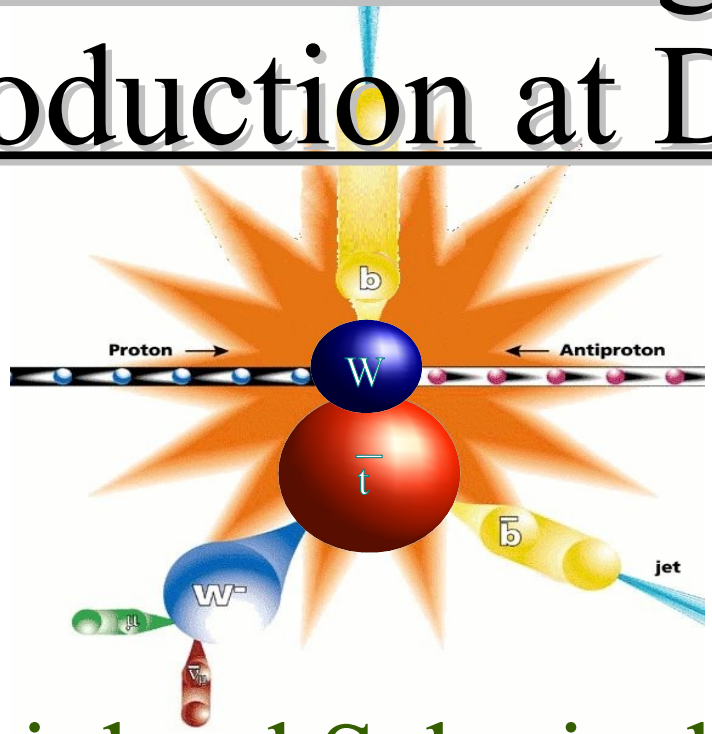
Observation of Single Top Production at DØ

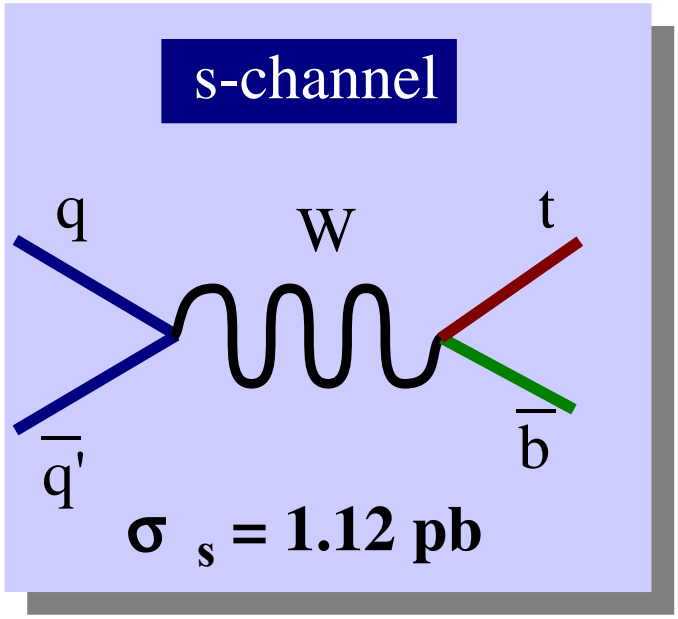


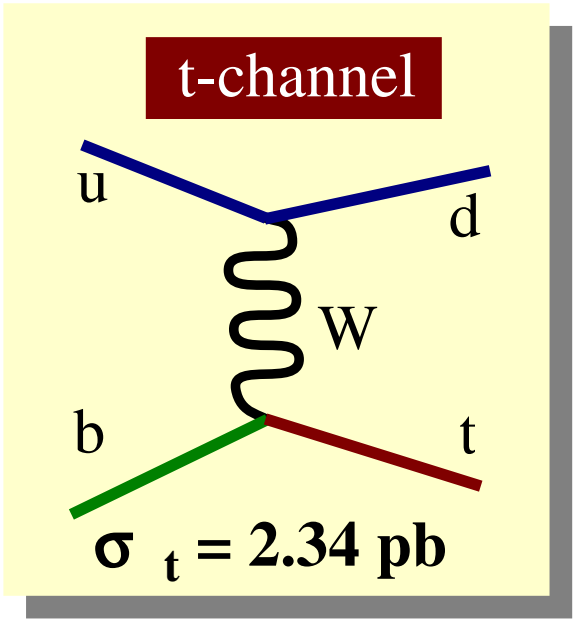
Reinhard Schwienhorst

MICHIGAN STATE UNIVERSITY

on behalf of the DØ collaboration

SM single top quark production





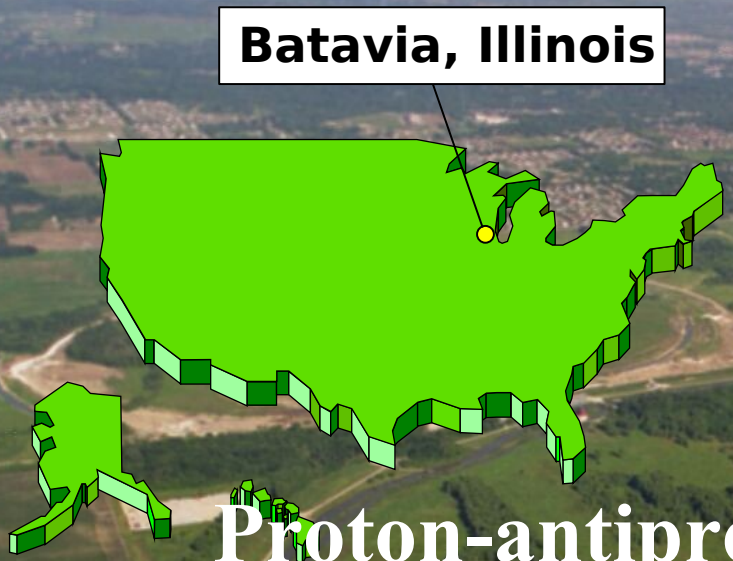
· Search:	PRD 63, 031101 (2000)
· Search:	PLB 517, 282 (2001)
· Search:	PLB 622, 265 (2005)
· W':	PLB 641, 423 (2006)
· Search:	PRD 75, 092007 (2007)
· Evidence:	PRL 98, 181802 (2007)
· FCNC:	PRL 99, 191802 (2007)
· W':	PRL 100, 211802 (2007)
· Evidence:	PRD 78, 012005 (2008)
· Wtb:	PRL 101, 221801 (2008)
· Wtb:	PRL 102, 092002 (2009)
· H^+:	(PRL) arXiv:0807.0859
· Observation:	(PRL) arXiv:0903.0850

σ_{tot} = 3.46 pb for m_{top} = 170 GeV (Kidonakis et al.)

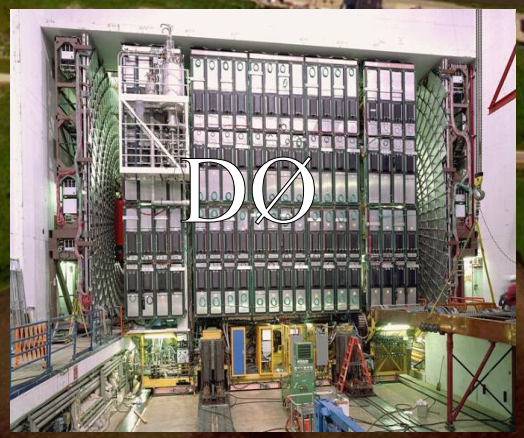
Tevatron Goals:

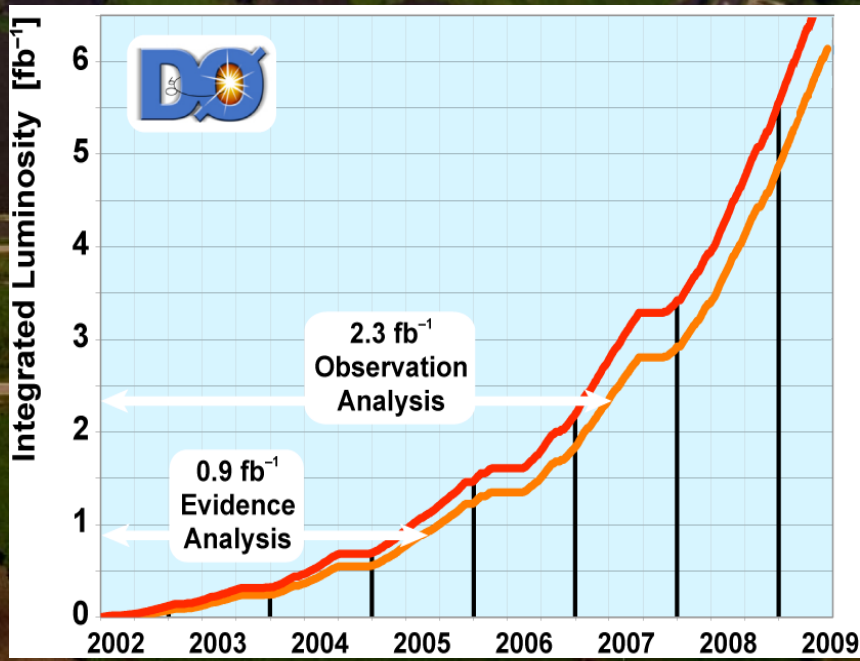
- Discover single top quark production
- Measure production cross sections σ_{s+t}, σ_s, σ_t
- First direct measurement of CKM matrix element V_{tb}
- Look for new physics
- Understand as background to many searches
- Establish techniques that will also be used in Higgs and other searches

Fermilab Tevatron

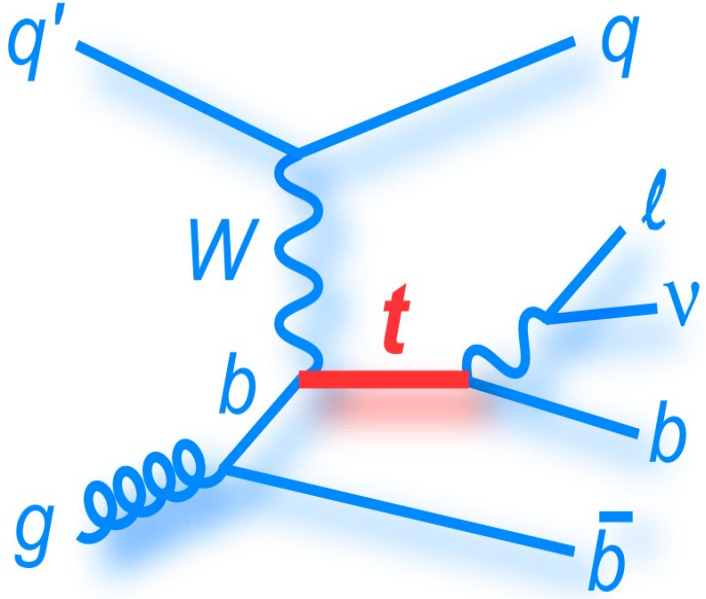


Proton-antiproton collider
CM energy 1.96TeV
→ *Energy frontier*
Instantaneous luminosity exceeding 3E32cm^{-2}s^{-1}
→ *Luminosity frontier*





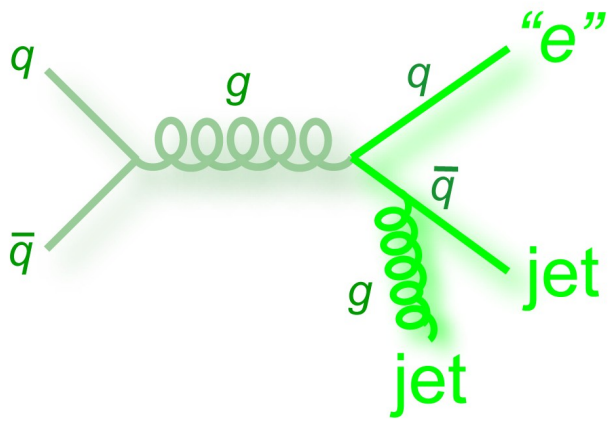
Single top event selection



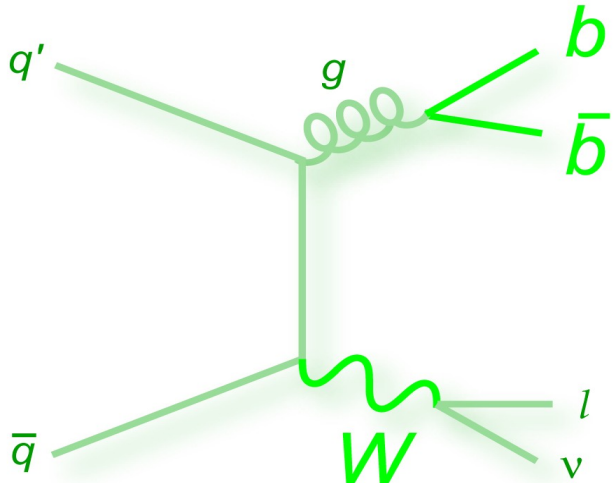
- Basic event signature (e or μ)
  - Include many triggers
  - One high-E_T leptons (>15GeV)
  - Missing transverse energy (>15GeV)
  - 2-4 jets (E_T>15GeV)
  - At least one b-tag

Backgrounds

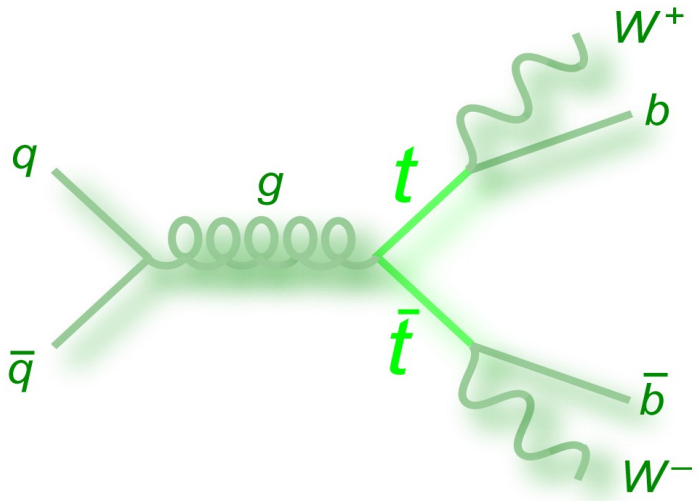
QCD multijets



W+jets: Wjj, Wcj, Wcc, Wbb

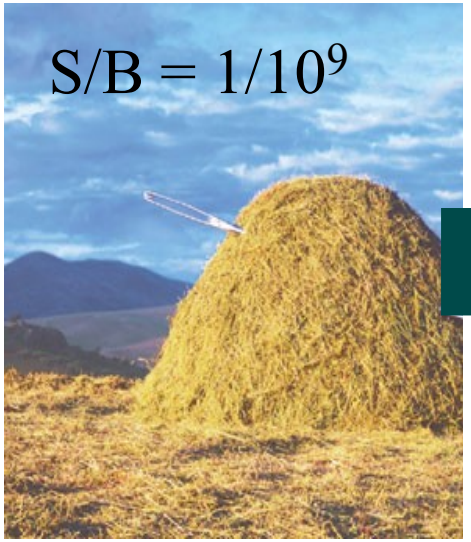


Top quark pairs

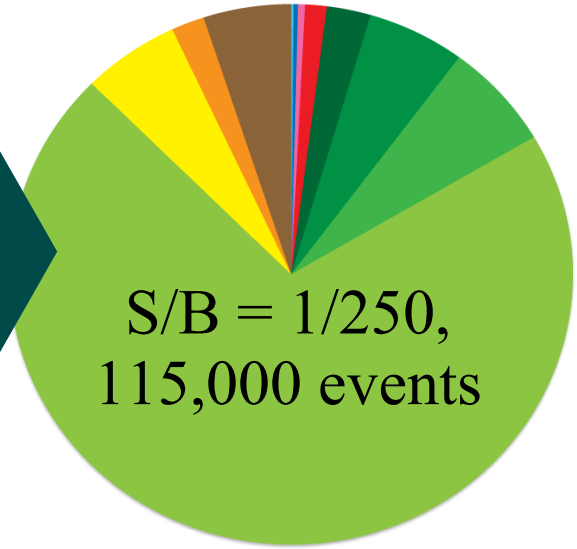


Analysis outline

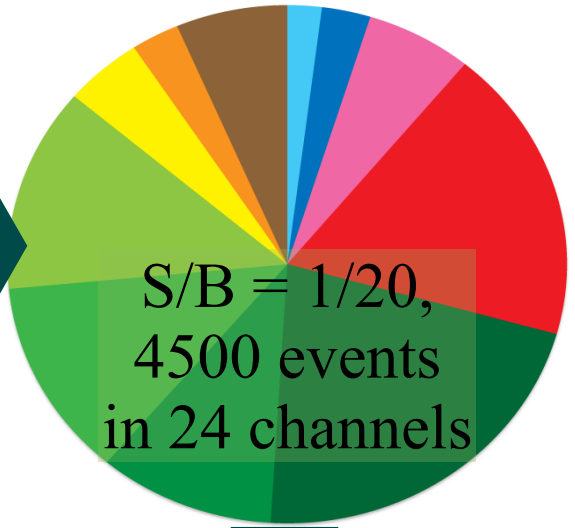
Trigger selection



Single top event kinematics

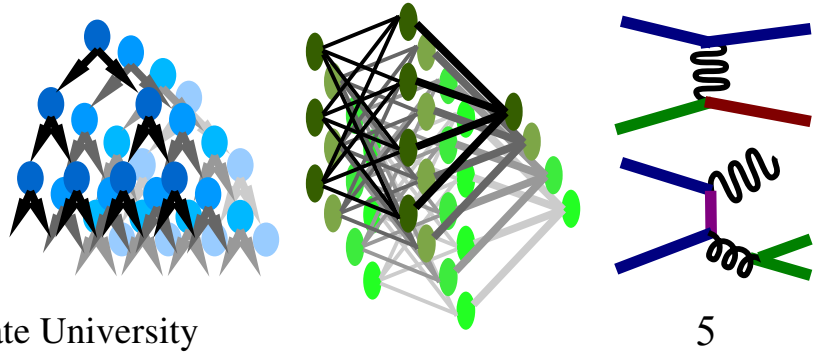


b-quark tagging

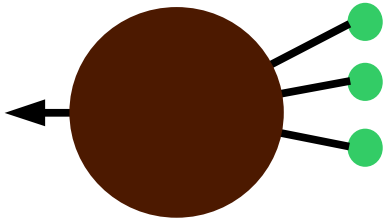


Multivariate techniques

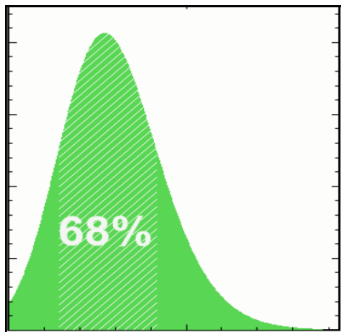
BDT BNN ME



Combination

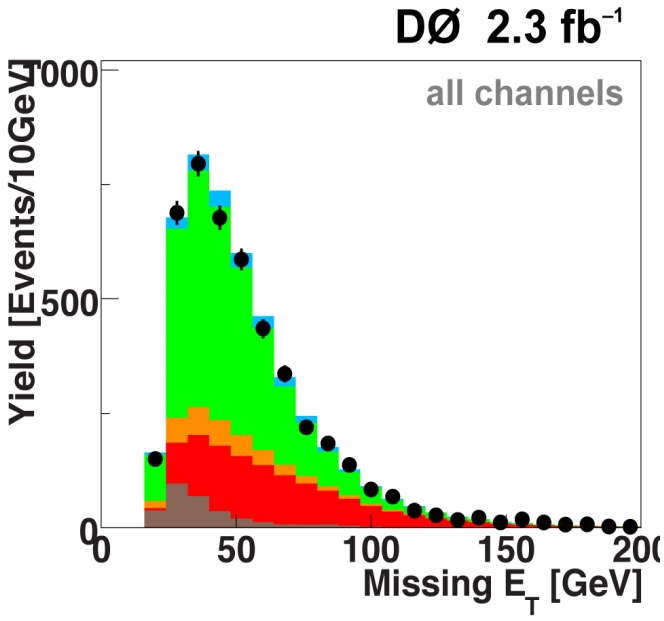


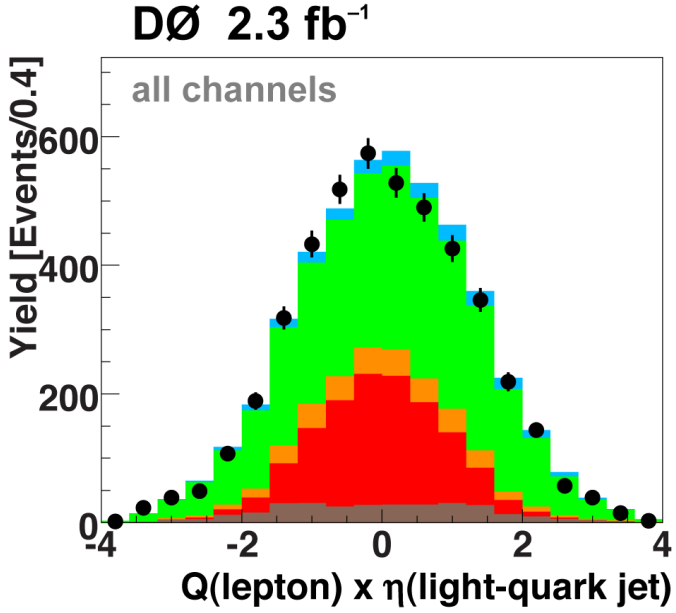
Statistical analysis

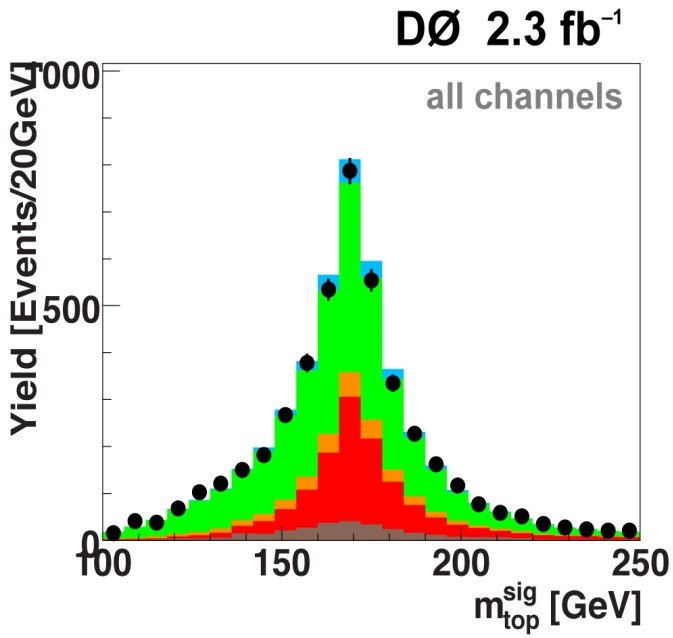


Discriminating variables

- Check data-background agreement for 600 variables
- Choose 20-64 variables for different MVAs in different channels
  - Object and event kinematics, angular correlations, top reconstruction, jet reconstruction



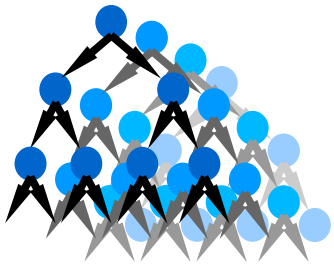




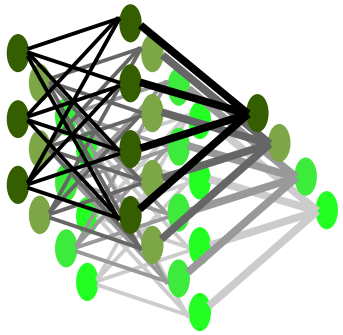
- Systematic uncertainties
  - Shape and normalization uncertainties
  - Background uncertainty 10% to 20%, larger in the signal region

Multivariate analysis methods

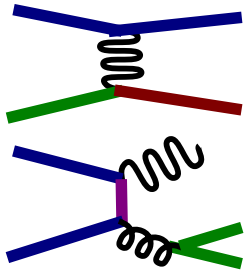
Boosted Decision Trees



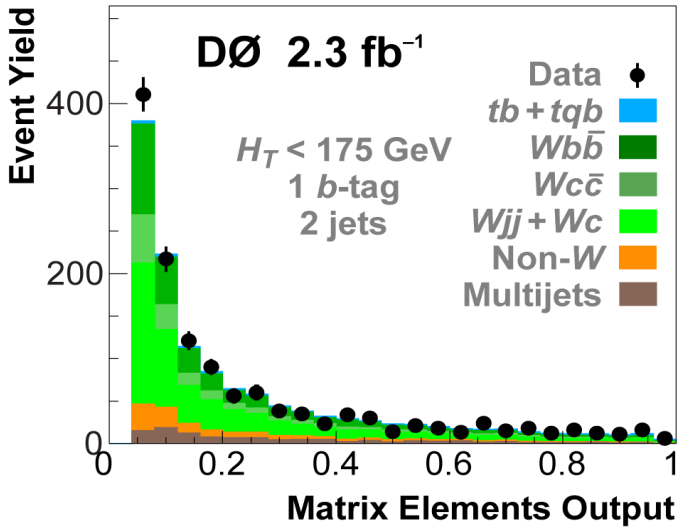
Bayesian Neural Networks

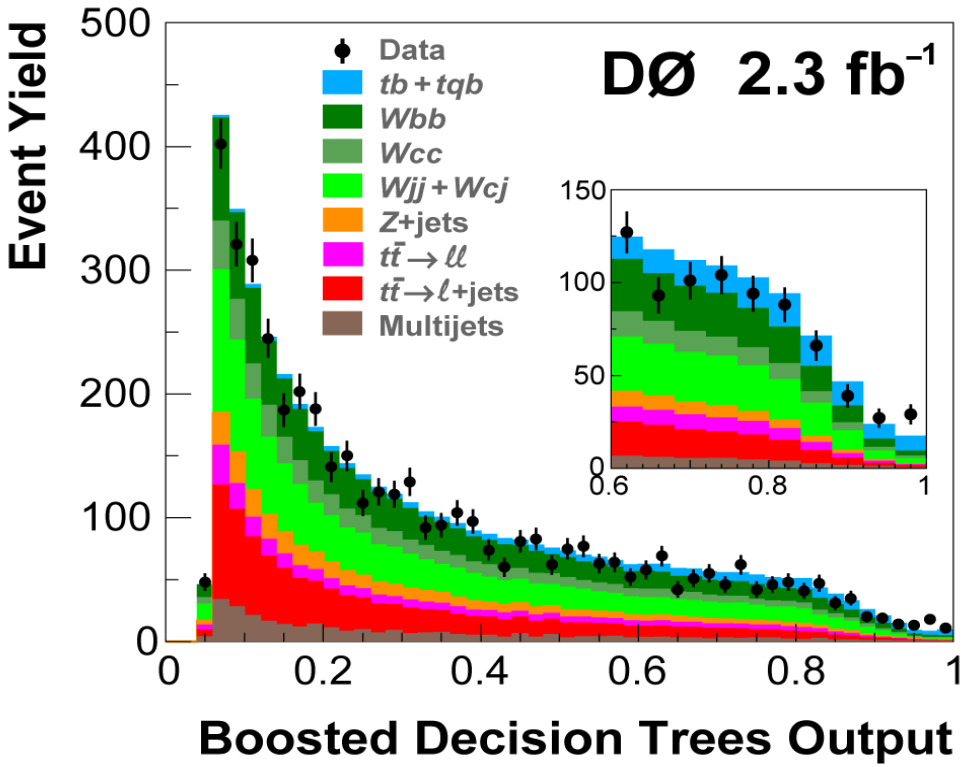


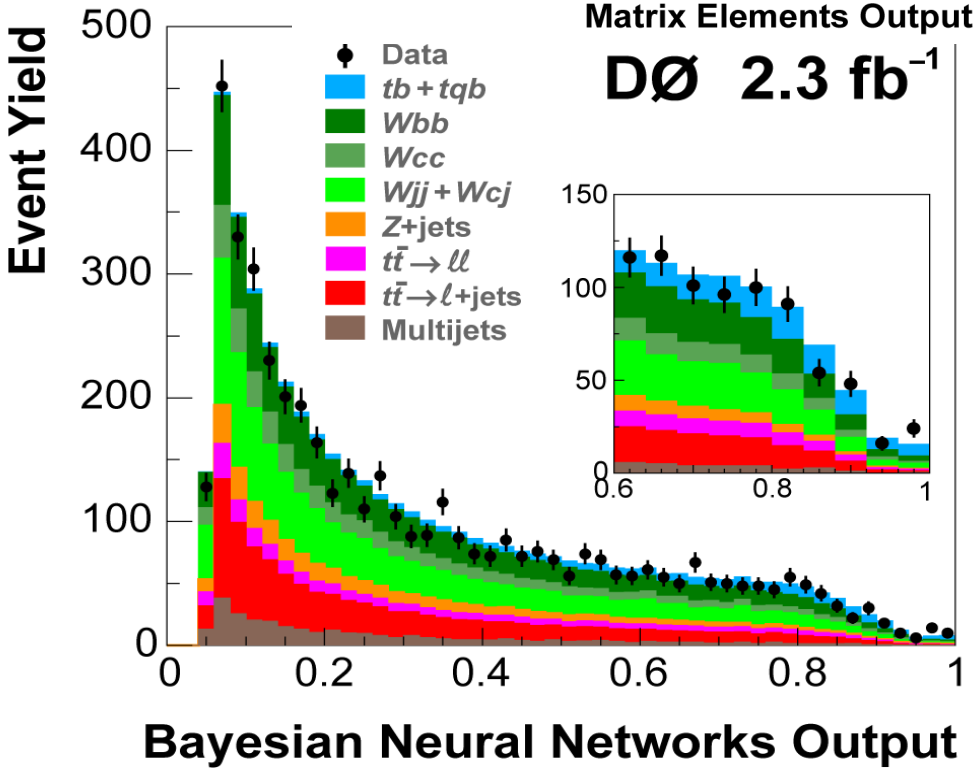
Matrix Elements



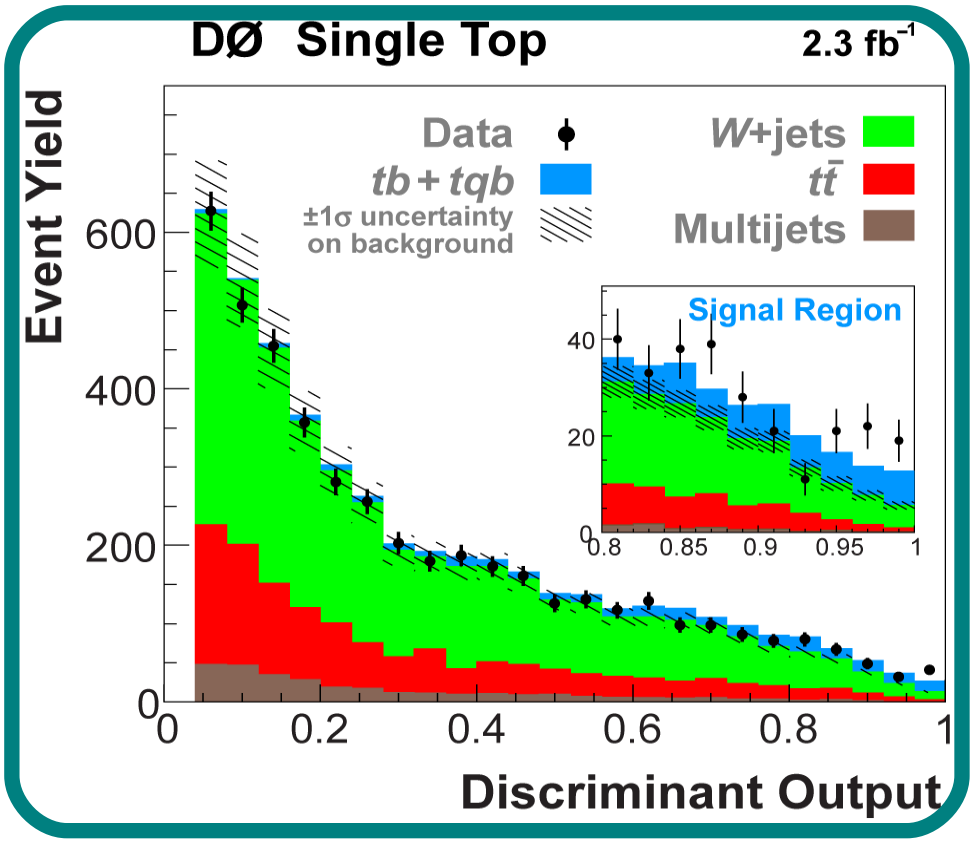
W+Jets Cross-Check Sample

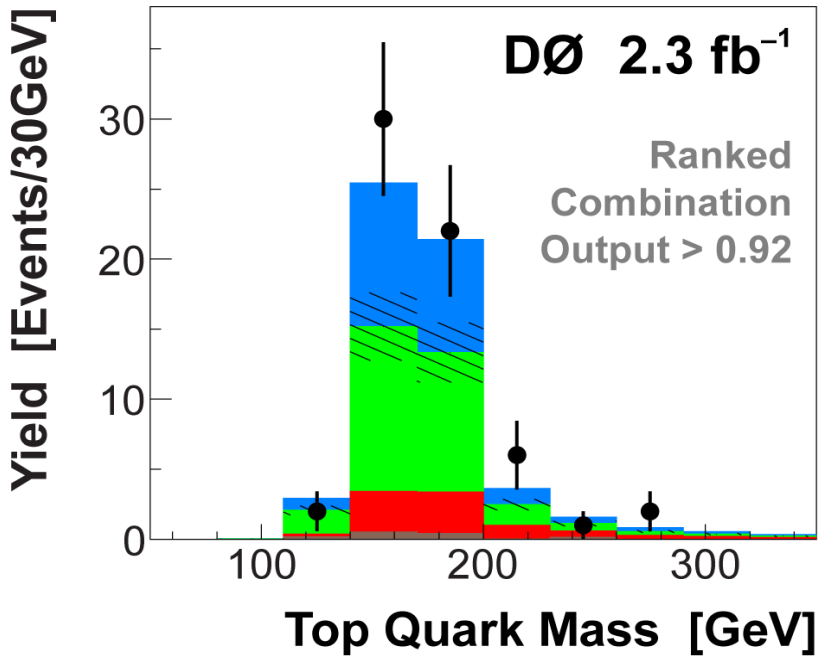


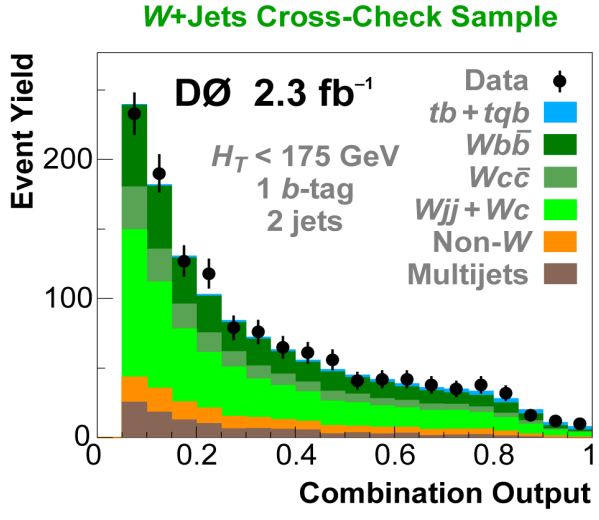


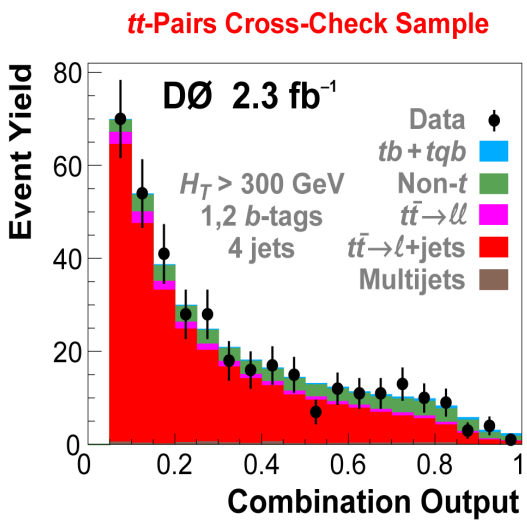


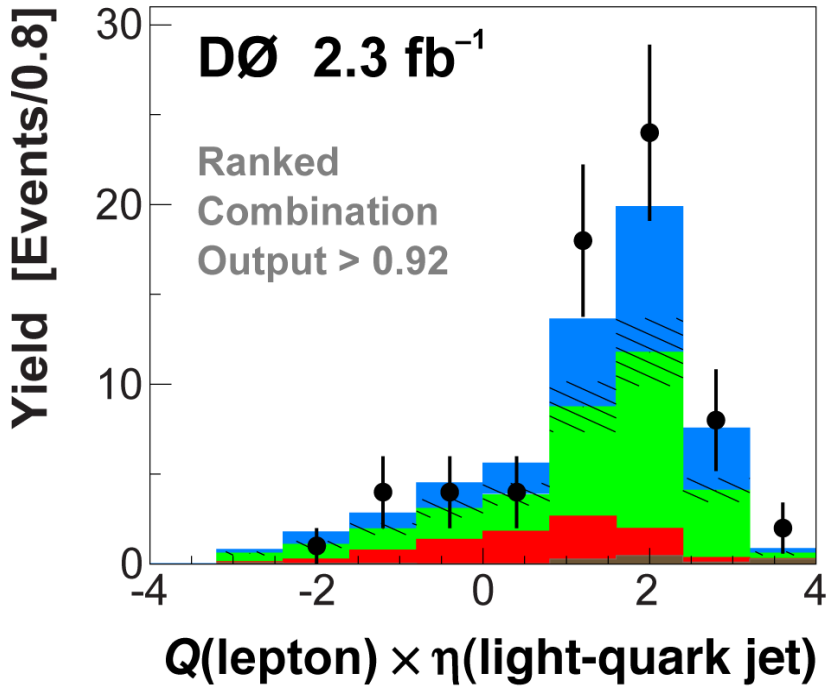
Combination: Another BNN









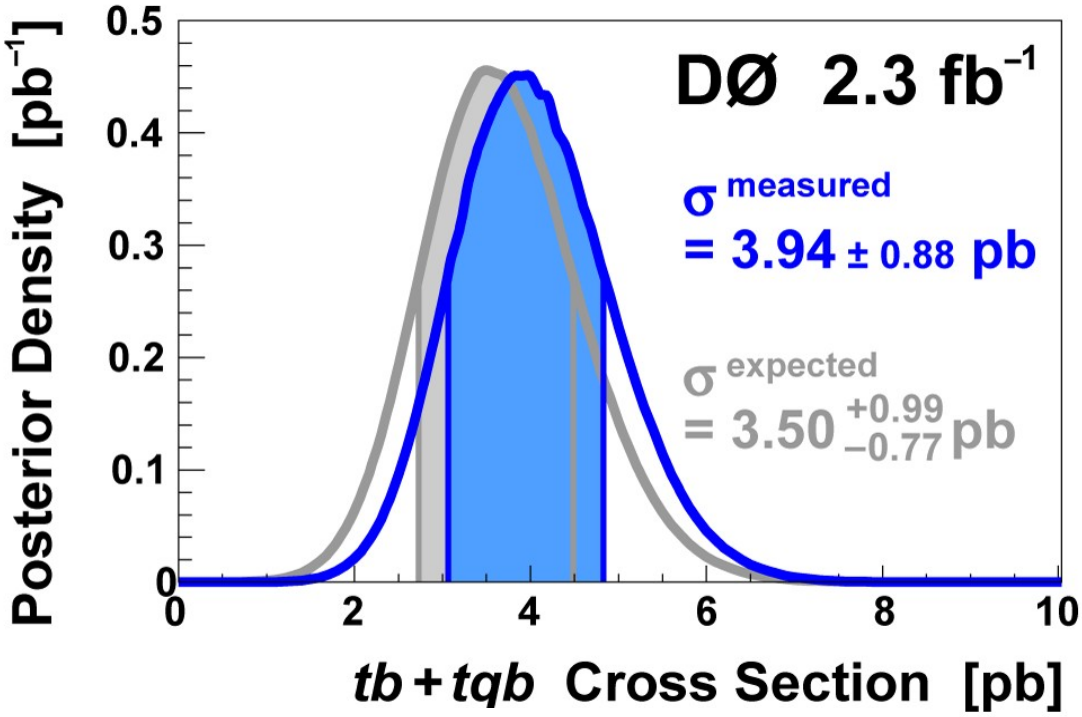


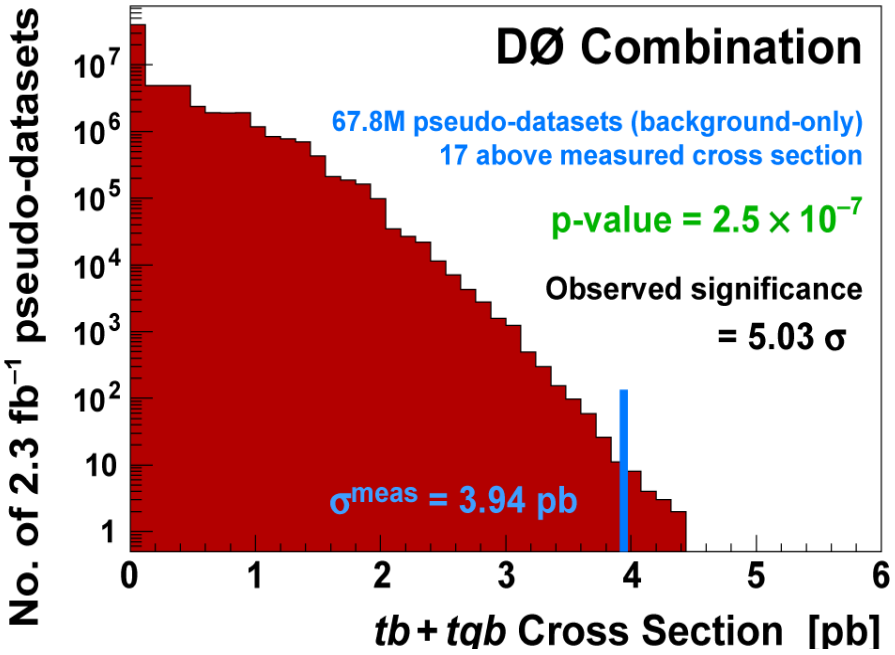
Cross section and significance

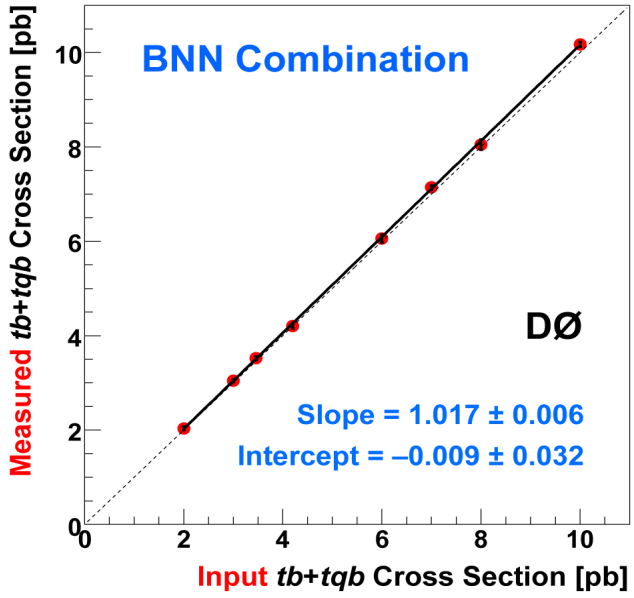
- Bayesian statistical analysis
  - Including all systematics and their correlations

$\sigma(s+t) = 3.94 \pm 0.88$ pb

- Significance and linearity from ensembles of pseudo-datasets

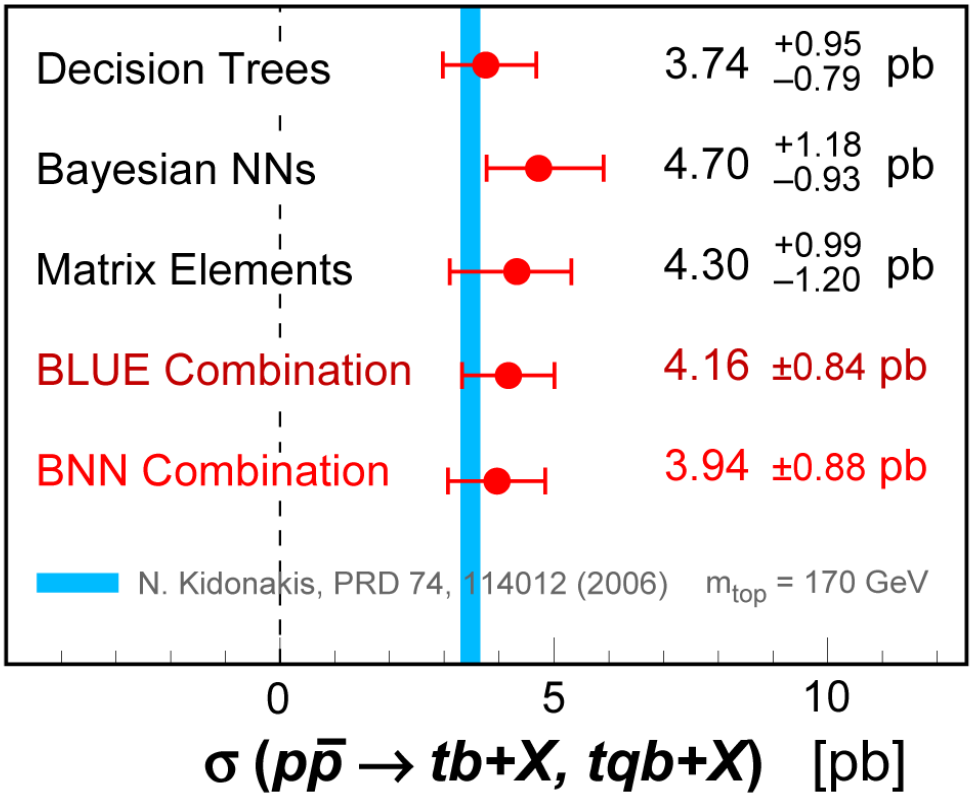


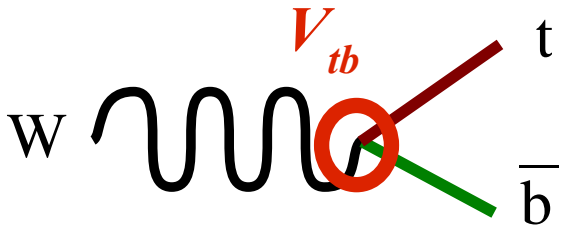




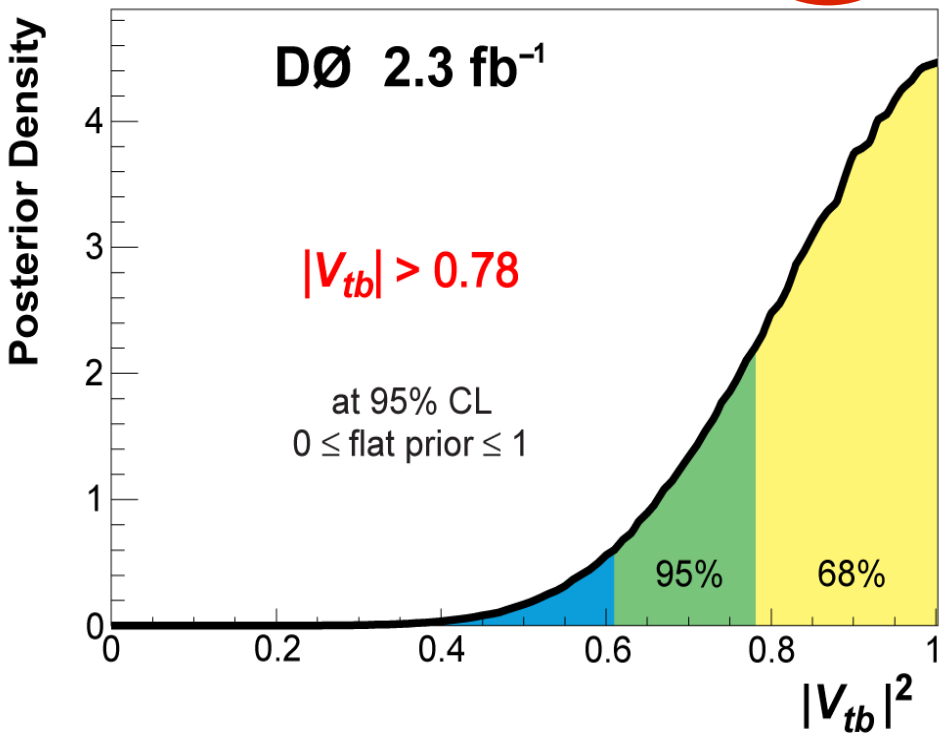
Summary and Vtb

DØ 2.3 fb^{-1} Single Top Results			
Analysis Method	Single Top Cross Section	Significance	
		Expected	Measured
Boosted Decision Trees	$3.74\ ^{+0.95}_{-0.79}$ pb	4.3 σ	4.6 σ
Bayesian Neural Networks	$4.70\ ^{+1.18}_{-0.93}$ pb	4.1 σ	5.4 σ
Matrix Elements	$4.30\ ^{+0.99}_{-1.20}$ pb	4.1 σ	4.9 σ
Combination	3.94 ± 0.88 pb	4.5 σ	5.0 σ





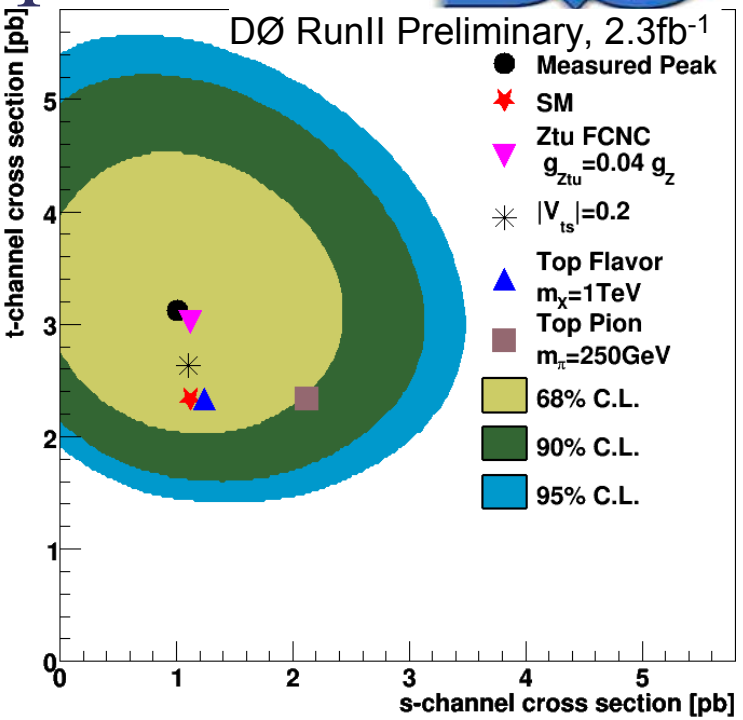
$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

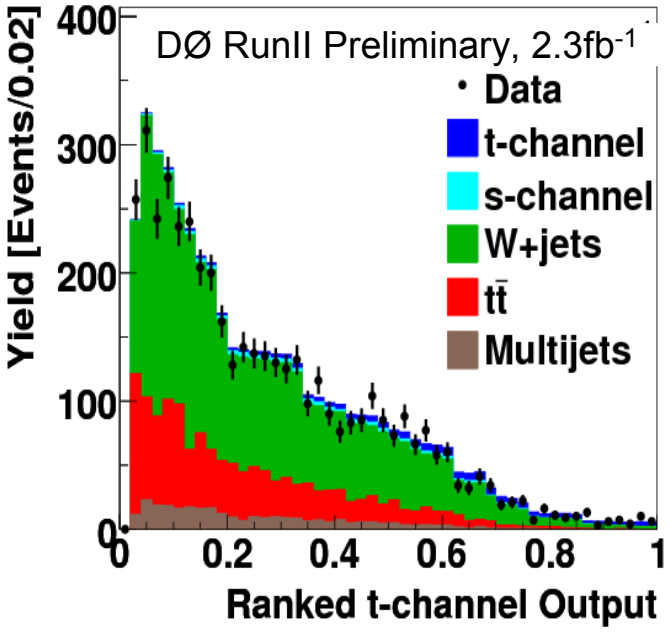


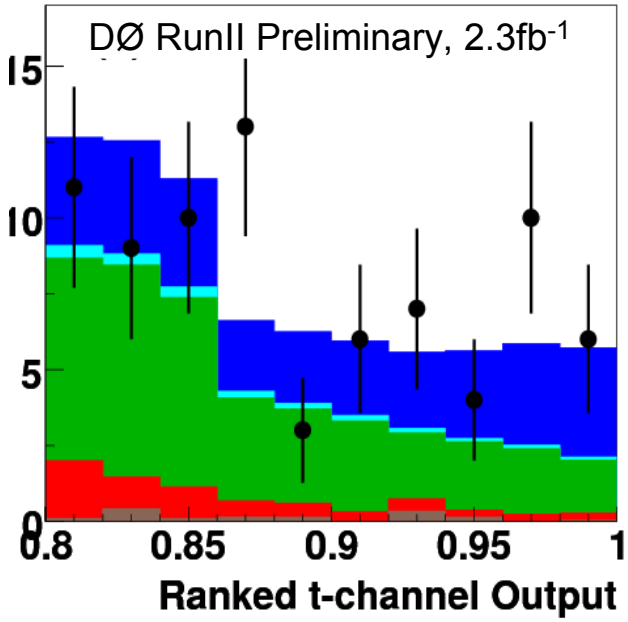
Submitted to PRL, arXiv:0903.0850

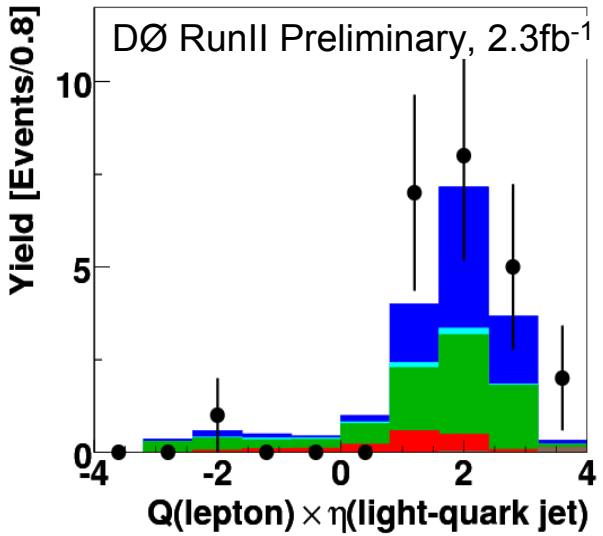
First evidence for t-channel production

- Train MVA filters for t-channel
- Measure t-channel and s-channel simultaneously
  - Remove s/t constraint
  - $\sigma(t) = 3.14\ ^{+0.94}_{-0.81}$ pb
    - Expected/observed significance: 3.7/4.8 SD
  - $\sigma(s) = 1.05 \pm 0.81$ pb









Conclusions

- We are learning a lot about the top quark at the Tevatron
- DØ has observed single top quark production at the 5.03 SD level with 2.3fb^{-1}
  - $\sigma(s+t) = 3.94 \pm 0.88$ pb
  - $|V_{tb}| > 0.78$ at 95% C.L.
- DØ has isolated the t-channel mode
  - Without assumptions about the s-channel cross section
  - $\sigma(t) = 3.14\ ^{+0.94}_{-0.81}$ pb
  - Significance 4.8 SD
- Updates with larger dataset and dedicated searches for new physics are in progress