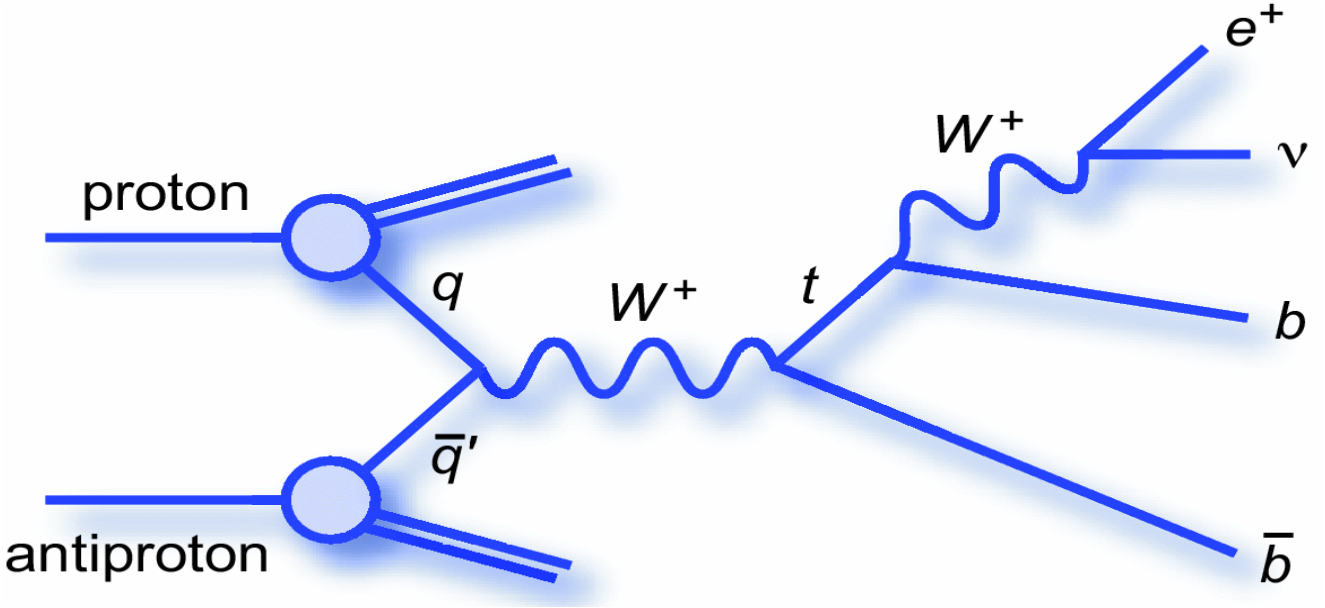
Status of Single Top Searches at the Tevatron



Reinhard Schwienhorst

MICHIGAN STATE UNIVERSITY

TEV4LHC Workshop, Fermilab, September 16 2004

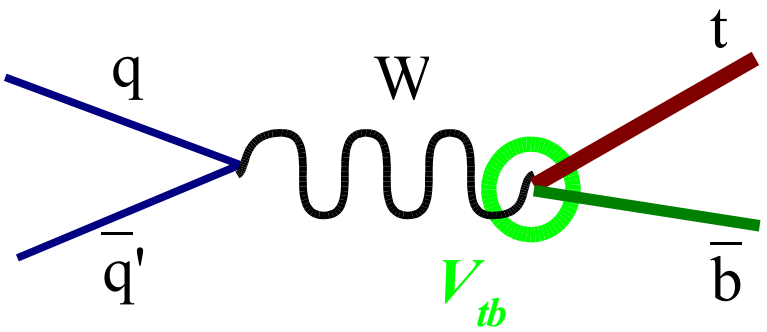
Outline

- Introduction
  - Standard Model Single Top Quark Production
  - Event Signature
  - Backgrounds
- Current Searches for Single Top Quark Production at DØ and CDF
  - Sensitive Variables
  - Current results
  - Analysis Status and Outlook
- The Phenomenological Connection
- Conclusions

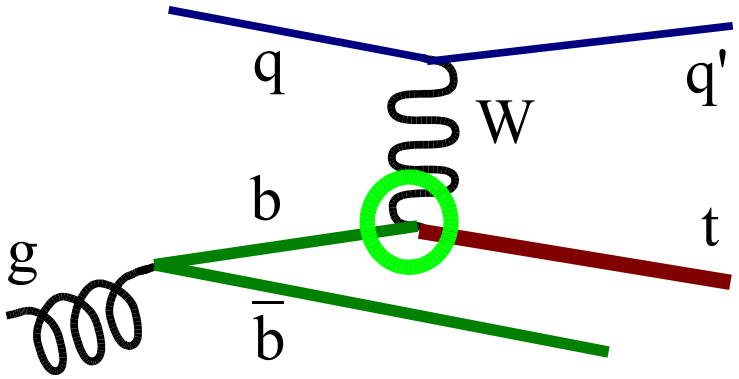
Notes:
- I will not discuss LHC Single Top searches
- I will not discuss non-SM Single Top

SM Single Top Quark Production at the Tevatron

s-channel



t-channel

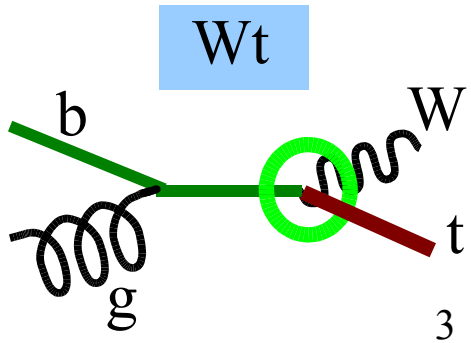


- Electroweak (charged current) production of top quarks

	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

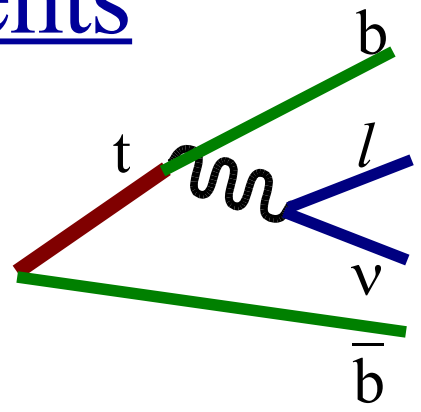
  - Tevatron Goal: Measure CKM matrix element V_{tb} (test CKM unitarity)
    - Observe top polarization
  - Discover new Physics
- Additional production mode at the LHC: Wt
  - Not discussed here (σ^{TEV}=0.09pb)

Wt



Identifying Single Top Events

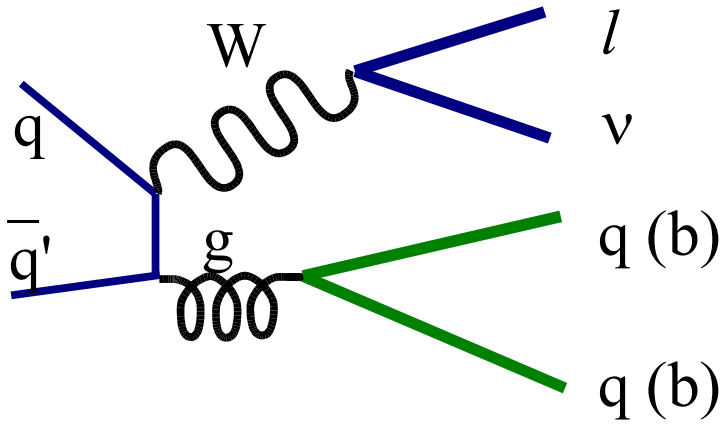
- Event signature:
  - 1 high-E_T lepton
  - $\not\!\!E_T$
  - ≥2 jets
    - ≥1 b-tagged jets



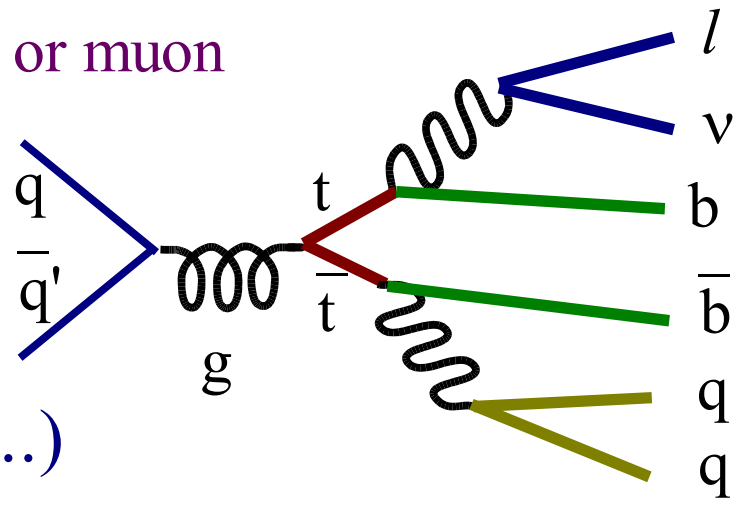
- Similar to top pair production in the lepton+jets channel
  - But fewer jets
  - Larger Backgrounds
- Similar to associated Higgs production
  - Single top s-channel is an important background to Higgs searches at the Tevatron
- Important Tools:
  - Good lepton ID
    - Reduce fake-lepton backgrounds
  - Excellent b-quark tagging
  - Good jet ID and resolution

Standard Model Backgrounds

- W/Z+jets production (real-*l*)
  - Wjj, Wcc, Wbb, Zjj, Zcc, Zbb, ...
  - Estimated from data (DØ)
  - Estimated from MC/data (CDF)

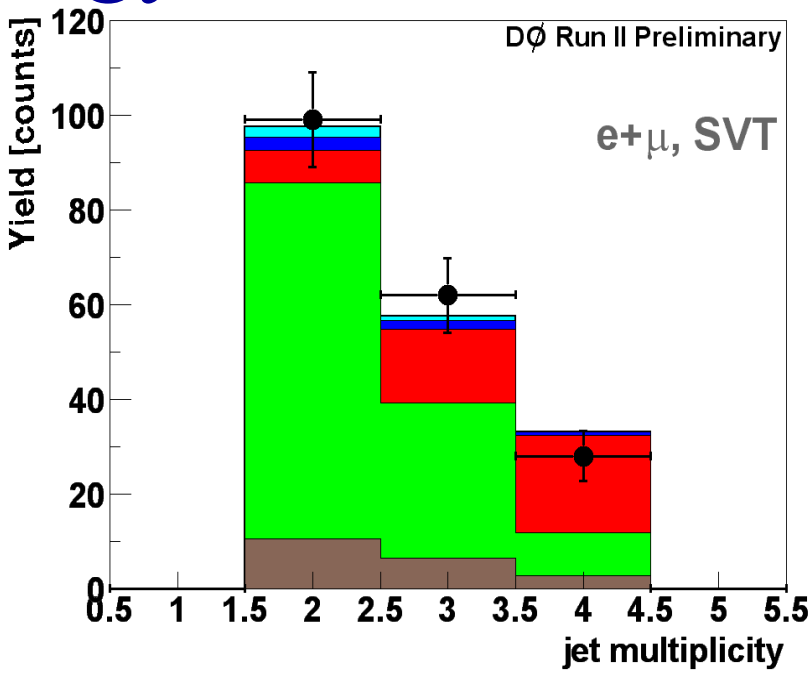


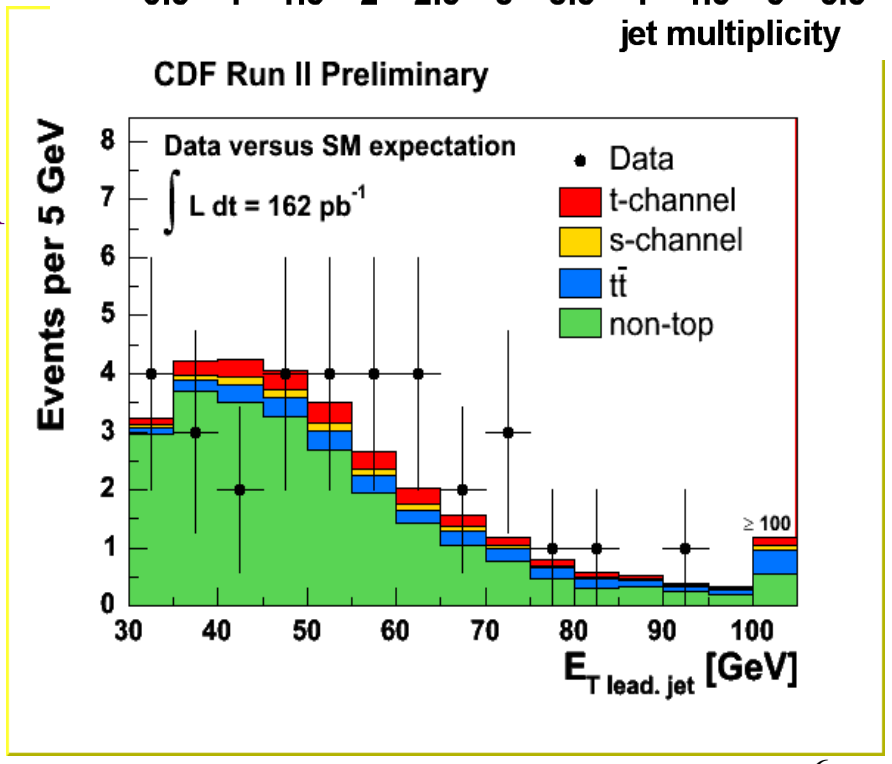
- Mis-reconstructed multi-jet events (fake-*l*)
  - Jet mis-identified as isolated electron or muon
  - Estimated from data
- Top-pair production
  - Estimated from MC
- Other (WZ, WW, Zττ, cosmic rays,...)
  - Estimated from MC (CDF)
  - Included in data W/Z+jets estimate (DØ)



Analysis Strategy

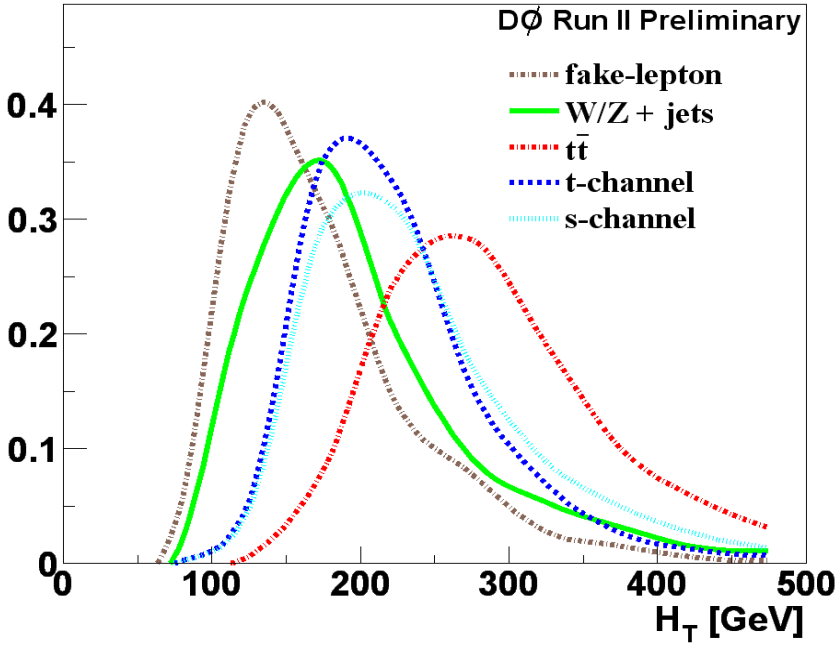
- Loose pre-selection cuts
  - Lepton, MET
    - E_T>15GeV (DØ), E_T>20GeV (CDF)
  - Jets: E_T>15GeV (DØ and CDF)
    - Large η range, maximize acceptance
  - B-tag requirement
  - Check background model
- Final Event Selection
  - Tight cuts to separate single top signal from backgrounds
  - Separately for s-channel and t-channel
    - and s+t combined
- Cross Section (limit) derivation
  - Event counting (DØ)
  - Template fit (CDF)

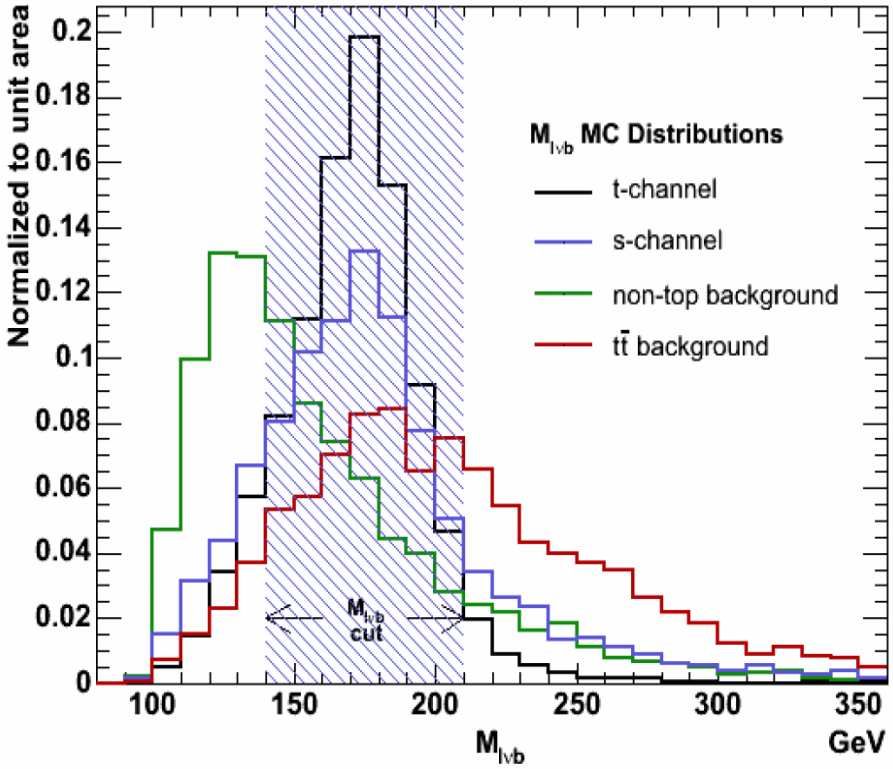


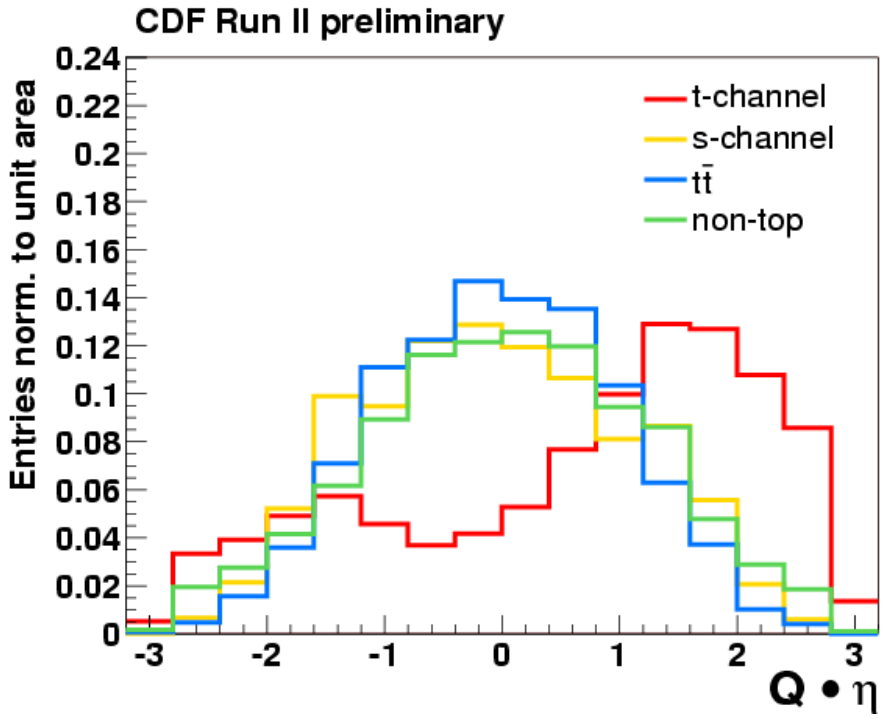


Variables used in the analysis

- Initial analyses are using simple variables for cuts or fits
  - $H_T = E_T(lepton) + MET + \Sigma_i E_T(jet_i)$
  - $M(top)$
  - t-channel: pseudorapidity of the light quark jet × lepton (top) charge





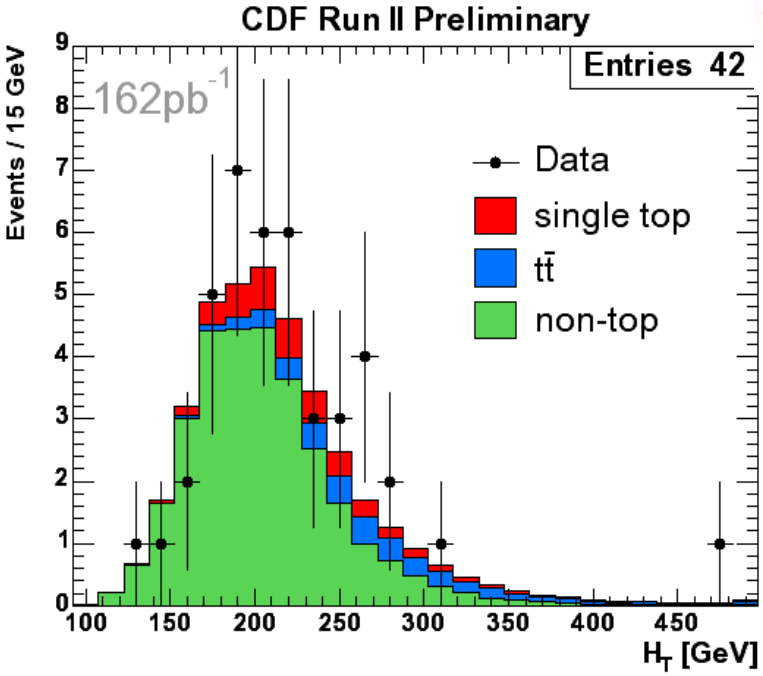


Current Results (160-170pb^{-1})

DØ Run II preliminiary

b-tagging algorithm:

Yields	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
Background sum	76±13	137±21	166±26
Observed	97	138	148



Systematic Uncertainties

MC signal: JES, trigger and tagger modeling, (DØ: ~20%, CDF: ~10%acc, 20-30% shape)

MC backgrounds: also normalization, ~25% → nuisance parameter in template fit

Data backgrounds: DØ: dominated by tagging probability estimate, ~20%

Observed/Expected limit at 95%CL:

σ_s < 19 / 16 pb

σ_t < 25 / 23 pb

σ_{s+t} < 23/20 pb

σ_s < 14 /12 pb

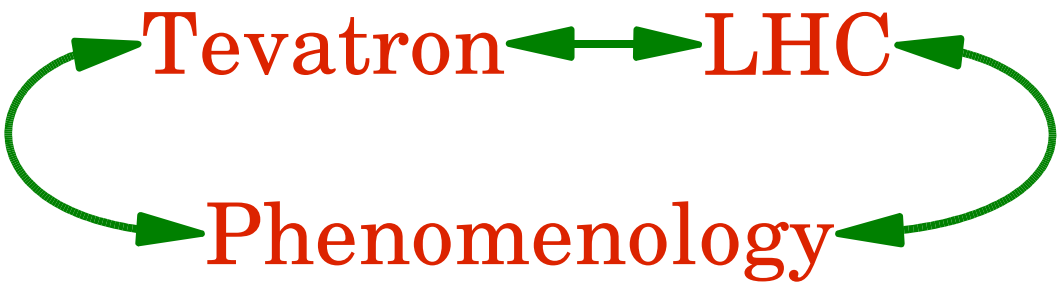
σ_t < 10 /11 pb

σ_{s+t} < 18 /14 pb

Analysis Status and Outlook

- Initial analysis started after Run II top pair production observation
- Current Results are already an improvement over Run I limit
  - More data, better detector
- Current analyses would need several fb^{-1} for observation
  - Particle ID, b-tagging not as efficient as predicted
    - Improvements in progress
  - Large systematic uncertainties
    - Background modeling, detector understanding, ...
- Analyses are not yet optimized
  - Working on multivariate analysis techniques (NN, Matrix Element, ...)
    - Required to make observation soon
  - Need accurate models for signal and background
    - Benefit from recent NLO calculations
  - Identify variables that give good signal-background separation

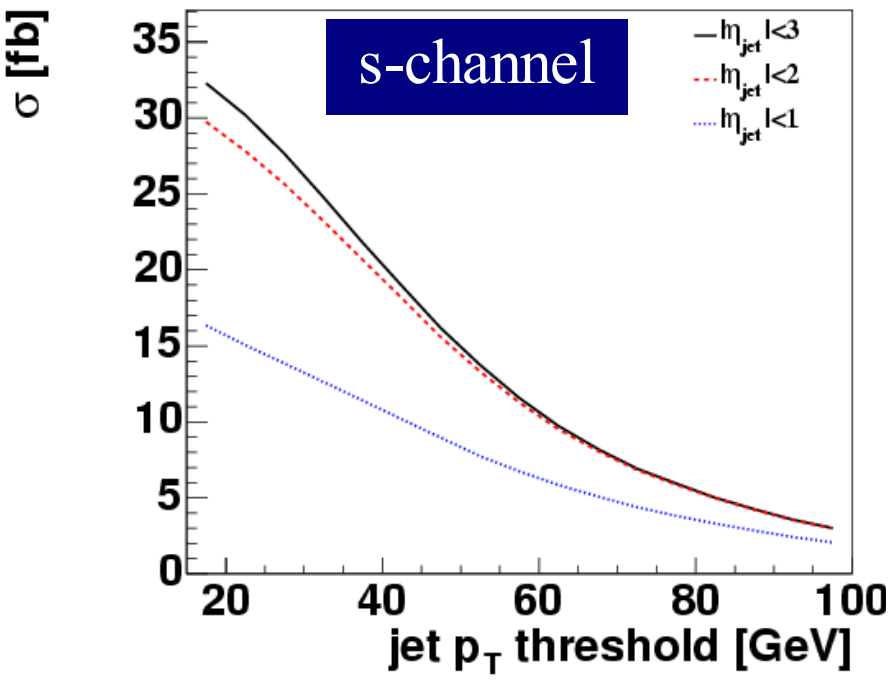
The Phenomenological Connection

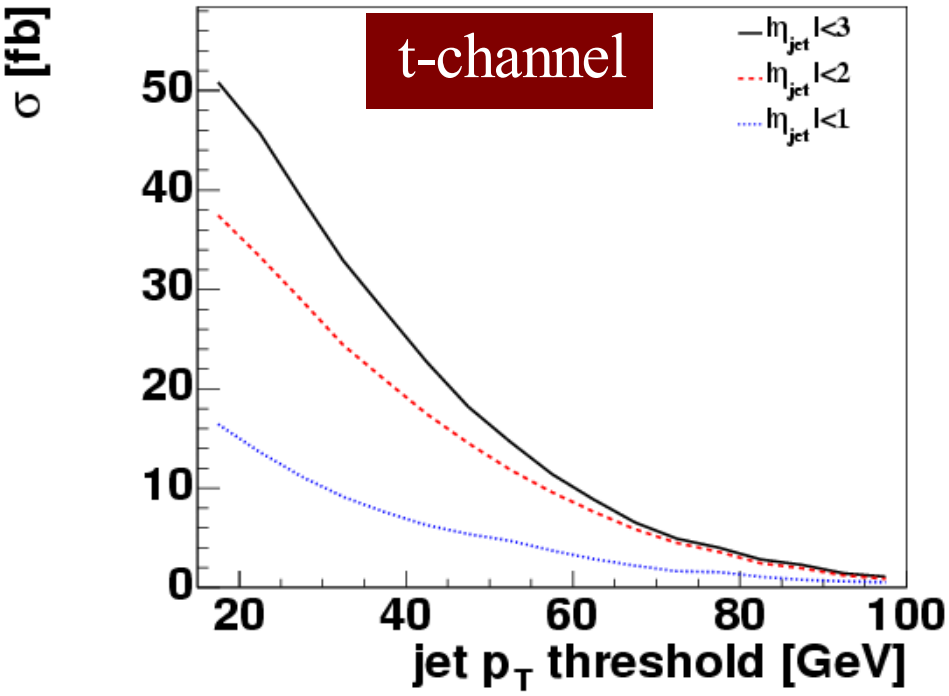


- Phenomenological studies provide important information
  - Cross sections, Distributions, correlations,...
  - How to combine the different t-channel diagrams in a generator
- Several recent phenomenology papers on single top at NLO at the Tevatron, more papers in preparation
  - Address signal and background issues
  - Studies of single top production (Z. Sullivan)
  - Single top production and decay at next-to-leading order (J. Campbell, R.K. Ellis, F. Tramontano)
  - Next-to-leading Order Corrections to Single Top Production and Decay at the Tevatron: 1. s-channel Process (Q. Cao, RS, C.-P. Yuan)

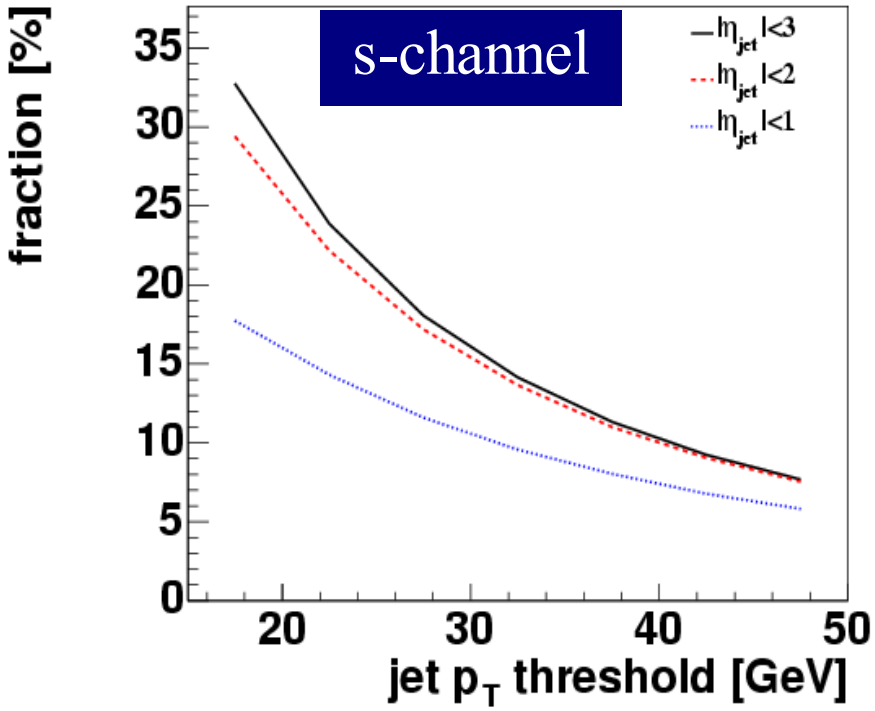
Example: Cross Section and Jet multiplicity

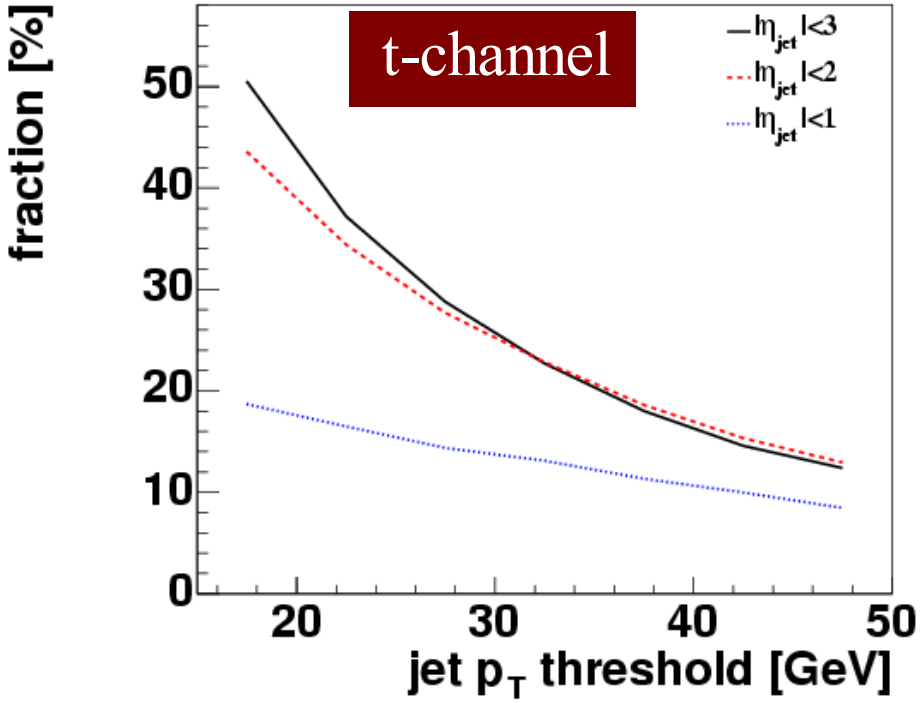
total cross section



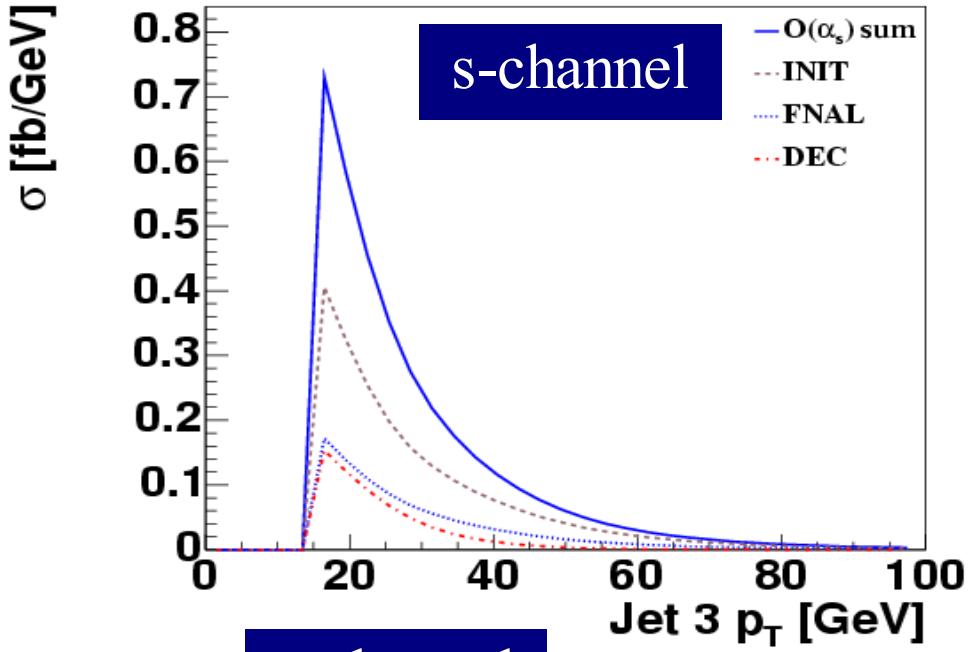


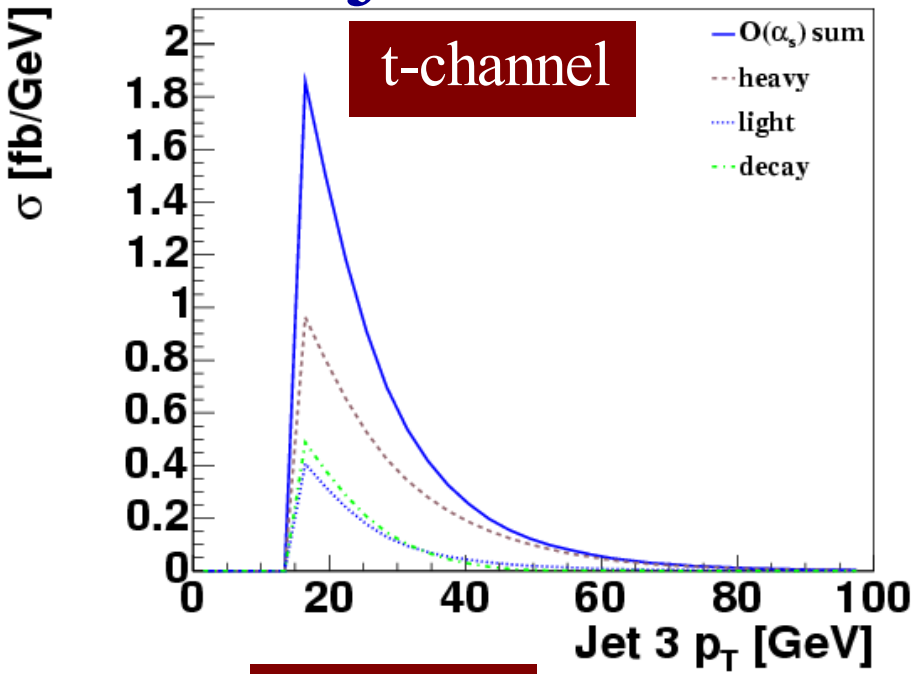
fraction of 3-jet events

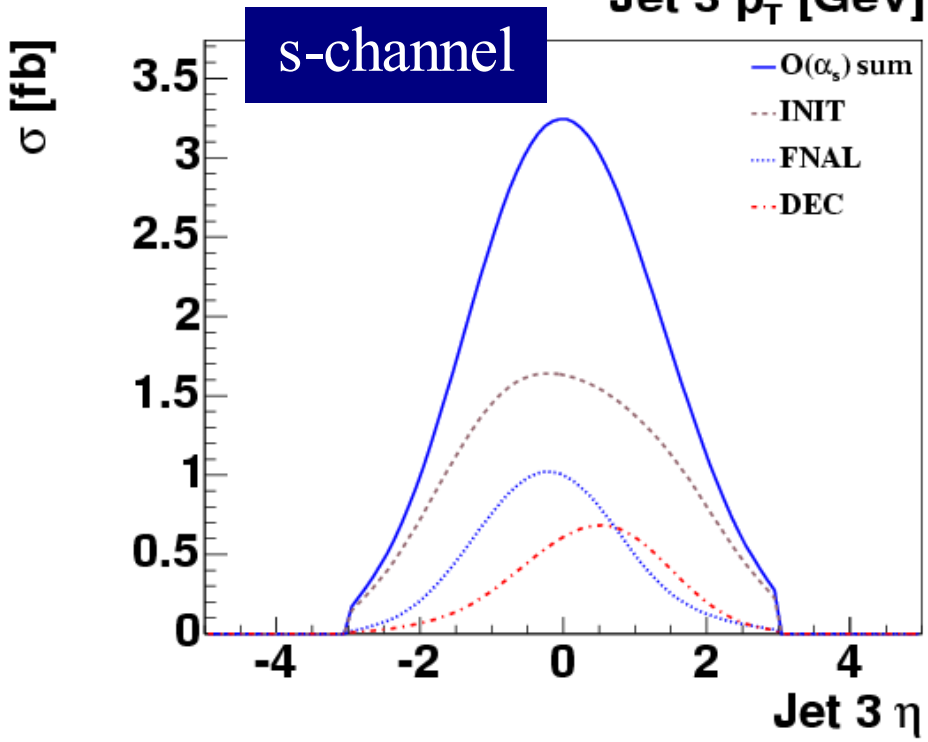


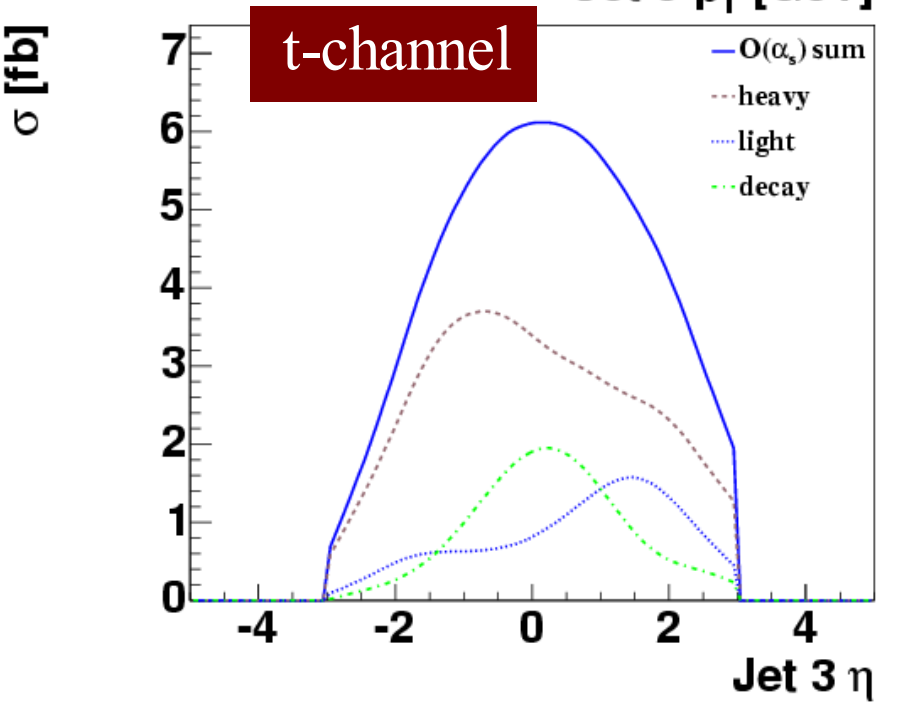


NLO distributions of 3rd jet









Conclusions

- Tevatron single top analyses have started
  - Focus on understanding data
  - First results are improvements over Run I limits
- Improvements to the analysis are needed for observation
  - Implement more advanced final analysis steps
  - Reduce systematic uncertainties
  - Improve efficiencies: ID, b-tagging, trigger, ...
  - In progress
- Cooperation with Phenomenologists is important
  - Model signal accurately
  - Model backgrounds accurately
  - New ideas for sensitive variables

Single Top Physics at the Tevatron is challenging and will be a very active field for the next few years