

A Top Pair Resonance Search At DØ

Amnon Harel

University of Rochester

APS April Meeting 2006, Dallas, Texas.

Tevatron Run II



The Tevatron delivered over 1fb^{-1} (per experiment).

The predicted integrated luminosity by 2009 is between 4 and 8fb^{-1}

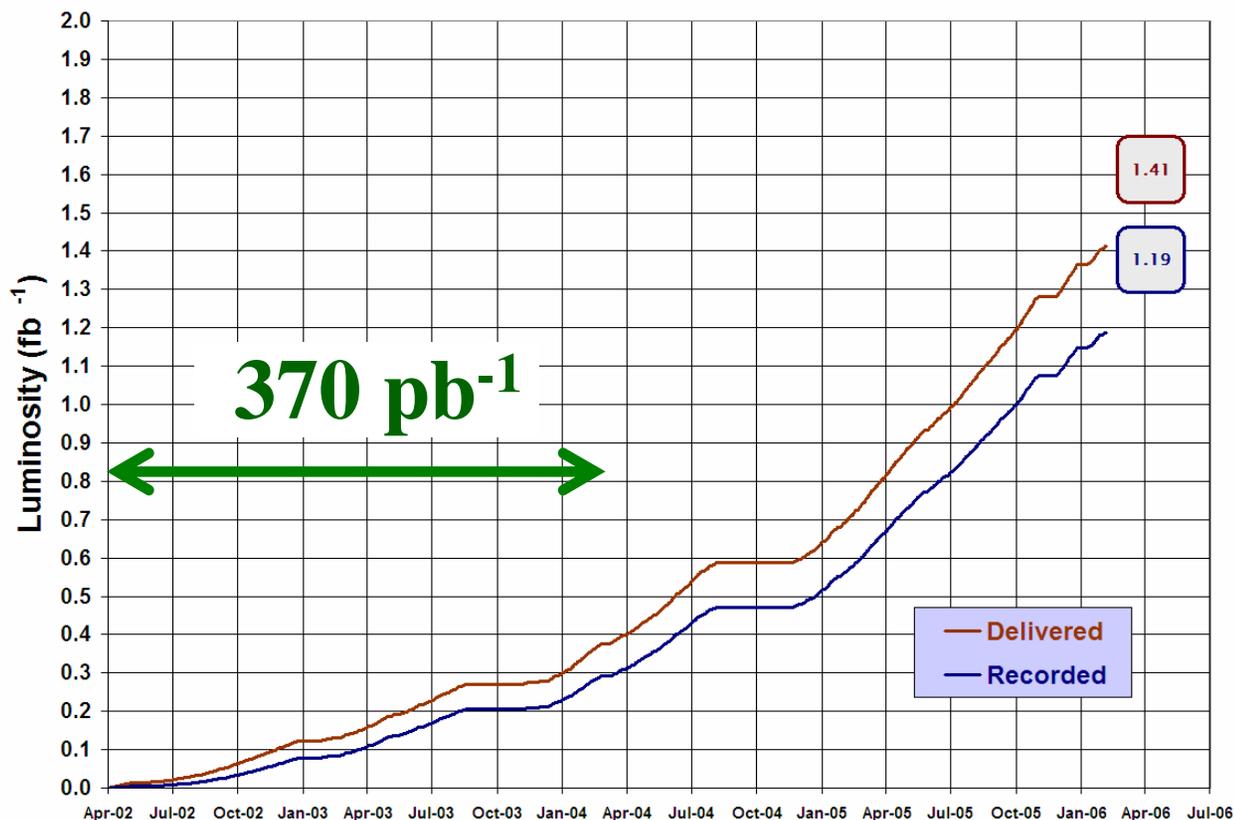
Tevatron Run II began on March 1st 2001.

The Tevatron collides protons and antiprotons at a center of mass energy of 1.96 TeV

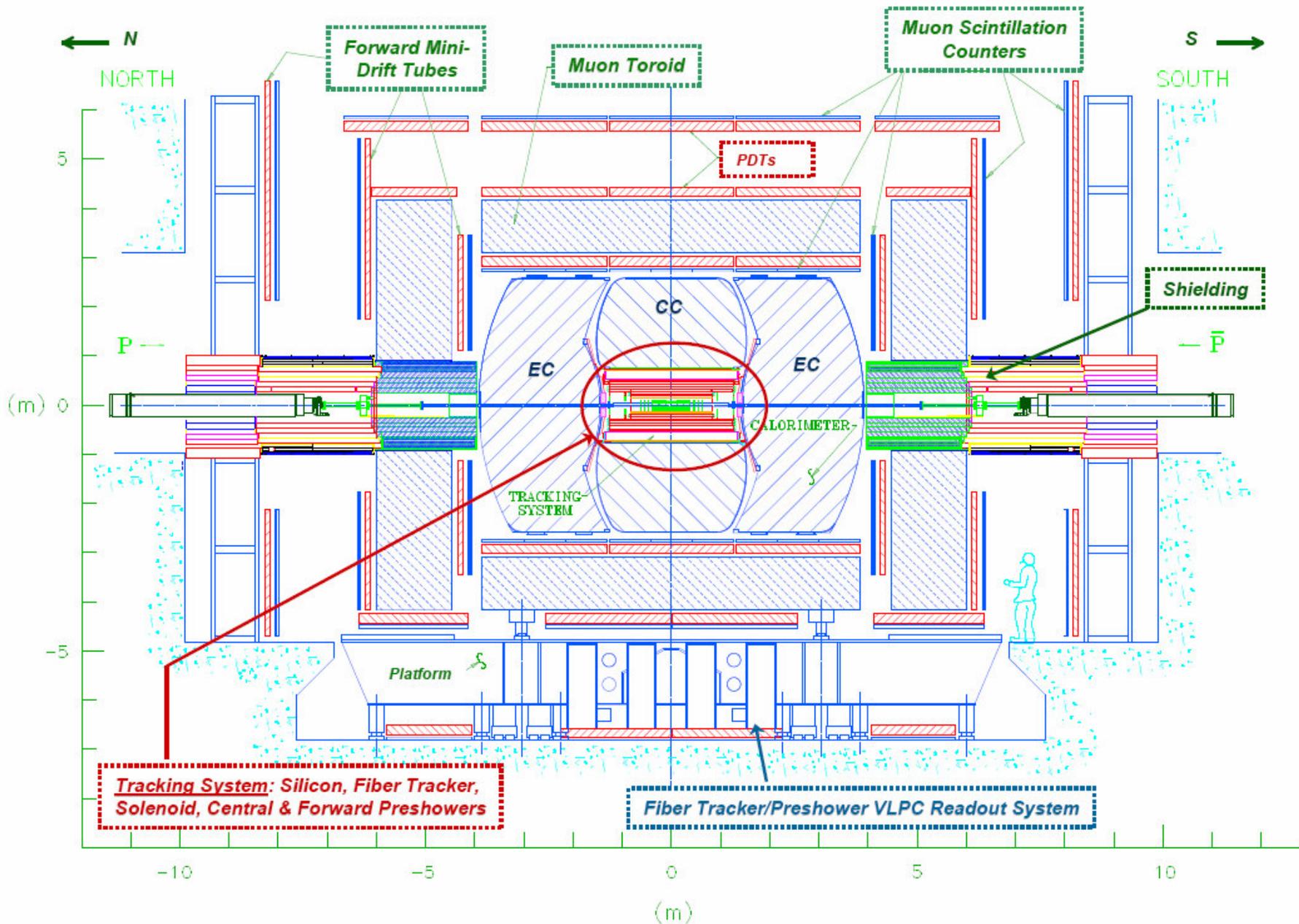


Run II Integrated Luminosity

19 April 2002 - 22 February 2006



The DØ Detector



Introduction

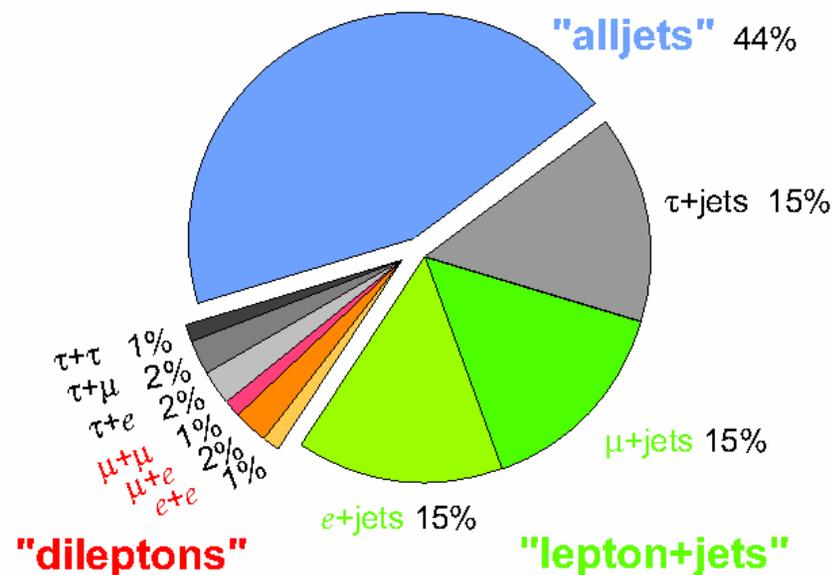
The large mass of the top quark suggests it may play a special role in electroweak symmetry breaking. The Standard Model predicts non resonant top production. A significant bump would indicate a narrow resonance \rightarrow new physics.

Top production studies serve in preparation for the LHC, where top production will be a large background for many new physics searches.

This search was done in the lepton + jets channel.

- the isolated lepton (e/μ , possibly through an intermediate τ) helps reduce multi jet background
- the large branching ratio yield good statistics

Top Pair Branching Fractions



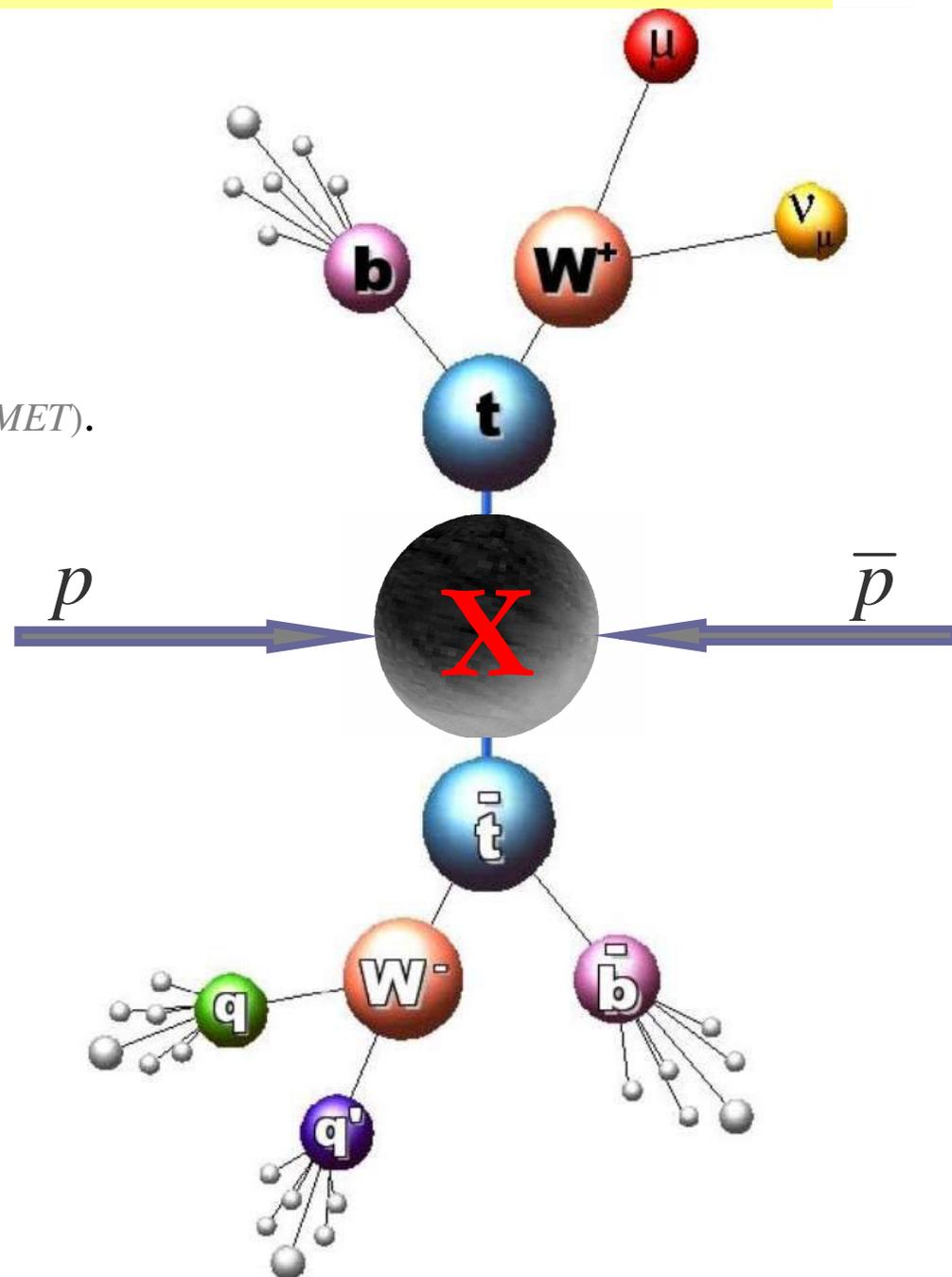
Event Selection

Main Signature

- A lepton (e/μ) + jets trigger.
- A $p_T > 20 \text{ GeV}$ isolated lepton with $|\eta| < 1.1$ (e) or $|\eta| < 2.0$ (μ).
- At least 20 GeV of missing transverse energy (MET).
- Four or more $p_T > 15 \text{ GeV}$ jets with $|\eta| < 2.5$
- At least one jet is b-tagged by reconstructing a displaced secondary vertex.

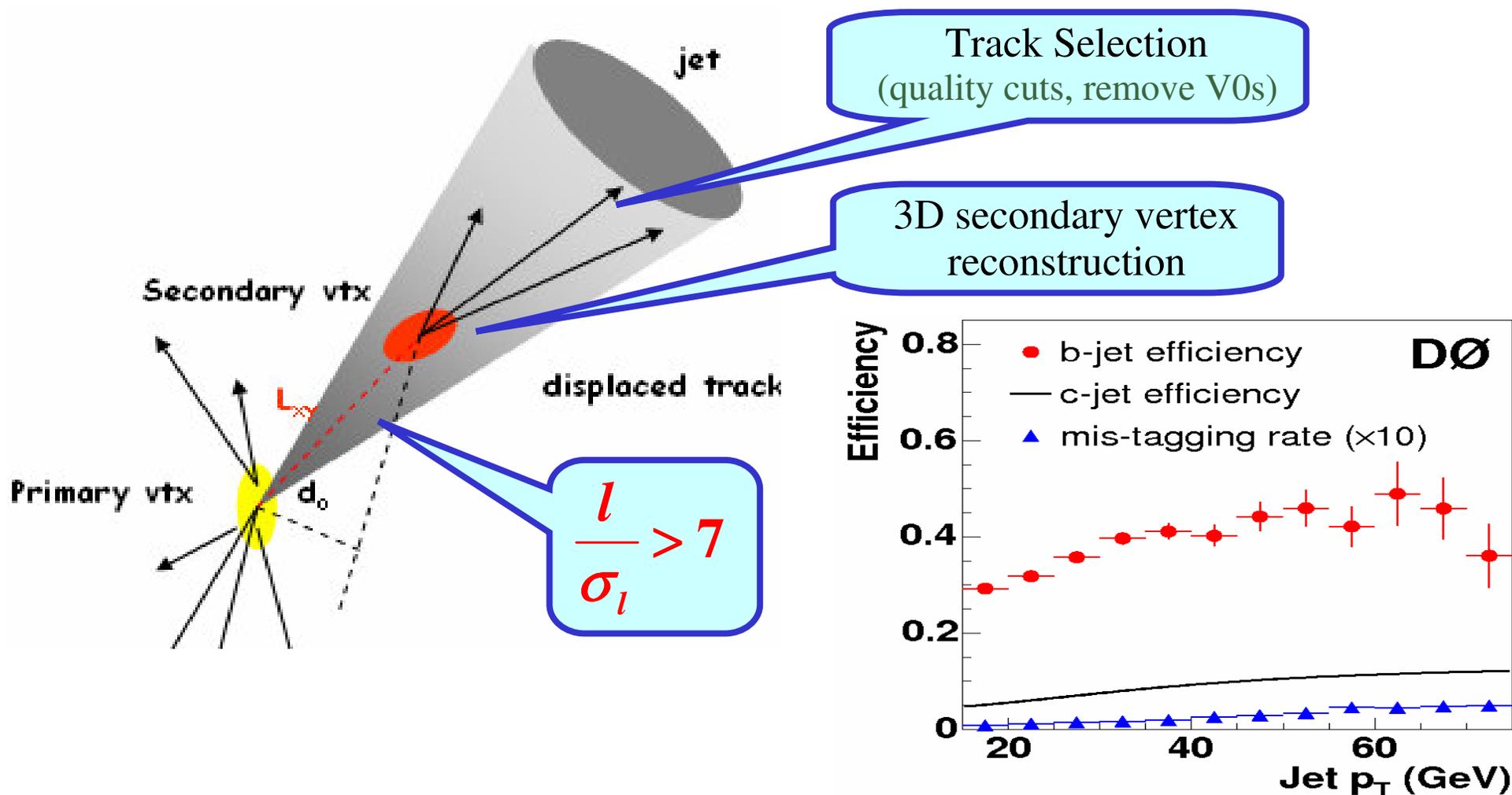
Additional Cuts

- Central primary vertex location ($|z| < 60 \text{ cm}$).
- A triangular cut in $\Delta\Phi(l, MET)$ vs MET
- A veto on a second high p_T lepton.
- Kinematic fit converges



B-tagging

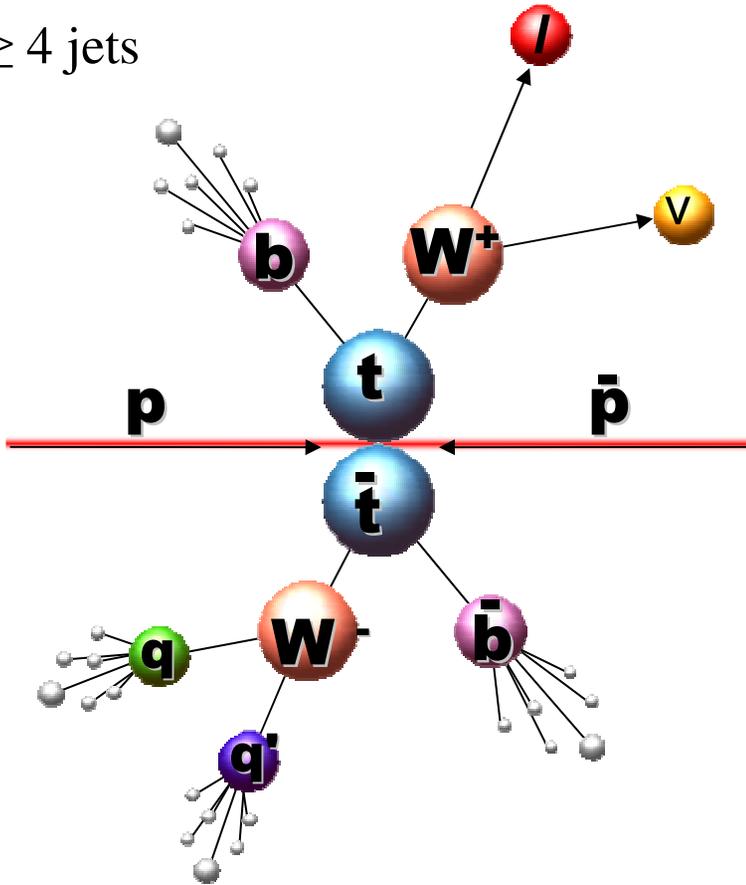
- B hadrons' lifetime: $c\tau \sim 450 \mu\text{m}$
- B hadrons travel $L_{xy} \sim 3 \text{ mm}$ before decay



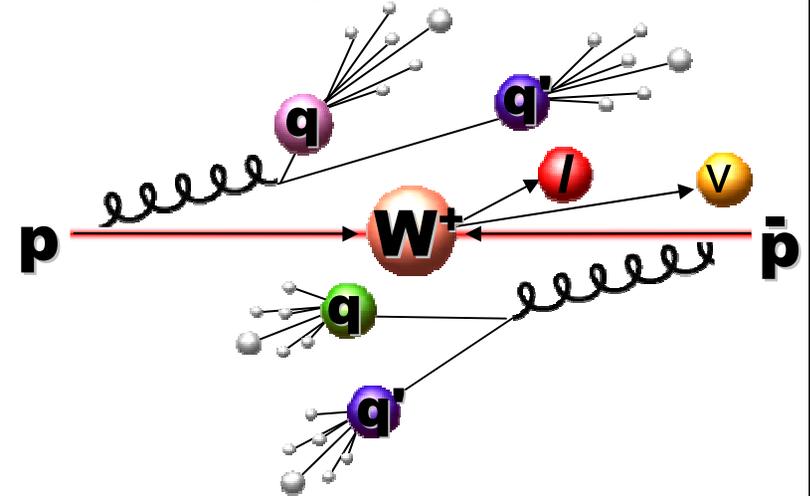
The Main Backgrounds

SM top pairs (l+jets)

- Same signature \rightarrow dominant background
- A lepton with high p_T
- A neutrino \rightarrow MET
- ≥ 4 jets

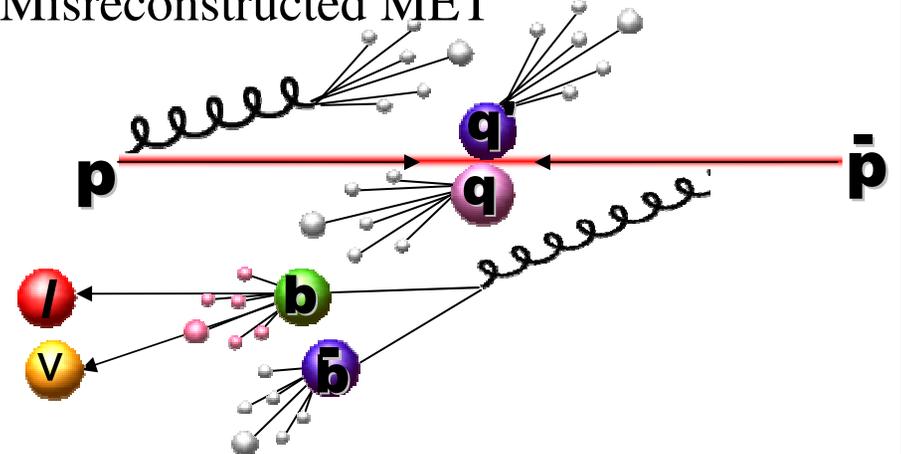


$W \rightarrow lv + \geq 4$ jets

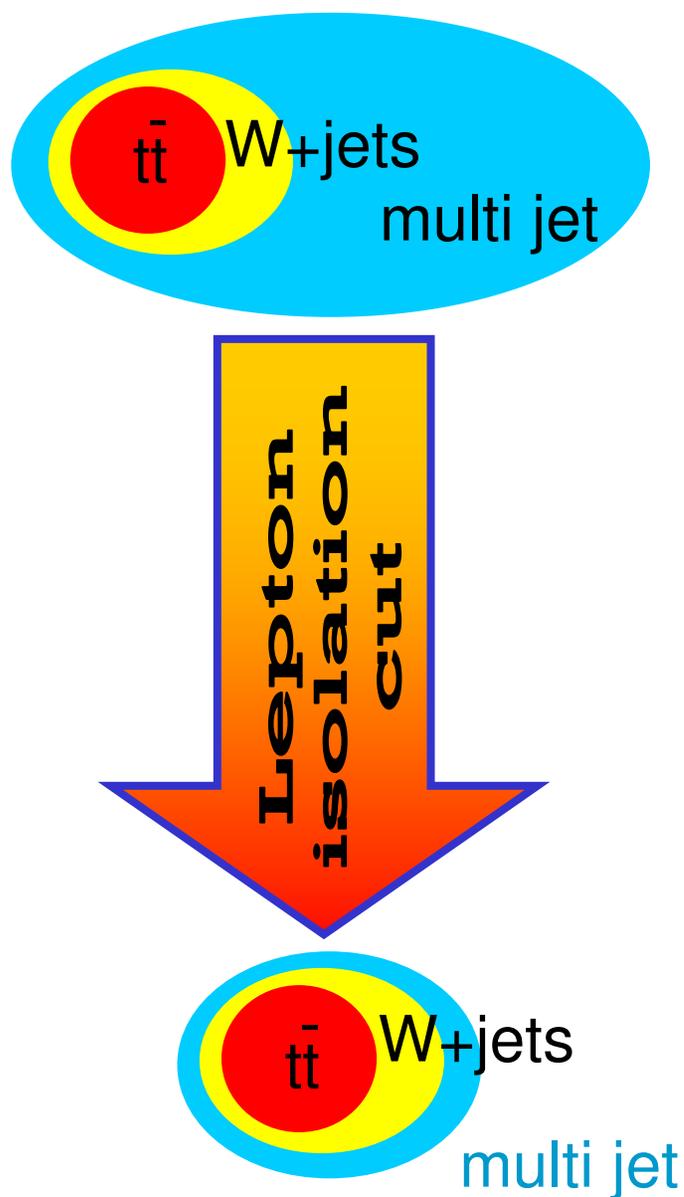


Multi jet events

- Fake isolated lepton (often $b \rightarrow lX$)
- Mismeasured MET



Multi jet Background Estimation



The efficiencies of μ -isolation & e-id are:

- Very different for real leptons and for multi jet events
- Well understood in the signal simulation

This makes them ideal for the matrix method:

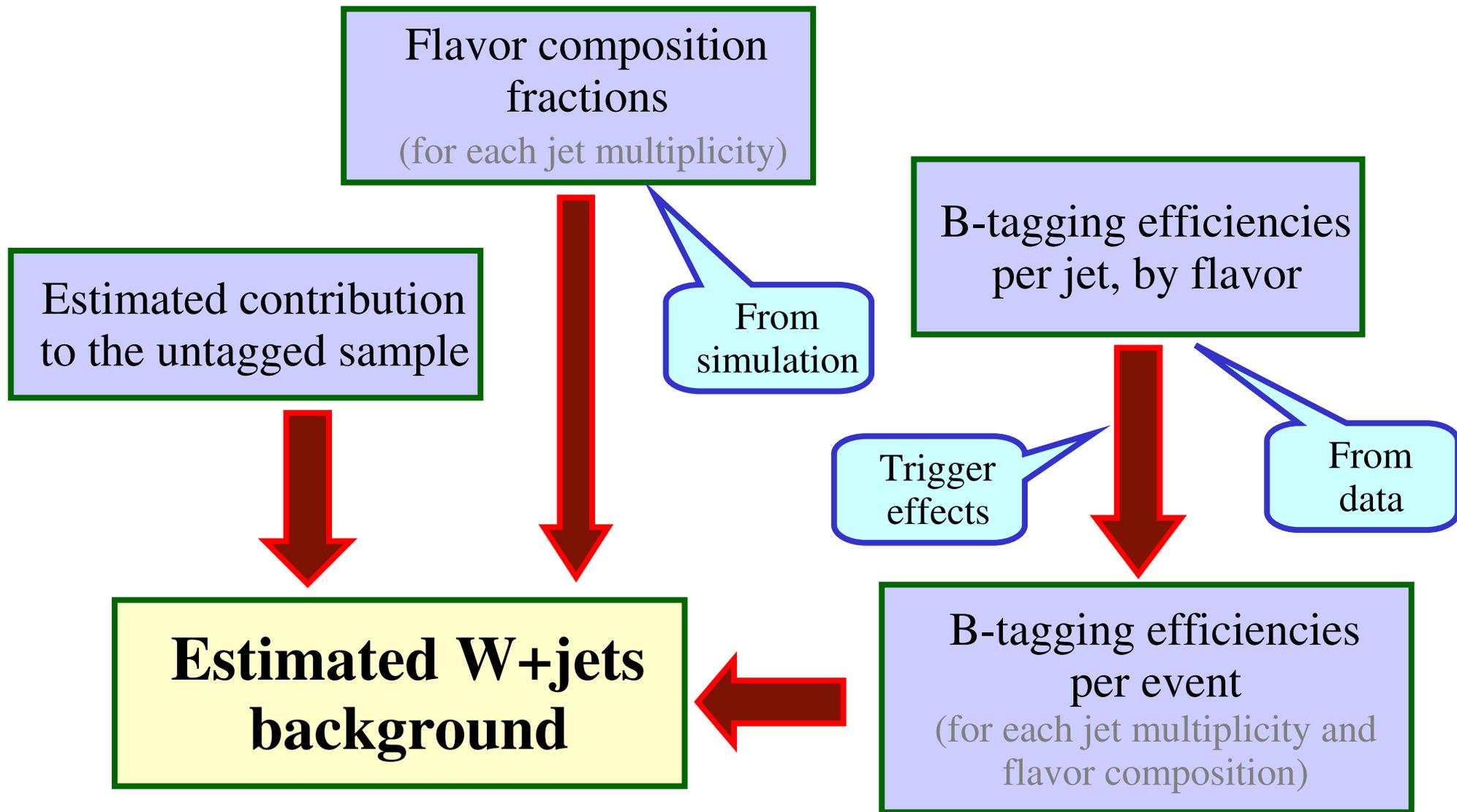
$$N_{\text{loose}} = N^{W+tt} + N^{\text{QCD}}$$

$$N_{\text{tight}} = \epsilon_{W+tt} N^{W+tt} + \epsilon_{\text{QCD}} N^{\text{QCD}}$$

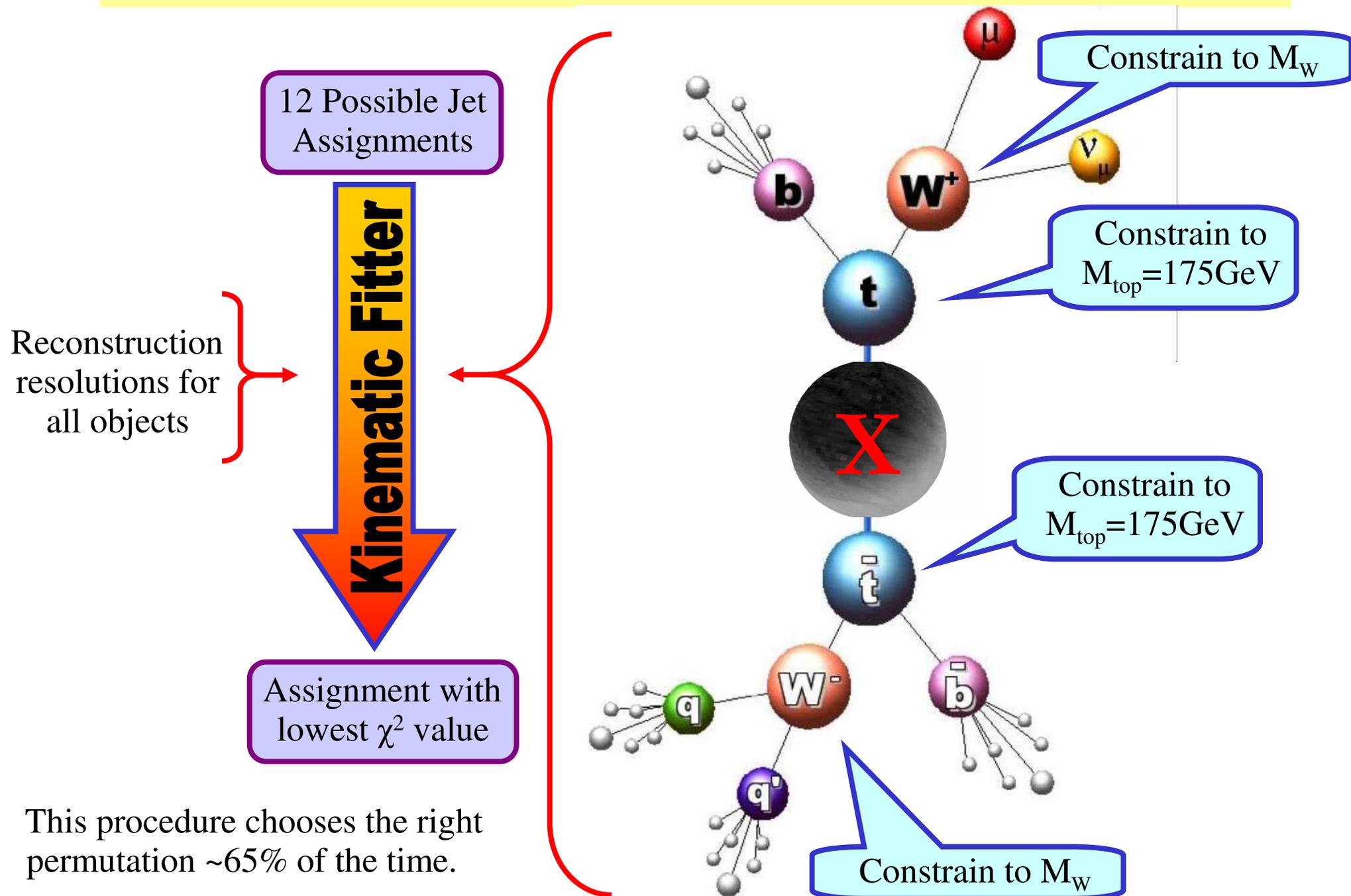
$$\epsilon_{W+tt} \approx 85\%, \quad \epsilon_{\text{QCD}} \approx 10-16\%$$

Derived from a similar
"untagged" data sample
depleted in true leptons

W+jets Background Estimation



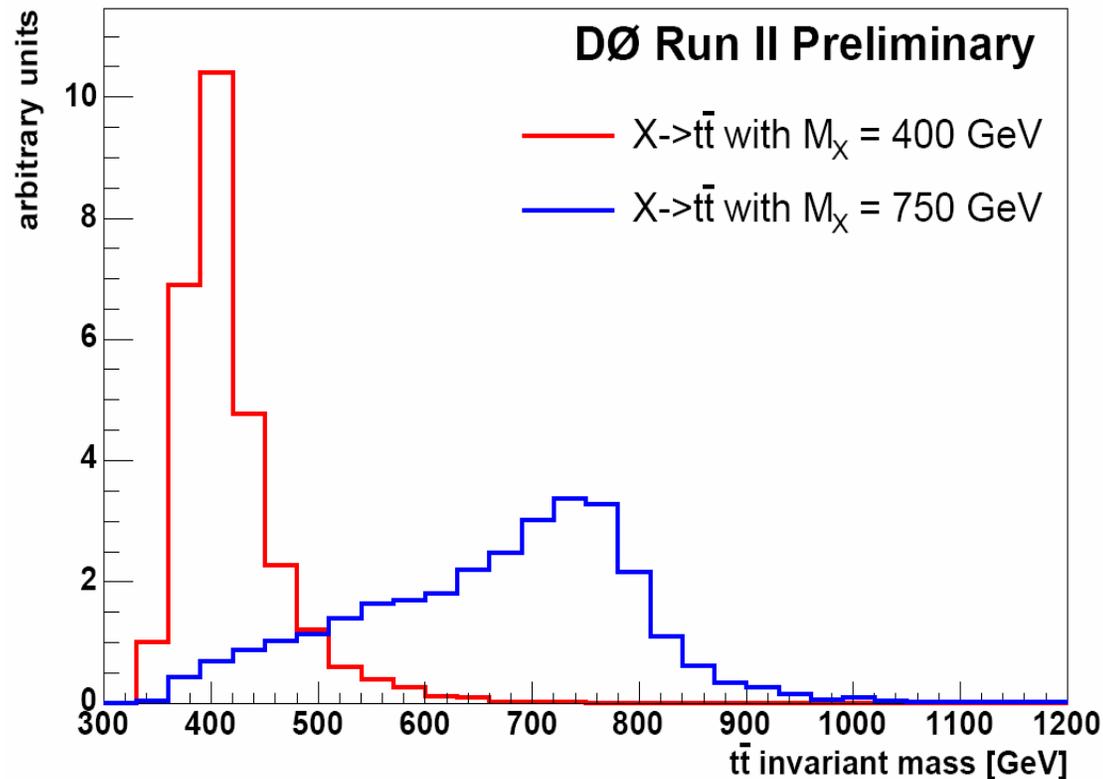
Kinematic Fit



Signal Mass Distributions

Simulated a Z' -like X using PYTHIA:

- spin=1
- produced in $q\bar{q} \rightarrow X$
- Forced to decay to a top pair.
- $\Gamma_X = 0.012M_X$



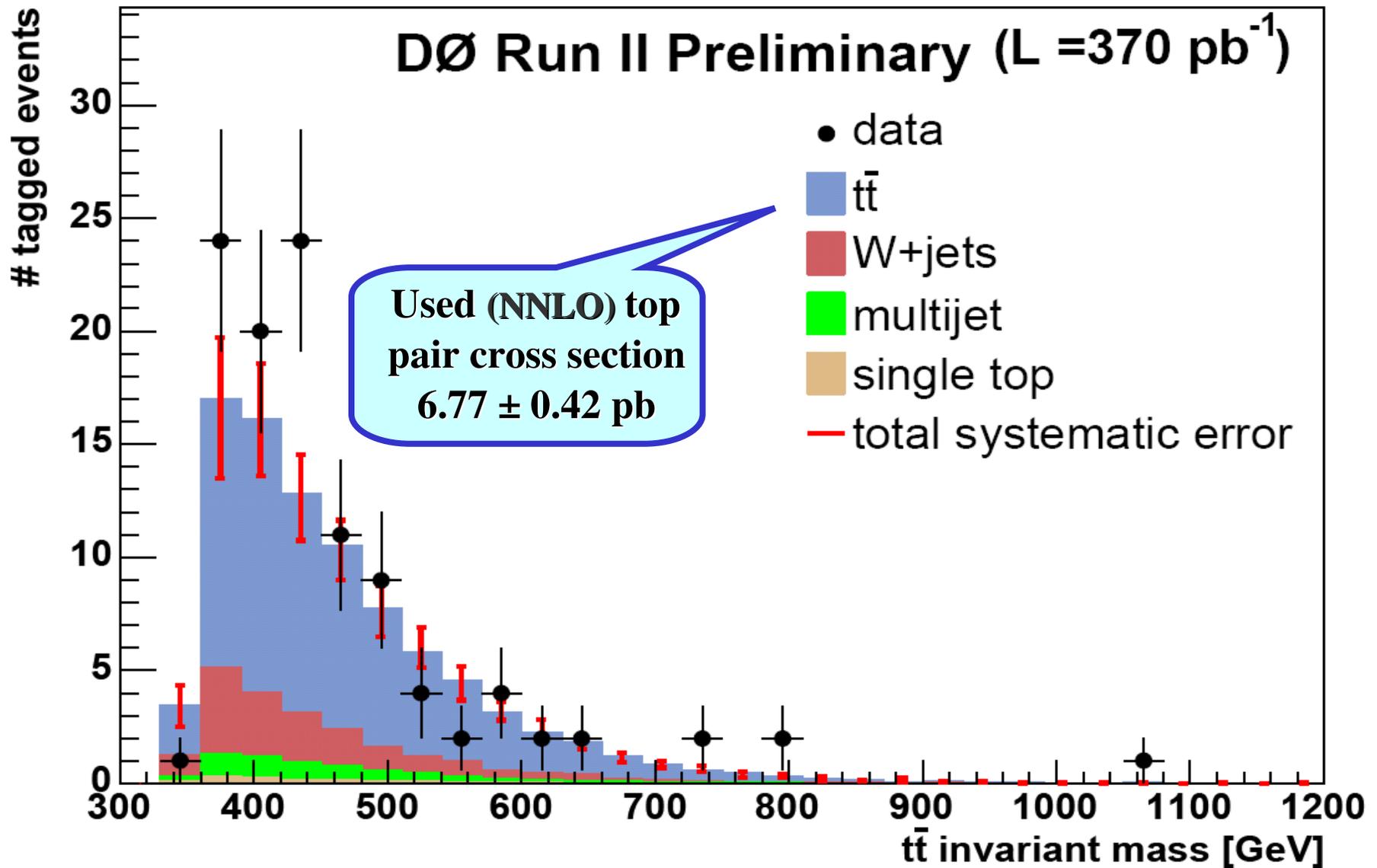
1. Two partons end up in one jet, and an additional gluon jet is picked up instead.
2. Many hard jets \rightarrow Inferior MET
3. PDFs enhance low mass production

Systematic Uncertainties

Effects on the overall normalization of SM contributions.

source	rel. syst. uncertainty (%)	
	σ^+	σ^-
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

Observed Mass Distribution

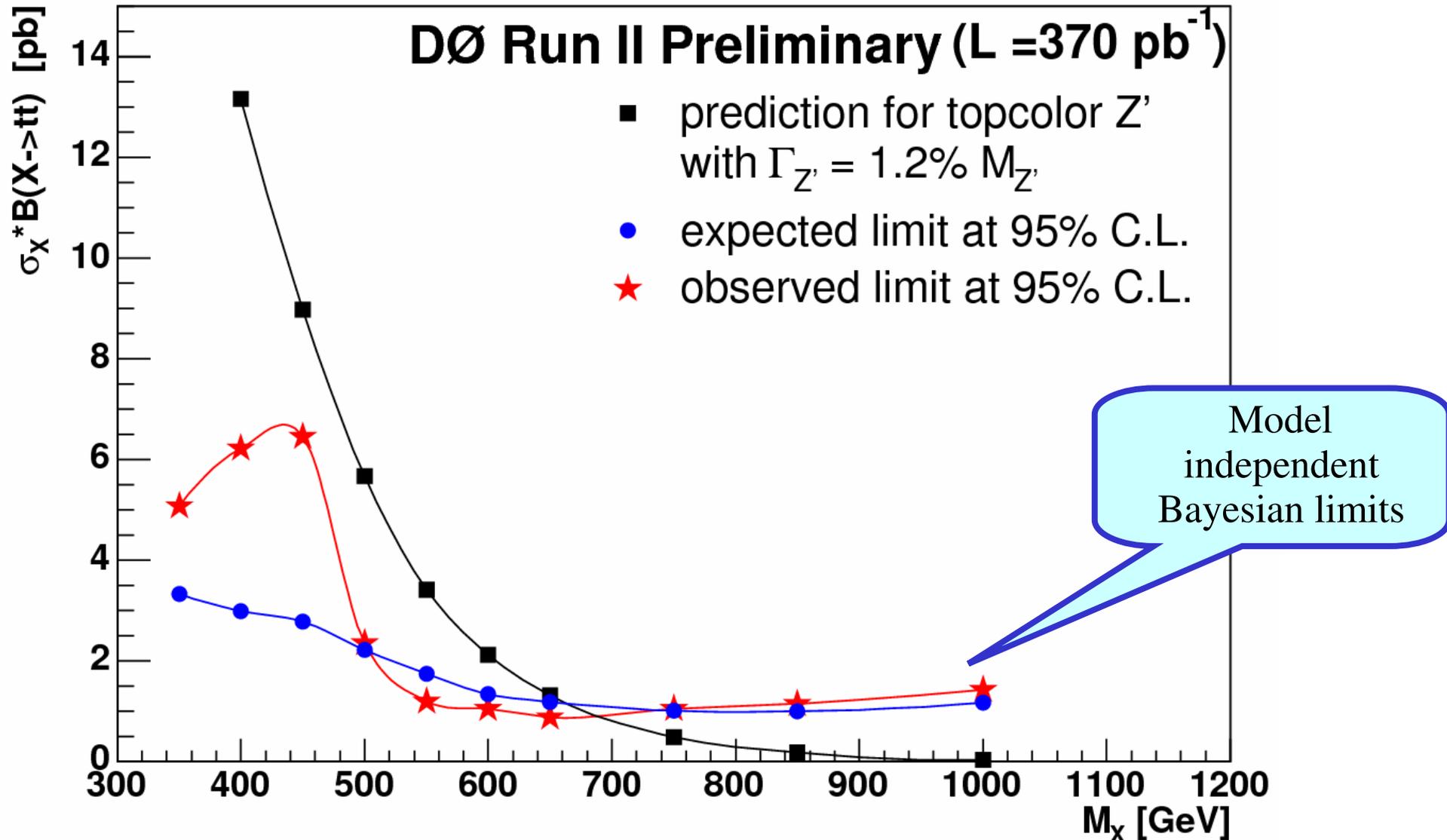


Number of events expected: $89.2^{+11.8}_{-13.3}$

Observed: 108

(in both channel combined)

Upper Limits



Exclusion for the leptophobic Z' boson (part of a topcolor model) in Harris, Hill, Parke, hep-ph/9911288: $M_{Z'} > 680 \text{ GeV}$

Conclusions

Performed a search for a narrow top pair resonance in the lepton + jets channel using 370 pb⁻¹ of integrated luminosity.

No evidence for resonant top pair production.

Set a limit on a leptophobic Z' : $M_{Z'} > 680 \text{ GeV}$