Single top production in ppbar collisions at $\sqrt{s}$ = 1.96 TeV with the DØ detector

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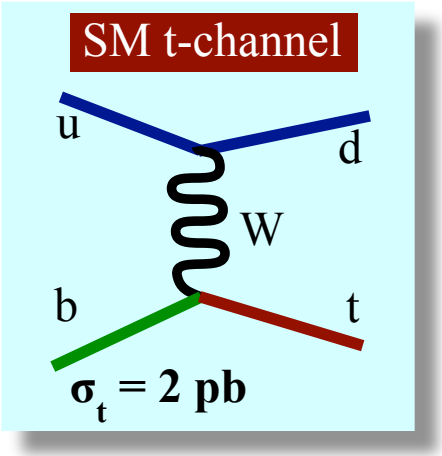
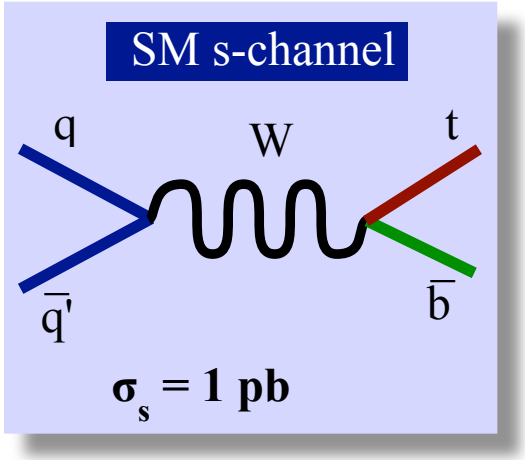
Michigan State University
For the DØ collaboration

Division of Particles and Fields of the American Physical Society 2011

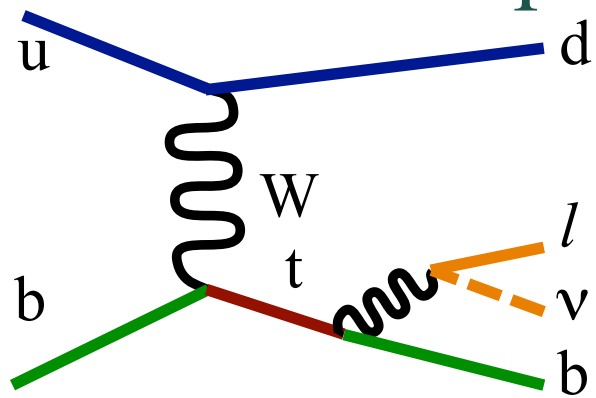
Single top quark production

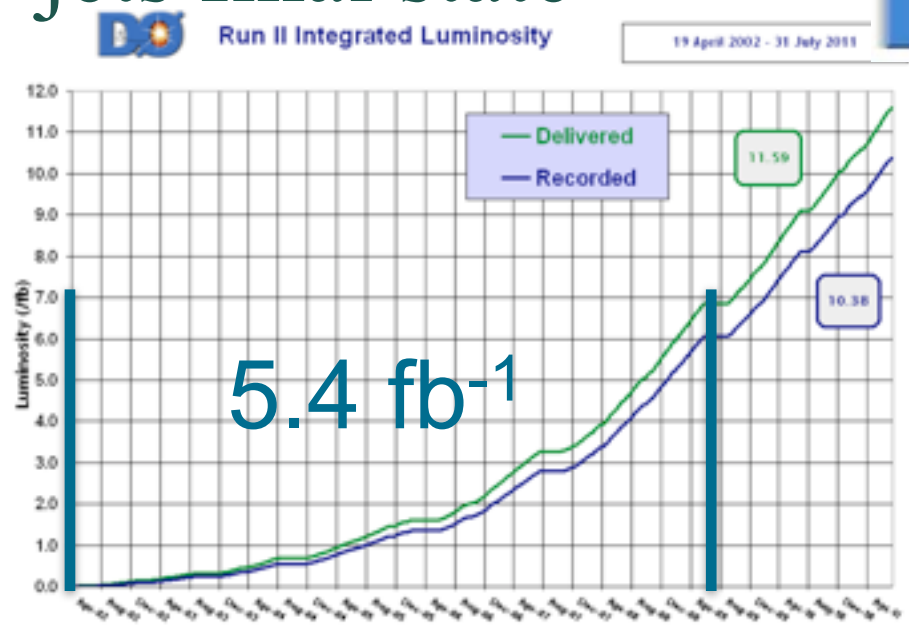




- Key to understanding electroweak interactions of top
  - Direct measurement of CKM matrix element $|V_{tb}|$
- Small signal, large backgrounds
  - Requires detailed understanding of entire detector
  - Multivariate analyses to isolate signal
- Sensitive probe to many new physics models

Lepton+jets final state

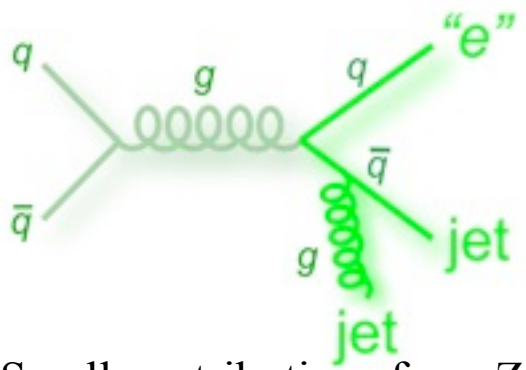


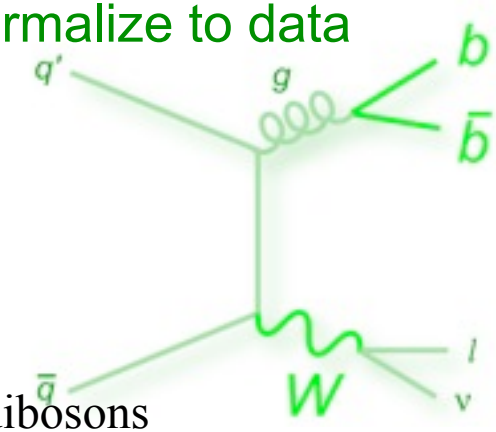


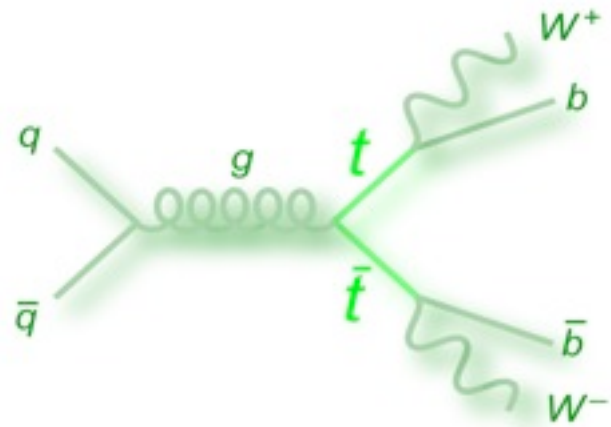
QCD multijets
- Model using data
- Normalize to data

W+jets: Wjj, Wcj, Wcc, Wbb
- Model using Alpgen
- Correct kinematics to data
- Normalize to data

Top quark pairs
- Model using Alpgen
- Normalize to resum.

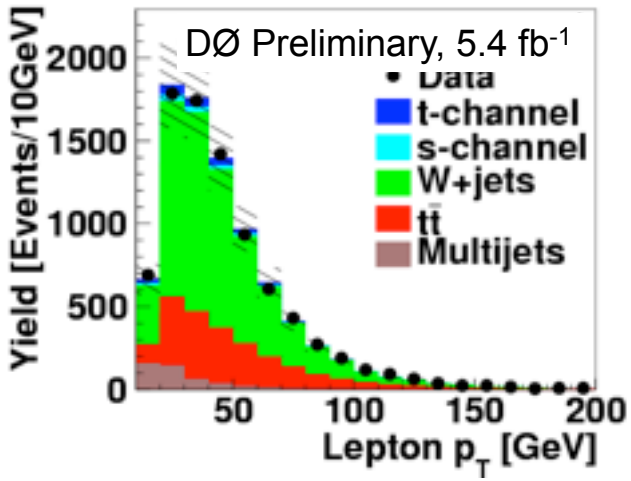


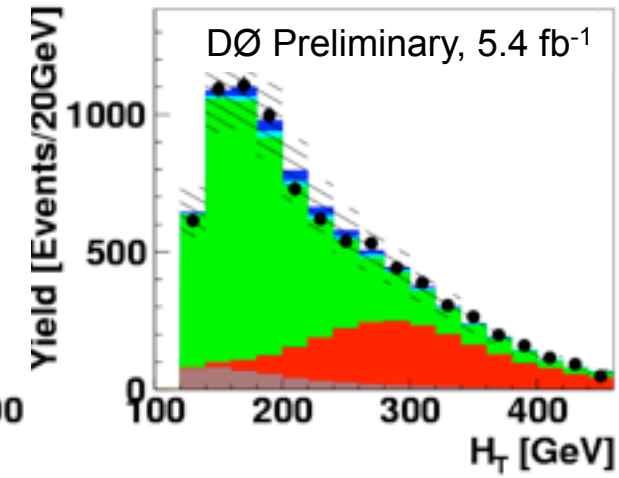




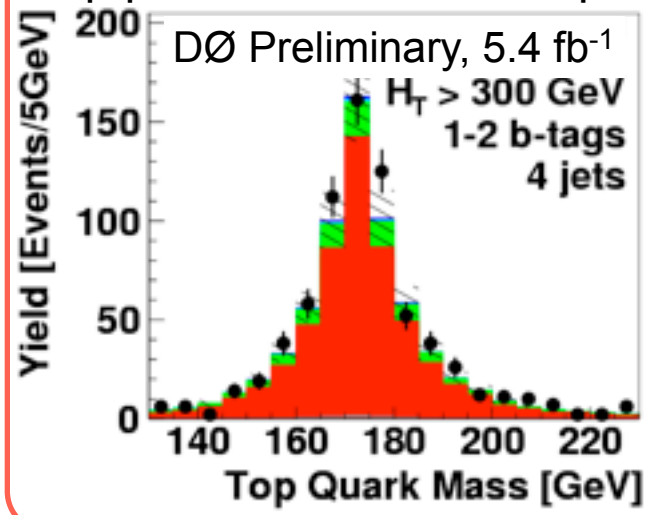
Small contributions from Z+jets, dibosons

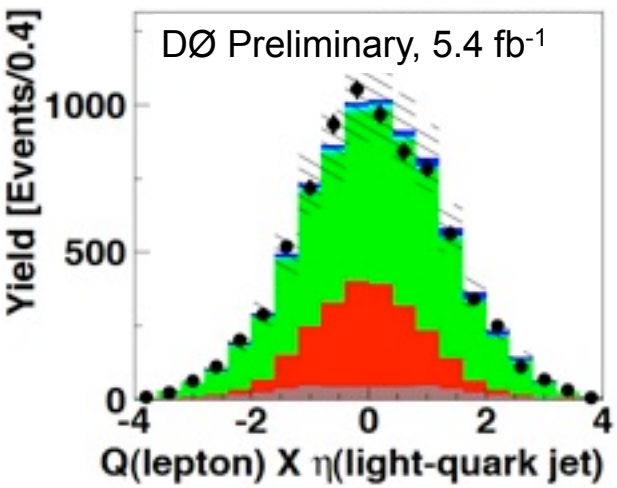
Background modeling

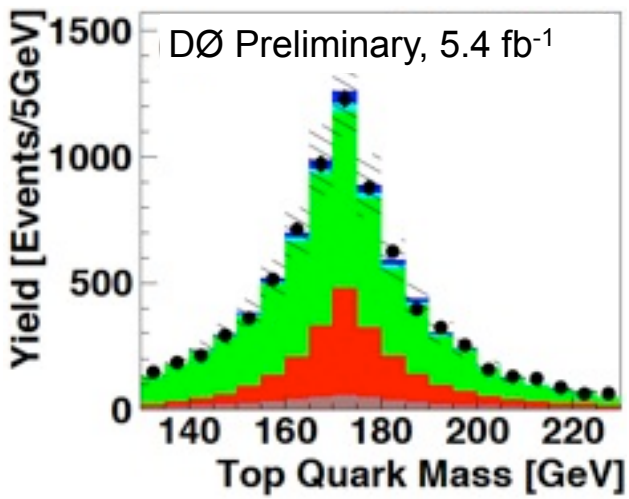




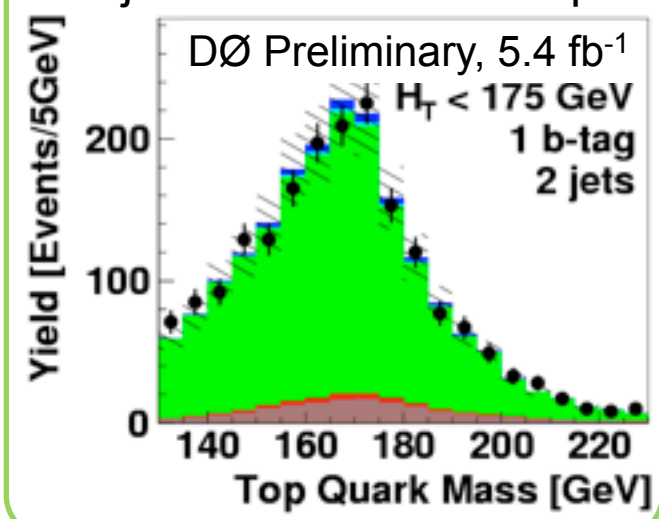
top pair cross-check sample







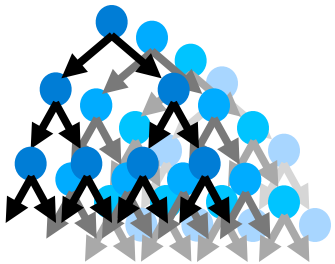
W+jets cross-check sample



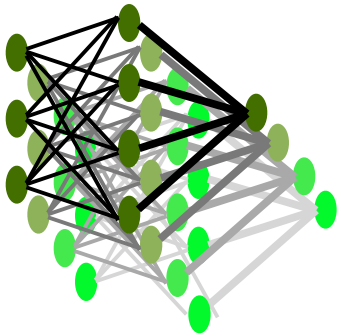
Multivariate analysis

- Several filters combined in one BNN

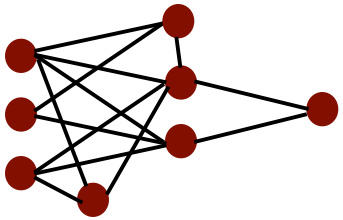
Boosted decision trees

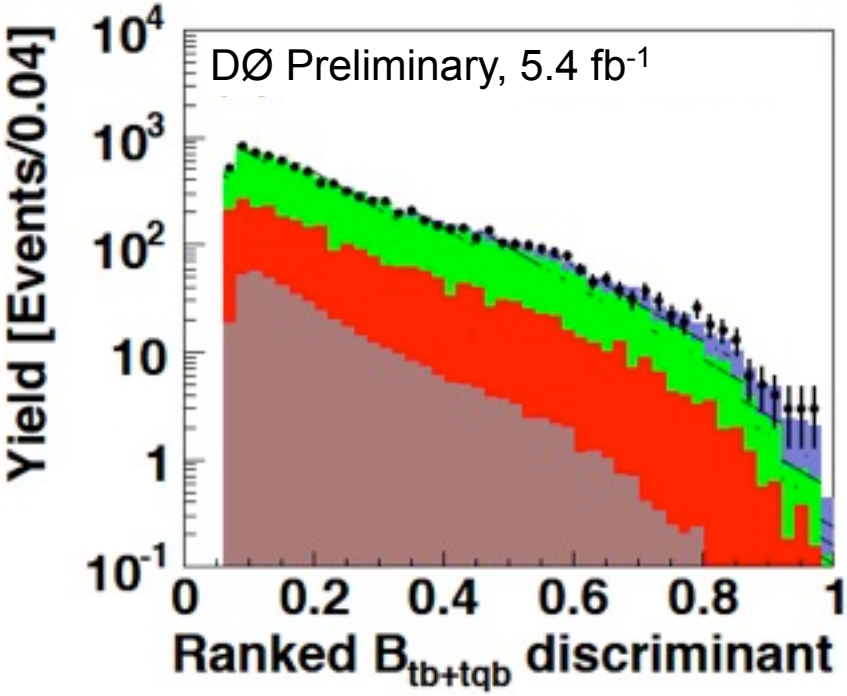


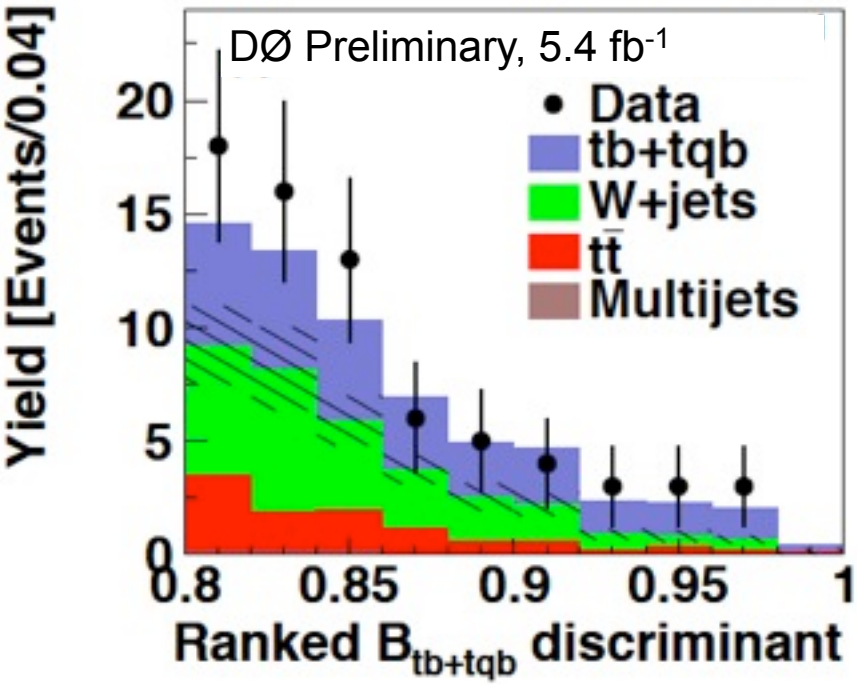
Bayesian neural networks



Neuro evolution



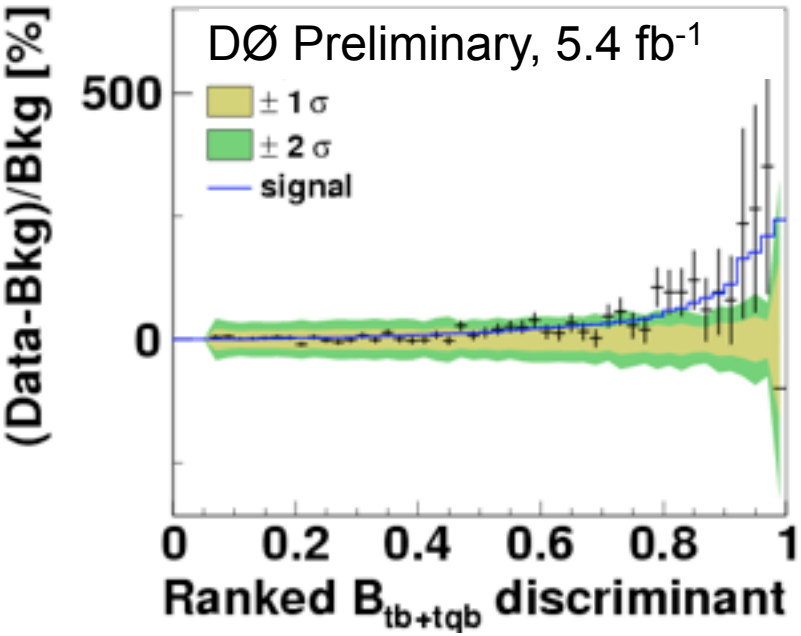


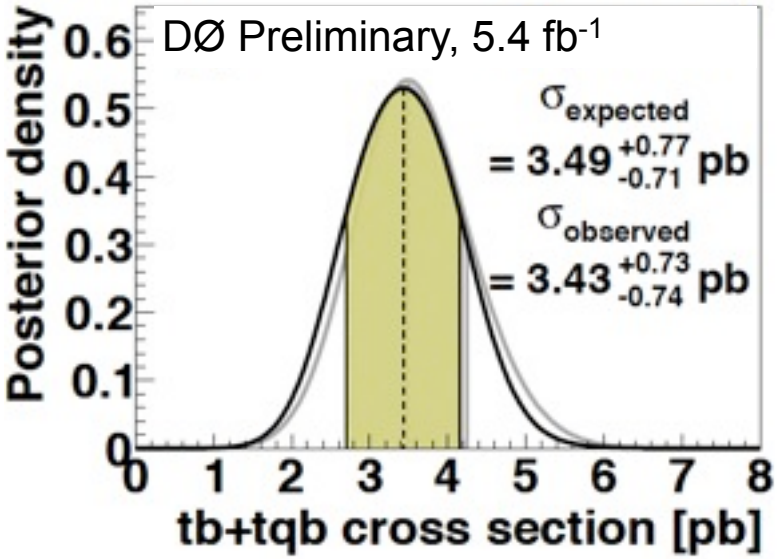


Cross section measurement

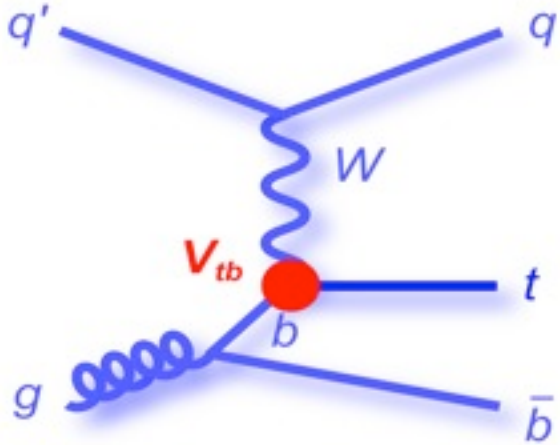
- Bayesian statistical analysis

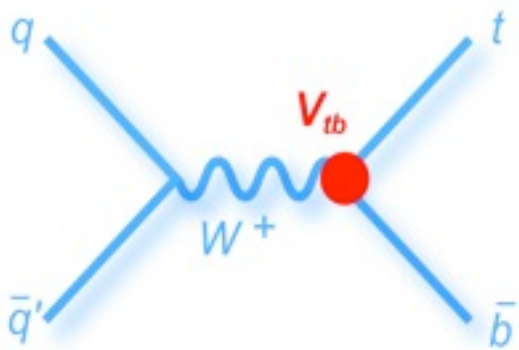
- **Dominant systematic uncertainties**:
  JES, JER,
  b-tagging efficiency,
  W + heavy jets normalization





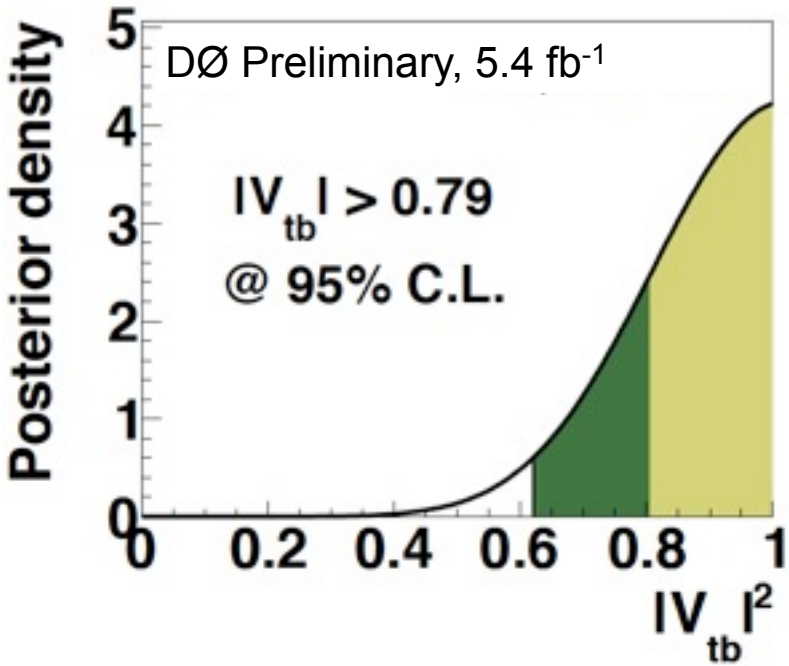
CKM matrix element V_{tb}



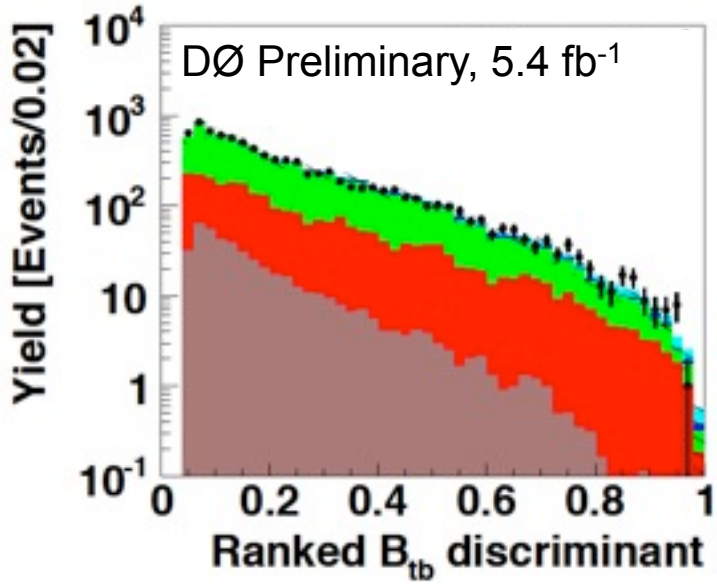


$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

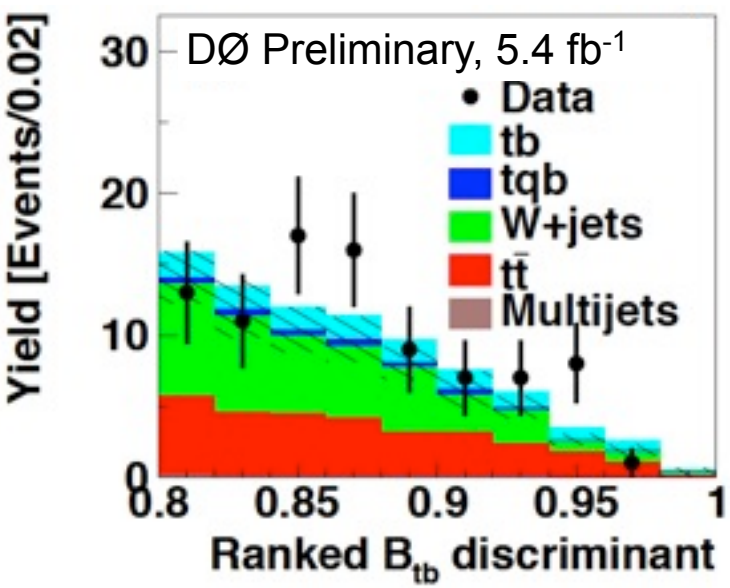
- Single top cross section $\propto |V_{tb}|^2$
- Assume
  - SM top quark decay: $|V_{td}|^2+|V_{ts}|^2 \ll |V_{tb}|^2$
  - Pure V-A and CP conserving Wtb vertex
- No assumption on number of families or unitarity

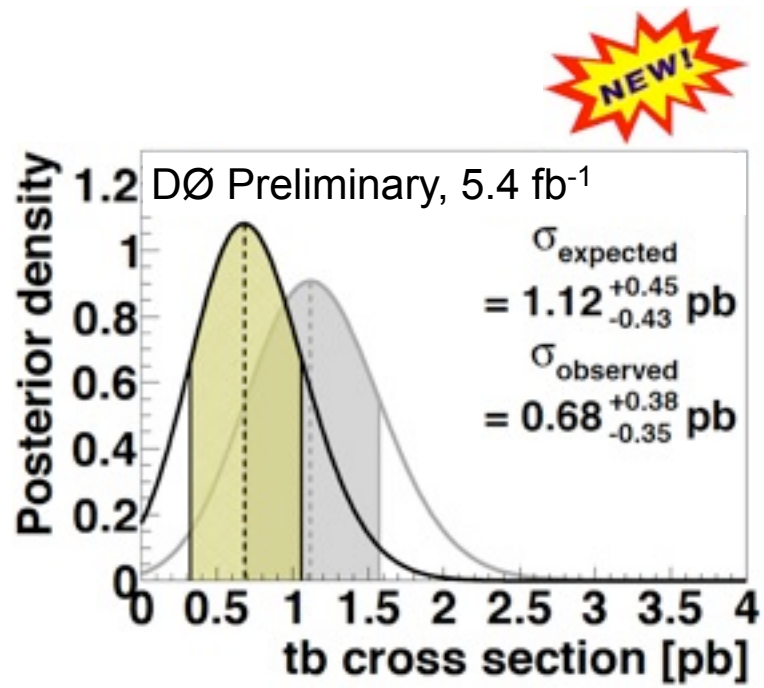


s-channel analysis



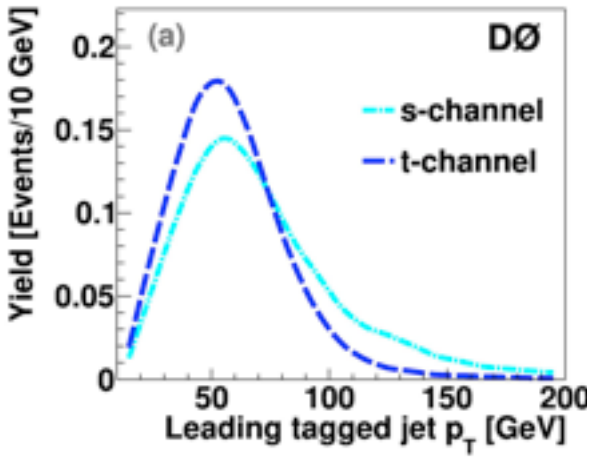
- Train MVA filters for s-channel signal
  - Include t-channel as background
- No evidence for s-channel yet
  - Significance ~ 2 SD

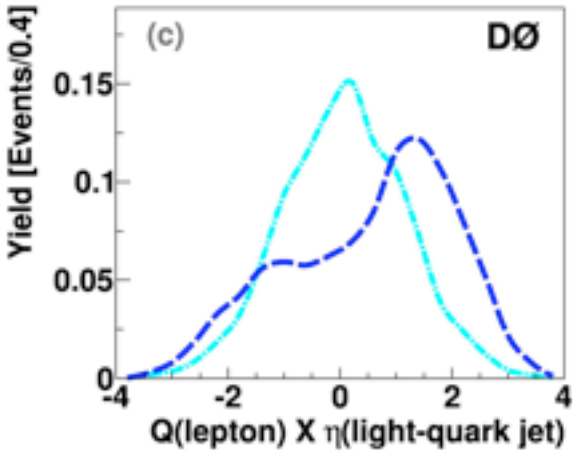


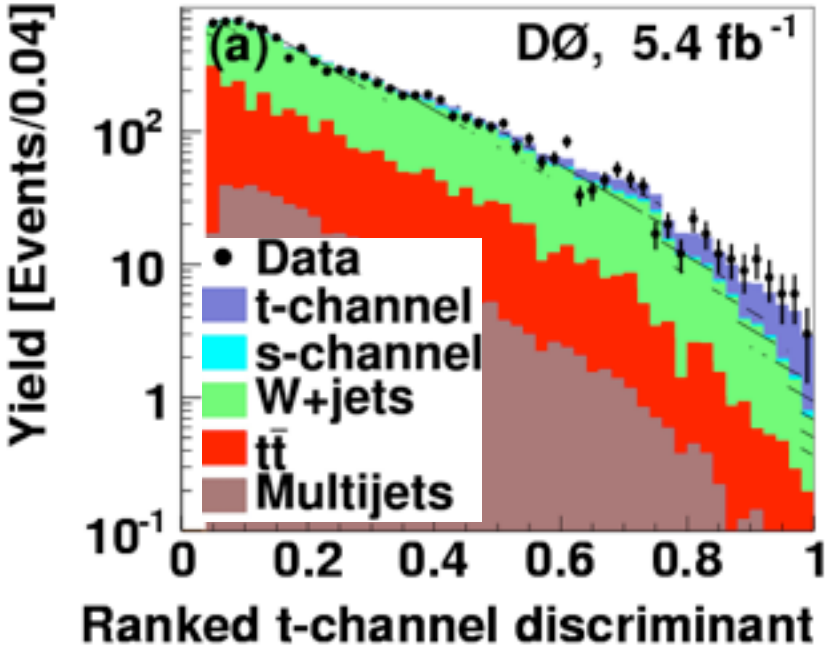


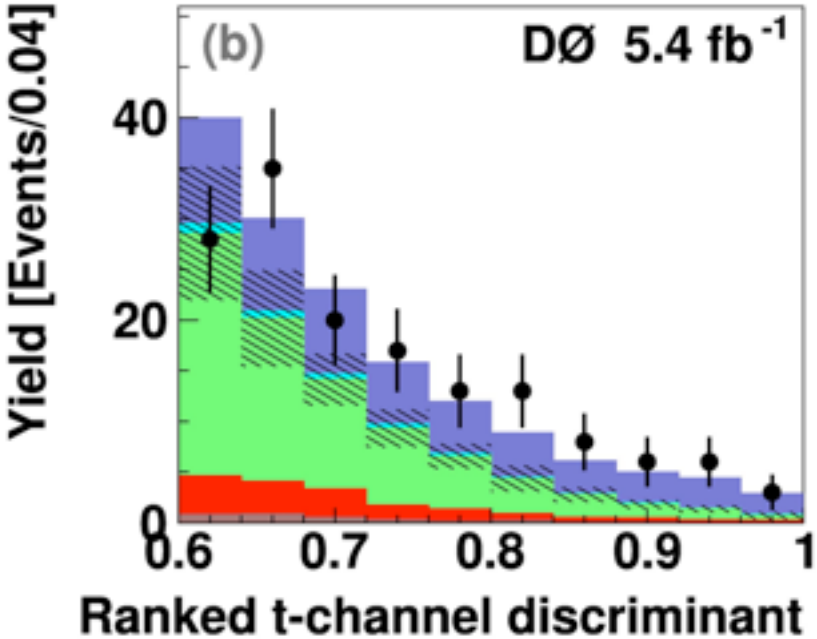
t-channel analysis

- Separate t-channel from backgrounds and from s-channel
- MVA discriminant
  - Combination of BDT, BNN, NEAT

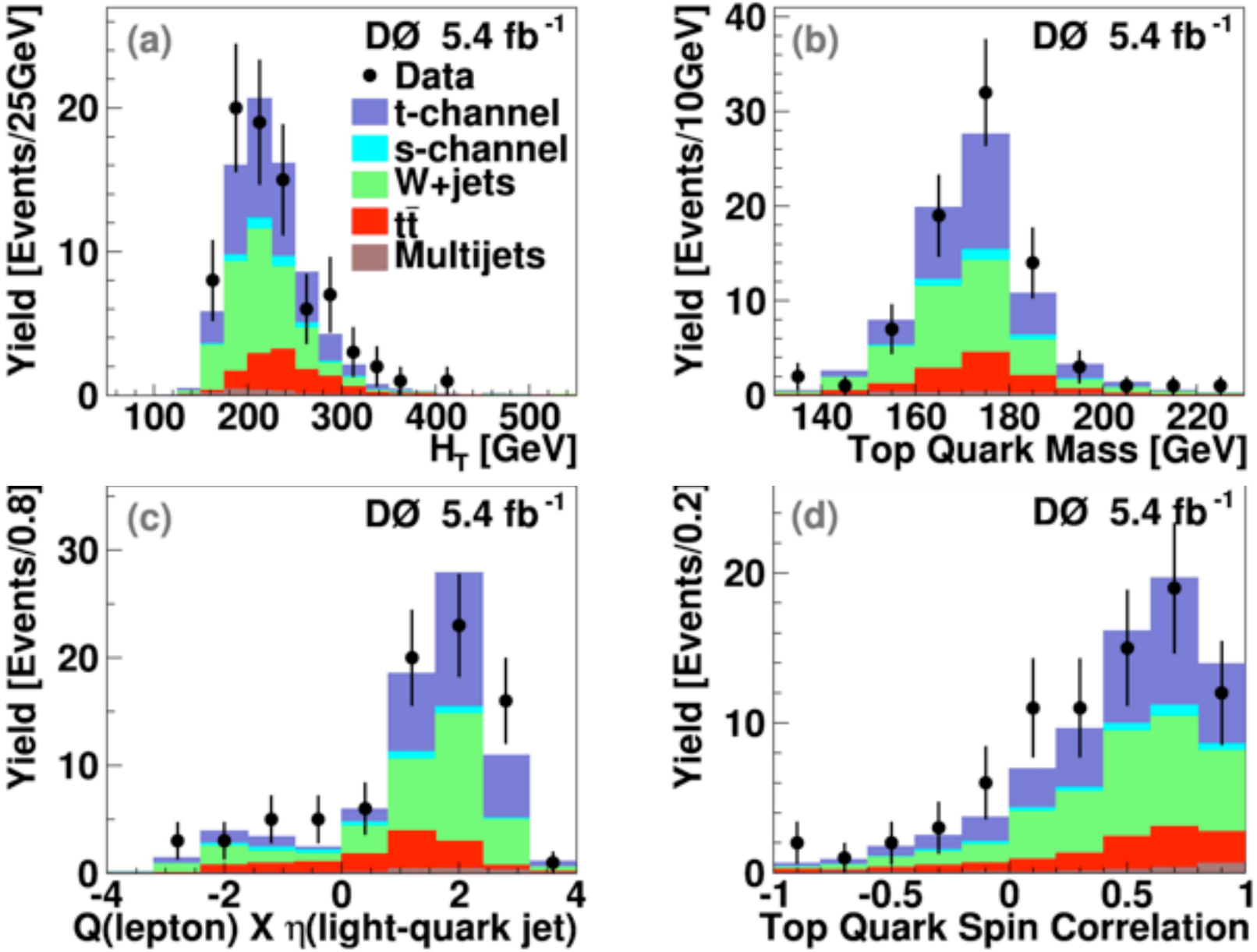




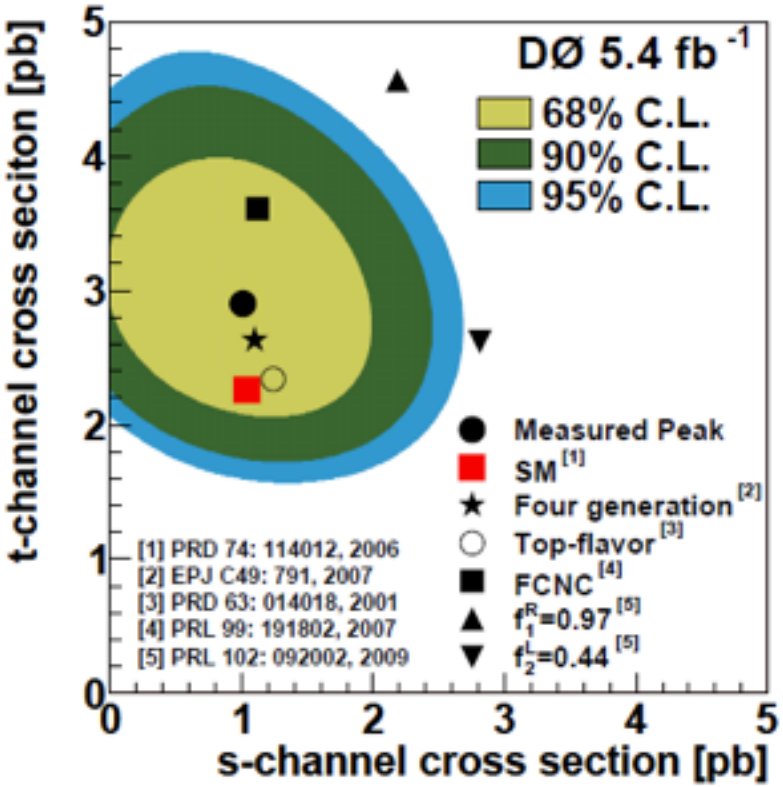


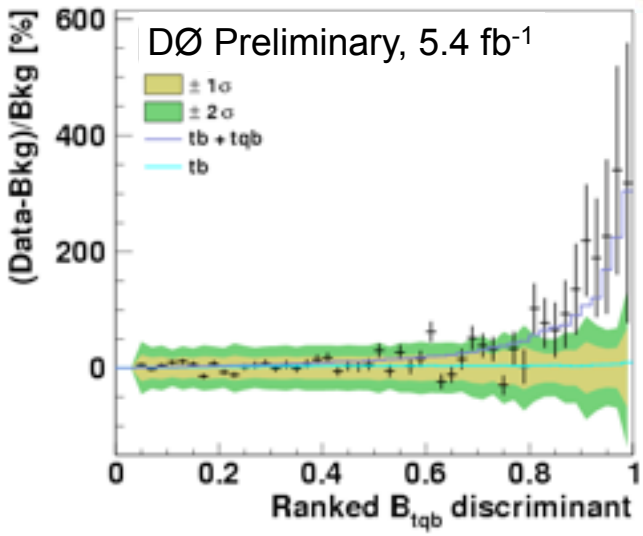


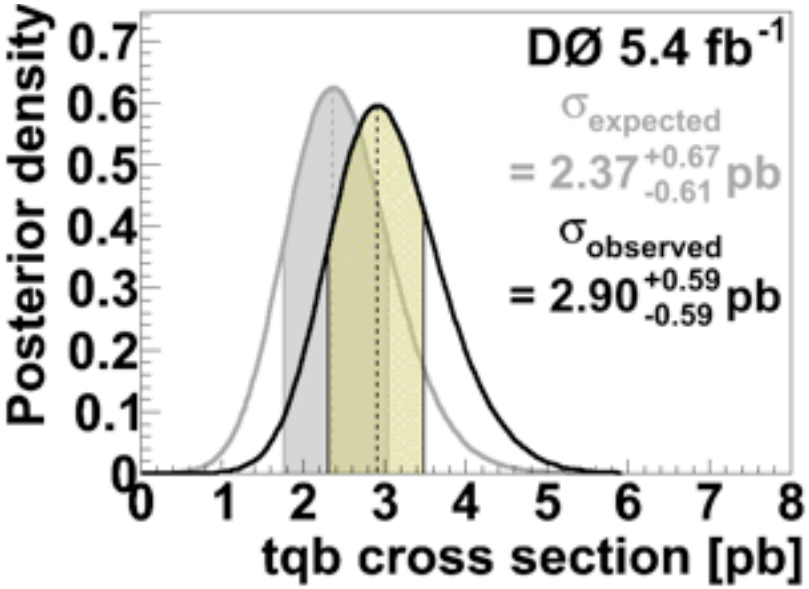
t-channel signal region



t-channel result



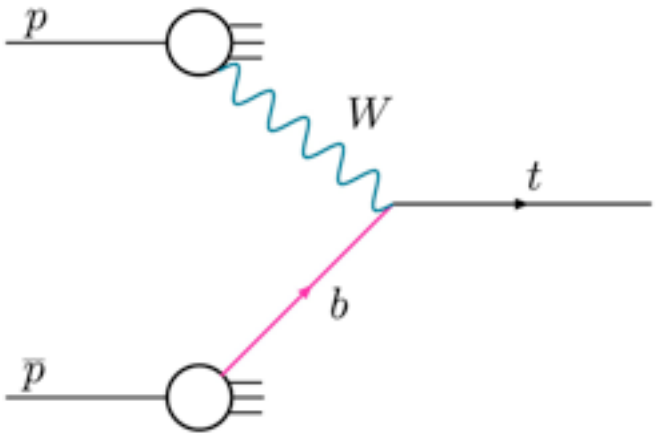




- t-channel measurement from integration over 2D posterior
  - no assumption about s-channel XS
  - $\sigma_{t\text{-channel}}$ = 2.90 ± 0.59 pb
  - $\sigma_{s\text{-channel}}$ = 0.98 ± 0.62 pb

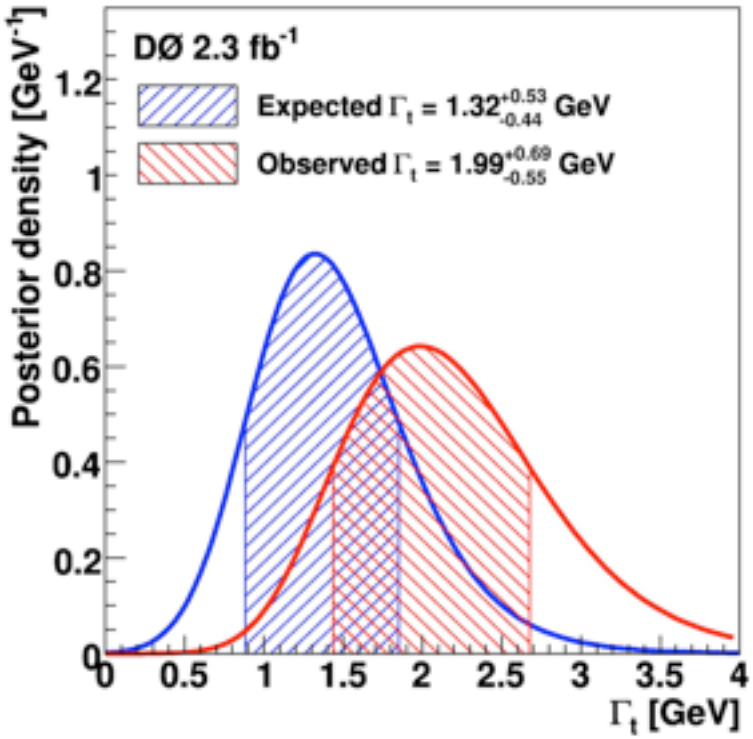
Observed significance > 5 SD

Top quark width



- t-channel cross section to measure top quark partial width
- combine with B(t→Wb) measurement to get total width

Measurement with 2.3 fb^{-1}



Total top width:

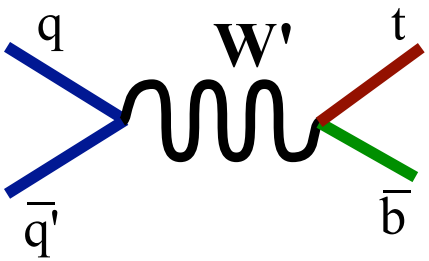
$$\Gamma_t = 1.99^{+0.69}_{-0.55}\ \text{GeV}$$

Top lifetime:

$$\tau_t = (3.3^{+1.3}_{-0.9}) \times 10^{-25}\ \text{s}$$

PRL 106, 022001 (2011)

Search for W' boson



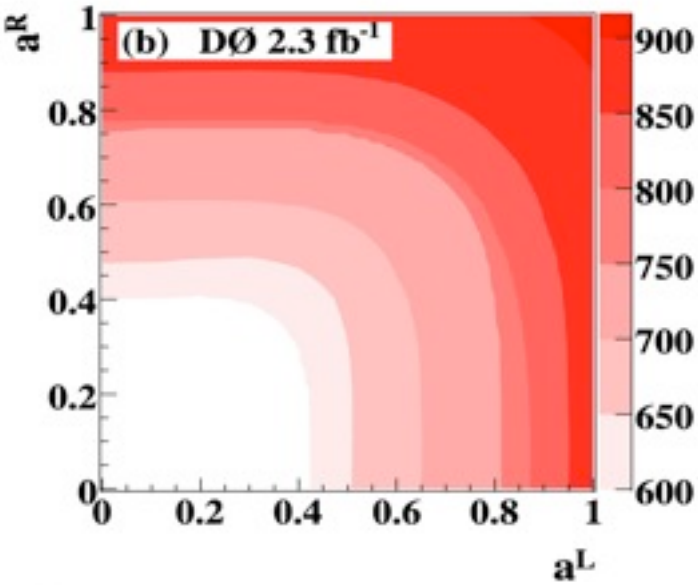
- Explore simultaneously left-handed and right-handed couplings
- 95% CL limits:

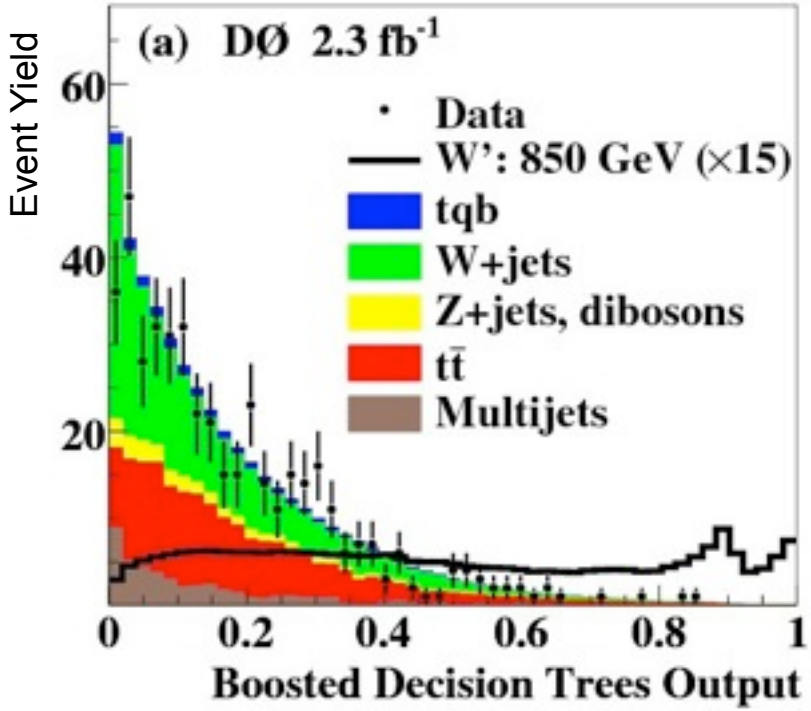
$M_{W'} > 863$ GeV (L only)

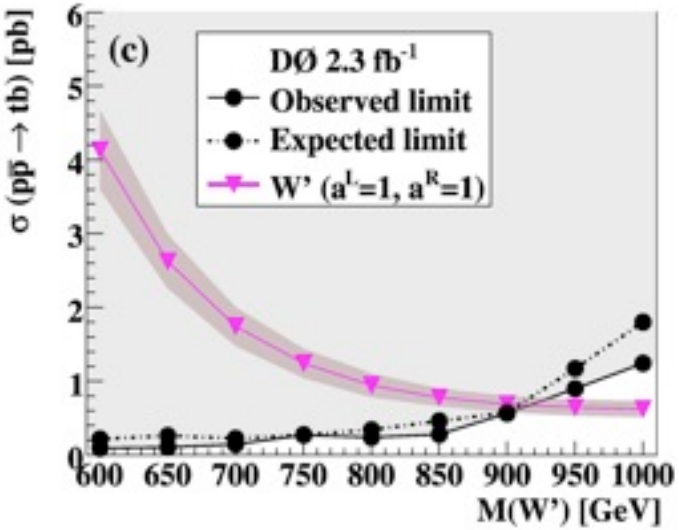
$M_{W'} > 885$ GeV (R, $M_{W'} < m_{nR}$)

$M_{W'} > 890$ GeV (R, $M_{W'} > m_{nR}$)

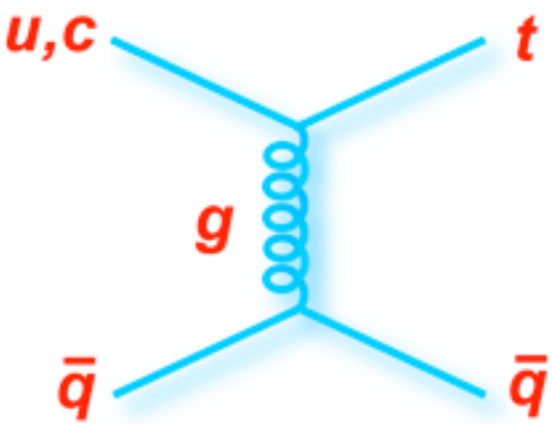
$M_{W'} > 916$ GeV (L+R)

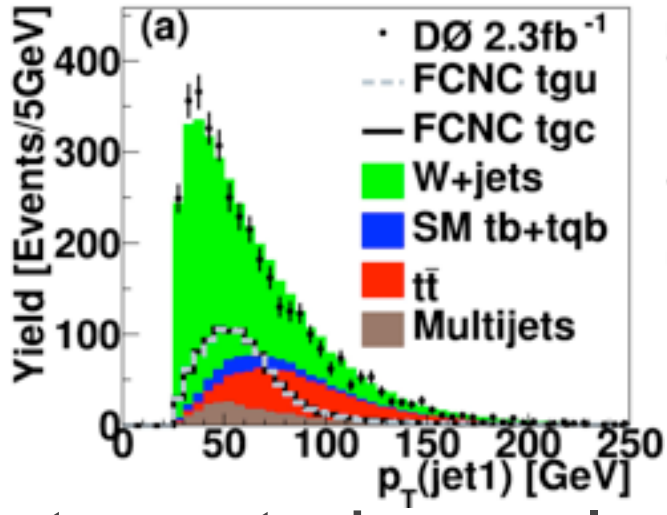


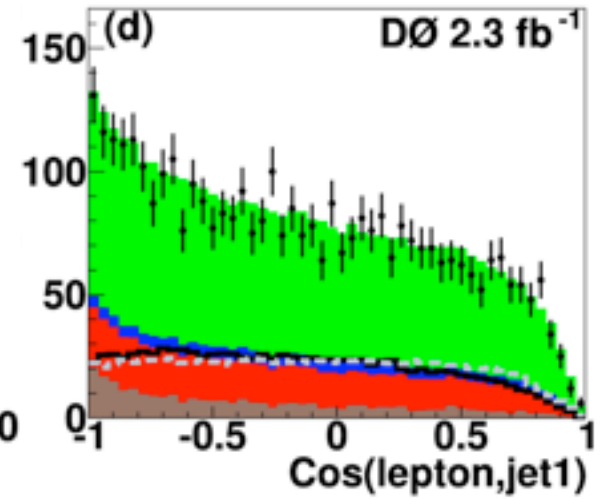




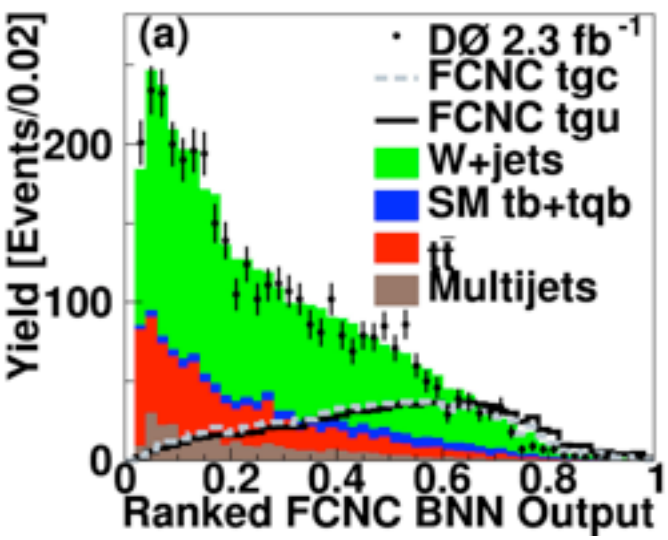
FCNC in single top







- same final state as t-channel single top
- different kinematics → multivariate filter



Limit on tgu and tgc couplings:

	tgu	tgc
Cross section	0.20 pb	0.27 pb
κ_{tgf}/Λ	0.013 TeV^{-1}	0.057 TeV^{-1}
$\mathcal{B}(t \to qg)$	2.0×10^{-4}	3.9×10^{-3}

Summary

- Updated single top results from DØ with 5.4 fb^{-1} of Tevatron data
- combined s+t measurement
  - 95% CL limit $|V_{tb}| > 0.79$
- t-channel observed at 5 SD
  - $\sigma_{t\text{-channel}} = 2.90 \pm 0.59$ pb
- Limits on new physics with 2.3 fb^{-1}
  - For W' boson with SM-like and non-SM couplings
  - FCNC couplings of top to up and charm quarks