# Search for a New Resonance Decaying into ttbar at Tevatron


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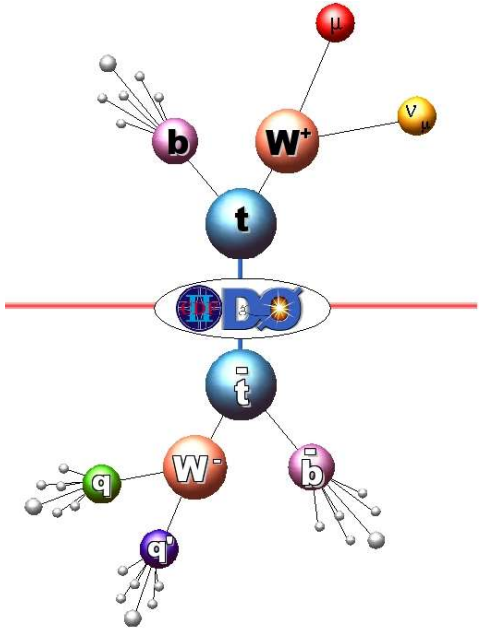
on behalf of the

CDF II and DØ

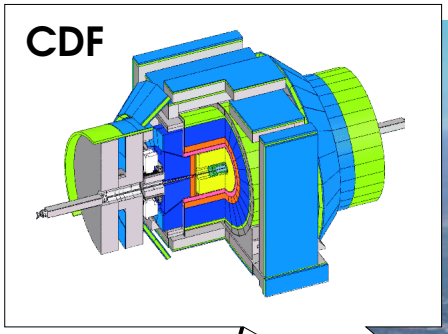
Collaborations

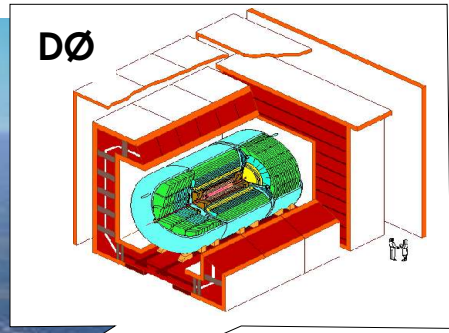

EPS 2005, Lisboa, Portugal

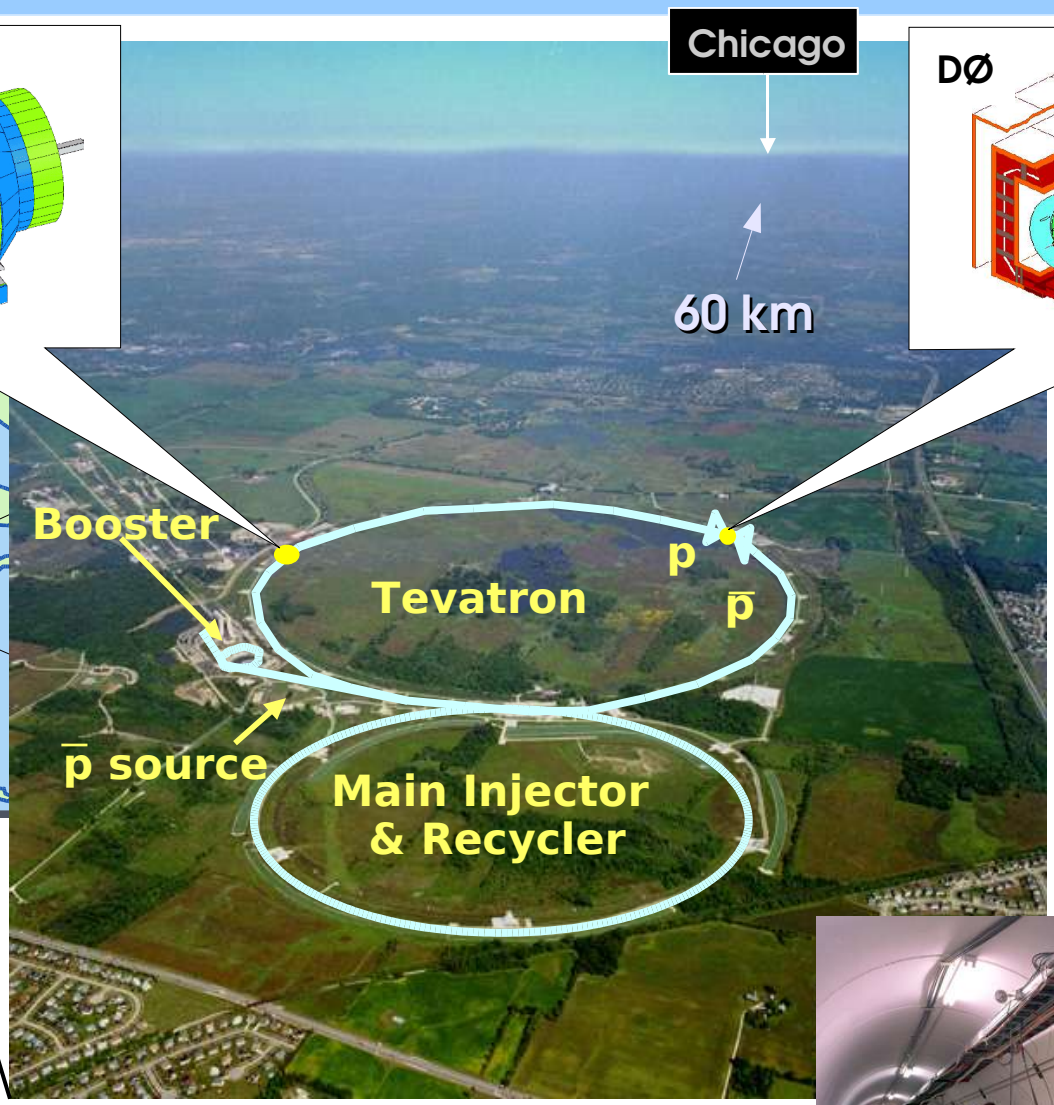
- Introduction
- Run I Results
- Run II Results
- Conclusions

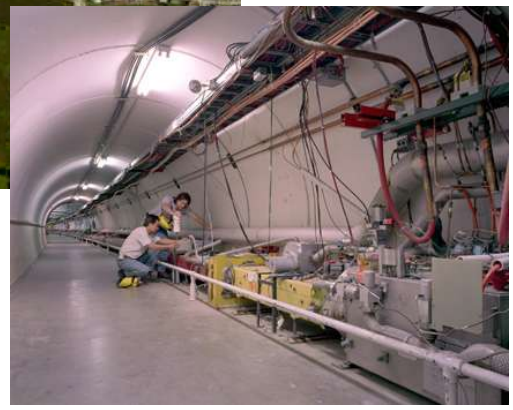


# The TEVATRON at Fermilab





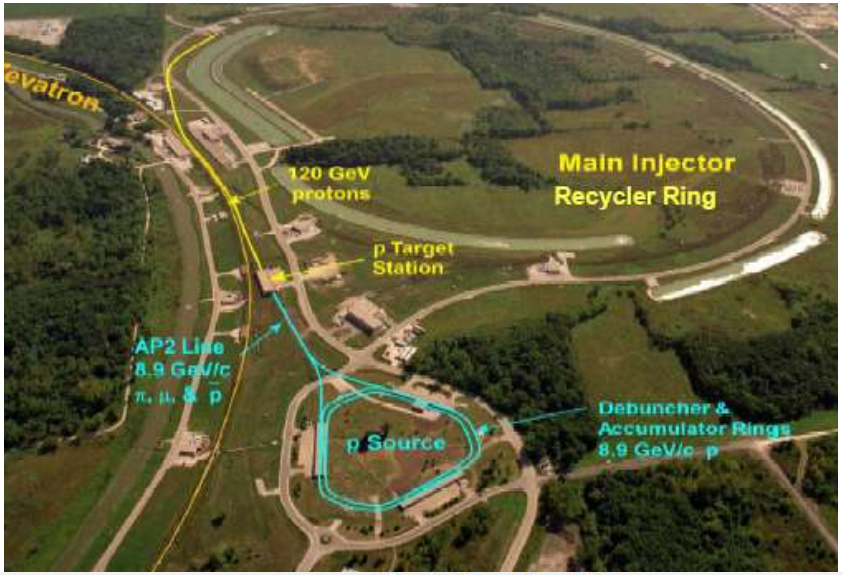
$\sqrt{s} = 1.96$ TeV

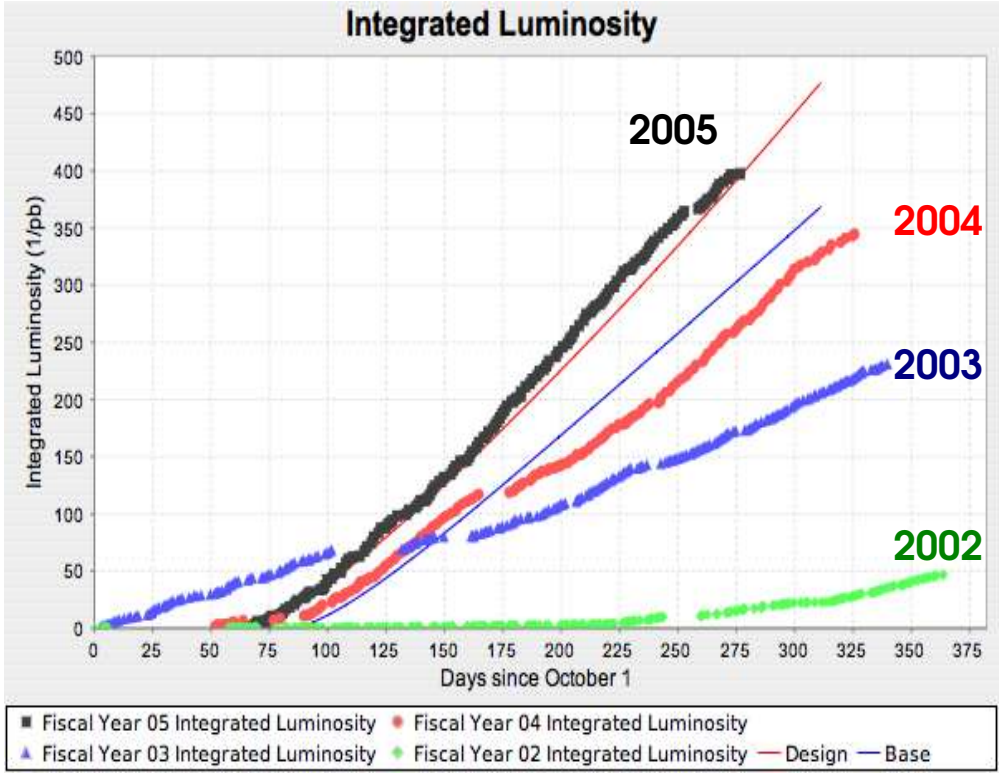
$\Delta t = 396$ ns

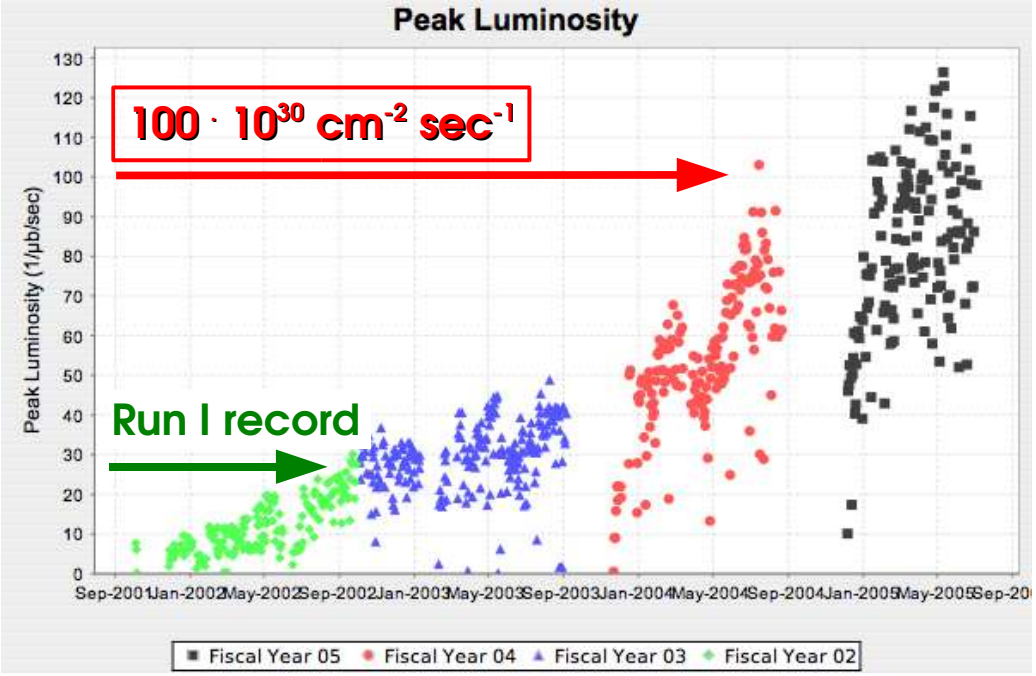
Run I 1987 (92)-95 $L_{int} \sim 125\ pb^{-1}$

Run II 2001-09

# The TEVATRON at Fermilab (2)




**Peak luminosity :**

- in spring 2002 passed Run I record
- in 2005 very good performance

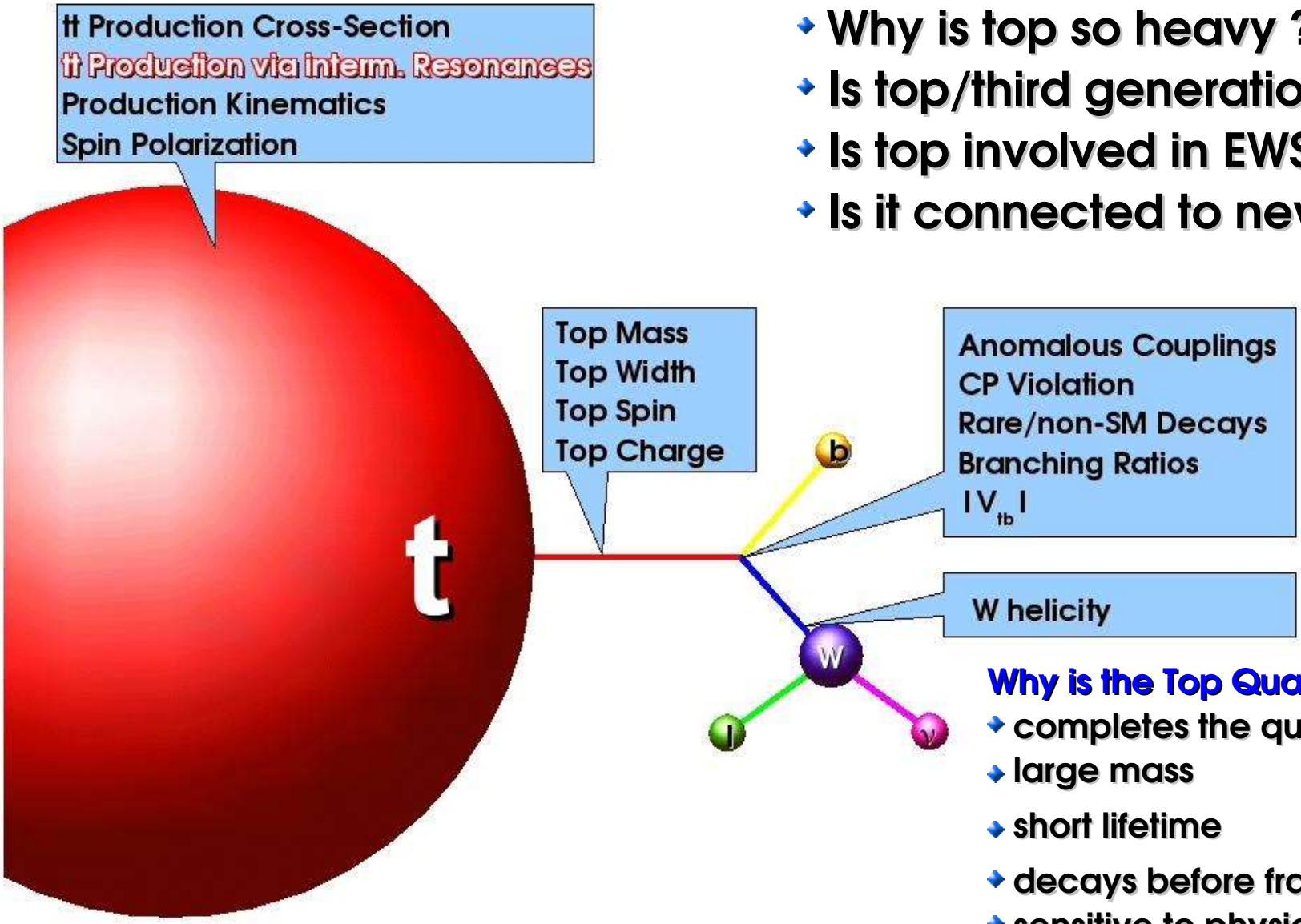
- Tevatron has delivered ~1 $fb^{-1}$ per exp.
- CDF and DØ ~800 $pb^{-1}$ recorded each
- current data taking efficiency is approaching ~90%

# Top Quark Physics

**Run I : top quark discovery**

**Run II: with high precision answer ...**

- Why is top so heavy ?
- Is top/third generation special ?
- Is top involved in EWSB ?
- Is it connected to new physics ?



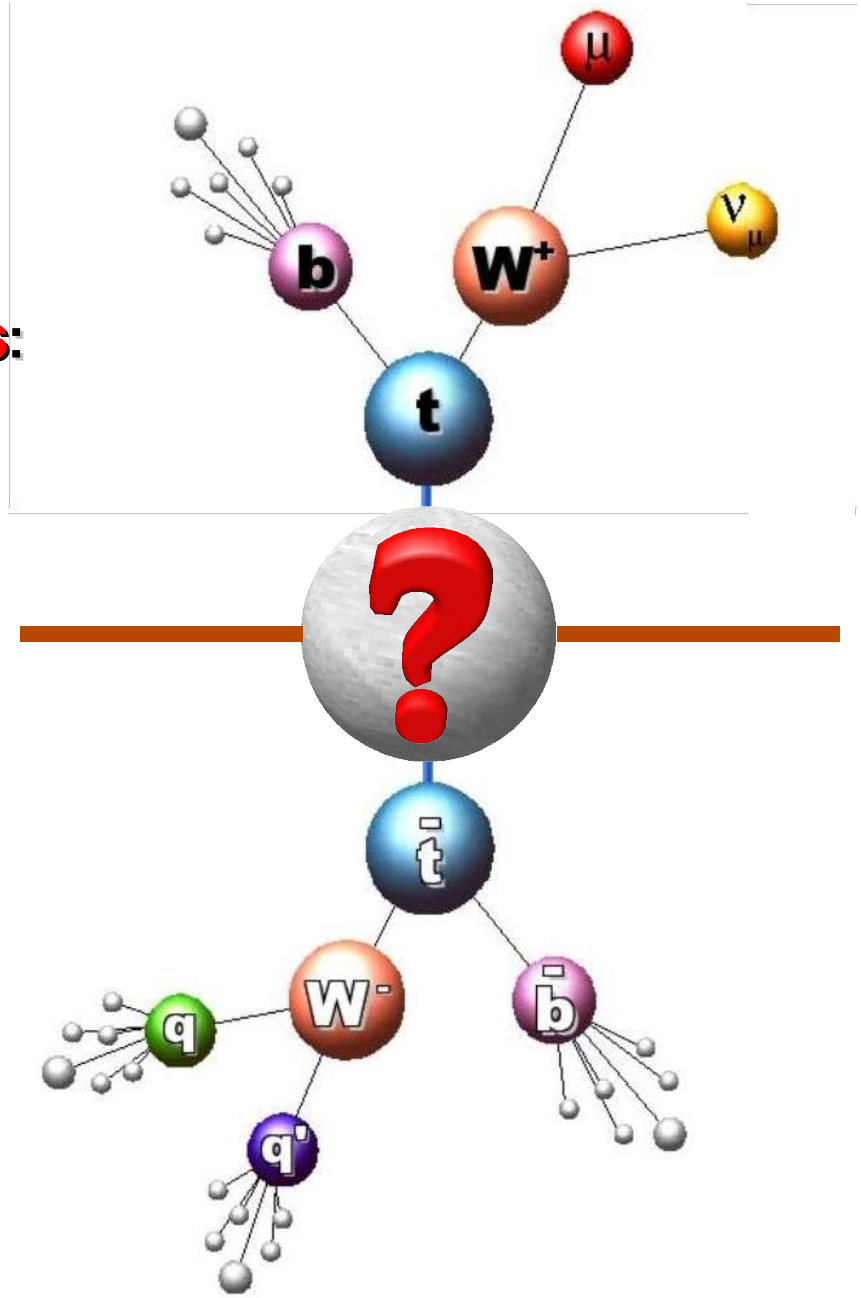

**Why is the Top Quark so interesting ?**

- completes the quark sector
- large mass $m_{top} \sim 175\ GeV / c^2$
- short lifetime $\tau \sim 5 \cdot 10^{-25} s \ll \Lambda^{-1}_{QCD}$
- decays before fragmenting
- sensitive to physics beyond the SM

# Search for ttbar production via new Resonances

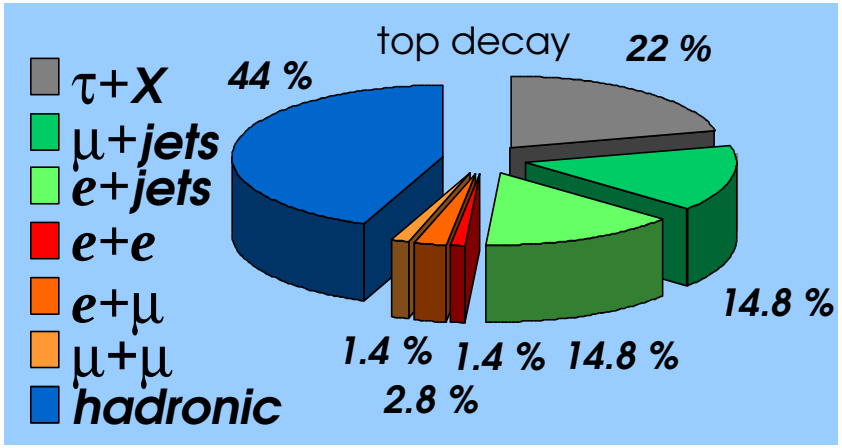
Harris, Hill, Parke, hep-ph/9911288

- No resonance production in ttbar system is expected in SM
- Some models predict ttbar bound states:
  → large top mass can be generated through dynamical ttbar condensate X
  → new strong gauge force coupling to 3rd generation
- e.g. topcolor assisted technicolor
  → predicts leptophobic Z' with strong 3rd generation coupling
- experimental check: search for bumps in ttbar reconstructed mass spectrum
- narrow: smaller than mass resolution of detector



# Decay Topology in ttbar

**Top quarks decay predominantly (~100%) to a W-Boson and a b-quark**

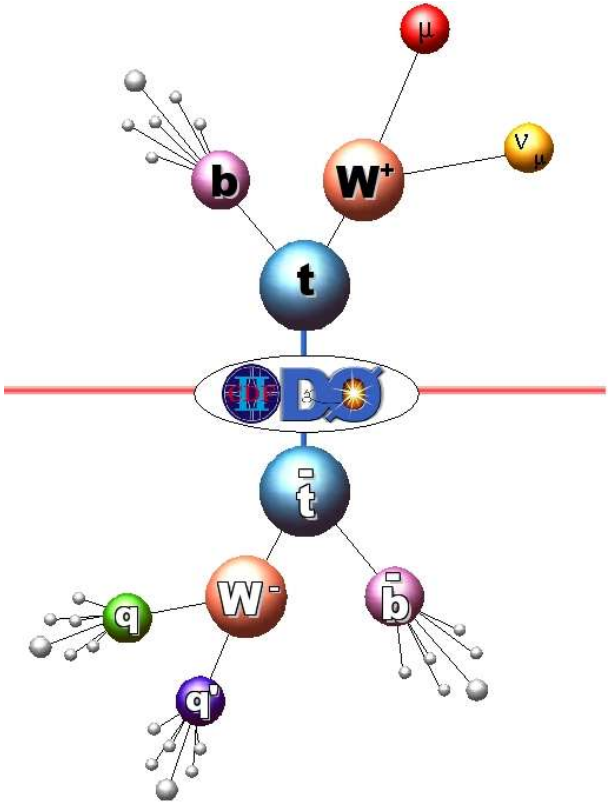



**Top-Antitop Signatures:**

`dilepton channel'
5% : 2 jets, 2 charged leptons, 2 ν

'lepton+jets channel'
30%: 4 jets, e or μ, 1 ν

'all-jets channel'
40%: 6 jets

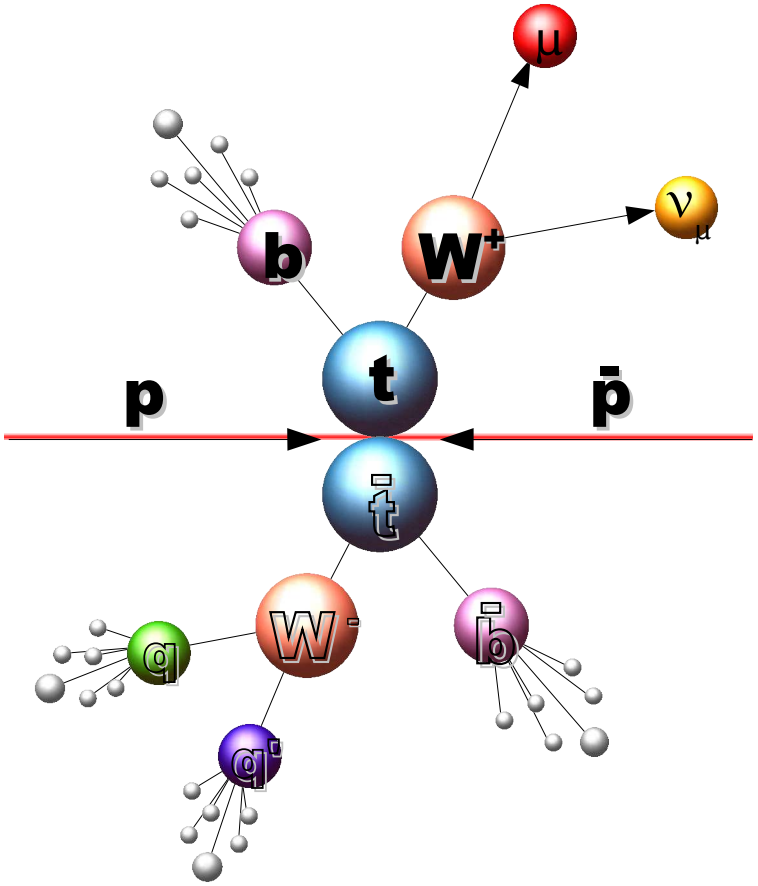



**always 2 jets are b-jets**

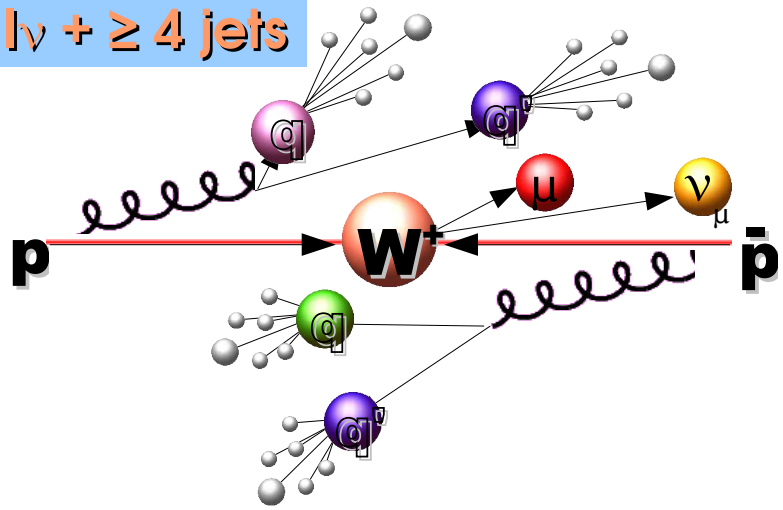
# Background Topology

**ttbar in SM (dominant background)**

- 1 lepton with high $p_T$
- 1 $\nu$ (missing transverse energy = MET)
- ≥ 4 jets



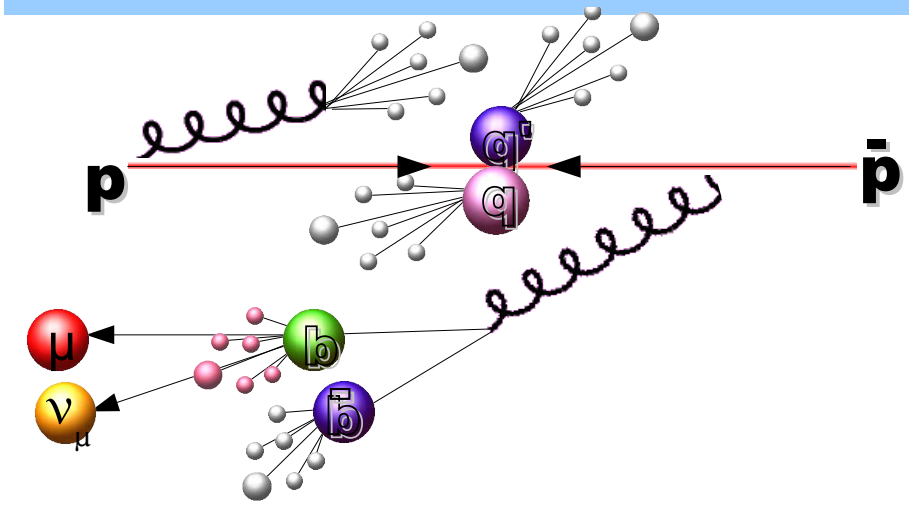

**W → lν + ≥ 4 jets**




**multijet background (QCD)**

**+ misreconstructed met**

**+ fake isolated μ or e**

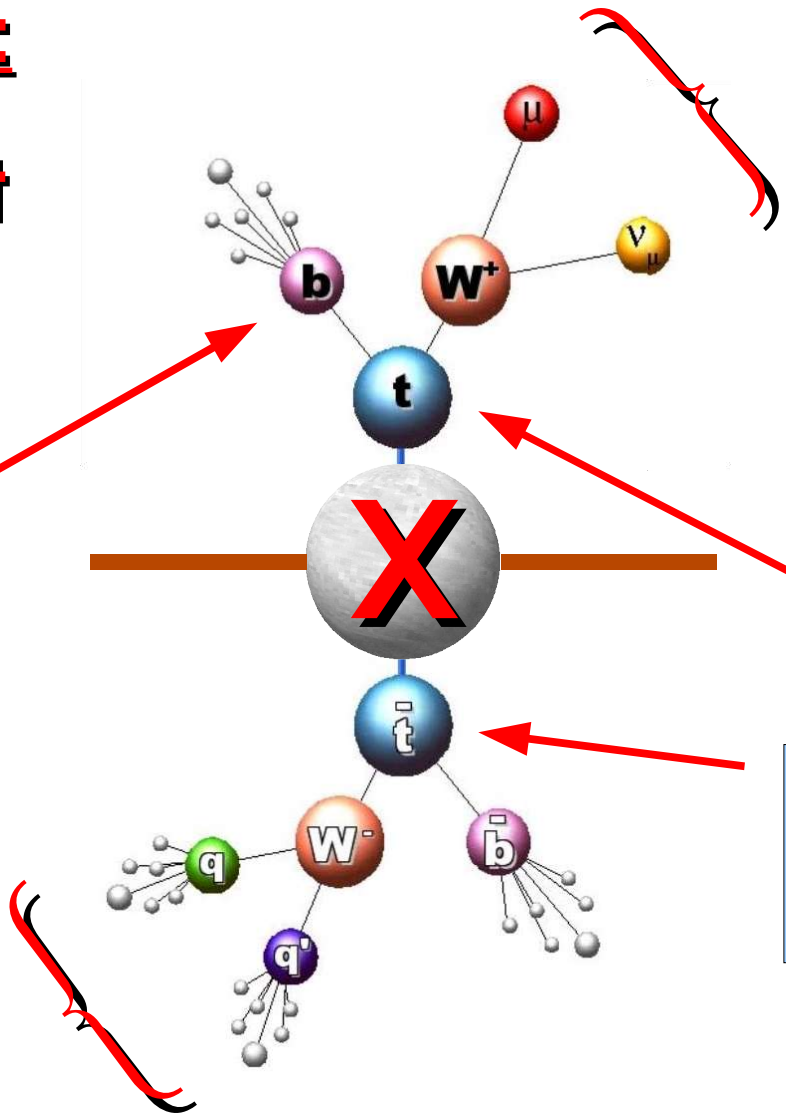


# Reconstruction of ttbar Invariant Mass

**12 jet-parton assignments:**

**kinematic fit lowest $\chi^2$**

**invariant W mass (2 $\nu$ solutions)**




**b-tag**

(not yet in DØ Run II)

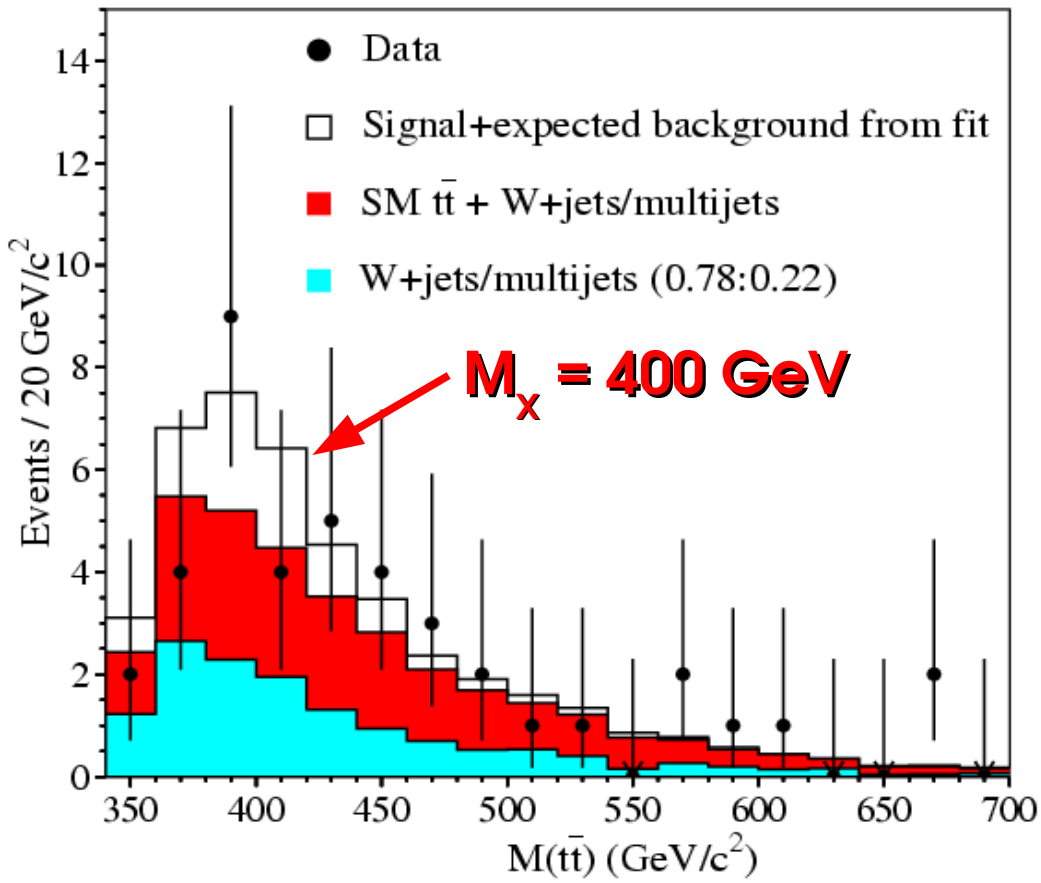
**$m_{top}$ = 175 GeV mass constraint**

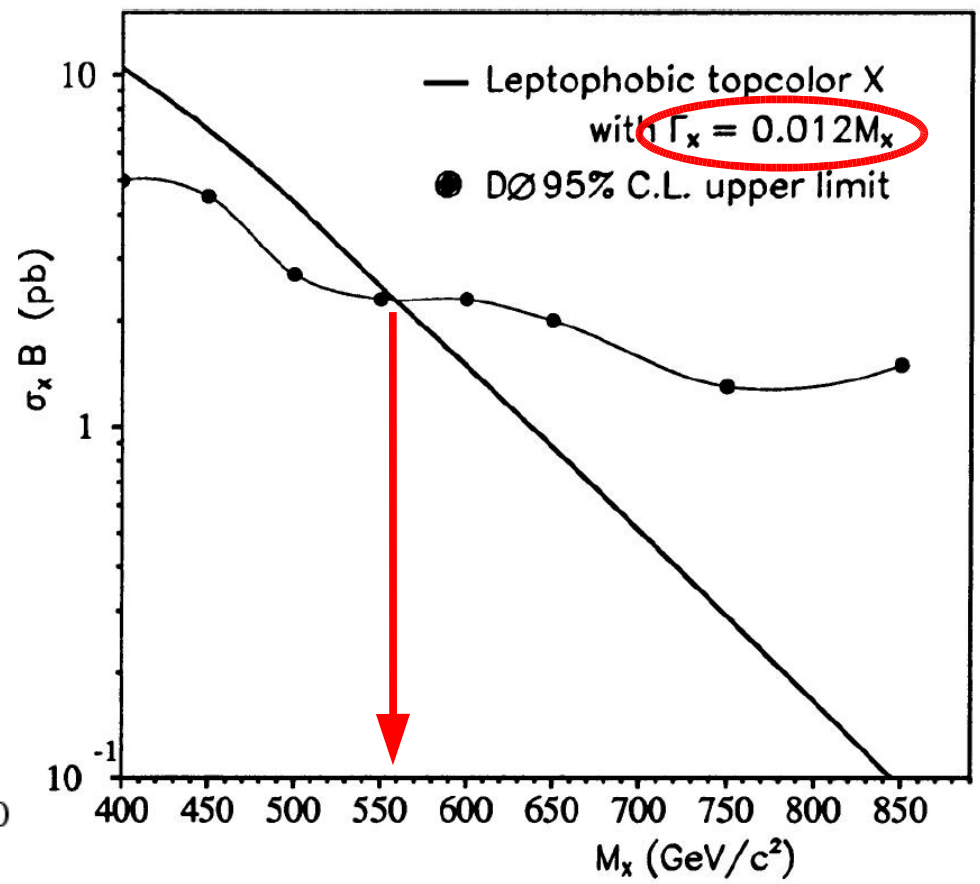
**Invariant W mass**

# Run I Results:

Phys. Rev. Lett. 92, 221804 (2004)

$\Gamma_X = 0.012\ M_X$



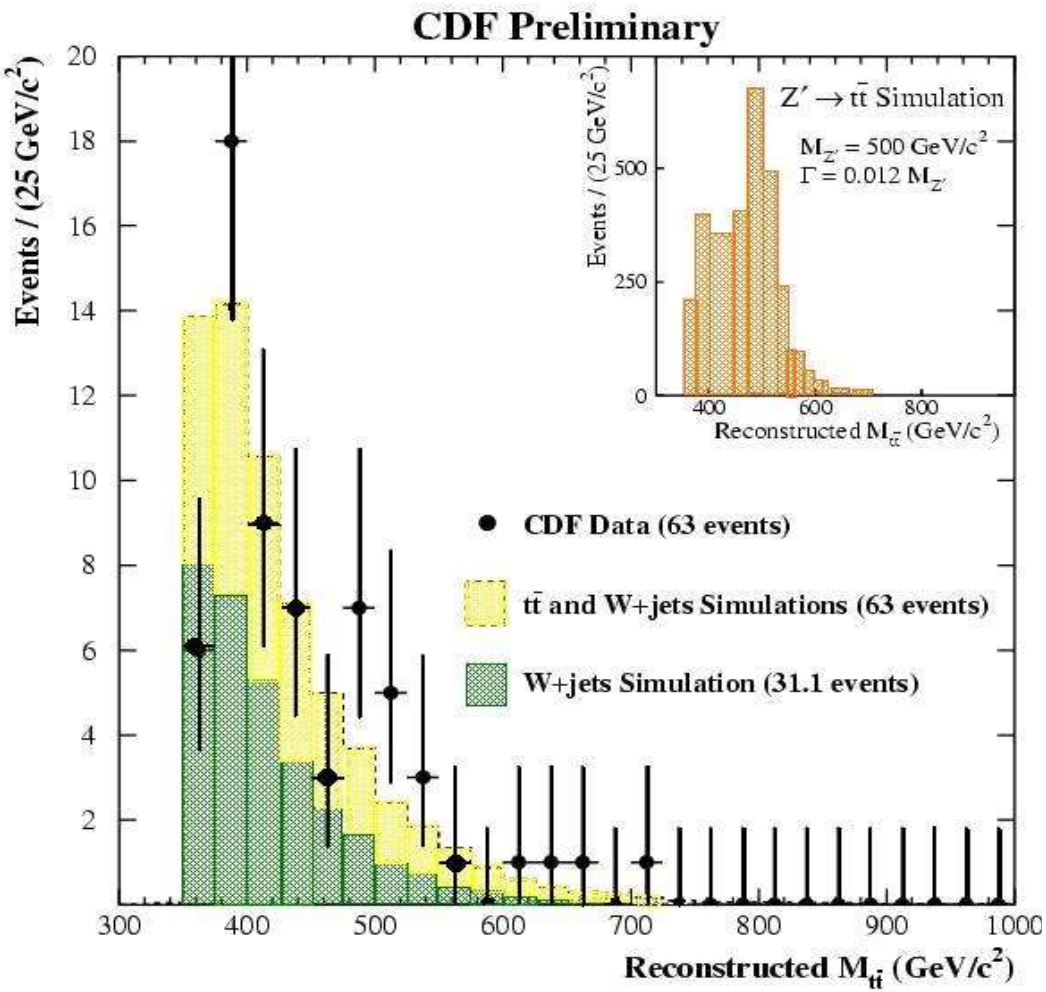



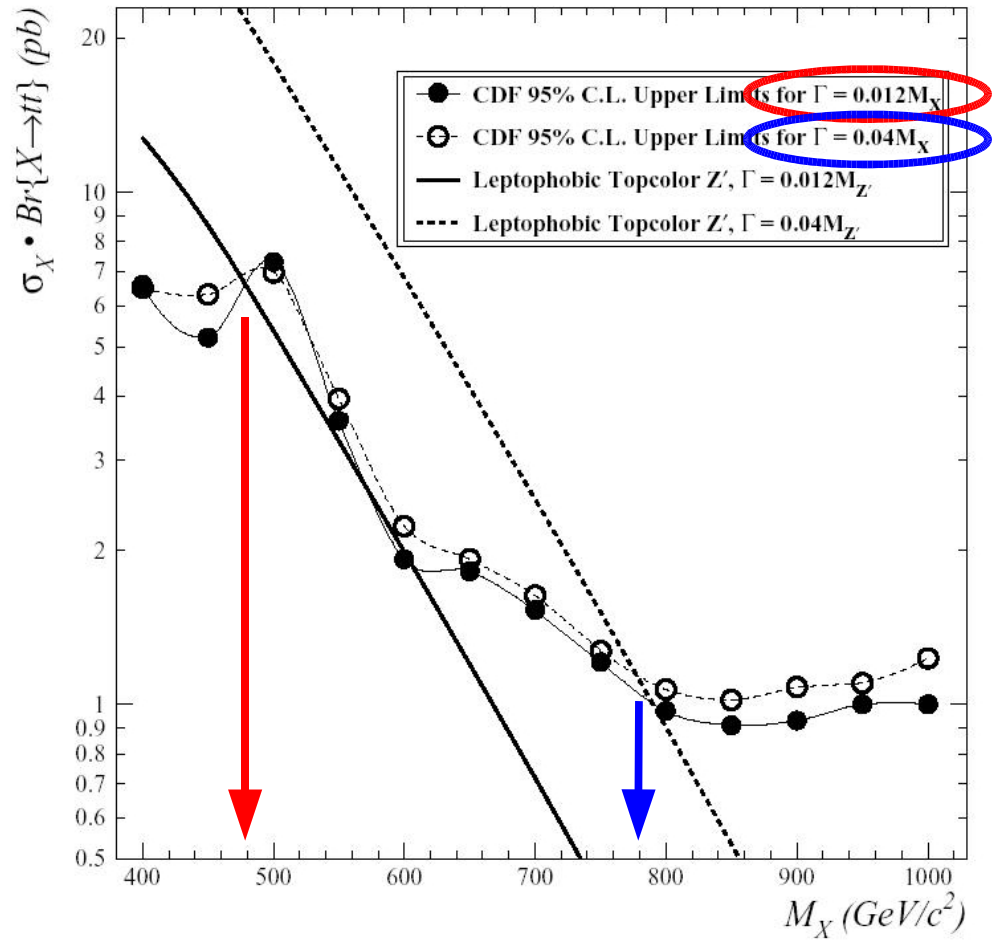

$M_X$ > 560 GeV

# Run I Results:

Phys. Rev. Lett. 85, 2062 (2000)

$\Gamma_X = 0.012\ M_X$




$M_X > 480$ GeV

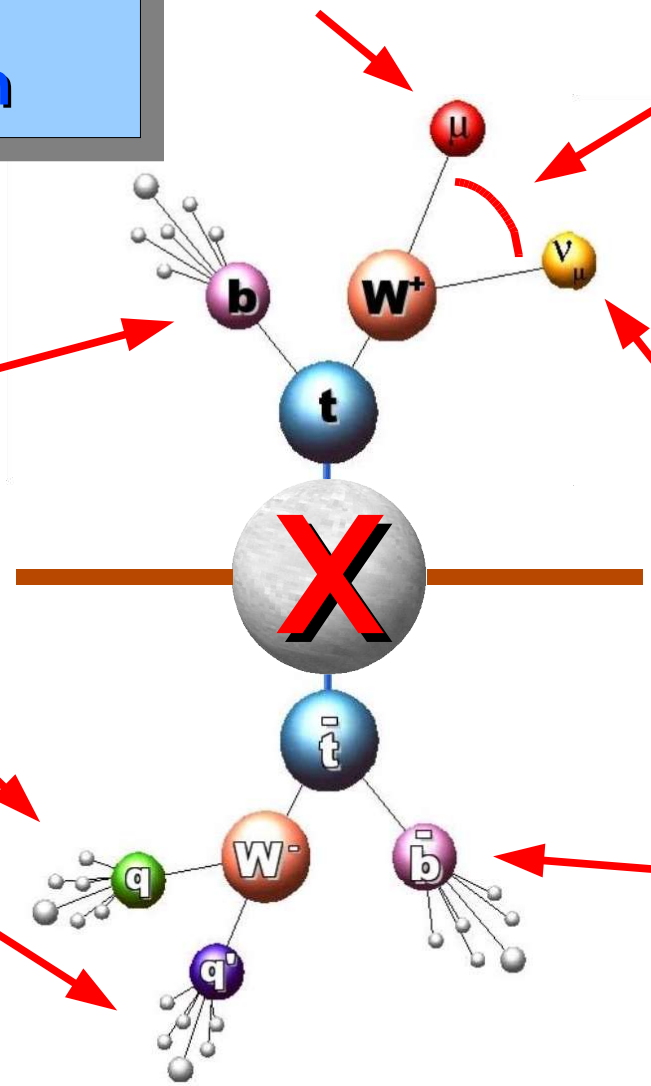
$M_X > 780$ GeV

# NEW Run II Result:

Abstract 290

e ($\mu$) isolated, $p_T > 20$ GeV,
$|\eta| < 1.1$ (2.0),
no other high $p_T$ lepton

minimum $\Delta\phi$




missing $E_T > 20$ GeV

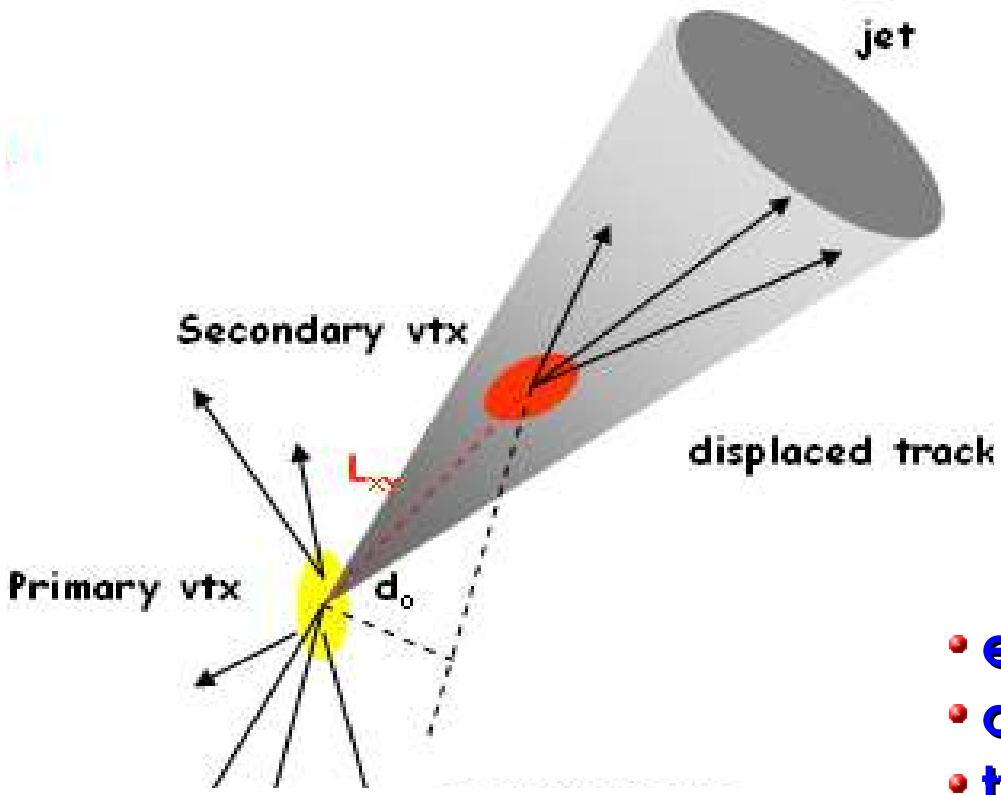
at least 4 jets,
$p_T > 15$ GeV,
$|\eta| < 2.5$

at least 1 jet
b-tagged
(secondary
vertex)

# b-tagging

- B hadrons lifetime $c\tau \sim 450\ \mu m$
- B hadrons travel $L_{xy} \sim 3$ mm before decay

SVT/SVX




- explicitly reconstruct 3D vertices
- cut on decay length significance
- ttbar event tagging efficiency ~60%

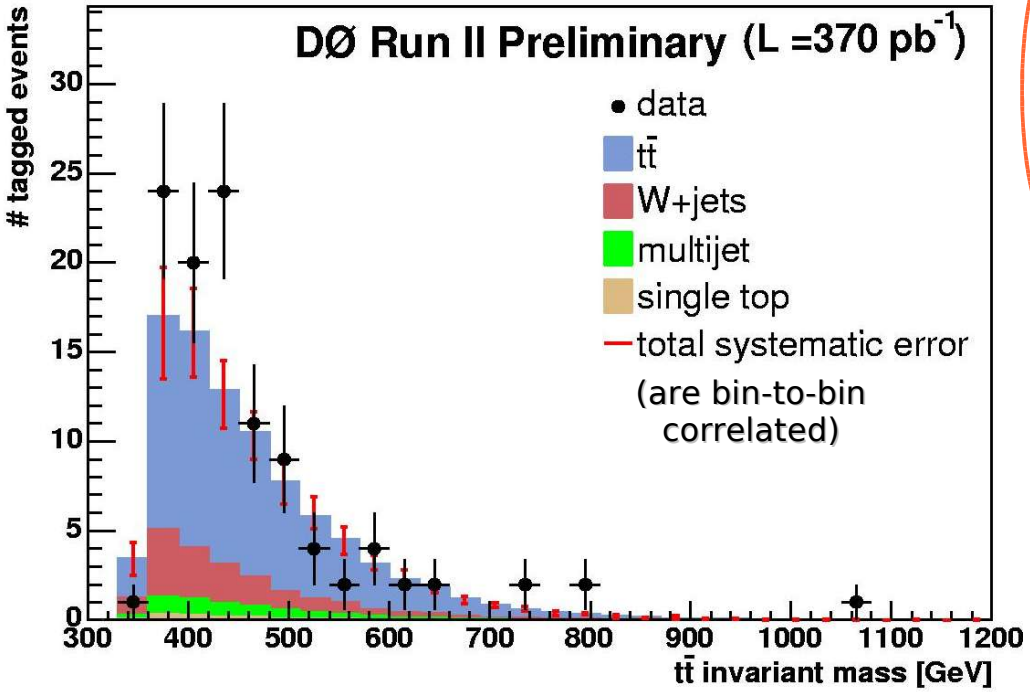
# Results for e, μ + jets combined

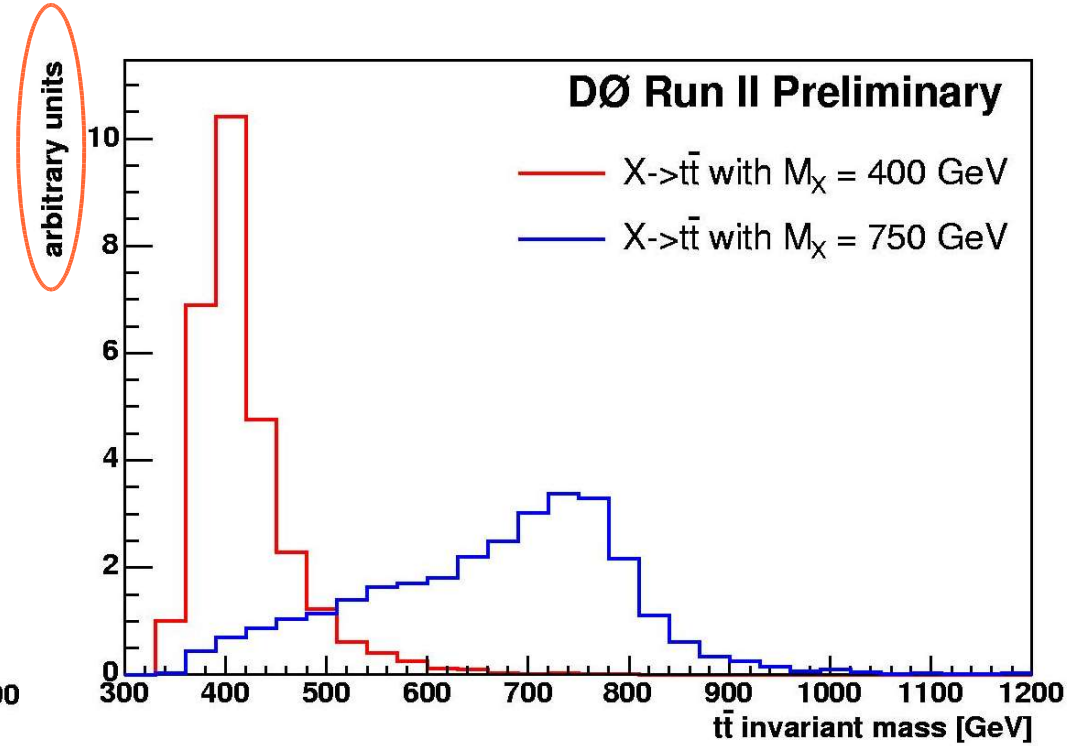
## Data and SM:

SM: use ttbar cross section

6.77 ± 0.42 pb (NNLO)

## Signal:




⇒ e, μ + jets combined: 108 events, 89.2 $^{+11.7}_{-13.2}$ expected

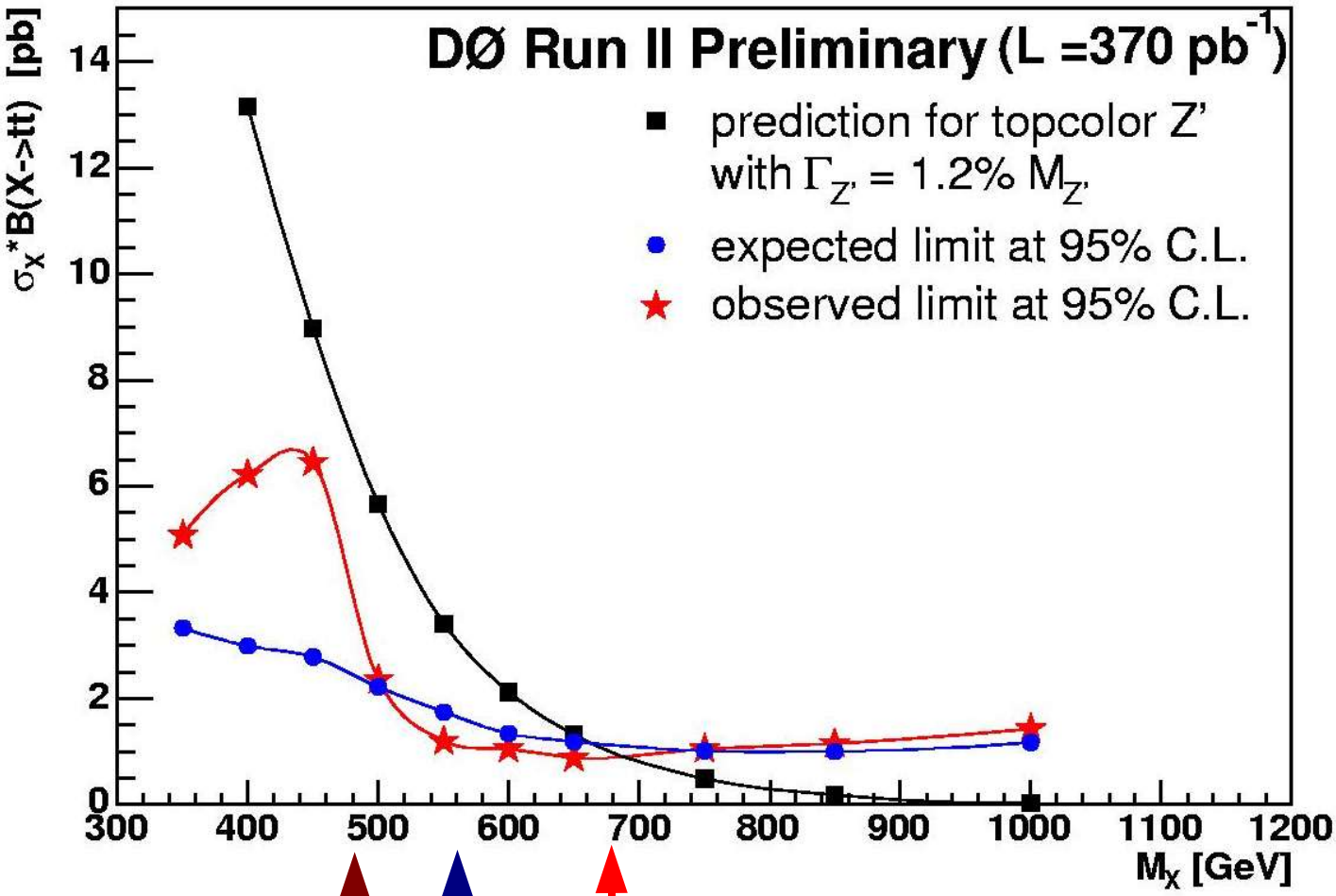
# Systematic Uncertainty

**relative systematic change on overall normalization of SM background:**

| source | rel. syst. uncertainty (%) | |
|---|---|---|
| | $\sigma^+$ | $\sigma^-$ |
| Top quark mass (includes effect on $\sigma_{t\bar{t}}$) | +8.7 | −7.6 |
| Signal subtraction from W+jets background estimate | +0.0 | −6.6 |
| Jet reconstruction | +5.6 | −6.9 |
| Luminosity | +4.6 | −4.6 |
| Theoretical uncertainty on $\sigma_{t\bar{t}}$ | +4.2 | −4.2 |
| $W$+jets flavor composition | +2.9 | −3.0 |
| Jet energy calibration | +2.7 | −3.2 |
| $b$-tagging rate | +2.6 | −2.6 |
| MC-to-data correction factors | +2.5 | −2.5 |
| Theoretical uncertainty on $\sigma_{singletop}$ | +0.2 | −0.2 |
| Total | +13.2 | −14.8 |

- **uncertainties which change shape of invariant mass distribution are also taken into account**

# Limits for e, μ + jets combined




$\Gamma_X = 0.012\ M_X$

- Bayesian approach to calculate 95% C.L. upper limits

CDF Run I | DØ Run I | DØ Run II

$\Rightarrow M_{Z'} > 680$ GeV

# Conclusions

- Search for ttbar production via intermediate resonance
- No evidence for a new resonance
- Run I and Run II results are consistent
- Cross Section limit
- Leptophobic Z': $M_{Z'} > 680$ GeV, $\Gamma_X = 0.012\ M_X$
- Improves Run I limit by 120 GeV
- Stay tuned for the CDF analysis to come

→ Very interesting to include more data into the analysis