



EPS 2005

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On behalf of the DØ collaboration

Measurement of the Top Quark Pair Production Cross Section in the Lepton+Jets Final State with DØ Run II Data

Two analyses presented

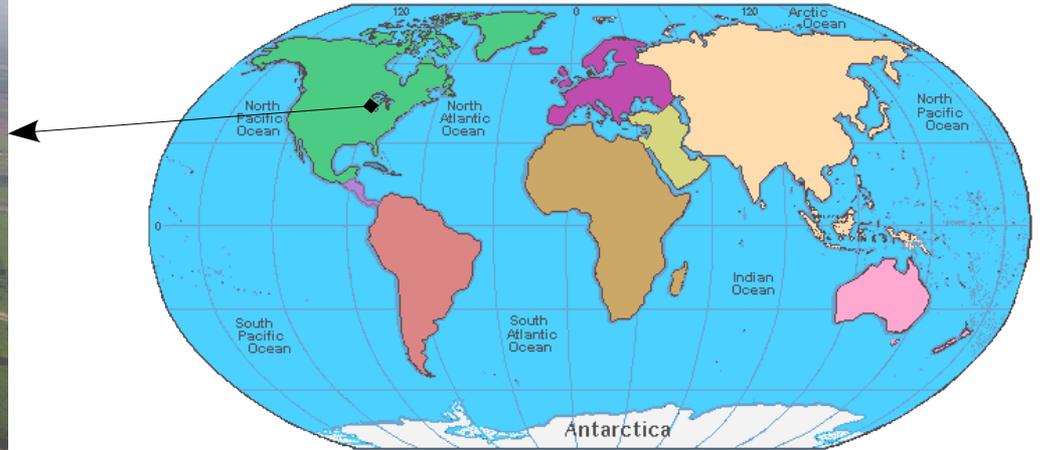
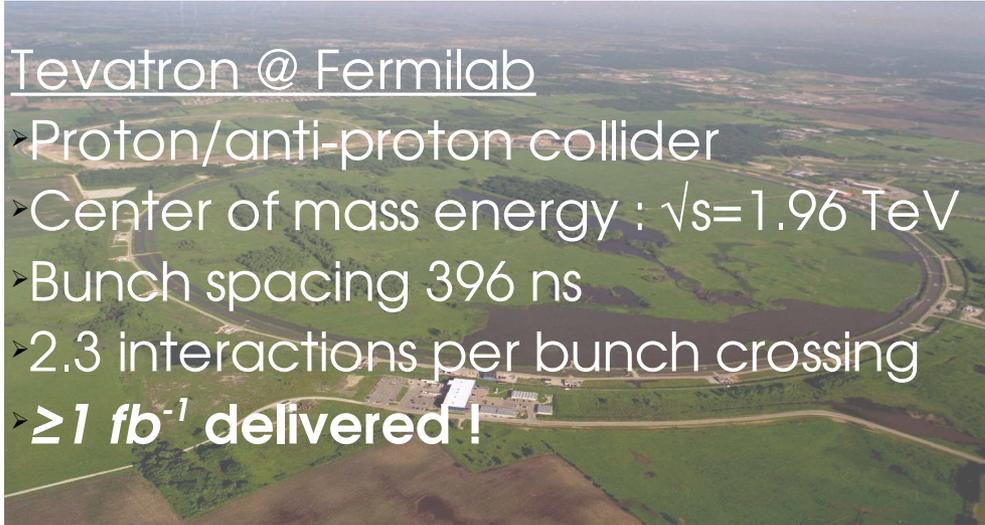
- ✓ Using event kinematics
- ✓ Using lifetime b-tagging



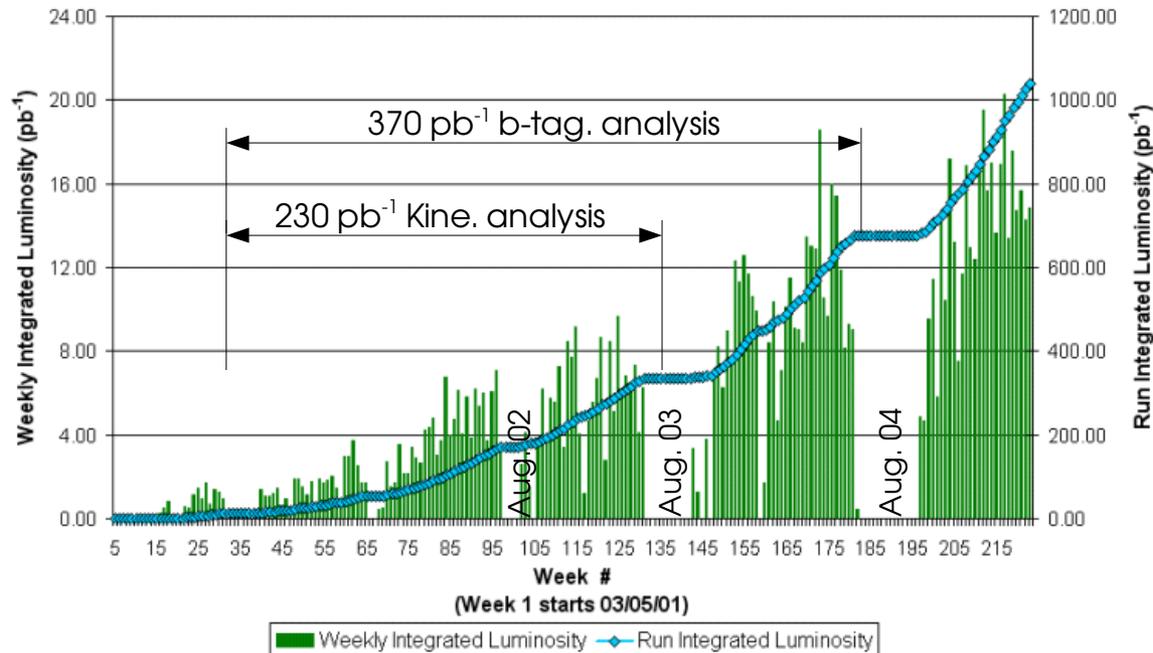
The Tevatron Run II

Tevatron @ Fermilab

- Proton/anti-proton collider
- Center of mass energy : $\sqrt{s}=1.96$ TeV
- Bunch spacing 396 ns
- 2.3 interactions per bunch crossing
- ≥ 1 fb⁻¹ delivered !



Collider Run II Integrated Luminosity





Top Quark

- 6th SM quark
- Large mass $174.3 \pm 3.4 \text{ GeV}/c^2$: “natural mass”
- Lifetime ($\sim 5 \cdot 10^{-25} \text{ s}$) shorter than hadronisation time ($\sim 10^{-23} \text{ s}$) : “free quark”
- $\text{BR}(t \rightarrow Wb) \sim 100\%$ (within SM)

Top production at the Tevatron ($\sqrt{s} = 1.96 \text{ TeV}$)

- ➔ Single top : electroweak process : 3 pb (mass = 175 GeV) not yet observed
- ➔ Pair production : strong process : $6.7 \pm 0.8 \text{ pb}$ (hep-ph/0303085, mass = 175 GeV)

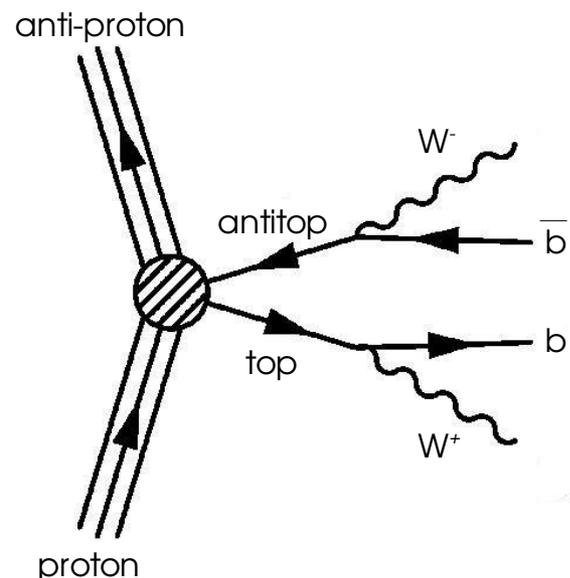
Top pair production of interest

- ✓ Study top quark's properties
- ✓ Test the SM/perturbative QCD
- ✓ Background to new physics signals

Top production at the LHC

- ➔ Single top production : 250 pb
- ➔ Pair production : 800 pb

Top quark pair decay



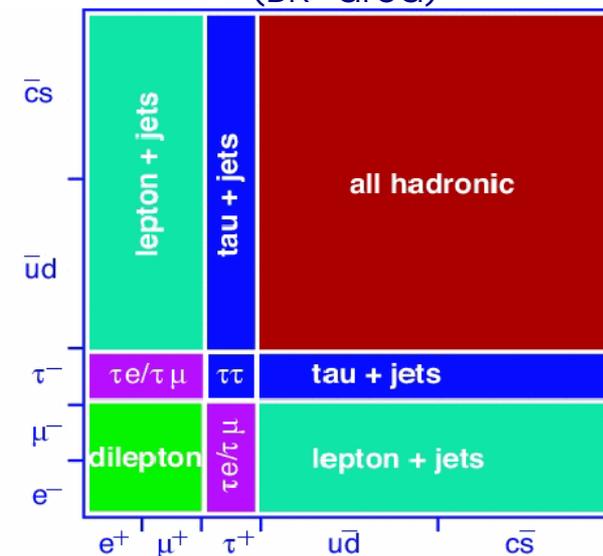
Top decays before hadronisation
BR($t \rightarrow Wb$) \sim 100%

→ W decay modes

- 67% : quark/anti-quark
- 11%/flavor : lepton/neutrino

→ At least 2 b-jets

Top pair decay modes
(BR~area)

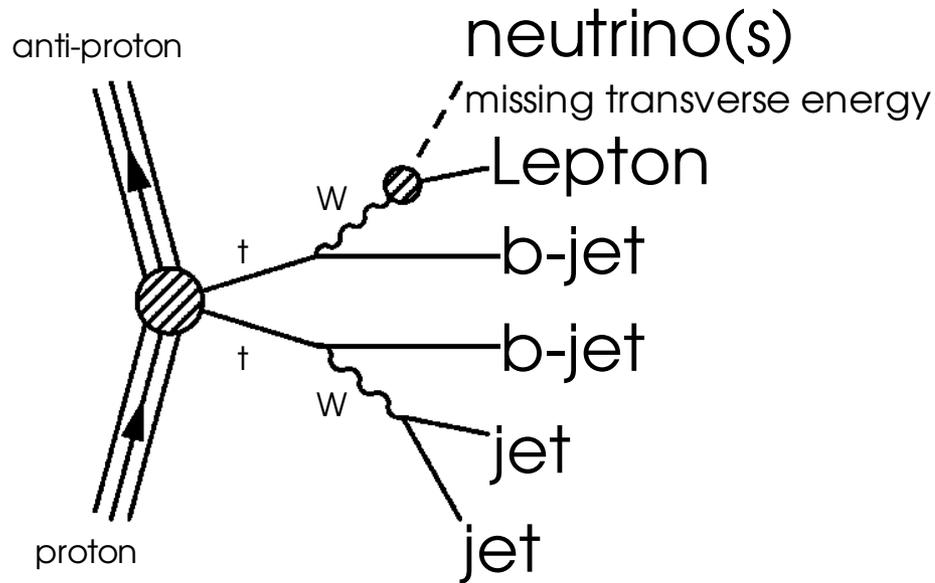


- **All hadronic** BR~45%
6 jets (at least 2 b-jets)
→ Large multijet background
- **Dilepton** BR($\ell\ell'$)~2.4%, BR($\ell\ell$)~1.2%
2 leptons, 2 neutrinos, 2 b-jets
→ Clean channel but low stat
- **Lepton+jets** BR~15%
1 lepton, 1 neutrinos, 4 jets (at least 2 b-jets)
→ Optimum stat/background

No $\tau+X$ analysis so far

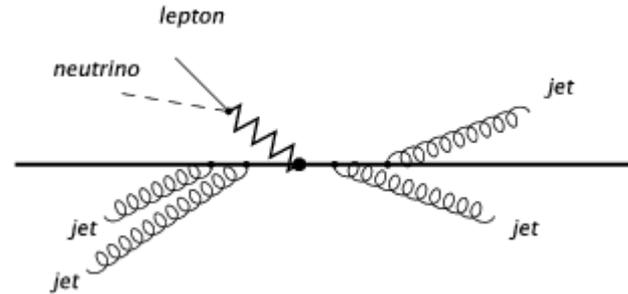
muon+jets and
electron+jets shown

Lepton + jets channel



Irreducible backgrounds

✓W from hard process + jets radiated



✓Single top + jets

✓Diboson → lepton + jets

Other backgrounds

✓QCD (estimated from data)

• Jet → fake e (ex. $\pi^0 \rightarrow 2\gamma$, $\eta \rightarrow 2\gamma$)

• Jet → fake μ (semileptonic b-decay)

✓Diboson → dilepton + jets

✓Top pair → dilepton channel

Event kinematics analysis

→W+jets is the main background

→QCD background

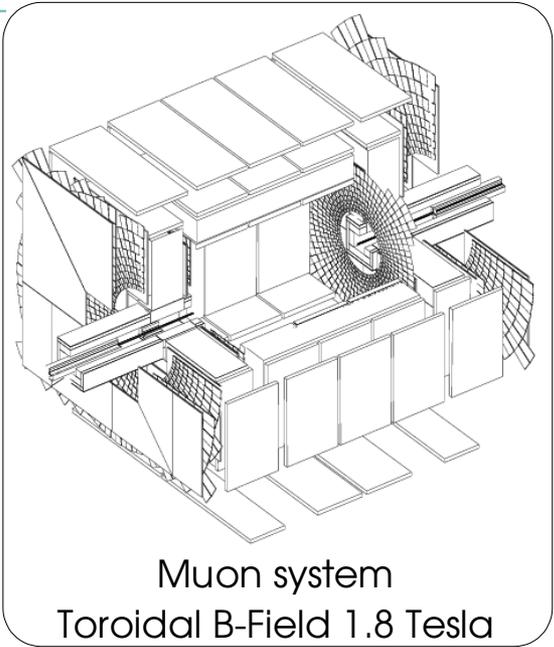
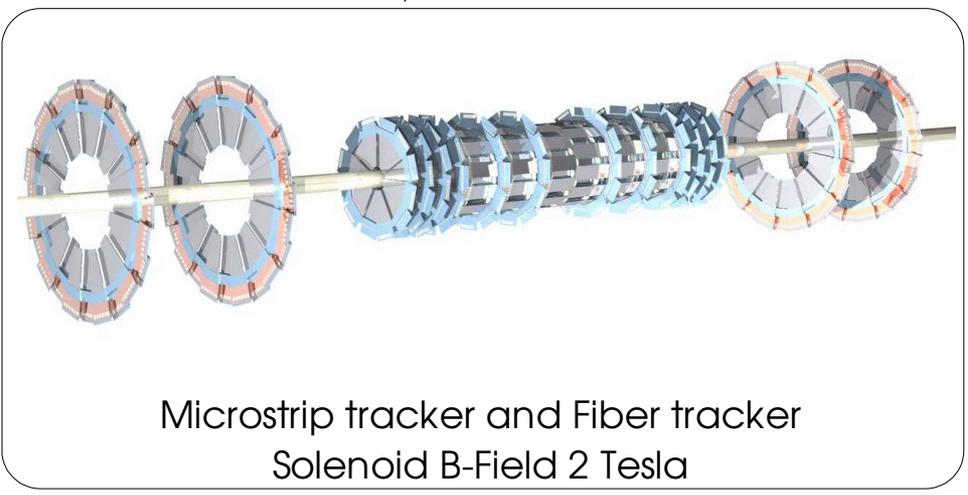
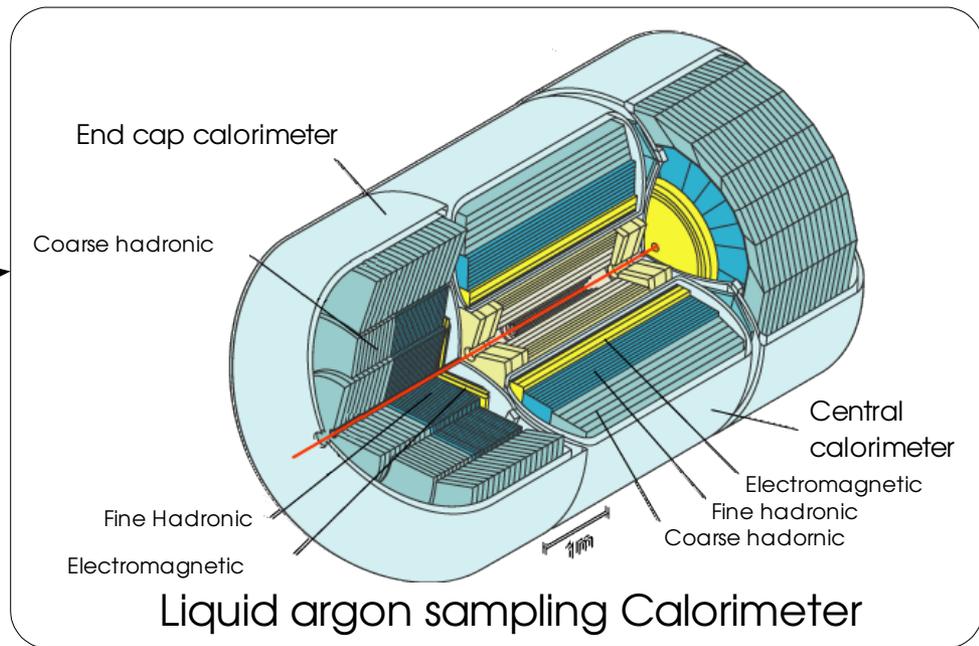
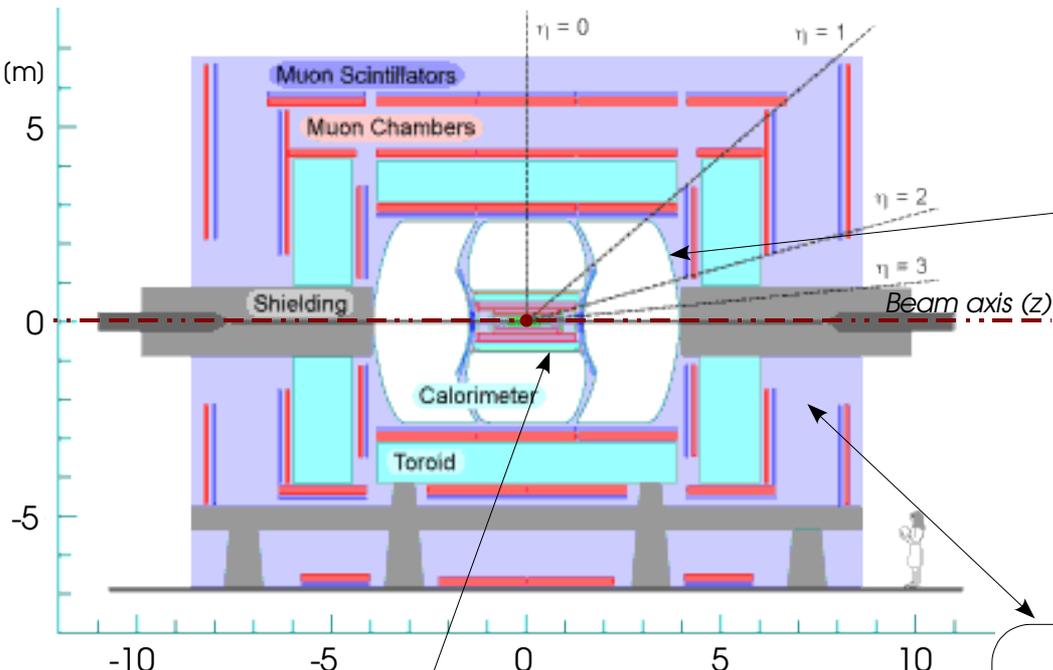
→Dilepton channel taken into account

b-tagging analysis

→W+jets jet flavour taken from Monte Carlo

→All others mentioned backgrounds taken into account

The DØ Run II detector



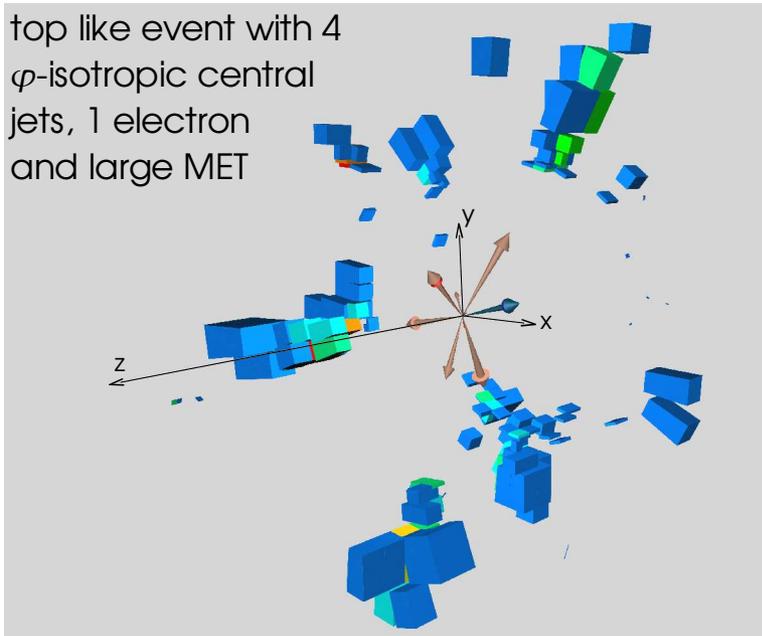
3 level trigger system

- Collision rate **2.5 MHz**
- L1. Calo., track and muon **2 kHz**
- L2. Calo., track, muon and **vertex 800 Hz**
- L3. online reconstruction **50 Hz**

Two analyses

Use the specificity of **event kinematics** of top pair decay to discriminate signal from backgrounds

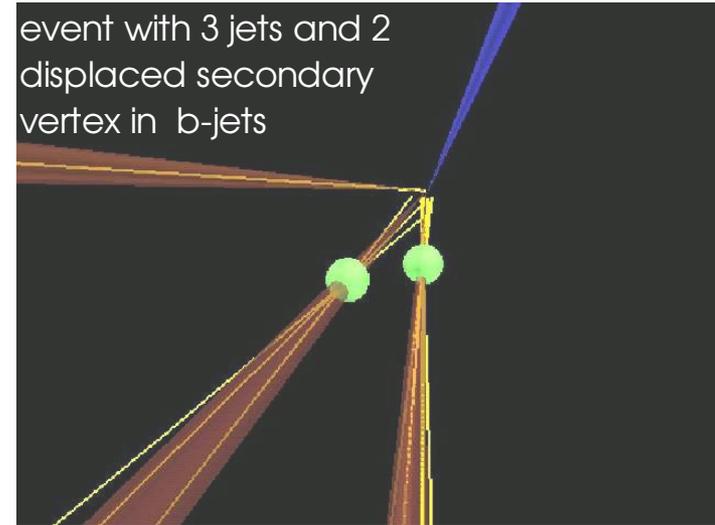
top like event with 4 φ -isotropic central jets, 1 electron and large MET



- Do not use the b-flavor of jets
- Backgrounds are W+jets like
- Fitting a discriminant distribution

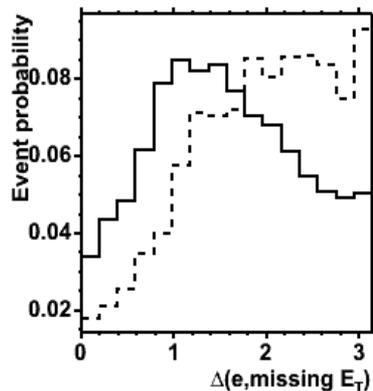
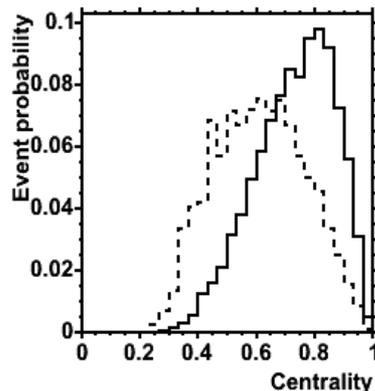
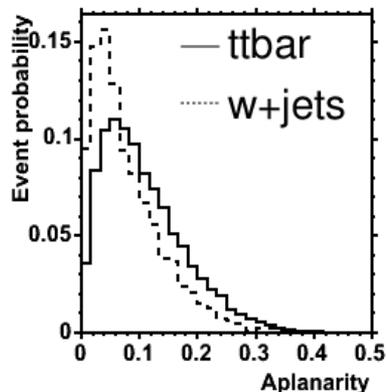
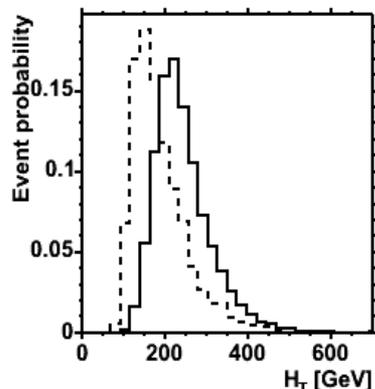
Use the **b-tagging** of one or two jets in top pair decay to increase signal over background ratio

event with 3 jets and 2 displaced secondary vertex in b-jets



- Use the b-flavor of jets
- Estimate the jet flavor in backgrounds
- Counting experiment

Event kinematics



W → ℓν

- W+jets : W boosted along z
- Top pair decays : W from top decay ⇒ greater p_T^W

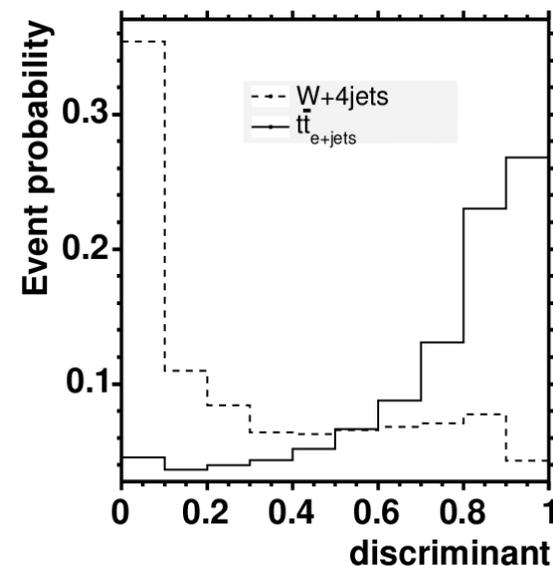
Jets

- W+jets : radiated jets
- Top pair decays : jets from top and W decays ⇒ greater p_T^{jet}

Top pair decay products are more isotropic

Discrimination :

→ 2-class (W+jets, signal) likelihood probability from 6 variables chosen to optimize stat ⊕ sys errors



Analysis using Event kinematics

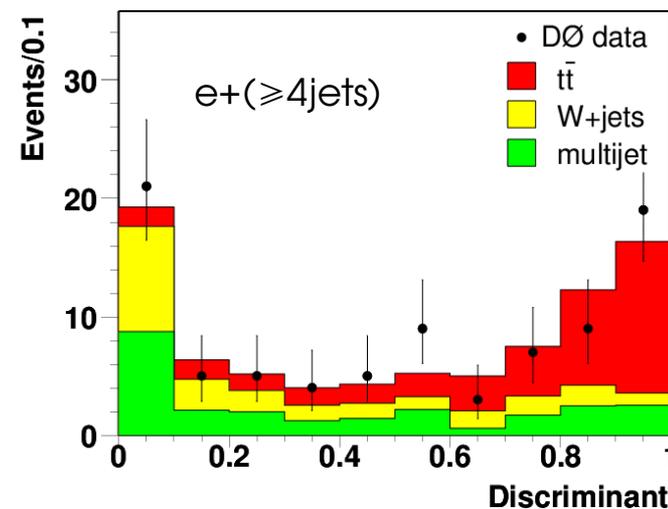
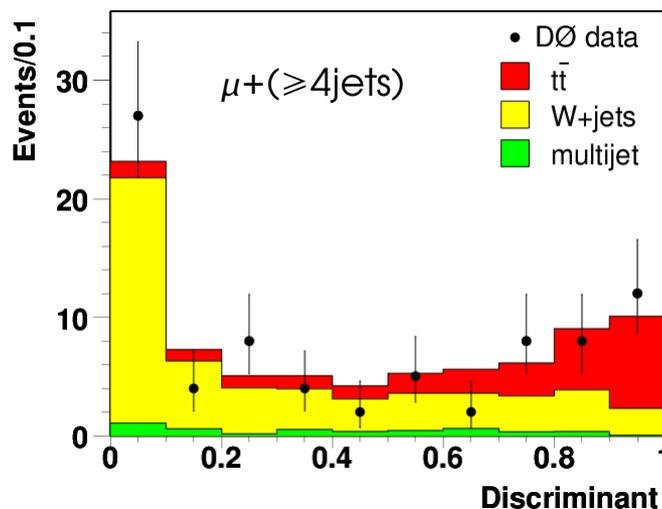
Lepton+jet trigger,
 $W(\rightarrow \ell \nu) + \text{jets } (p_T > 20 \text{ GeV})$ selection
 (≥ 4 jets) signal eff.=12%

- Fourth inclusive jet multiplicity
- Estimation of QCD background purely from data
- Dilepton channel contamination relative to signal estimated

Likelihood optimisation

⊗ Kinematics discriminant distribution
 discriminate signal from background

⊗ QCD background estimation
 discriminate QCD from W+jets



Lepton+jets final state

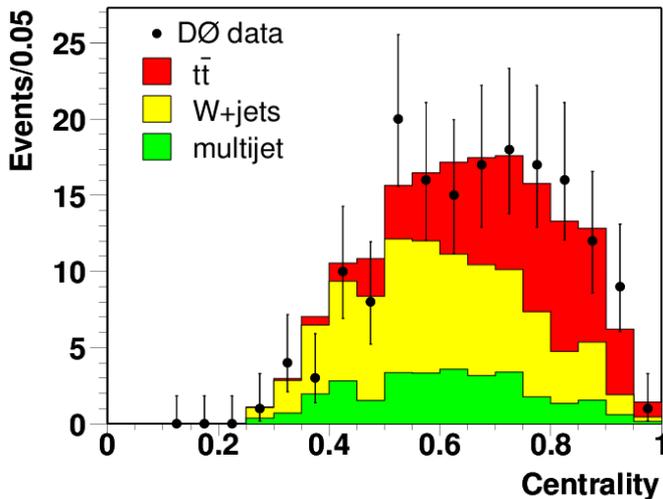
Event kinematics analysis
230 pb⁻¹

Systematics : 22%
*Jet energy calibration 18%

$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{Kine. e+jets} = 8.2_{-1.9}^{+2.1} (stat)_{-1.3}^{+1.9} (syst) \pm 0.5 (lumi) pb$$

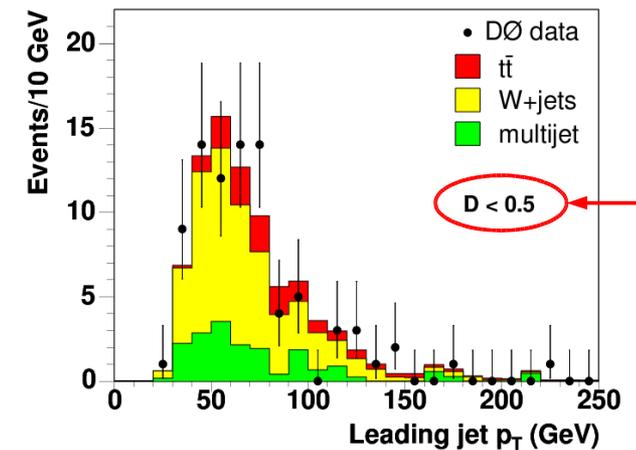
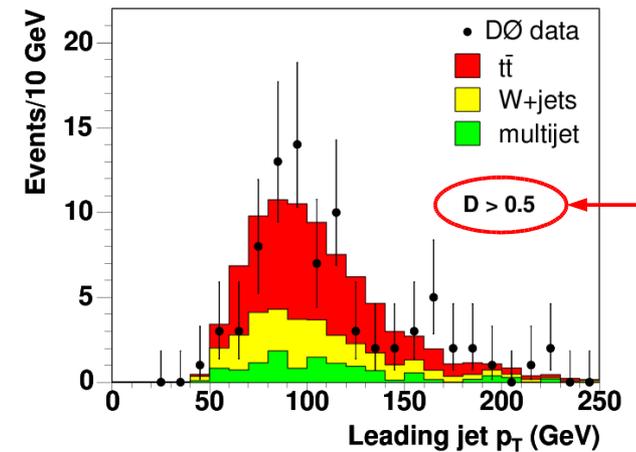
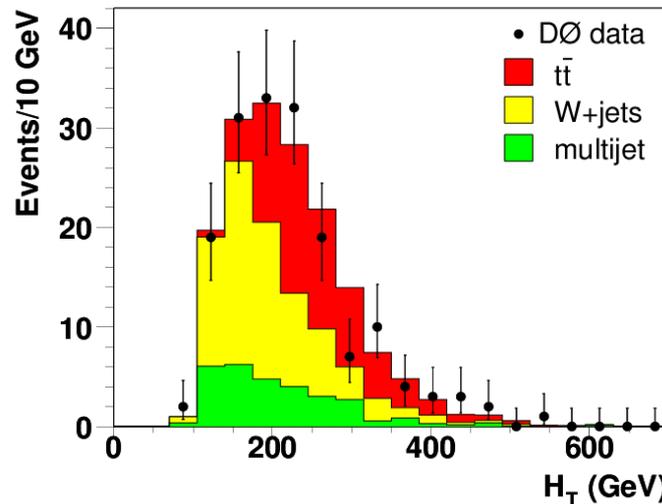
$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{Kine. \mu+jets} = 5.4_{-1.6}^{+1.8} (stat)_{-1.0}^{+1.2} (syst) \pm 0.4 (lumi) pb$$

$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{Kine. lepton+jets} = 6.7_{-1.3}^{+1.4} (stat)_{-1.1}^{+1.6} (syst) \pm 0.4 (lumi) pb$$



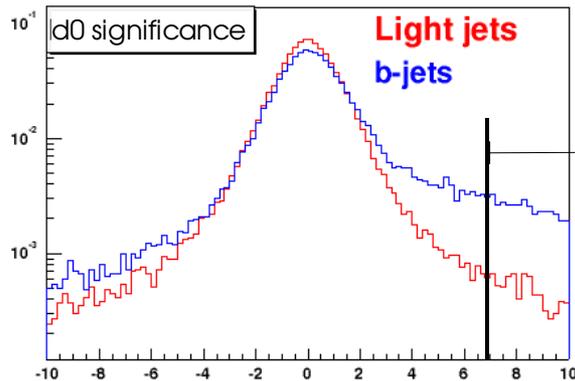
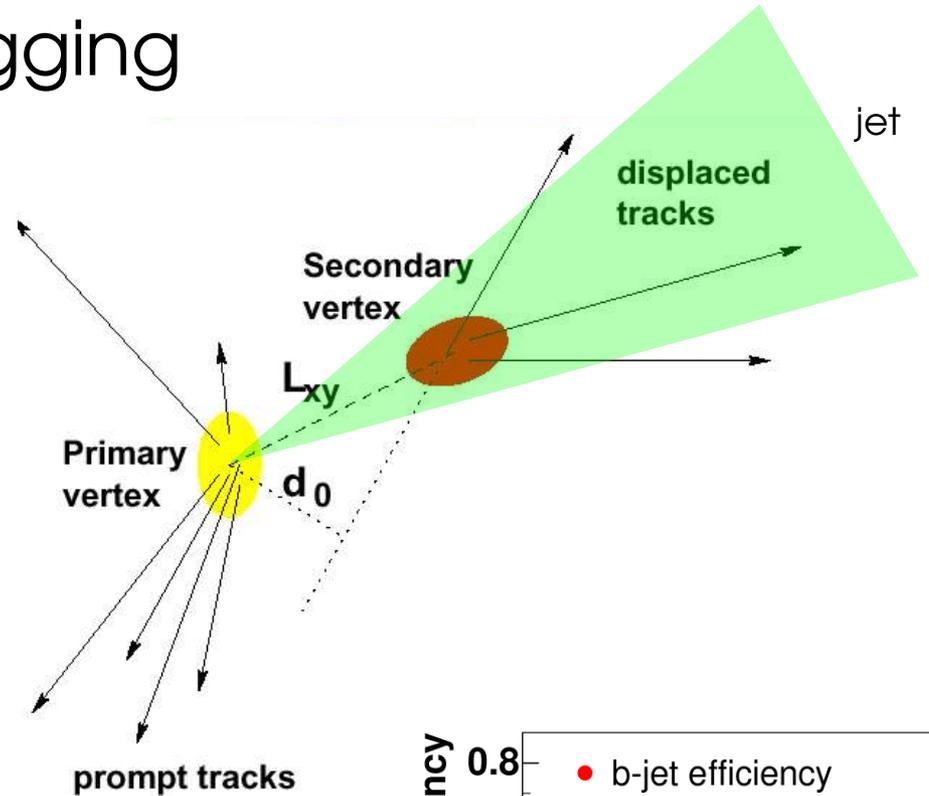
Excesses modeled by signal simulation

Sample with large transverse energy



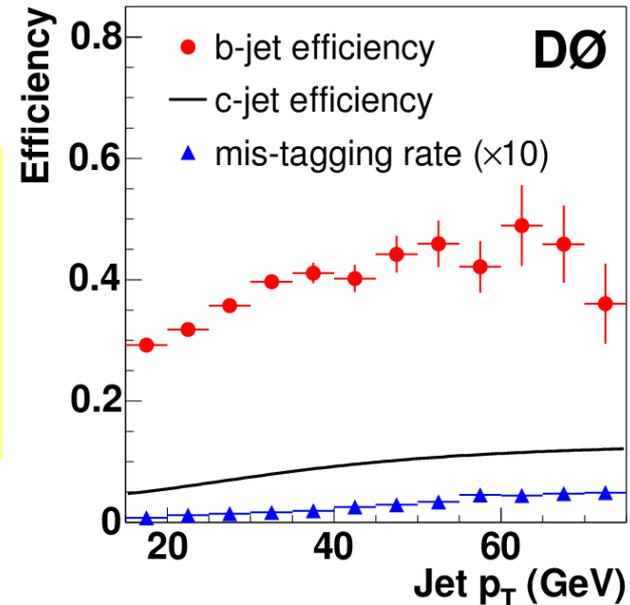
b-tagging

- B-hadrons (lifetime ~ 1.5 ps) don't decay at PV
- SV significantly displaced ($500\mu\text{m}$ to few mm) from PV
- B decay tracks with large PV impact parameter (d_0)



b-jet identification
SVT (secondary vertex tagger)
→ signal b-tagging efficiencies

- ✓ 45% with 1 tag
- ✓ 15% with 2 tags



Analysis using b-tagging

Lepton+jet trigger,
 $W(\rightarrow \ell \nu) + \text{jets}$ ($p_T > 15$ GeV) selection
 (=3jets) eff.=11%, (≥ 4 jets) eff.=13%

- Third and fourth inclusive jet multiplicity
- Estimation of QCD background purely from data
- $W + \text{jets}$ normalisation from data
 - $W + \text{jets}$ Flavor composition from MC simulation
- Other backgrounds from NLO cross sections
 - single top, diboson

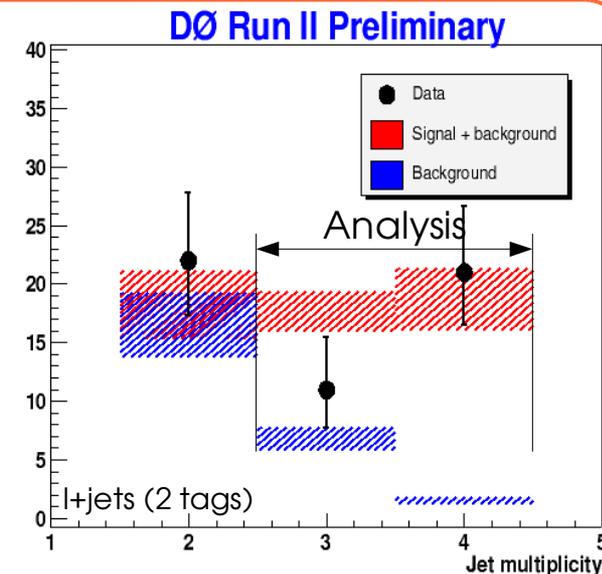
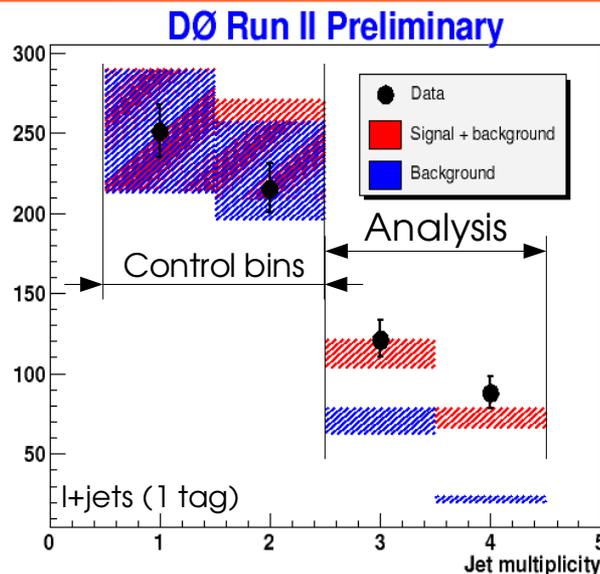
Likelihood optimisation

⊗ Estimation of number of events with 1 and 2 jets tagged

Determine the signal content in 8 independent channels

⊗ Nuisance of systematic sources

Allow for shift of X_{sec}



Lepton+jets final state

b-tagging analysis

370 pb⁻¹ DØ Preliminary

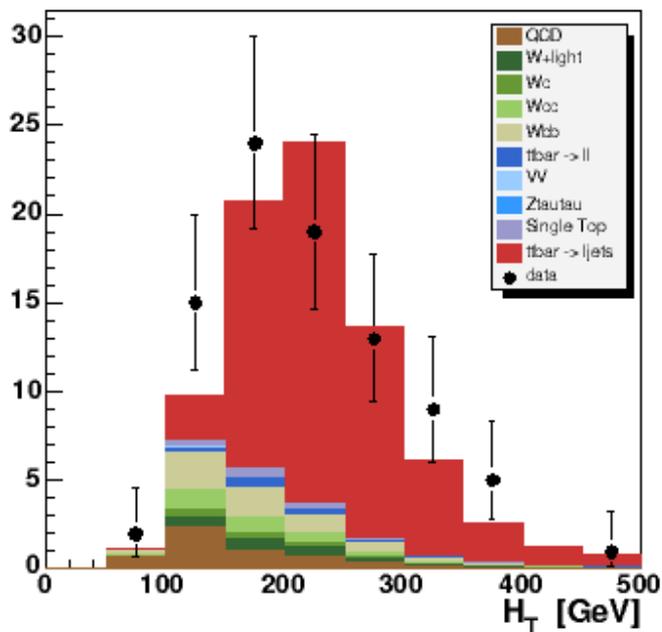
<u>Systematics :</u>	<u>11%</u>
*W+jets flavor composition	5%
*btag efficiency in data	5%

$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{btag. e+jets} = 8.5_{-1.4}^{+1.6} (stat + syst) \pm 0.6 (lumi) \text{ pb}$$

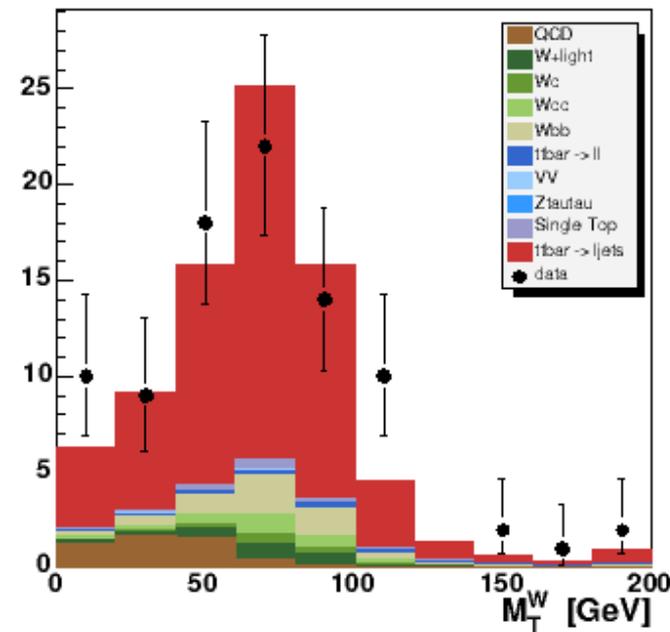
$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{btag. \mu+jets} = 7.6_{-1.4}^{+1.7} (stat + syst) \pm 0.5 (lumi) \text{ pb}$$

$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{btag lepton+jets} = 8.1_{-1.2}^{+1.3} (stat + syst) \pm 0.5 (lumi) \text{ pb}$$

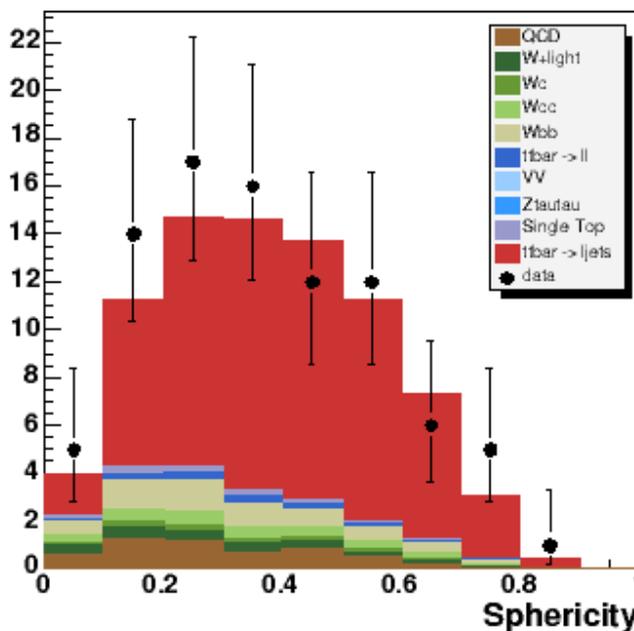
Large transverse energy



Presence of W boson



Top enriched sample





Summary

Event kinematics analysis 230 pb⁻¹

$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{Kine.lepton+jets} = 6.7_{-1.3}^{+1.4} (stat)_{-1.1}^{+1.6} (syst) \pm 0.4 (lumi) \text{ pb}$$

PLB, hep-ex/0504043, FERMILAB-PUB-05/079-E (230 pb⁻¹)

Lifetime b-tagging analysis

$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{btaglepton+jets} = 8.6_{-1.5}^{+1.6} (stat + syst) \pm 0.6 (lumi) \text{ pb}$$

PLB, hep-ex/0504058, FERMILAB-PUB-05/087-E (230 pb⁻¹)

370 pb⁻¹ DØ Preliminary

$$\sigma_{p\bar{p} \rightarrow t\bar{t}+X}^{btaglepton+jets} = 8.1_{-1.2}^{+1.3} (stat + syst) \pm 0.5 (lumi)$$

- ✓ Good agreement with the theoretical prediction of 6.7±0.8 pb
- ✓ Precision measurement era of Tevatron Run II

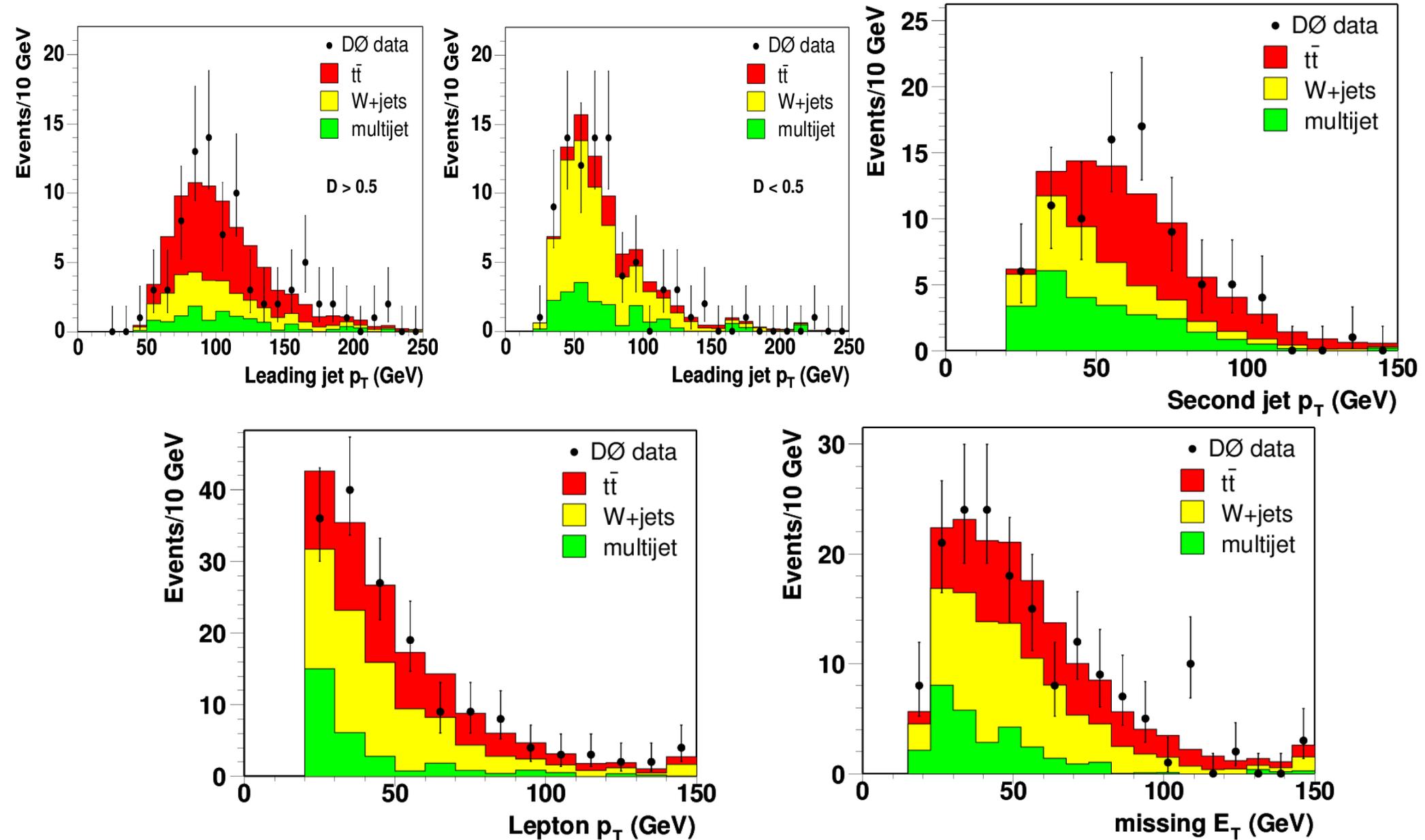
Work in progress

- Event kinematics analysis improvement
- Improved detector calibration
- Control the dominant systematics
- ≥1fb⁻¹ delivered by the Tevatron !

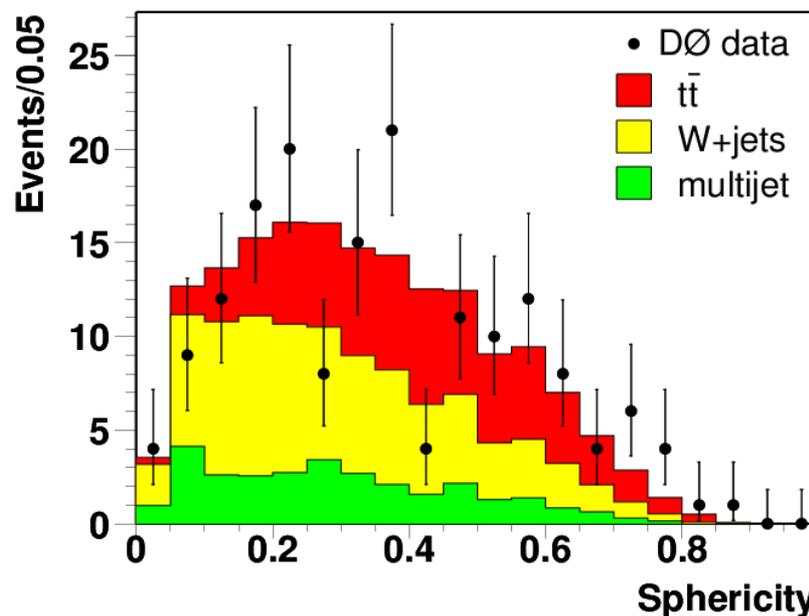
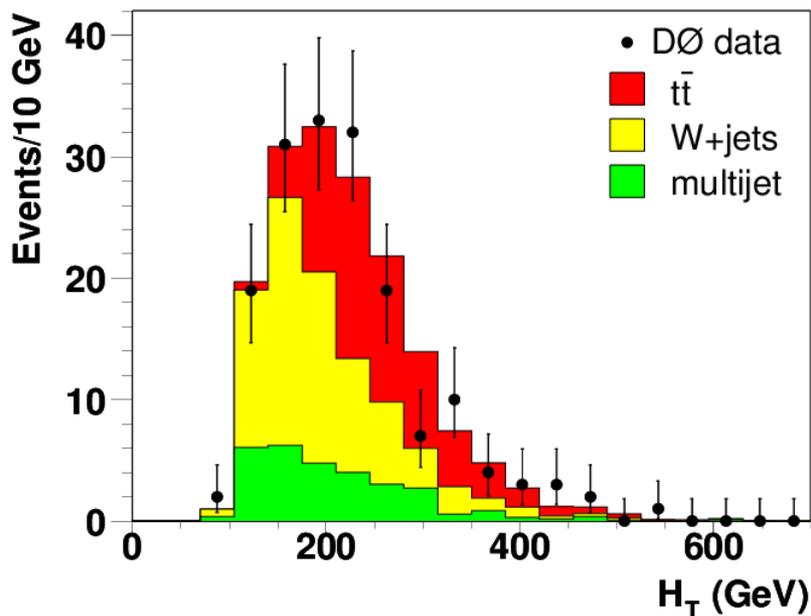
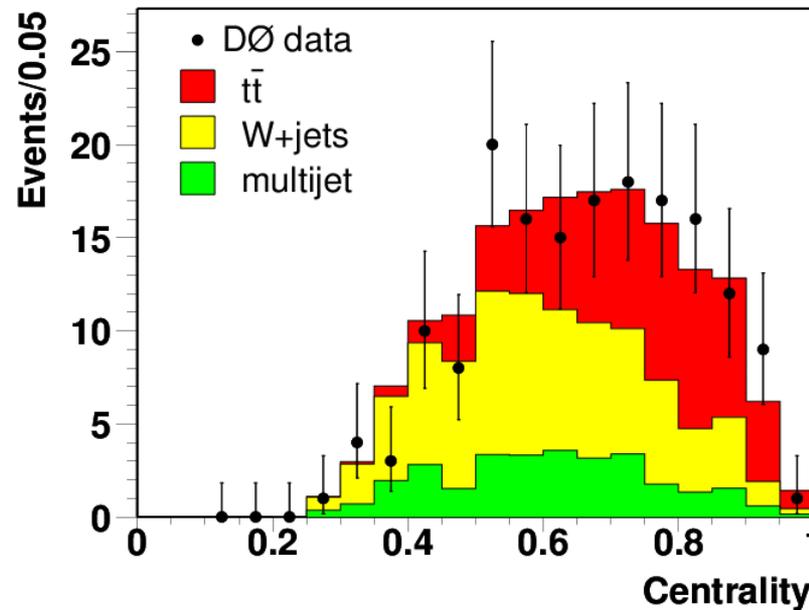
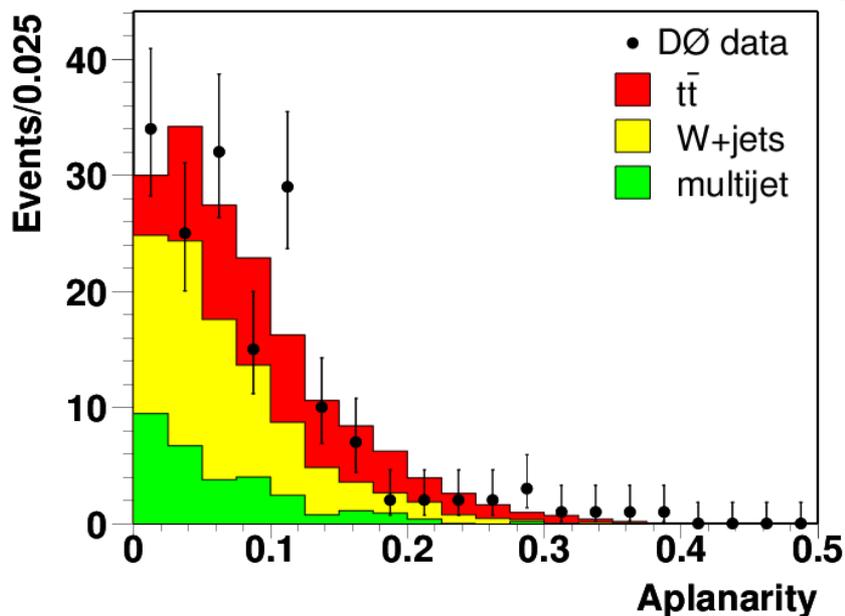


Backup

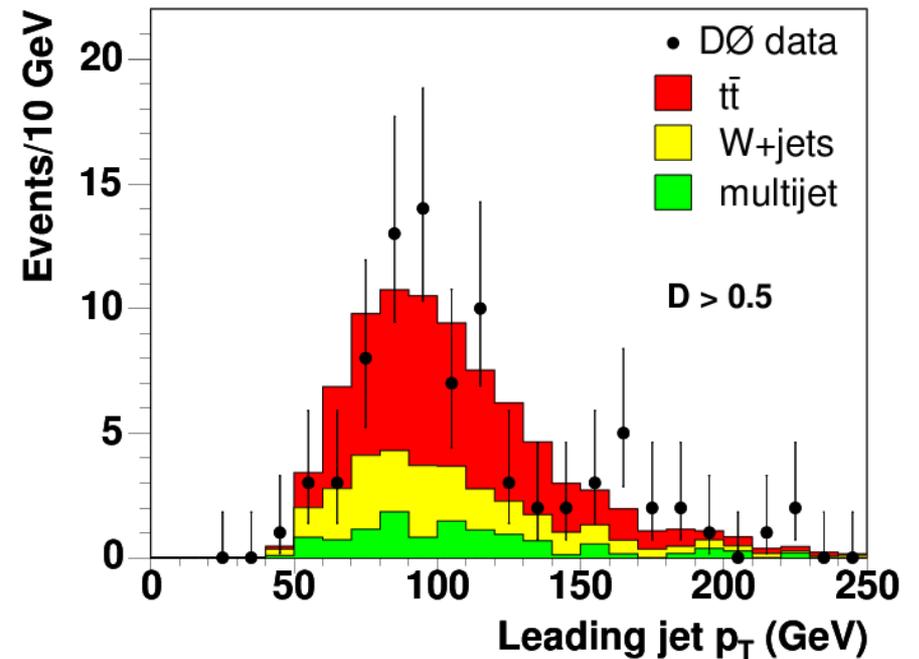
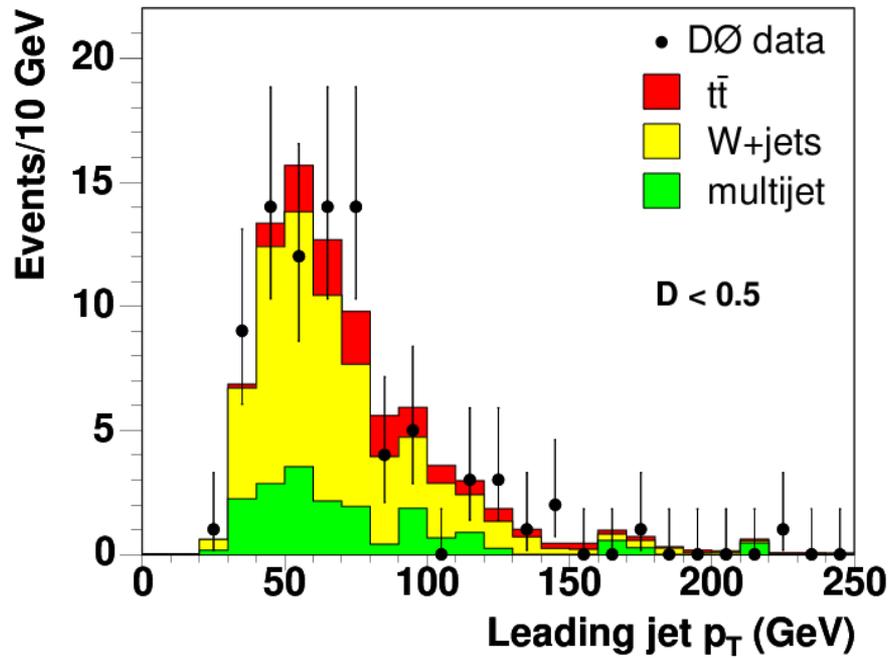
Control plots Kine. (a)



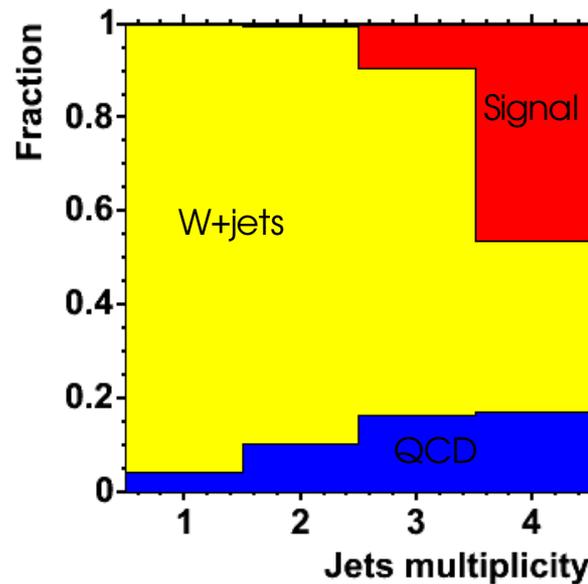
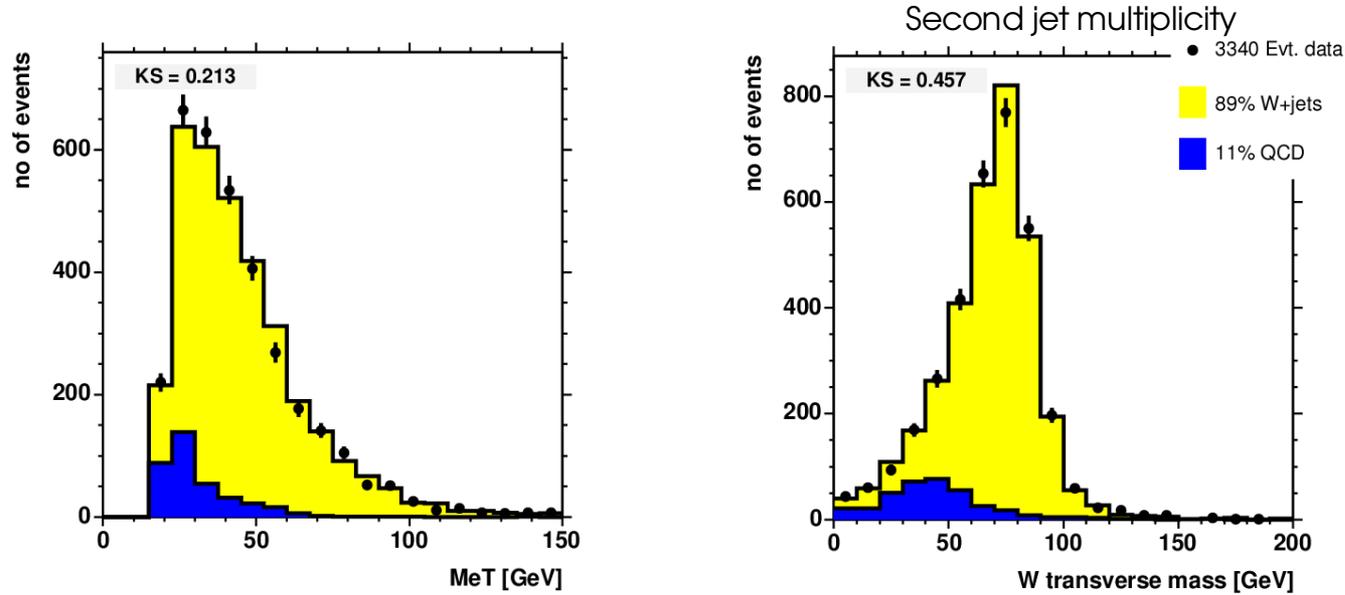
Control plots Kine. (b)



Control plots Kine. (c)



Control plots Kine. (d)



Control plots, btag.

