Reinhard Schwienhorst

# Search for W' boson production in the top quark decay channel

MICHIGAN STATE
UNIVERSITY

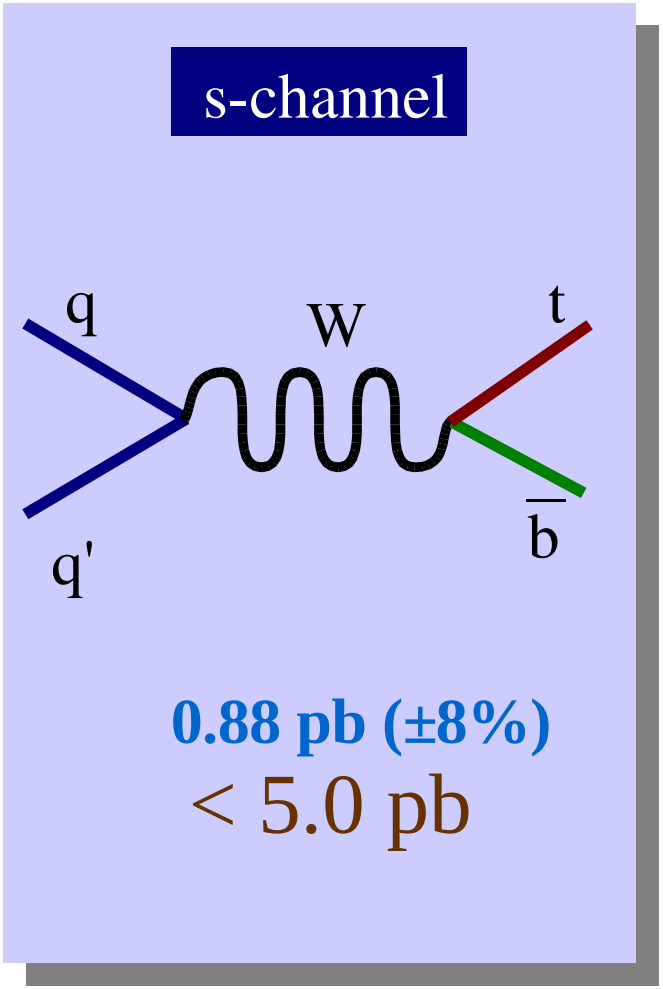
on behalf of the DØ collaboration

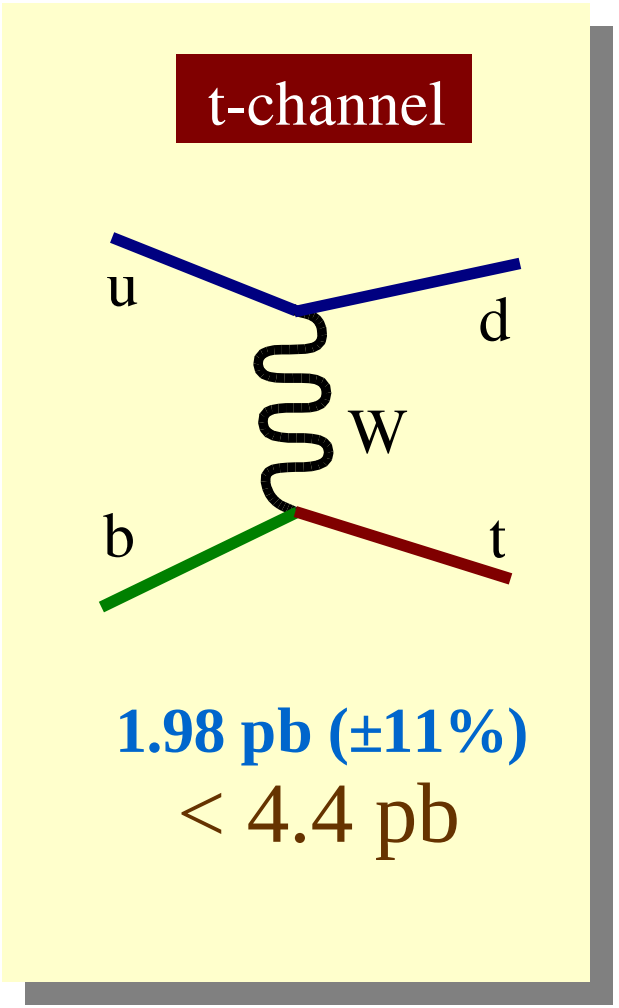
Pheno 2006

# Outline

- Introduction
  - Single top quark production
  - New heavy boson W'
- Analysis procedure
- Result
- Conclusions

# Single Top Quark Production



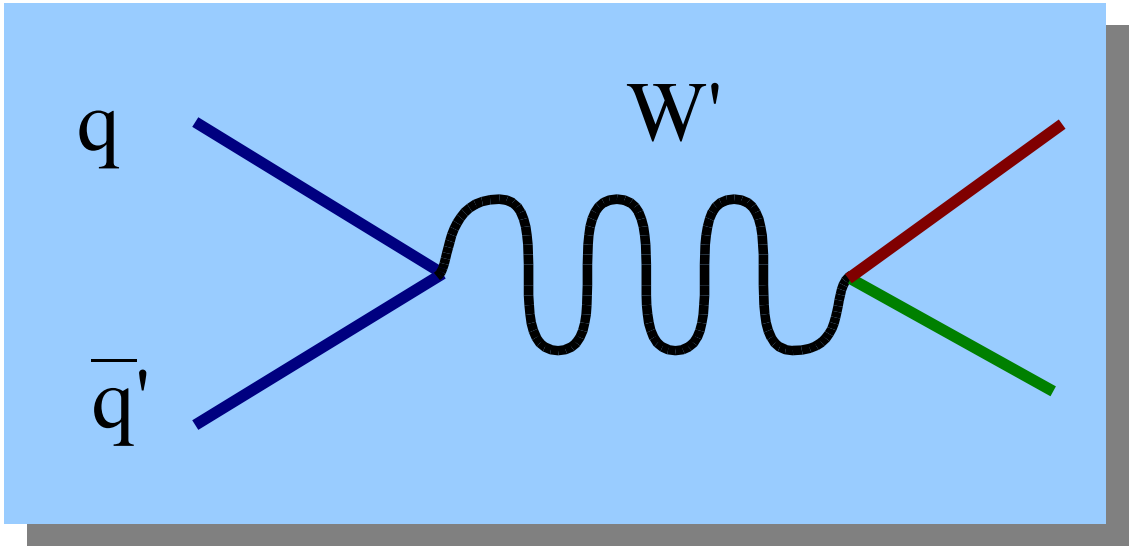

NLO calculation: **0.88 pb (±8%)** **1.98 pb (±11%)**

DØ 95% CL limit: < 5.0 pb < 4.4 pb

- Neural Network analysis with 230 $pb^{-1}$ published
- Likelihood-based analysis with 360 $pb^{-1}$
  - See talk by Ernest Aguilo on Tuesday

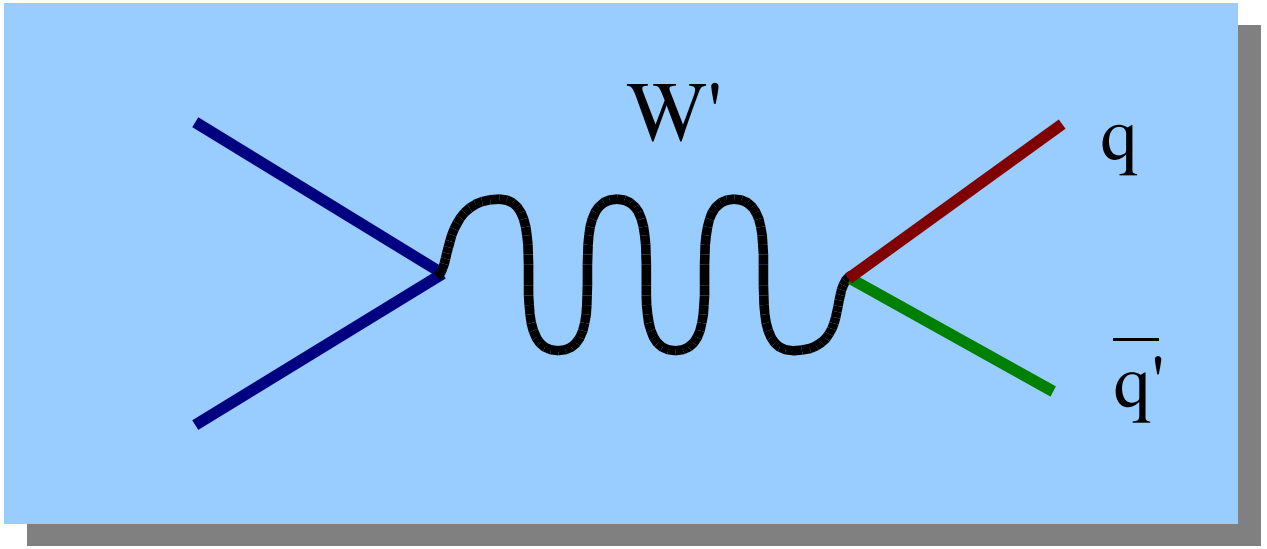
# New heavy boson W'

- Many extensions of the SM involve heavy gauge bosons
  - Typically called W' and Z'
  - From larger, extra gauge symmetry groups
  - Could interact differently with leptons and quarks
- Current limits: M(W'→leptons) > 786 GeV



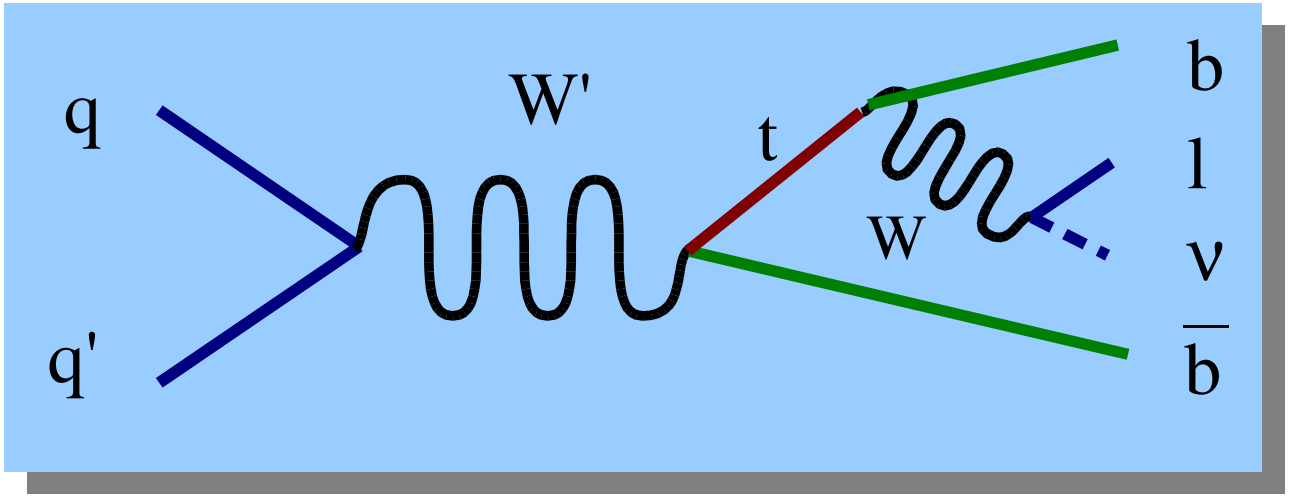
# W' in the hadronic channel

- W' might only decay hadronically
  - Example: right-handed interaction, $M(\nu_R) > M(W')$
  - Current limits: $M(W' \rightarrow qq') > 800$ GeV

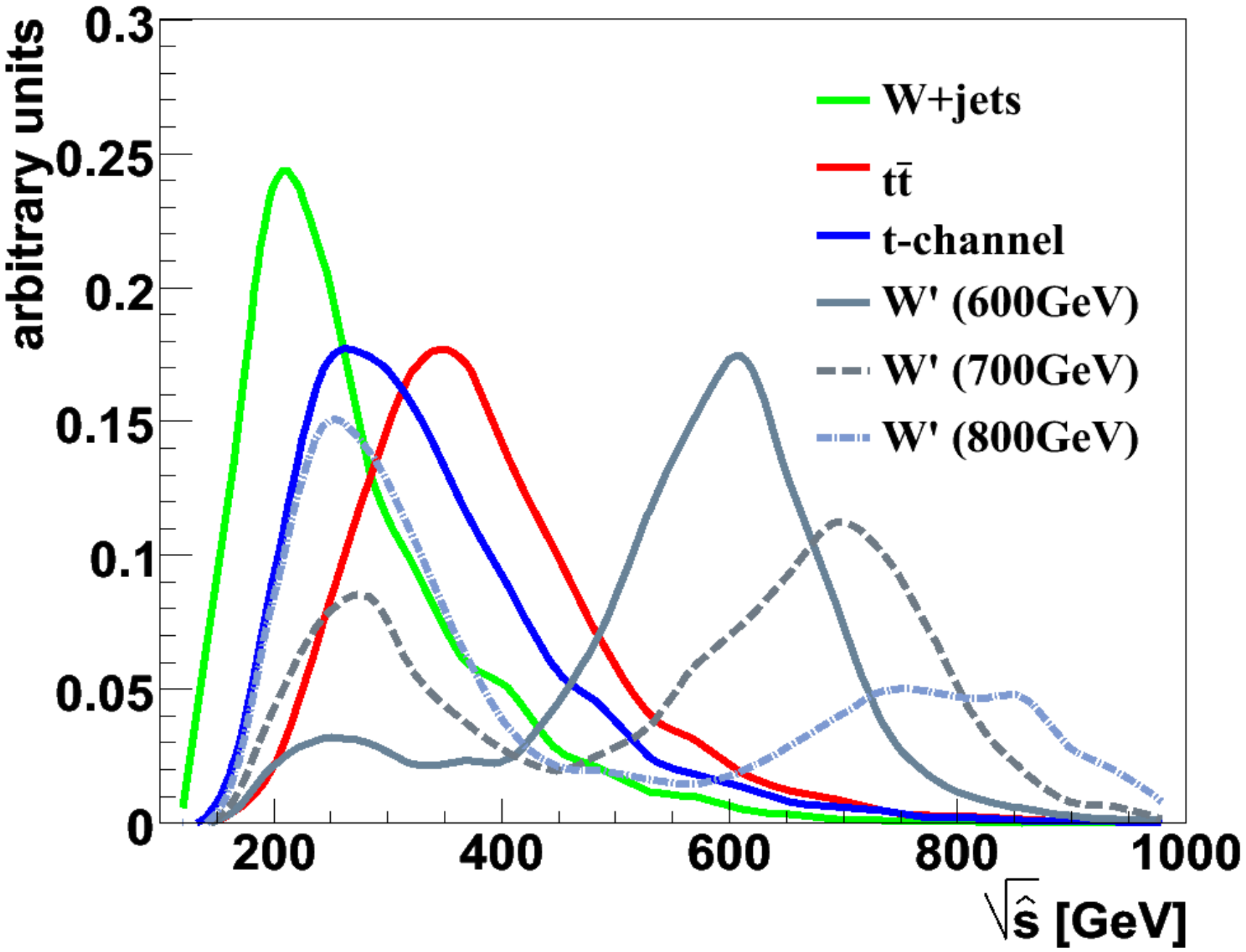


# W' in the single top quark channel

- Single top quark production is the ideal place to search for hadronic decays of a W'
  - New physics coupling to heavy quark
  - Current limit (CDF Run I): M(W') > 566 GeV
- W' model used here: W'→tb with SM-like couplings
  - Include interference with SM W boson in event generation



# W' final state invariant mass

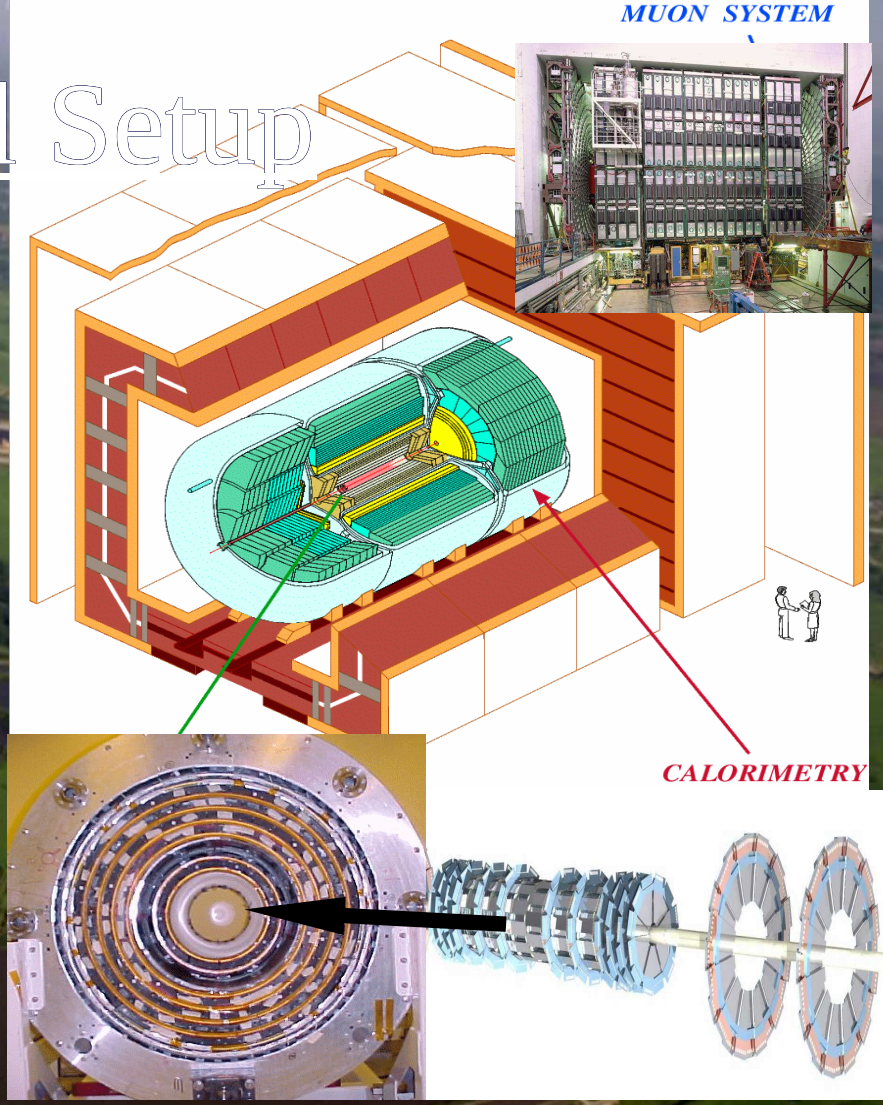


# Experimental Setup

Fermilab Tevatron in Run II

**Proton-Antiproton Collider**
**CM Energy 1.96TeV**

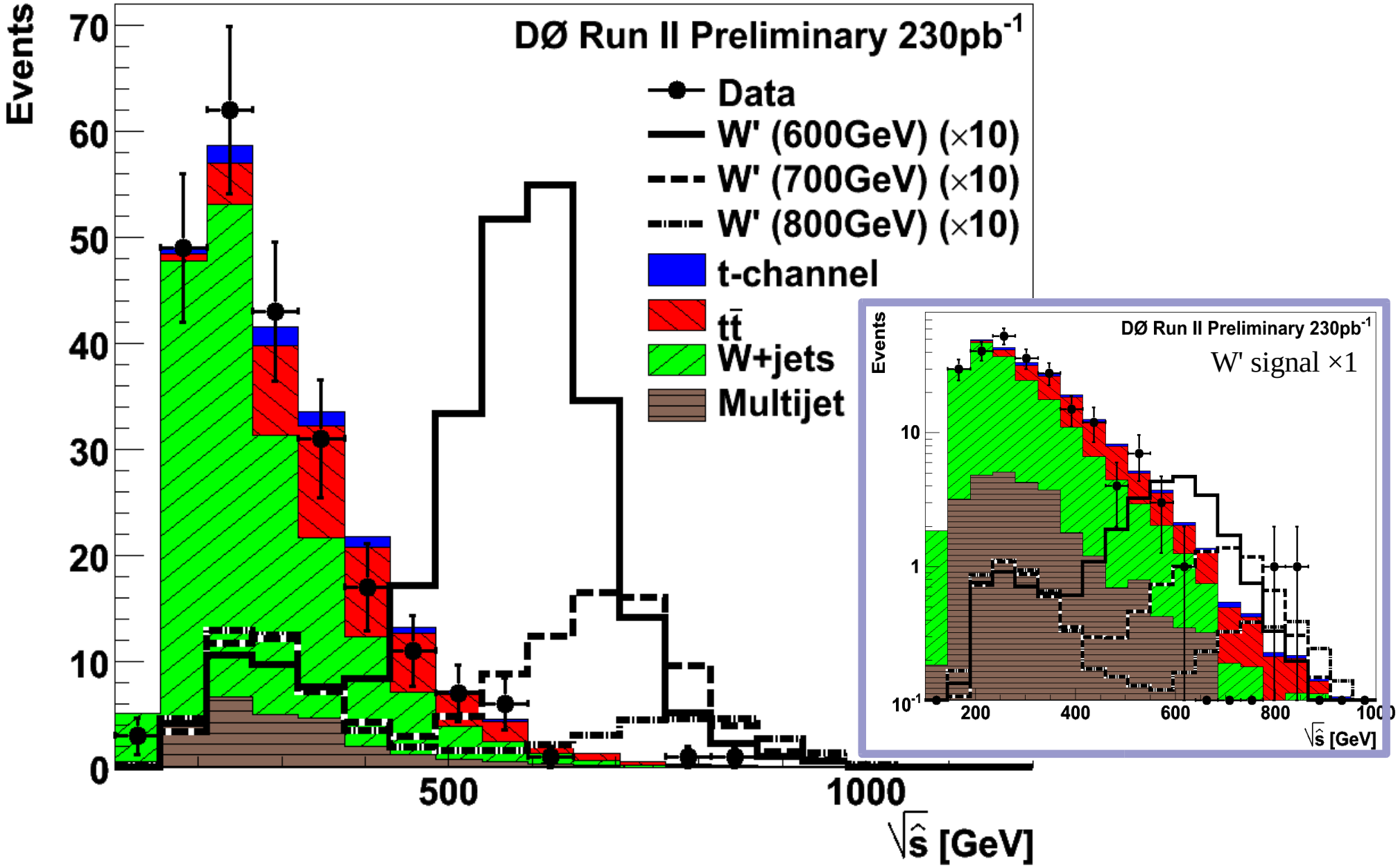
→ *Energy Frontier*



# Analysis procedure

- Follow procedure used in DØ single top publication
  - 230 $pb^{-1}$ dataset
  - Same background estimation methods, efficiencies, ...
- Apply s-channel single top selection cuts
  - Lepton $p_T$>15GeV, MET>15GeV, jet $p_T$>15GeV
  - Jet selection: $2 \leq n_{jets} \leq 3$
    - Reduce top pair background
- Analyze final state invariant mass distribution
  - Probe several W' mass points

# Final state invariant mass



# Limit Setting Procedure

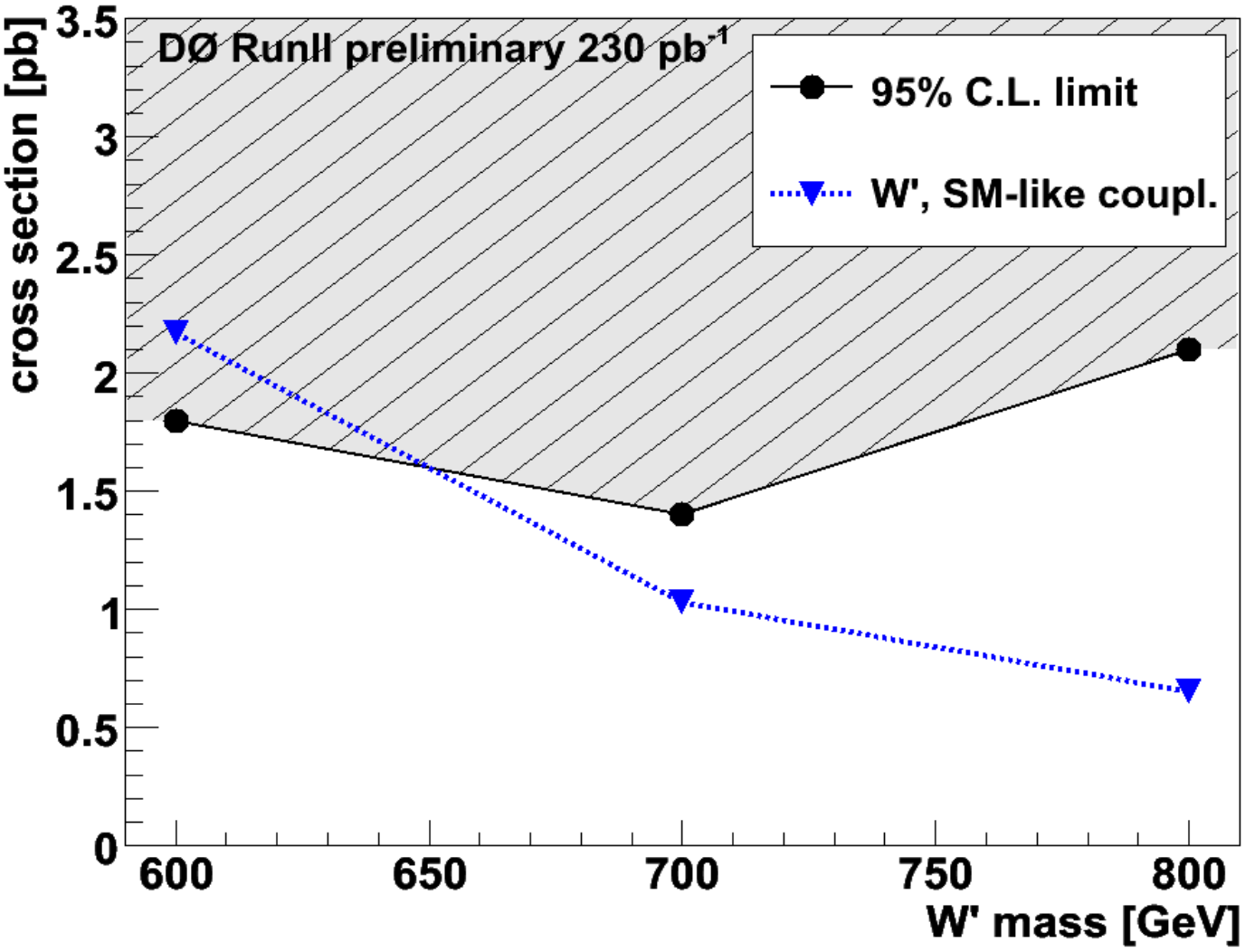
- Use $\sqrt{\hat{s}}$ distribution to set limits
  - In window $400\text{GeV} \leq \sqrt{\hat{s}} \leq 1000\text{GeV}$
- Including all systematic uncertainties

| | signal | backgrounds |
|---|---|---|
| • b-tag modeling | 4 – 16% | 5 – 20% |
| • Jet energy calibration | 1 – 2% | 15 – 30% |
| • Others (trigger, ID, ...) | 1 – 5% | 1 – 5% |

- Set limits separately for M(W') = 600 GeV, 700 GeV, 800GeV

| | $\sigma_{600\ \text{GeV}}$ | $\sigma_{700\ \text{GeV}}$ | $\sigma_{800\ \text{GeV}}$ |
|---|---|---|---|
| **Expected limit:** | < 1.8 pb | < 1.6 pb | < 2.1 pb |
| **Measured limit:** | **< 1.7 pb** | **< 1.4 pb** | **< 2.1 pb** |

# Result

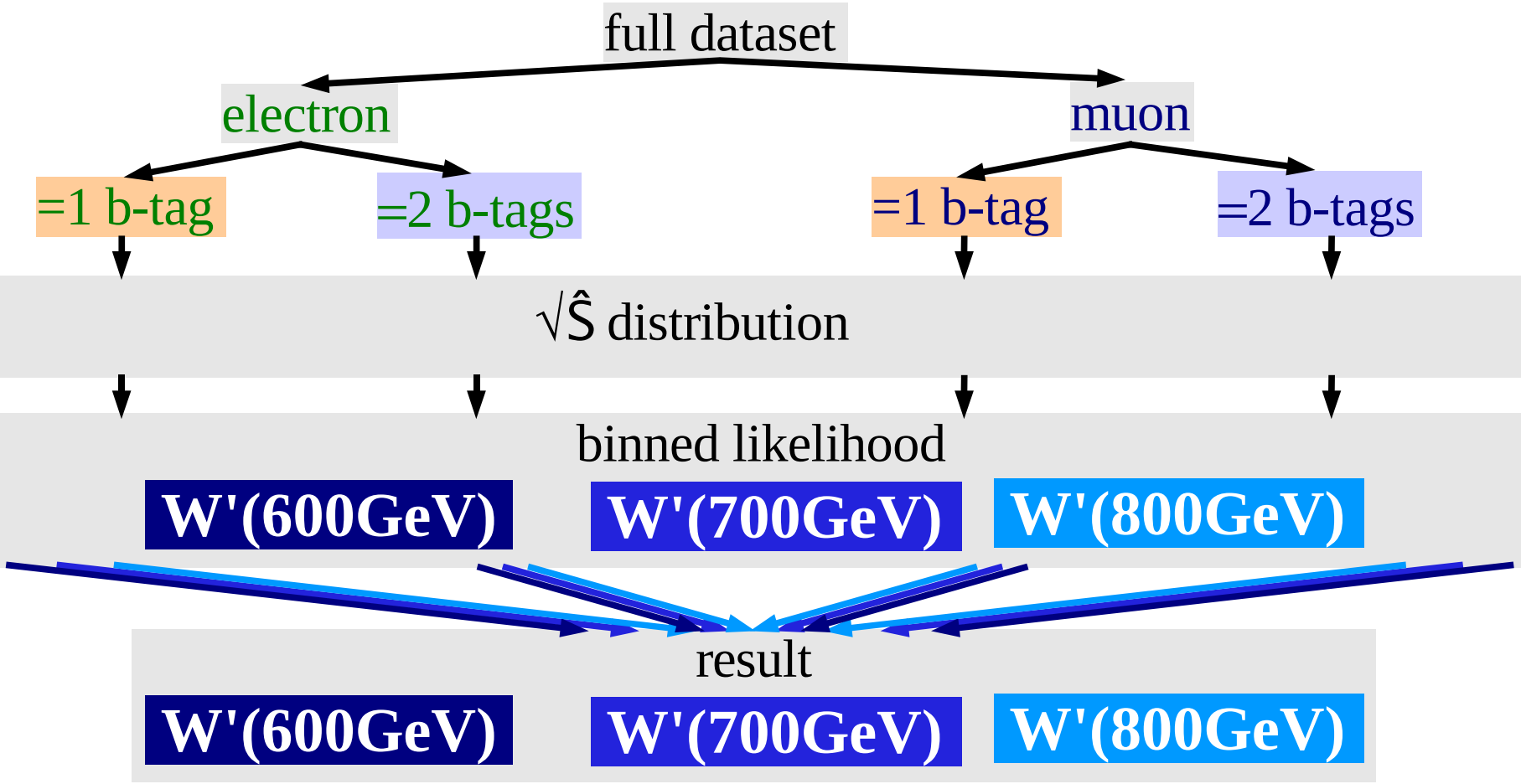

DØ RunII preliminary 230 pb-1
95% C.L. limit
W', SM-like coupl.
cross section [pb]
3.5
3
2.5
2
1.5
1
0.5
0
600
650
700
750
800
W' mass [GeV]

# Conclusions/Outlook

- Search for new heavy boson W' in 230pb$^{-1}$ of DØ data
  - Model: left-handed W' with SM couplings
  - Including interference with SM
- No evidence for a W' boson
- Mass limit: M(W') > 650 GeV
- Outlook:
  - Also test other W' models (right-handed coupling, ...)
  - With several fb$^{-1}$, can reach more than 800 GeV

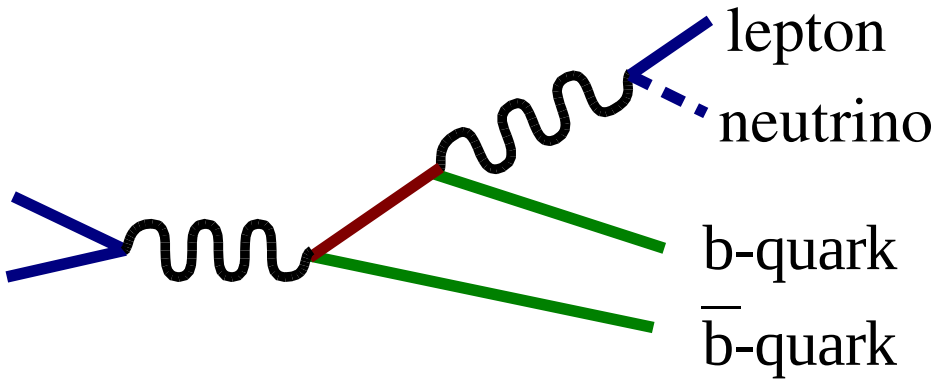
# Additional Material

# Analysis Strategy



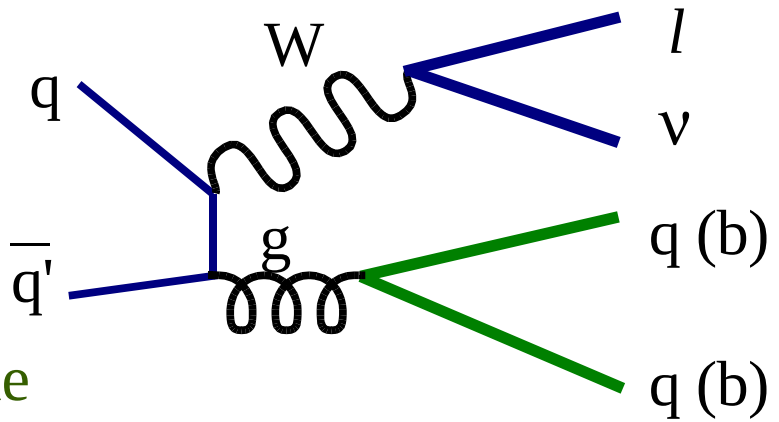
# Event Selection

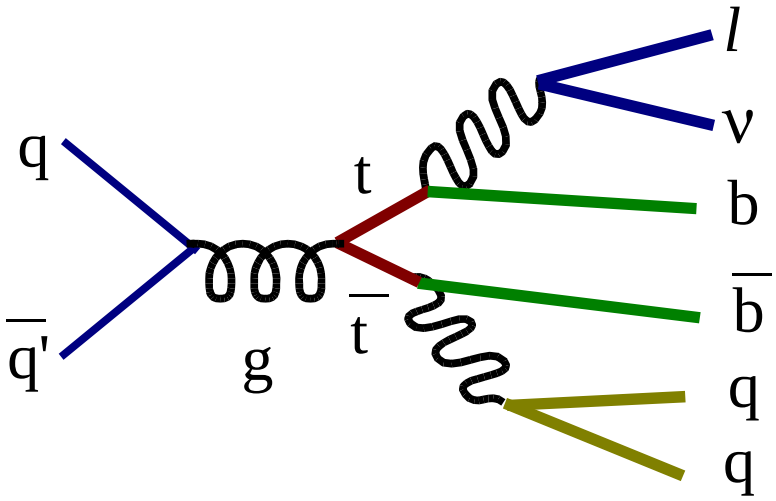
- Trigger:
  - Electron + ≥1 jets, muon + ≥1 jets
- Lepton:
  - 1 electron: $p_T > 15$GeV, $|\eta^{det}|<1.1$
  - 1 muon: $p_T > 15$GeV, $|\eta^{det}|<2.0$
- Neutrino: $\not\!\!E_T > 15$GeV
- Jets:
  - $p_T > 15$GeV, $|\eta^{det}|<3.4$, $p_T$ (jet 1)> 25GeV
    $|\eta^{det}(jet1)|<2.5$
  - $2 \le n_{jets} \le 3$
  - ≥ 1 b-tagged jet
- Reject mis-reconstructed events



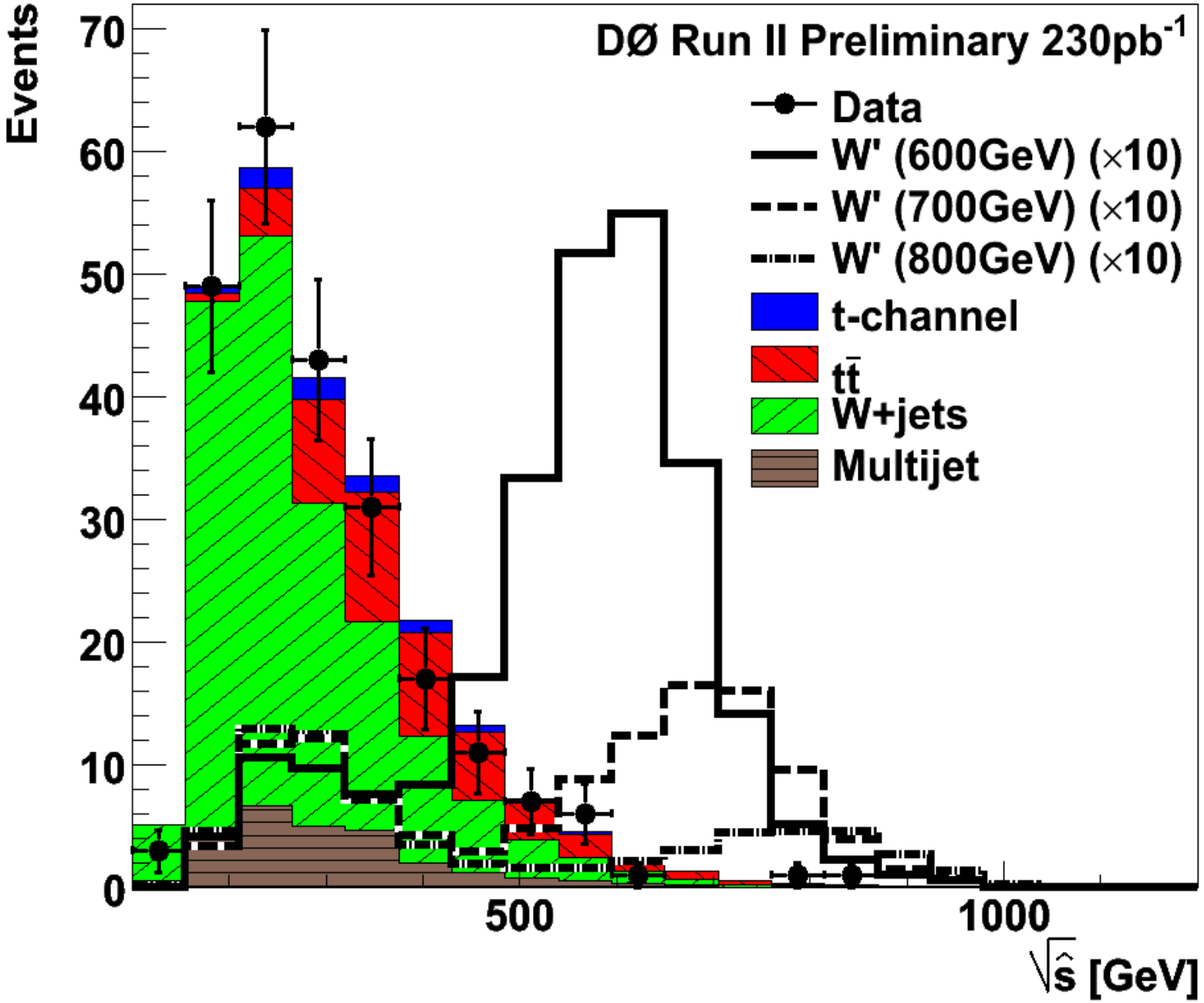
# Background Modeling

- Based on data as much as possible
- W/Z+jets production
  - Estimated from MC/data
    - Distributions from MC
    - Normalization from pre-tagged sample
    - Flavor fractions from NLO
- Multijet events (misidentified lepton)
  - Estimated from data
- Top pair production
  - Estimated from MC
- Diboson (WZ, WW)
  - Estimated from MC



# Final state invariant mass



# Final State Invariant Mass