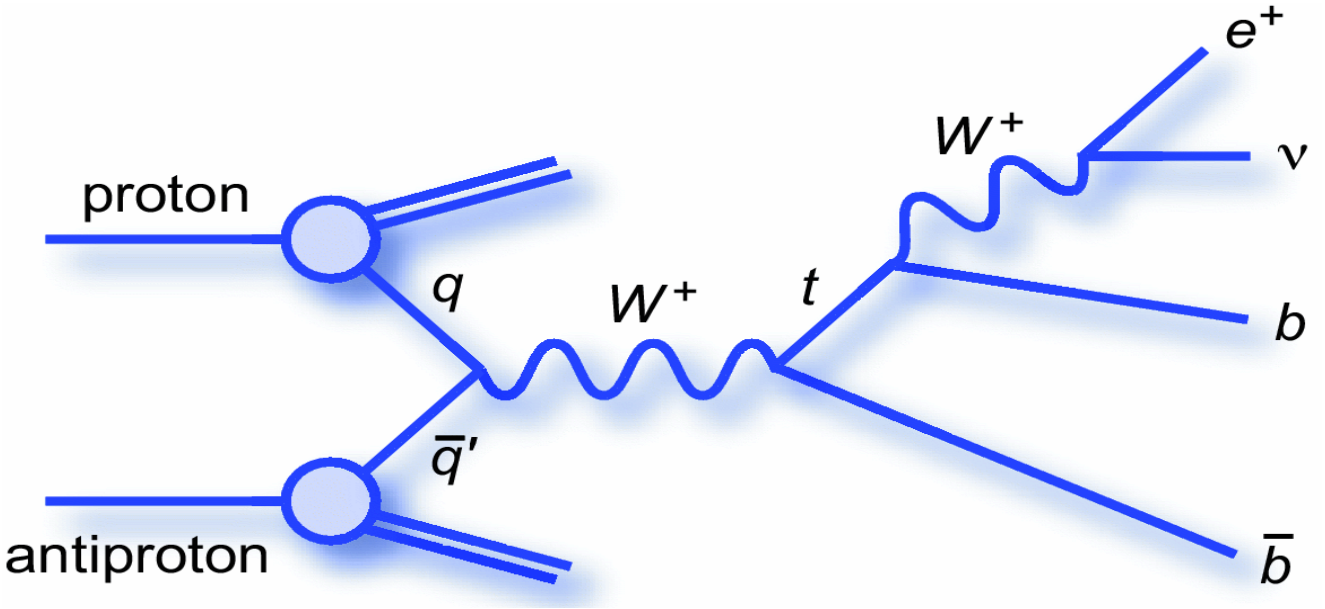
Search for Single Top Production



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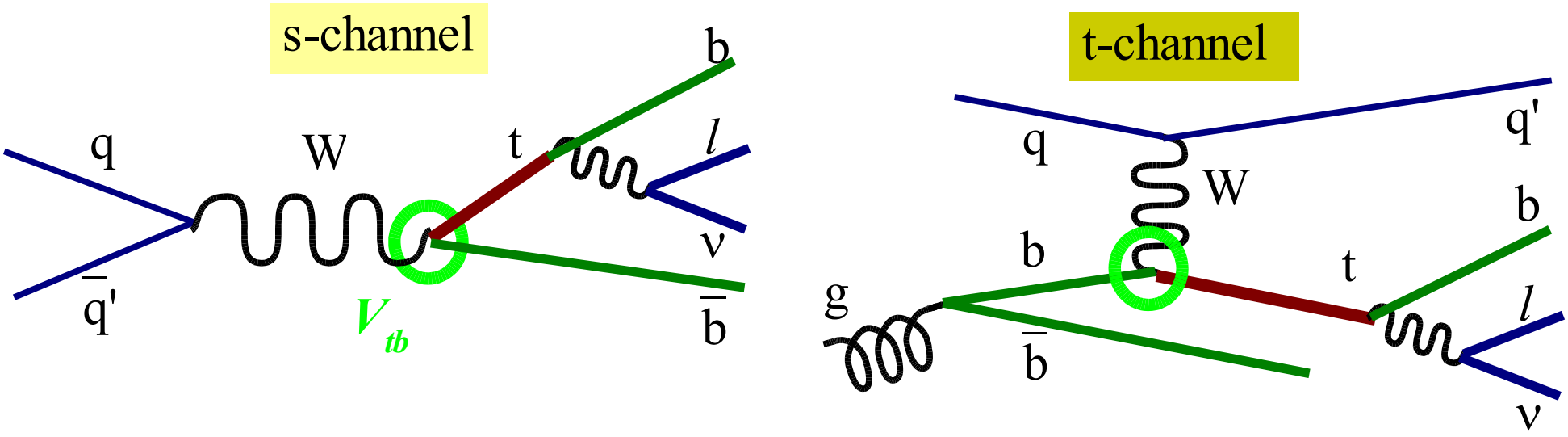
Outline

- Introduction
  - Standard Model Single Top Production
  - Backgrounds
- Search for Single Top Quark Production at DØ
- Search for Single Top Quark Production at CDF
- Conclusions/Outlook

Standard Model Single Top Quark Production



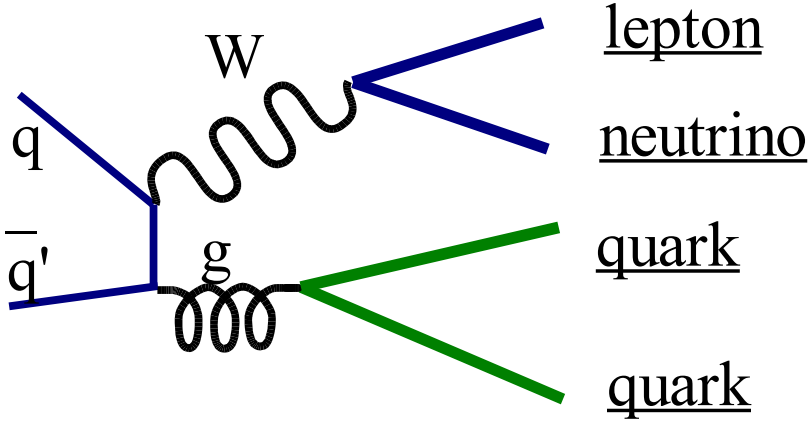
- Electroweak (charged current) production of top quarks

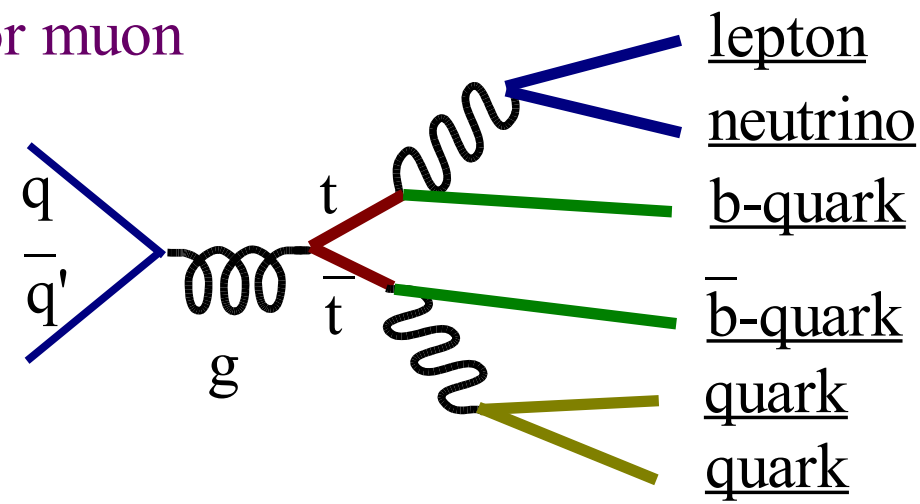
	s-channel	*t-channel*	*s+t channel*
– NLO cross-sections:	0.88pb ± 8%	1.98pb ± 11%	
– Run I 95% CL limits, DØ:	<17pb	<22pb	
CDF:	<18pb	<13pb	<14pb

  - Measure CKM matrix element V_{tb} (test CKM unitarity)
  - Discover new Physics
  - Observe top polarization
- Event Signature: 1 high-E_T lepton, MET, ≥2 jets (≥1 b-tagged jets)

Backgrounds

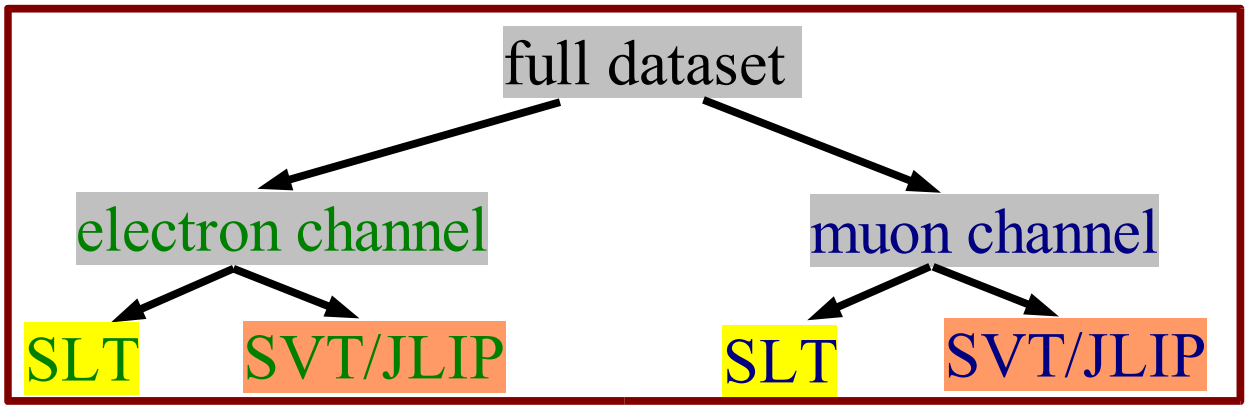
- W/Z+jets production (real-*l*)
  - Wjj, Wcc, Wbb, Zjj, Zcc, Zbb, ...
  - Estimated from data (DØ)
  - Estimated from MC/data (CDF)
- Mis-reconstructed multi-jet events (fake-*l*)
  - Jet mis-identified as isolated electron or muon
  - Estimated from data
- Top-pair production
  - Estimated from MC
- Other (WZ, WW, Zττ, cosmic rays,...)
  - Estimated from MC (CDF)
  - Included in data W/Z+jets estimate (DØ)



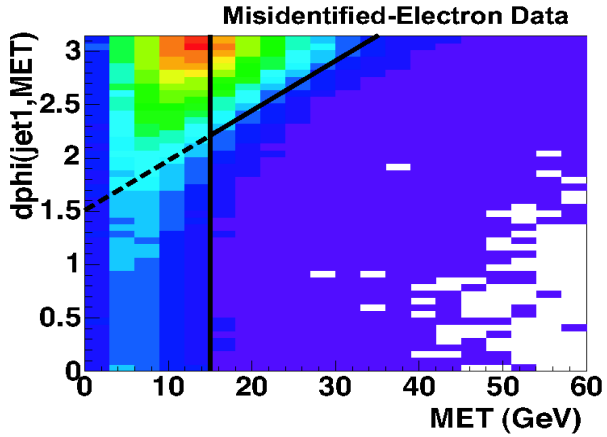


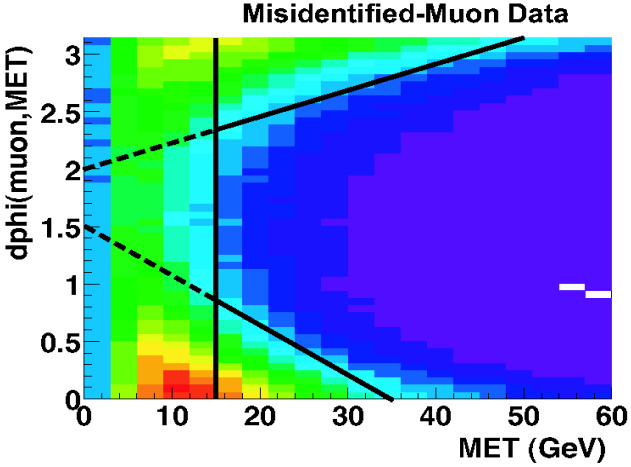
Search for Single Top Quark Production

- Dataset: 156-168pb^{-1} DØ Run II data
- Preselection
  - 1 high-pt lepton (E_T>15GeV)
    - $|\eta^{det}|$<1.1 (e); $|\eta^{det}|$<2.0 (μ)
  - Missing E_T>15GeV
  - 2 Jets, E_T>15GeV, $|\eta^{det}|$<3.4
  - Leading jet E_T>25GeV, $|\eta^{det}|$<2.5
- Split Analysis into orthogonal channels
  - Study separately, then combine results

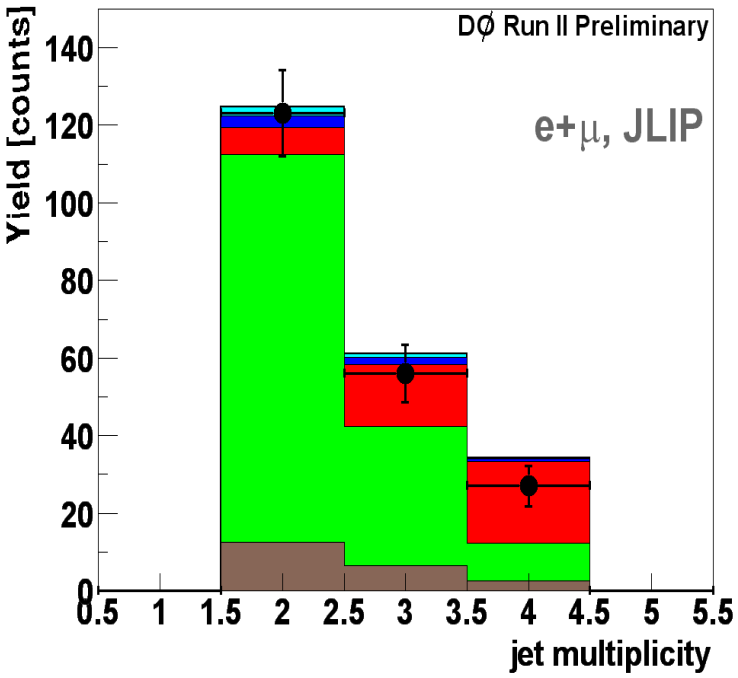


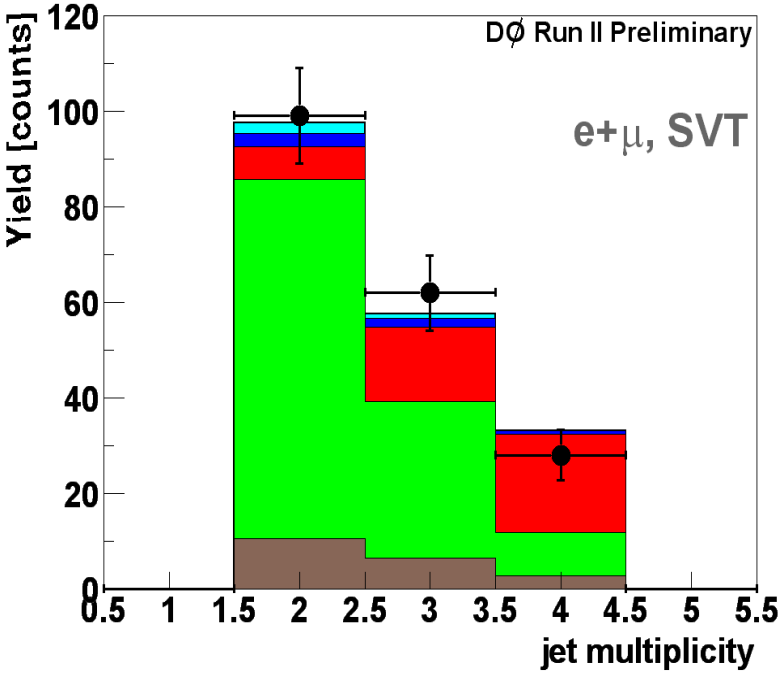
- ≥1 b-tagged jet
  - Soft-lepton-tag (SLT)
  - Secondary vertex tag (SVT)
  - Jet-lifetime probability tag (JLIP)
- Reject mis-reconstructed events



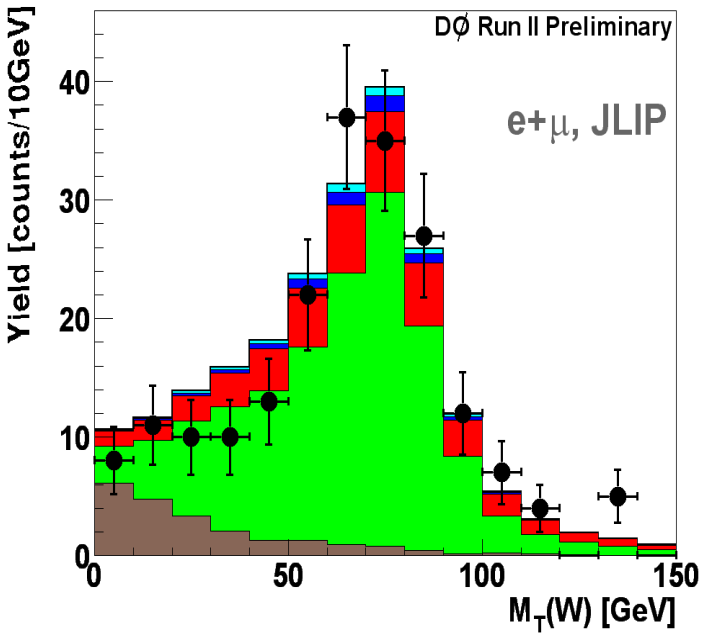


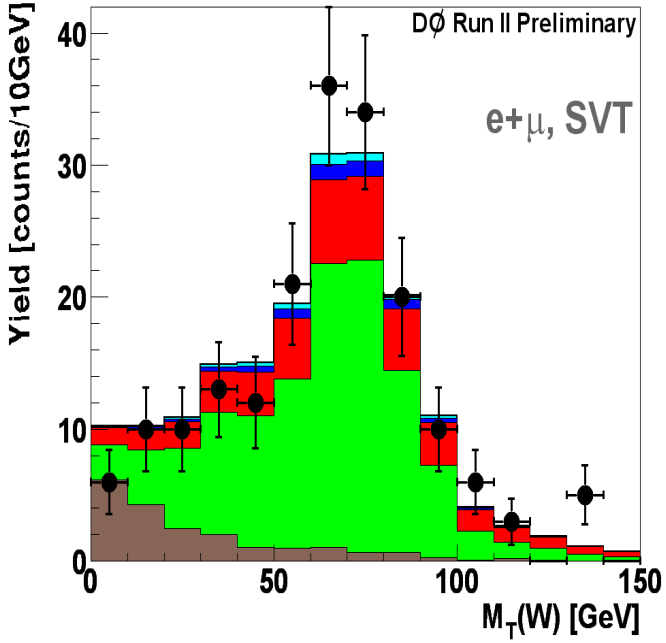
Data – Background Model Comparison

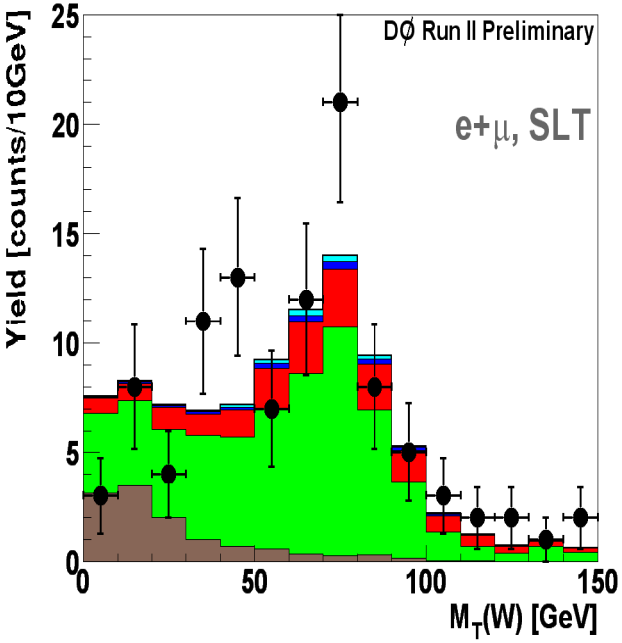




Data
fake-lepton
W/Z + jets
$t\bar{t}$
t-channel
s-channel

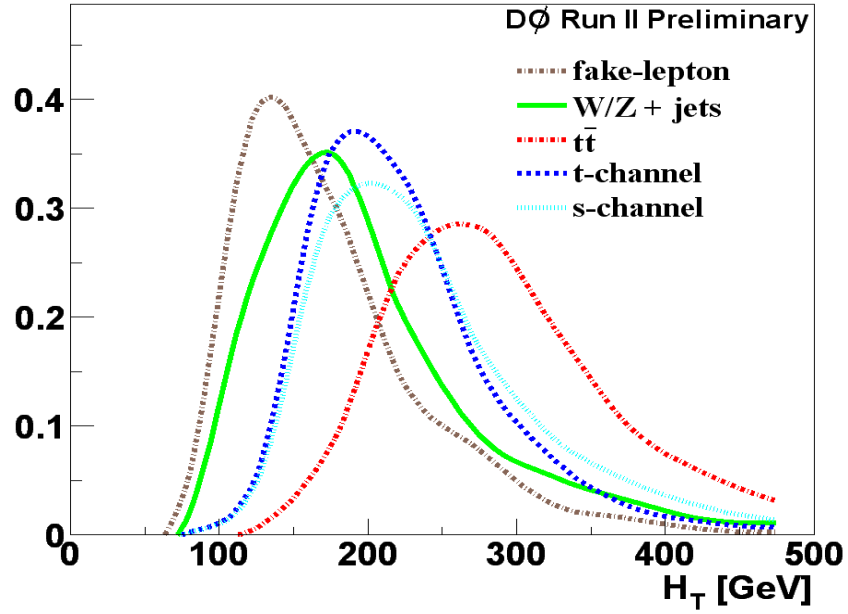


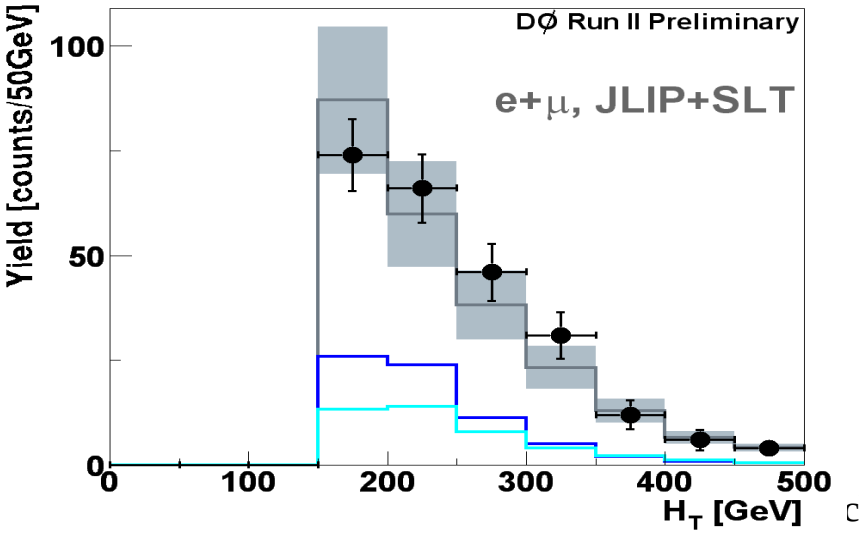


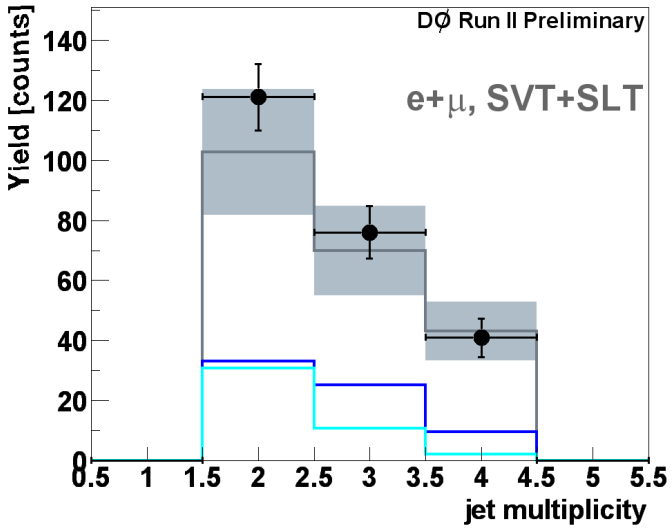


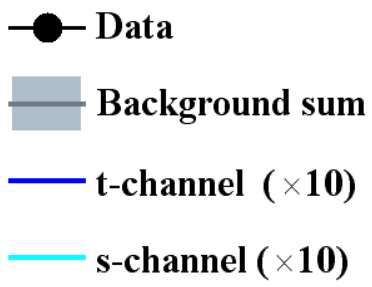
Final Event Selection

- Simple cut to remove largest background (W/Z+jets)
  - $H_T = E_T(lepton) + MET + \Sigma_{i=1,2} E_T(jet_i)$ >150GeV
- Systematic Uncertainties
  - MC signal: dominated by jet energy scale, trigger and tagger modeling, ~20%
  - MC backgrounds: also normalization, ~25%
  - Data backgrounds: dominated by tagging probability estimate, ~20%





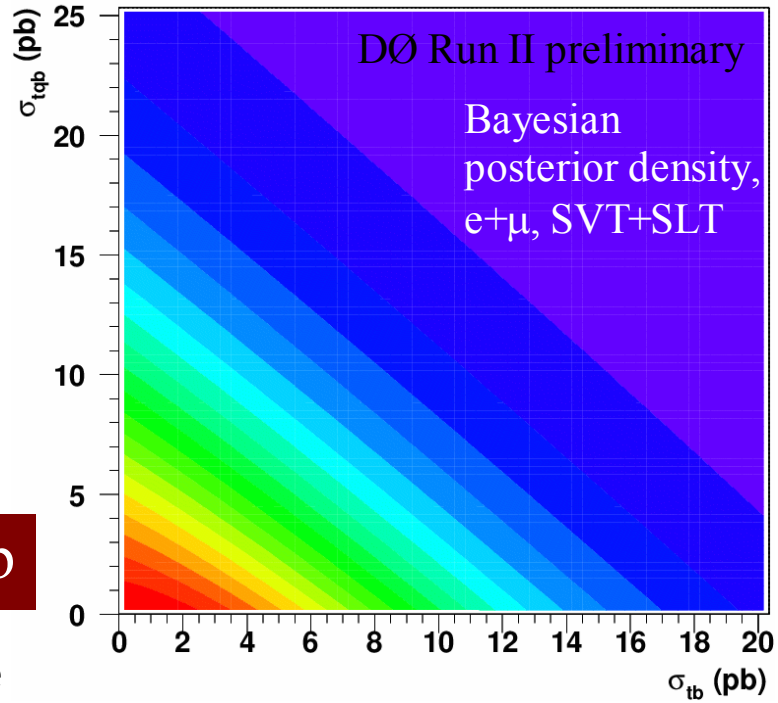




Result and Cross Section Limit

Electron+muon yield	SLT	SVT	JLIP
Signals			
s-channel	1.3±0.3	3.1±0.8	3.2±0.7
t-channel	1.7±0.4	5.1±1.3	5.3±1.3
Backgrounds			
$t\bar{t}$	17.8±4.1	43.2±10.4	43.7±10.9
W/Z+jets + fake-l	58.4±11.5	94.2±17.7	122.2±23.9
Sum of backgrounds	76±11	137±21	166±26
Observed	97	138	148

- Cross section limit with Bayesian approach
  - Include systematic uncertainties and correlations
  - Also computed CLs method limits
    - Similar result, different interpretation
  - Most sensitive Channel: e+μ, SVT+SLT



Observed/Expected limit at 95%CL:

σ_s < 19 / 16 pb

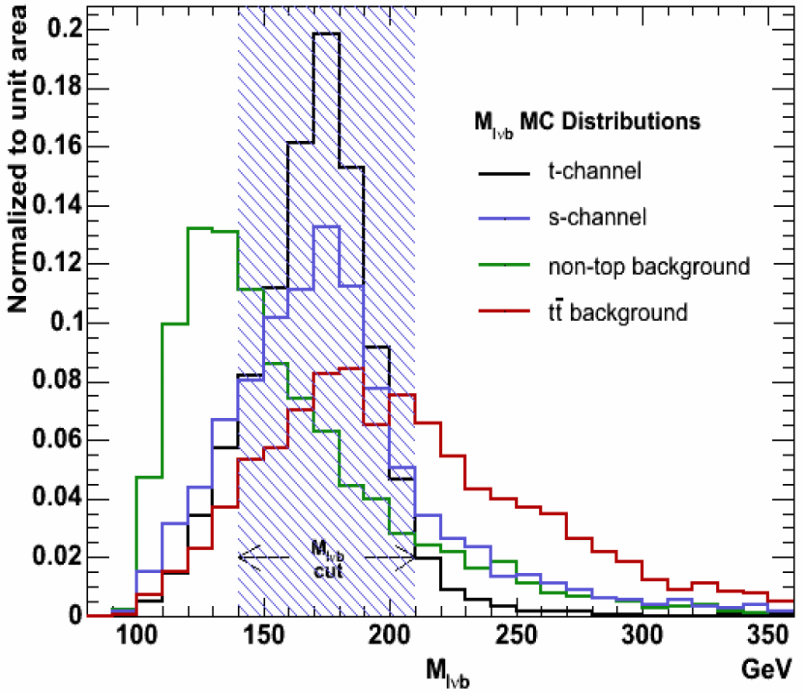
σ_{s+t} < 23/20 pb

σ_t < 25 / 23 pb

Search for Single Top Quark Production

- Dataset: 162pb^{-1} CDF Run II data
- Preselection
  - 1 lepton, E_T>15GeV, |η|<1.0
  - Missing E_T>20GeV
  - 2 Jets, E_T>15GeV, |η|<2.8
  - ≥1 b-tagged jet (SecVtx)
- Topological selection
  - 140GeV < $M_{l\nu b}$ < 210GeV
  - E_T(jet 1)>30GeV (t-channel only)
- Event yield:

	Combined search	*t-channel search*
s-channel	1.19± 0.25	1.16± 0.24
t-channel	2.39± 0.56	2.34± 0.54
tt pairs	3.47± 1.04	3.39± 1.02
non-top	20.7± 4.1	17.4± 3.3
Total Predicted	27.8± 4.3	24.3± 3.5
Observed	28	25

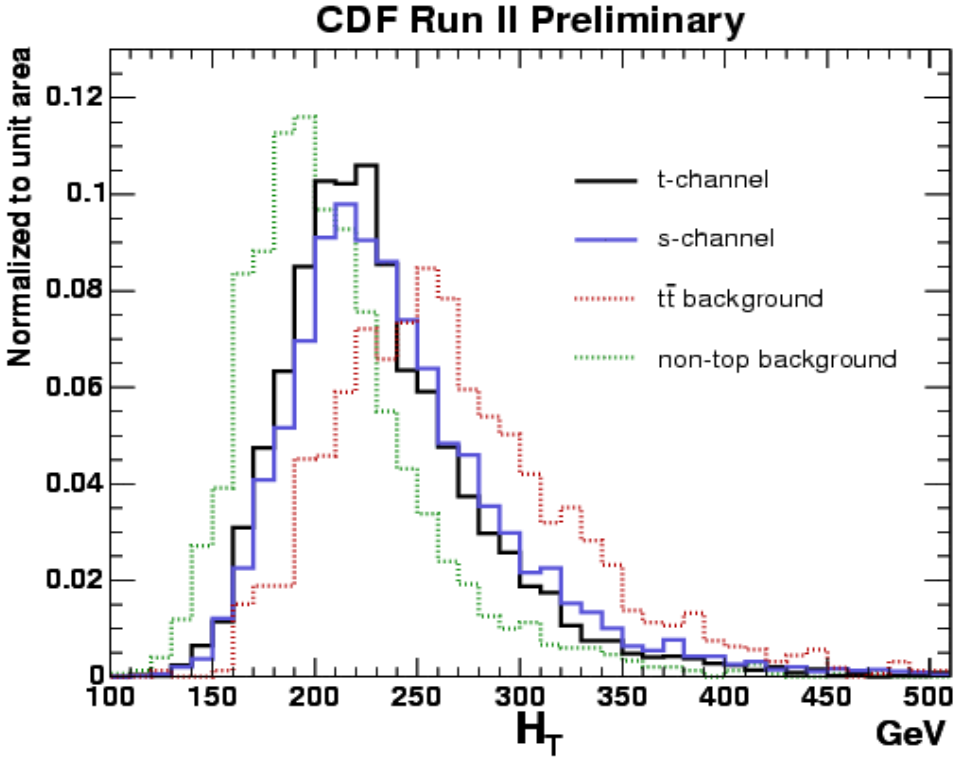


Analysis Strategy

- Combined search:
  - Near term, aimed at discovery of single top production
- Separate searches for s- and t-channel
  - Long term, needed to study underlying Physics

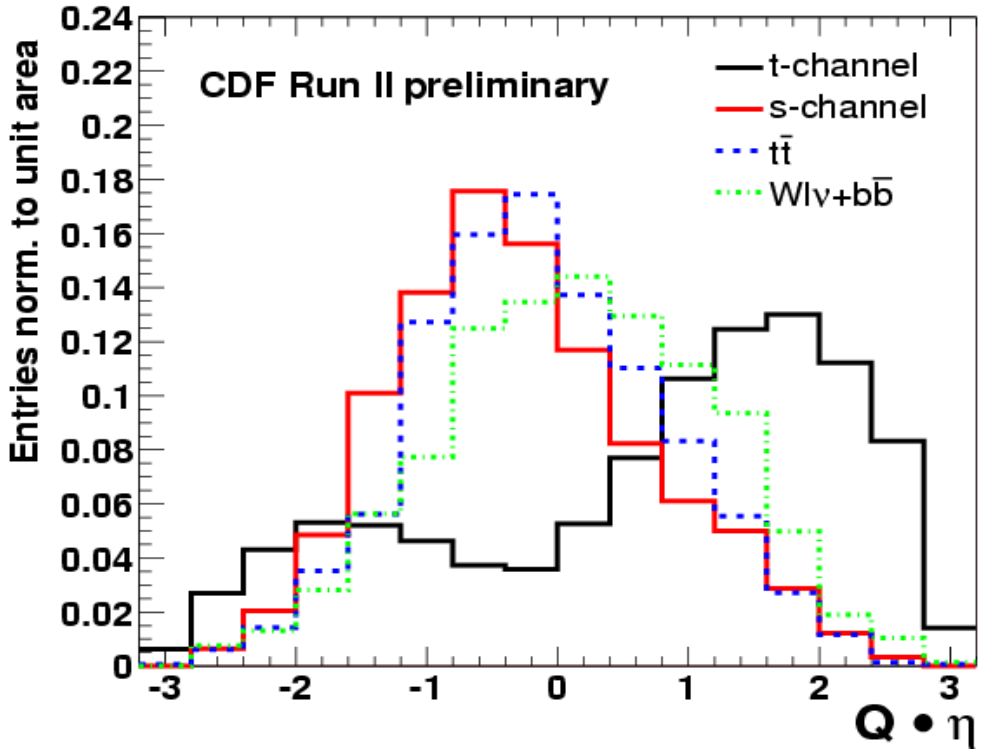
Combined search

$H_T = E_T(\text{lepton}) + \text{MET} + \Sigma_i E_T(\text{jet}_i)$



t-channel search

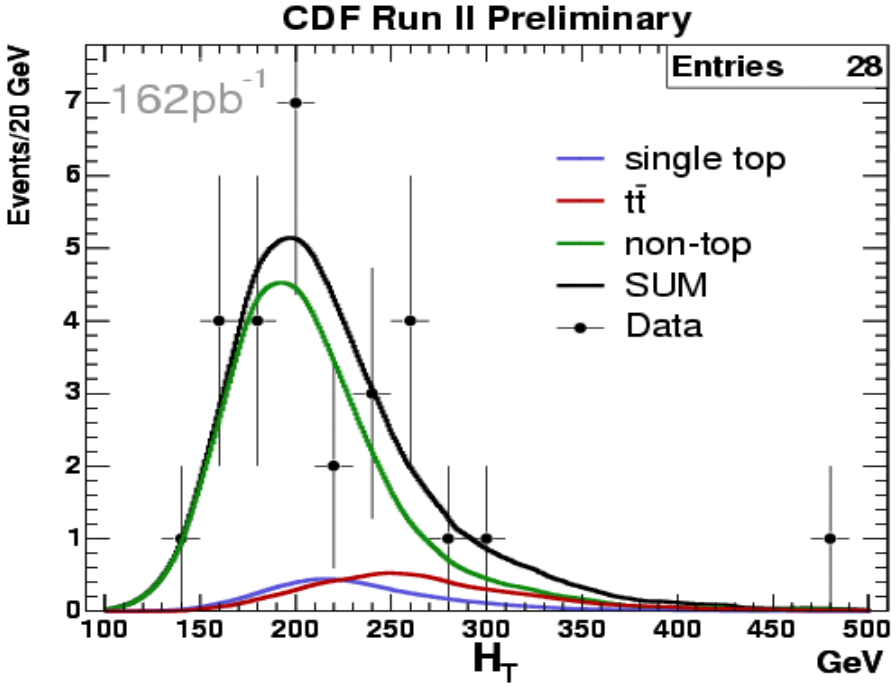
Q (lepton) × η (untagged jet)



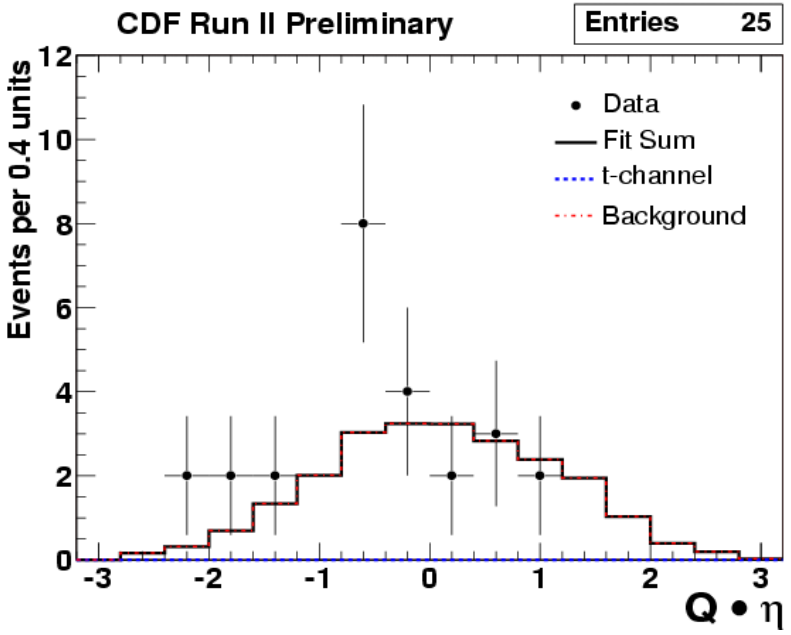
Likelihood Fit to Data

- Maximum likelihood fit to H_T or Q×η data distributions
  - Using MC templates: single top (Pythia), tt (Herwig), non-top: Wbb (Alpgen)
  - Backgrounds are allowed to float within uncertainty on expected yield
  - For each signal and background, define fit parameter $\beta_i = \frac{\mu_i}{\mu_i^{SM}} = \frac{\sigma_i}{\sigma_i^{SM}}$

Process	β_{fit}	Poisson μ
Single Top	0.64 ± 1.55	2.30 ± 5.55
$t\bar{t}$	0.98 ± 0.30	3.40 ± 1.03
Non-top	1.04 ± 0.19	21.46 ± 3.81
$\Sigma\,\mu$	–	27.16



Process	β_{fit}	Poisson μ
t-channel	0.0 ± 1.39	0.0 ± 3.3
s-channel	1.01 ± 0.21	1.2 ± 0.24
$t\bar{t}$	1.06 ± 0.29	3.6 ± 1.0
non-top	1.04 ± 0.16	18.1 ± 2.7
$\Sigma\,\mu$	–	22.8



Cross Section Limit

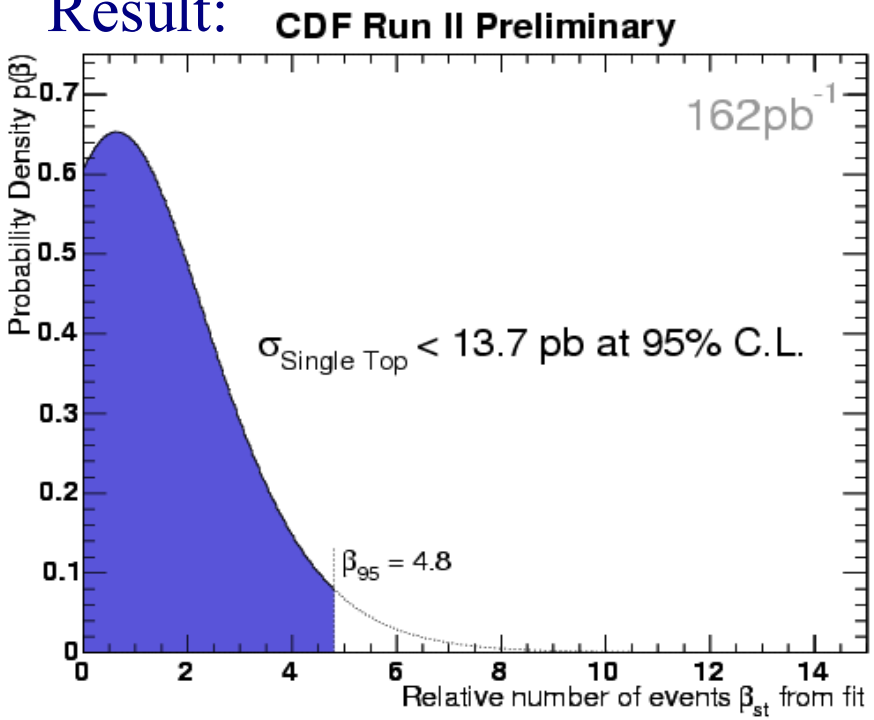
- Bayesian approach to set cross section limit
- Systematic uncertainties included by convoluting likelihood:

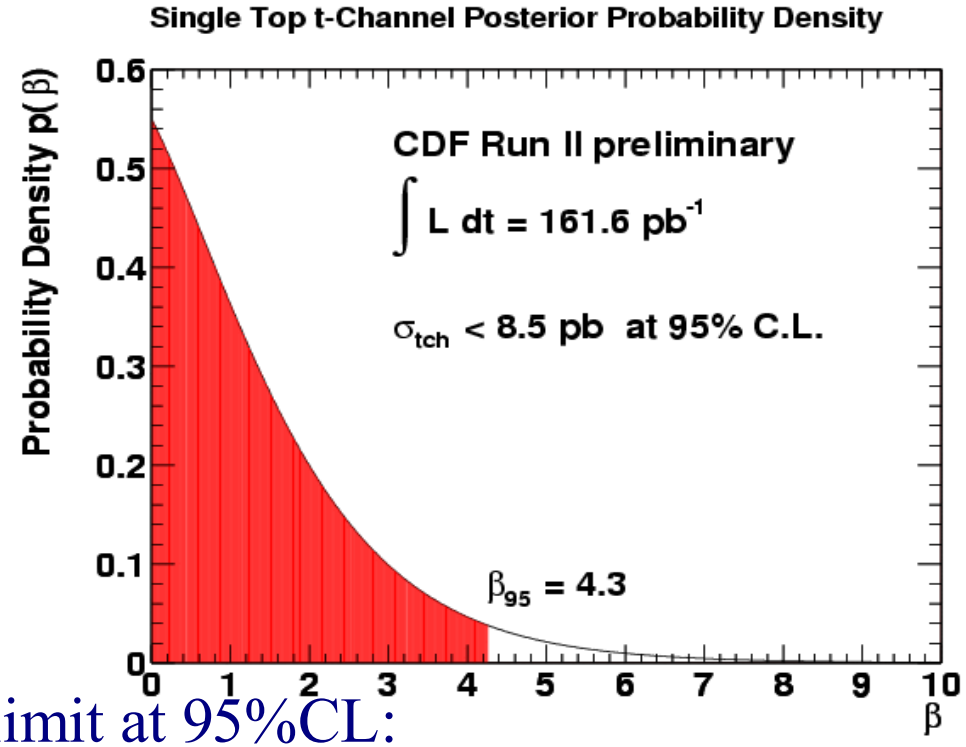
$$\mathbf{L_{sm}}(\beta) = \int_{-\infty}^{+\infty} \mathbf{L}(\beta') \cdot \frac{1}{\sigma(\beta)\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{\beta-\beta'}{\sigma(\beta)}\right)^2\right) \mathbf{d}\beta'$$

$\sigma^2(\beta) = \Delta^2_{\text{Norm}} + \Delta^2_{\text{Shape}}$

- *Normalization*: Δ_{Norm} ~20%
- *Shape*: Δ_{Shape} ~22% (combined)
  ~54% (t-channel)

Result:





Observed/Expected limit at 95%CL:

σ_{s+t} < 13.7 /14.1 pb

σ_t < 8.5 /11.3 pb

Conclusions/Outlook

- Searches for Single Top Quark Production have started in Run II
  - Focus on understanding of data
  - Current result improvement over Run I limit
- Work towards observation of Single Top
  - Keep acceptance as high as possible
    - Selection cuts, b-tagging
  - Improve detector understanding and background modeling
    - Reduce systematic uncertainties
  - Employ advanced analysis techniques
    - Both DØ and CDF working on several methods
    - Likelihood ratio, Multivariate analysis (AIDA), Neural Networks, Matrix Element,...