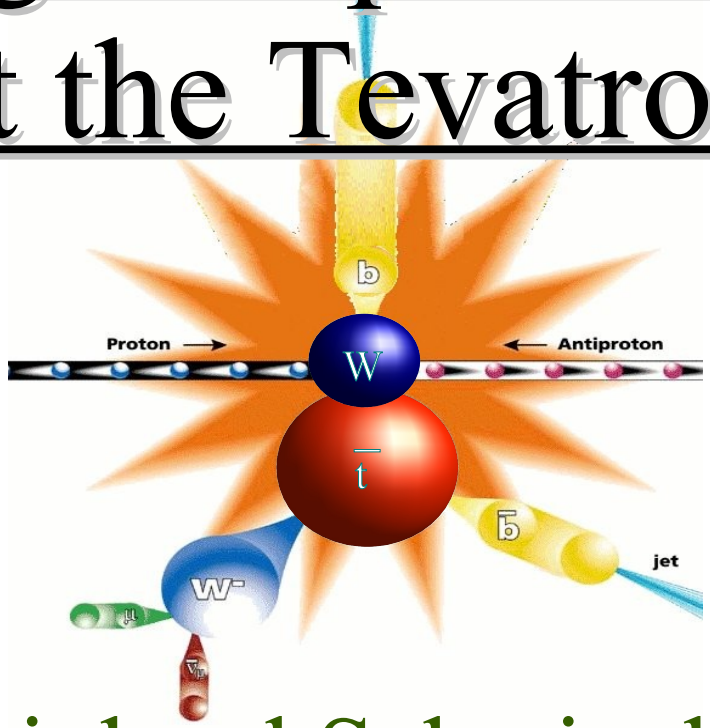
Single Top and Vtb at the Tevatron



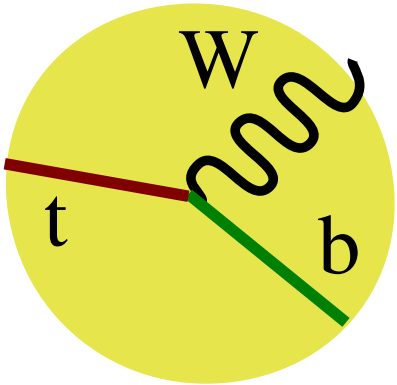
Reinhard Schwienhorst

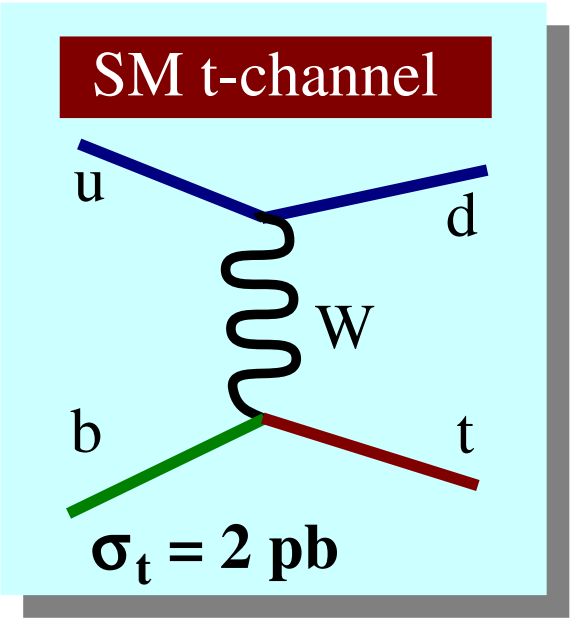
MICHIGAN STATE UNIVERSITY

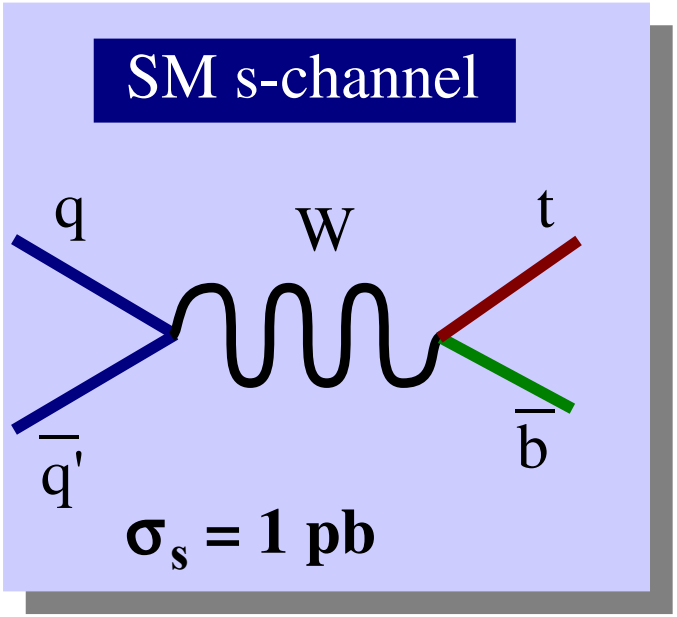
on behalf of the CDF and DØ collaborations

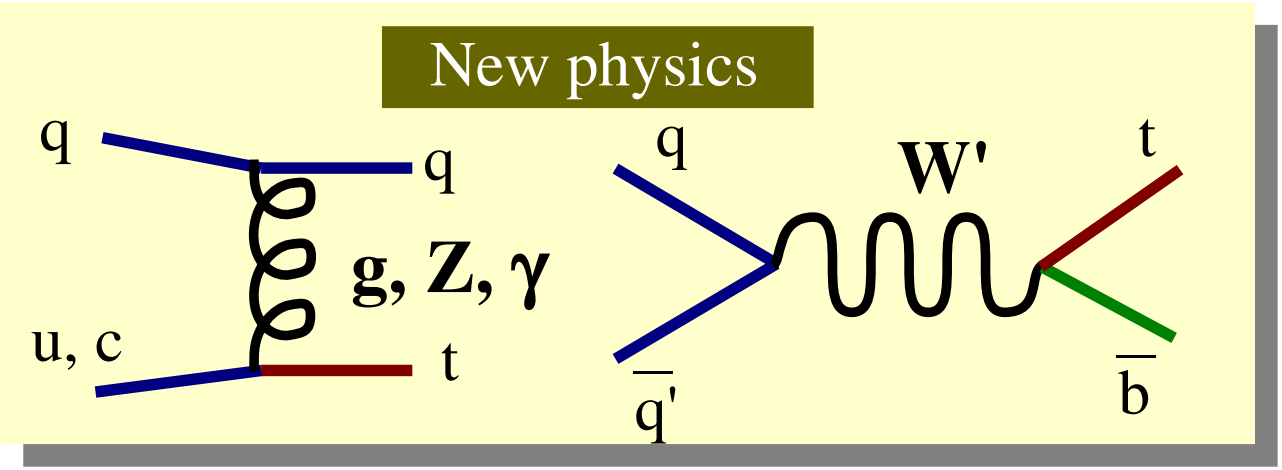
22nd Rencontres de Blois, 2010

The tWb vertex

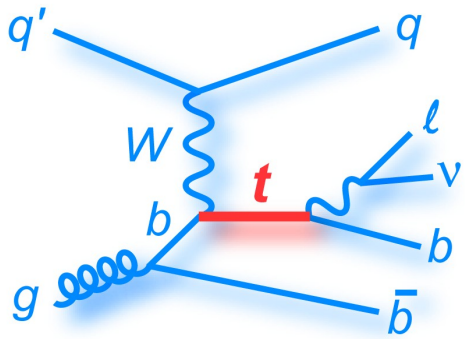








Single top modeling



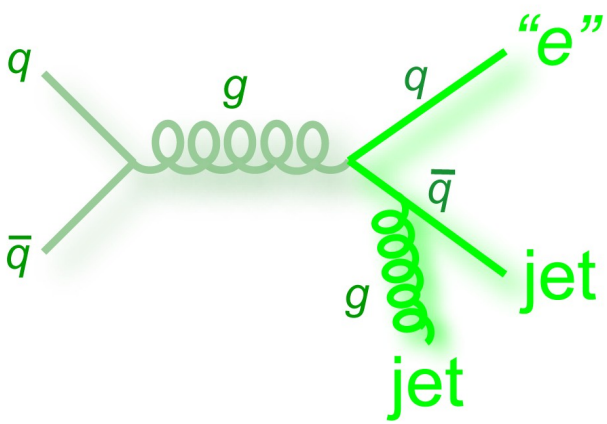
- Generate signal that reproduces NLO distributions
- Top mass 170GeV (DØ), 175GeV (CDF)
- Normalize to resummation (DØ), NLO (CDF)

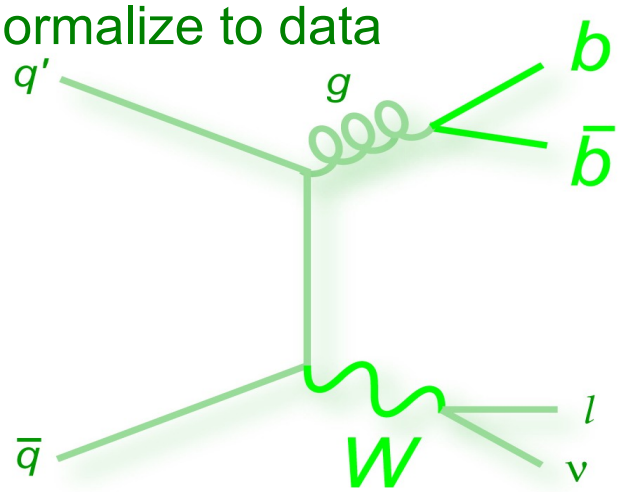
Backgrounds

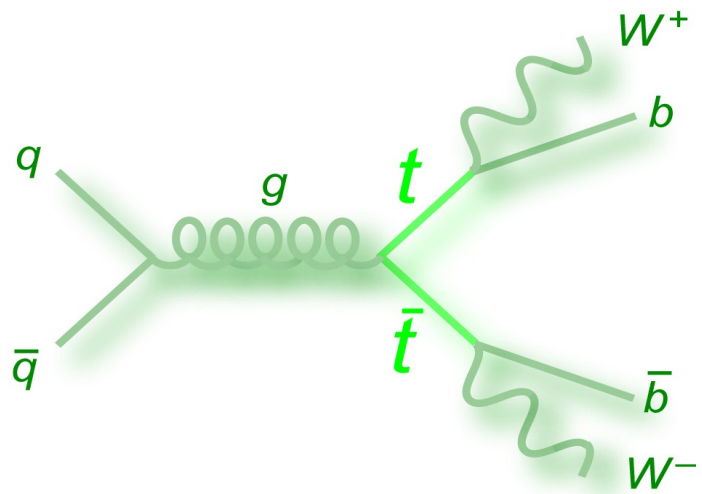
QCD multijets
- Model using data
- Normalize to data

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.







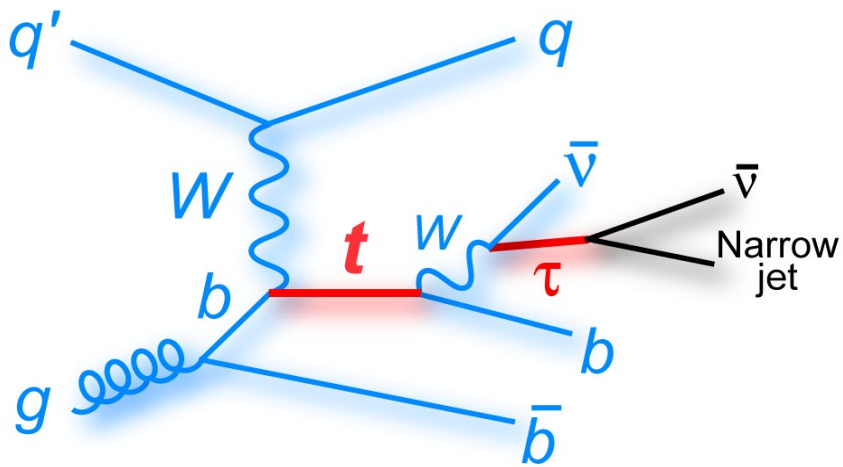
Small contributions from Z+jets, dibosons

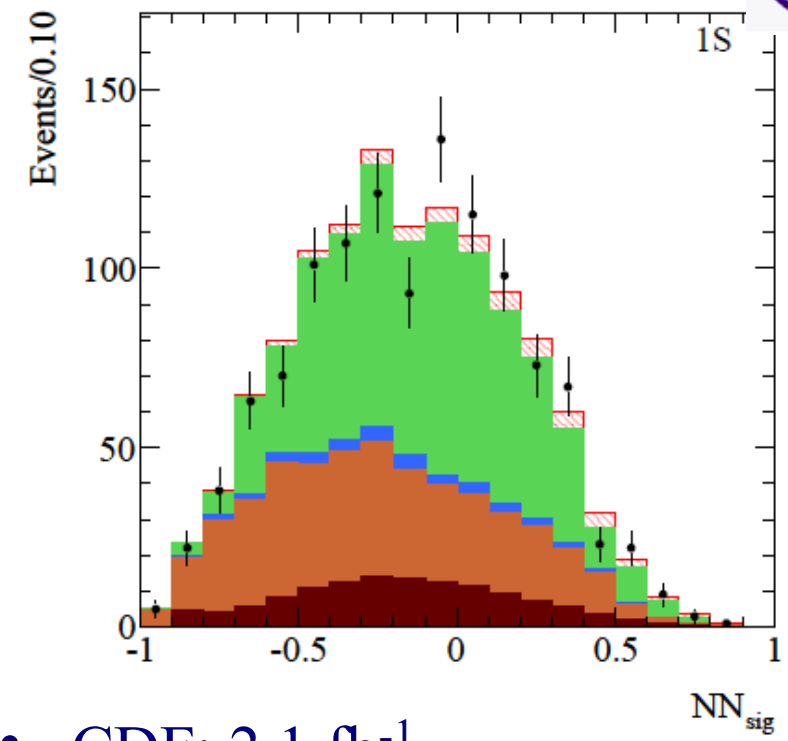
Event samples

- Basic event signature (e or μ)
  - Include many triggers
  - One high-E_T lepton
  - Missing transverse energy
  - 2-4 jets (DØ), 2-3 jets (CDF)
  - At least one b-tag
- Also define cross-check samples
  - W+jets, ttbar, pretag

	DØ 2.3 fb^{-1}	CDF 3.2 fb^{-1}
	Lepton+$\not{E}_T$+jets / *b*-tagged	
tb + *tqb* signal *1,*2	223 ± 30	191 ± 28
W+jets	2,647 ± 241	2,204 ± 542
Z+jets, dibosons	340 ± 61	171 ± 15
$t\bar{t}$ pairs *1,*2, *3	1,142 ± 168	686 ± 99
Multijets	300 ± 52	125 ± 50
Total prediction	4,652 ± 352	3,377 ± 505
Data	4,519	3,315

Event samples: tau leptons





- DØ: 4.8 fb^{-1}
- BDT to identify τ leptons
- Expect 72 τ+jets single top events
  - Total background 3845
- BDT for final analysis
  - 44-70 variables

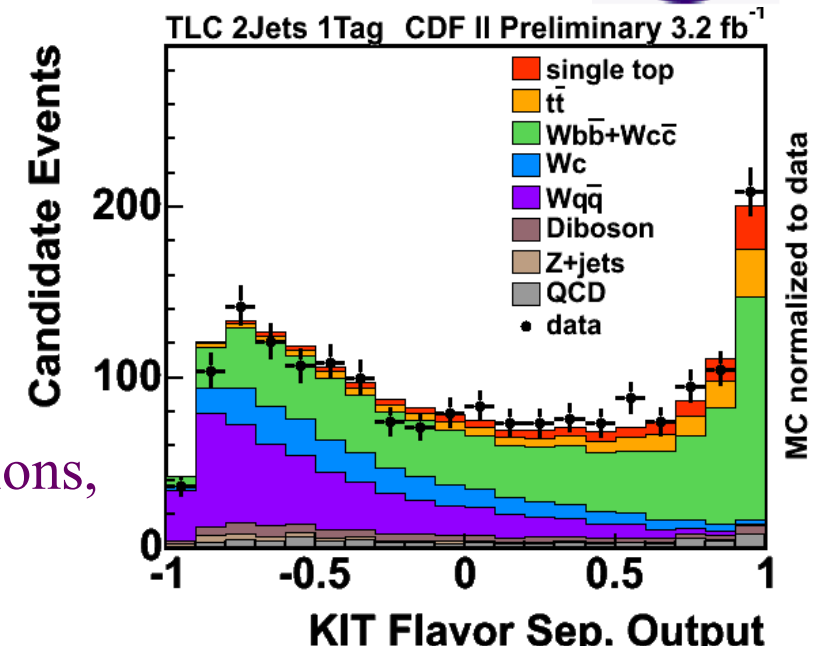
PLB 690, 5 (2010)

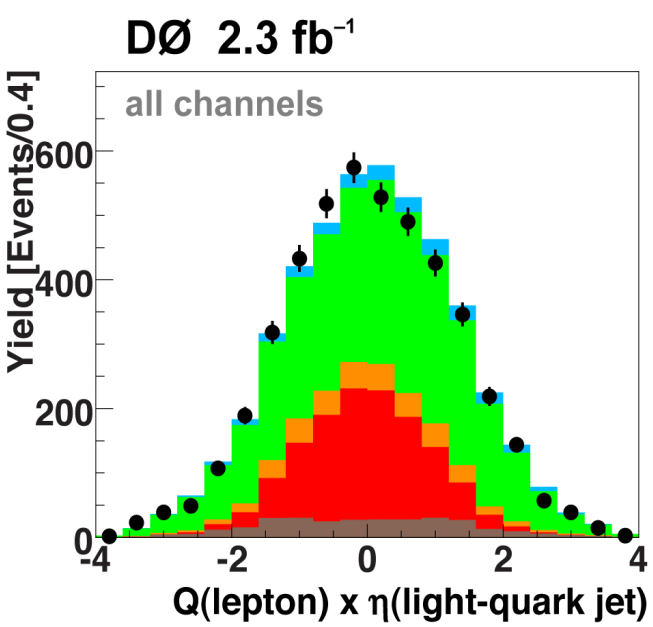
- CDF: 2.1 fb^{-1}
- Select events with large MET+jets
- Expect 64 single top events
  - Total background 1400
- NN to reject multijet background
- Included in combination

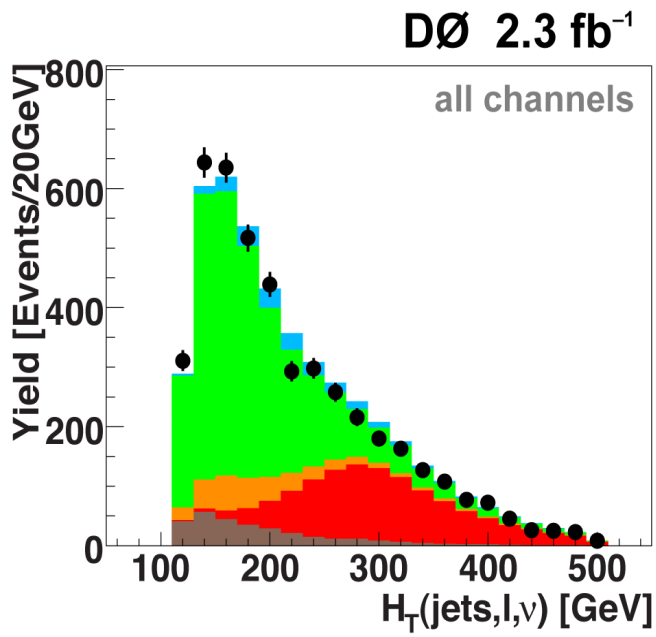
PRD81:072003 (2010)

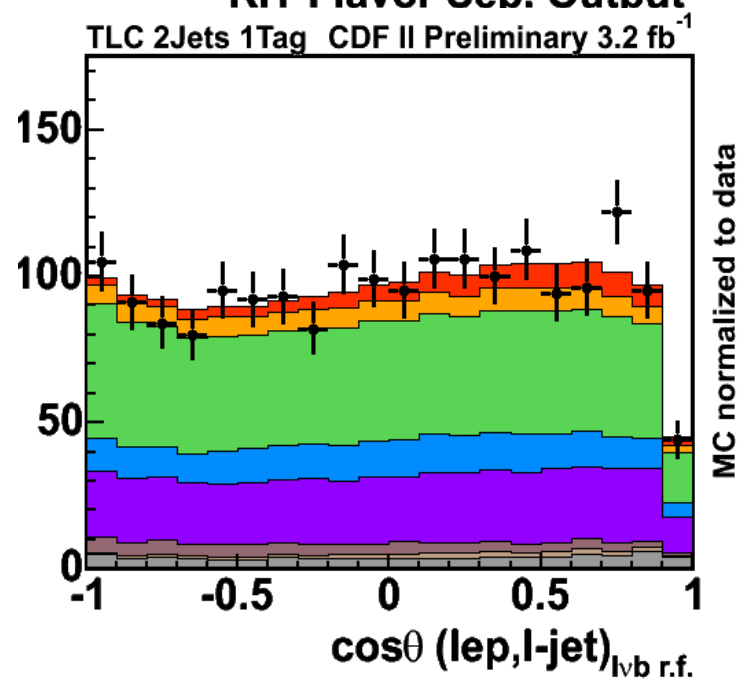
Kinematic variables

- Investigate several hundred variables
  - No single variable can isolate signal
  - Check data-background agreement
- Choose 10-64 variables for different MVAs in different channels
  - Object and event kinematics, angular correlations, top and jet reconstruction, b-tagging





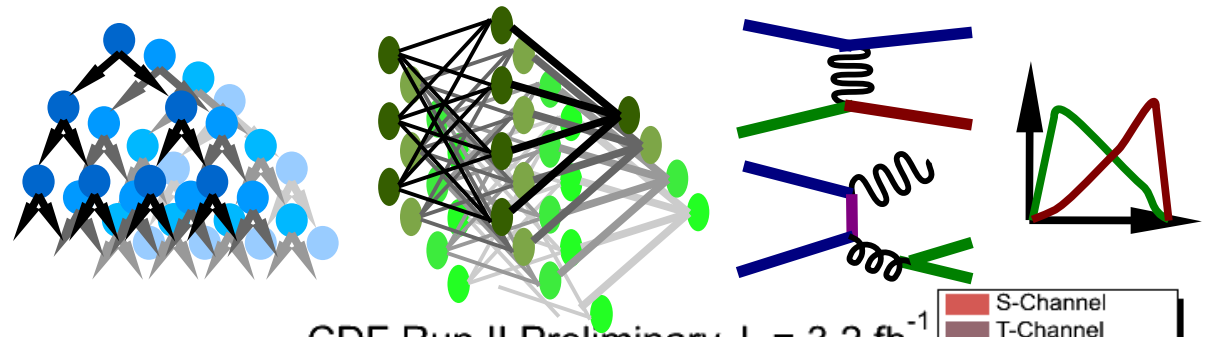


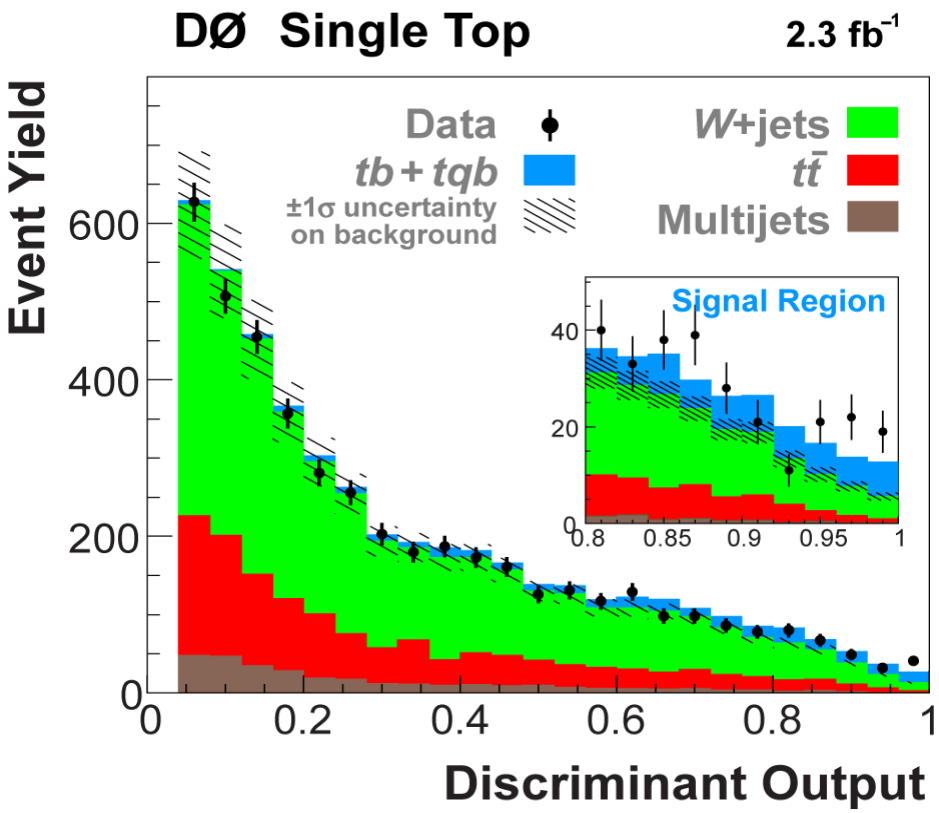


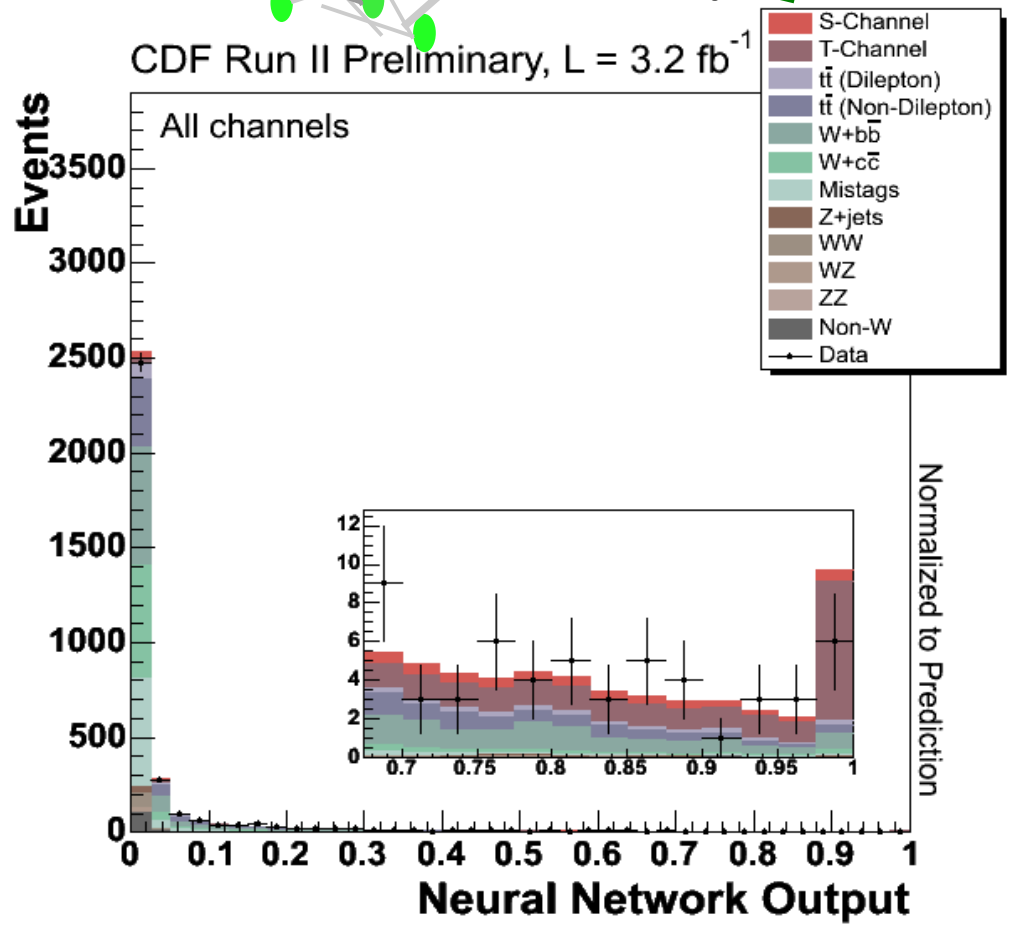
Multivariate analysis

- Several multivariate filters combined in one final discriminant
  - BNN (DØ)
  - NEAT (CDF)

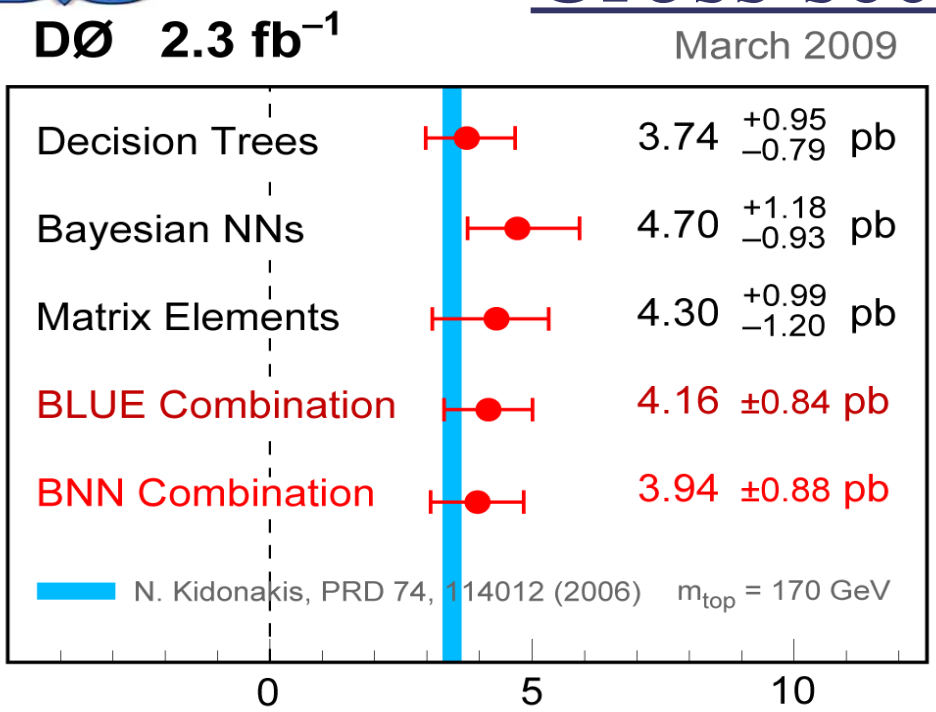
Boosted Decision Trees | **Neural Networks** | **Matrix Elements** | **Likelihood**

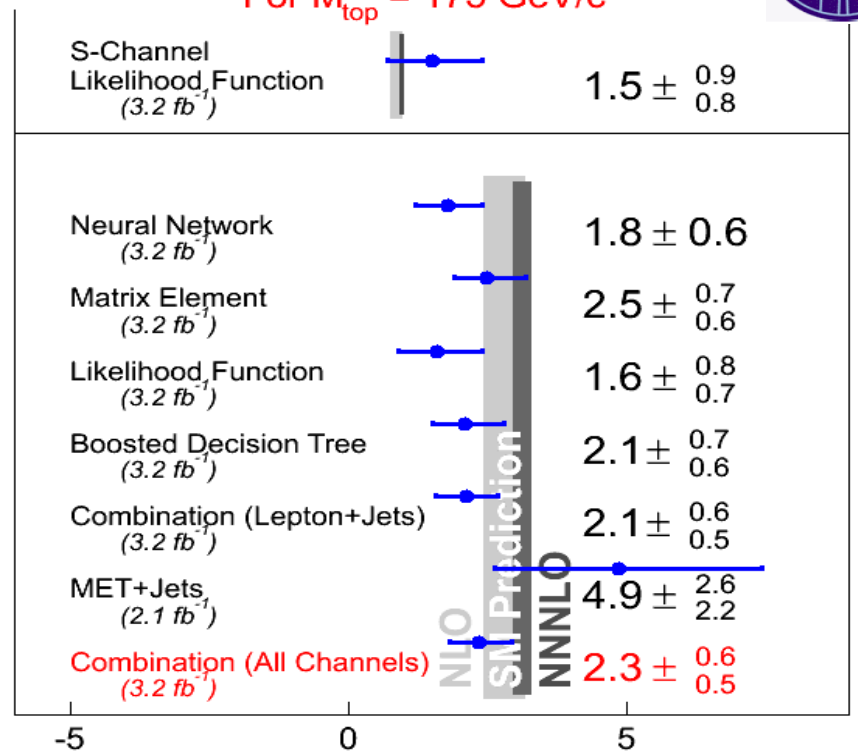


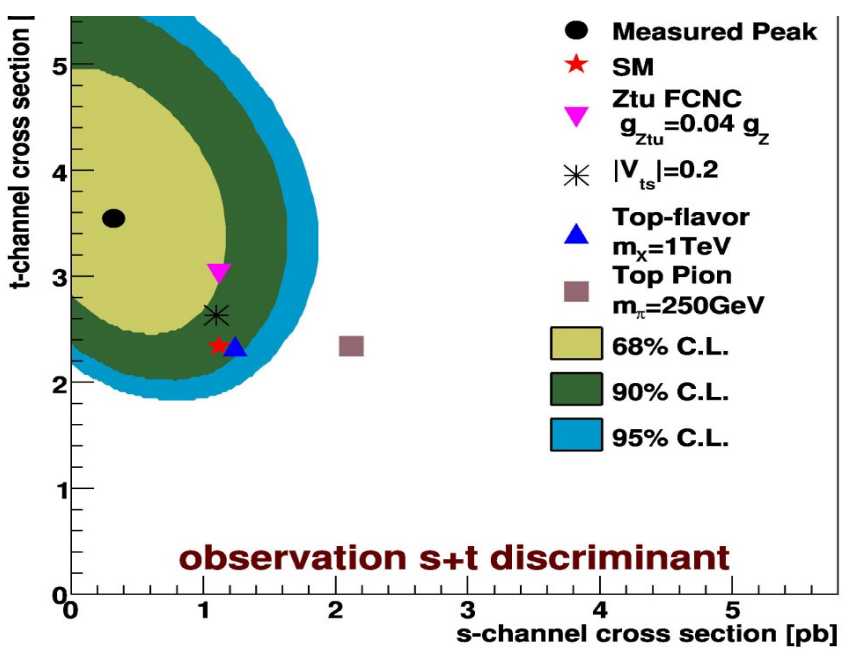


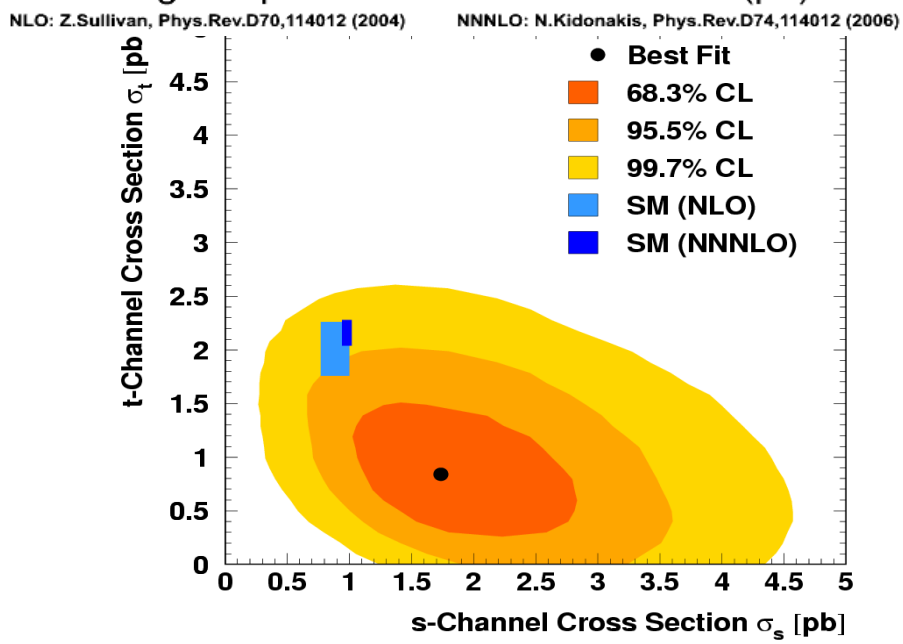


Cross sections



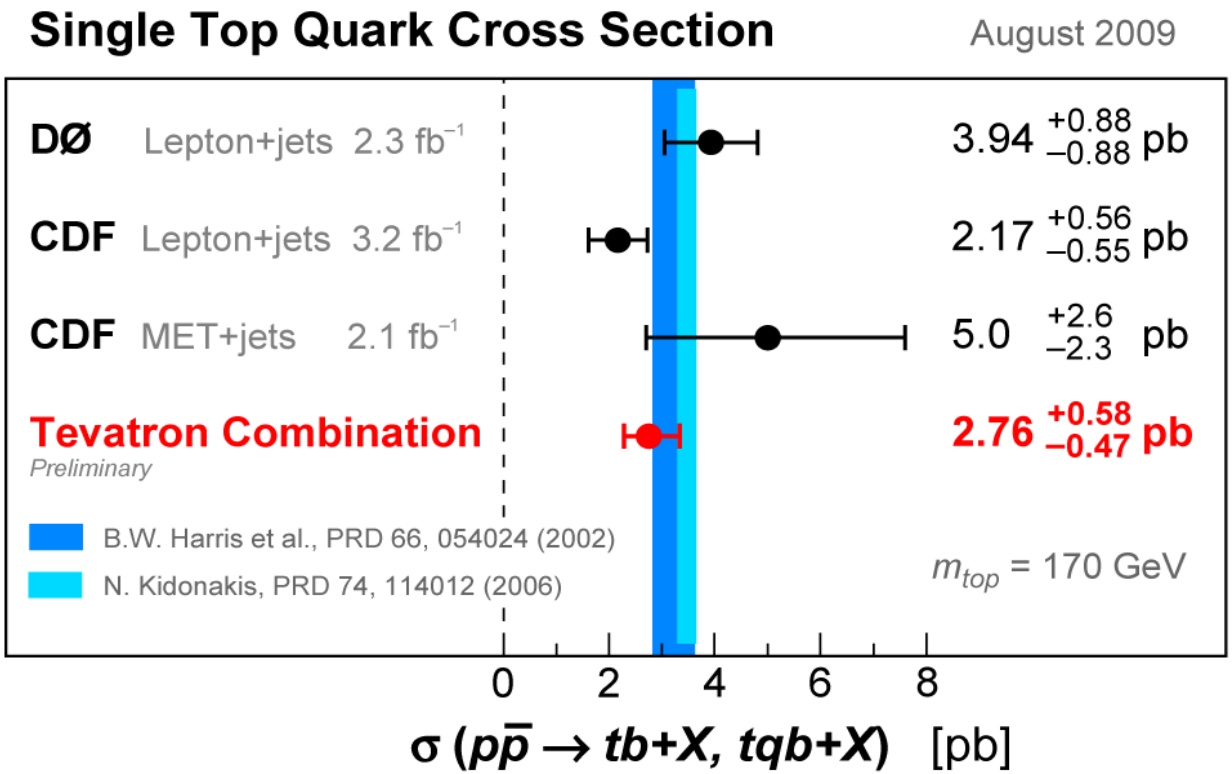


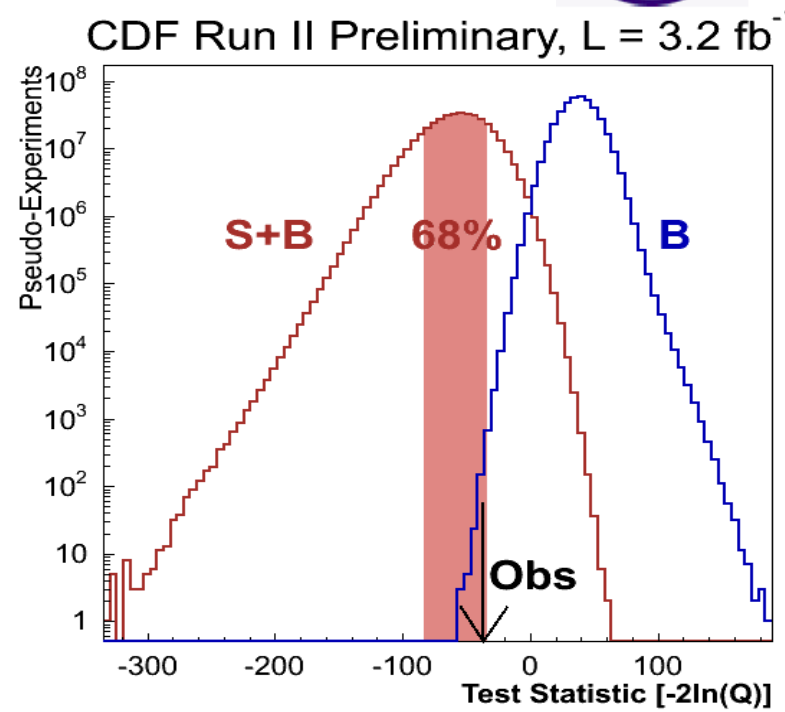


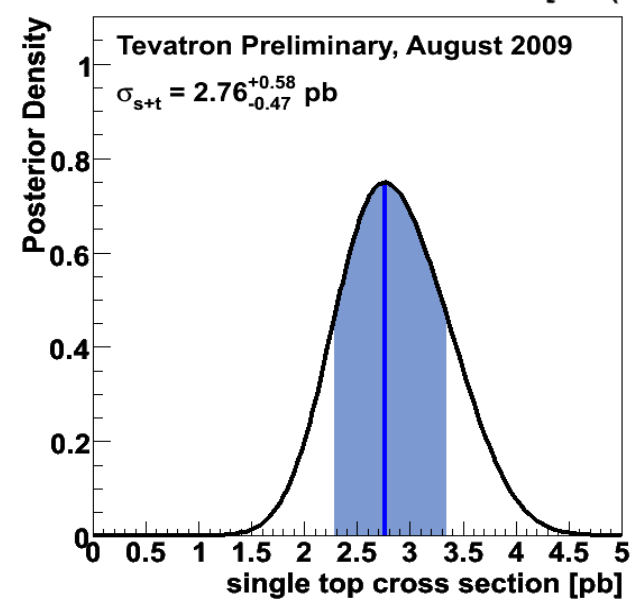


Tevatron combination

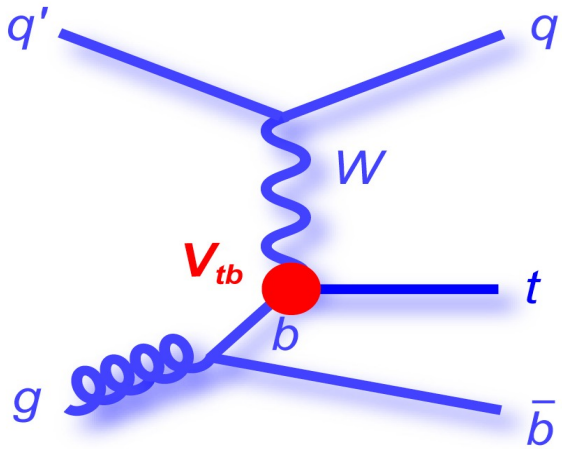
- Each experiment observes 5 σ significance
- DØ and CDF measurements are consistent to 1.6 σ
- Combination of MVA distributions
  - Bayesian statistical analysis
  - Taking all uncertainty correlations into account

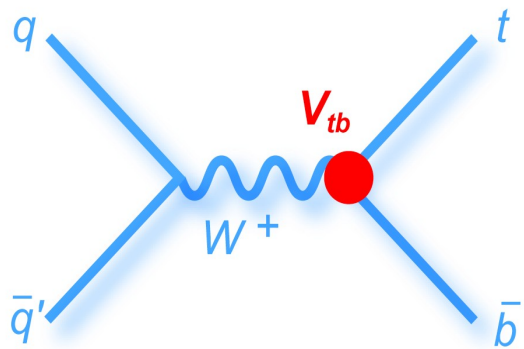






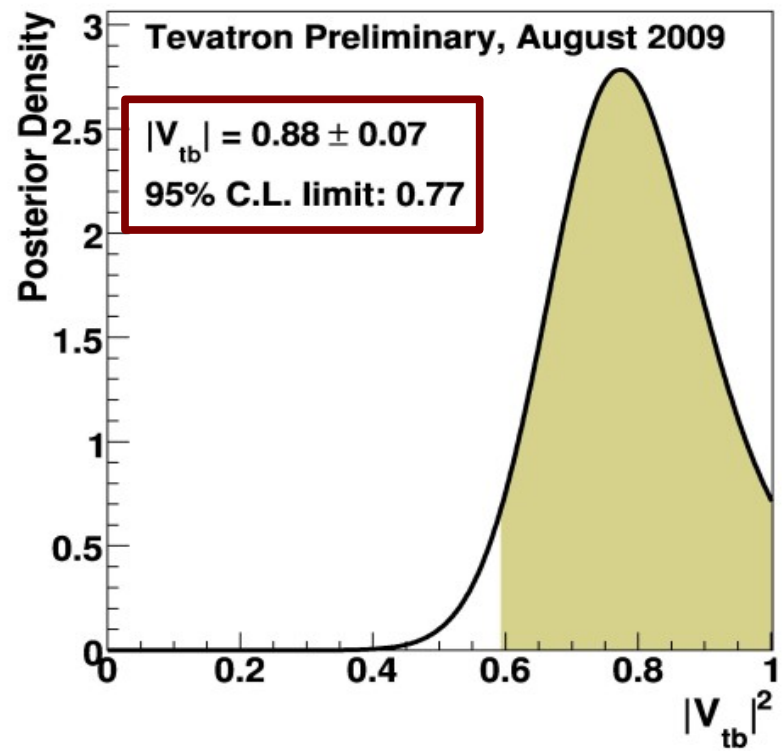
CKM matrix element Vtb





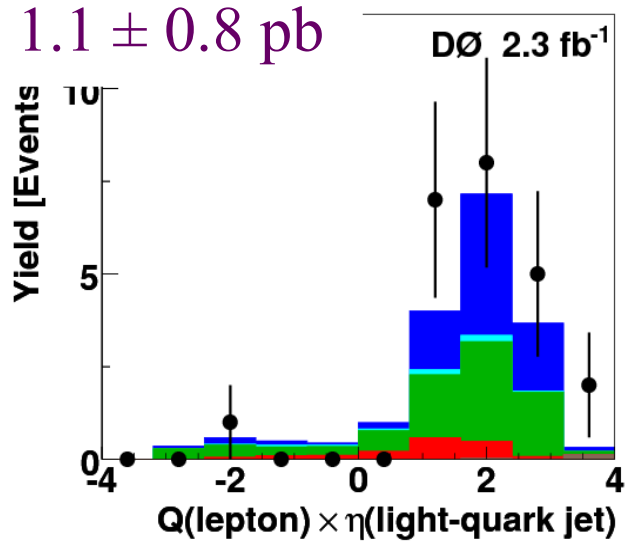
$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

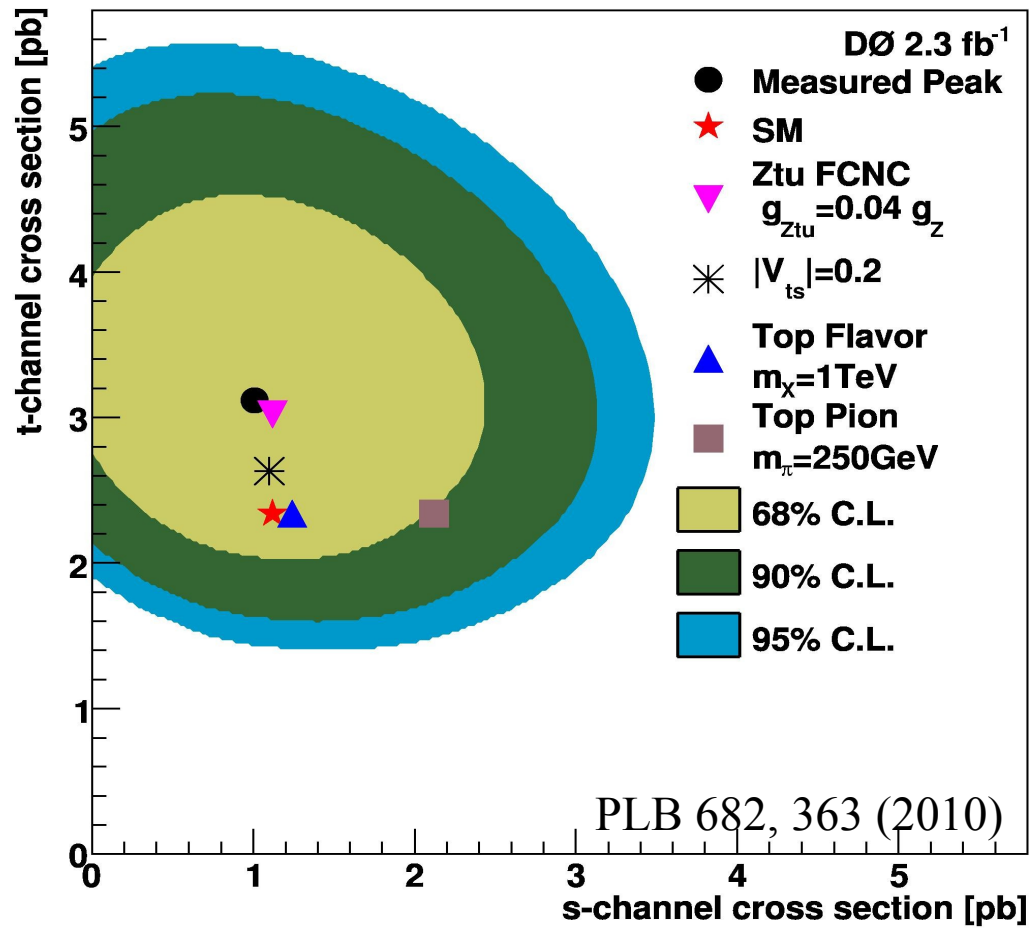
- Cross section μ $|Vtb|^2$
  - Assume SM top quark decay: $|Vtd|^2+|Vts|^2 \ll |Vtb|^2$
  - Pure V-A and CP conserving Wtb vertex
- No assumption on number of families or unitarity



t-channel production and top width

- Dedicated t-channel search
- $\sigma(t) = 3.1 \pm 0.9$ pb
  - Exp/obs significance: 3.7/4.8 SD
- $\sigma(s) = 1.1 \pm 0.8$ pb

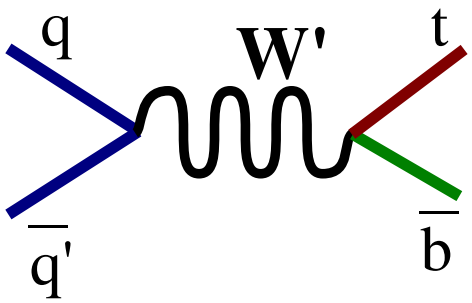




Top width:

- σ(t-chan) $\propto$ partial width $\Gamma(t \to Wb)$
- No assumptions about s-channel
- $R = \mathcal{B}(t \to Wb)/\mathcal{B}(t \to Wx)$ to obtain full width
- Result: $\Gamma_t = 2.05^{+0.57}_{-0.52}$ GeV $\quad \tau_t = (3.2^{+1.1}_{-0.7}) \times 10^{-25}$ (0.3 ys!)

Search for W' boson



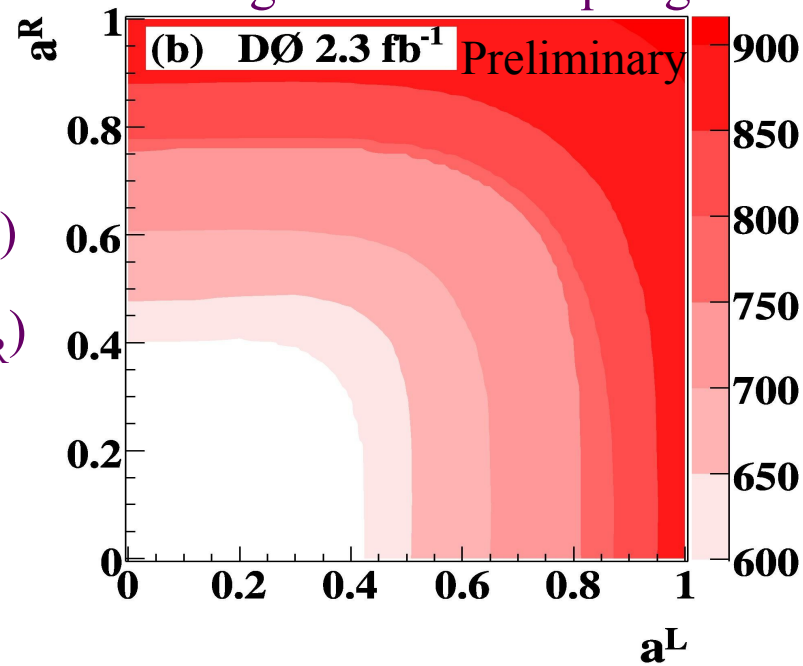
- Explore simultaneously left-handed and right-handed couplings
- 95% CL limits:

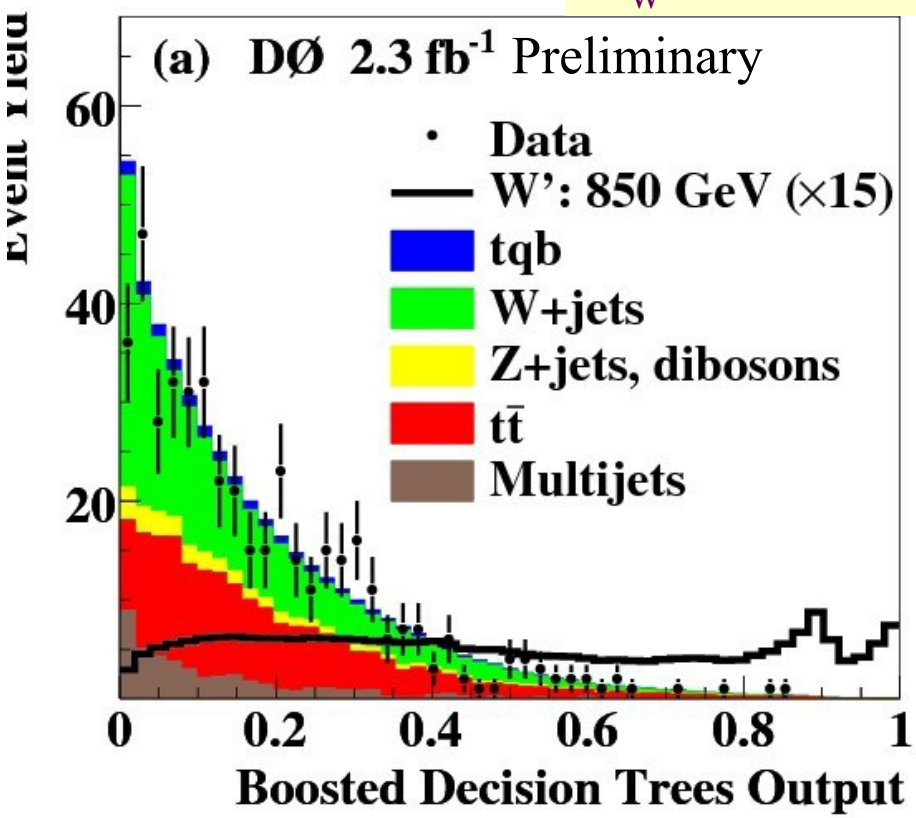
$M_{W'} > 863$ GeV (L only)

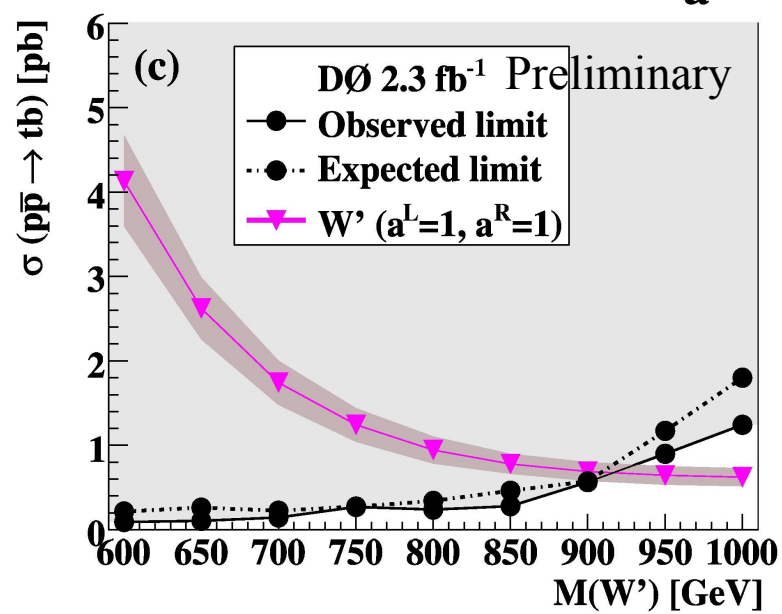
$M_{W'} > 885$ GeV (R, $M_{W'} < m_{\nu R}$)

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

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

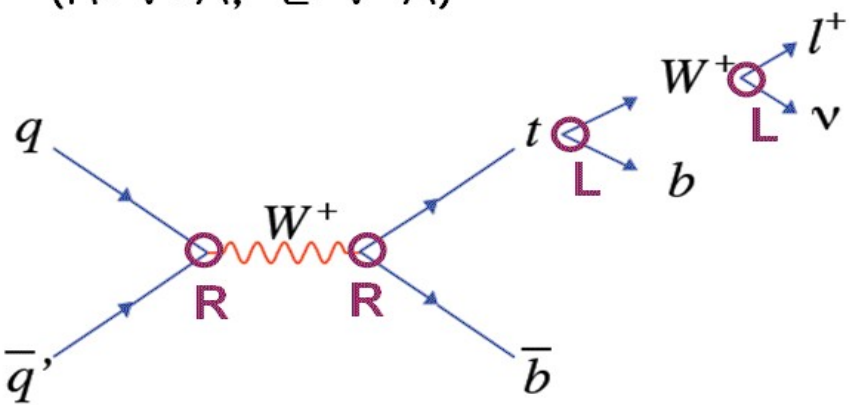


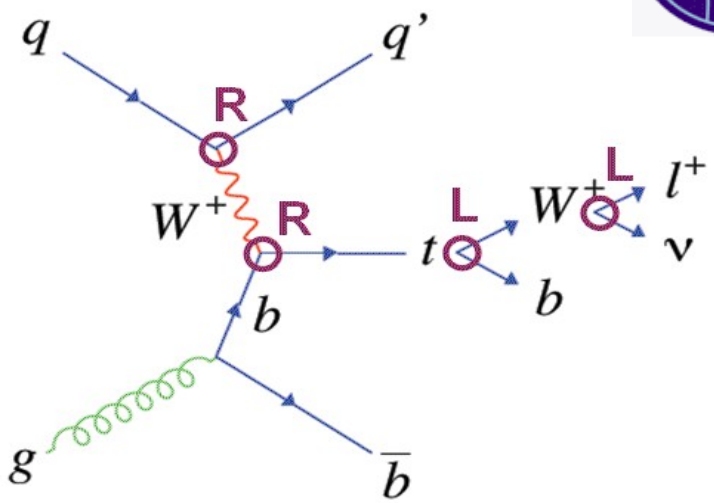


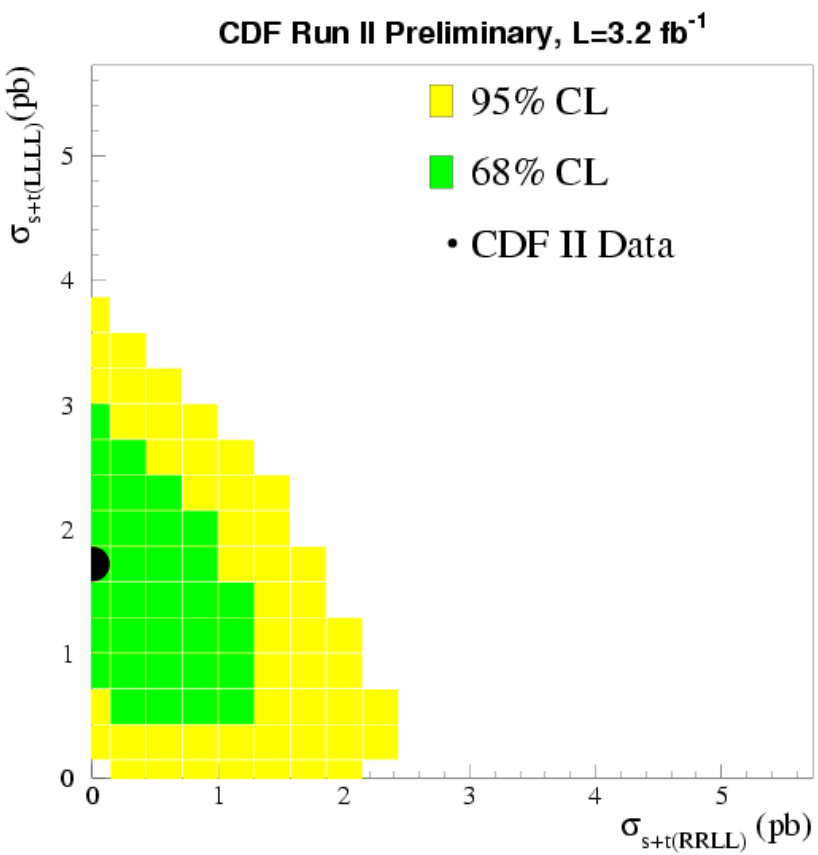


Top quark polarization

(R: V+A, L: V−A)





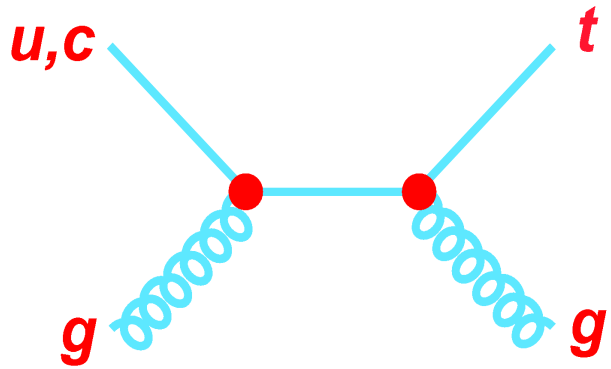


- Multivariate analysis using likelihood function
- Test for right-handed coupling in top production
- Result:

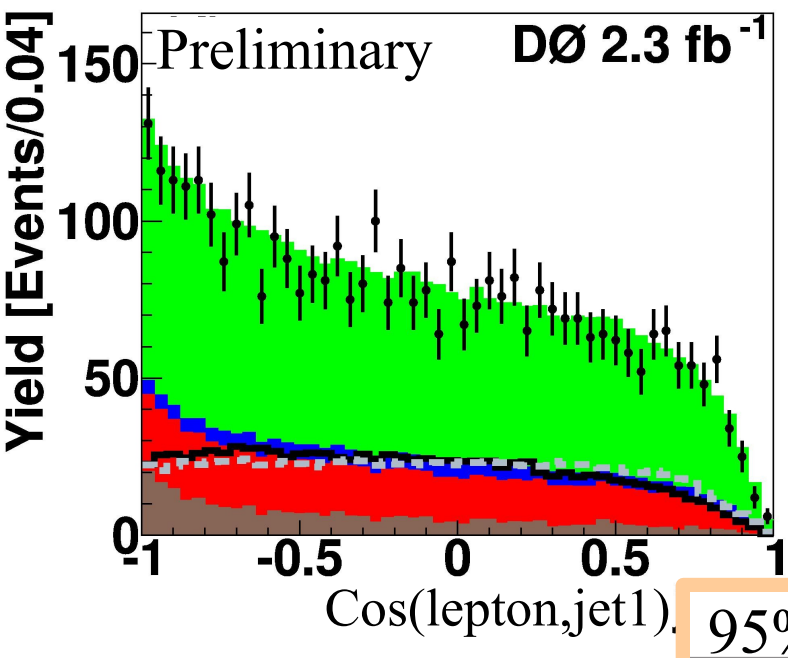
$\sigma_{LLLL} = 1.72$ pb, $\sigma_{RRLL} = 0.0$ pb

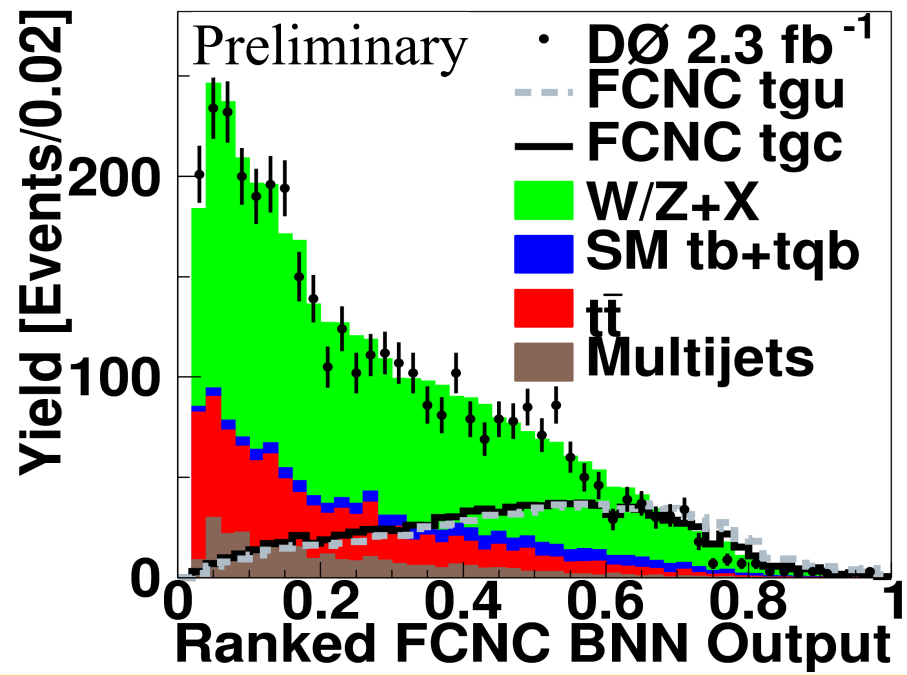
$$polarization = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} = -1^{+1.5}_{-0}$$

Gluon-FCNC in single top



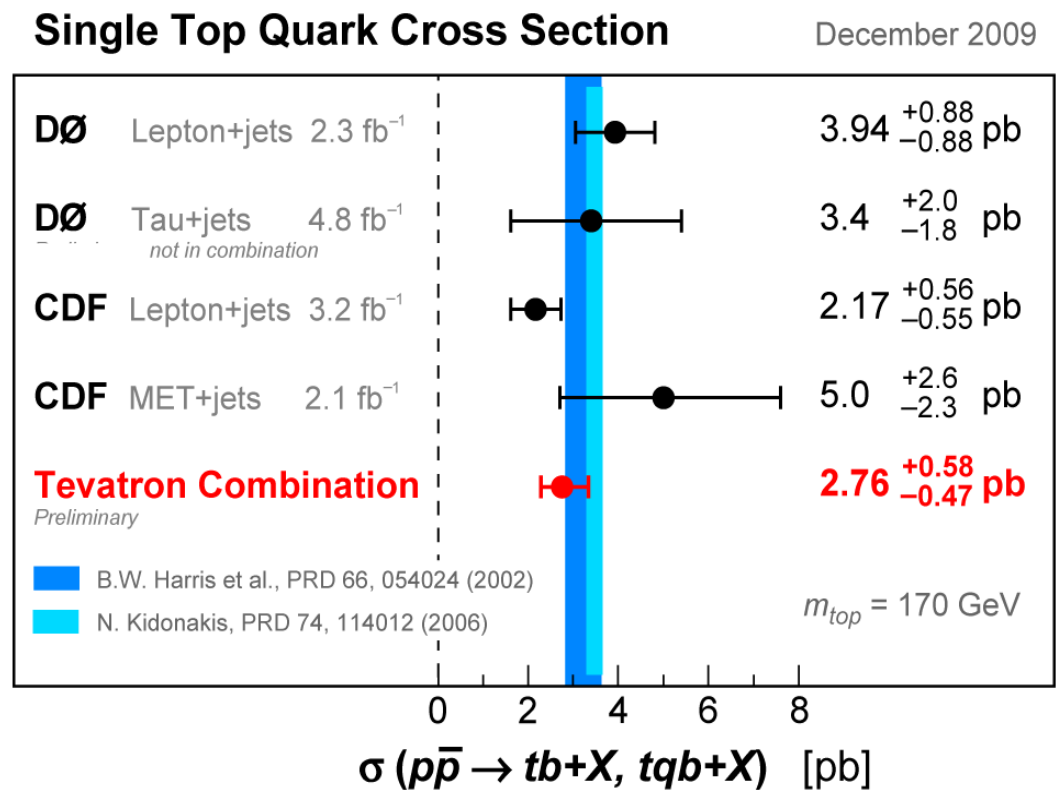
- Same final state as t-channel
- multivariate analysis using BNN





95% CL limits:	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}

Submitted to PLB,
arXiv:1006.3575

Conclusions

- Single top physics studies the electroweak coupling of the top quark
- Single top observation and first Vtb measurements by DØ and CDF
- Tevatron combination measures:
  - σ(s+t) to 21% precision
  - |Vtb| to ~8% precision
- First separate t-channel measurement
- Many searches for new physics
- Updates with larger dataset in progress
  - Separate s-channel from t-channel
  - More searches for new physics