Status of Top Quark Analyses at DØ

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On behalf of the DØ Collaboration

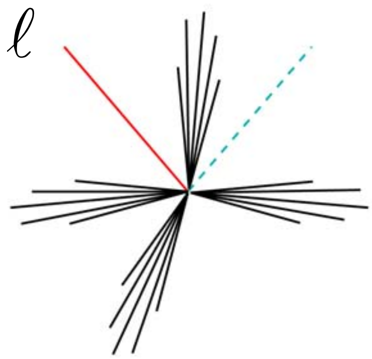
Measurement of the top production cross section with Run II data

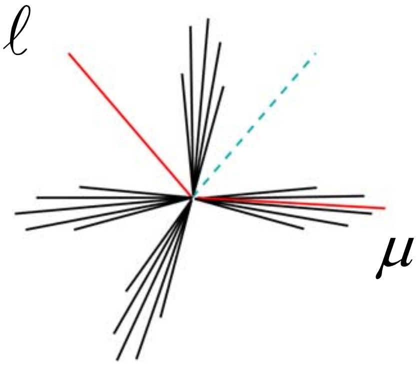
Improved measurement of the top mass with Run I data

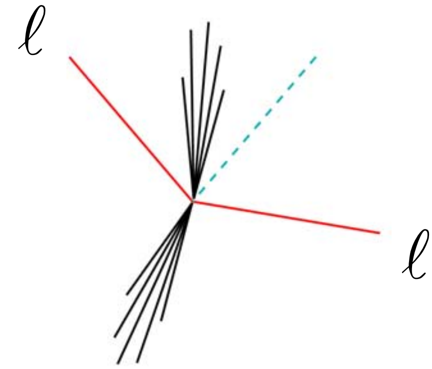
First Measurement of the $t\bar{t}$ Cross Section at $\sqrt{s}$=1.96 TeV

Measurement based six analysis channels:

Lepton+jets (topological)	Lepton+jets (soft muon tag)	dileptons







e+jets, μ+jets	e+jets/μ, μ+jets/μ	eμ and μμ
Br = 14.7%	Br = 14.7%	Br = 2.5 and 1.2%
Efficient	*Pure*	*Pure and efficient*
Not very pure	*Not very efficient*	*Low branching*

Cross section at Run II ~30% higher than at Run I

Predictions ranging from 5.4 to 7.4 pb — *Cacciari et. al. HEP-PH 0303085*

Data sample from mid-August until mid-January

with luminosities from 30 to 50 pb^{-1}

Triggers

Use calorimeter and muon system at all levels of the trigger (L1, L2 and L3)

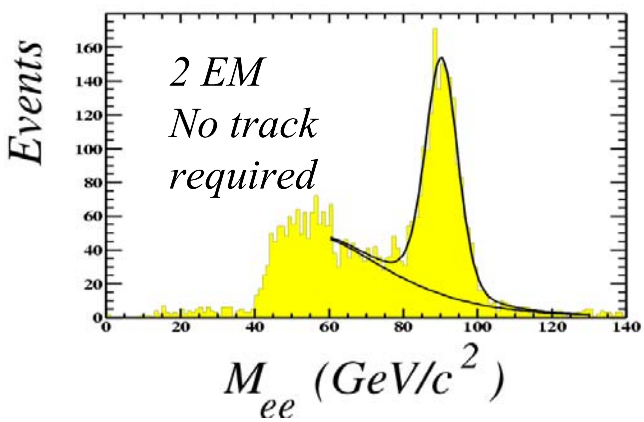
Object Identification

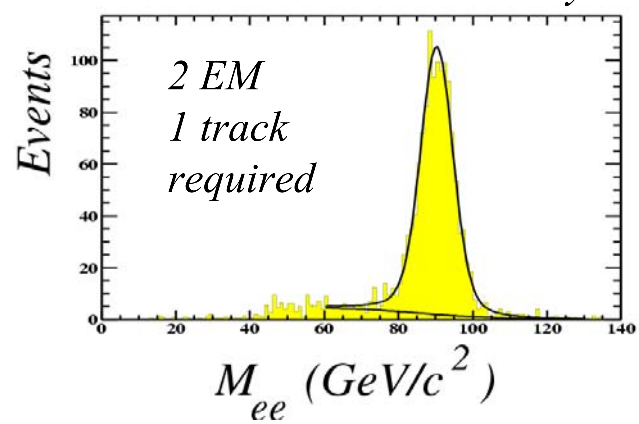
Reconstruction of Jets and Jet energy scale:

Improved legacy 0.5 cone algorithm with JES corrections
(see talk by B. Kehoe)

Reconstruction of electrons (only central):

- *Select EM particles (simple cone, shower shape, EM fraction)*
- *Match with track (ϕ, η, and E/p)*



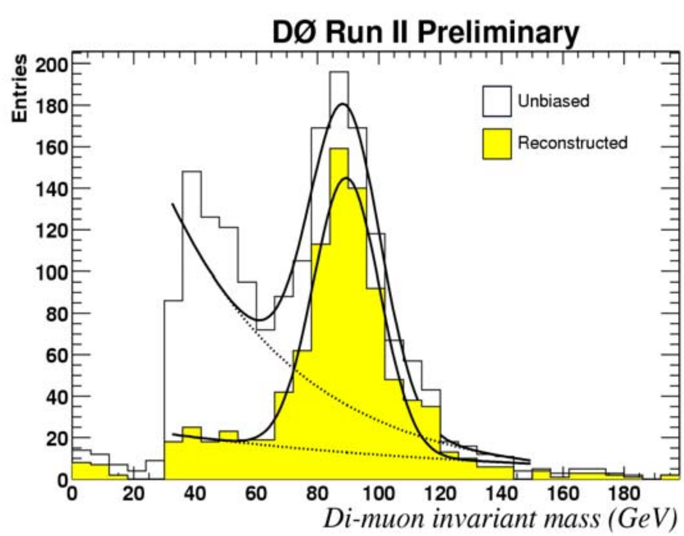


Reconstruction of muons:

ID
- *Tracks in Muon system*
- *Tracks in Central Tracker*

- *Minimum Ionization in the calorimeter*

Used for redundancy only to measure efficiencies



Missing Transverse Energy:

From calorimeter with JES corrections (and muon correction)

Dimuon Channel

Luminosity $42.6\ pb^{-1}$

Selection criteria:

2 isolated muons, $MET(M_{\mu\mu})$, H_T and more than 2 Jets

Backgrounds:

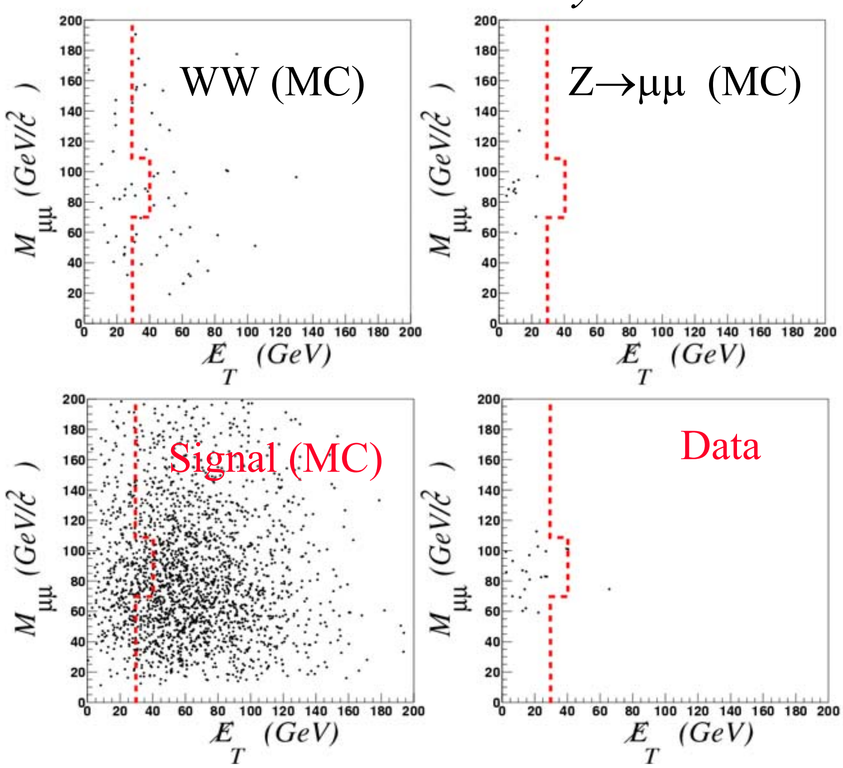
Instrumental

Estimated from data
- $Z \to \mu\mu$
- $DY \to \mu\mu$
- QCD Heavy Flavor

Physical backgrounds

from MC
- $Z \to \tau\tau$
- $WW \to \mu\mu$

DØ Run II Preliminary



$Z \to \mu\mu$	0.20±0.11
$DY \to \mu\mu$	0.20±0.20
QCD	0.18±0.18
$Z \to \tau\tau$	0.02±0.02
WW	0.00±0.00
Background	**0.60±0.30**
Signal*	**0.3±0.04**
Data	**2**

* For $\sigma = 7pb$

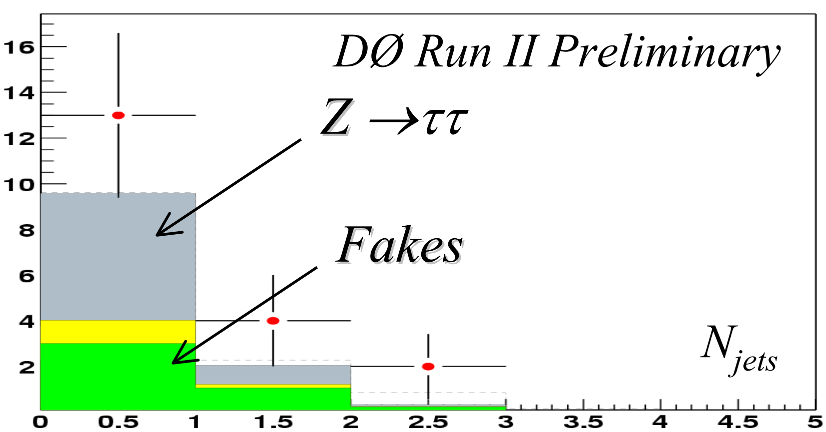
$e\mu$ Channel

Luminosity 33.0 pb^{-1}

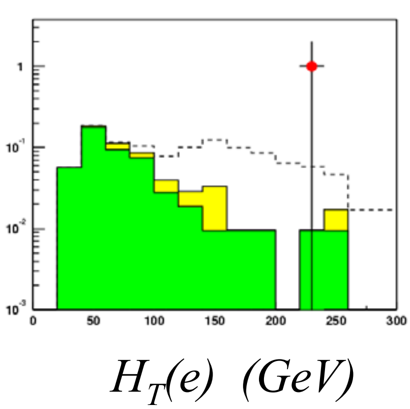
Selection criteria: 1 electron, 1 isolated muons, MET, MET_{CAL}, $H_T(e)$ and more than 2 Jets

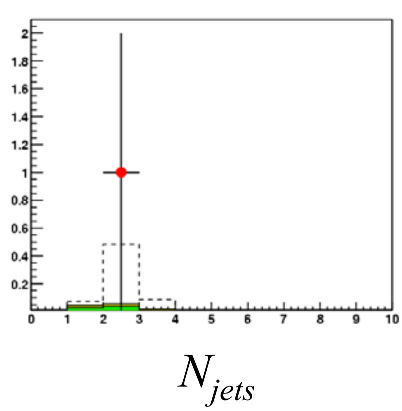
Backgrounds:

Instrumental	Physical backgrounds
QCD and W+jets	from MC: $Z \to \tau\tau$, $WW \to \mu\mu$
Estimated from data (Fakes)	

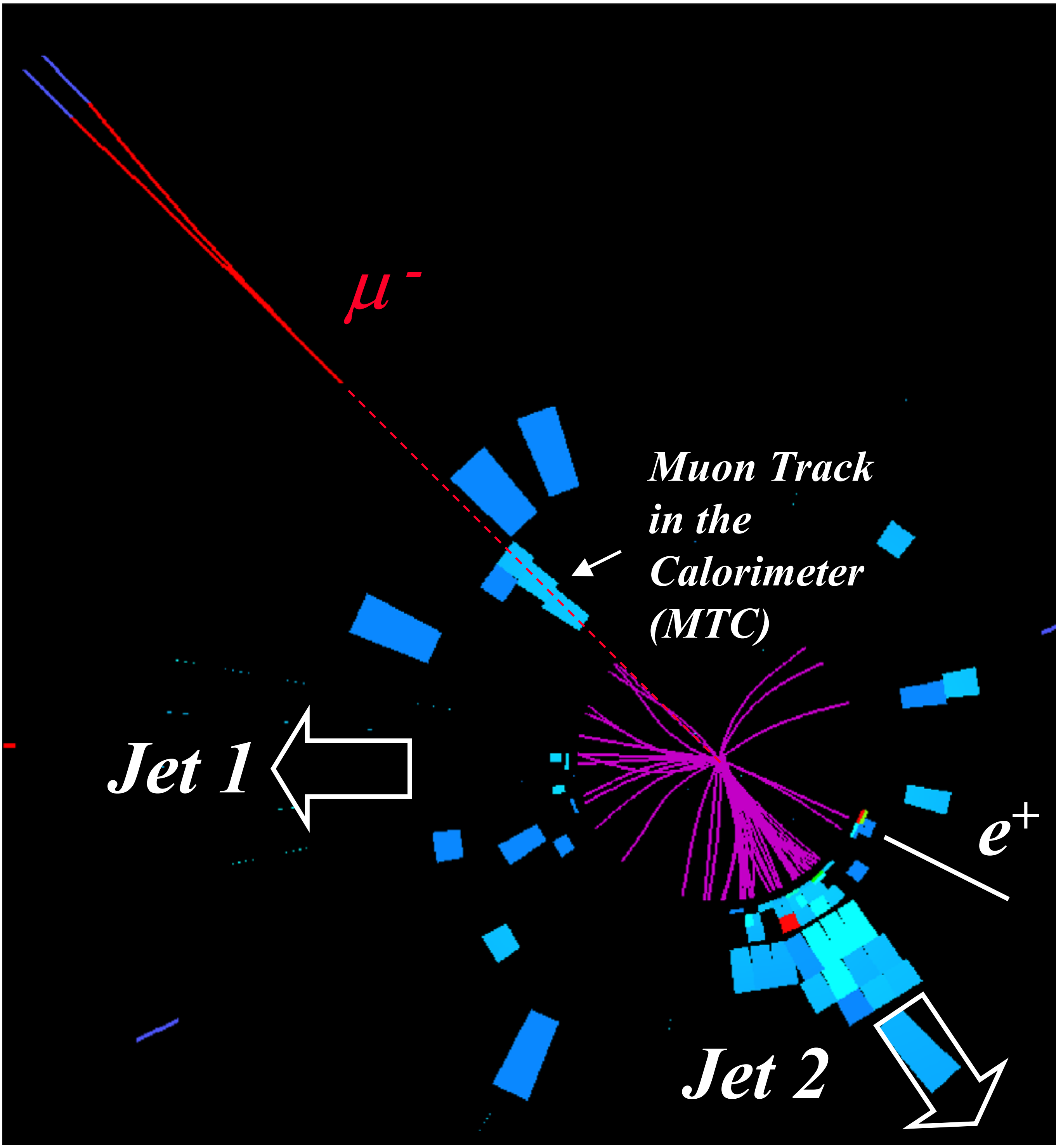


Fakes	0.05±0.01
$Z \to \tau\tau$	0.02±0.01
WW	0.00±0.00
Bkg	0.07±0.01
Signal*	0.5±0.01
Data	1





* For $\sigma = 7pb$



eμ Candidate Event

Lepton-plus-Jets Analyses

Luminosities: e+jets 49.5 pb^{-1} and μ+jets 40.0 pb^{-1}

Backgrounds: QCD multi-jets and W multi-jets

Method:
- Preselect a sample enriched in W events
- Evaluate QCD multi-jet (as a function of N_{jets})
- Estimate W+4jets assuming Berends scaling
- Apply topological selection

Preselection:

1 EM object or muon, MET, soft muon veto

QCD background evaluation (matrix method):

Separate W+tt and QCD with loose (L) and tight (T) lepton characteristics. Efficiencies (L→T) for signal ε_{W+tt} and background ε_{QCD} are measured independently:

"Matrix method"
- e+jets: Track match to the EM object
- μ+jets: Muon isolation

$$\begin{cases} N_L = \tilde{N}_{W+t\bar{t}} + \tilde{N}_{QCD} \\ N_T = \varepsilon_{W+t\bar{t}} \tilde{N}_{W+t\bar{t}} + \varepsilon_{QCD} \tilde{N}_{QCD} \end{cases} \Rightarrow \begin{cases} \tilde{N}_{W+tt} = \varepsilon_{W+tt} \dfrac{N_T - \varepsilon_{QCD} N_L}{\varepsilon_{W+tt} - \varepsilon_{QCD}} \\ \tilde{N}_{QCD} = \varepsilon_{QCD} \dfrac{\varepsilon_{QCD} N_L - N_T}{\varepsilon_{W+t\bar{t}} - \varepsilon_{QCD}} \end{cases}$$

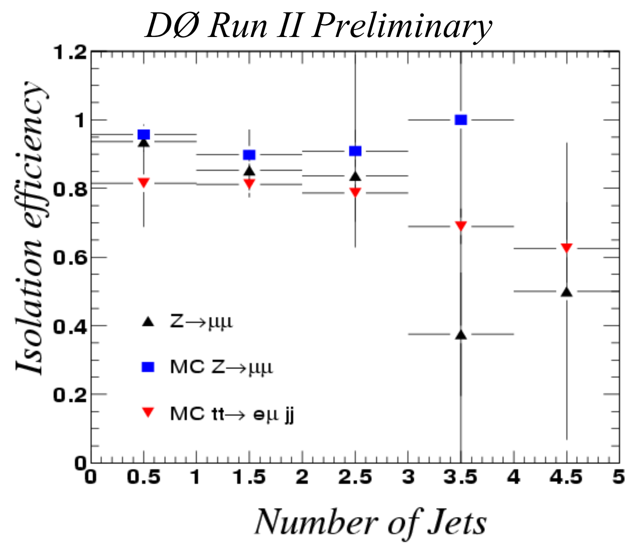
Signal probabilities…

… are obtained from benchmark signal samples of $Z \to ee$ or $\mu\mu$

Non trivial dependence of ε_{W+tt} w.r.t. N_{jets} (especially in the μ+jets case)…

$\Rightarrow$ Correction taken from MC

ε_{W+tt} vs N_{jets}



Background nature

μ+jets

QCD Background essentially due to Heavy Flavor semi-leptonic decays

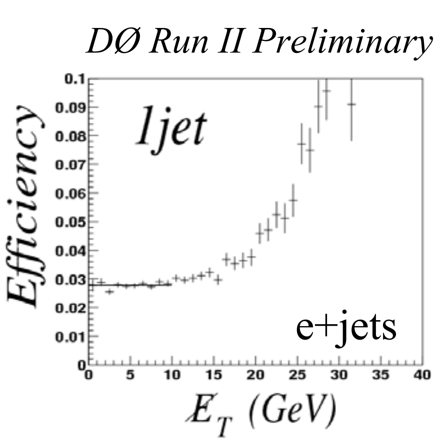
e+jets

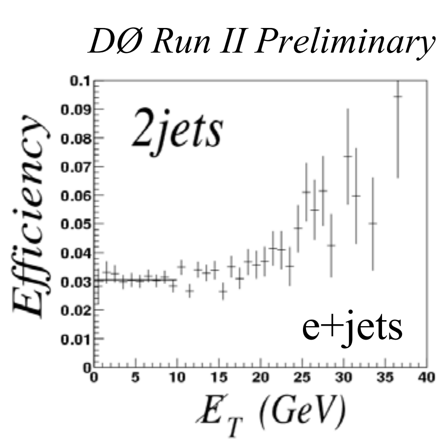
QCD Background due to leading π^0 or compton QCD events and Fake track or γ conversion

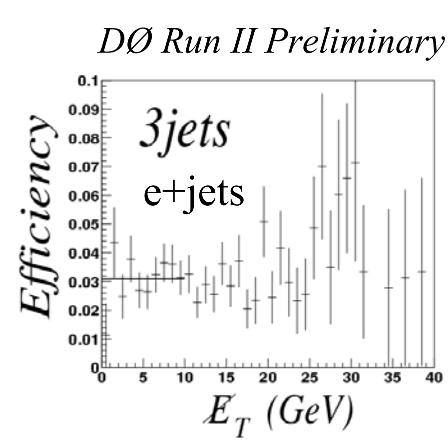
Background Probabilities…

… are obtained from benchmark QCD samples with low MET

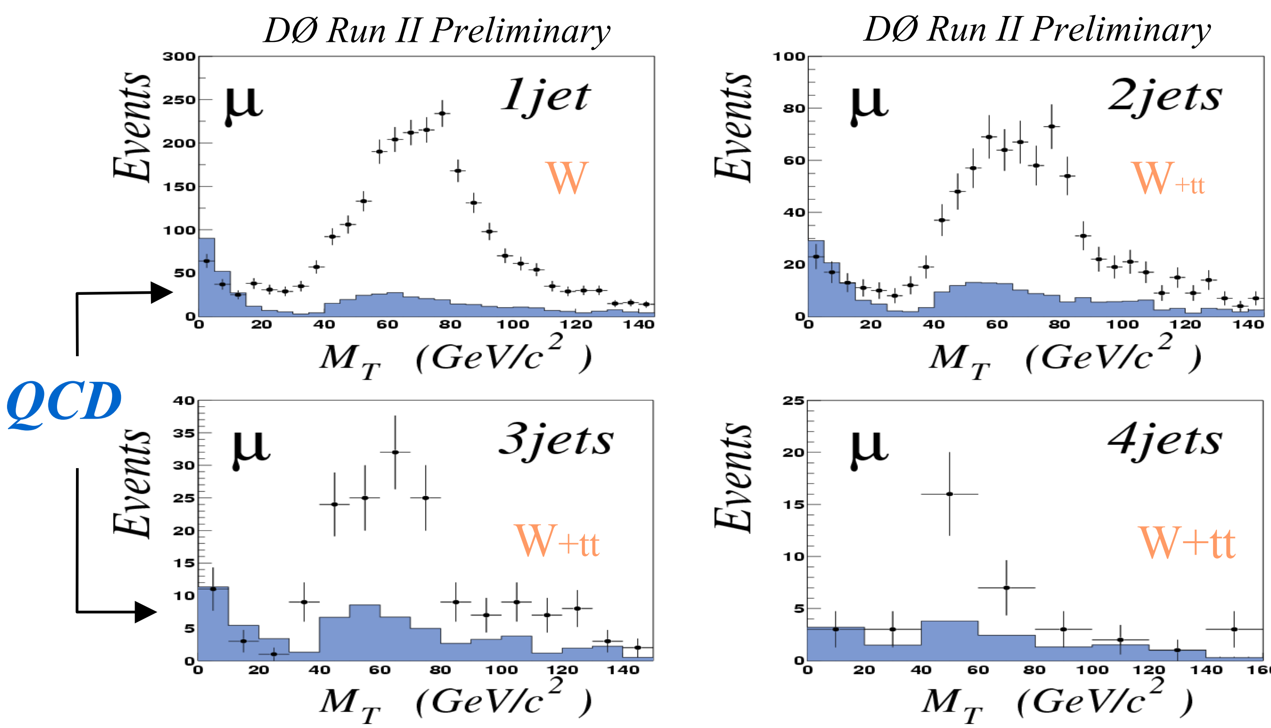
Dependence of the ε_{QCD} w.r.t. MET and N_{jet} …

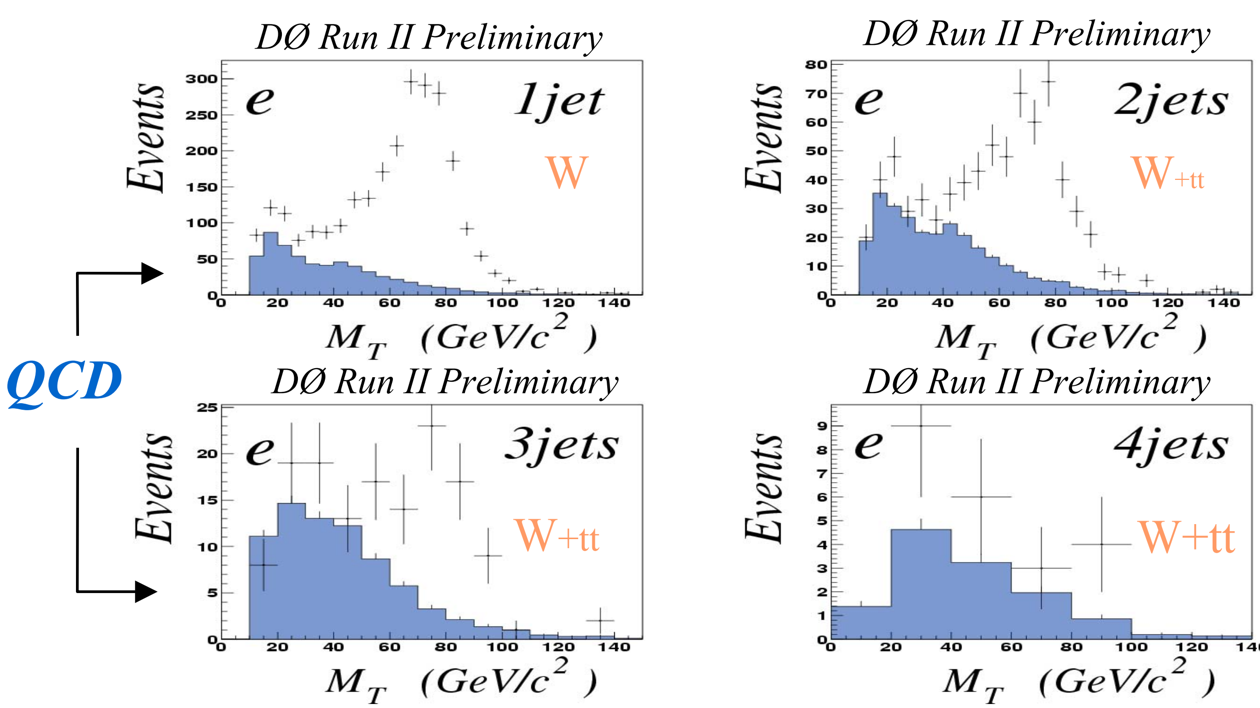






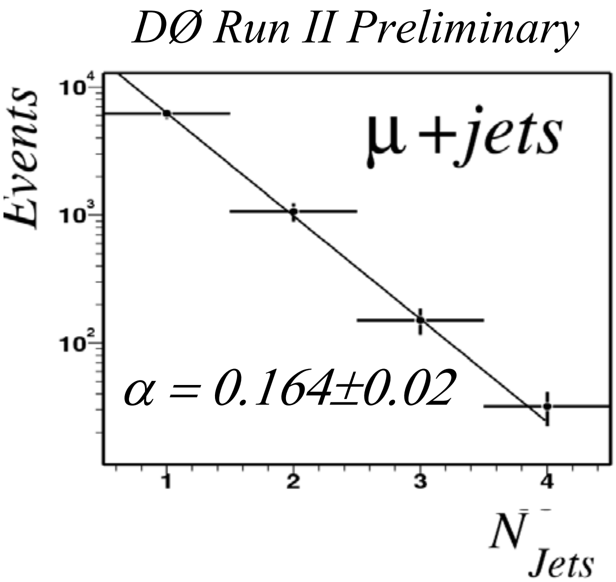
Estimation of the QCD background:

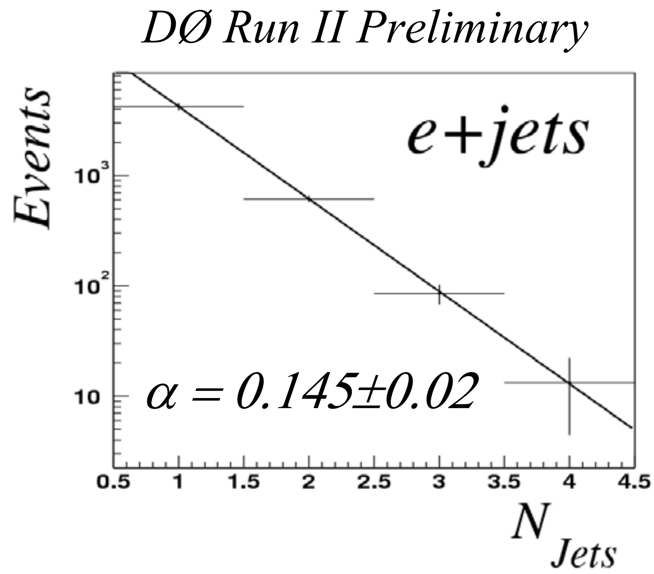




Berends scaling:

$$\alpha \equiv \frac{\sigma(W+(n+1)_{jets})}{\sigma(W+n_{jets})}$$





Estimation of the W background for $N_{jets} \geq 4$:

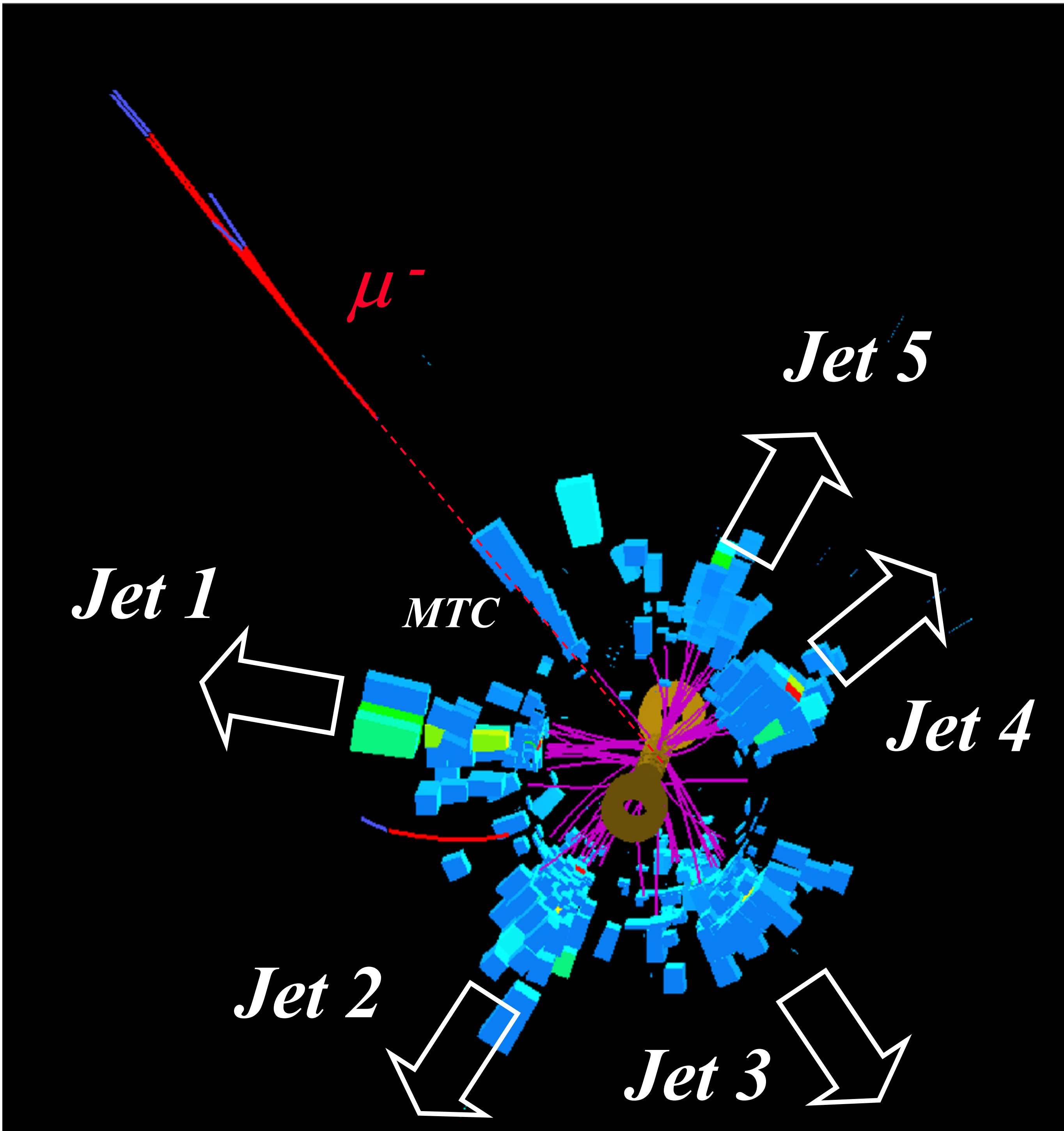
$$\tilde{N}_W^4 = \begin{cases} 24.2 \\ 11.9 \end{cases} \qquad \tilde{N}_{QCD}^4 = \begin{cases} 11.9 \\ 12.5 \end{cases} \qquad N_{obs}^4 = \begin{cases} 38 \ (\mu\text{+jets}) \\ 22 \ (e\text{+jets}) \end{cases}$$

Apply topological cuts:

Apalanarity and HT

Analysis	N_W	N_{QCD}	Bkg. Tot.	Signal*	N_{obs}
e+jets	1.3±0.5	1.4±0.4	2.7±0.6	1.8	4
μ+jets	2.1±0.9	0.6±0.4	2.7±1.1	2.4	4

* For σ = 7pb



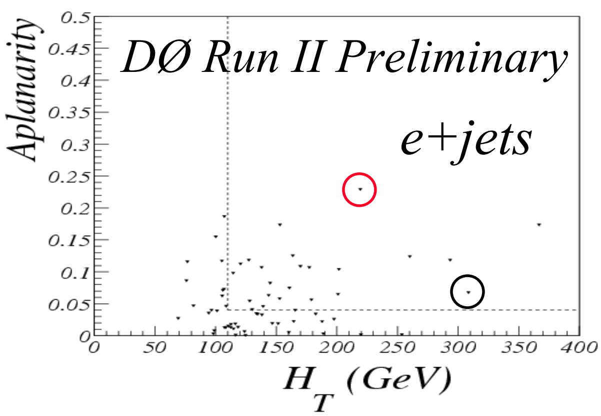
μ+jets Candidate Event

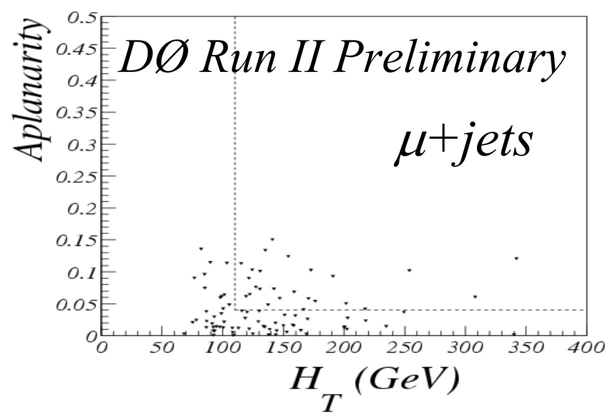
Soft Muon Tag Analyses

Selection before Soft Muon Tag

- Use the same preselection as l+jets
- Require at least 3 jets
- Apply mild topological cuts

$\Rightarrow$ (Loose/Tight sample)
- 75/23 (μ+jets)
- 459/27 (e+jets)





When SMT is applied:
- 1/0 (μ+jets)
- 9/2 (e+jets)

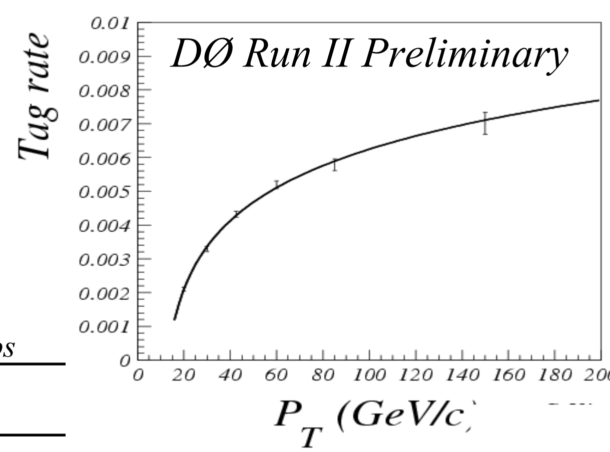
$$\Rightarrow \tilde{N}_{QCD}^{SMT} = \begin{cases} 0.2 \pm 0.2\ (\mu) \\ 0.2 \pm 0.1\ (e) \end{cases}$$

QCD background. from matrix method

W bkg. from Tag rate functions:

$$\tilde{N}_{W}^{SMT} = \begin{cases} 0.4 \pm 0.1\ (\mu) \\ 0.0 \pm 0.1\ (e) \end{cases}$$

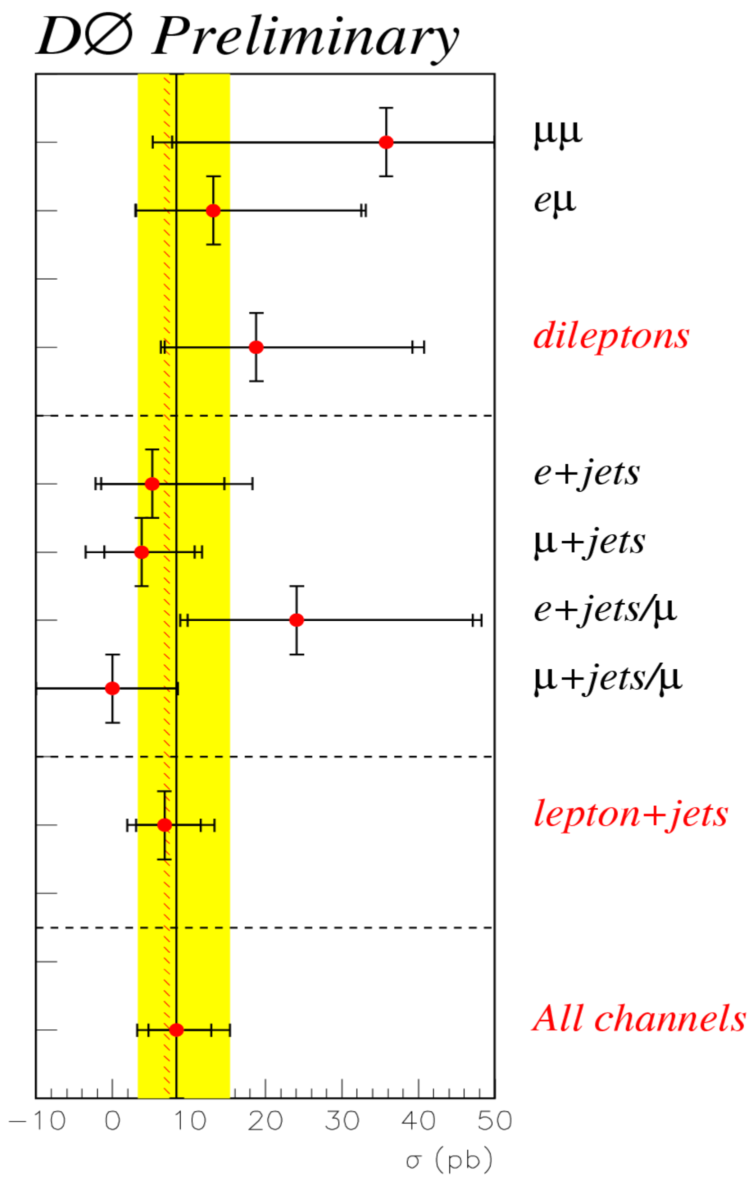
Analysis	Bkg. Tot.	Sig.*	N_{obs}
e+jets	0.2±0.1	0.5	2
μ+jets	0.6±0.3	0.4	0



* For $\sigma = 7pb$

Cross Section Measurement

Combining the observation of all channels an excess of 3σ is observed, compatible with a signal expectation at the 35% CL



The combined cross section is:

$$\sigma = 8.4\,^{+4.5}_{-3.7}\,(stat)\ ^{+5.3}_{-3.5}\,(syst) \pm 0.8\,(lumi)\ pb$$

Status of the Top Mass Measurement in the Lepton+Jets Channels at Run I

Likelihood method using most available information

Uses DØ Run I statistics (125 pb^{-1}) & selection → 91 events

Signal and background probability (simple realistic model):

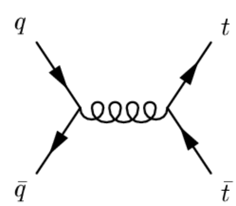
$x \rightarrow$ reconstructed objects in the event (leptons, jets)

$\alpha \rightarrow$ Parameter to estimate

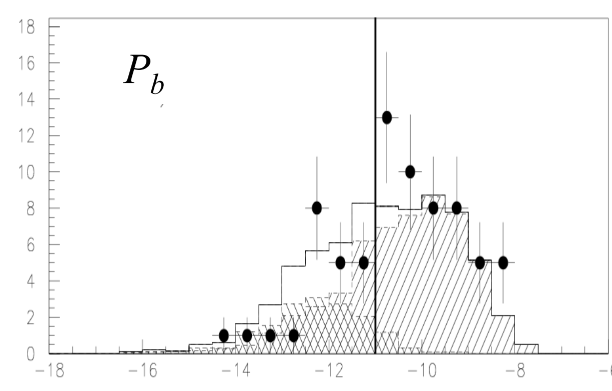
Folding object resolutions

$$\overline{P}(x;\alpha) = \underbrace{Acc(x)}_{\text{Acceptance}} \times \frac{1}{\sigma} \int \underbrace{d^n\sigma(y;\alpha)}_{\text{Matrix element}} dq_1\, dq_2\, \underbrace{f(q_1)\, f(q_2)}_{\text{PDF's}} \underbrace{W(x,y)}_{\text{Transfer Functions}}$$

Signal (No ISR or FSR)



Background (VECBOS)



Independent of α

Additional cuts for this analysis:

4 Jets exclusively: 71 events

P_b.: 22 events (pure sample)

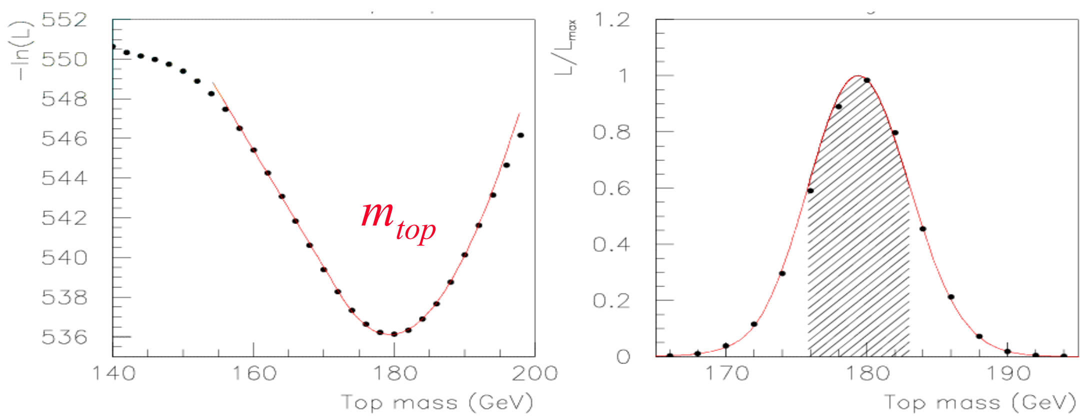
Likelihood definition:

$$-\ln L(\alpha) = -\sum_{i=1}^{N} \left\{ \ln\left[c_1 P_{t\bar{t}}(x_i;\alpha) + c_2 P_{bkg}(x_i) \right] \right\} + N \int A(x) \left[c_1 P_{t\bar{t}}(x;\alpha) + c_2 P_{bkg}(x) \right] dx$$

Estimate the signal and background contributions and m_{top}:

Signal
$c_1=12$

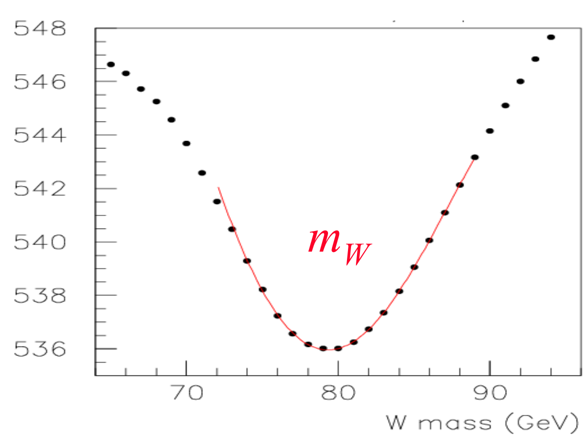
W Bkg
$c_2=10$



$$m_{top} = 179.9 \pm 3.6 \quad (stat)\ GeV/c^2$$ *(5.6 GeV from PRD 58 052001,1998)*

Large improvement on the statistical uncertainty (~2.4× stats)

Jet Energy Scale	**5.6 GeV**
Signal model	*1.5 GeV*
Background model	*1.0 GeV*
Multiple interactions	*1.3 GeV*



Expect a substantial improvement in the JES systematic

Conclusions and Outlook

D0 measurement of the tt cross section at $\sqrt{s}$=1.96 TeV carried out at Tevatron Run II:

$$\sigma = 8.4\,^{+4.5}_{-3.7}\,(stat)\ ^{+5.3}_{-3.5}\,(syst)\ \pm\ 0.8\,(lumi)\ pb$$

Short term perspective: *Dielectron channel and Lifetime tagging analyses*

Medium term perspective: *Complete analyses of mass and cross sections*

Status of the new top Run I mass measurement:

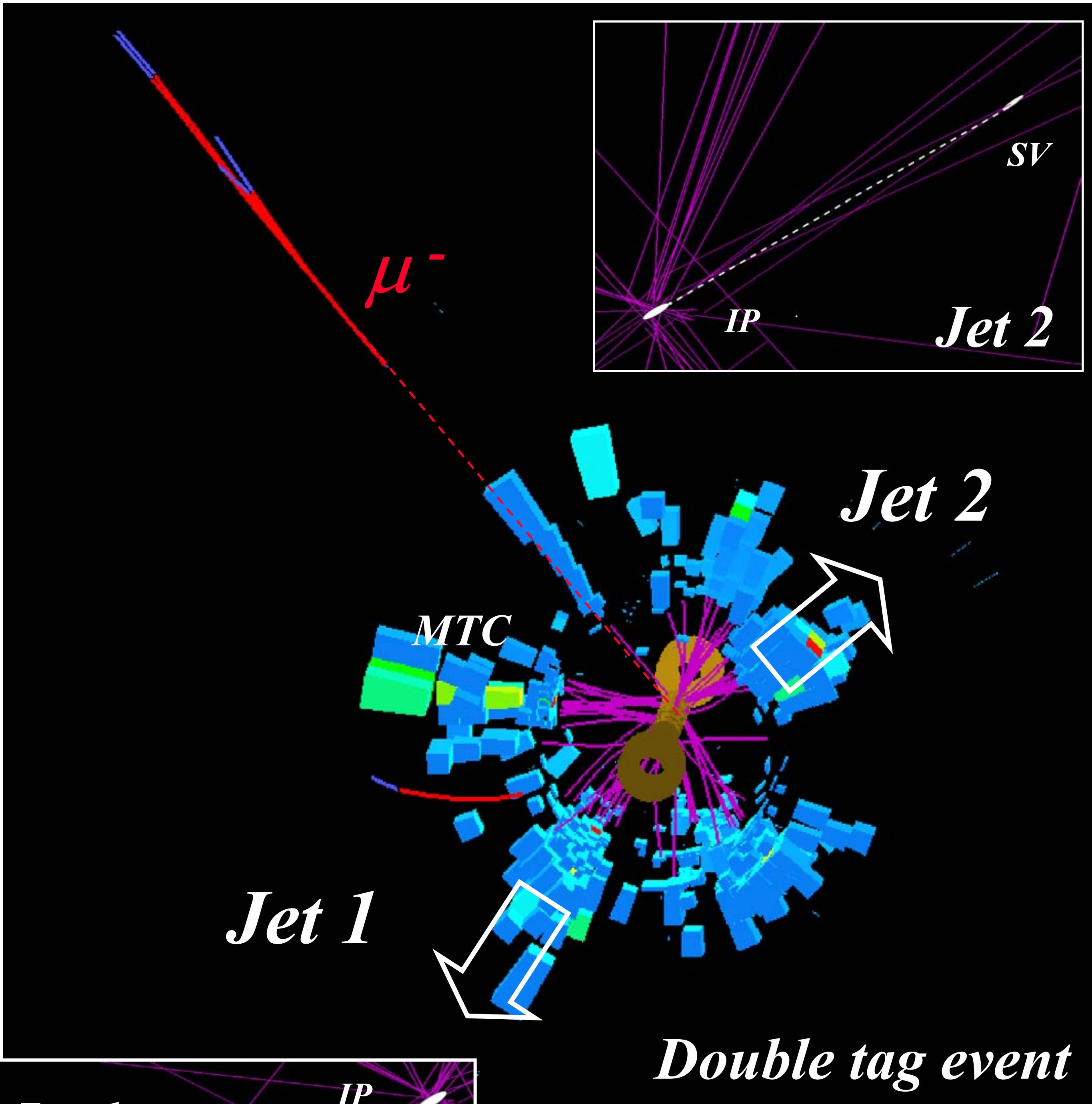
$$m_{top} = 179.9 \pm 3.6\ \ (stat)\ \pm 6\ \ (syst)\ \ GeV/c^2$$

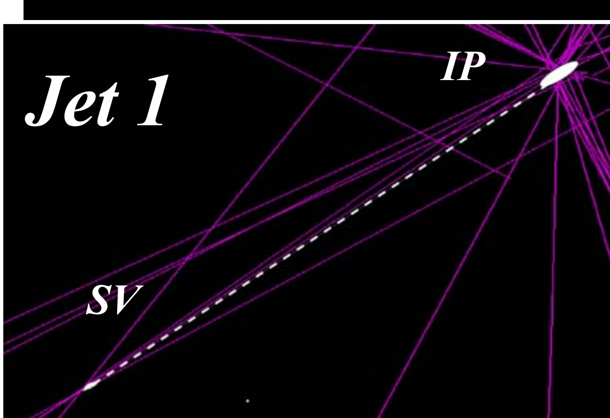
Short term perspective: *Improve JES systematic uncertainty,W helicity (Run I)*

Medium term perspective:Top Properties (W helicity,spin correlations) and single top with Run II data

Long term perspective: *top mass* $2fb^{-1} \rightarrow 2.7\ GeV$

$15fb^{-1} \rightarrow 1.3GeV$





μ+jets
Candidate Event