Single top quark production at 4 fb^{-1}

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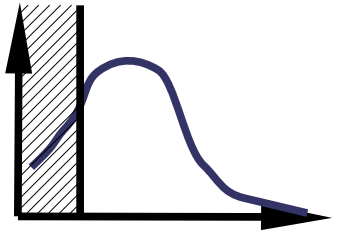
Outline

- The Past
- The Present
- The Future
  - Measurements
  - Searches
  - Systematics
- Conclusions

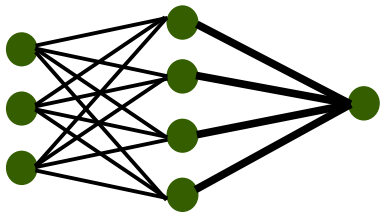
The Past

- Emphasis on understanding single top quark production
- Separating it from the backgrounds
- Identifying sensitive variables
- Exploring multivariate classifiers

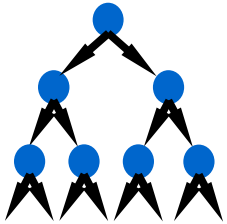
Cut-Based



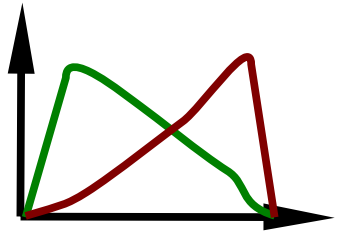
Neural networks



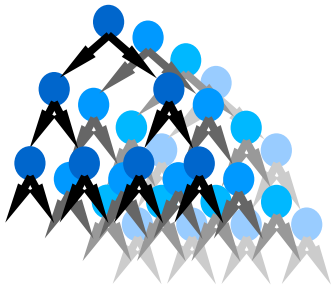
Decision trees



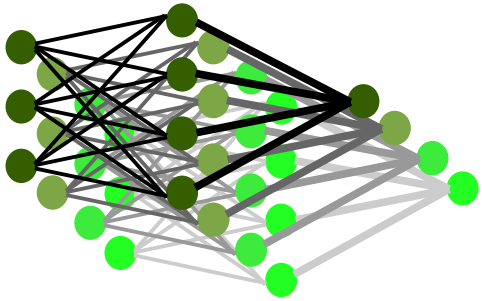
Likelihood



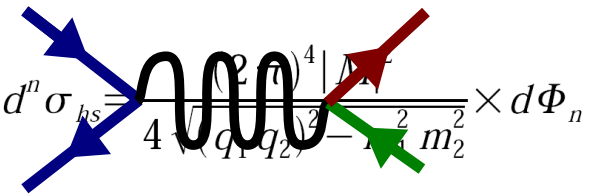
Boosted decision trees



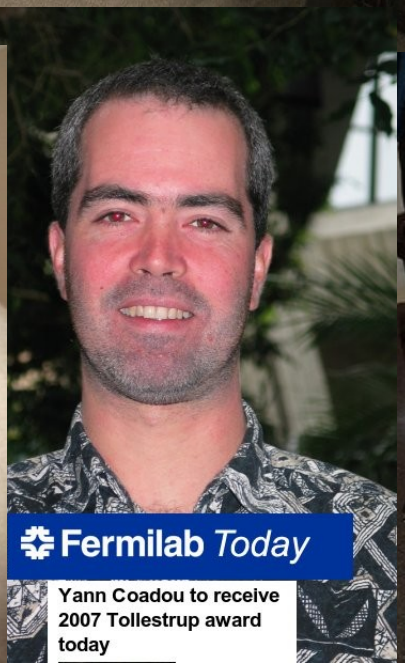
Bayesian neural networks



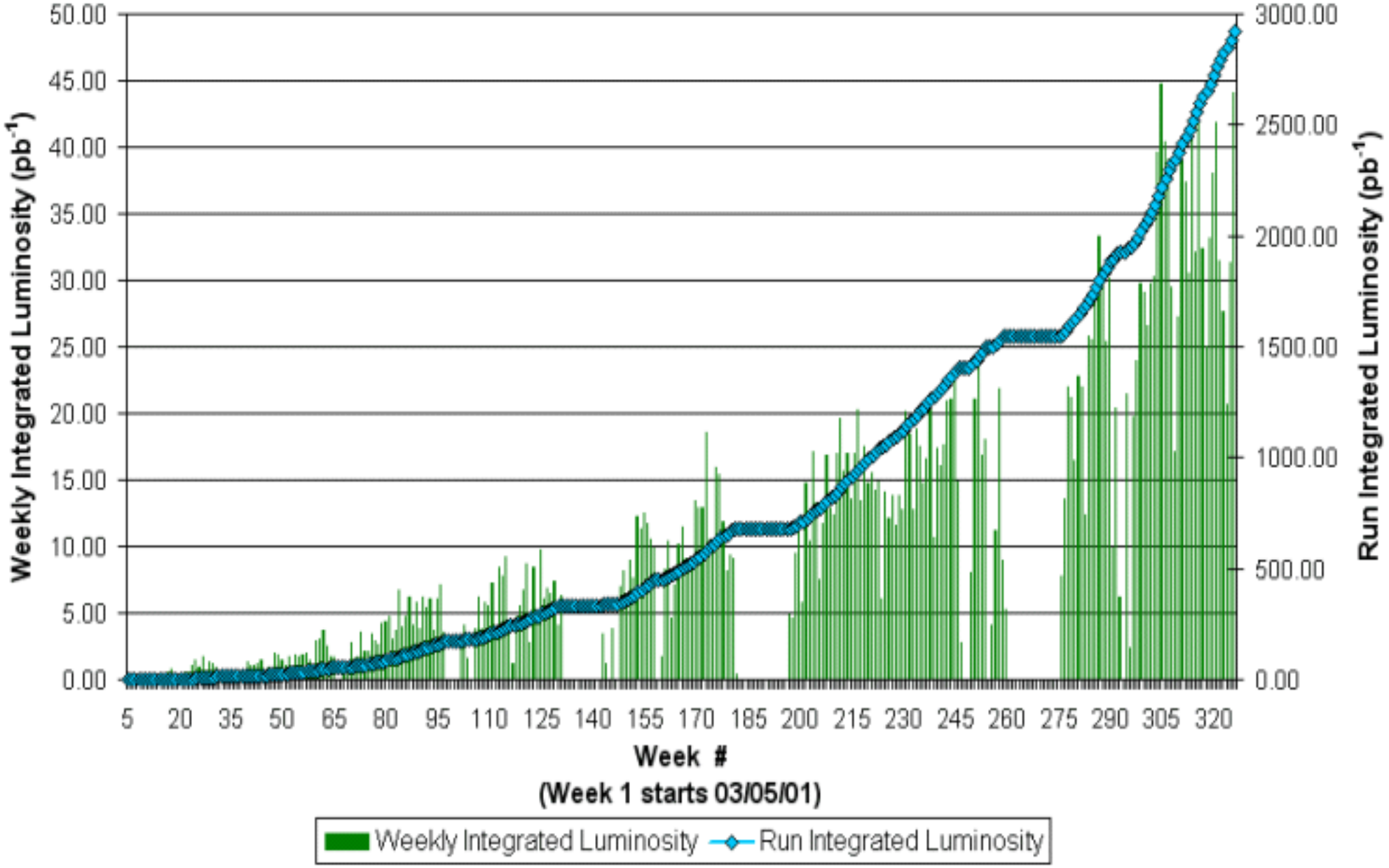
Matrix Elements



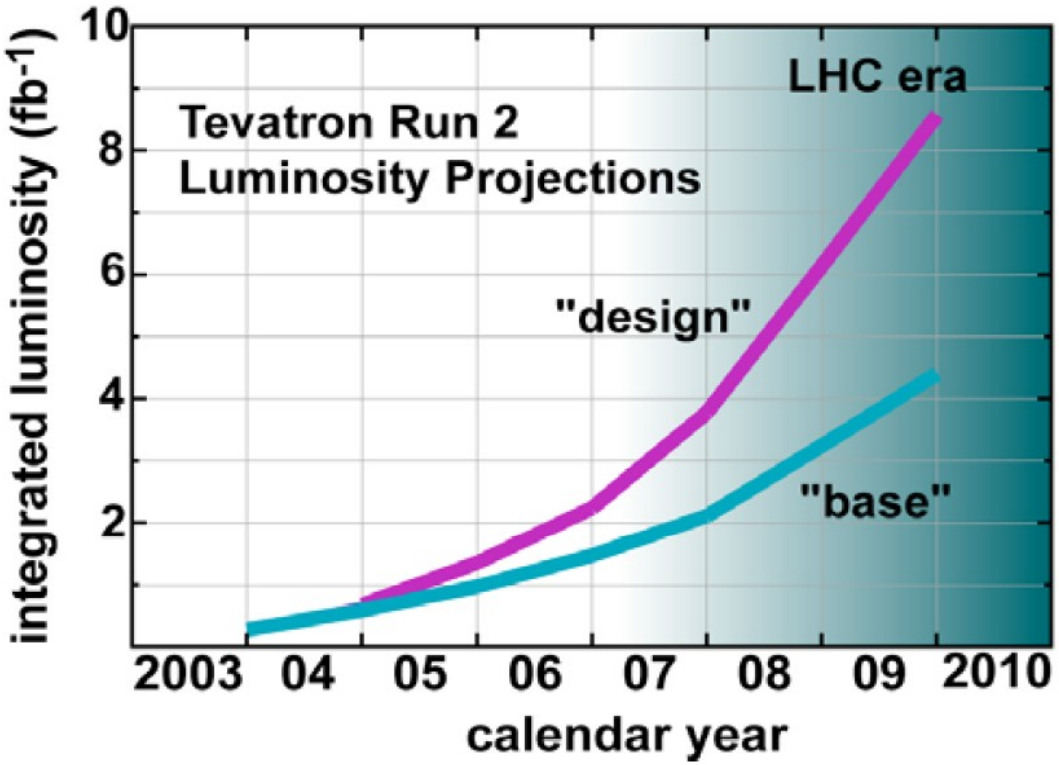
The Past


Fermilab Today
Yann Coadou to receive 2007 Tollestrup award today

The present challenge



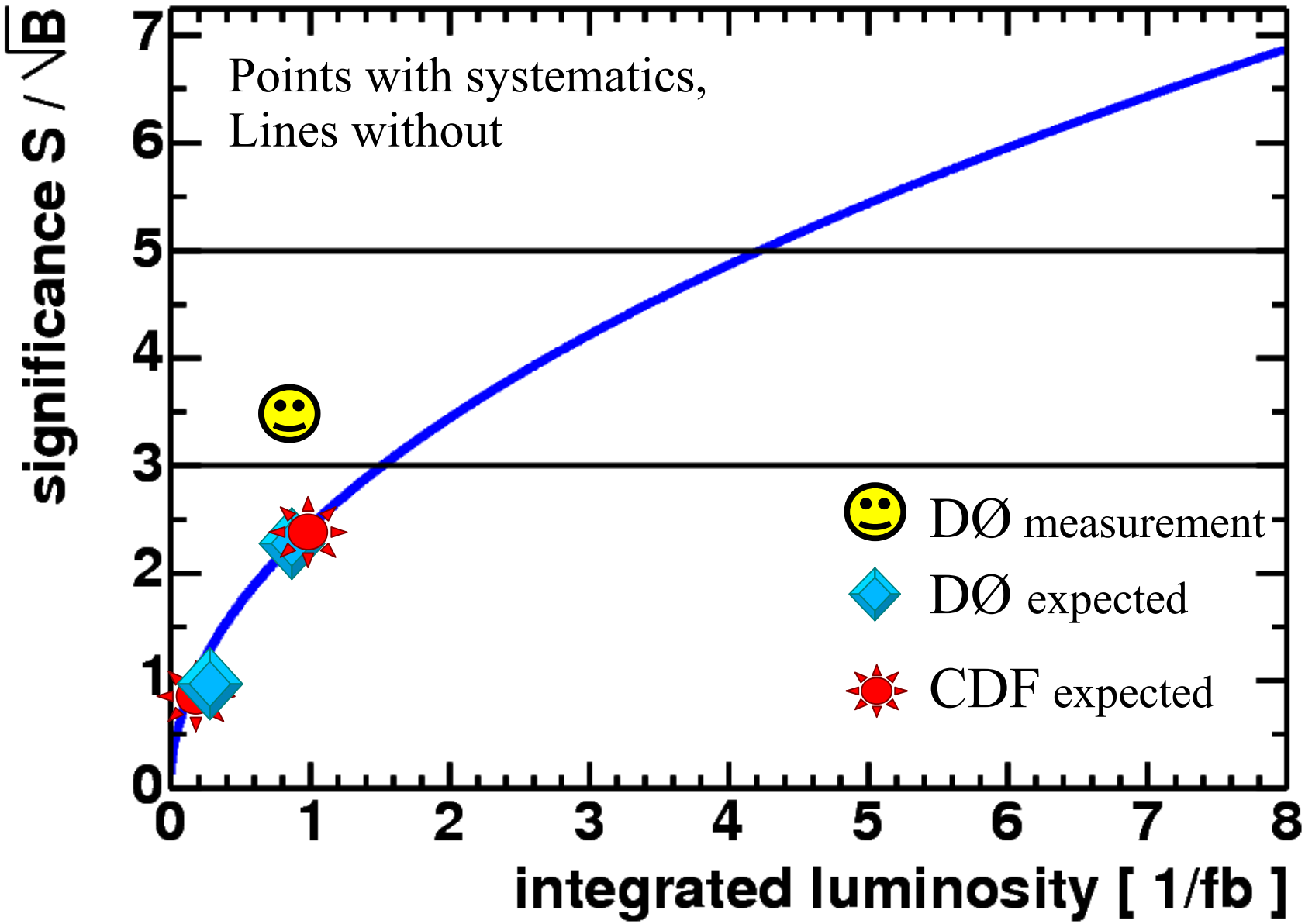
The future



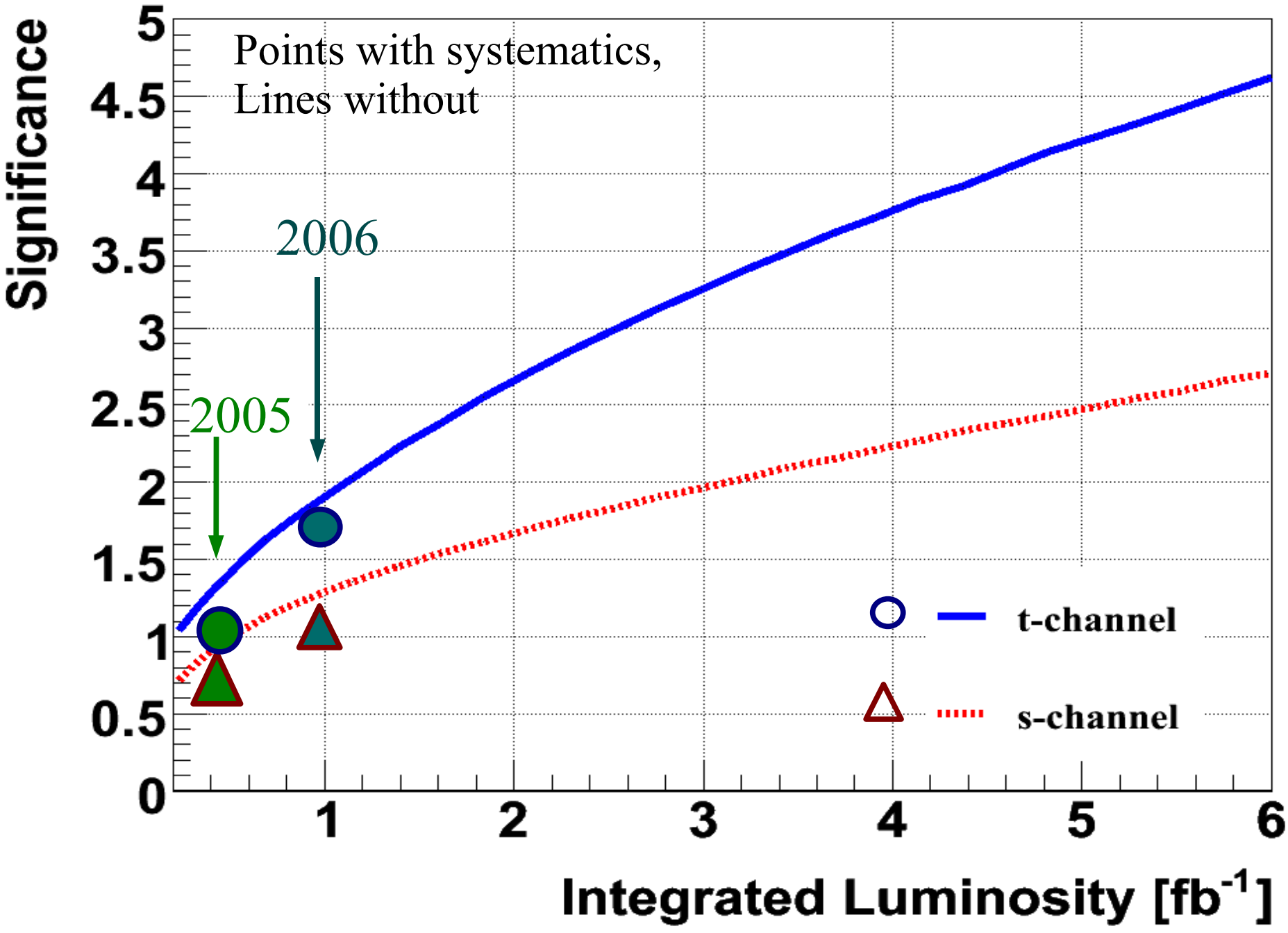
- We will likely be analyzing 4 fb^{-1} in 2009
  - Possibly already in 2008

Prospects for s+t

Projection by CDF for P5 in 2005

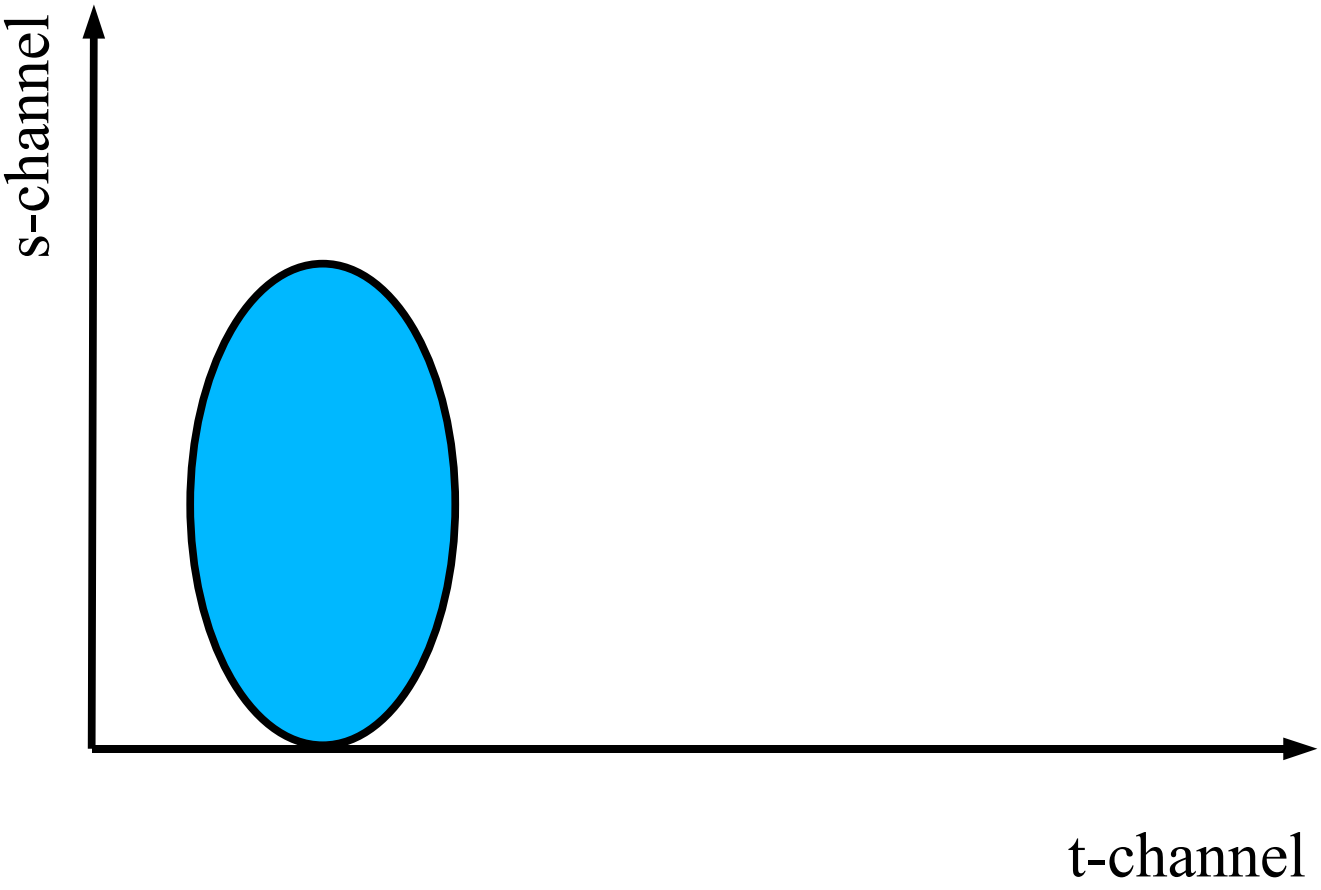


Prospects for s and t separately



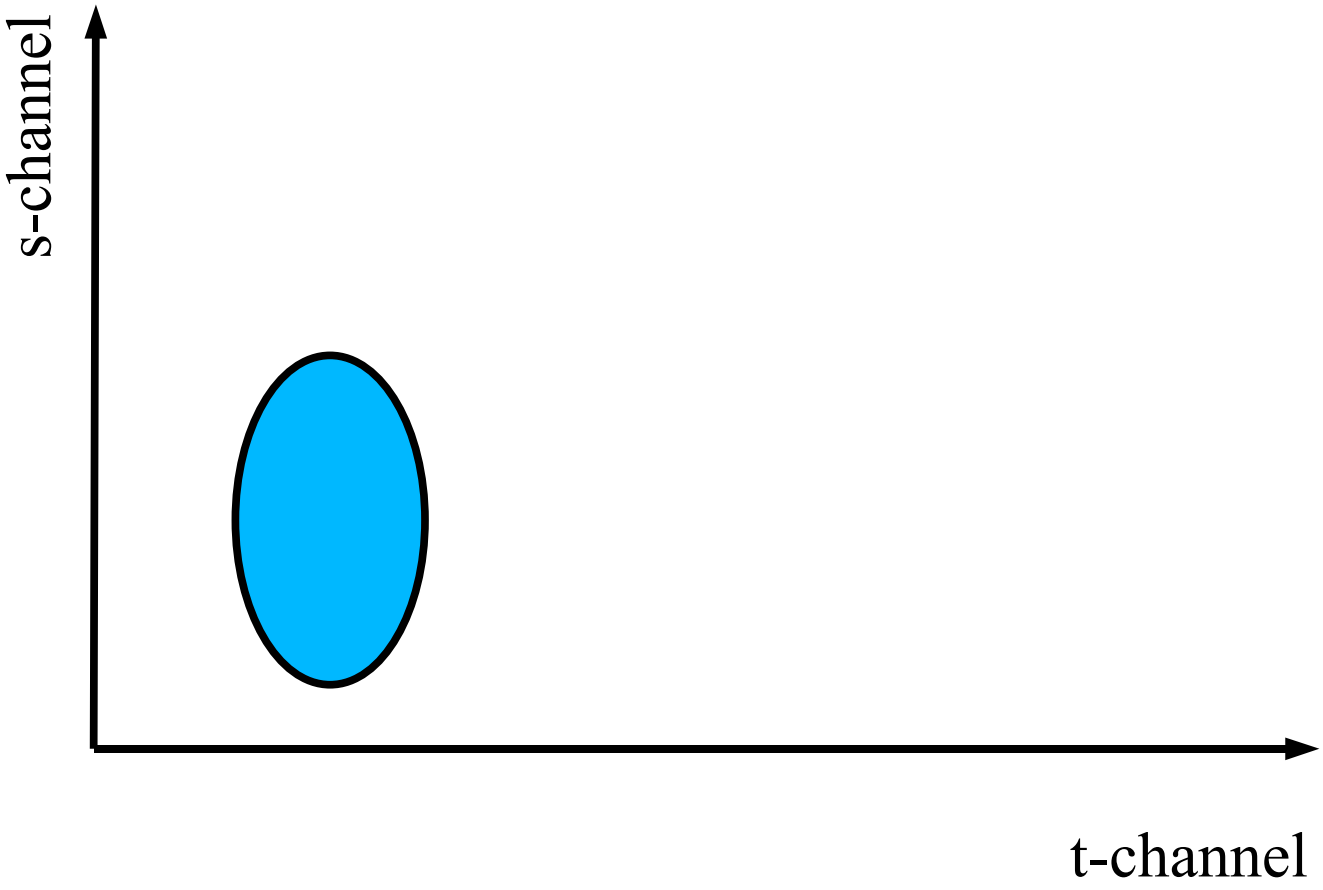
Today

- 1 sigma ellipse



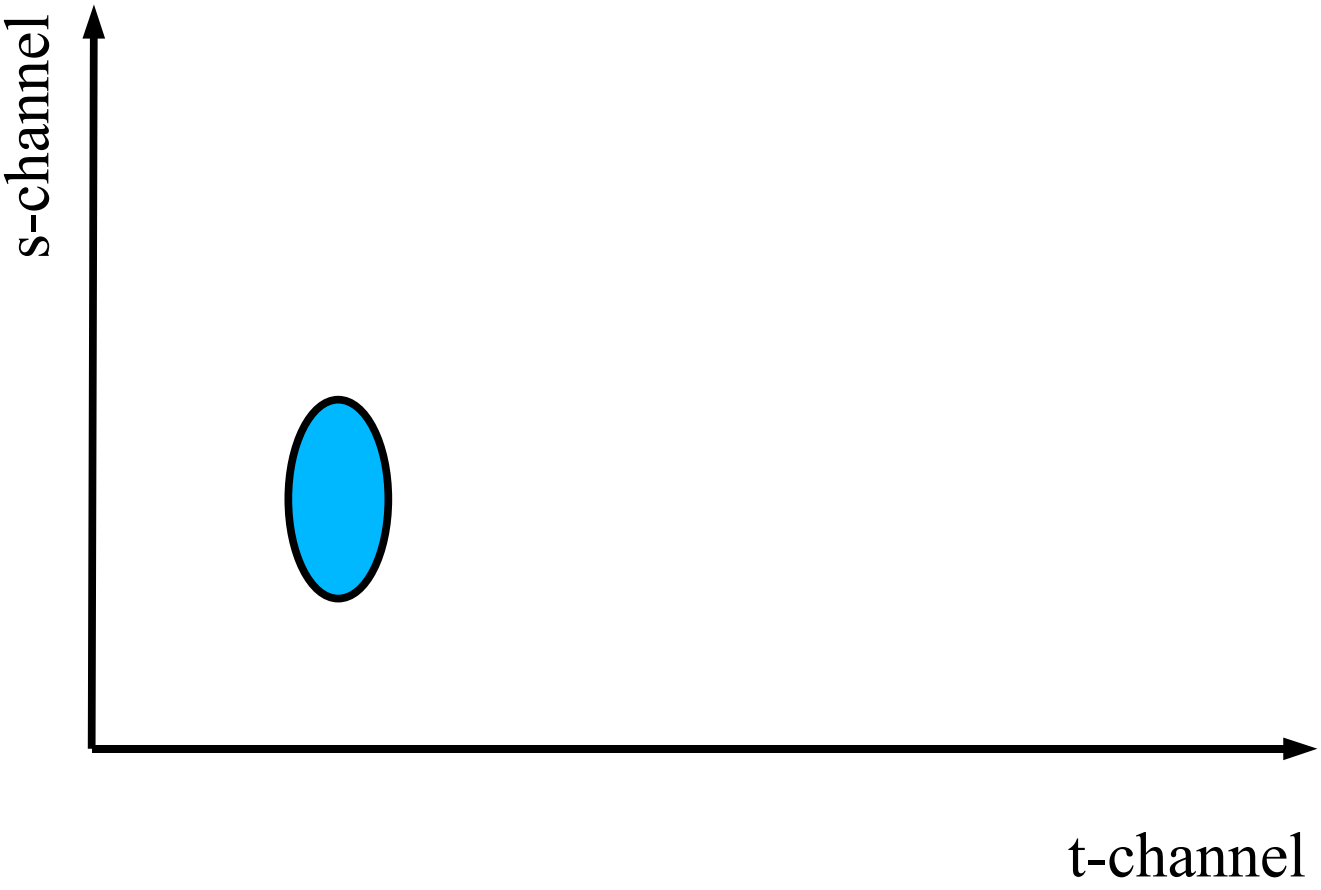
2 fb^{-1}

- 1 sigma ellipse



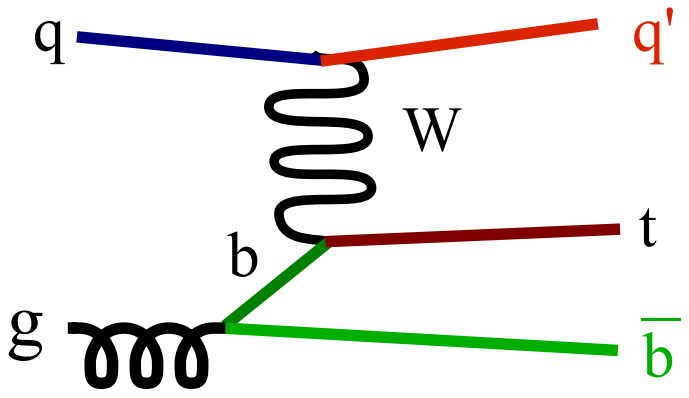
4 fb^{-1}

- 1 sigma ellipse



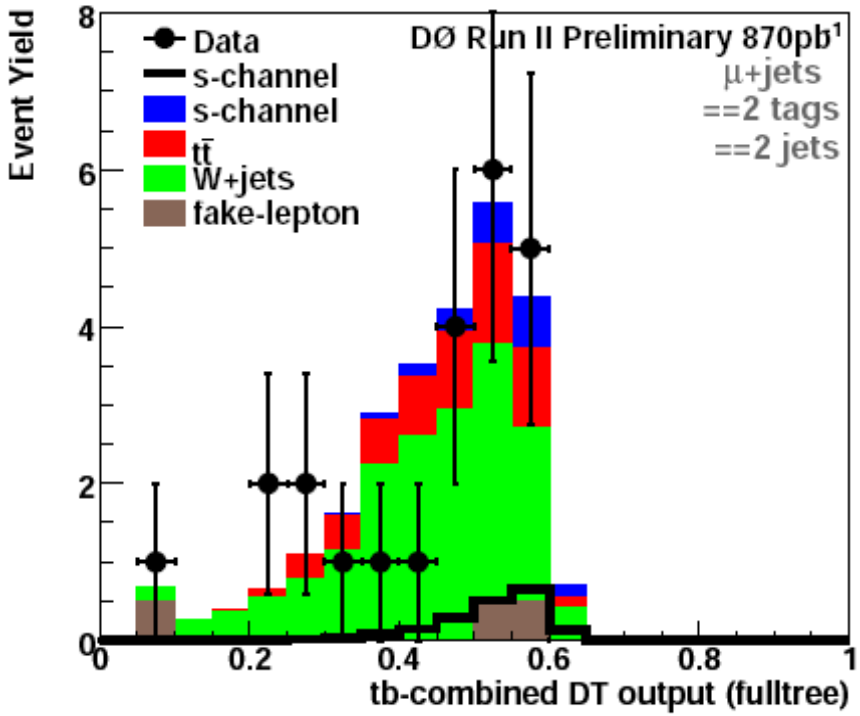
Measurements

- "Observation of single top production" paper
- Measure s+t cross section
- Measure Vtb
  - Precision measurement
- Measure t-channel cross section separately
- Measure t-channel differential cross section
    - Light quark jet p_T and η
      - Same mechanism as Higgs production through WW fusion
    - Third jet p_T and η and flavor composition
      - Measure b-quark PDF
- Top polarization
  - From t-channel
- Top mass
  - Is it really the SM top quark?



Cross section measurement in the s-channel

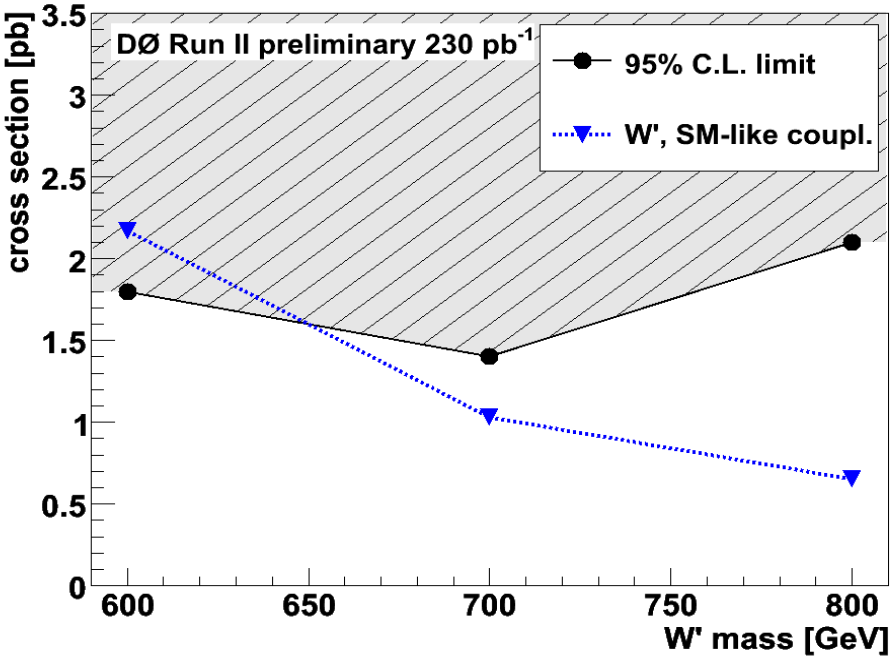
- Measure s-channel cross section individually
  - Should be close with 4 fb^{-1}
  - Further improvements required
  - Same final state particles as Higgs associated production
- Background in the s-channel search is even larger than in s+t
  - Wbb, ttbar



- T-channel is a background in the s-channel search
  - As big as the signal
  - Normalization is non-trivial:
    - Normalize to SM? → Also fixes s-channel to SM
    - Normalize to data? → Large uncertainty

Extending existing searches

- New heavy boson W'
  - With SM-like left-handed couplings
  - With right-handed couplings



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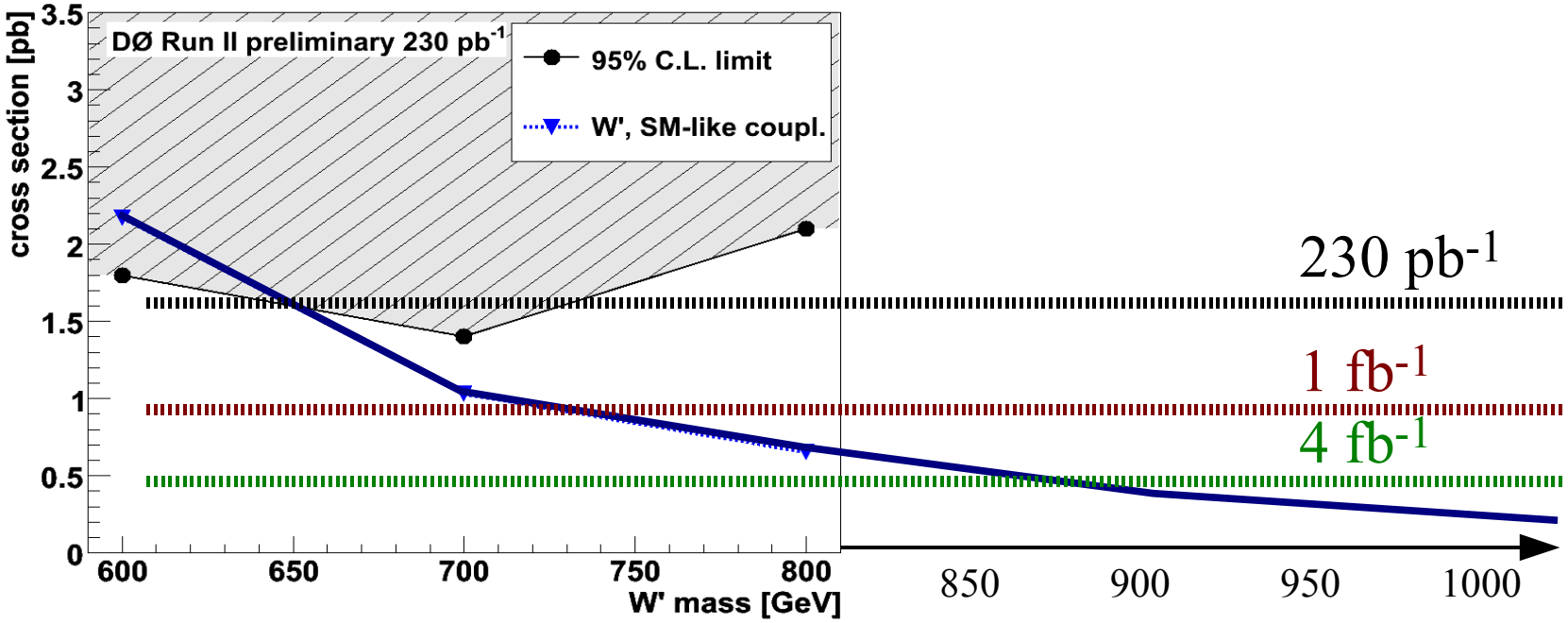
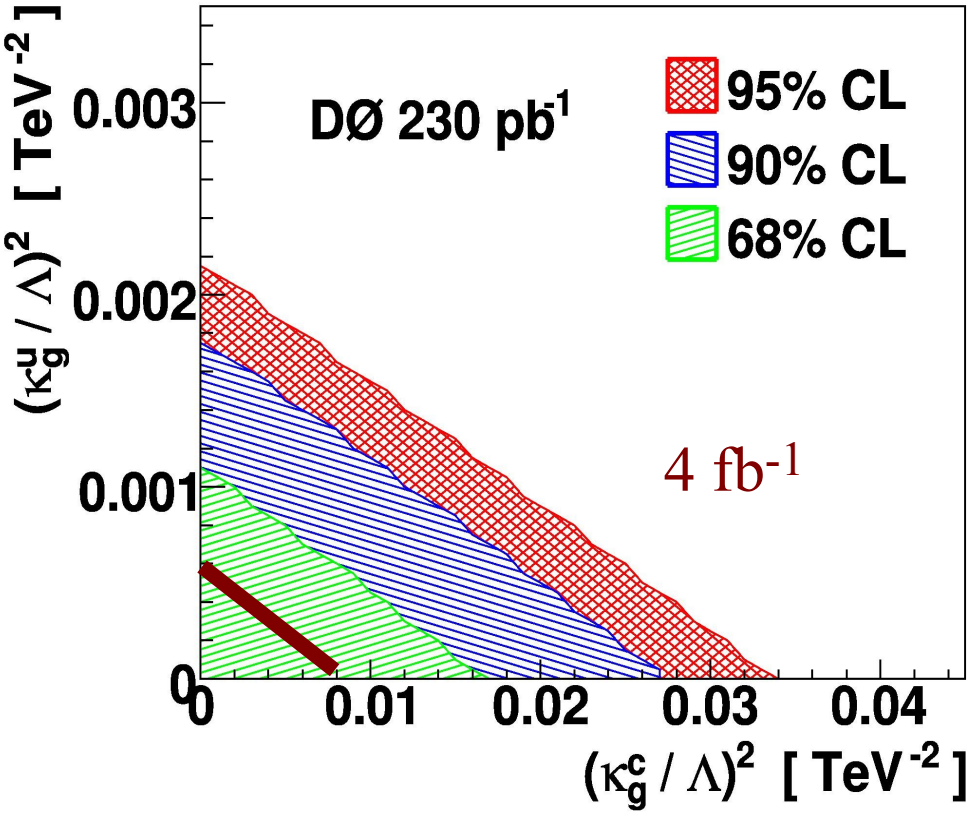


  - Plus multivariate approach
  - Reach: close to 900 GeV

Extending existing searches

- New heavy boson W'
  - With SM-like left-handed couplings
  - With right-handed couplings
  - Reach: close to 900 GeV

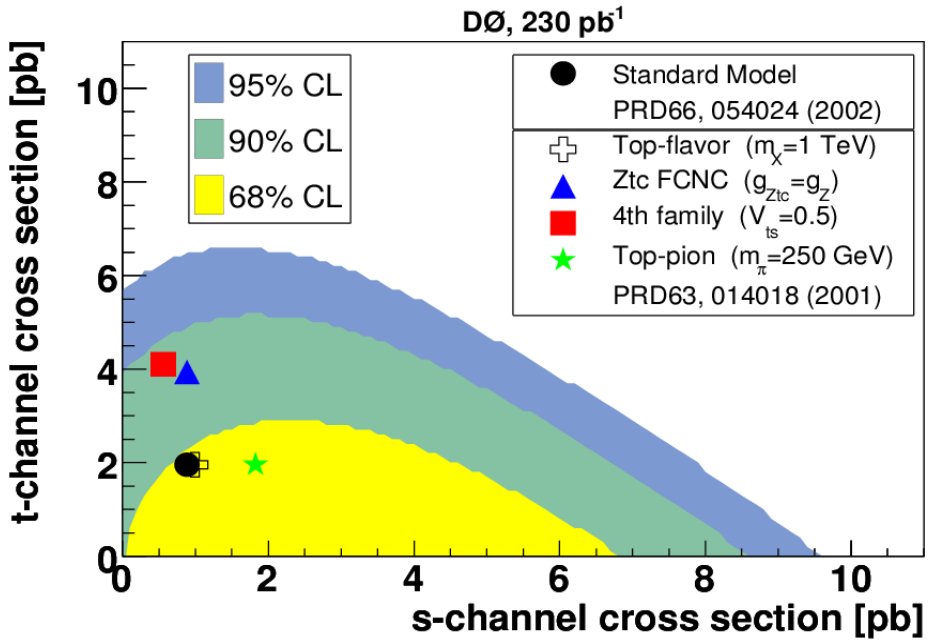
- FCNC
  - Coupling to gluon
  - Multivariate classifier (NN)
  - Statistics-limited
  - Improvements:
    - B-tagging
    - Classifier



Other searches

- Modified electroweak couplings
  - Right-handed couplings
  - Tensor couplings
  - Interference effects

- Searches in two dimensions
  - W' with right-handed couplings
  - Combined 2d s vs t and ttbar helicity measurement



Systematic uncertainties

- Today:
  - B-tagging
  - Background normalization (ttbar and W+jets)
    - W+jets flavor composition
  - Jet fragmentation modeling
- Tomorrow
  - Use more b-tagging information
    - Larger uncertainty
  - Improved background modeling
  - Evaluate uncertainties better
    - Jet fragmentation (Pythia vs Herwig, ISR/FSR, or ?)
  - Include more uncertainty components
    - PDF uncertainties
    - Signal modeling uncertainties (difference to NLO)

Contributions to the Cross Section Uncertainty	
Systematics component	
Luminosity	0.62 pb
$t\bar{t}$ cross section	0.47 pb
Matrix method	0.96 pb
Trigger	0.46 pb
Primary vertex	0.31 pb
Lepton ID	0.47 pb
Jet ID	0.18 pb
Jet fragmentation	0.56 pb
Jet energy scale	0.16 pb
Tag-rate functions	1.01 pb
Combined systematics	1.29 pb
Statistics	1.22 pb
Total uncertainty	1.43 pb

(systematics table from the DT note)

Conclusions

- With 4 fb^{-1} we will make many measurements based on the s+t and t-channel datasets
  - Systematic uncertainties will become more and more important
- With 4 fb^{-1} we will be close to 3 sigma evidence for s-channel production
- We will continue to do many searches for new physics
- Single top physics with 4 fb^{-1} will be rich in topics