



## Search for Single Top Quark Production at DØ

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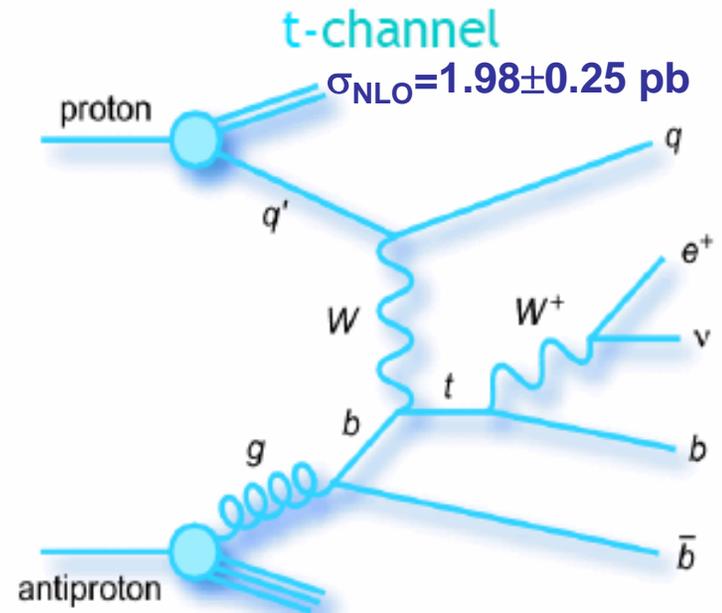
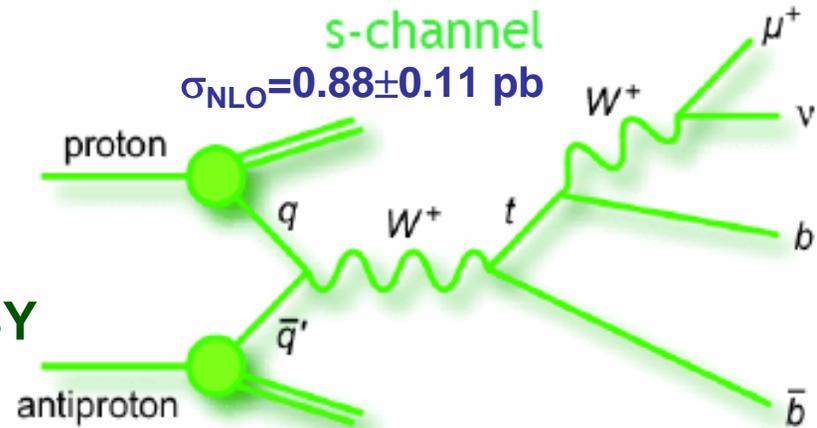
**On Behalf of the DØ Collaboration**



# Single Top Quark Production

## Single Top: Electroweak Interaction

- Direct measurement of the  $|V_{tb}|$  CKM matrix element
- New physics: 4<sup>th</sup> generation etc...
  - s-channel is sensitive to  $W'$ , SUSY
  - t-channel is sensitive to FCNC
- $W$ +jets background study helps many physics searches, e.g. SM Higgs
- Study top polarization, mass



## Topology:

- Energetic isolated lepton (from  $W$ )
- Missing  $E_T$  ( $\nu$  from  $W$ )
- One b-quark jet (from top)
- A light flavor jet and/or another b-jet

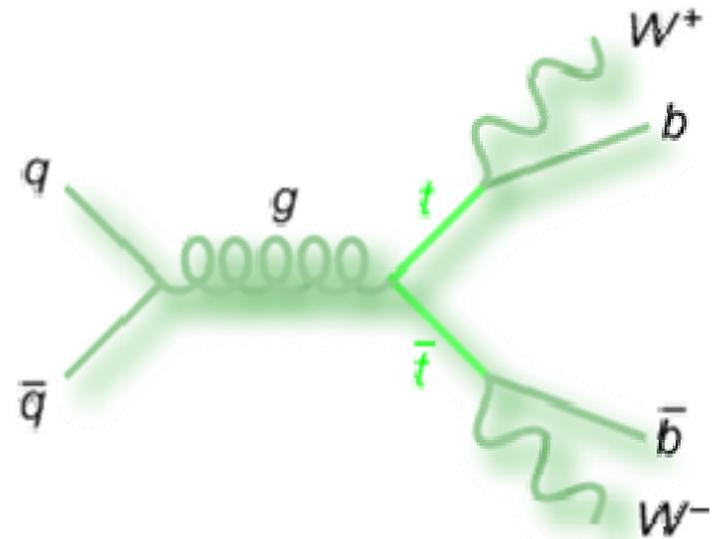
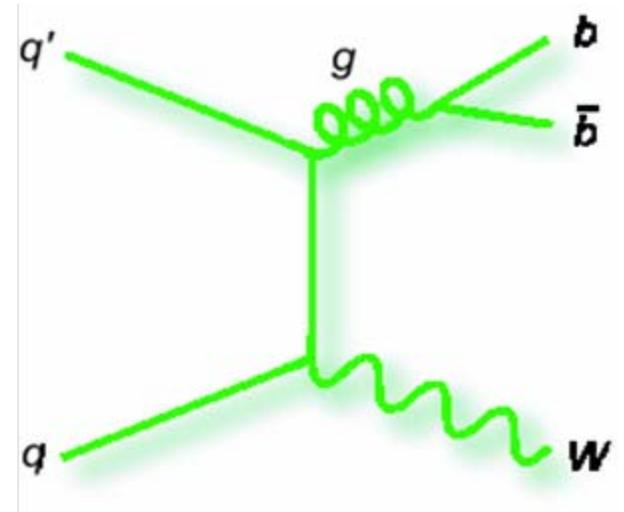


## Signal:

- Modified version of CompHEP
- Distributions agree well with ZTOP & MCFM

## Background:

- W+jets production
  - Estimated from data & MC
  - Wbb to Wjj fraction from MCFM
  - Distributions from ALPGEN
  - Normalization from pre-tagged data sample
- Top pair production
  - ALPGEN
- Multijet events
  - Misidentified electron
  - Estimated from data
- WW, WZ
  - ALPGEN





## Event Selection

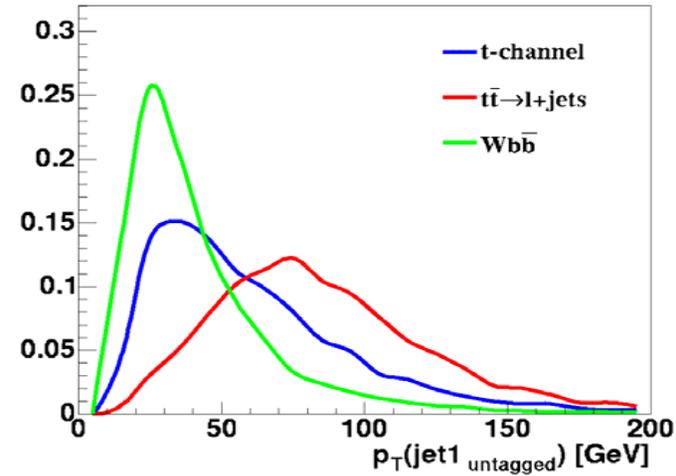
- Select W-like events
- Remove background-like events
- Maximize signal acceptance

## Separate Signal from Background

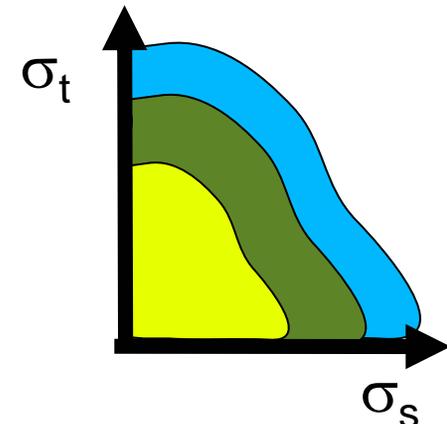
- Compare data with Monte Carlo
- Find discriminating variables
- Multivariate analyses
  - Simple Cuts, Decision Trees, Neural Networks, Likelihoods

## Determine Cross Section (Limit)

- Event counting
- Use shape information
- Bayesian approach



$$L = \frac{P(S)}{P(S) + P(B)}$$





# Event Selection and Yields

## One isolated lepton (e, $\mu$ ):

- $P_T > 15$  GeV
- $|e(\mu)| < 1.1$  (2.0)

## Missing $E_T > 15$ GeV

## Jets:

- $2 \leq N_{\text{jets}} \leq 4$
- $E_T > 15$  GeV
- $|\eta| < 3.4$
- $E_T^{\text{Jet1}} > 25$  GeV

## Other clean-up cuts

	s-channel	t-channel
Cuts acceptance	23%	22%
b-tag eff	54%	38%
Signal yield	9.5	15.0
Backgnd yield		452
Data		443
S/B	1/50	1/30

## Main Contributions

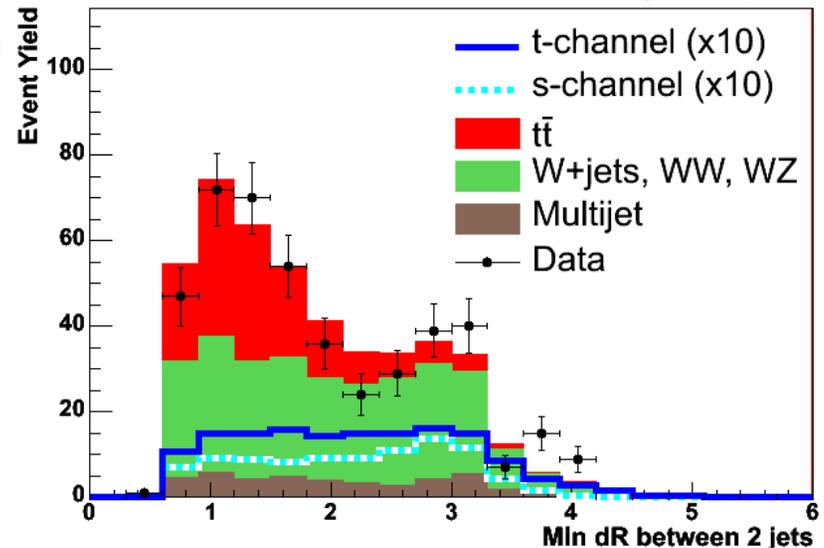
- $W_{jj} \sim 47\%$ ,  $W_{bb} \sim 12\%$
- tt lepton+jets  $\sim 21\%$ , tt dilepton  $\sim 6\%$
- Multijet  $\sim 10\%$
- s- or t-channel as background to the other  $\sim 3\%$



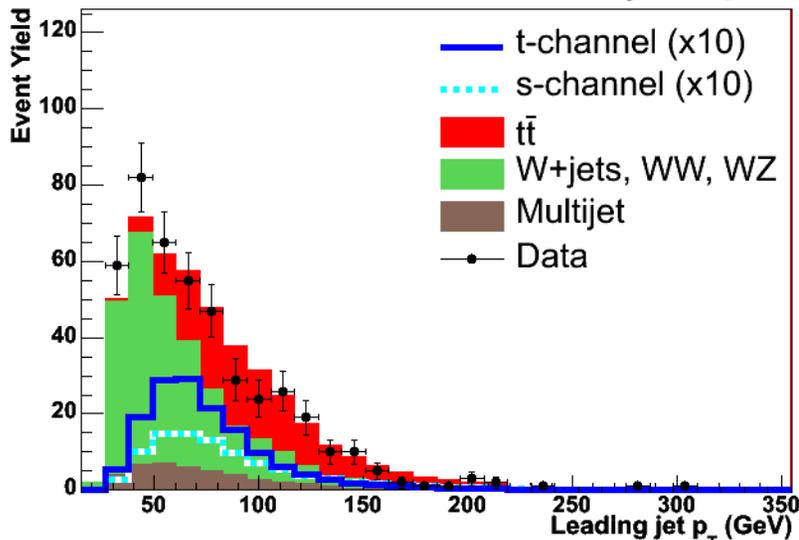
# Separate Signal from Background

- Show good agreement between data and Monte Carlo
- Choose variables with good discriminating power
- Use all categories: angular correlations, object kinematics, event kinematics,

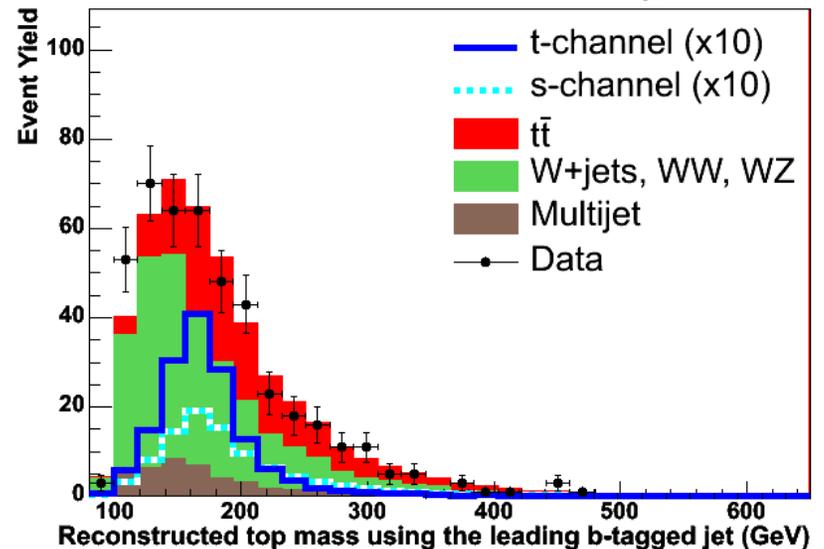
DØ Run II Preliminary, 370 pb<sup>-1</sup>



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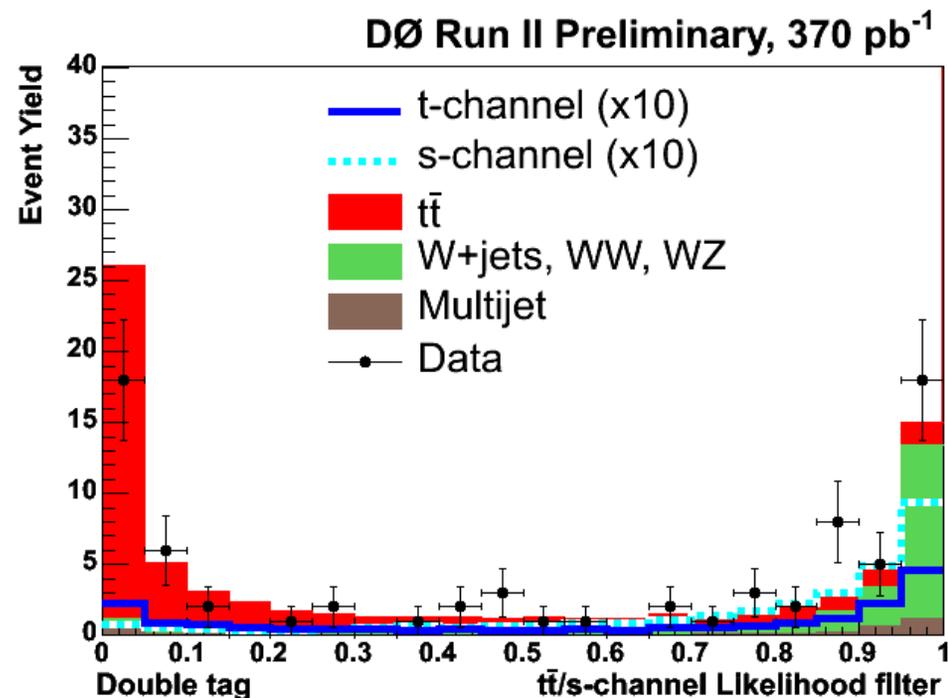
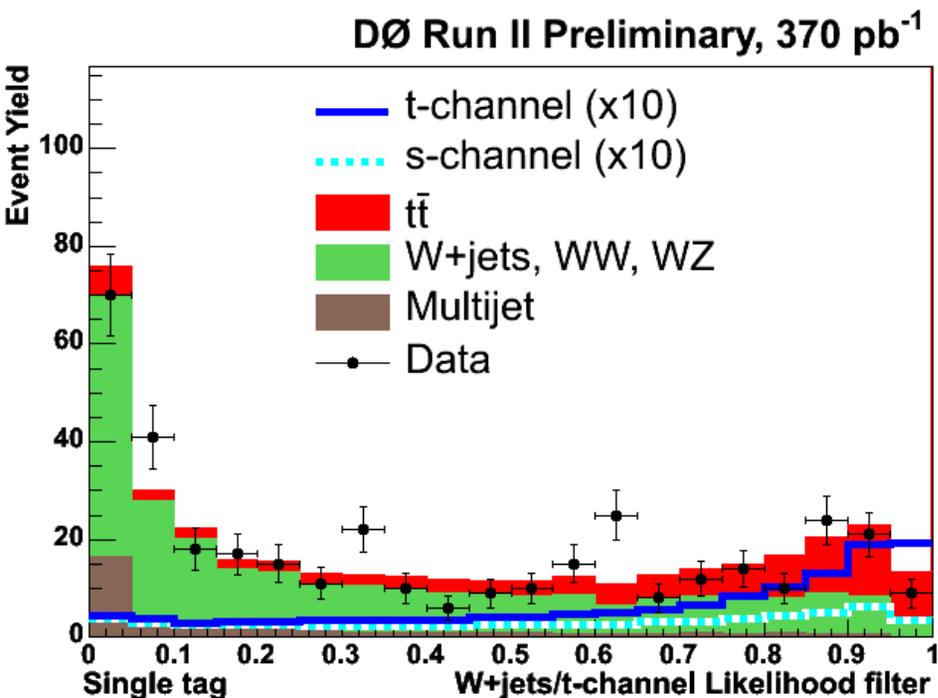


# Multivariate Method: Likelihood Discriminant

Build  $Wbb$  and  $tt$  discriminants for s- and t-channel, and each separately for  $e$ ,  $\mu$ , single and double tags samples

- totally 16 likelihoods
- Between 7-10 variables in the likelihoods

Use 2D histograms as input for binned likelihood

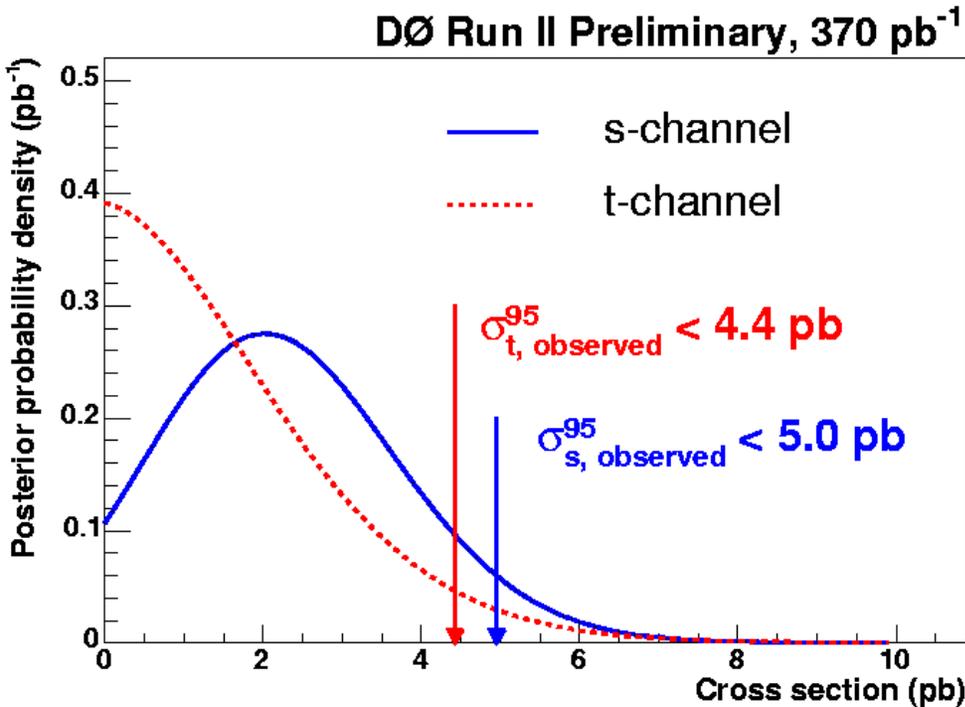




# Likelihood Discriminant Results

## Multivariate analysis + shape information from output

- Factor 2 better than simple cuts
- Including bin-by-bin systematics and correlations
- Uncertainties: b-tag 6-17%, JES 5%, trigger 5%, theory  $\sigma$  18%
- Set 95% CL upper cross section limit with Bayesian approach to combine channels (e,  $\mu$ , single and double tags)



		s-channel	t-channel
DØ Lhood 370/pb	Observed	5.0	4.4
	Expected	3.3	4.3
CDF NN 695/pb	Observed	3.2	3.1
	Expected	3.7	4.2

Competitive expected limit  
More data coming into analyses



# Conclusions & Outlooks

**Single top quark production has not yet been observed**

**The D0 Run II Single top search is improving**

- **Better CAL calibration, Jet Energy Scale ...**

**Will have single top results with  $1 \text{ fb}^{-1}$  soon**

- **Improved b-tagging and expecting new Matrix Element analysis**
- **Getting very close to observation!**

**Already sensitive to new physics**

**The Tevatron experience will help the LHC**

- **Precision studies with large statistics at LHC**

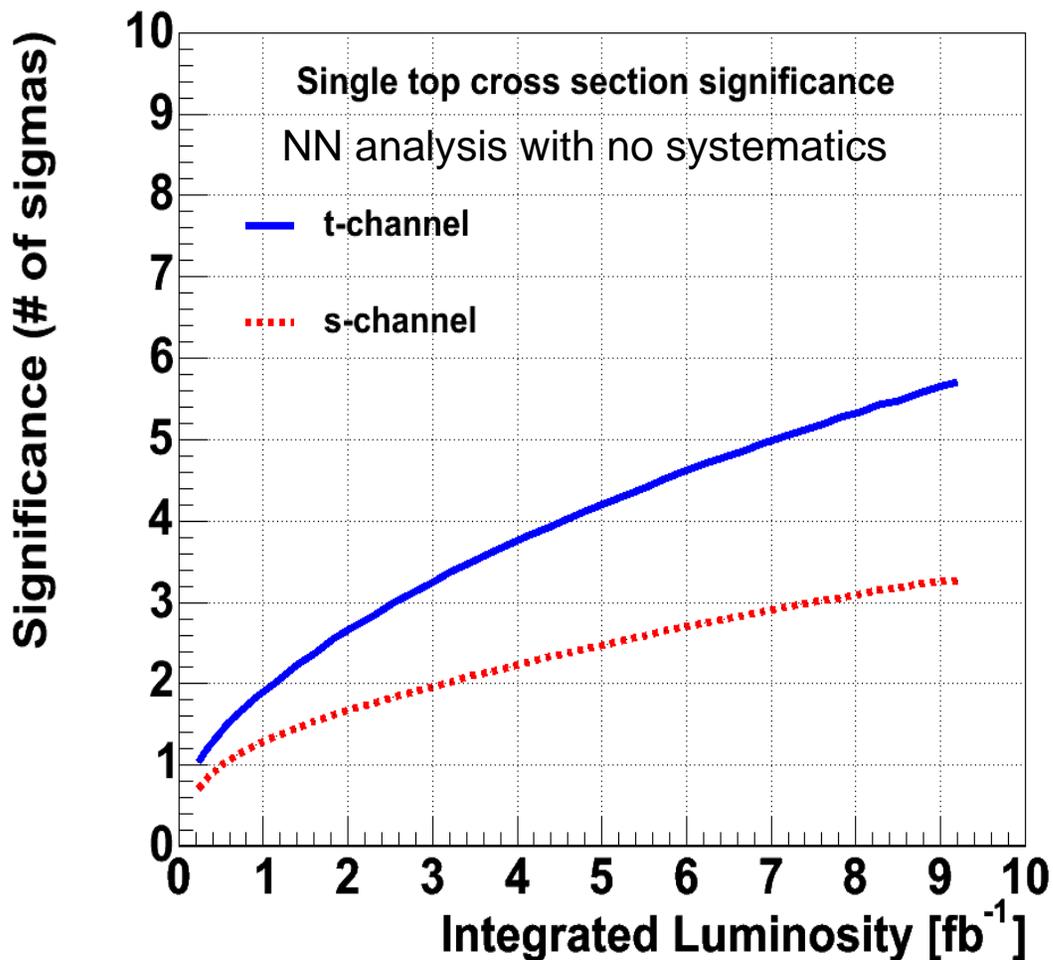


# Backup Slides



# Luminosity Sensitivity

**With current analysis, we would need several  $\text{fb}^{-1}$  for an observation of SM single top**



Working on many fronts to improve:

- Trigger efficiency
- Object ID: e,  $\mu$ , jet, b
- Jets resolution
- Add more channels
- Background estimation
- Reduction of systematics
- Bkgnd-signal separation



Relax assumption of SM cross sections for s- and t-channel  
Study sensitivity to beyond SM models in the  $(\sigma_s, \sigma_t)$  plane

