Single Top Production Cross Section Measurement at DØ

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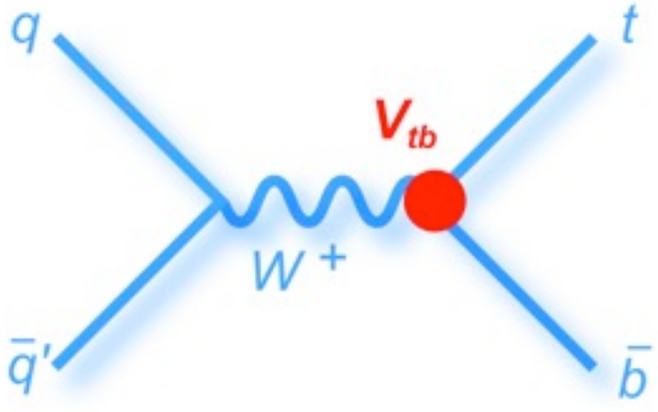
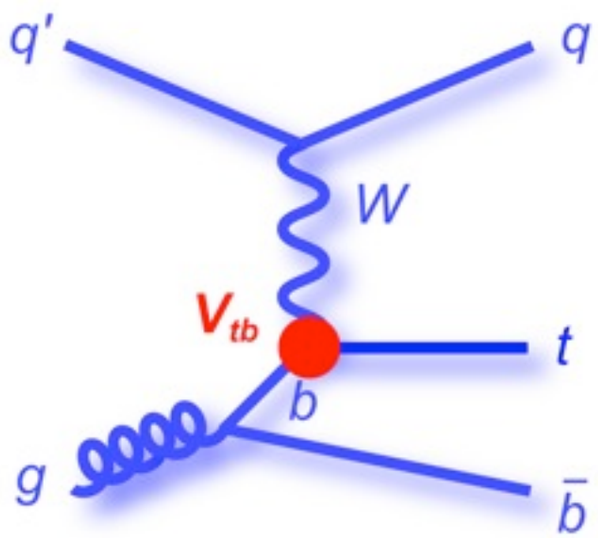
EW Top Quark Production

s-channel



$\sigma_{SM} = 1.04 \pm 0.04$ pb

t-channel



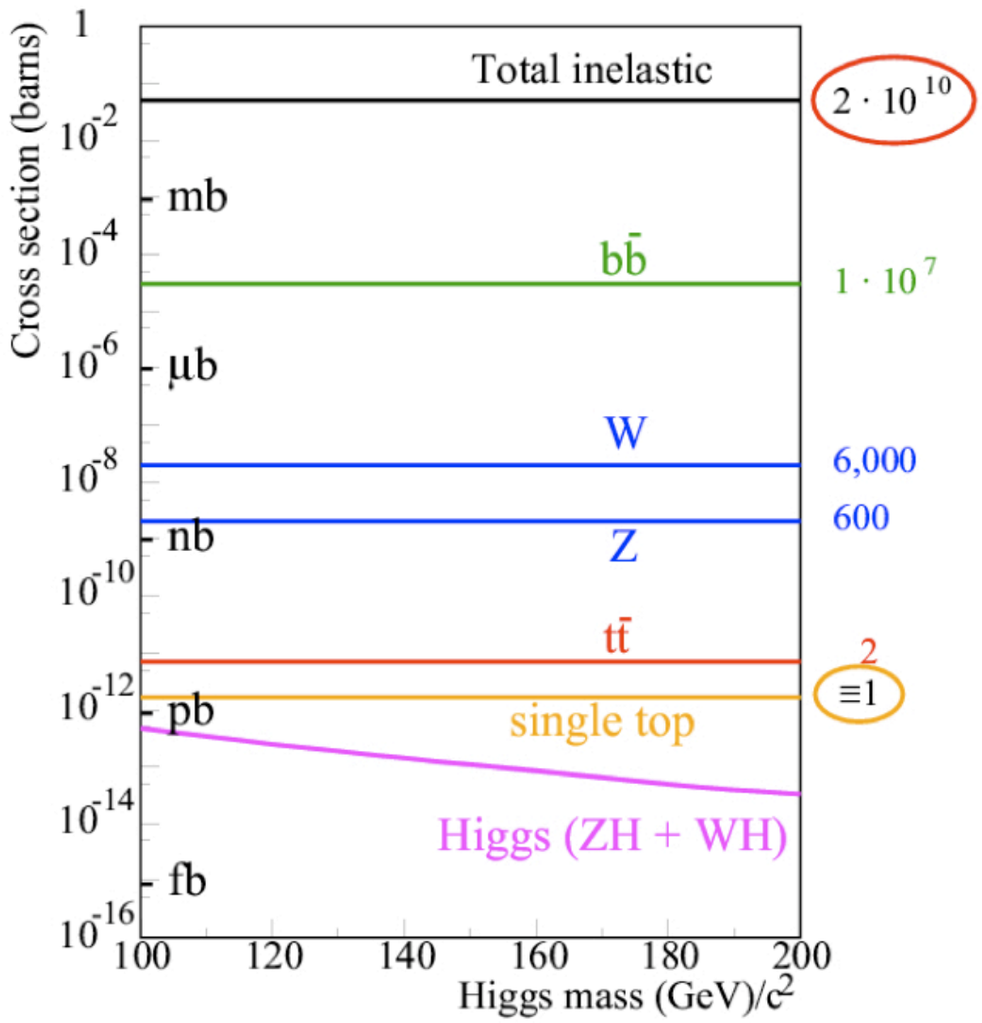
$\sigma_{SM} = 2.26 \pm 0.12$ pb

$M_{top} = 172.5$ GeV

N. Kidonakis, PRD 74.114012 (2006)

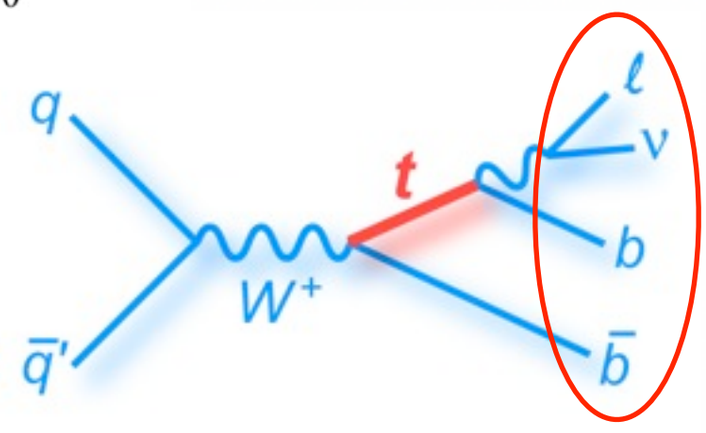
- Measure the two important single top production modes at Tevatron: *s* and *t* channel
- Directly probe the CKM matrix element |Vtb|
- Measure the top decay width
- New physics can change σ_s and σ_t differently:
  - σ_s: New bosons
  - σ_t: FCNC, anomalous couplings
- $\sigma_{s(SM)} \simeq 5$, $\sigma_{t(SM)} \simeq 65$pb @LHC 7TeV

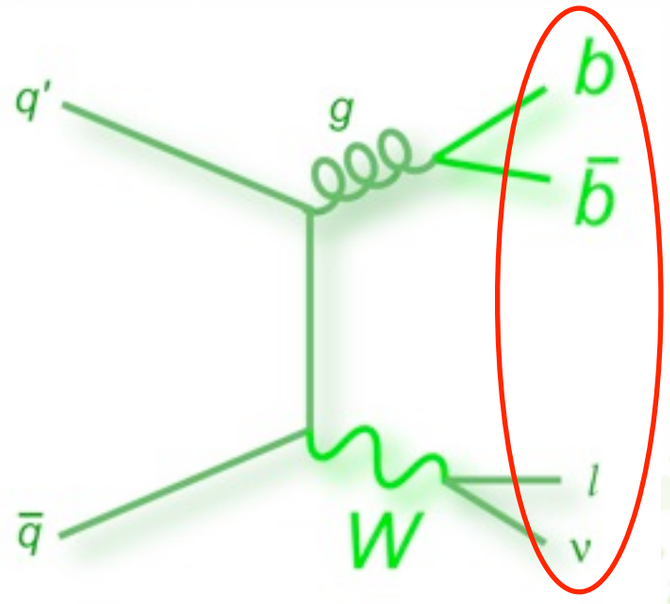
A Challenging Analysis



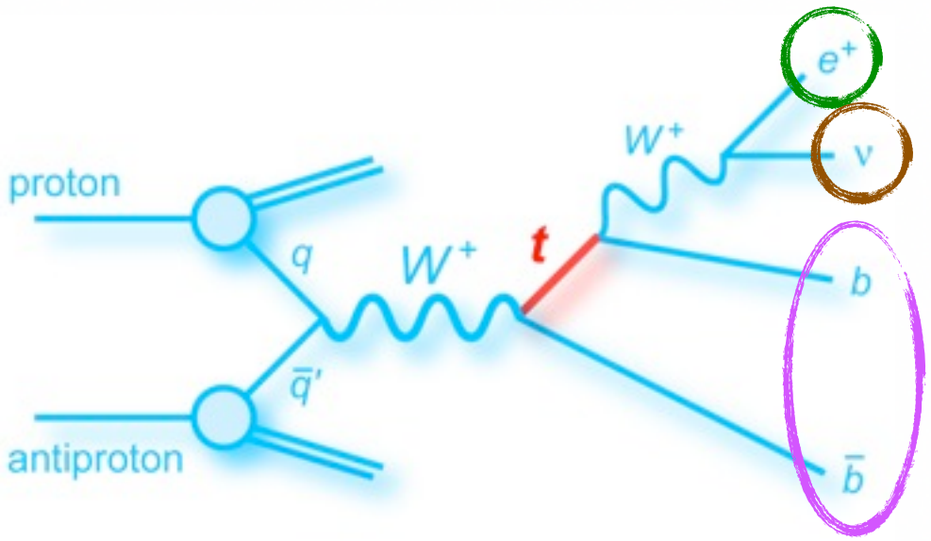
- Small cross section: ~3pb
- Background dominated
- Same final states as the background (e.g. W+jets)
- Observed after 14 years of top pair observation!

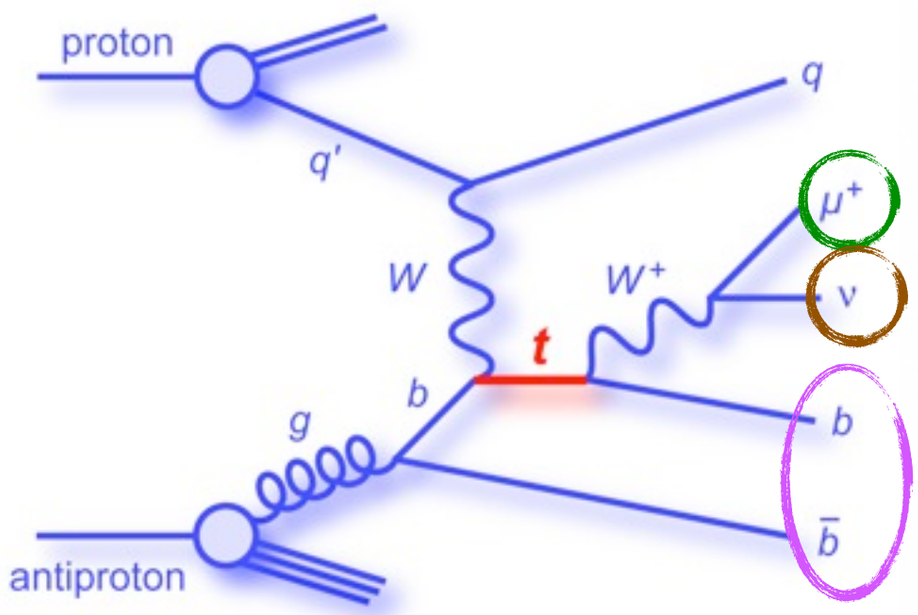
Main background:
W+jets,
~6000×signals





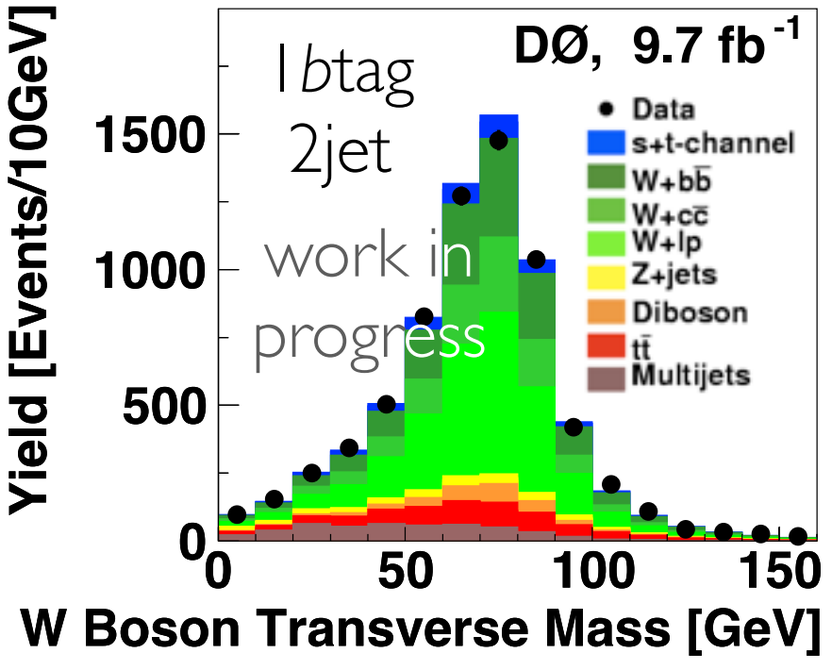
Event Selection

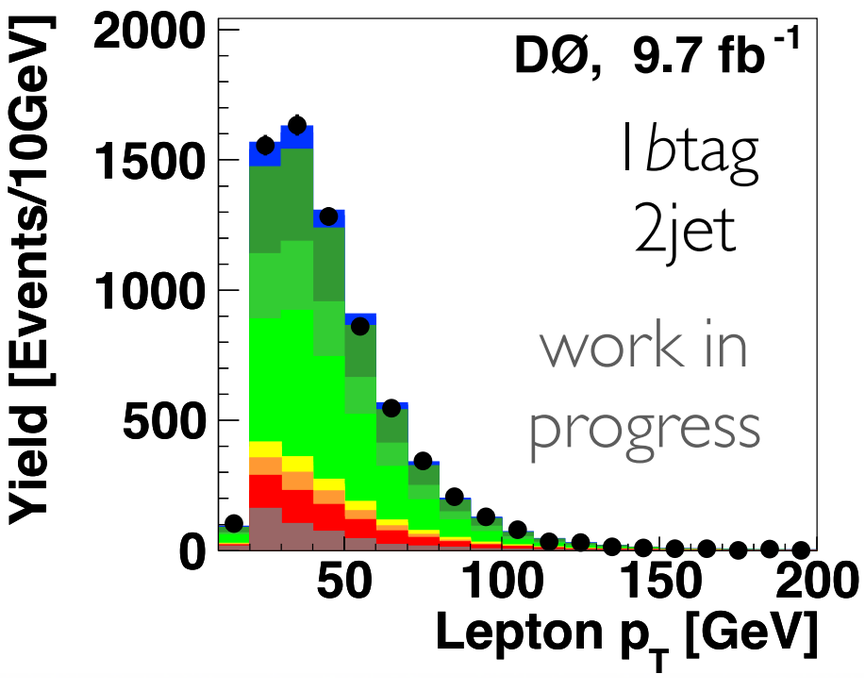




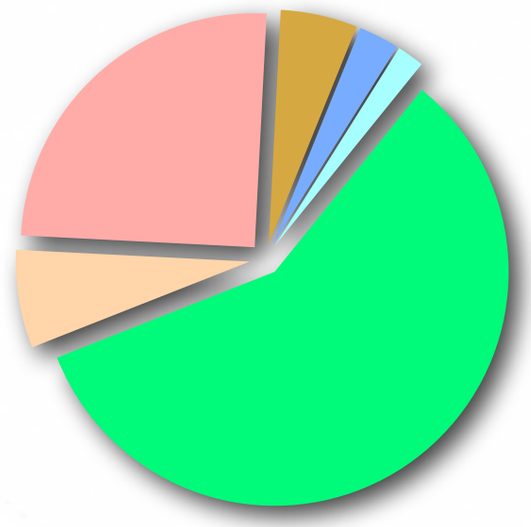
- 9.7 fb^{-1} data (full Tevatron data)
- One high p_T isolated electron or muon: $p_T > 20$ GeV
- Large missing energy
- Two or three jets
  - $p_T > 20$ GeV, $|\eta^{det}| < 2.5$
  - The leading jet $p_T > 25$ GeV
- Total transverse energy (H_T) cut to reject multijet background
- Require one or two identified *b*-jets (*b*-tagging)

Signal & Background Modeling





- Signals: CompHEP+Pythia
- W+jets & top pair: Alpgen+Pythia
- Multijet: Data with none-isolated lepton
- Normalize W+jets and Multijet to data
- *s*-ch: *t*-ch: Backgrounds = 1: 1.4: 50

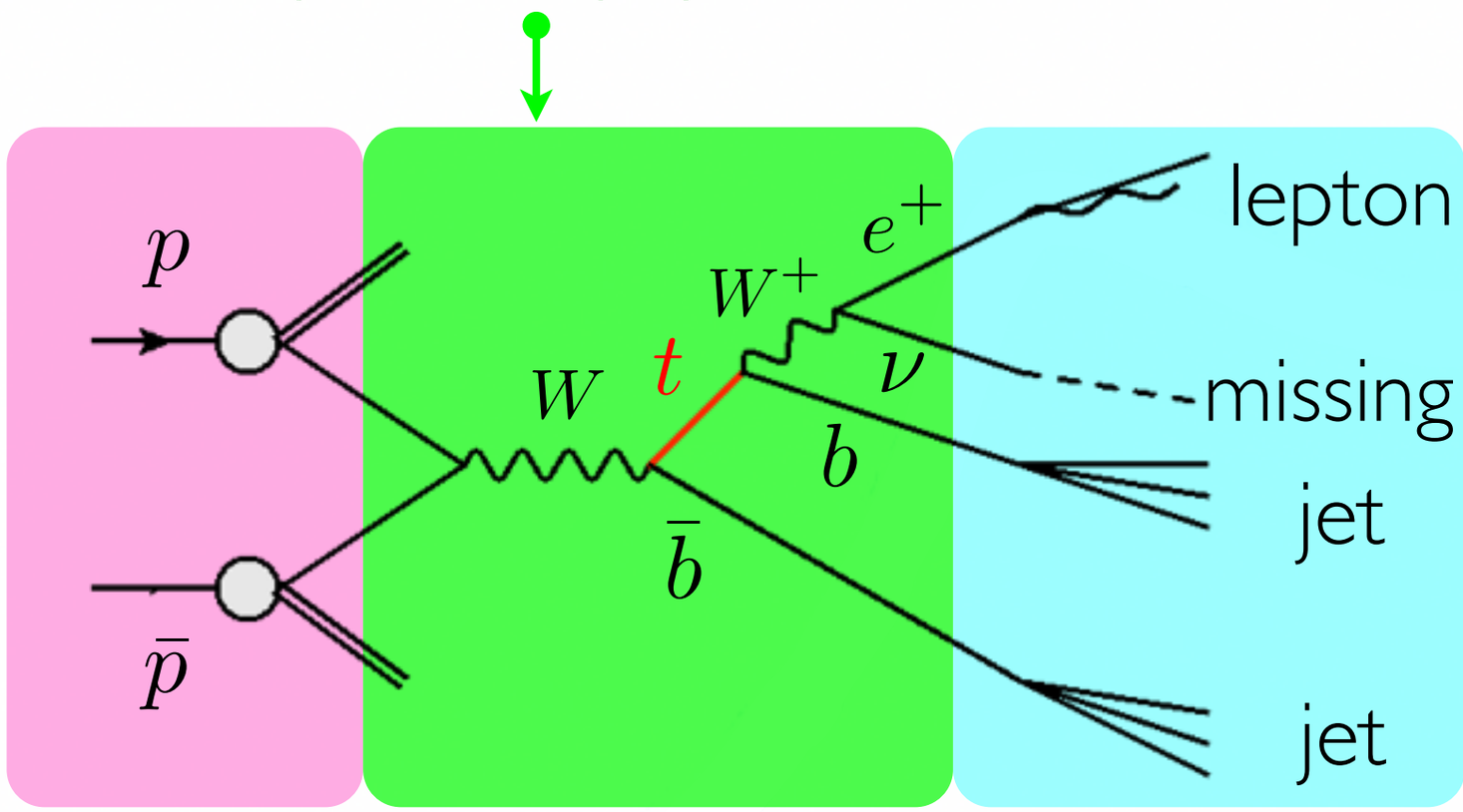


t-channel	*s*-channel
W+jets	Z+jet, dibosons
top pair	Multijet

Matrix Element Method

$$P(\vec{x}) = \frac{1}{\sigma^{obs}} \sum_{x,y} \sum_{i,j} \int f_i(q_1) dq_1 f_j(q_2) dq_2 \frac{\partial \sigma_{hs,ij}(\vec{y})}{\partial \vec{y}} W(\vec{x}, \vec{y}) d\vec{y}$$

LO Matrix Element (MadGraph)



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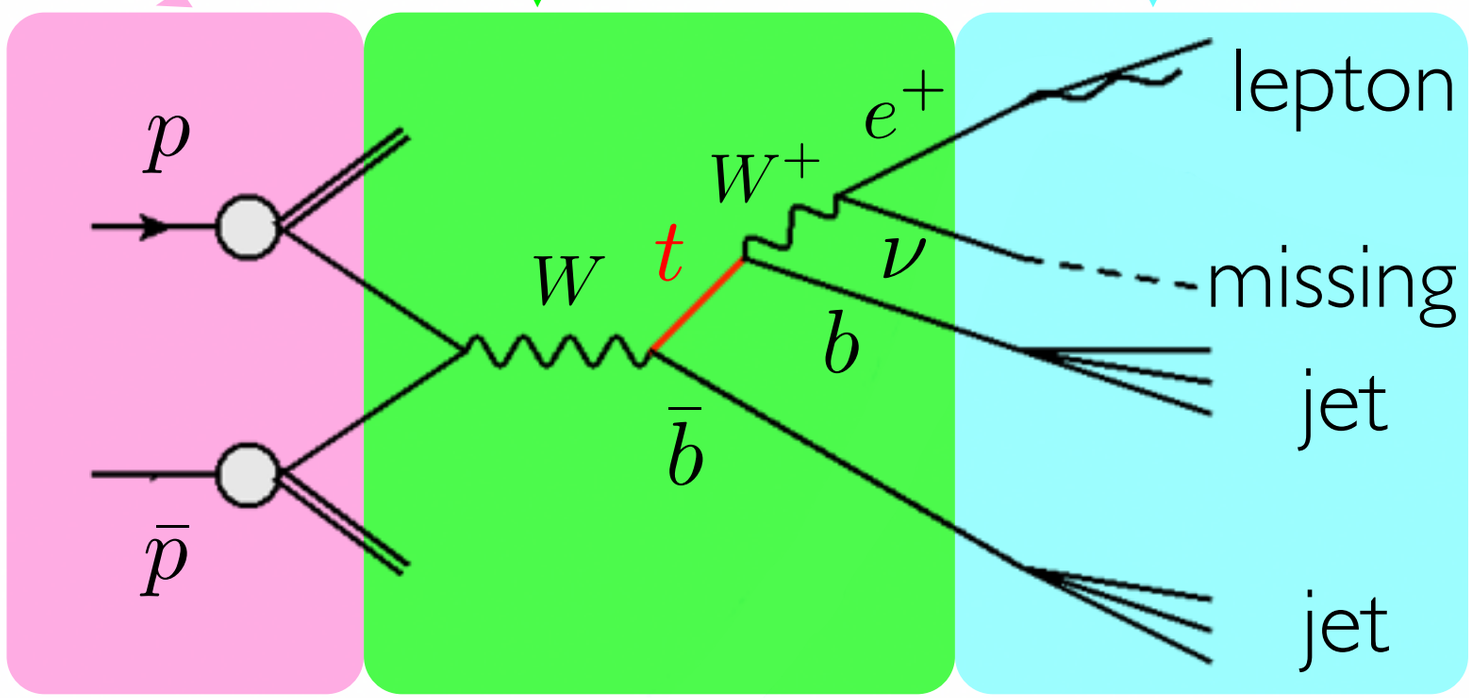
CTEQ6L PDF NLO α_s

LO Matrix Element (MadGraph)

Detector Resolution: Transfer Functions for electrons, muons and jets



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Jet-Parton Assignment; Utilize *b*-ID

CTEQ6L PDF NLO α_s

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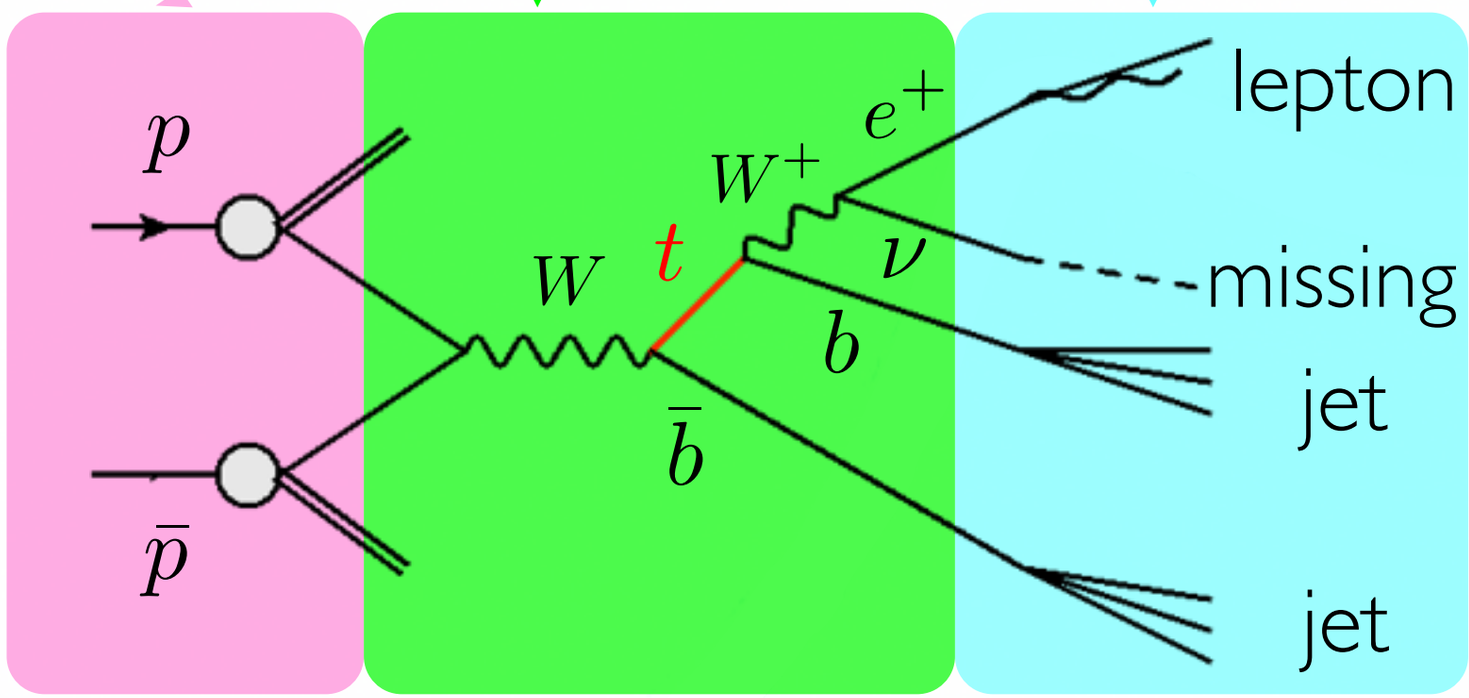

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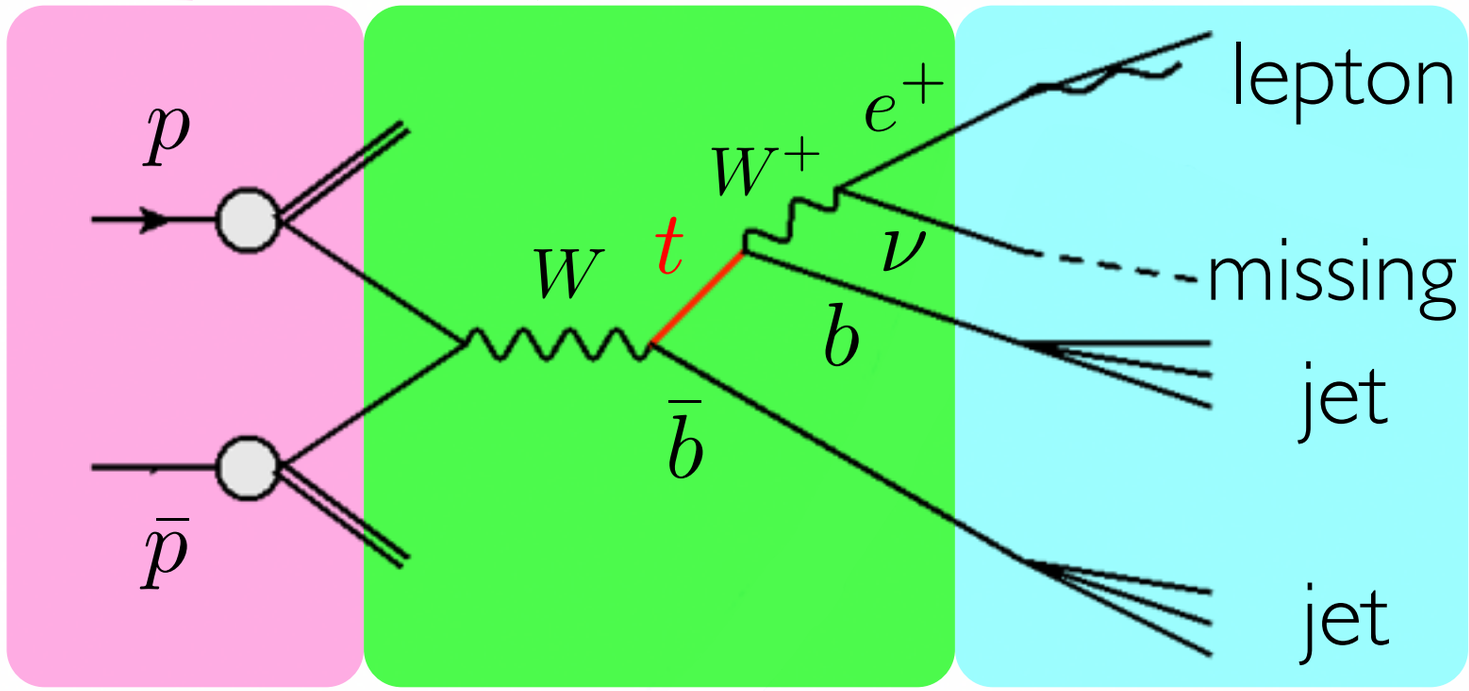
Jet-Parton Assignment; Utilize *b*-ID

CTEQ6L PDF NLO α_s

LO Matrix Element (MadGraph)

Detector Resolution: Transfer Functions for electrons, muons and jets

- Efficiently returns full event information
- Only partially correlated to other MVAs



ME Discriminant

- ME Processes:

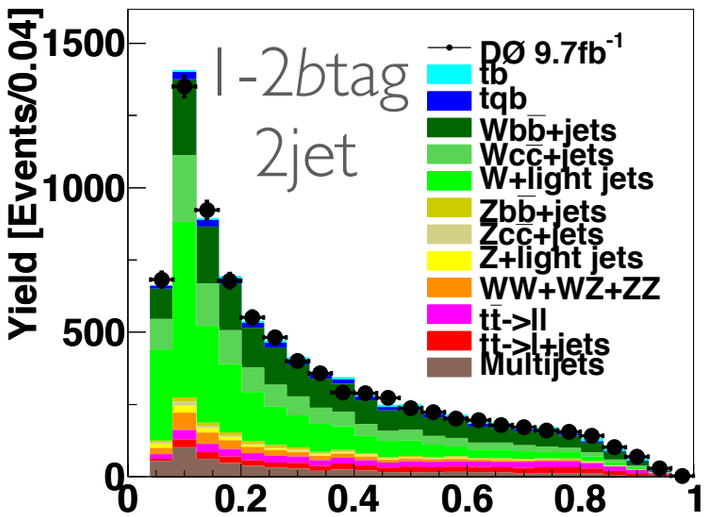
	2 Jet	3 Jet
Single Top	tb, tq	tbg, tqb, tqg
Background	Wbb, Wcg, Wgg, top pair, WW, WZ, ggg	Wbbg, Wugg, top pair

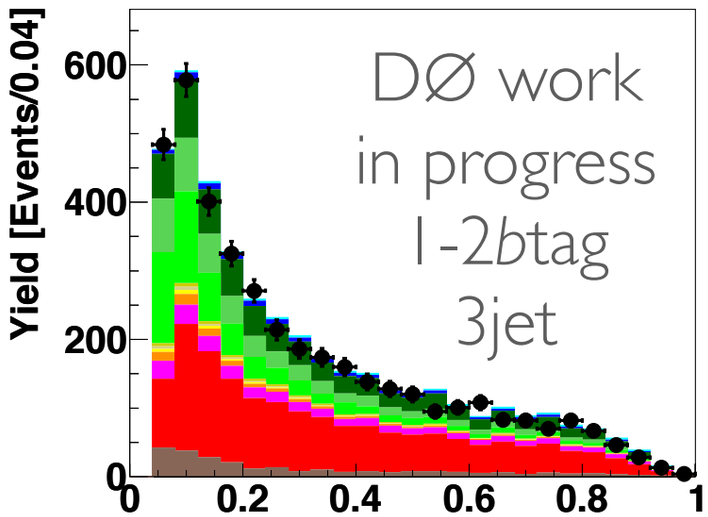
- Discriminant: Likelihood ratio
  - *b*-ID output information included

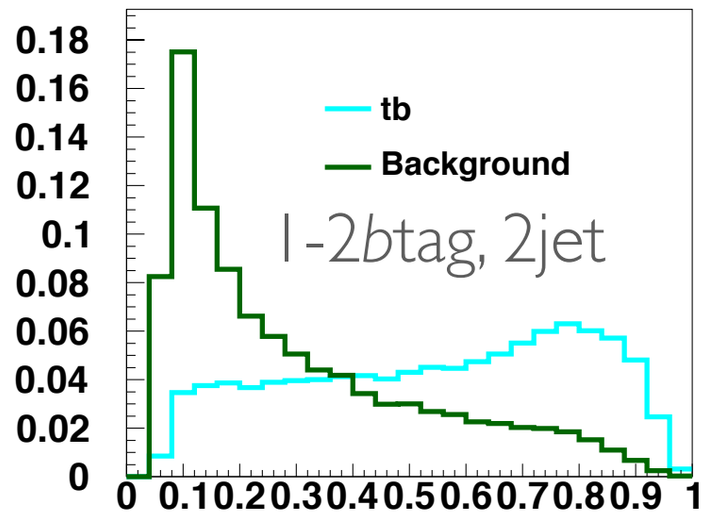
$$D(x) = \frac{P_{sig}(x)}{P_{sig}(x) + P_{bkgd}(x)}$$

Discriminant Output

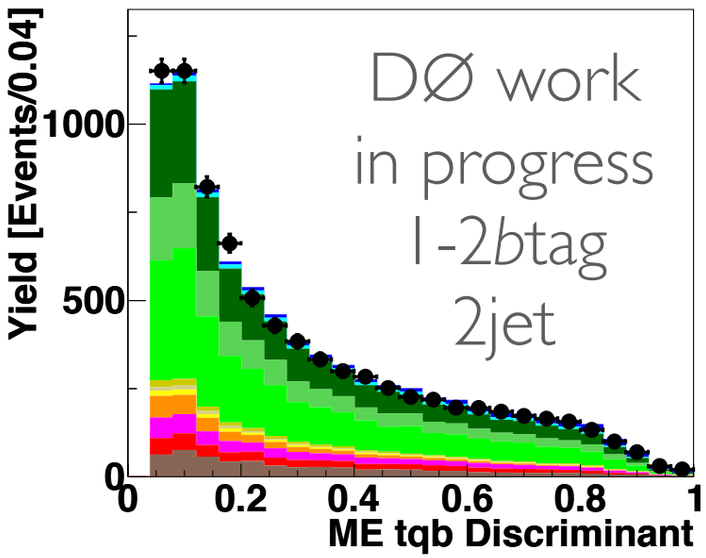
s-channel discriminant

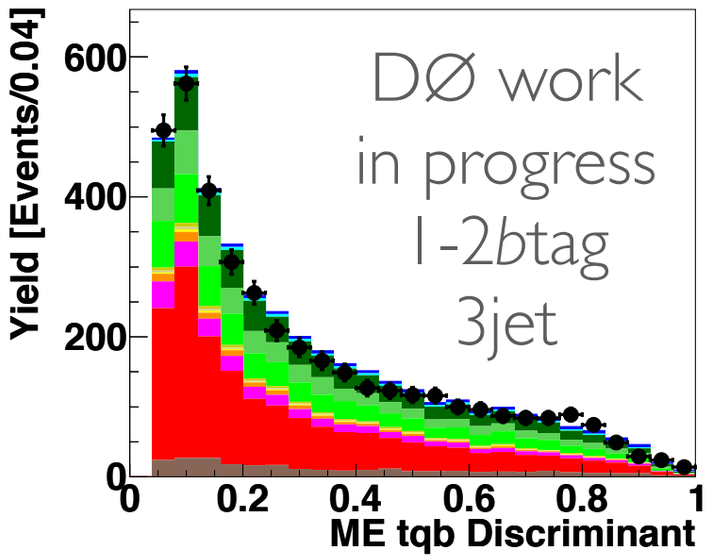


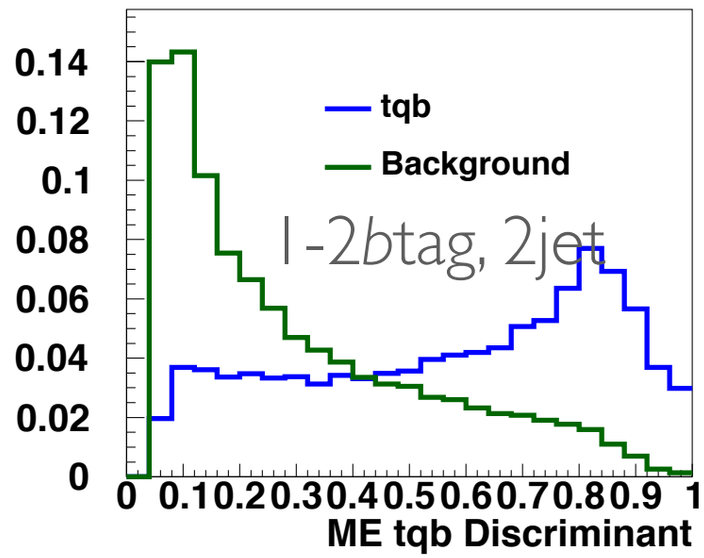




t-channel discriminant

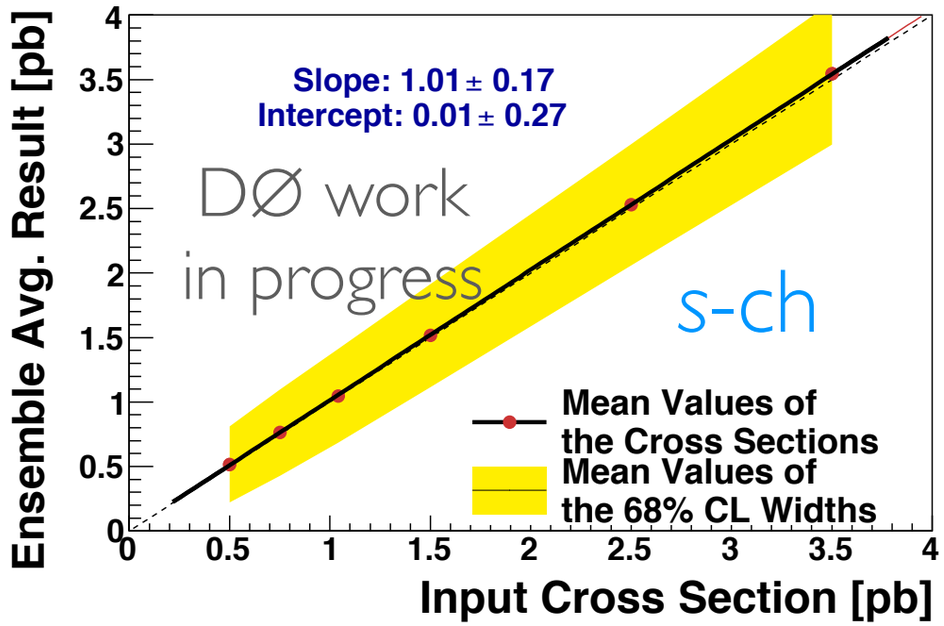


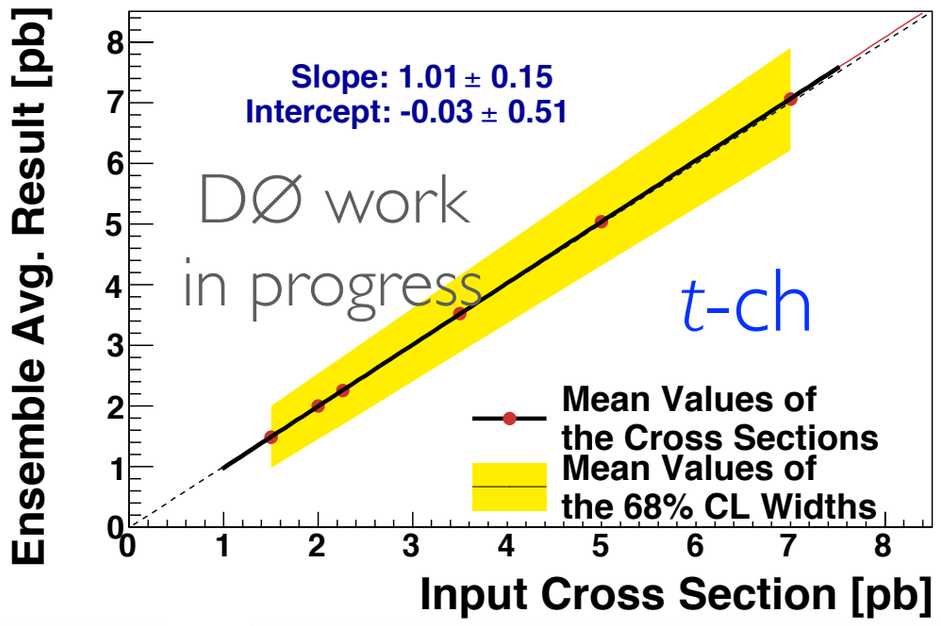




Ensemble Test

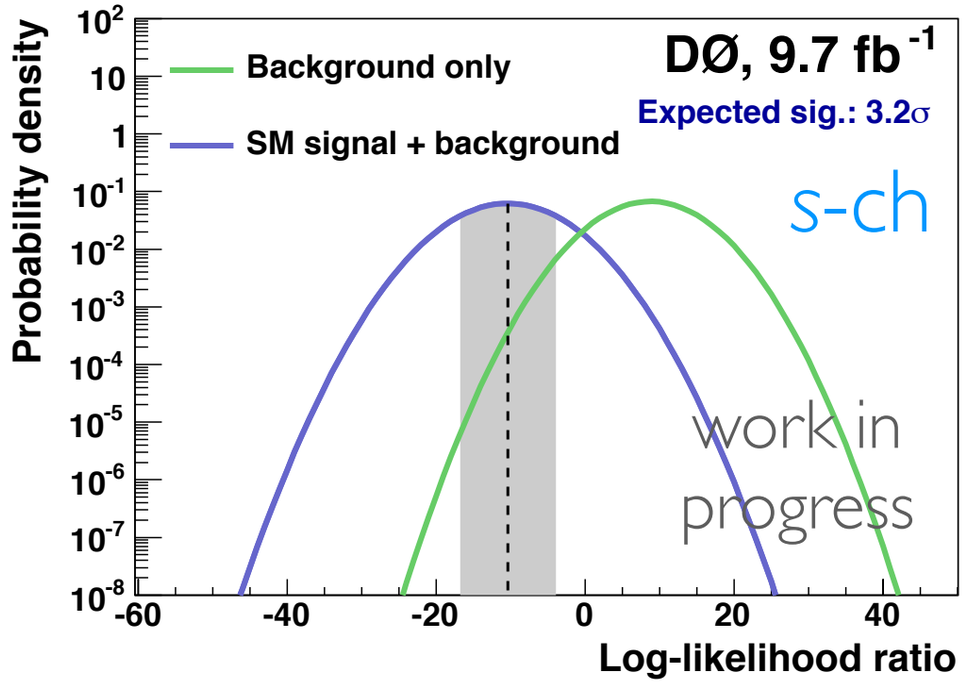
- Bayesian approach
  - Binned likelihood
- Uniform, non-negative prior for signal cross section
- All the uncertainties and their correlations taken into account
- SM ensemble averages as the expected results:
  - *s*-ch: $1.05^{+0.38}_{-0.35}$ pb
  - *t*-ch: $2.26^{+0.58}_{-0.54}$ pb
- No calibration needed

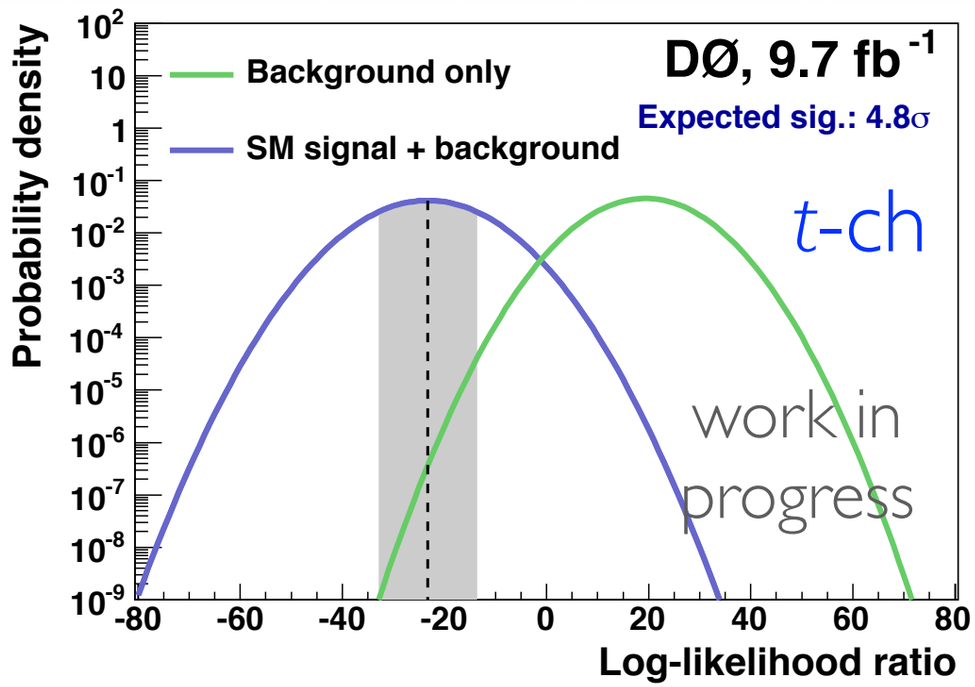




Expected Significance

- Asymptotic approximation of the log-likelihood ratio (LLR)
- With a uniform prior, the asymptotic probabilities of B and S+B are Gaussians
- Expected p-values:
  - *s*-ch: 6.3e-04 (3.2 s.d.)
  - *t*-ch: 6.4e-07 (4.8 s.d.)
- Previous DØ *t*-ch: 5.5 s.d.





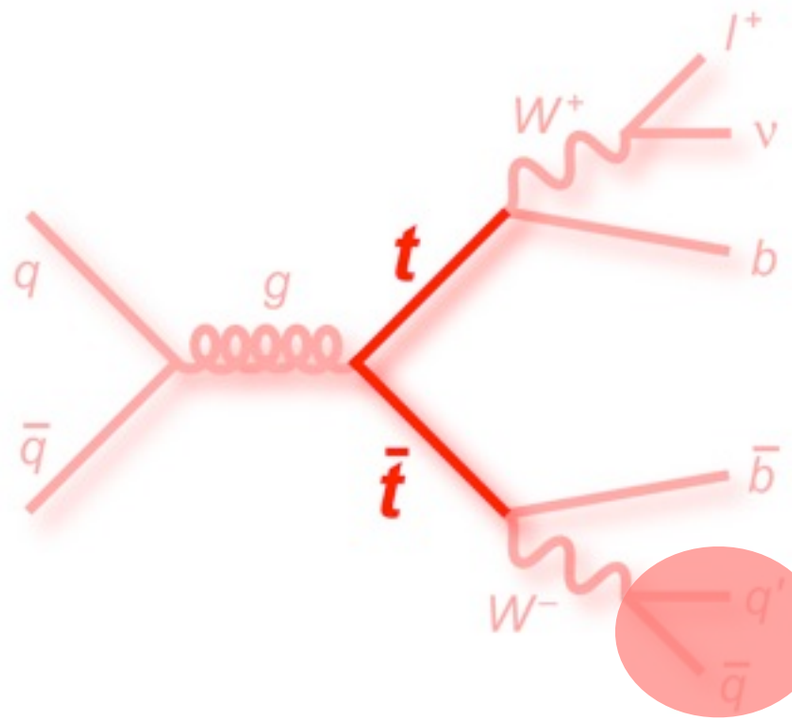
Summary

- Measuring the *s*- and *t*-ch single top production cross section individually at DØ with the full Tevatron Run II data, 9.7 fb^{-1}
- A legacy measurement at a proton-antiproton collider with $\sqrt{s} = 1.96$ TeV
- Two multivariate analyses, the Boosted Decision Trees and Bayesian Neural Network, ongoing
- Will combine the Matrix Element method and the two multivariate analyses
- Will have the results with data soon

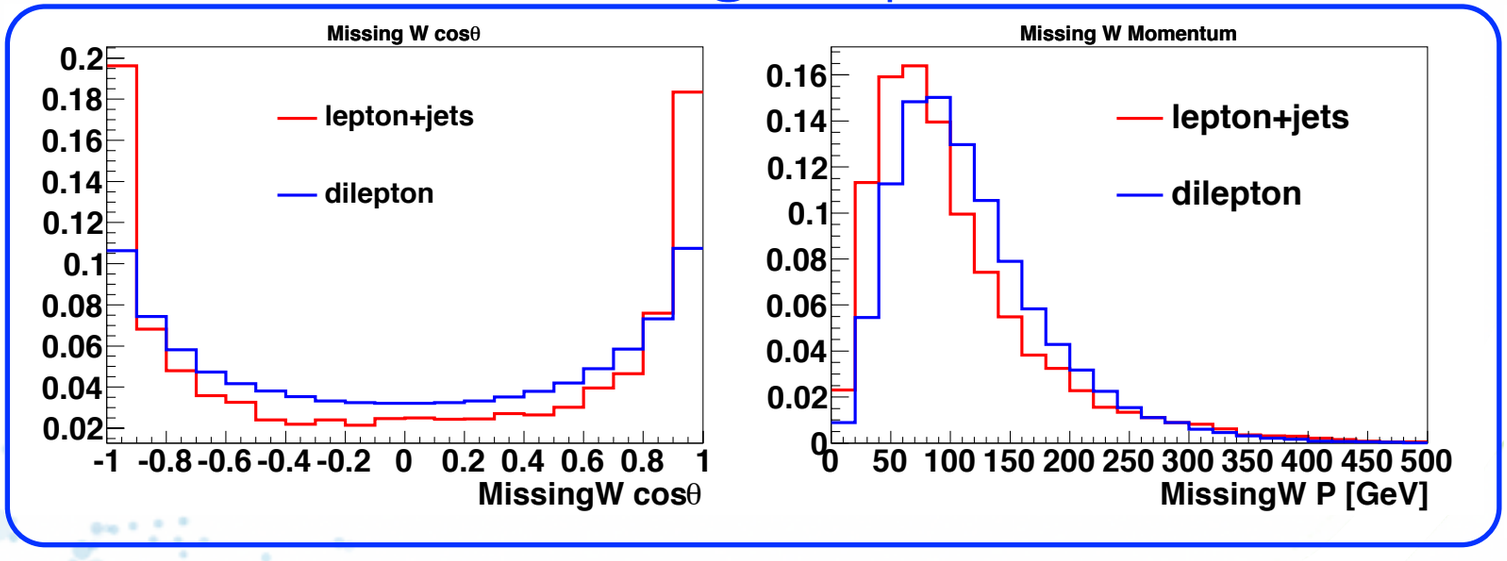
Backup Slides

ttbar: Missing Jets Modeling

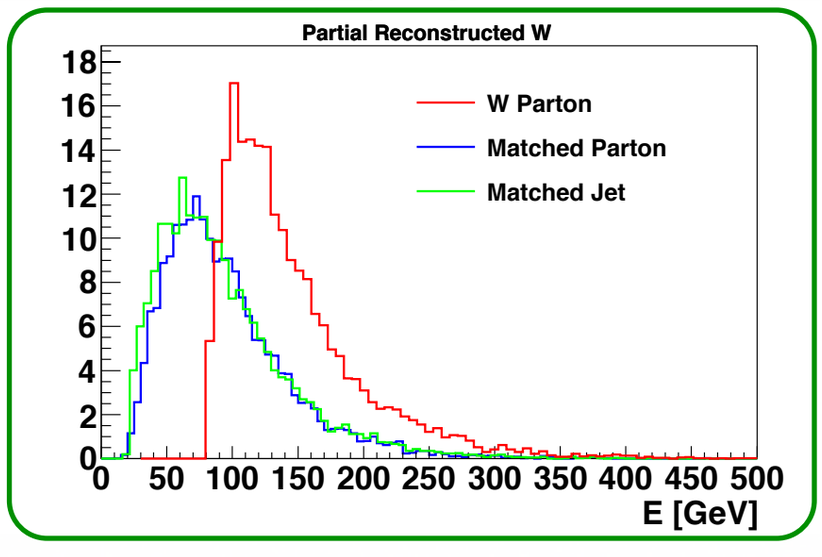
- ttbar yields in 2jet & 3jet bins are comparable to single top
- Light-jets are more likely to be lost than b-jets
- Use MC to derive a prior of missing jet (3jet) or missing W (2jet)



Missing W prior

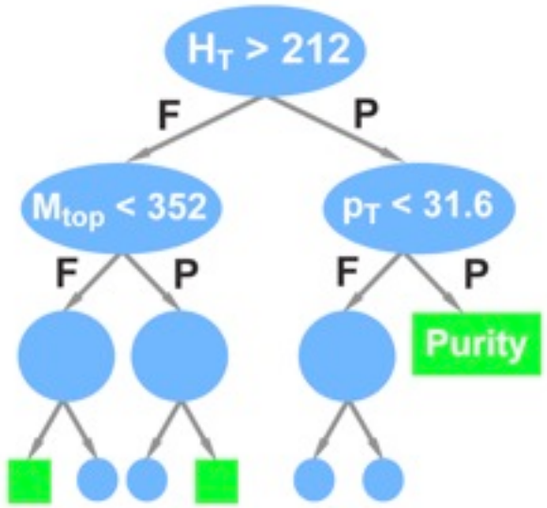


Missing Jet

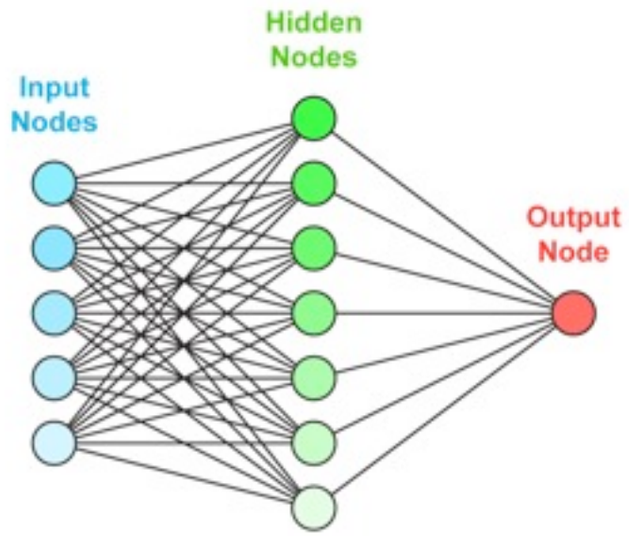


Analysis Techniques

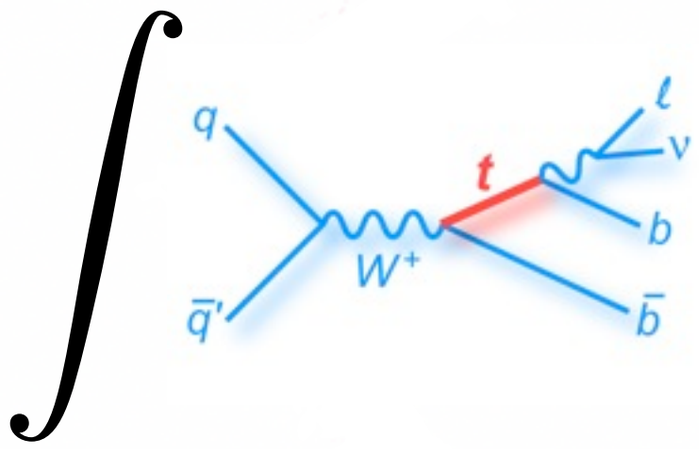
BDT



BNN



ME



Use BNN to combine the 3 methods