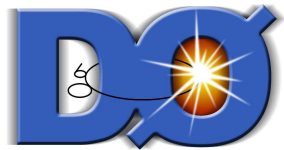


Search for $t\bar{t}$ -Resonances in the Lepton+Jets Final State



Thorsten Schliephake
(University of Wuppertal)

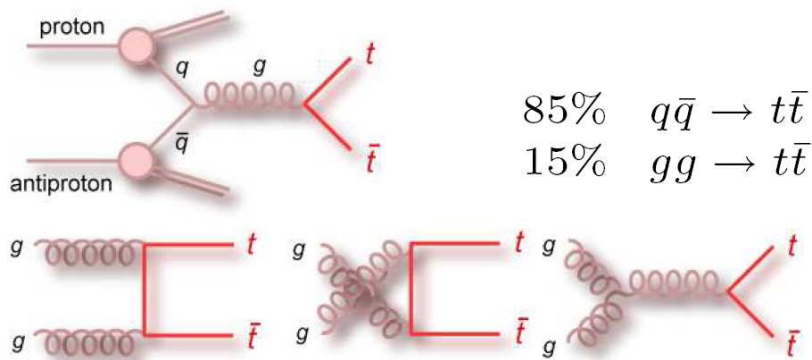


for the $D\bar{O}$ collaboration

- Selection & background estimation
- Invariant mass distributions
- Limit

Top Quark Pair Production and Decay

Strong Top Production



- $\sigma(t\bar{t}) = 7.3 \pm 0.7 \text{ pb}$
($m_t = 172.5 \text{ GeV}$)
- Around 7k $t\bar{t}$ per 1 fb^{-1} expected

Decay Modes

Top quarks decay to bW ($\sim 100\%$)

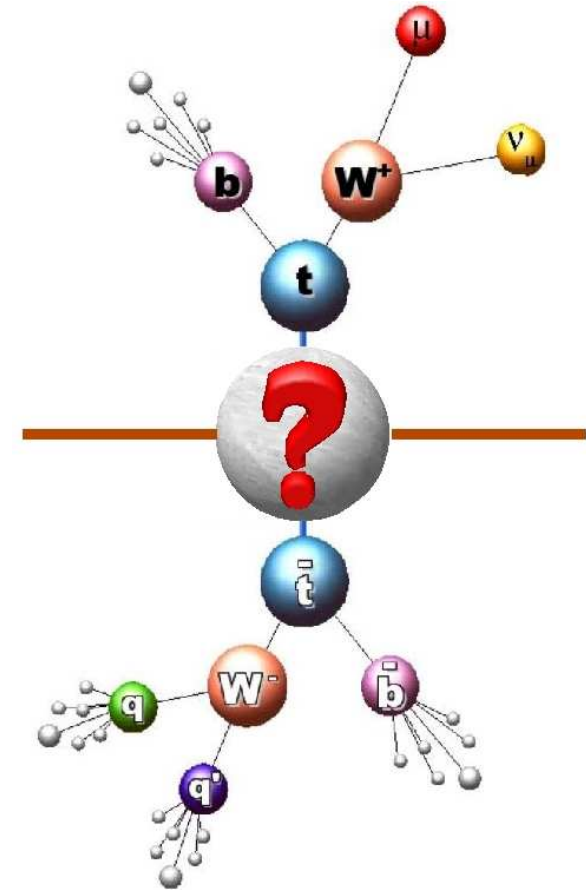
- Dilepton ($2b + 2l + 2\nu$)
- Lepton+jets ($2b + 2q + l + \nu$)
- Alljets ($2b + 4q$)

Top Pair Decay Channels

$c\bar{s}$	electron+jets muon+jets tau+jets	dileptons	all-hadronic		
$u\bar{d}$			all-hadronic		
τ^-			tau+jets		
μ^-			muon+jets		
e^-	electron+jets				
W decay	e^+	μ^+	τ^+	$u\bar{d}$	$c\bar{s}$

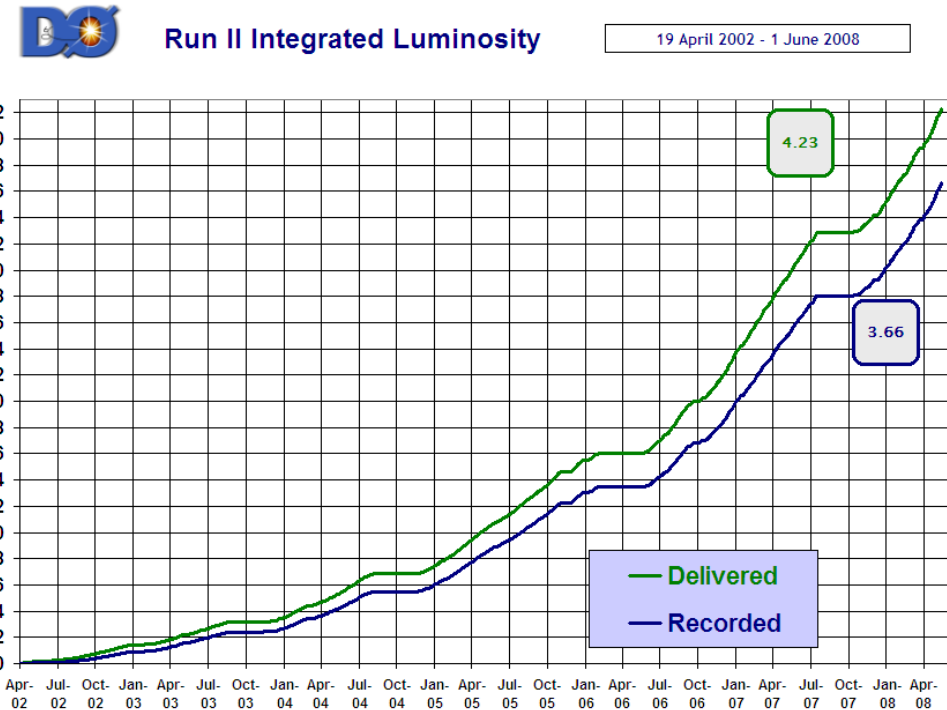
Resonant Production of Top Pairs

- No resonance production in $t\bar{t}$ expected in SM, but some models predict bound $t\bar{t}$ -states
 - Axigluon
 - Coloron / KK-gluon
 - Top-color assisted technicolor: Z'
 - Graviton
 - ...
- Such a resonance should create a bump in differential cross-section $\frac{d\sigma}{dm_{t\bar{t}}}$
- Assume its width is smaller than detector mass resolution



Tevatron

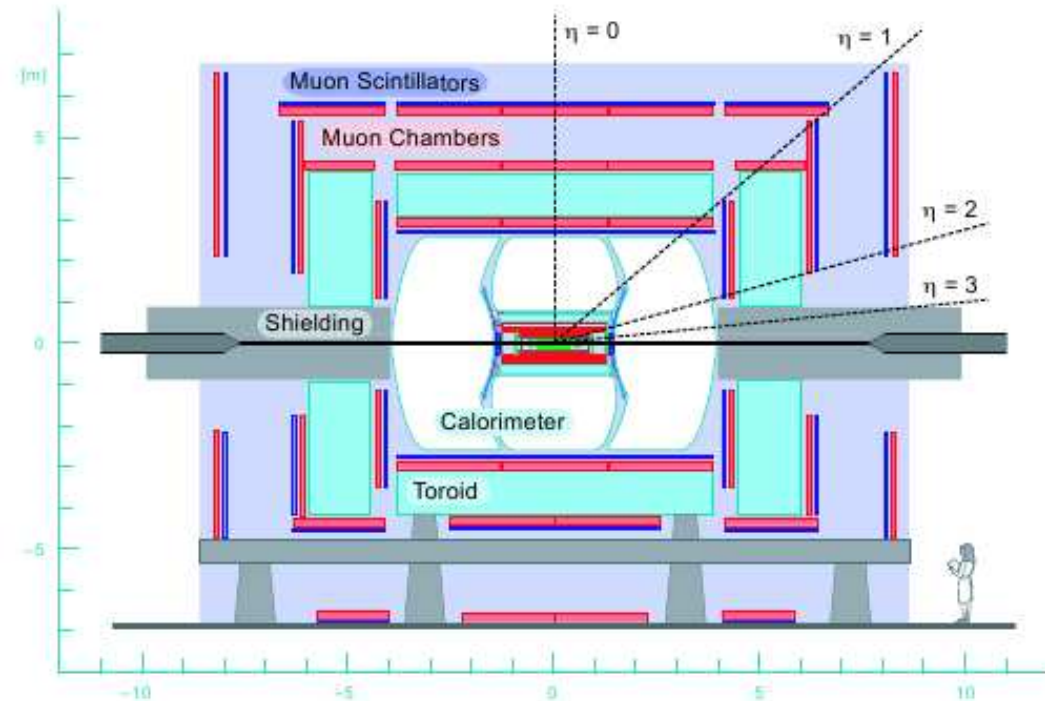
- $p\bar{p}$ -accelerator:
 - Circumference: 7 km
 - Run II since 2001
 - $\sqrt{s} = 1.96$ TeV
 - 2 Experiments:
 - CDF
 - DØ



> 4 fb⁻¹ integrated luminosity delivered
almost 4 fb⁻¹ on disk

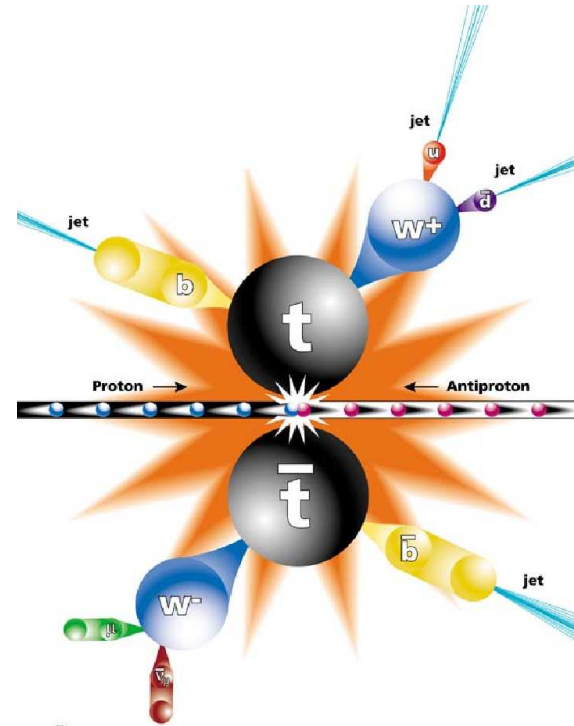
The DØ Detector

- 4π -detector
(20 m · 12 m · 12 m)
- Tracking: SMT & CFT
 - Tracks of charged particles
 - Secondary vertices
- Calorimeter: Sampling Ur/LAr
 - Energy of jets, electrons
- Muon spectrometer:
3 layers of drift tubes & scintillators
 - Identification of μ 's



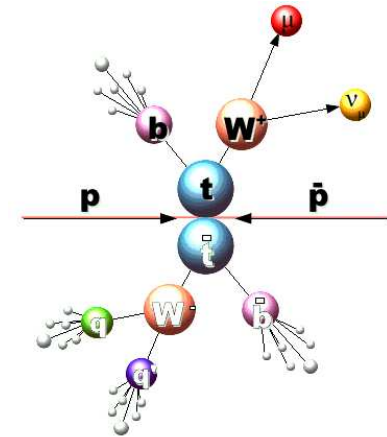
Selection of Data set

- Data set: $\sim 2.1 \text{ fb}^{-1}$
- l+jets physics signature:
lepton + neutrino + ≥ 4 jets
- Cuts for $t\bar{t}$ cross-section:
 - ≥ 3 jets with $p_T \geq 20 \text{ GeV}$, $|\eta| < 2.5$
 - Leading jet $p_T \geq 40 \text{ GeV}$
 - ≥ 1 b-tag
 - $\cancel{E}_T \geq 20$ (25) GeV for e+jets (μ +jets)
 - One isolated lepton
 - Electron with $p_T \geq 20 \text{ GeV}$
 - μ with $p_T \geq 25 \text{ GeV}$

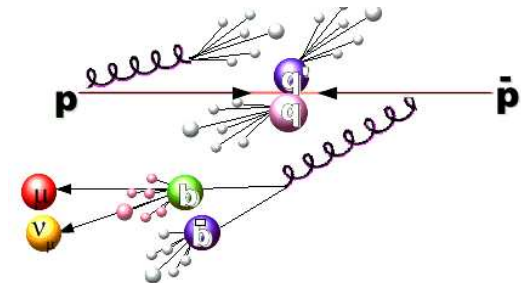


Background Estimation

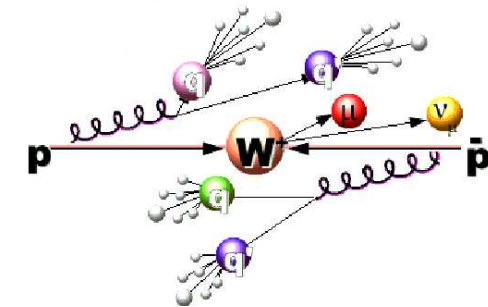
- $t\bar{t}$, Z +jets, single top and diboson:
MC normalized to NLO theoretical cross-section



- Multijet:
taken from data with depleted signal

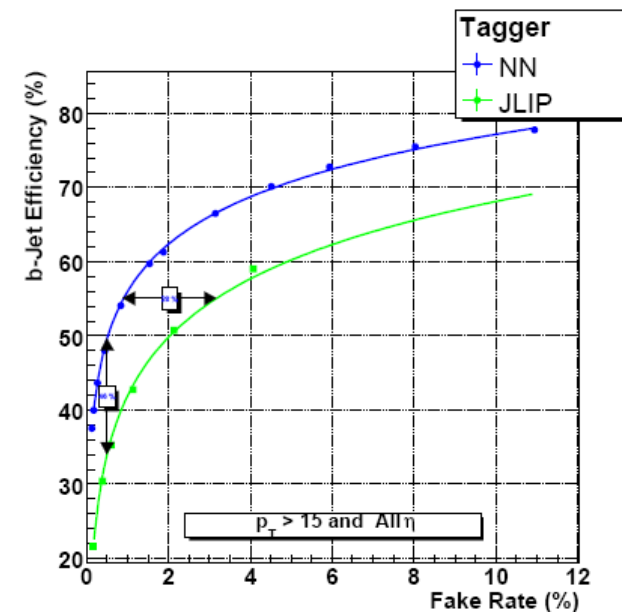
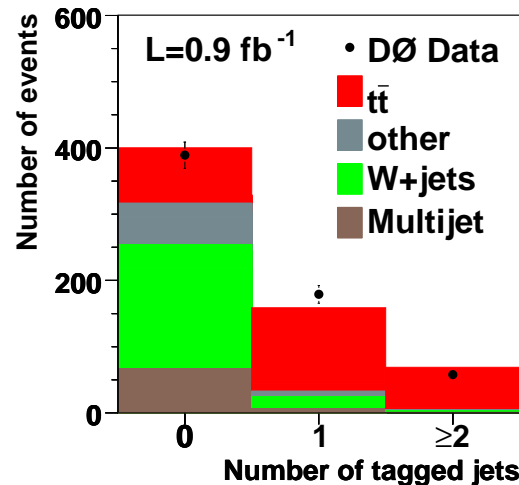
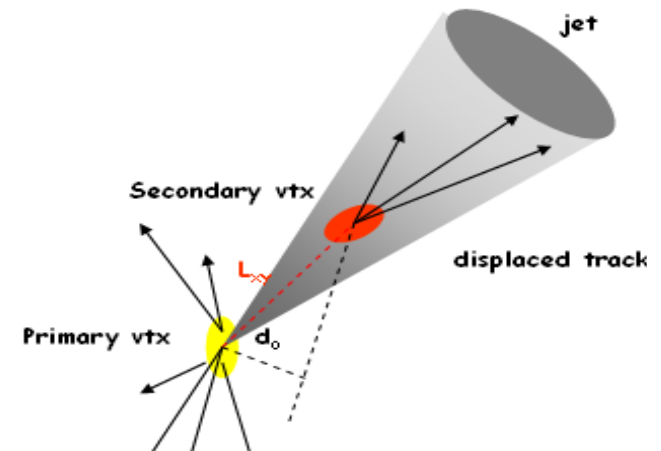


- W +jets:
cross-section normalised to data,
shape from Monte Carlo



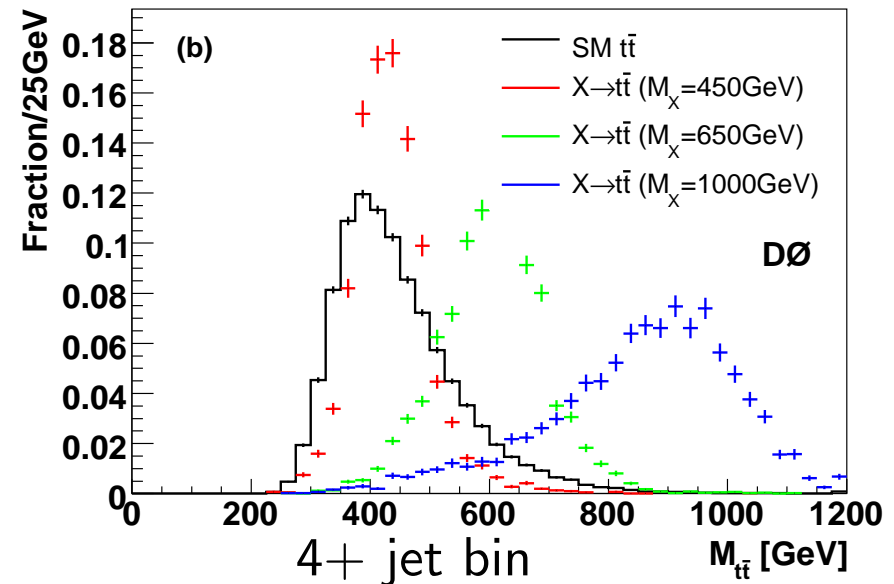
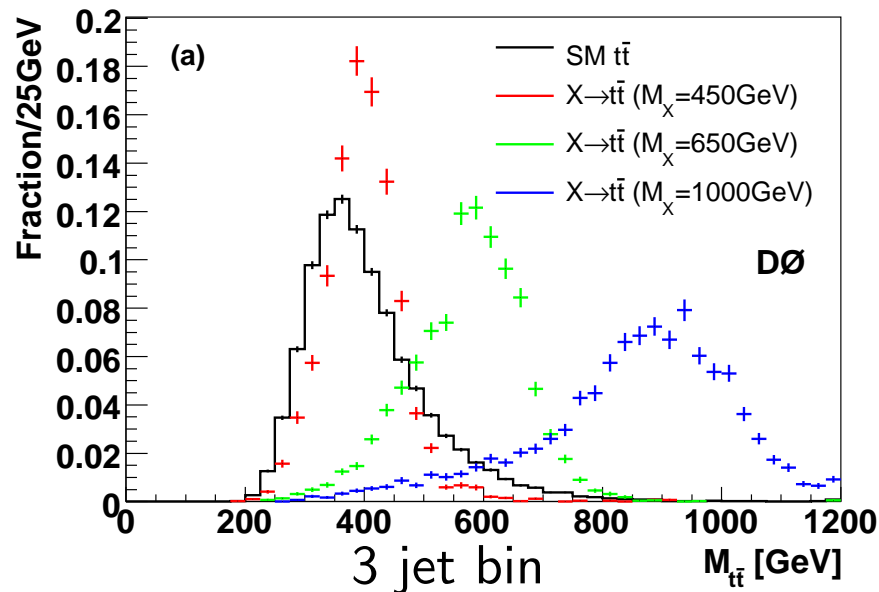
Neural Network b-tag Algorithm

- Use high lifetime of b of ~ 1.6 ps
- Variables from several tagging algorithms:
 - Impact parameter significance of tracks
 - Probability jet originates from primary vertex
 - Secondary vertices properties
- Efficiency for tagging b-jets $\sim 54\%$ with a fake rate of $\sim 1.2\%$



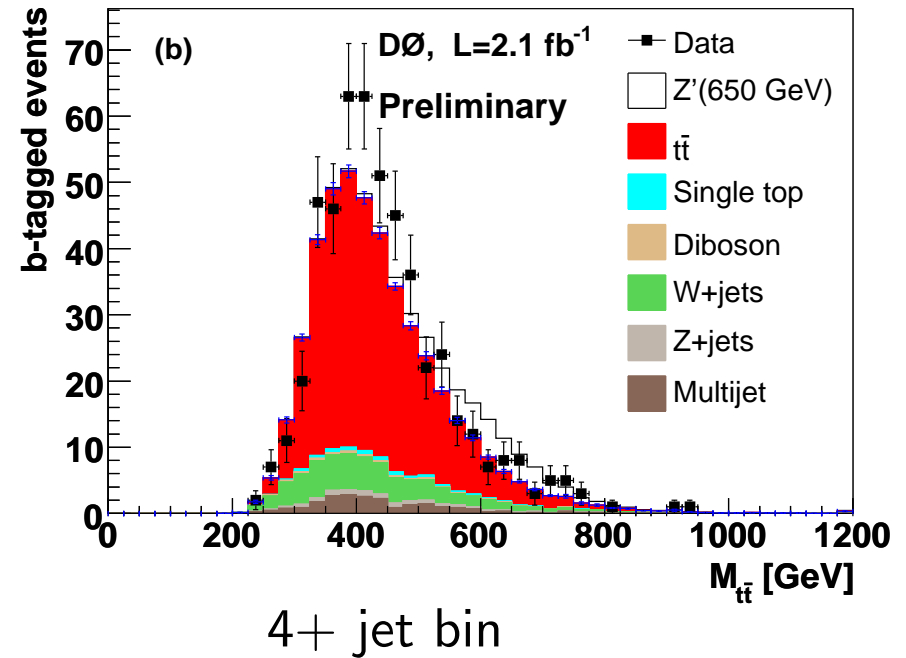
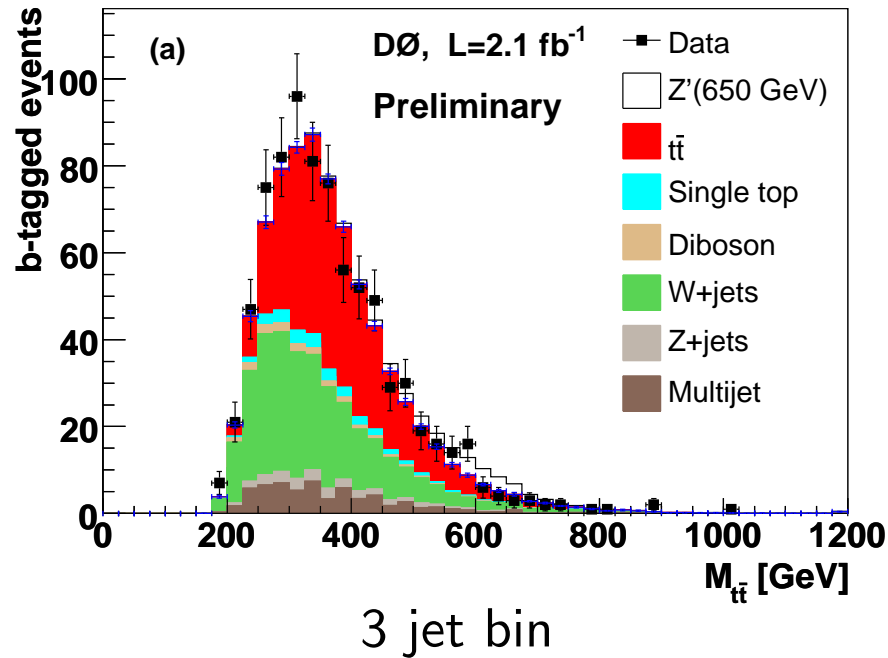
Reconstruction of Invariant Mass of the $t\bar{t}$ System

- Reconstruct $m_{t\bar{t}}$ directly from ℓ , ν and up to 4 leading jets (no constraint fit)
- Neutrino: p_x, p_y components from \cancel{E}_T and p_z^ν from $M_W^2 = (p^\nu + p^l)^2$



- Resonant production shows more narrow $M_{t\bar{t}}$ distributions than SM $t\bar{t}$
- With increasing resonance mass discrimination gets better, though resolution gets worse

Top Pair Invariant Mass Distribution



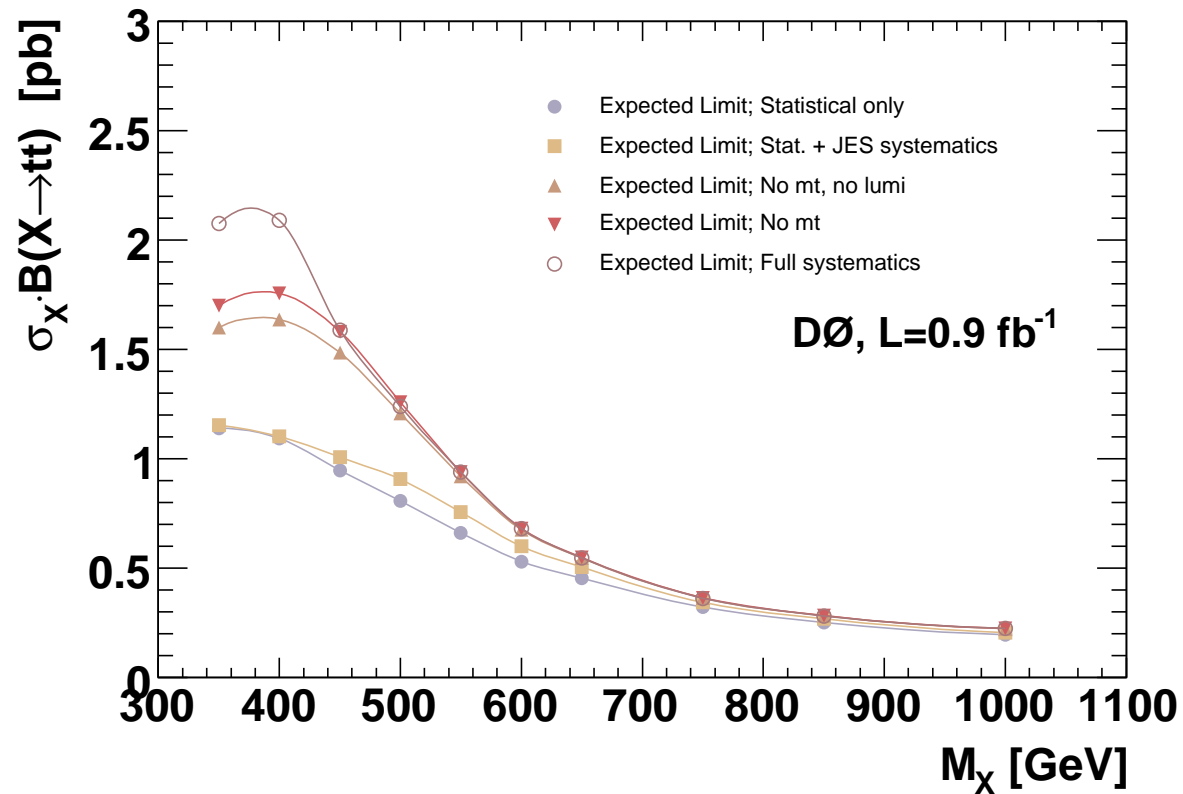
- No resonance signal is observed
- Set limits on resonance production

Limit calculation

- Invariant mass spectrum used for binned likelihood fit
- Bayesian approach used:
 - Use flat prior in $\sigma_X \times B(X \rightarrow t\bar{t}) \geq 0$
 - Keep upper bound of prior large enough stay away from boundary
 - Scan through resonance masses (350 - 1000 GeV)
 - Assume Poisson distributed events
 - Use multivariate Gaussian for systematics
 - Use posterior to calculate 95 % C.L. limit

Systematic Uncertainties (Expected Limits)

Expected limits are computed by using background prediction as “observation”

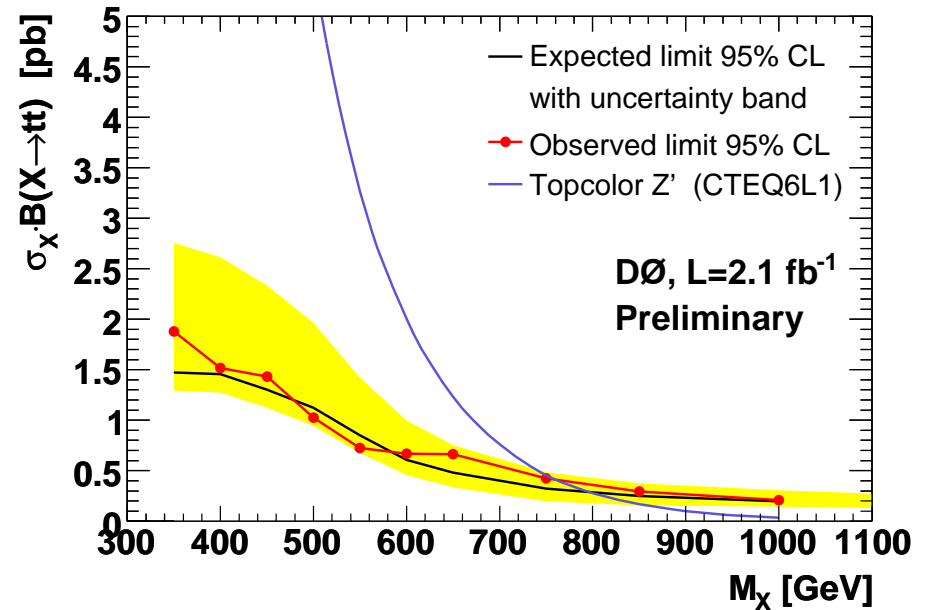
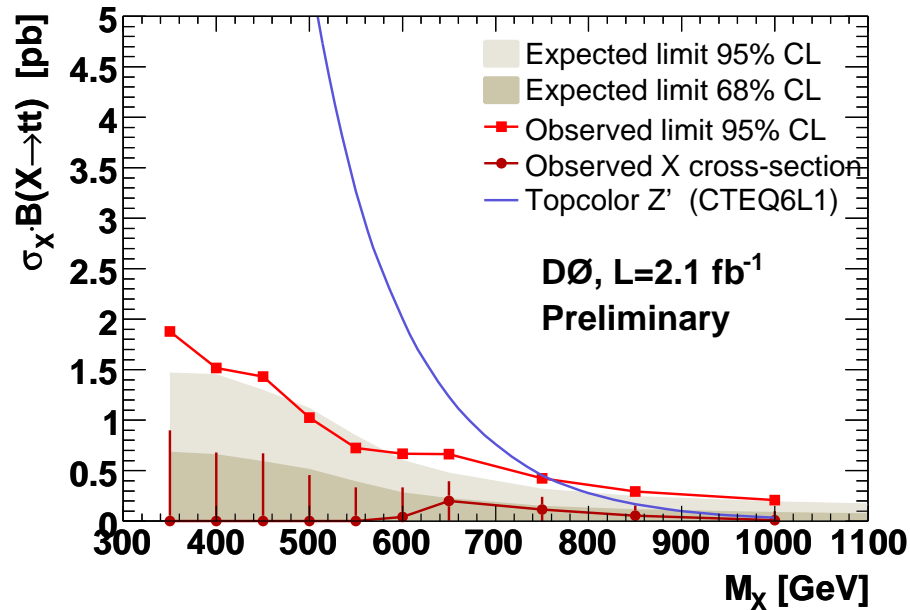


Systematics scale and/or change the background shape:

- JES affects medium M_X
- Luminosity, efficiencies, ... scale like bkg shape
- m_t affects low M_X

High M_X stat. dominated

Top Resonance Results (2.1 fb^{-1})



- All measured $\sigma_X \cdot B(X \rightarrow t\bar{t})$ close to zero (max. deviation $\sim 1\sigma$)
- Thus we set limits on $\sigma_X \cdot B(X \rightarrow t\bar{t})$ below 2 pb for all masses
- Benchmark Top-color assisted technicolor Z' : **Expected Limit: $M_{Z'} > 795 \text{ GeV}$**
Observed Limit: $M_{Z'} > 760 \text{ GeV}$
 CDF Observed Limit: $M_{Z'} > 725 \text{ GeV}$

[FERMILAB-PUB-07-455-E]

Conclusion

- Search for $t\bar{t}$ resonances in the $l+jets$ channel performed
- Measured distribution of $M_{t\bar{t}}$ in 2.1 fb^{-1} of $D\emptyset$ data
- No deviation from SM was observed, yet
- Limits are set for $\sigma \times BR(X \rightarrow t\bar{t})$
 - Topcolor assisted technicolor Z' yields:
 - Observed Limit: $M_{Z'} > 760 \text{ GeV}$
 - Cross-sections limits \Rightarrow

