Search for Single Top Quarks through FCNC interactions at DØ

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(on behalf of the DØ Collaboration)

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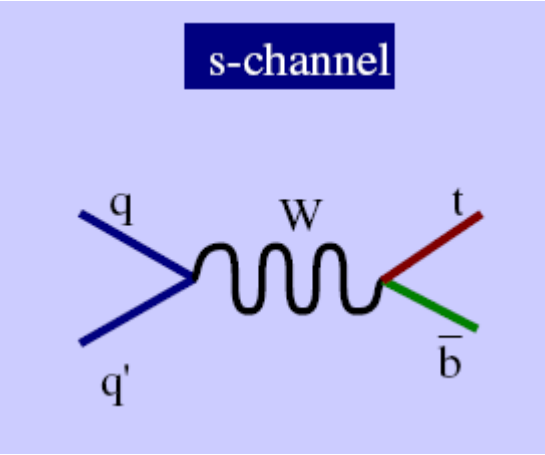
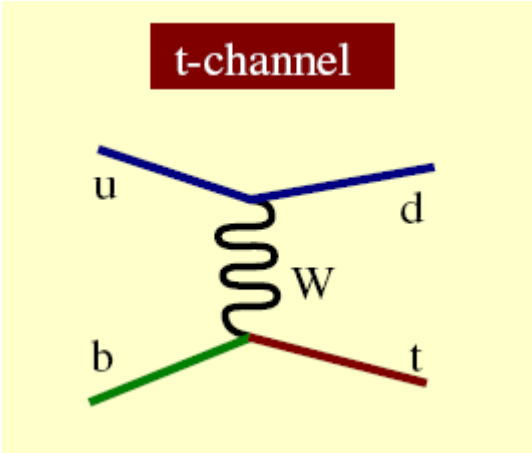
Outline

- Introduction
  - FCNC production of single top quarks, and the status of searches
- Analysis details
  - Signal and background modeling
  - Selections
  - Event yields
- Kinematic distributions
- Neural Network analysis
- Results and Conclusions

Single top quark production



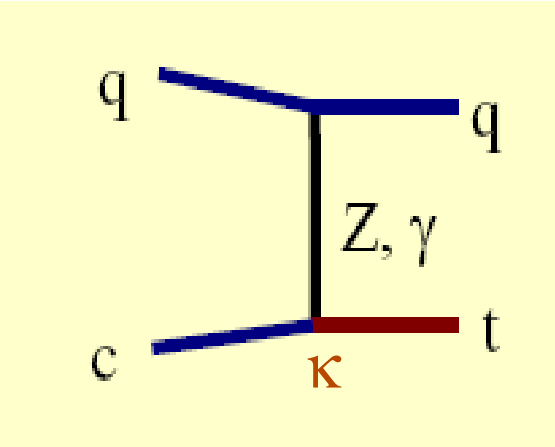
Standard Model

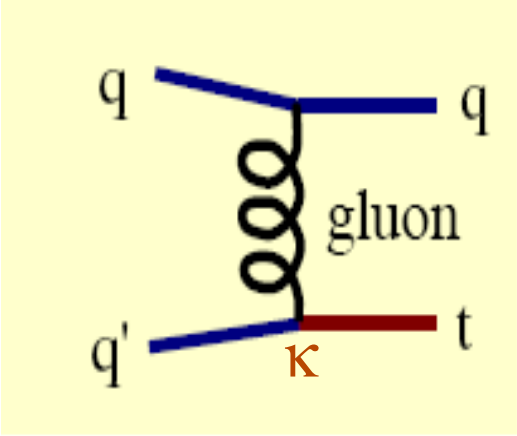


σ_{NLO} = 0.88 ± 0.07 pb (Tevatron)

σ_{NLO} = 1.98 ± 0.22 pb (Tevatron)

- Additional single top events are also possible, from non-SM interactions, for example, from ***flavor-changing neutral-currents* (FCNC)**





- Resulting cross sections can be significantly enhanced (~ 8 pb, Tevatron) depending on the coupling κ

Status of FCNC searches in single top production

- Exchange of a Z/γ:

  - Limits on FCNC decays of the top quark

    - $B(t \rightarrow q\gamma) < 0.032$, and $B(t \rightarrow qZ) < 0.33$,

      (CDF, at Tevatron) Phys. Rev. Lett. 80, 2525, 1998

  - Limits on FCNC couplings, from studies of single top-quark production and decay

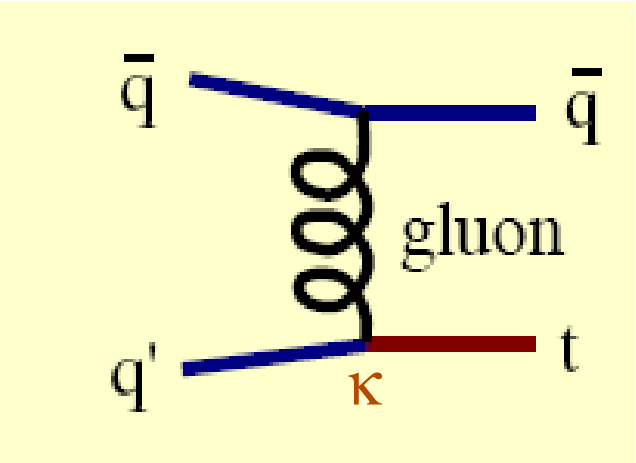
    - $\kappa_{\gamma, Z} < 0.4$, (L3 at LEP) Phys. Lett. B549, 290

    - $\kappa_{\gamma} < 0.174$, (ZEUS at HERA) Phys. Lett. B559, 153

- Exchange of a gluon:

Effective Lagrangian:

$$\frac{\kappa_f}{\Lambda} g_s \bar{f} \sigma^{\mu\nu} \frac{\lambda^a}{2} t G^a_{\mu\nu} + h.c.$$



where,

f: *u*-quark, or *c*-quark

G: gauge field tensor of gluon

κ_f: strength of *tgu* or *tgc* couplings

Λ: scale of new physics

- Recent results using data from HERA

  - $\kappa_{u,c} / \Lambda < 0.4$ TEV^{-1}, hep-ph/0604119

Signal and background modeling

- Signal: We generate two sets of signals using CompHEP
  - $\kappa_u / \Lambda = 0.03\ \mathrm{TeV}^{-1}$, $\kappa_c / \Lambda = 0$
  - $\kappa_u / \Lambda = 0$, $\kappa_c / \Lambda = 0.03\ \mathrm{TeV}^{-1}$

- Background:

  - W/Z+jets production
  - Mis-reconstructed multi-jet events
  - Top-pair (ttbar) production (lepton+jets, dilepton)
  - Diboson production
  - SM single top production
    (s-channel “tb”, t-channel “tqb”)

Data sample and selections

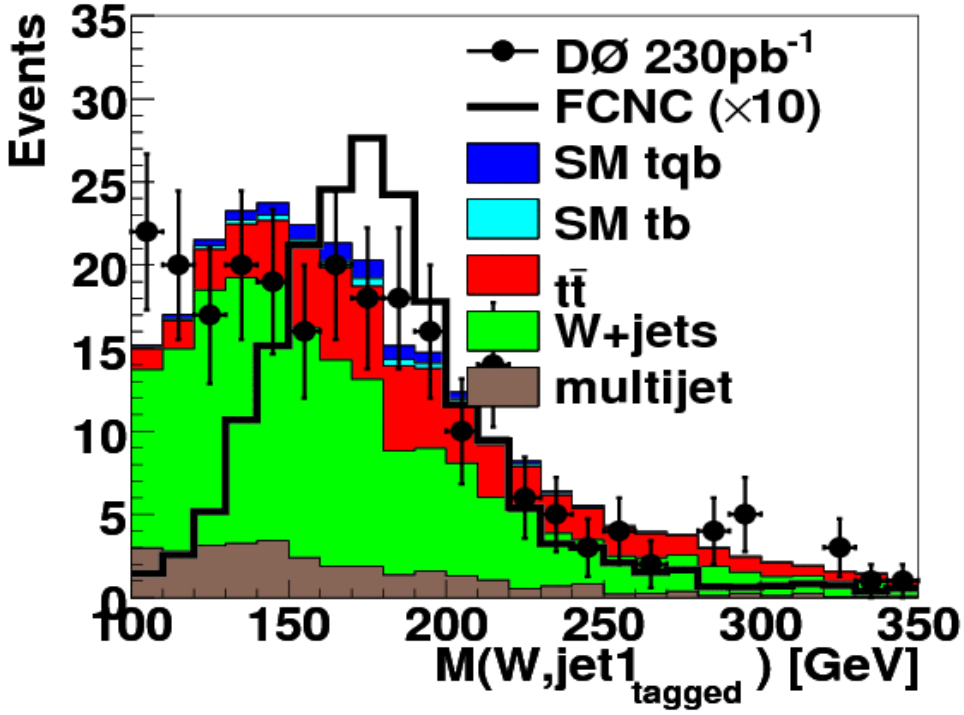
- Data sample: **230 pb^{-1}** of DØ Run II data (Phys. Lett. B {622}, 265, 2005)
- Selections
  - We use the same selections as for the search for SM single top quarks
    - Leptons
      - One high-pT lepton (pT > 15 GeV), pseudorapidity, $|\eta^{det}| < 1.1$ (electron) $|\eta^{det}| < 2.0$ (muon)
    - Missing ET
      - MET > 15 GeV
    - Jets
      - 2 < Njets < 4
      - $E_T > 15$ GeV, $|\eta^{det}| < 3.4$
      - Leading jet $E_T > 25$ GeV, $|\eta^{det}| < 2.5$
  - But require only one 1 b-tagged jet (secondary vertex tagging)

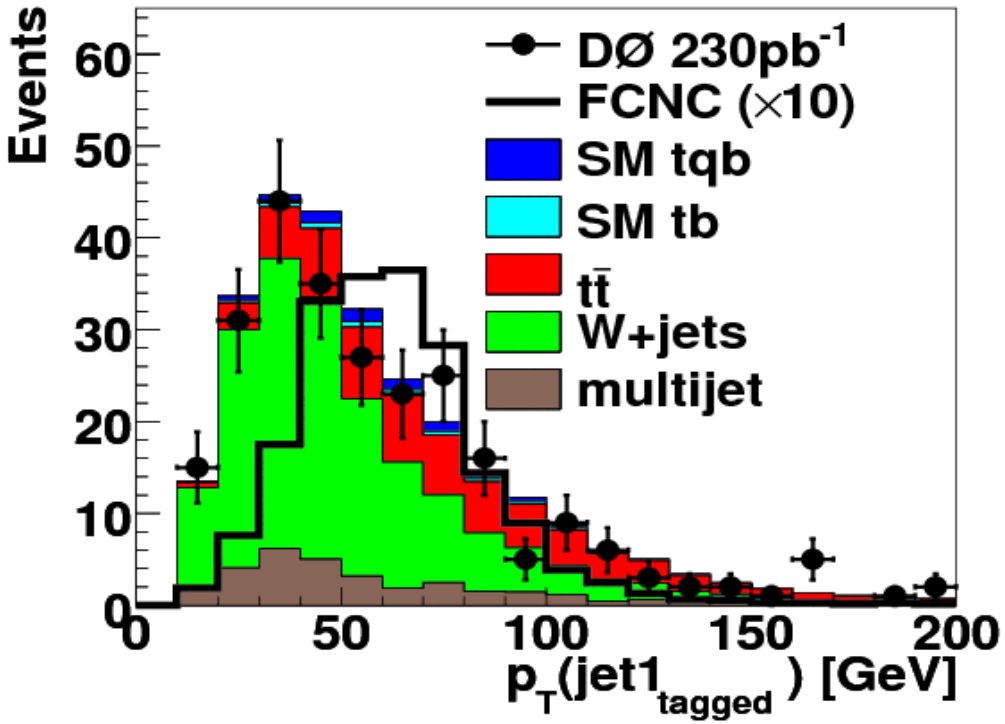
Event yields

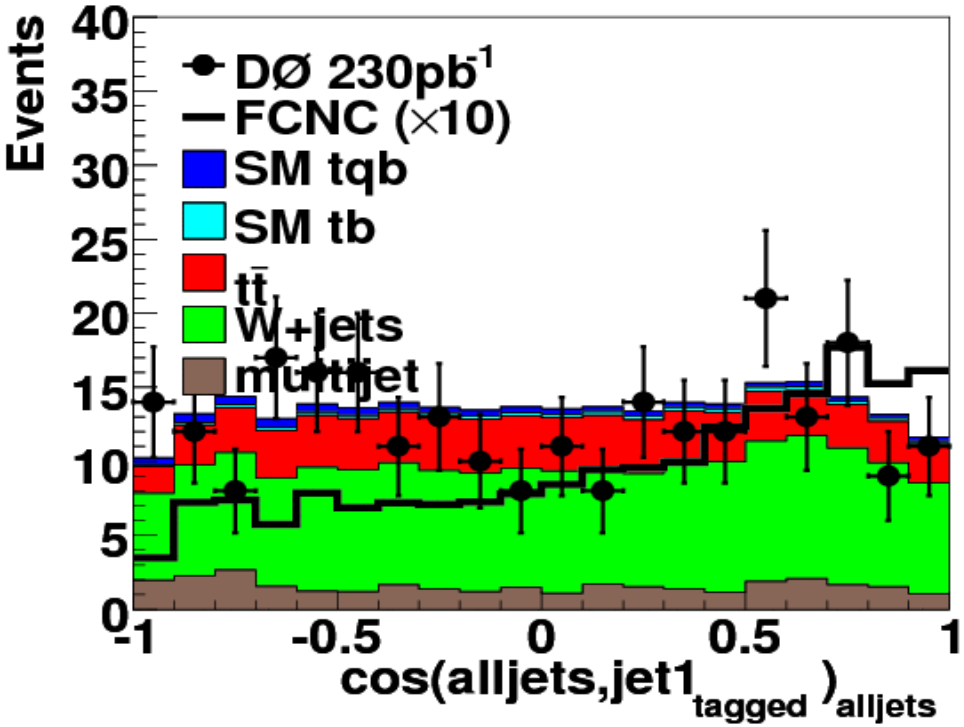
	Electron channel	**Muon channel**
Signal		
FCNC *(u+c)*	9.0	10.4
Backgrounds		
SM Single top*(s+t)*	6.4	6.1
ttbar*(lepjets, dilep)*	31.8	31.4
W/Z +jets	84.6	76.8
multijets	13.7	17.2
Sum of Backgrounds	**136.5**	**131.5**
Observed	**134**	**118**

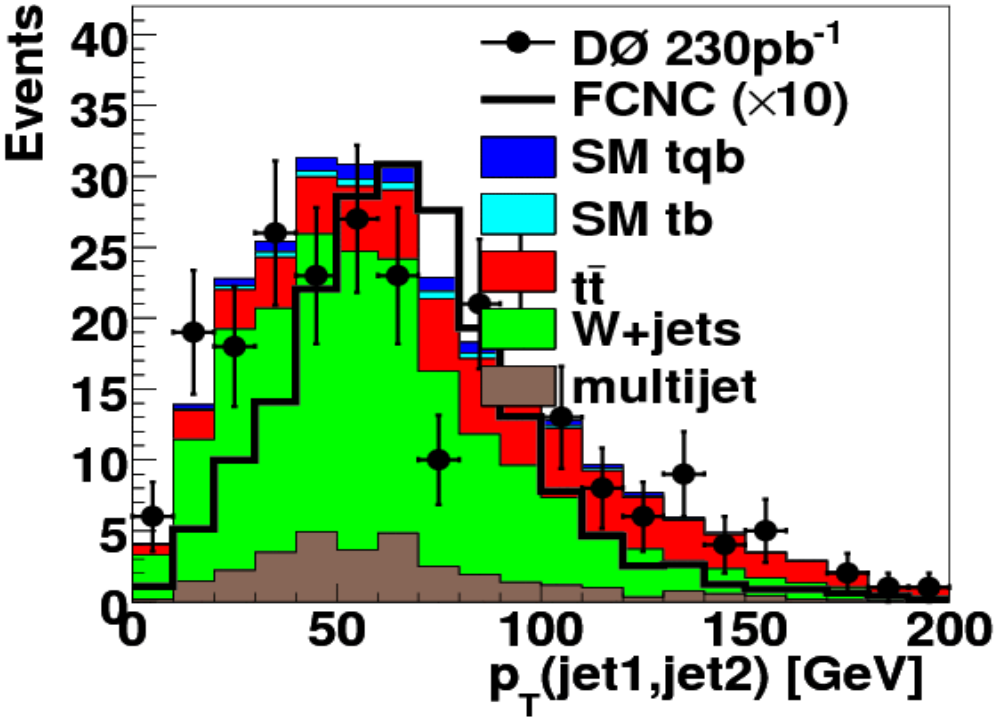
- Systematic Uncertainties
  - MC-based signal and backgrounds : dominated by jet energy scale, trigger and tagger modeling, **~ 20-25%**
  - Data-based backgrounds : dominated by tagging probability estimate, **~ 20%**

Kinematic distributions







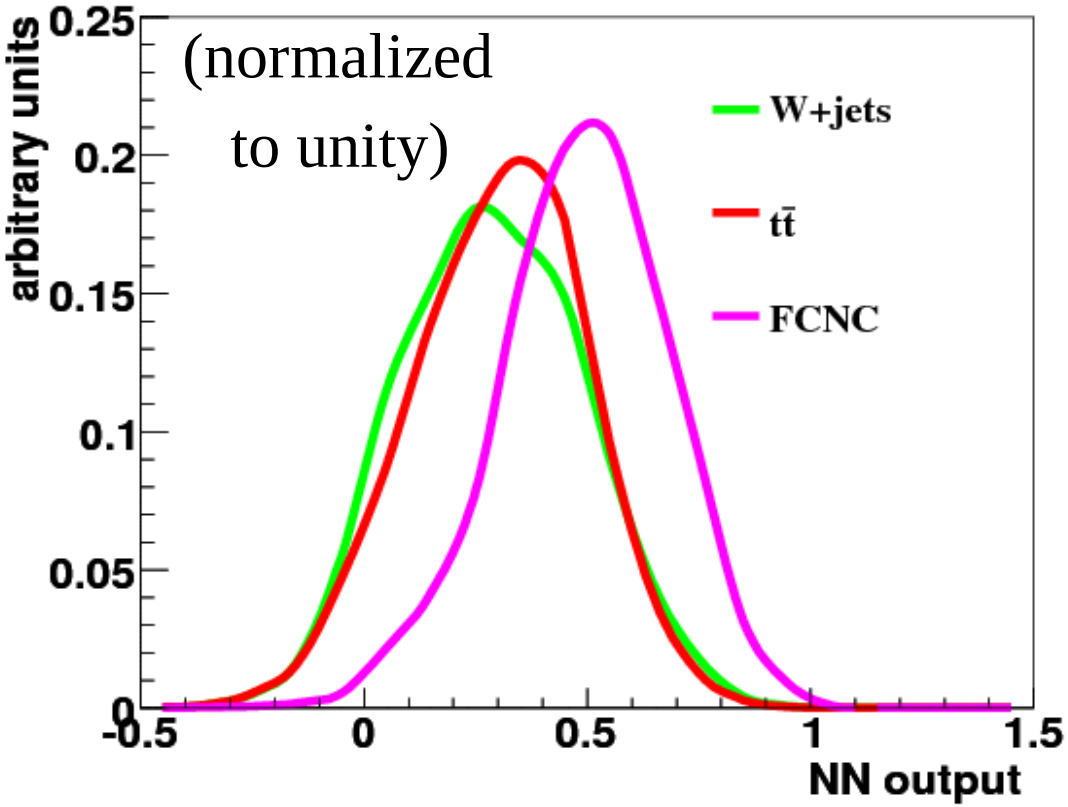


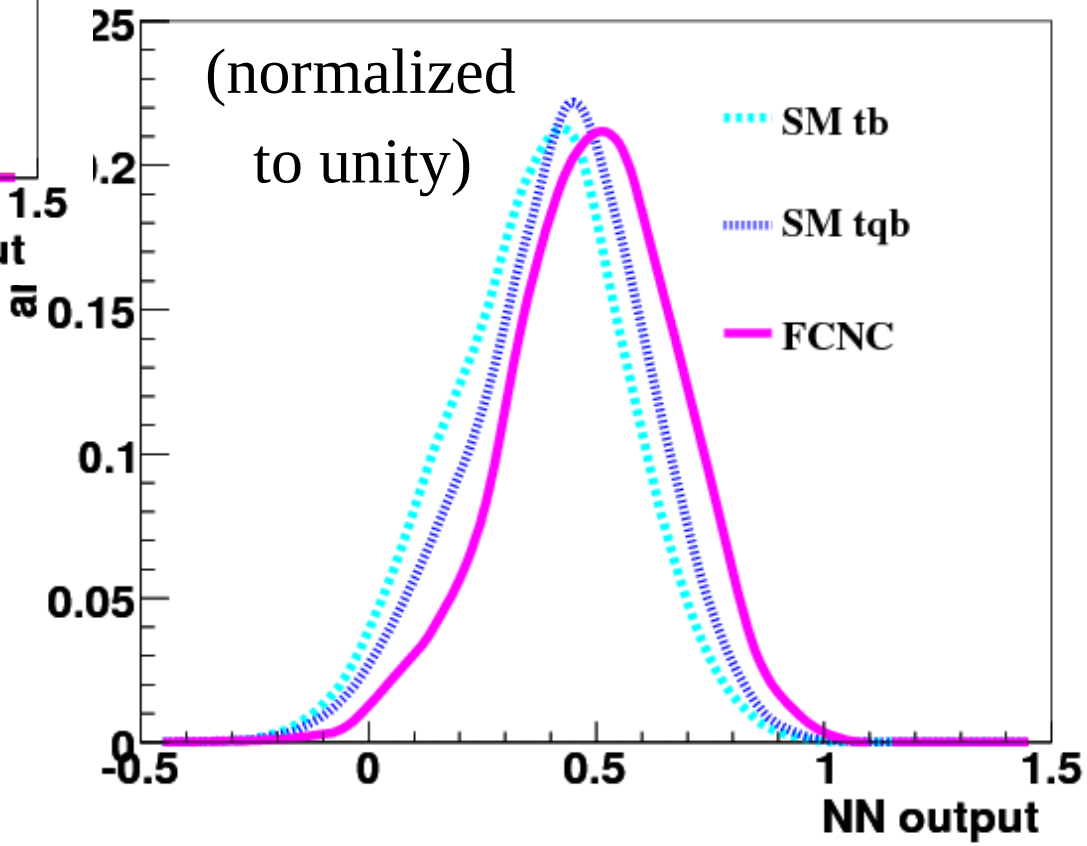
Neural Network analysis

- We use the following nine variables as input
  - Top Mass (reconstructed using the leading tagged jet)
  - Pt(leading tagged jet)
  - Cos(alljets, leading tagged jet) in the *alljets rest* frame
  - Pt(jet1, jet2)
  - Pt(lepton)
  - η(lepton)
  - DeltaR(leading jet, lepton)
  - DeltaR(leading jet, second leading jet)
  - Cos(leading jet, lepton) in the *lab* frame

- We train the Neural Network (MLPfit), using the **sum** of *tgc* and *tgu* processes as *signal*, and the **sum** of all remaining processes as *background*

Neural Network results
(electron and muon channels combined)



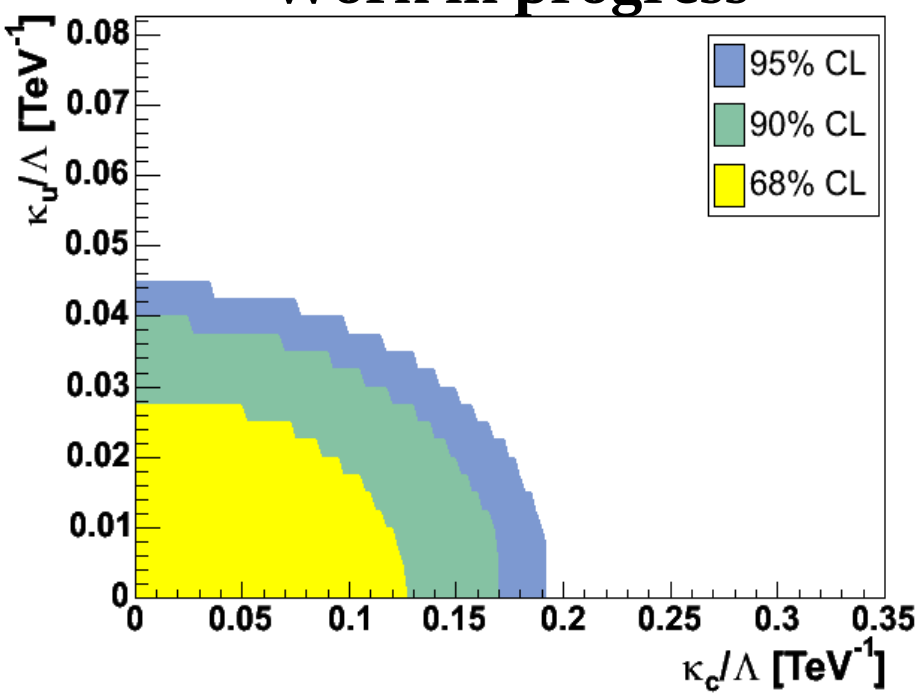


Results: Expected limits

- We set Data to the estimated background yield, in any bin
- We use Bayesian statistics to extract limits on κ_u / Λ and κ_c / Λ

  (assume flat priors for the two couplings)
- We consider all bin-by-bin systematic uncertainties, and their correlations

Work in progress



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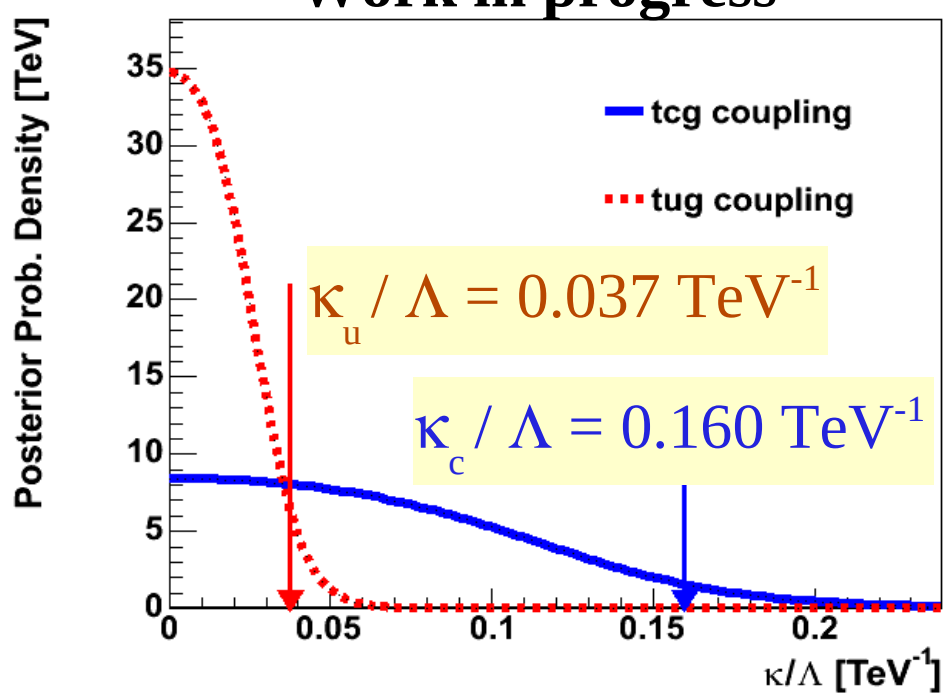

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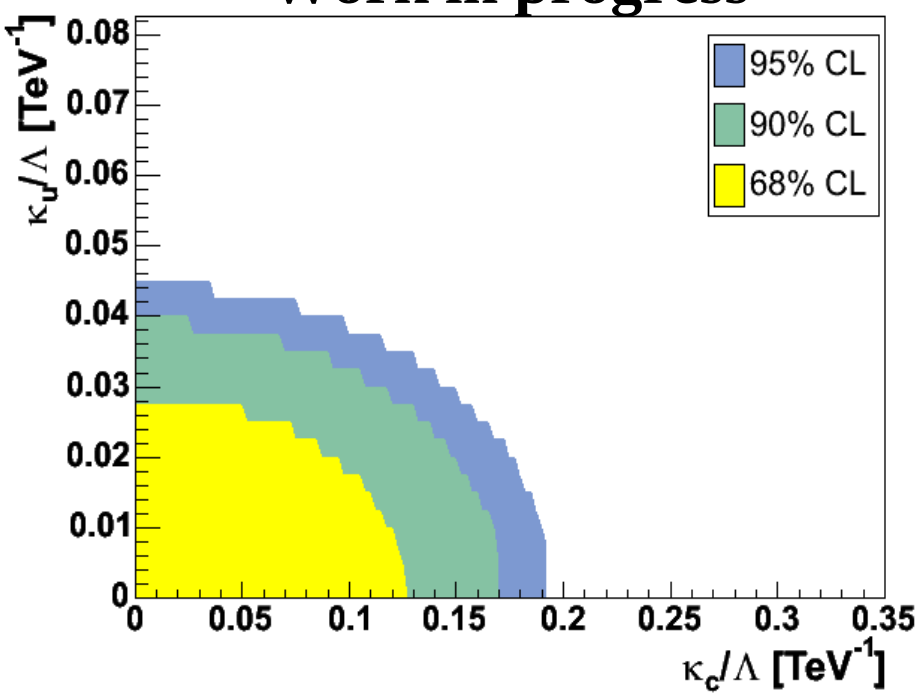

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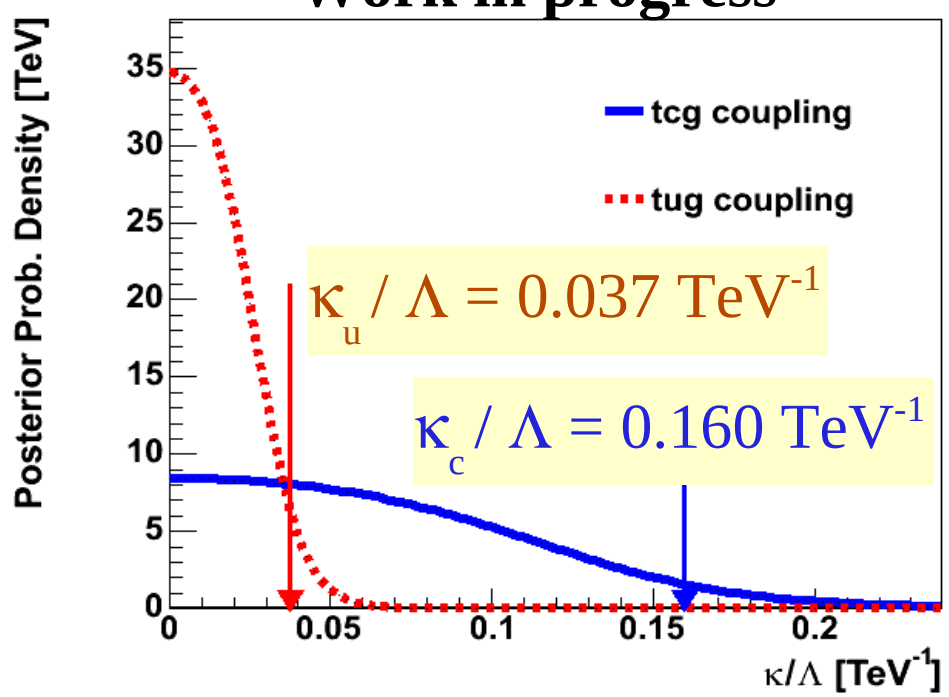
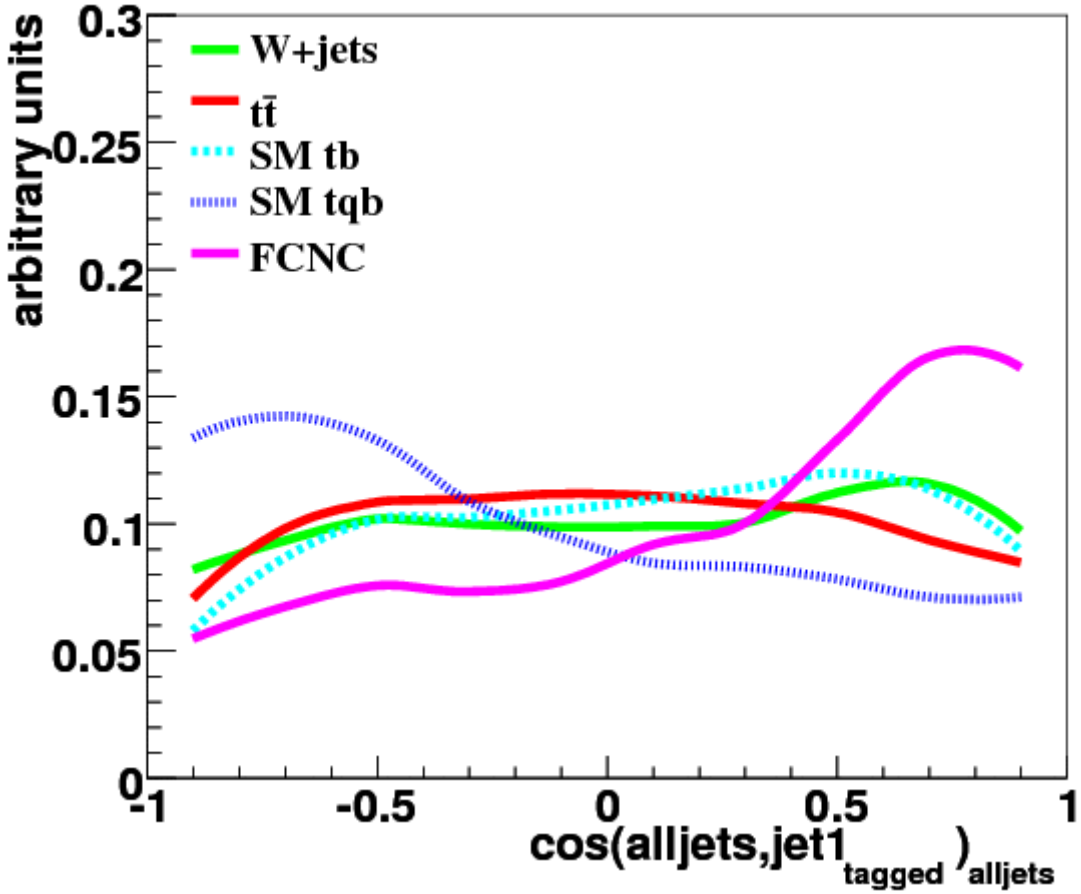


Results using data from HERA (*ep*-collisions)

$\kappa_{u,c} / \Lambda <$ **0.4 TEV^{-1}**, hep-ph/0604119

Conclusions

- DØ performed a first search for FCNC interactions involving the top quarks
  - This can offer a potentially new view of physics beyond the Standard Model
  - No significant evidence of FCNC events has been found
  - Our sensitivity is much better than any previous results
- Work is in progress to improve the limits
  - Explore input variables that offer more discriminating power between the non-SM signals and backgrounds
- We are aiming for a publication soon, with the measured limits also

Back-up slides

Distributions (normalized to unity), showing differences in shapes for the FCNC and the SM tqb processes