Search for Production of Single Top Quarks in the Electron+Jets Channel at DØ

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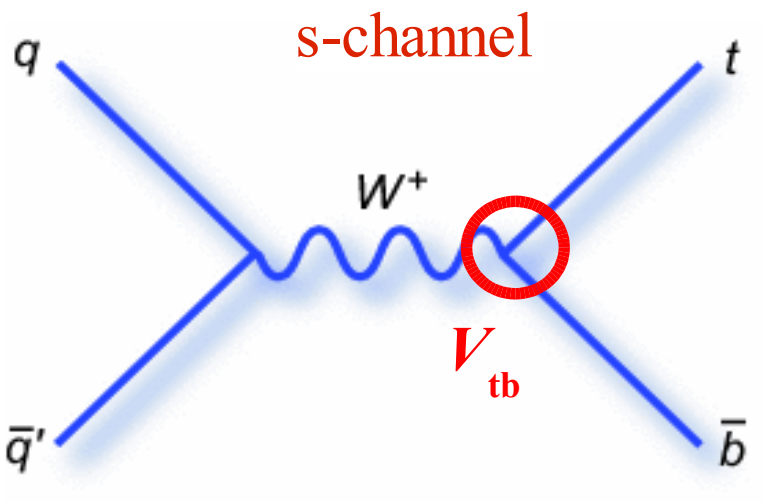
(on behalf of the DØ Collaboration)

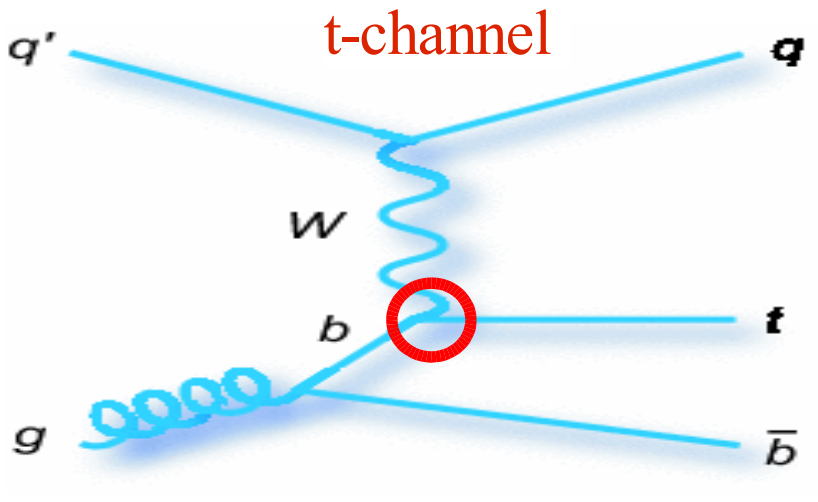
DPF, Aug. 30, 2004.

Plan of talk

- Introduction
  - Production of Single Top Quarks
  - Event Signature
- Single Top Analysis
  - Backgrounds
  - b-tagging Methods
  - Event Selection
  - Event Yields
- Results
- Conclusions and Outlook

Single Top Quark Production in the Standard Model





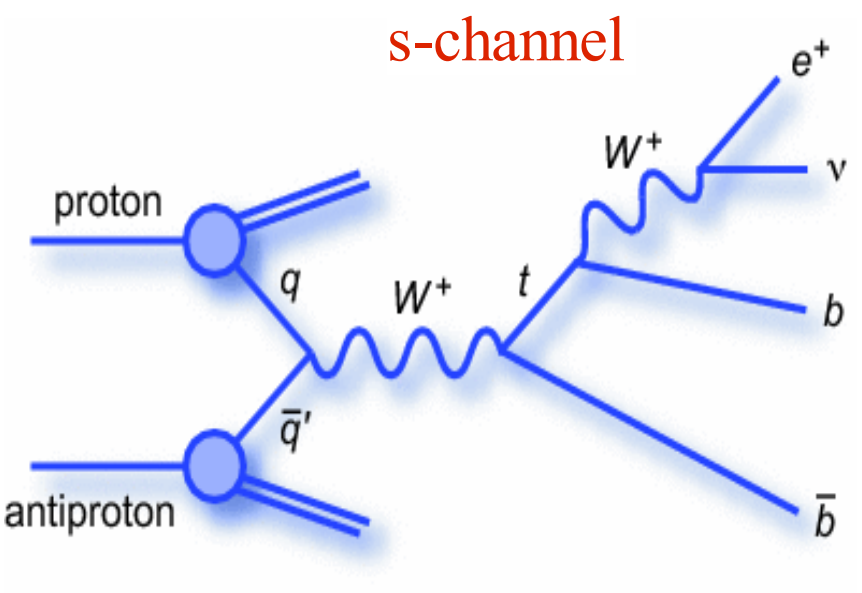
- **Electroweak Production of Single Top Quarks**

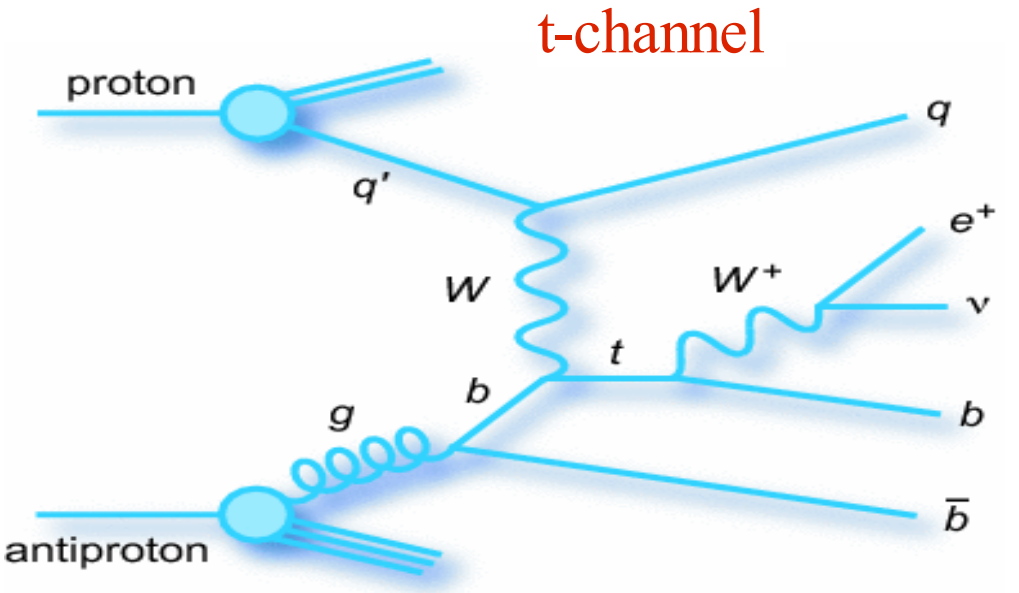
	s-channel	t-channel	s+t channel
- NLO cross section ($\sqrt{s}$=1.96 TeV):	**0.88pb ± 8%**	**1.98pb ± 11%**	
- Tevatron Run I limits: (at 95% CL) **DØ** :	< 17 pb	< 22 pb	
CDF :	< 18 pb	< 13 pb	< 14 pb

- Run II: higher cross sections, higher integrated luminosity, high b-tagging efficiency - Expect Discovery !

- Discovery important in order to:
  - Measure CKM matrix element V_{tb}
  - Observe top-quark polarization
  - Discover new physics

Single Top Event Signature

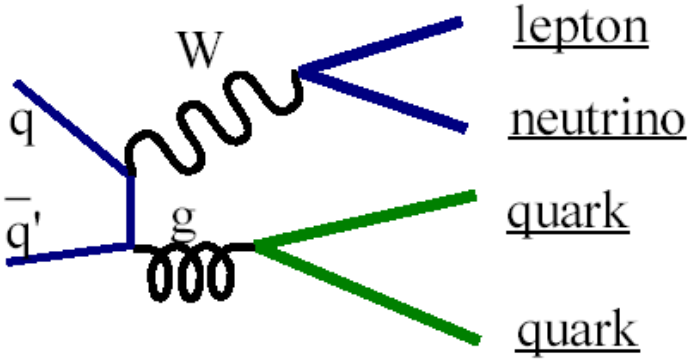




- One high-E_T lepton (**electron** or muon),
- Missing transverse energy **MET** (neutrino)
- ≥ **2 jets**
  - s-channel: 2 b-quark jets
  - t-channel: 2 b-quark jets, 1 light quark jet

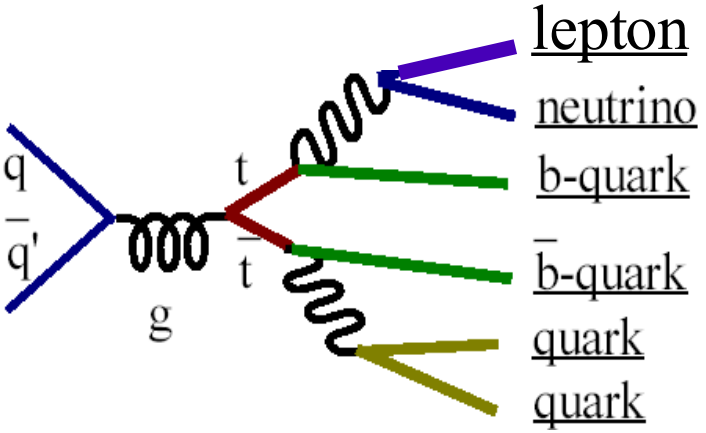
Backgrounds: Electron+Jets Channel

- W/Z + jets production (real-*lepton*)
  - Estimated using **data**
  - Wjj, Wcc, Wbb, Zjj, Zcc, Zbb, ...
  - WZ, WW, Zττ (negligible)



- Mis-reconstructed multi-jet events (fake-*lepton*)
  - Jet mis-identified as isolated electron
  - Estimated using background-dominated **data**
    - reverse "likelihood" cut for electron-ID

- Top-pair ($t\bar{t}$) production
  - Lepton+jets, dilepton
  - Estimated from **MC**

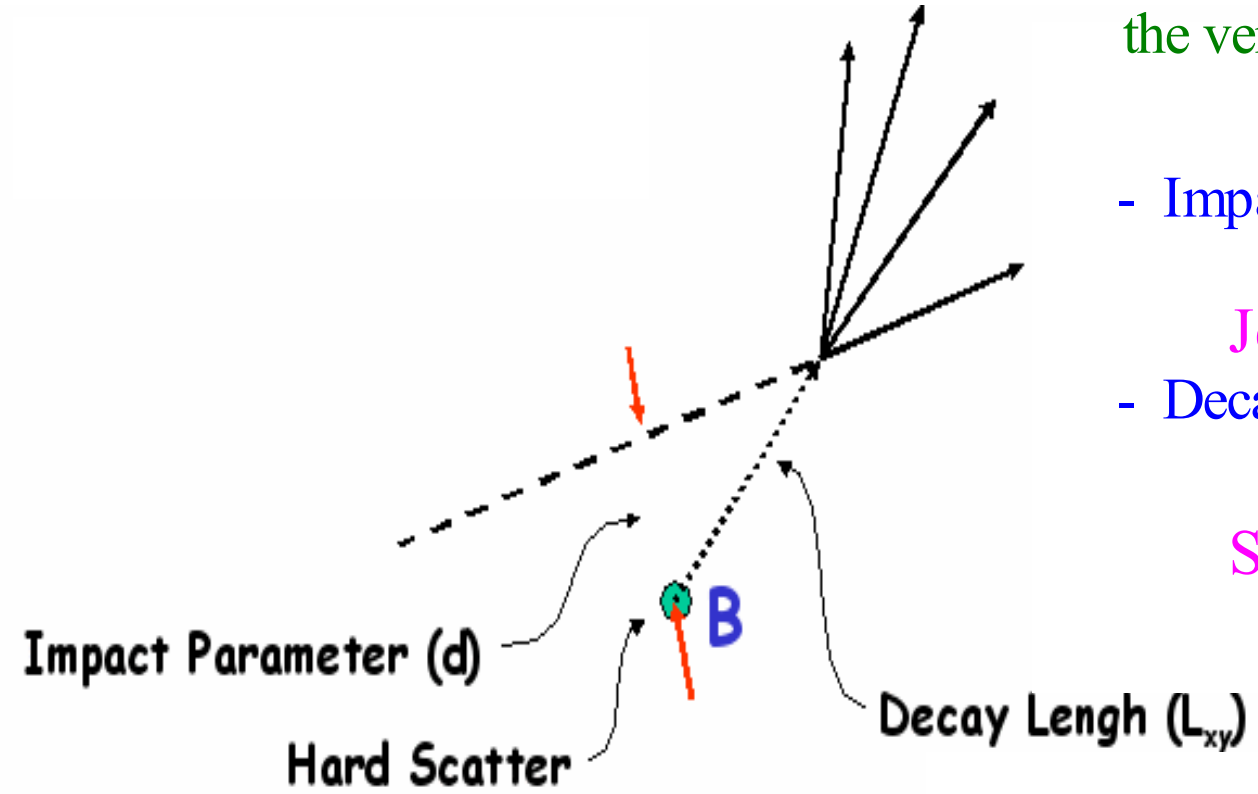


b-tagging methods

- Use three different tagging algorithms to identify b-quark jets

- Muon-in-jet from B-meson decay
  - Soft-Lepton Tag (SLT)

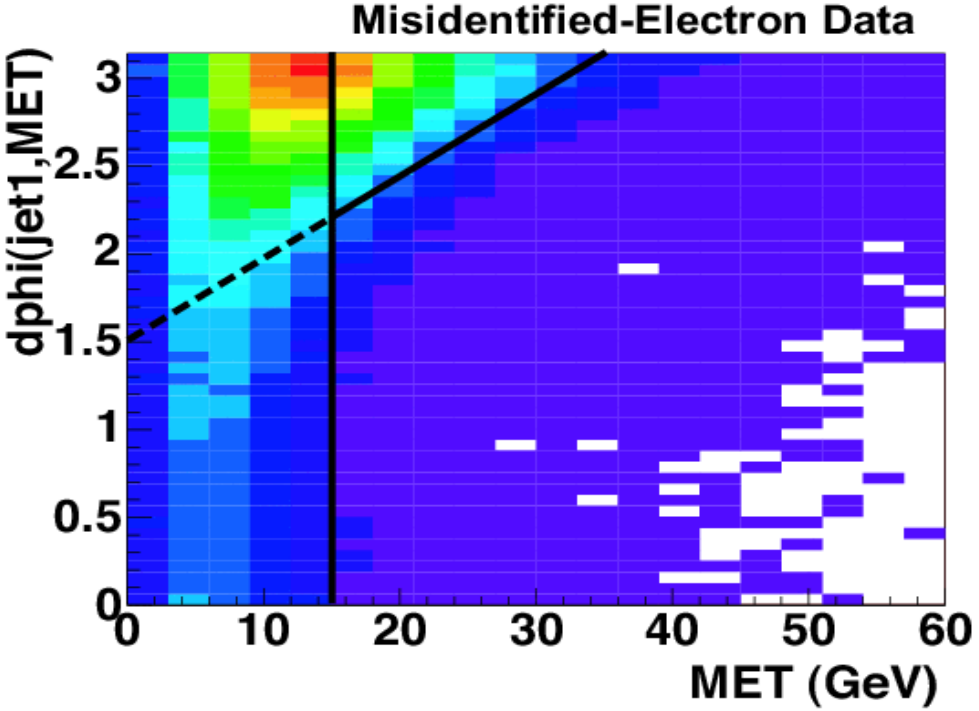
- Tracking-based Lifetime Taggers
  - B-meson has finite lifetime
  - Travels some distance from the vertex (~1mm) before decaying



- Impact Parameter (IP) Significance
  $d / \sigma(d)$
  Jet Lifetime IP Tag (JLIP)
- Decay Length Significance
  $L_{xy} / \sigma(L_{xy})$
  Secondary Vertex Tag (SVT)

Data Sample and Event Selection: Electron+Jets channel

- Data sample: **156-169 pb^{-1}** of DØ Run II data
- Preselections:
  - One high-E_T electron (E_T > 15 GeV), pseudorapidity $|\eta^{det}| < 1.1$
  - MET > 15 GeV
  - $2 \leq$ Njets ≤ 4: E_T > 15 GeV, $|\eta^{det}| < 3.4$
  - Leading jet E_T > 25 GeV, $|\eta^{det}| < 2.5$
  - Also reject mis-reconstructed events : "triangle" cuts



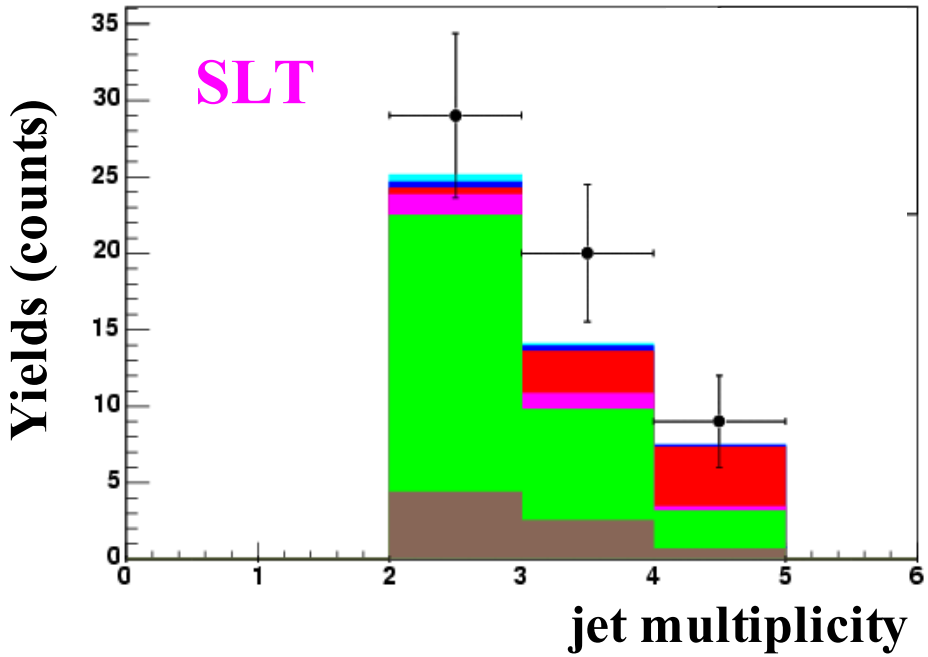
- Reject events with muons in them

("orthogonal" electron and muon samples)

- $\geq$ 1 b-tagged jet (SLT, SVT, JLIP)

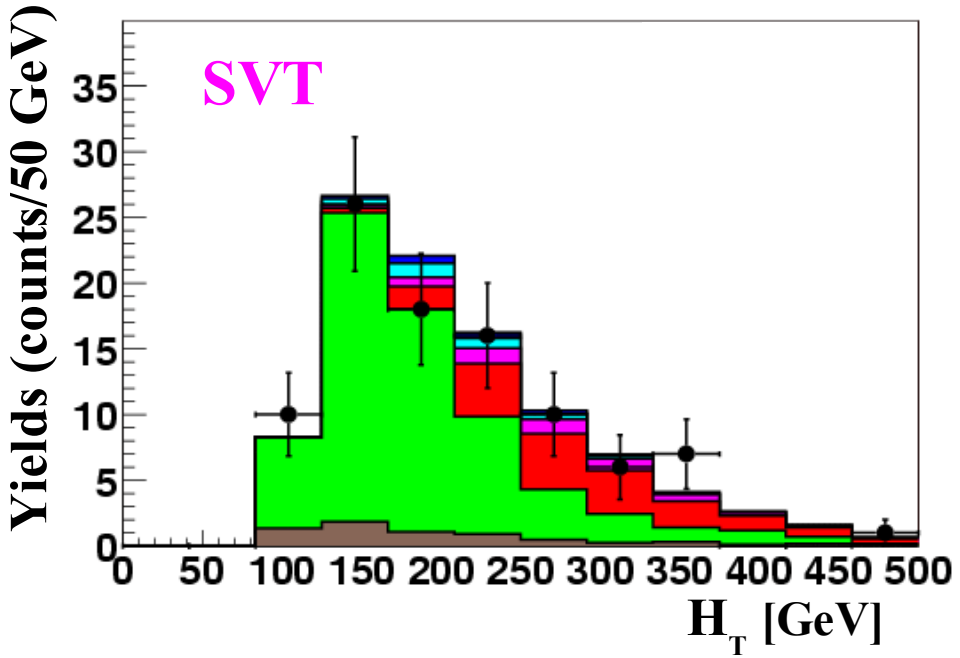
(SLT sample is orthogonal to the SVT and JLIP samples)

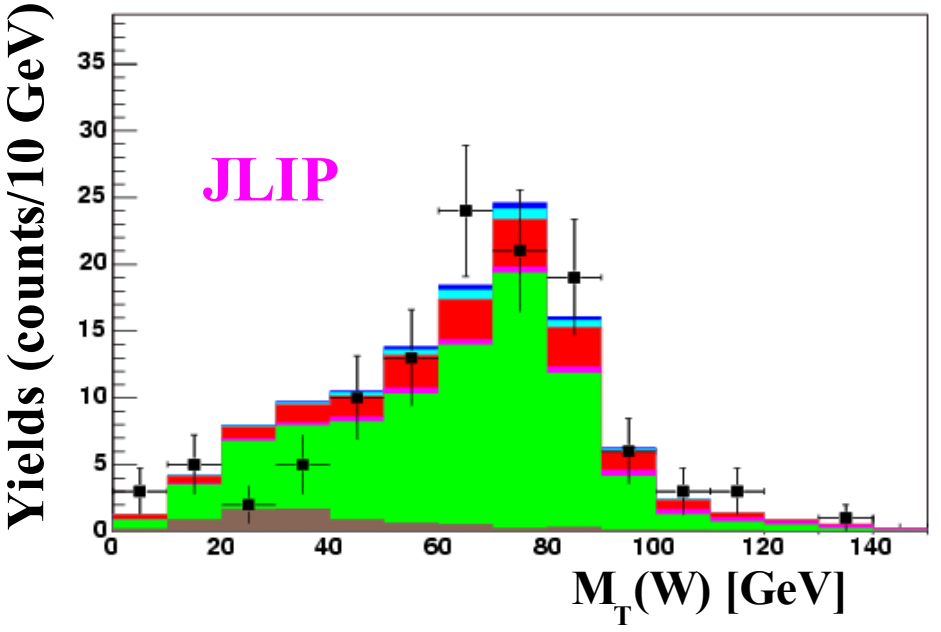
Event Yields : After Preselections



Electron+Jets Channel

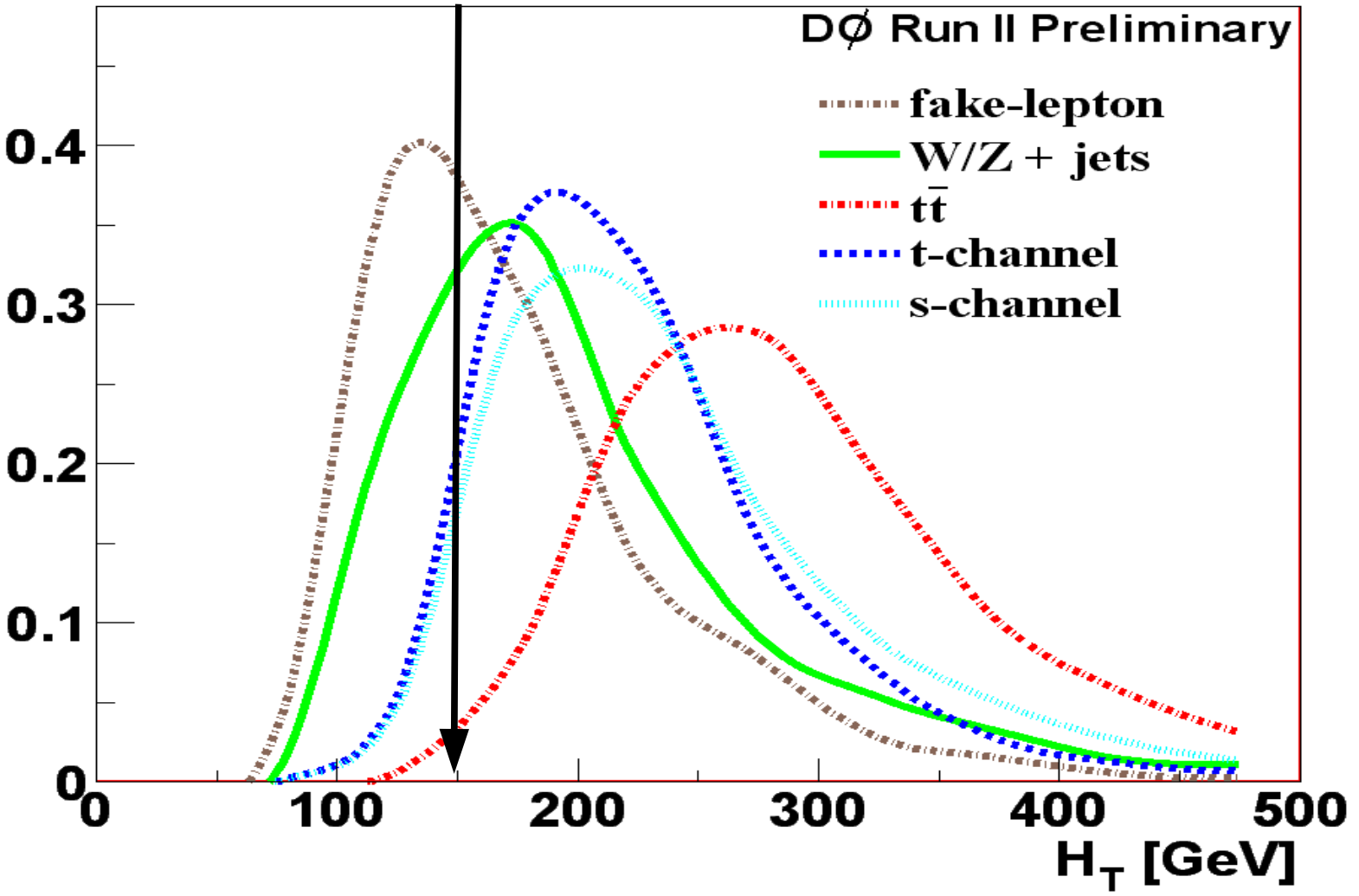
- Data
- fake-lepton
- W/Z + jets
- $t\bar{t}$ (lepton+jets)
- $t\bar{t}$ (dilepton)
- t-channel
- s-channel



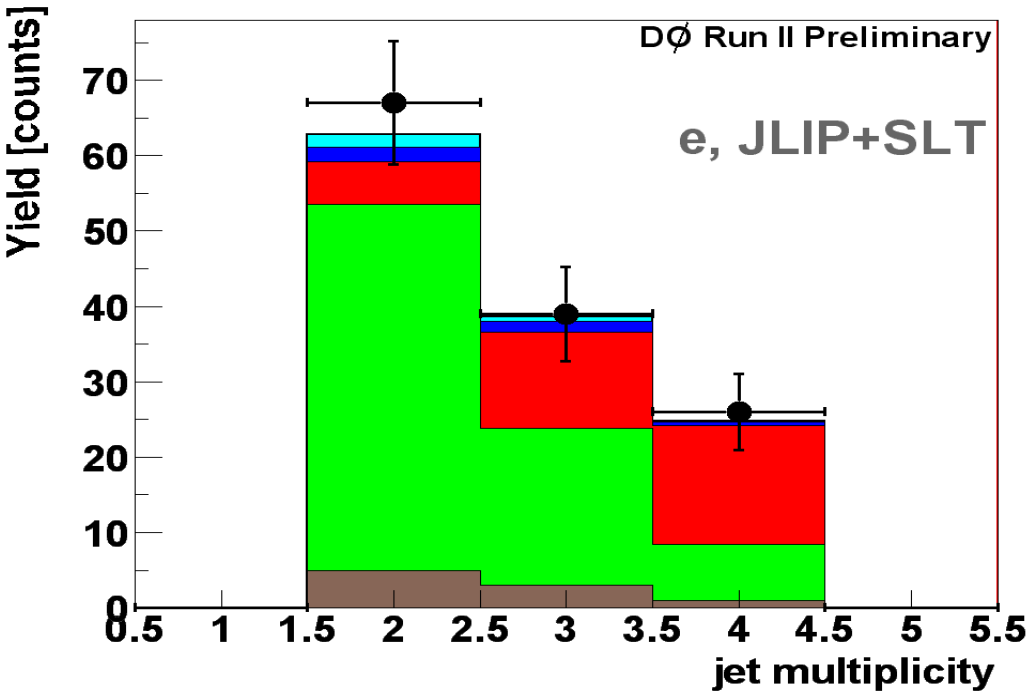


Final Selection: Electron+Jets channel

- Simple cut to reduce largest background (W/Z +jets)
  - $H_T \equiv E_T(\text{electron}) + \text{MET} + \sum_{i=1,2} E_T(\text{jet}_i)$ **> 150 GeV**

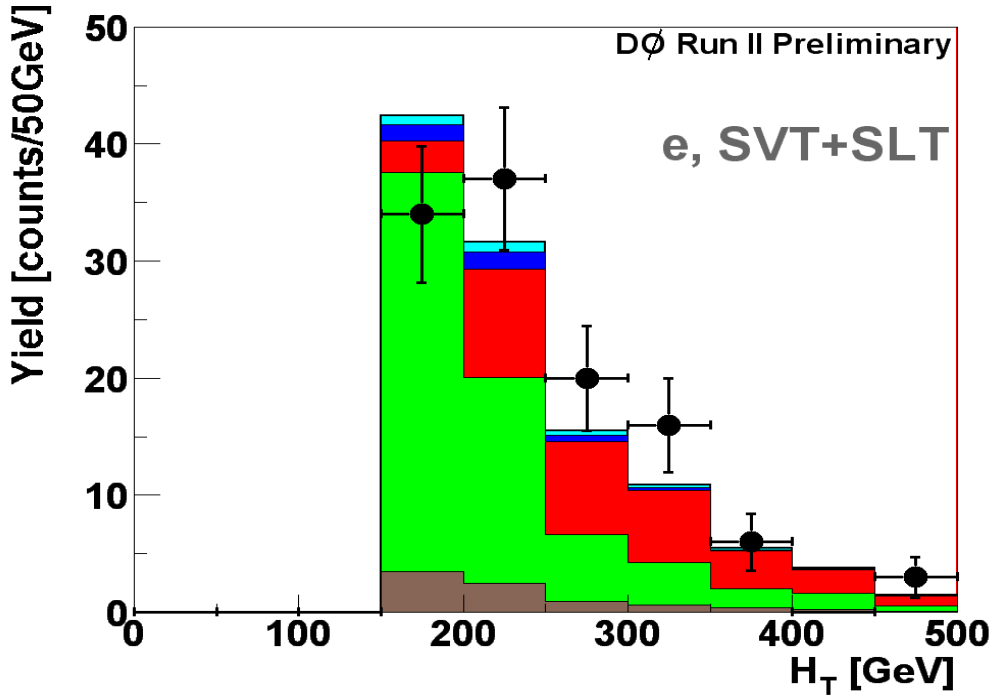


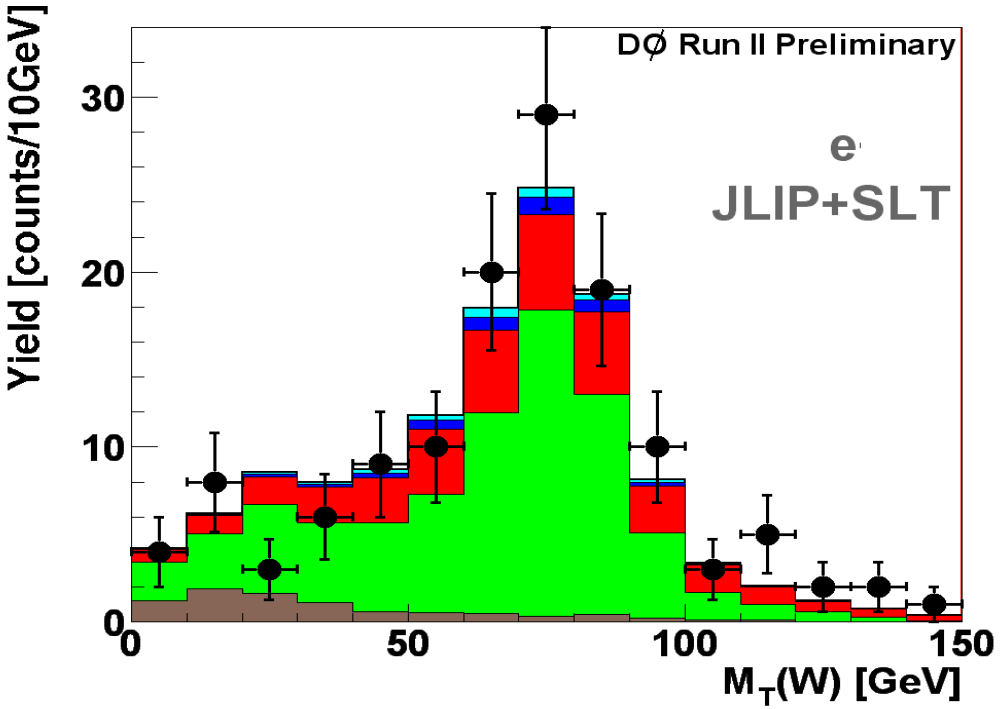
Event Yields : After Final Selection



Electron+Jets Channel

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





Event Yields: Electron+Jets channel

	SLT	SVT	JLIP
Signals			
s-channel	0.7 ± 0.1	1.8 ± 0.4	1.8 ± 0.4
t-channel	0.9 ± 0.2	3.0 ± 0.7	3.0 ± 0.7
Backgrounds			
tt (lepton+jets and dileptons)	9.7 ± 1.8	24.1 ± 4.7	24.5 ± 4.9
W/Z +jets and fake-l	25.7 ± 4.1	45.8 ± 8.9	62.2 ± 12.5
Sum of Backgrounds	**35 ± 5**	**70 ± 10**	**87 ± 13**
Observed	**54**	**63**	**78**

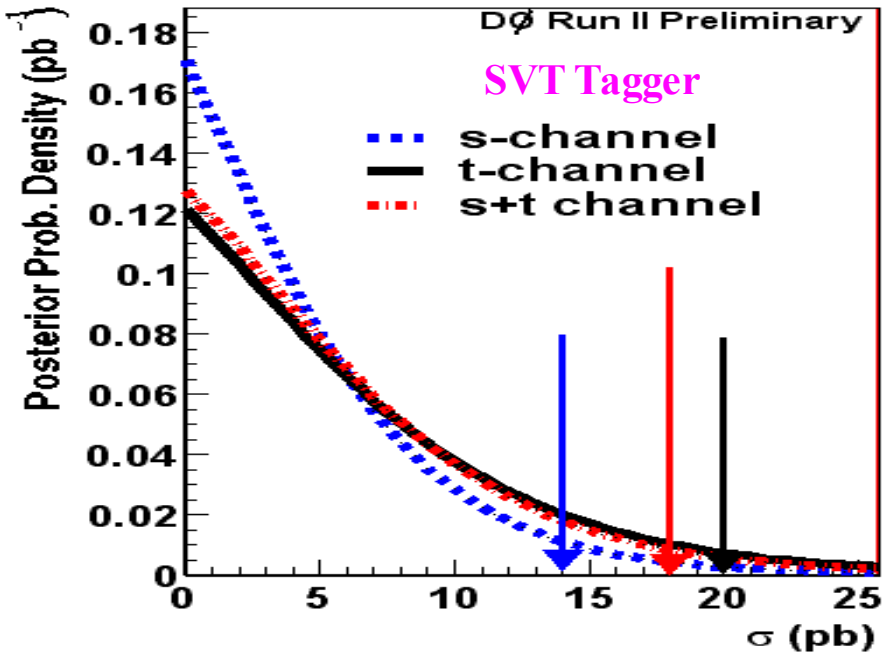
- Systematic Uncertainties
  - MC Signal acceptance : dominated by jet energy scale, trigger, and tagger modeling, **~ 20%**
  - MC-based background yields : also includes normalization, **~ 25%**
  - Data-based background yields : dominated by tagging probability estimate, **~ 20%**

Results: Limits for Single Top Production cross section

- Use Bayesian approach (with *flat* prior for single top cross section)
- Include systematic uncertainties and correlations (Multi-Variate Gaussian)
- Also use CL_s method for setting limits (different interpretation, but results similar)

Observed/Expected limit at 95% CL (Bayesian approach)

	σ_s	σ_t	σ_{s+t}
SLT	σ_s < 53/26 pb	σ_t < 81/42 pb	σ_{s+t} < 72/35 pb
SVT	σ_s < 14/18 pb	σ_t < 20/24 pb	σ_{s+t} < 18/21 pb
JLIP	σ_s < 16/20 pb	σ_t < 22/27 pb	σ_{s+t} < 20/24 pb



Conclusions and Outlook

- First search for single top quark production in DØ Run II
  - Focus on understanding of data
  - Current sensitivity better than in Run I

- Work towards observation of single top
  - Improve detector understanding and background modeling
    - Reduce systematic uncertainties
  - Keep acceptance as high as possible
    - Improve selections, b-tagging
  - Employ advanced analysis techniques
    - Neural Networks for better background rejection
    - Limit setting using shapes of kinematic distributions

Backup Slides

Modeling of Signal and MC Backgrounds

Signal: Single Top Production

- **COMPHEP** (corrected to NLO), with
- PYTHIA: include underlying event, ISR/FSR, hadronization
- TAUOLA: decay tau leptons
- EVTGEN: decay B-hadrons
- $Q^2 = m_t^2$ (s-channel), $Q^2 = (m_t/2)^2$ (t-channel)
- Parton distribution functions (PDF): **CTEQ6.1M**

MC-based Backgrounds: Top-pair (tt) production

- LO **ALPGEN**, with
- PYTHIA: include underlying event, ISR/FSR, hadronization
- TAUOLA: decay tau leptons
- EVTGEN: decay B-hadrons
- cross section scaled to NLO
- $Q^2 = m_t^2$
- Parton distribution functions (PDF): **CTEQ6M**

Background Estimation