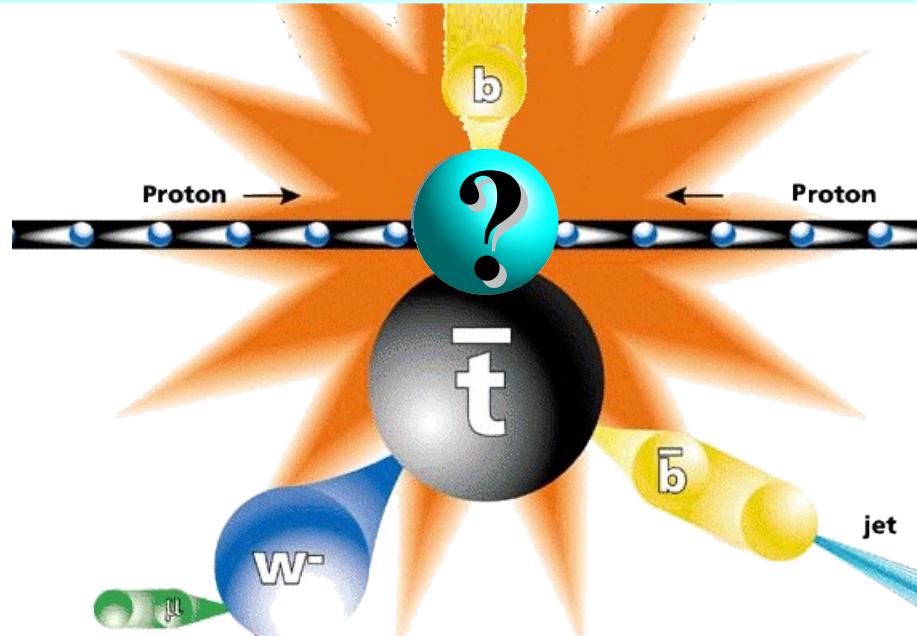


Search for non-standard production of single top quarks at DØ



Reinhard Schwienhorst

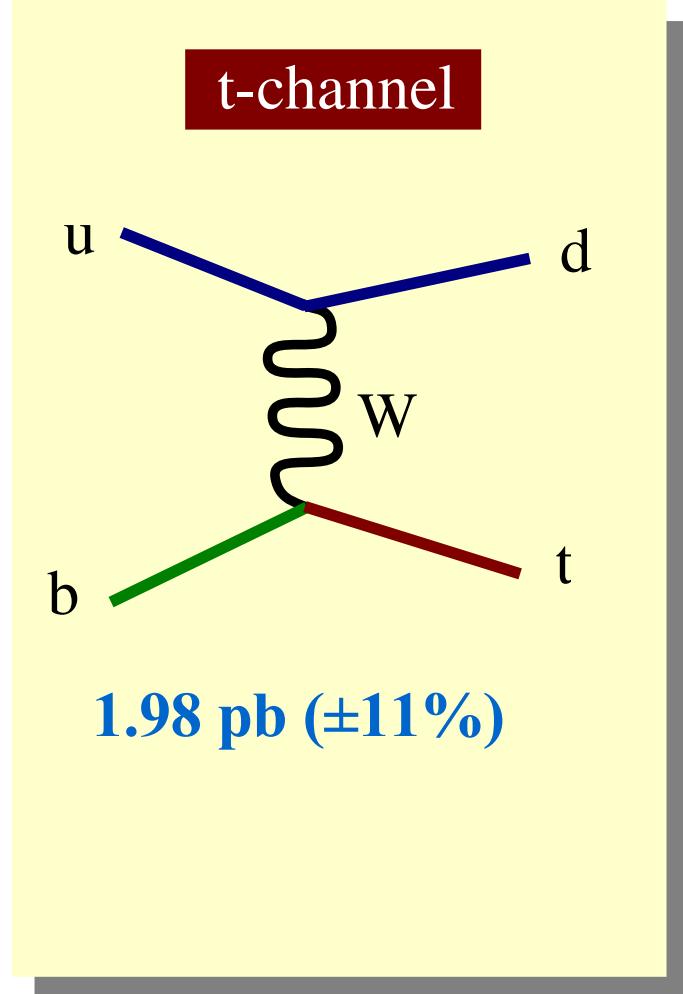
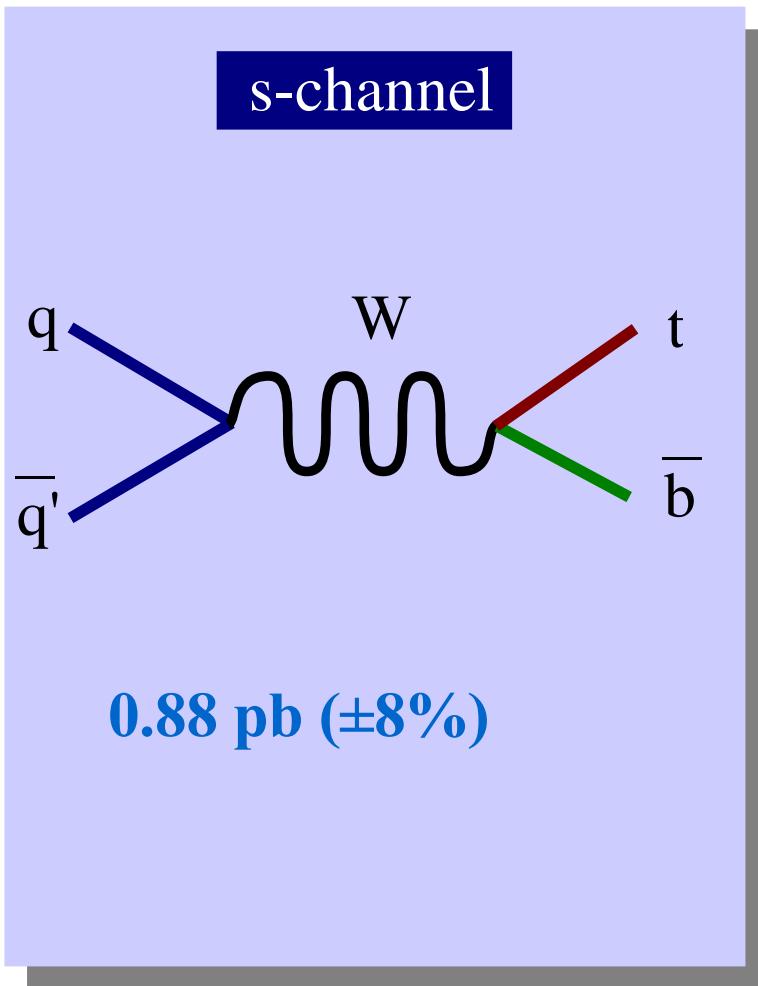
MICHIGAN STATE
UNIVERSITY

For the DØ collaboration

Outline

- Introduction
 - Single top quark production
 - New Physics
- Search for flavor changing neutral currents
- Search for new heavy boson W'
- Conclusions

Single Top Quark Production

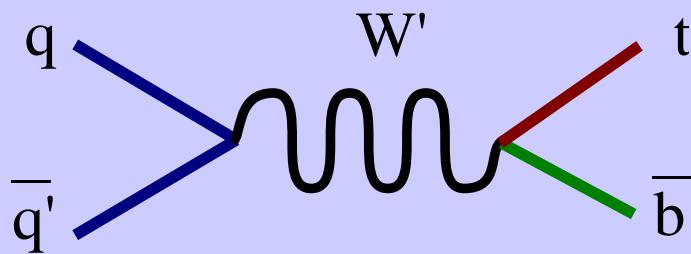


- Evidence for single top quark production with 1fb^{-1}
 - See other talks in this session
 - Observe excess above SM expectation \rightarrow new Physics?



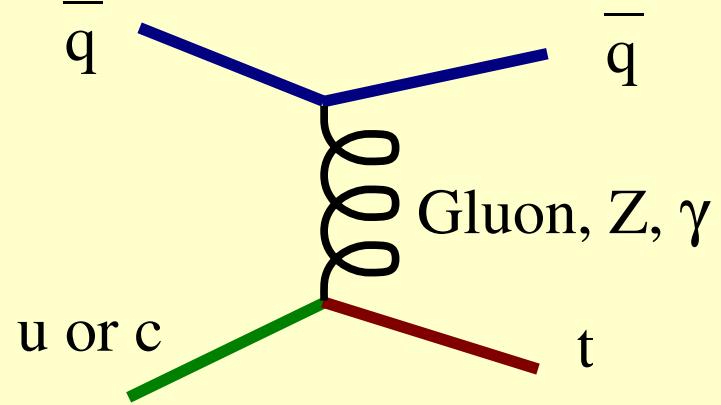
New Physics in Single Top Quark Production

s-channel:
new boson W'



- Heavy resonance decaying to top quark
- Focus on W' decay to $t\bar{b}$
- Include right-handed and left-handed interactions
- Assume SM-like W' couplings

t-channel:
FCNC



- Additional top quark coupling to light quarks
 - Z or γ coupling
→ excellent limits from top decay, Hera, LEP
- Focus on gluon coupling

Flavor Changing Neutral Currents and the top quark

- Exchange of a Z/γ :

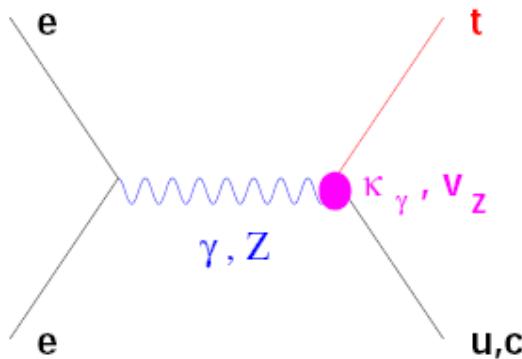
- Searches for top quark FCNC decays

$$B(t \rightarrow q\gamma) < 0.032 \quad (\kappa_\gamma < 0.4)$$

$$B(t \rightarrow qZ) < 0.33 \quad (\kappa_Z < 0.7)$$

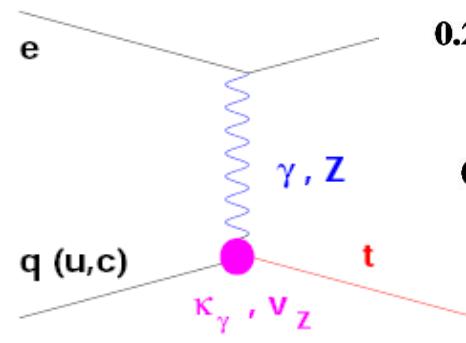
Phys. Rev. Lett. 80, 2525, Phys. Lett. B426, 393 (1998)

- Single top quark production searches



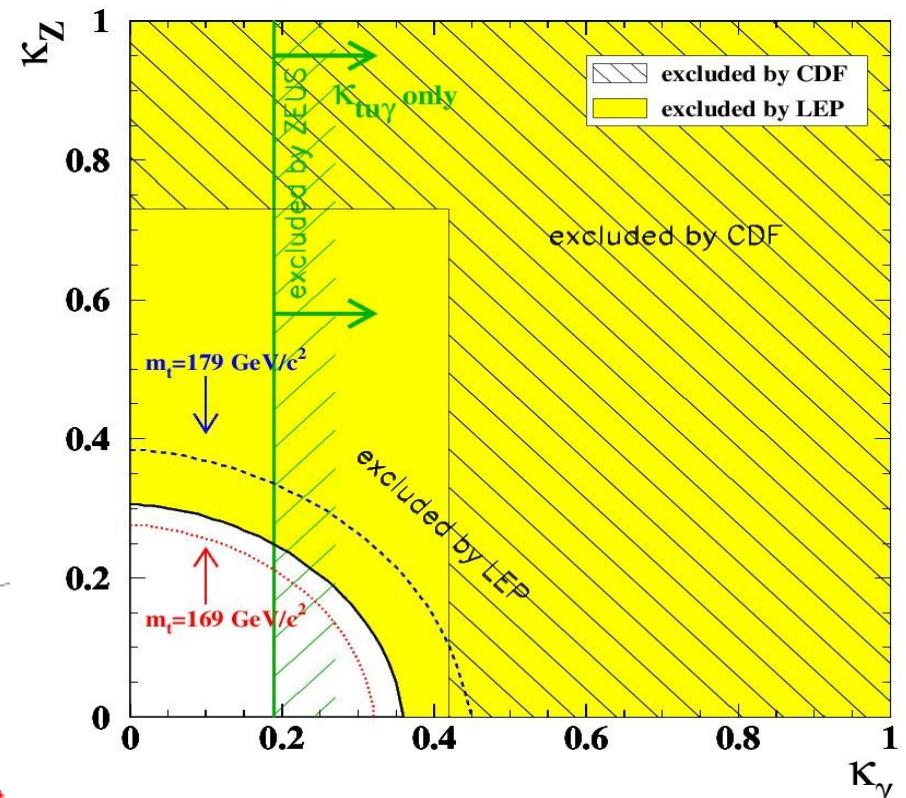
$$\kappa_{\gamma, Z} < 0.4 \text{ (L3 at LEP)}$$

Phys. Lett. B549, 290 (2002)



$$\kappa_\gamma < 0.18 \text{ (ZEUS at HERA)}$$

Phys. Lett. B559, 153 (2004)



- Exchange of a gluon:

- Phenomenological results based on single top quark searches at HERA

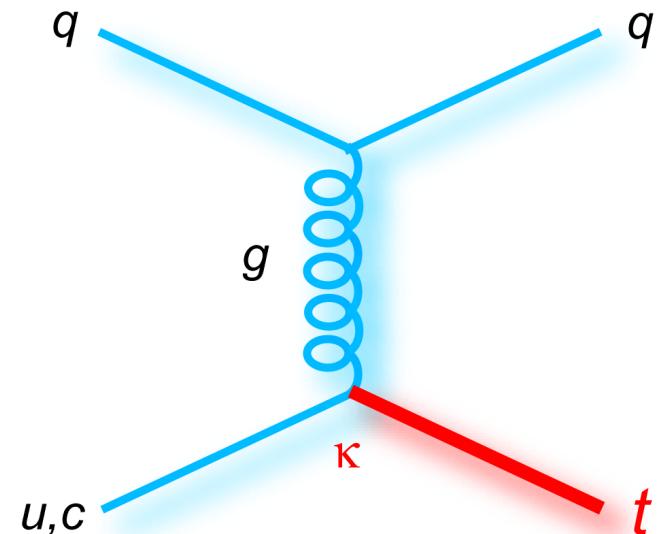
$$\kappa_{u, c} / \Lambda < 0.4 \text{ TeV}^{-1} \quad (\text{hep-ph/0604119})$$

Gluon FCNC coupling to top quarks

- Cross section is proportional to FCNC top quark coupling to up or charm quarks

$$\sigma \propto (\kappa_{u,c} / \Lambda)^2$$

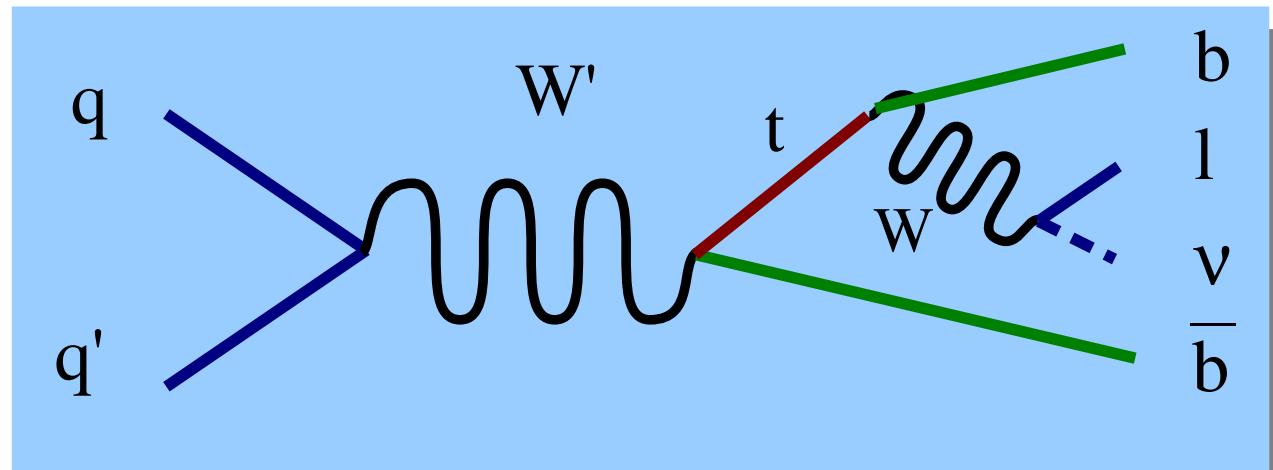
- Λ is the scale of the new physics
- κ_u (κ_c) is the strength of the tgu (tgc) coupling



- Same final state as t-channel single top quark
 - Modification of overall single top quark production rate
 - Different matrix element \rightarrow different kinematics
 - Form multivariate classifier to maximize signal sensitivity

New heavy boson W'

- Many extensions of the SM involve heavy gauge bosons
 - Typically called W' and Z'
 - Current limit: $M(W' \rightarrow \text{leptons}) > 786 \text{ GeV}$
 - If W' only couples to hadrons: $M(W' \rightarrow q\bar{q}') > 800 \text{ GeV}$
- 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): $M(W') > 566 \text{ GeV}$
- W' model used here: $W' \rightarrow tb$ with SM-like couplings
 - Include interference with SM W boson in event generation

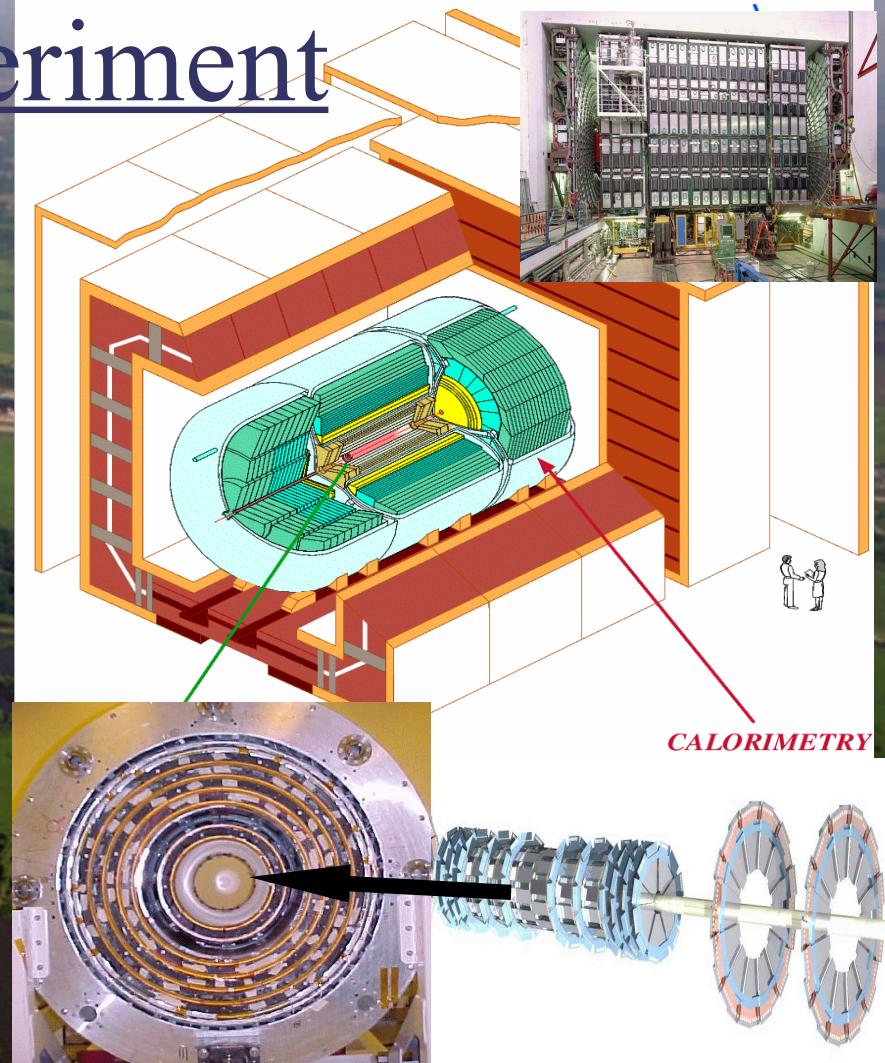


Tevatron and DØ Experiment

Tevatron
Proton-Antiproton Collider
CM Energy 1.96TeV

→ *Energy Frontier*

DØ experiment
230 pb⁻¹ of data for this analysis





Analysis procedure

- Data sample: **230 pb⁻¹** of lepton+jets data
(lepton: electron or muon)

[Phys. Lett. B **622**, (2005)]
(\geq one b-tagged jets)

- Backgrounds:

- W/Z+jets and diboson production (“W+jets”)
- Top-pair production (“ttbar”)
- Multi-jet events
- SM single top

- Selections:

- Leptons: $p_T > 15 \text{ GeV}$
 $|\eta_{\text{det}}| < 1.1$ (electron)
 $|\eta_{\text{det}}| < 2.0$ (muon)
- MET: $15 \text{ GeV} < \text{MET} < 200 \text{ GeV}$
- Njets: $2 \leq \text{Njets} \leq 4$
- Jets: $E_T > 15 \text{ GeV}, |\eta_{\text{det}}| < 3.4$
- Leading jet: $E_T > 25 \text{ GeV}, |\eta_{\text{det}}| < 2.5$

Separate into
single tags and double tags
for W' search

Require
exactly one b-tagged jet
for FCNC search

Gluon FCNC coupling to top quarks

- Use neural networks to separate the FCNC signals from the backgrounds
 - Signal: sum of both tgc and tgu
 - Background: sum of all SM processes

- 10 discriminating variables

Individual object kinematics

p_T (jet1), p_T (tagged jet),

η (lepton), Missing E_T

Global event kinematics

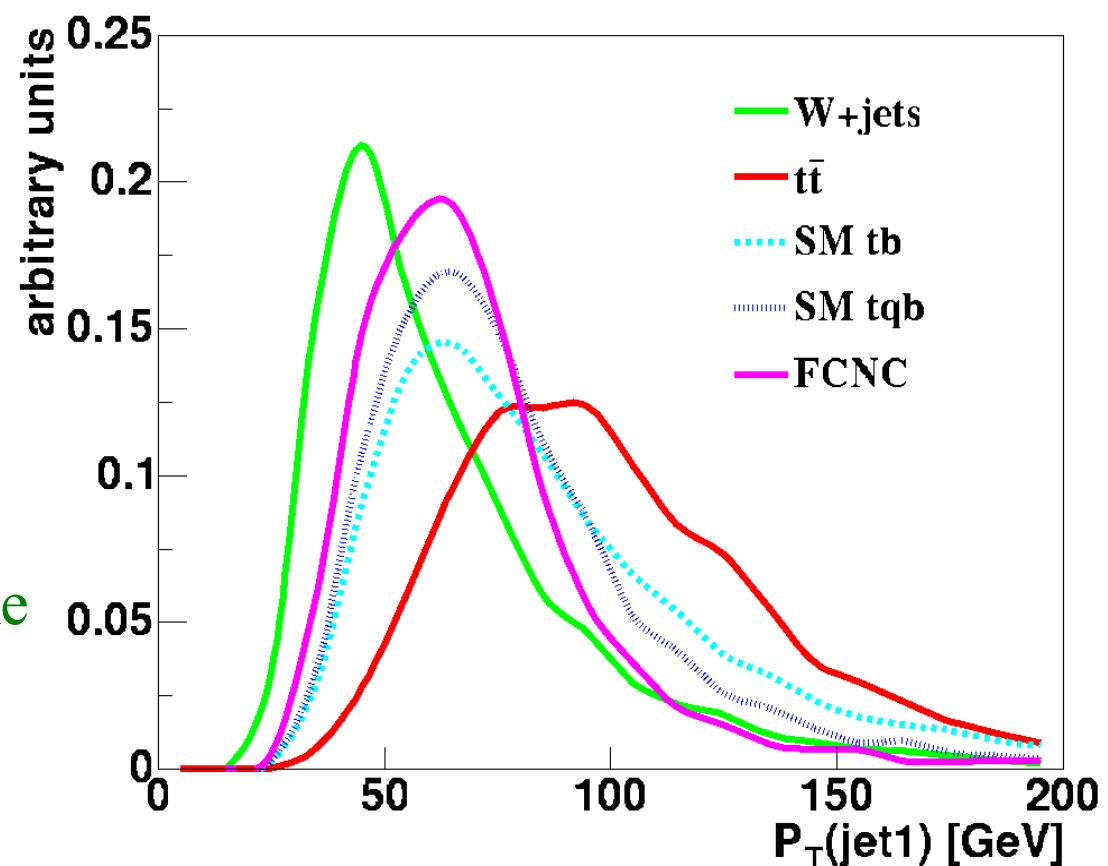
H_T (jet1, jet2), $p_T(W)$,

p_T (jet1, jet2), $M(\text{all jets})$,

Top Mass (using tagged jet)

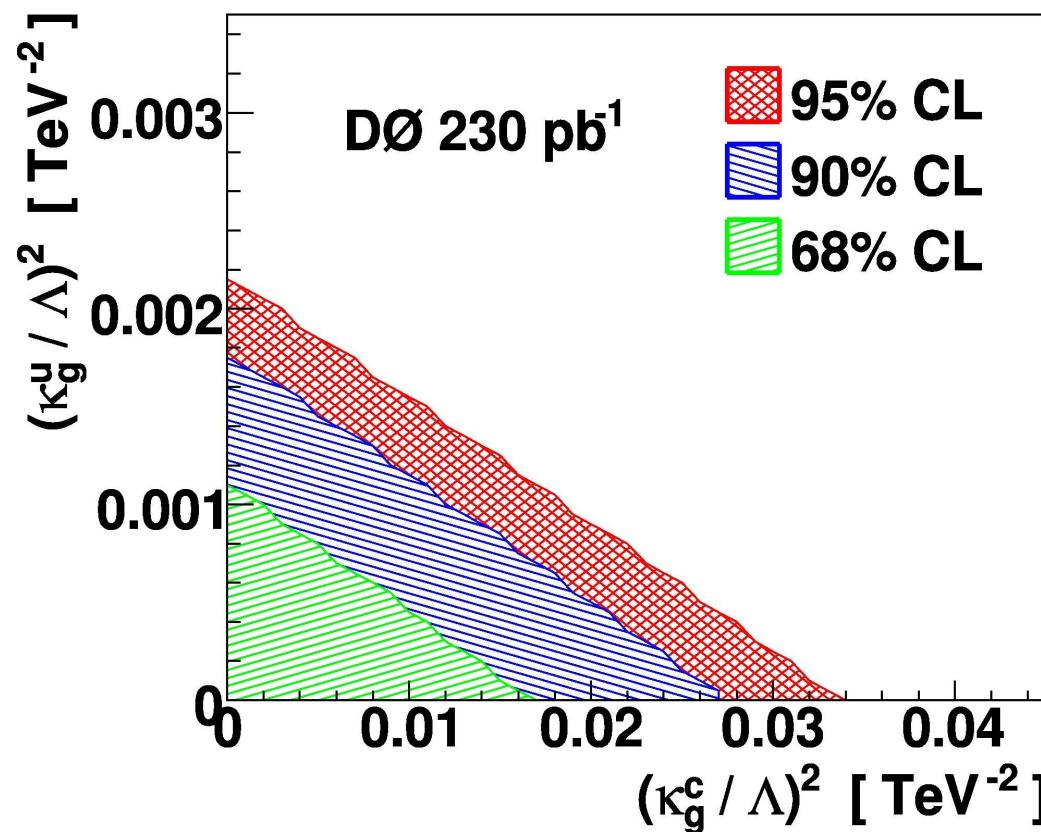
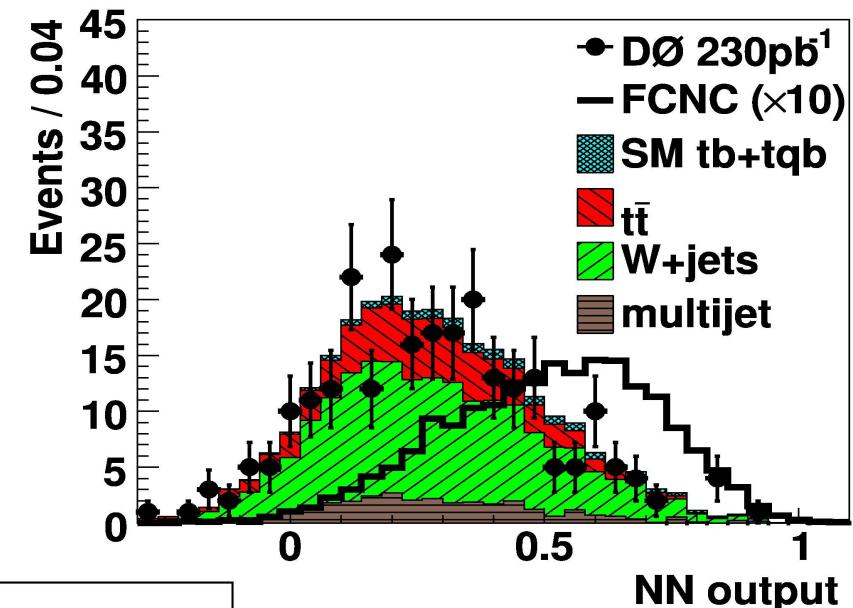
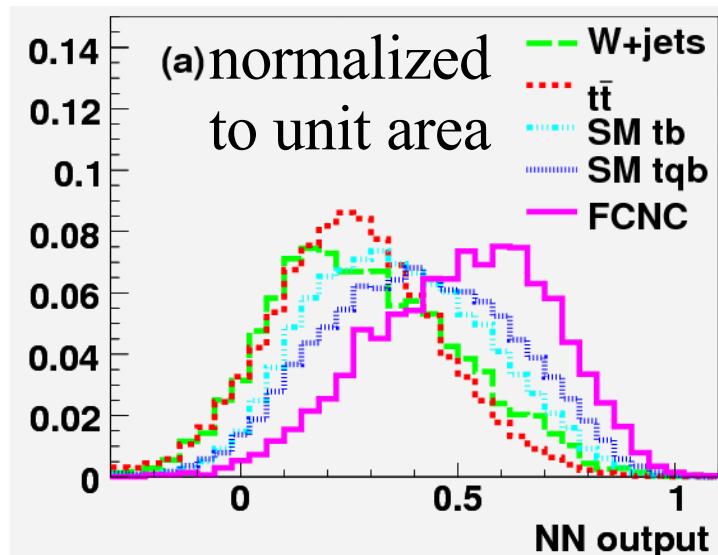
Angular correlations

$\text{Cos}(\text{lepton}, \text{jet1})$ in the lab frame





FCNC result



95% C.L. Coupling limit:

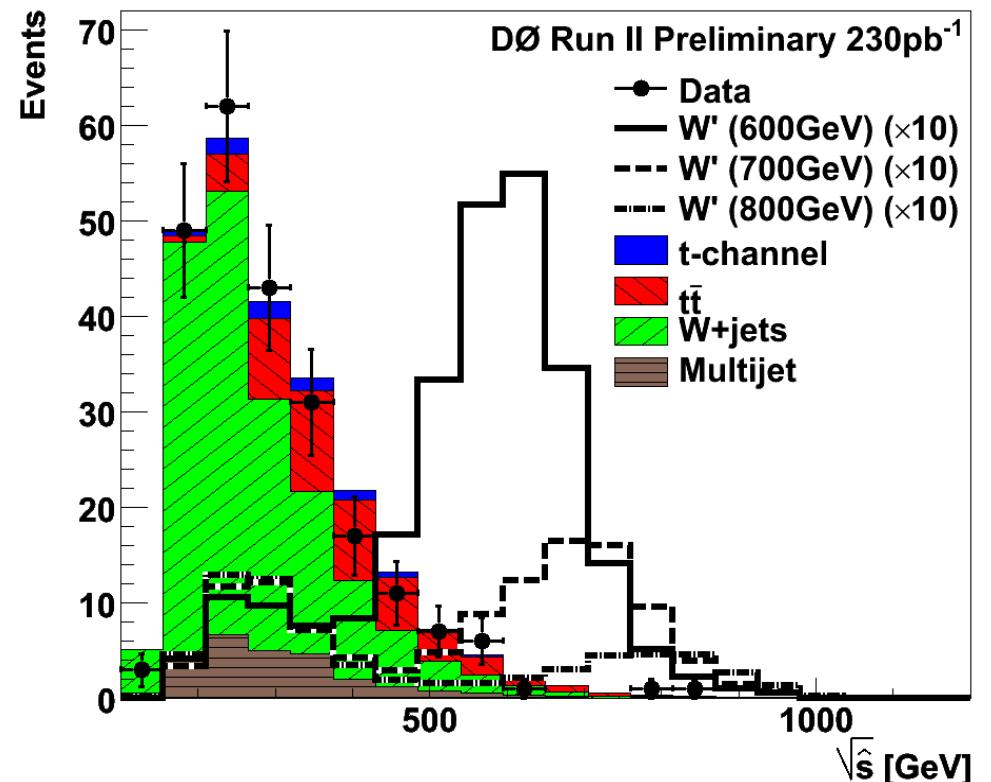
$$\kappa_u^u / \Lambda < 0.037 \text{ TeV}^{-1}$$

$$\kappa_c^c / \Lambda < 0.148 \text{ TeV}^{-1}$$

Submitted to PRL

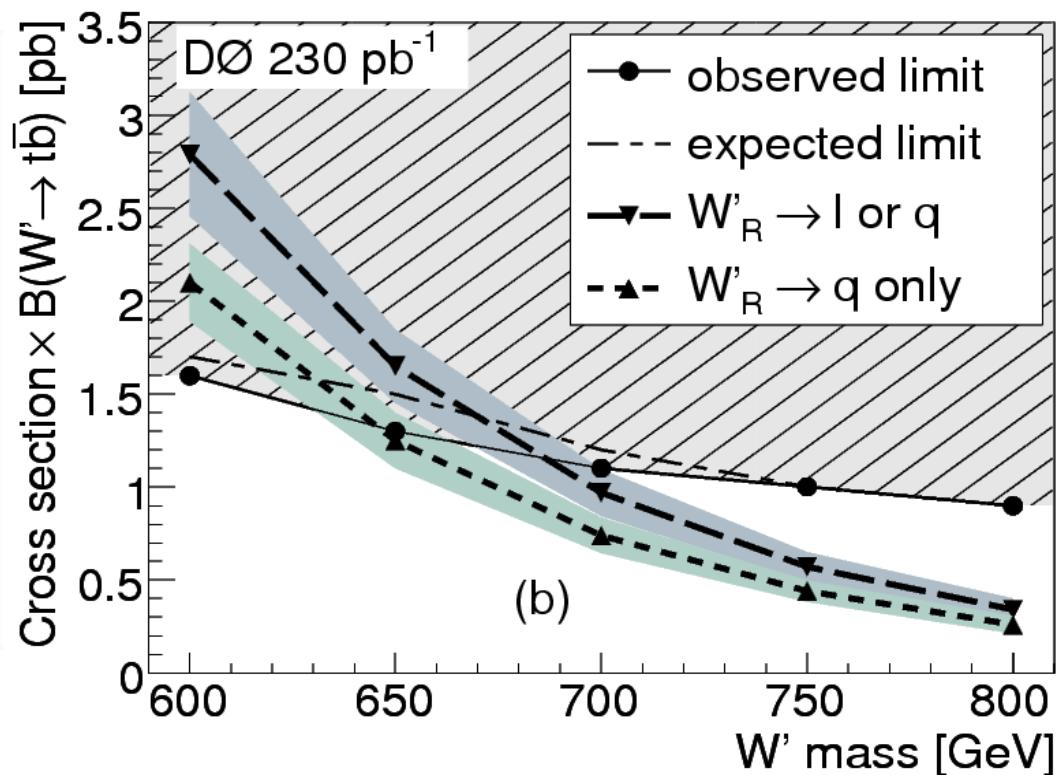
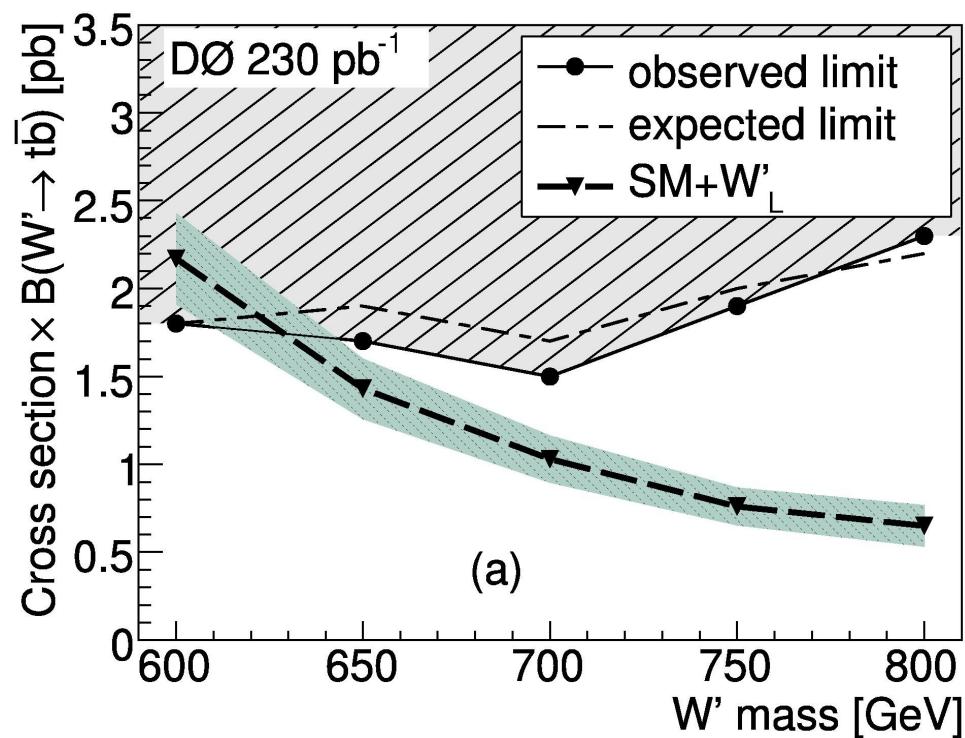
W' analysis procedure

- Use final state invariant mass ($\sqrt{\hat{S}}$) distribution to set limits
 - For several masses between 550 GeV and 800 GeV
- Bayesian limit setting approach
- 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%

W' Results



At the 95% C.L.: $M(W'_L) > 610 \text{ GeV}$

$M(W'_R \rightarrow l \text{ or } q) > 630 \text{ GeV}$
 $M(W'_R \rightarrow q \text{ only}) > 670 \text{ GeV}$

PLB 641, 423 (2006)



Conclusions/Outlook

- Search for new physics in 230 pb^{-1} of DØ data
- No evidence for flavor-changing neutral currents
 - Improve limits on FCNC gluon couplings by factor 4-10
- No evidence for a W' boson
 - Set mass limit for several different W' coupling scenarios
 - Improved limits for W'_L and W'_R
- Outlook:
 - Repeat searches with larger datasets
 - Currently analyzing 1 fb^{-1} sample
 - “Evidence” dataset
 - Expect to accumulate 4 fb^{-1} to 8 fb^{-1}
 - Extend searches to other new single top physics signals