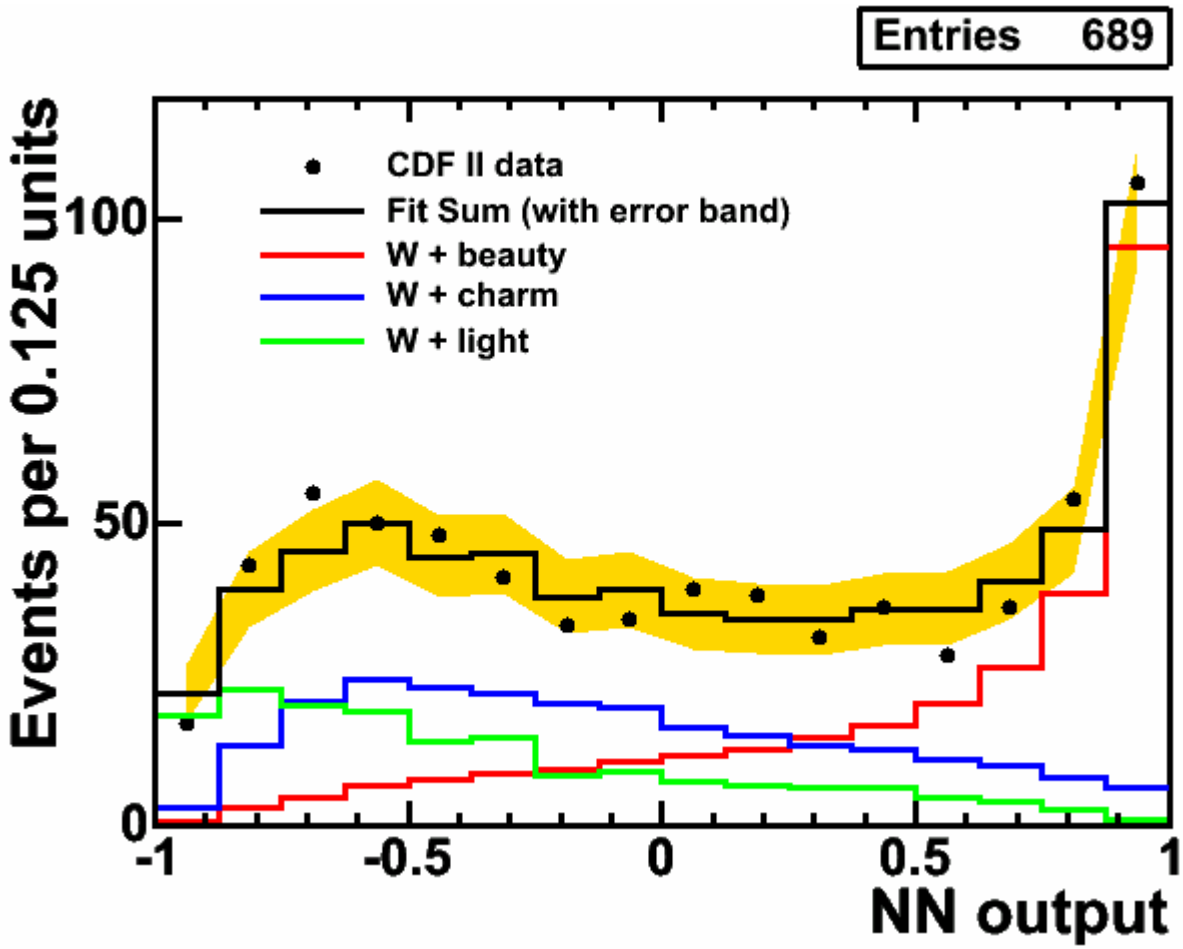


- Multivariate likelihood method
  - Build likelihood by looking at collection of 1-D histograms of signal and background
  - Total likelihood given by product of likelihoods for individual variables
  - Doesn't take advantage of correlations
- Neural Network
  - Maps input variables to continuous distribution between -1 (background) and 1 (signal)
  - Takes correlations among variables into account
  - Obtained through iterative training procedure

Extension to b-tagging

- Sources of W + b-tagged events
  - W + beauty (single-top, W + $b\bar{b}$)
  - W + charm (W + $c\bar{c}$, W + c)
  - W + light (W + mistag)
- Use a Neural Network to separate
  - 25 variables
  - Tag displacement
  - Invariant mass of tagged tracks
  - Track multiplicity
  - Semileptonic decays
- Good separation. If used for cut (NN output > 0):
  - 82% efficiency for real b vertices
  - Rejects 60% of backgrounds

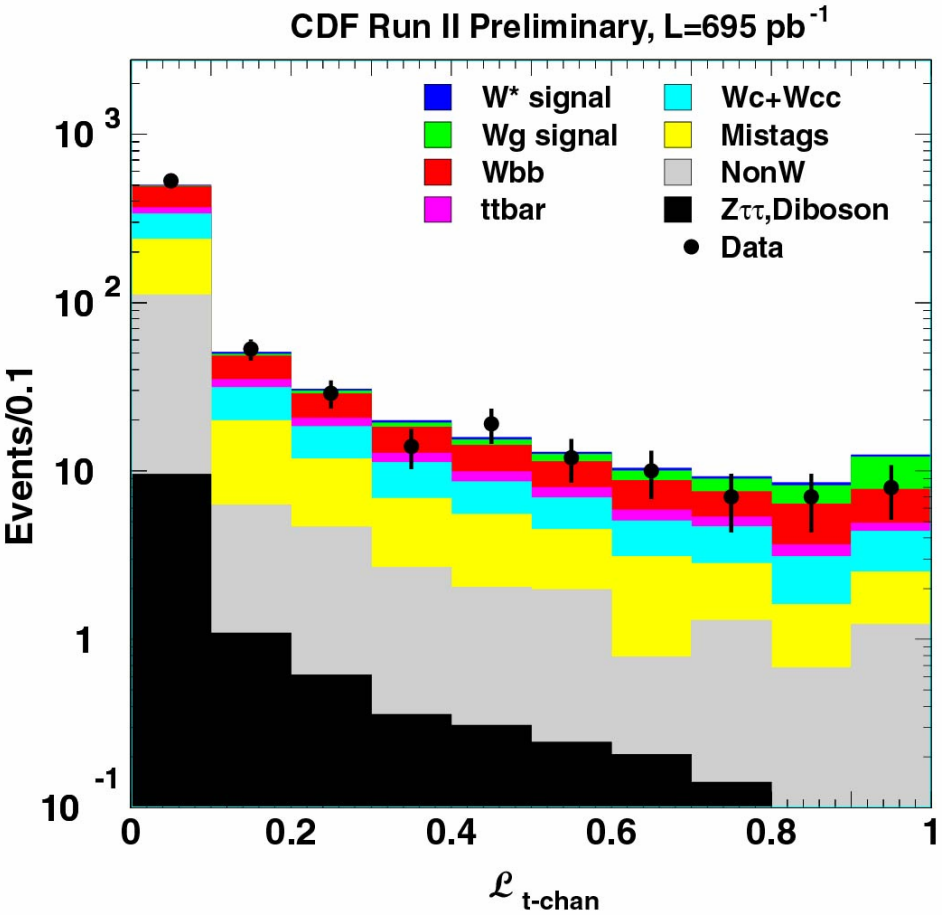
W + 2 jet events with ≥1 b-tag



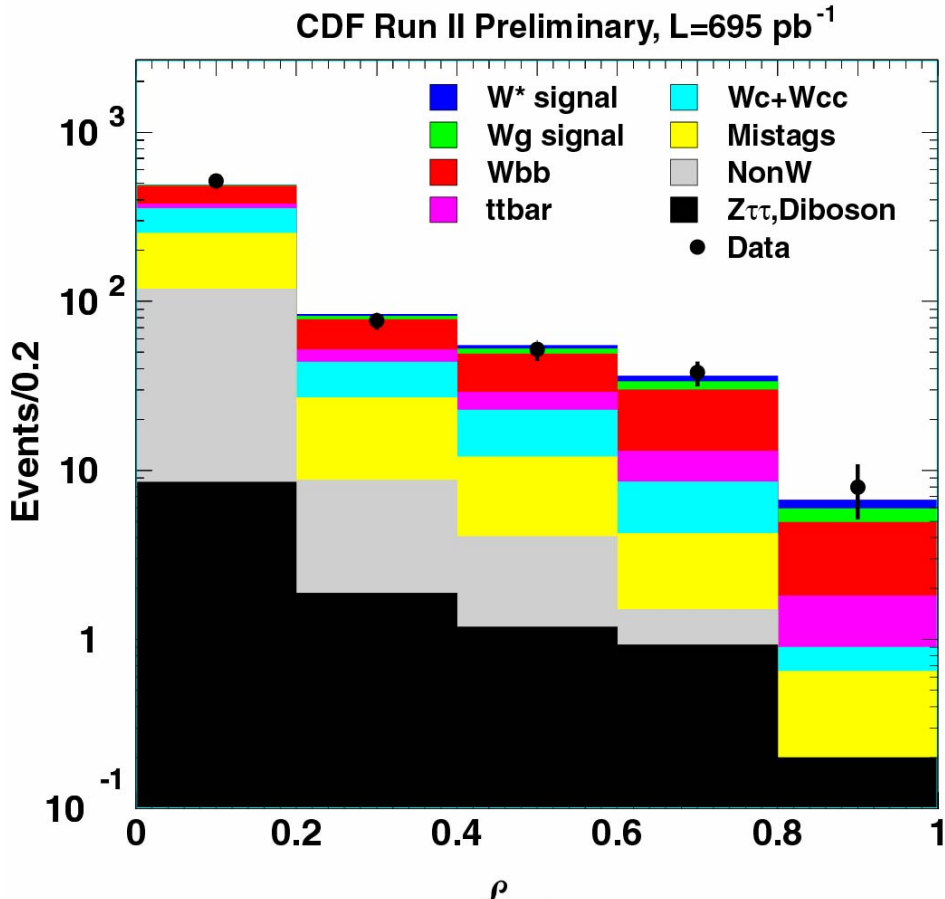
Combined vs Separate Searches

- Combined search
  - Look for s- and t-channel production simultaneously
  - Assume SM ratio between s- and t-channel contributions
  - Best sensitivity for seeing overall single-top
- Separate searches
  - Consider s- and t- channel as independent components
  - Set separate limits on the two processes
  - Useful for searching for non-SM effects
  - Multivariate likelihood
    - Fit for either s- or t-channel with other single-top contribution fixed
  - Neural network analysis
    - Fit for s- and t-channel simultaneously
    - Produce 2-D limit contour

Likelihood



t-channel (7 variables)



s-channel (6 variables)

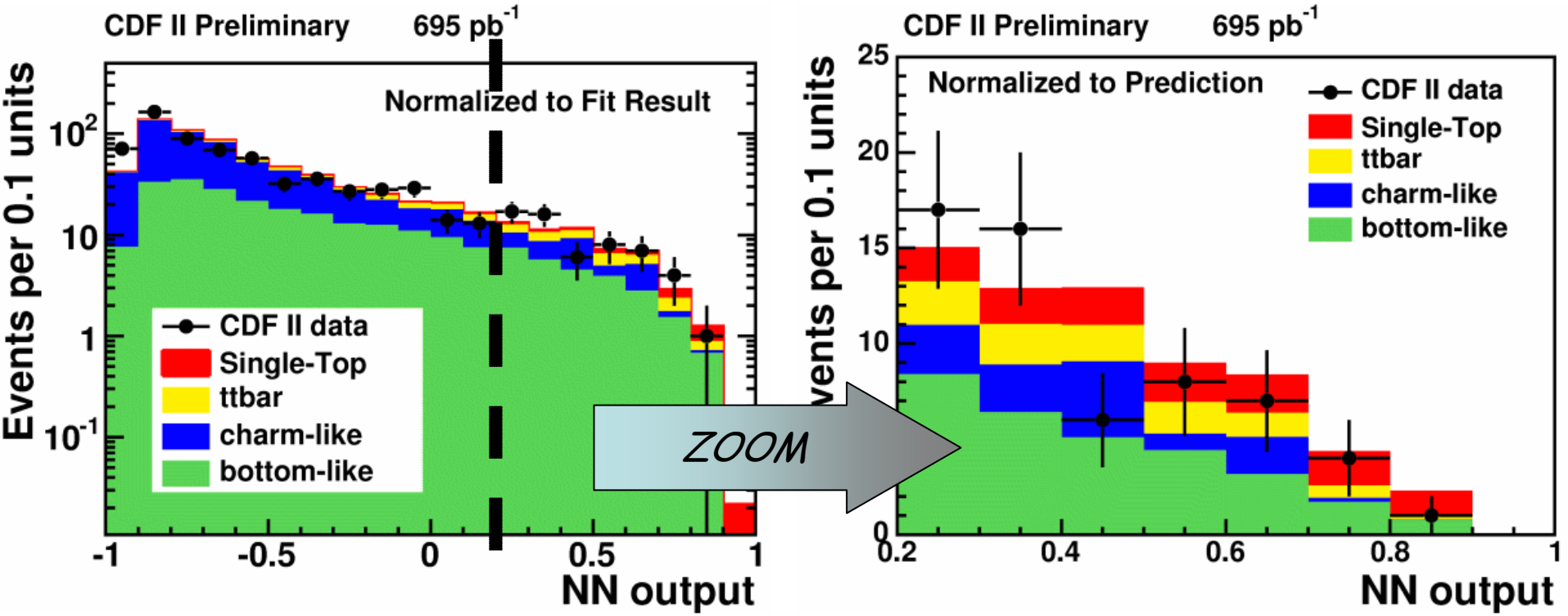
- Variables: H_T, $Q \times \eta$, lepton-neutrino-bottom and dijet invariant masses, angles, NN b-tag output, Leading-order matrix element

Likelihood Results

- Test data against two hypotheses
  - H_0: No single-top; just SM backgrounds
  - H_1: SM backgrounds plus single-top with some cross section
- Set limit by varying cross section for H_1 until we reach 95% confidence level limit
- Expected limits assume SM backgrounds only

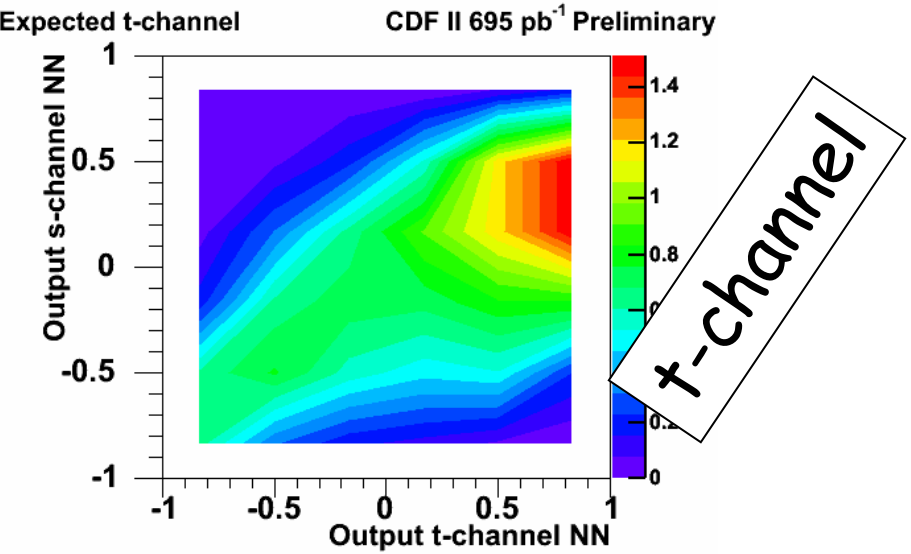
Channel	s+t-channel	t-channel	s-channel
SM expectation (σ_{NLO})	2.9 ± 0.4 pb	2.0 ± 0.3 pb	0.9 ± 0.1 pb
Expect 95% C.L. Limit	3.4 pb	2.6 pb	5.7 pb
Observed 95% C.L. Limit	4.3 pb	2.9 pb	5.1 pb

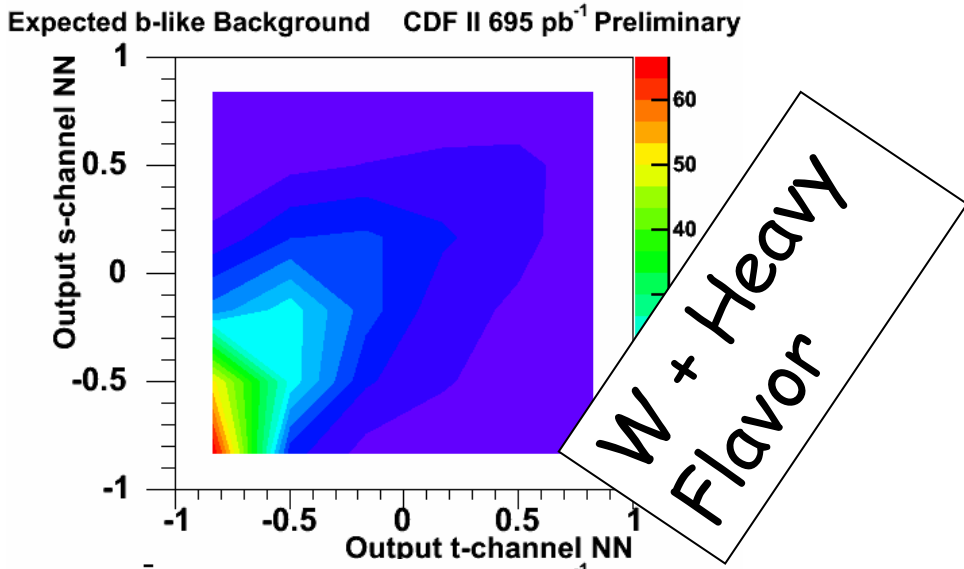
Neural Net (Combined Search)

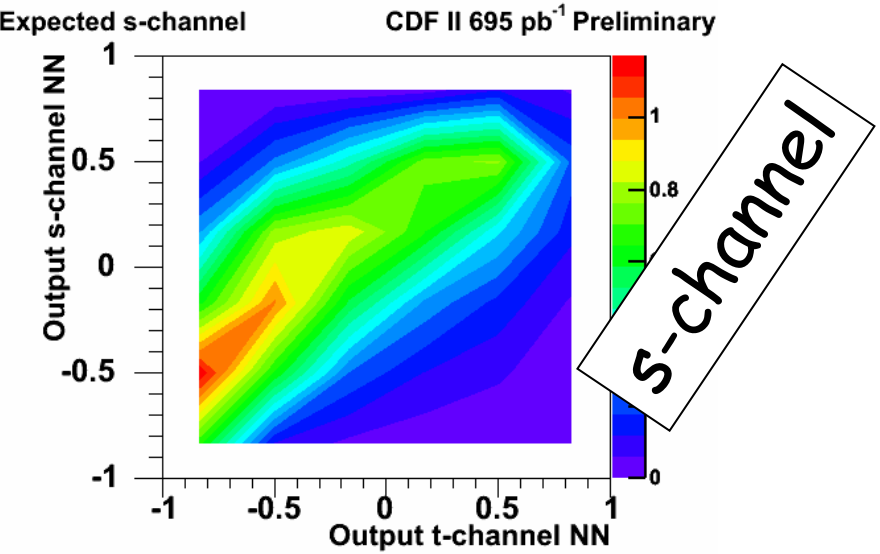


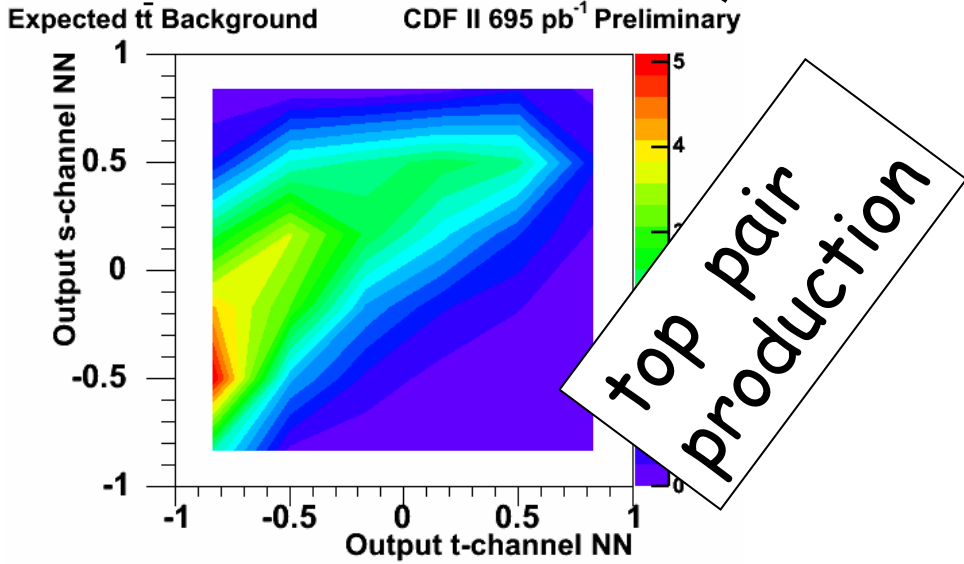
- Single NN trained with combination of s- and t- channel as signal
- 14 Variables: $\ell\nu b$ and dijet invariant masses, $Q\times\eta$, angles, jet E_T and η, W-boson η, kinematic fitter quantities, NN b-tag output

Neural Net (Separate Search)









- Two NN's trained separately for s-channel and t-channel

Neural Net Results

Best fit combined search:

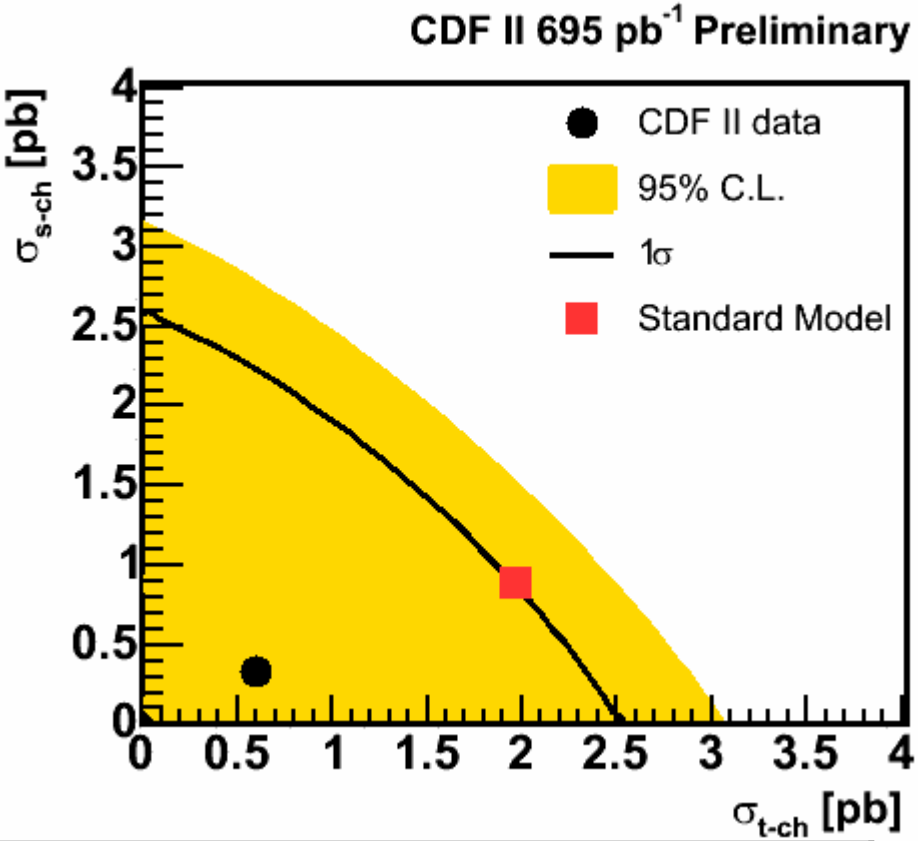
$$\sigma_{t+s} = 0.8^{+1.3}_{-0.8}\,(stat)^{+0.2}_{-0.3}\,(syst)pb$$

Best fit separate search:

$$\sigma_{s-ch} = 0.3^{+2.2}_{-0.3}\,(stat)^{+0.5}_{-0.3}\,(syst)\ pb$$

$$\sigma_{t-ch} = 0.6^{+1.9}_{-0.6}\,(stat)^{+0.1}_{-0.1}\,(syst)pb$$

- Expected 95% confider level limit assumes SM amount of single-top



Channel	s+t-channel	t-channel	s-channel
SM expectation (σ_{NLO})	2.9 ± 0.4 pb	2.0 ± 0.3 pb	0.9 ± 0.1 pb
Expect 95% CL Limit	5.7 pb	4.2 pb	3.7 pb
Observed 95% CL Limit	3.4 pb	3.1 pb	3.2 pb

Conclusion and Prospects

Channel	s+t-channel	t-channel	s-channel
SM expectation (σ_{NLO})	2.9 ± 0.4 pb	2.0 ± 0.3 pb	0.9 ± 0.1 pb
Likelihood $\sigma_{95\%}$	4.3 pb	2.9 pb	5.1 pb
NN $\sigma_{95\%}$	3.4 pb	3.1 pb	3.2 pb

- Current limits are getting close to SM expectation
- Projections (ignoring systematics)
  - 2.4 σ excess with 1 fb^{-1}
  - 3 σ excess around 1.5 fb^{-1}
- We currently have ~ 1 fb^{-1} of analysis quality data ready to analyze for the summer
- Stay tuned!