Status of Top Quark Analyses at DØ

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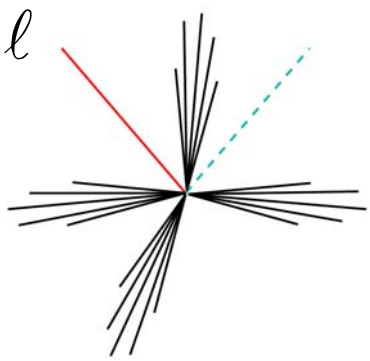
On behalf of the DØ Collaboration

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

Measurement based six analysis channels:

Lepton+jets (topological)

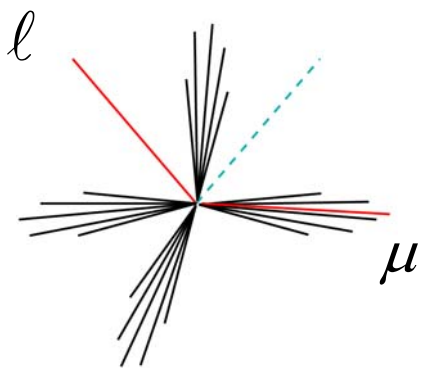


e+jets, μ+jets

Br = 14.7%

Efficient
Not very pure

Lepton+jets (soft muon tag)

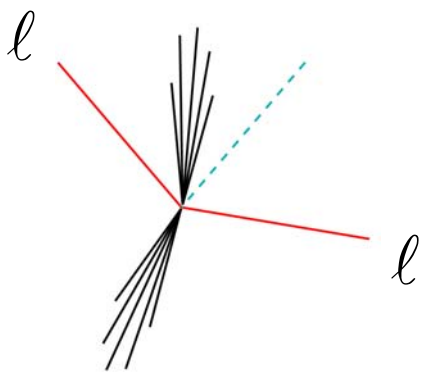


e+jets/μ, μ+jets/μ

Br = 14.7%

Pure
Not very efficient

dileptons



eμ and μμ

Br = 2.5 and 1.2%

Pure and efficient
Low branching

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

Predictions ranging from 6.7 to 7.5 pb

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

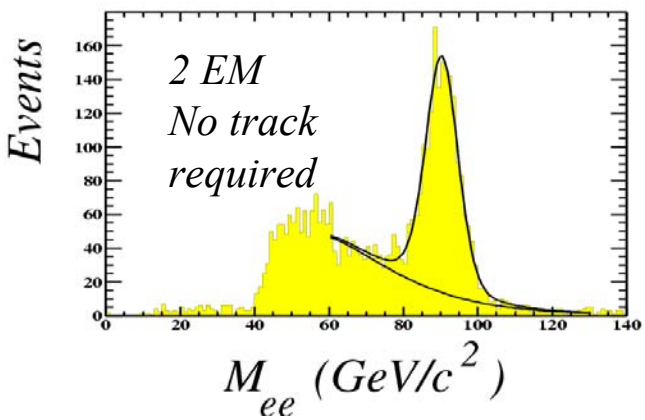
Reconstruction of Jets and Jet energy scale:

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

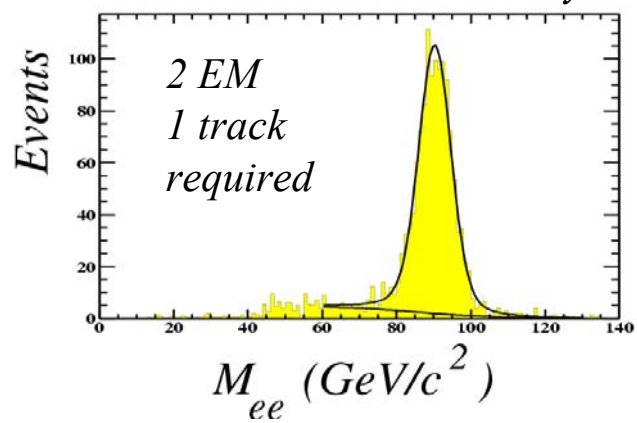
Reconstruction of electrons (only central):

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

DØ Run II Preliminary



DØ Run II Preliminary

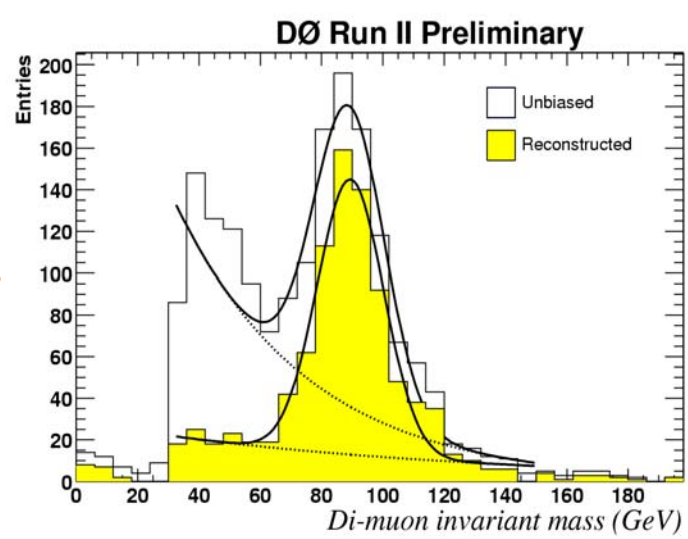


Reconstruction of muons:

ID
- Tracks in Muon system
- Tracks in Central Tracker

- Minimum Ionisation 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:

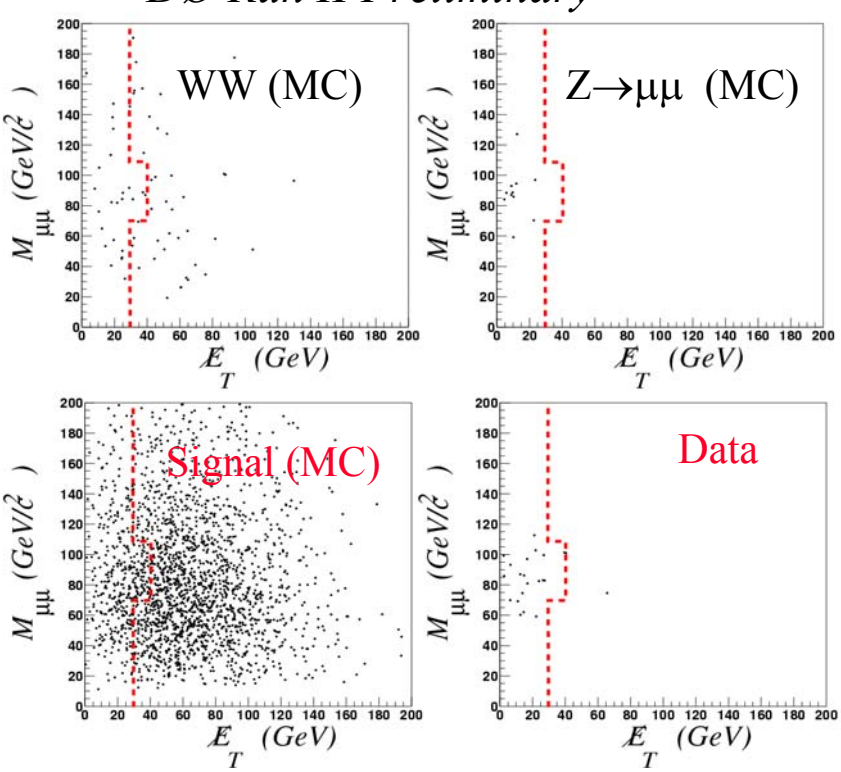
Instrumental

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 $\sigma = 7pb$

eμ 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:

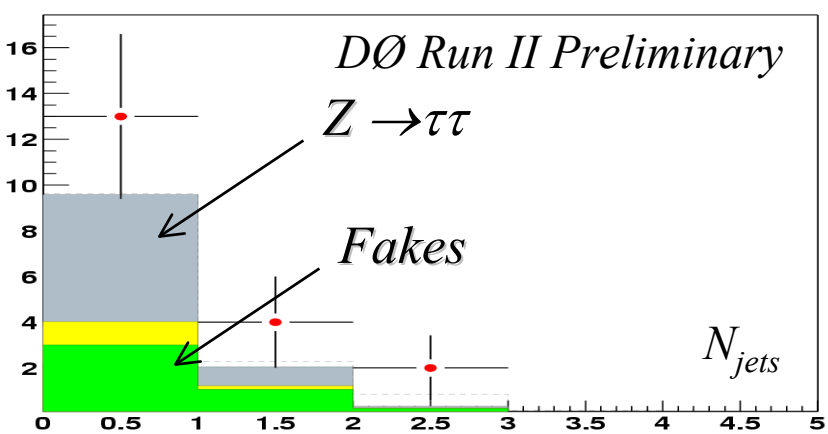
Instrumental

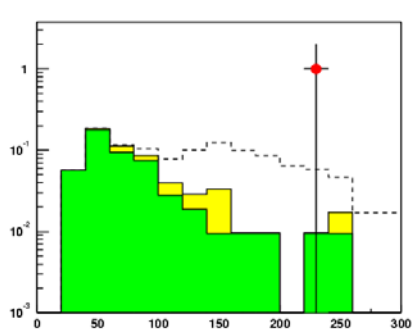
QCD and W+jets

Estimated from data (Fakes)

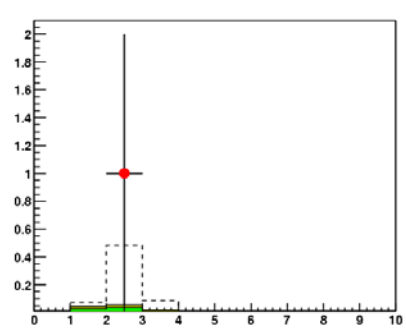
Physical backgrounds

from MC $\begin{cases} Z \rightarrow \tau\tau \\ WW \rightarrow \mu\mu \end{cases}$





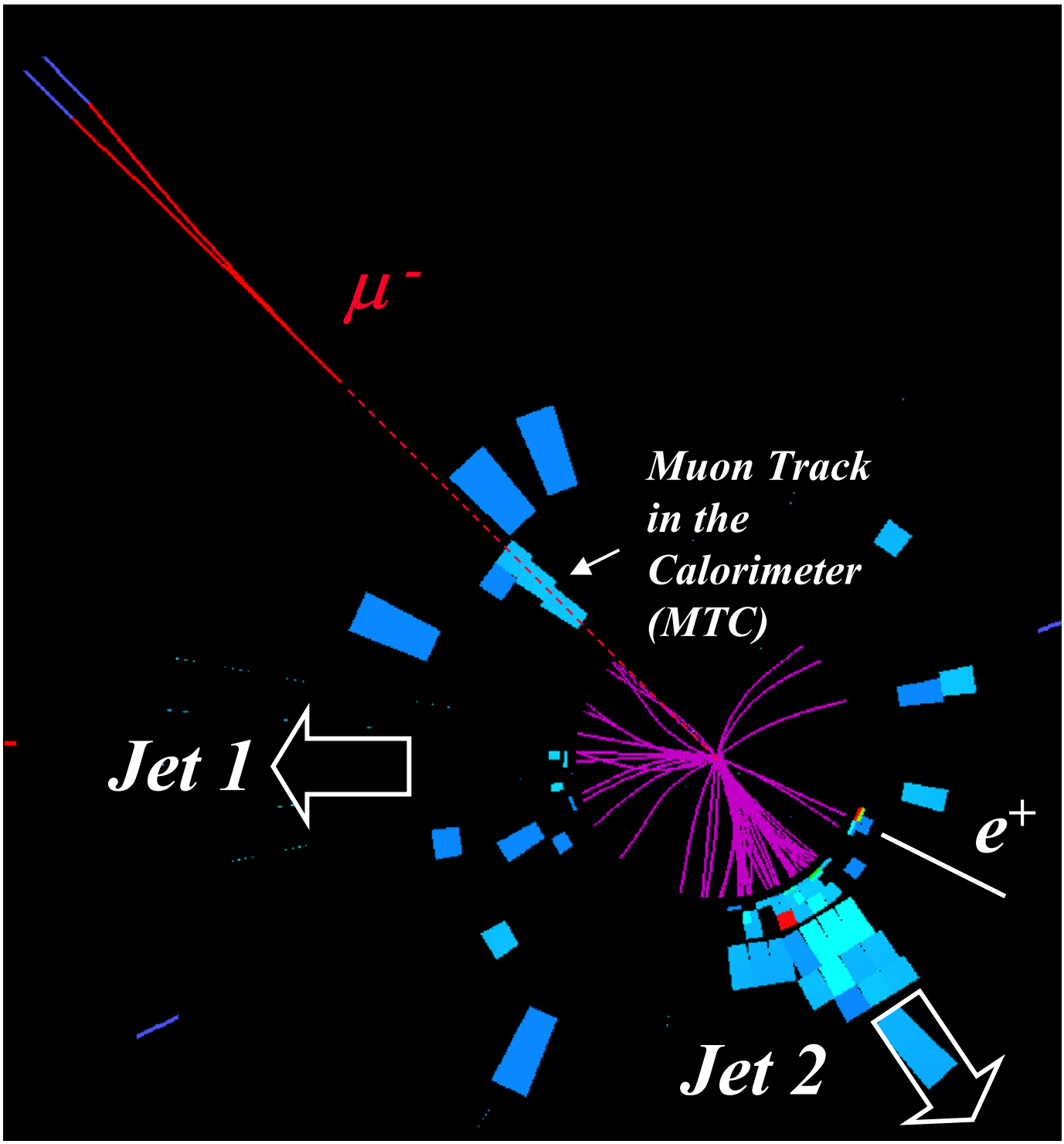
$H_T(e)$ (GeV)



N_{jets}

Fakes	*0.05±0.01*
Z →ττ	*0.02±0.01*
WW	*0.00±0.00*
Bkg	*0.07±0.01*
*Signal**	*0.5±0.01*
Data	*1*

** For σ = 7pb*



$e\mu$ 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*

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

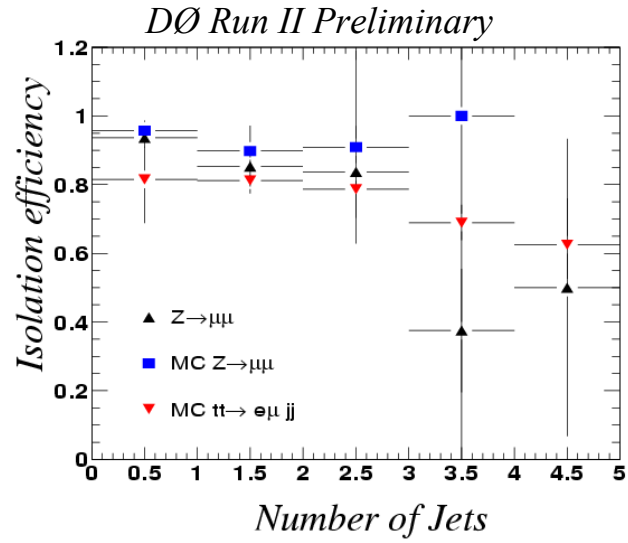
Signal probabilities…

… are obtained from benchmark signal samplesn of $Z \rightarrow ee$ 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

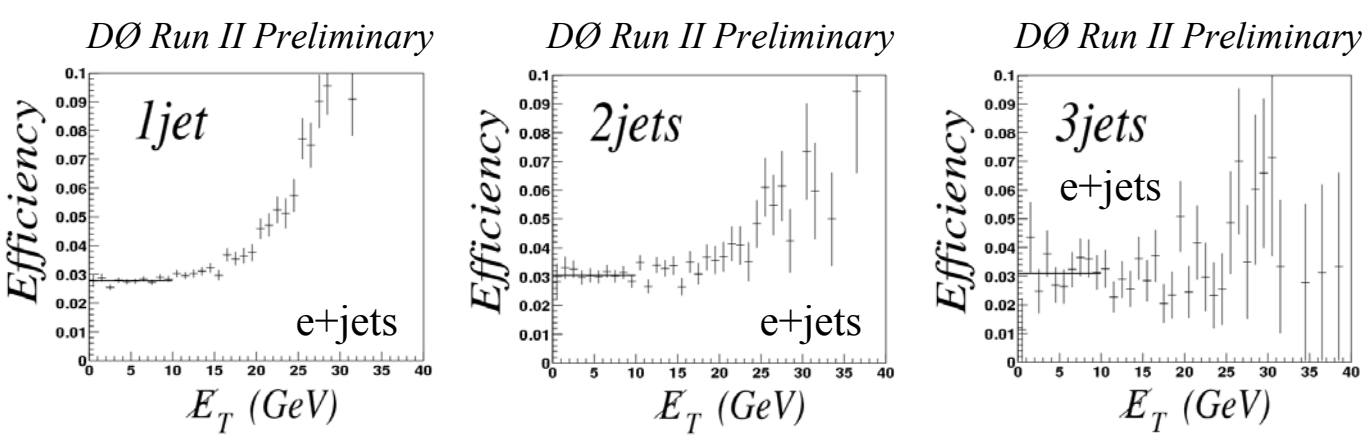
e+jets

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

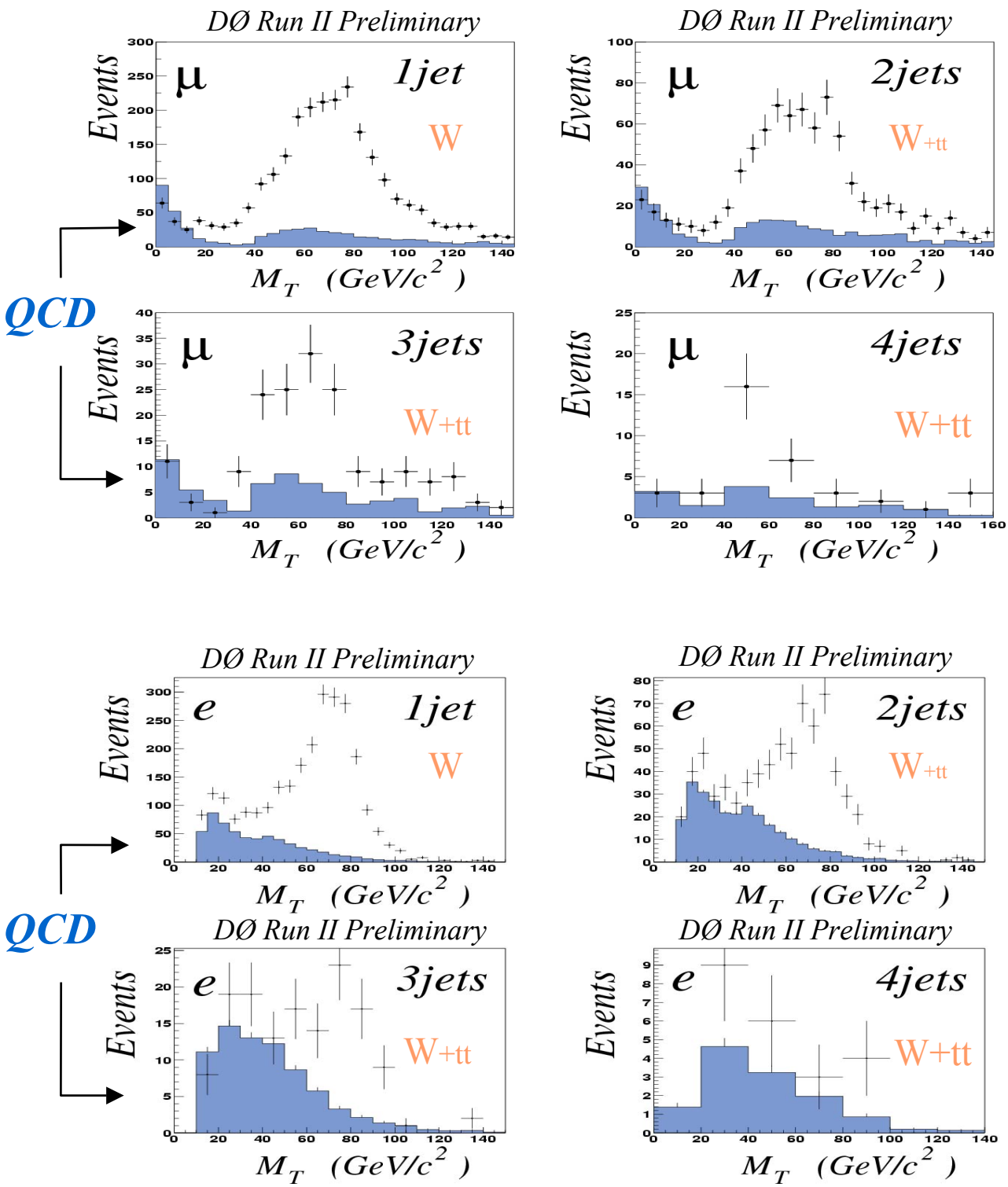
Background Probabilities…

… are obtained from benchmark QCD samples with low MET

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

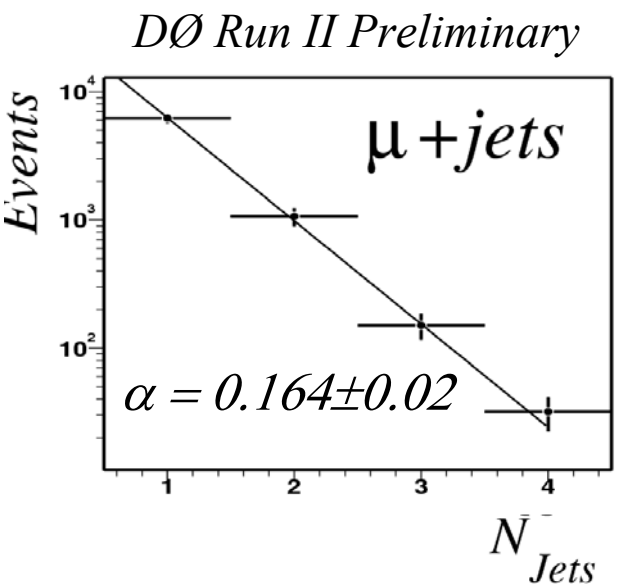


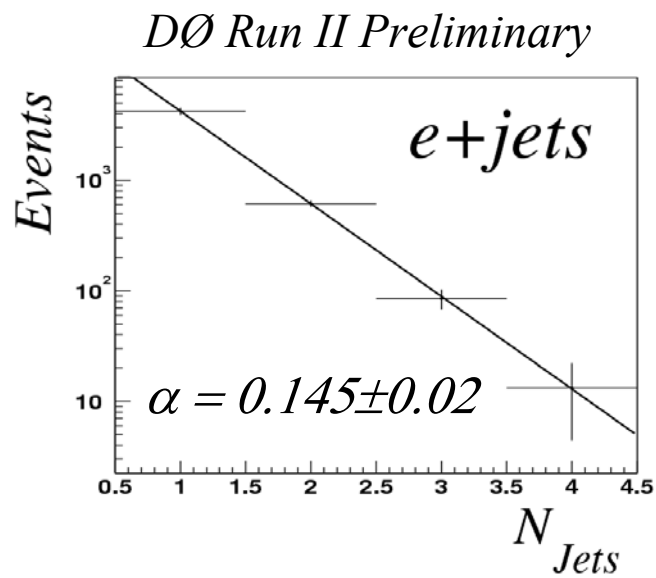
Estimation of the QCD background:



Berends scaling:

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





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

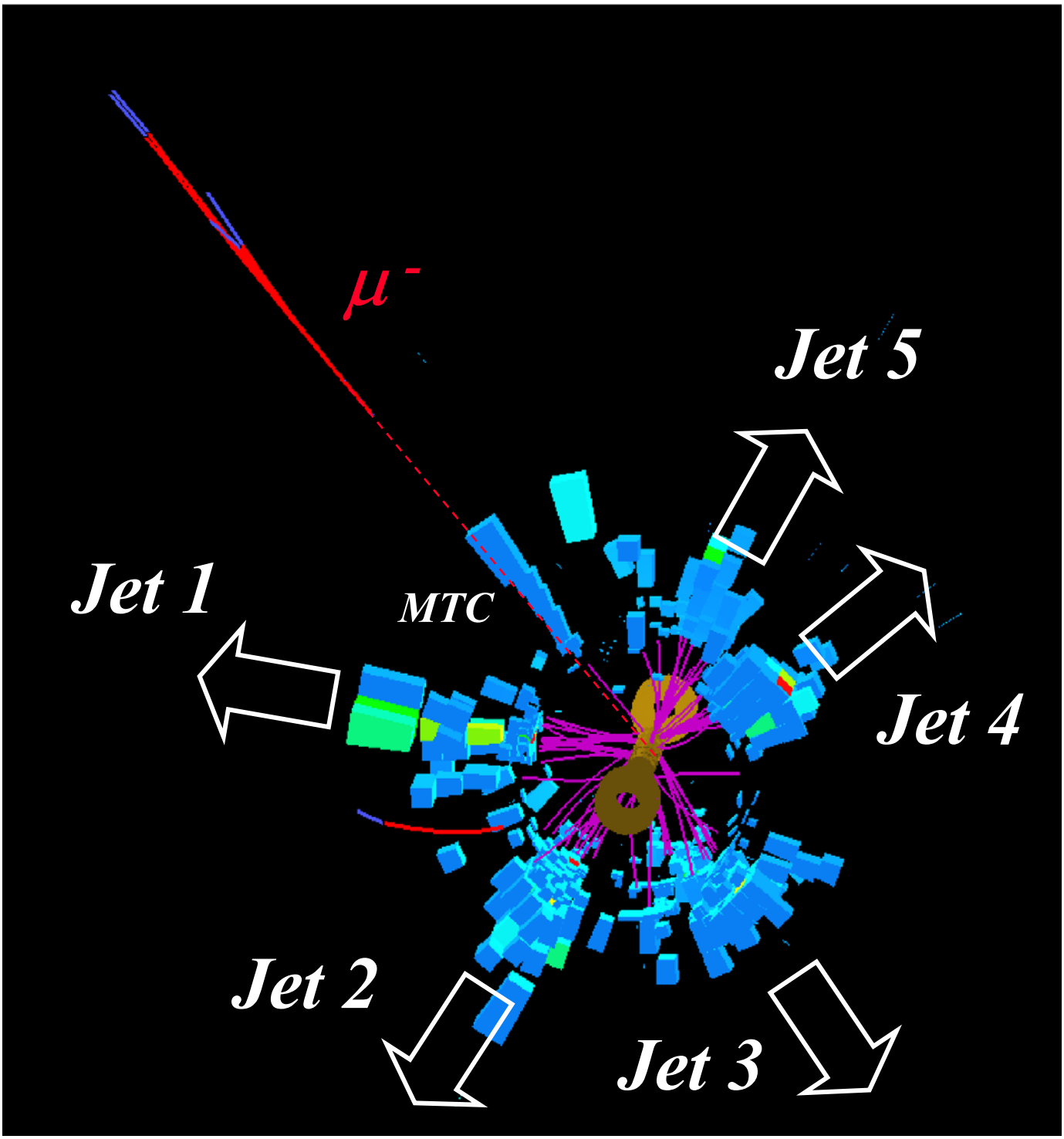
$$\tilde{N}^4_W = \begin{cases} 24.2 \\ 11.9 \end{cases} \qquad \tilde{N}^4_{QCD} = \begin{cases} 11.9 \\ 12.5 \end{cases} \qquad N^4_{obs} = \begin{cases} 38 \ (\mu\text{+jets}) \\ 22 \ (e\text{+jets}) \end{cases}$$

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 $\sigma = 7pb$



μ+jets Candidate Event

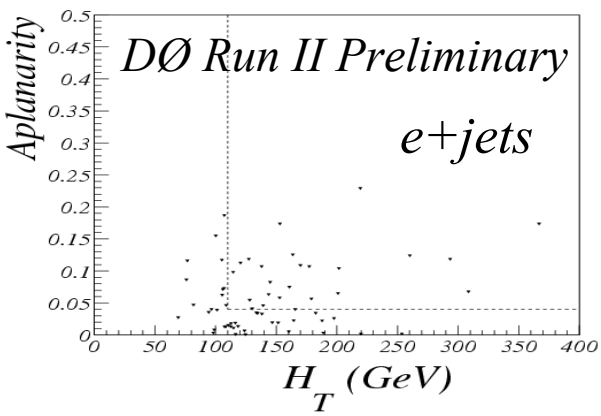
Soft Muon Tag Analyses

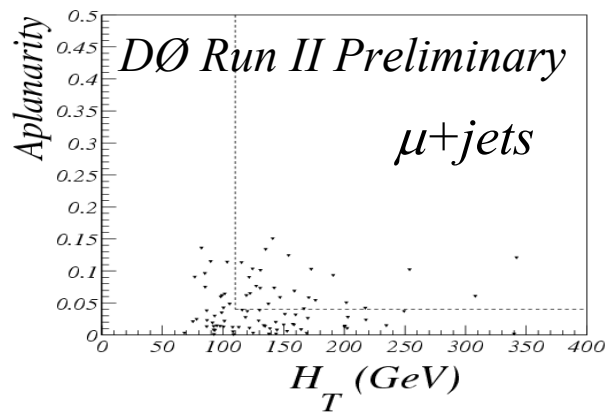
Selection before Soft Muon Tag

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

(Loose/Tight sample)

$\Rightarrow$ 75/23 (μ+jets), 459/27 (e+jets)



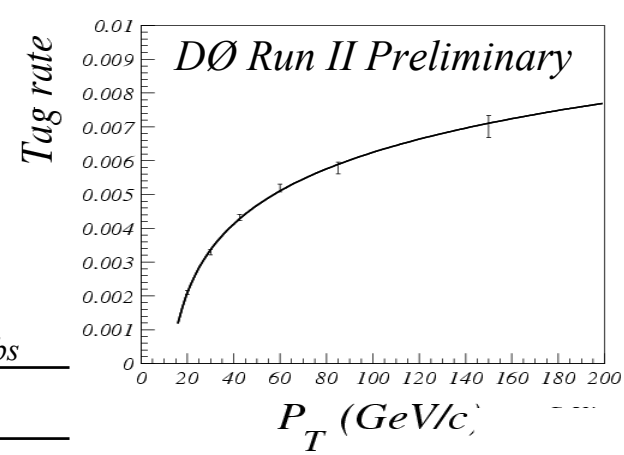


When SMT is applied: 1/0 (μ+jets), 9/2 (e+jets) $\Rightarrow$ $\tilde{N}_{QCD}^{SMT}$ = 0.2±0.2 (μ), 0.2±0.1 (e)

QCD background. from matrix method

W bkg. from Tag rate functions:

$\tilde{N}_{W}^{SMT}$ = 0.4±0.1 (μ), 0.0±0.1 (e)

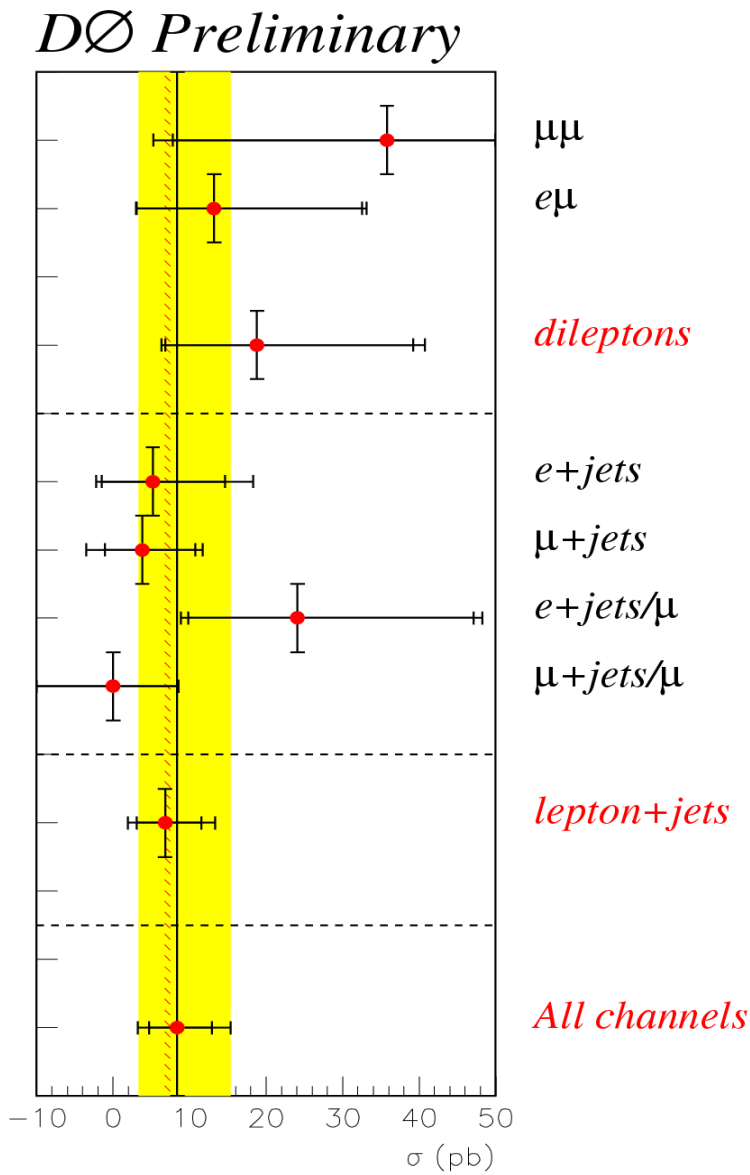


Analysis	Bkg. Tot.	Sig.*	N_{obs}
e+jets	0.2±0.1	0.5	2
μ+jets	0.6±0.3	0.4	0

* For σ = 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):

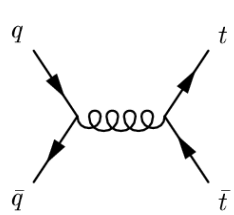
x → reconstructed objects in the event (leptons, jets)

α → Parameter to estimate

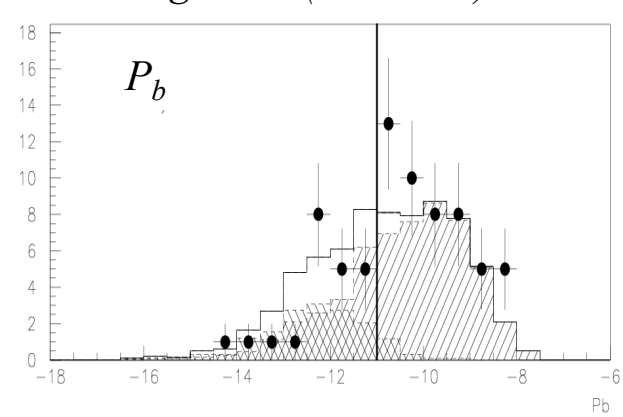
Folding object resolutions

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

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)

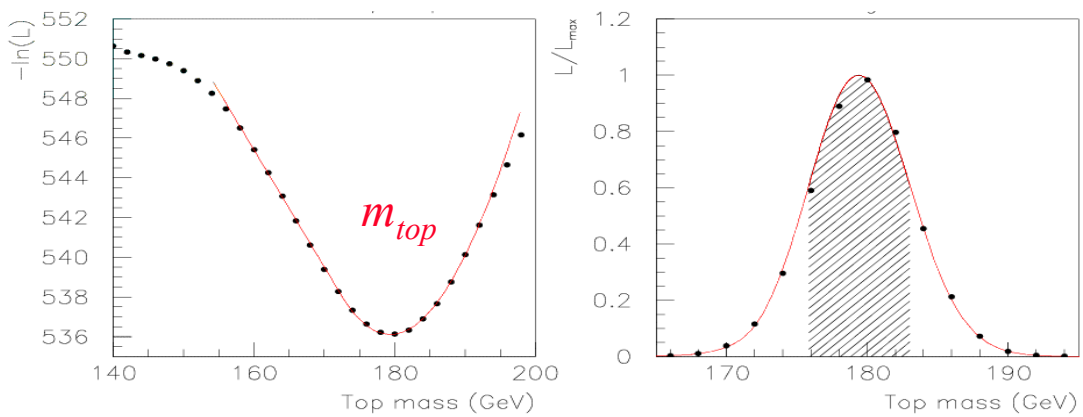
Likelihood definition:

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

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

Signal
$c_1=12$

W Bkg
$c_2=10$

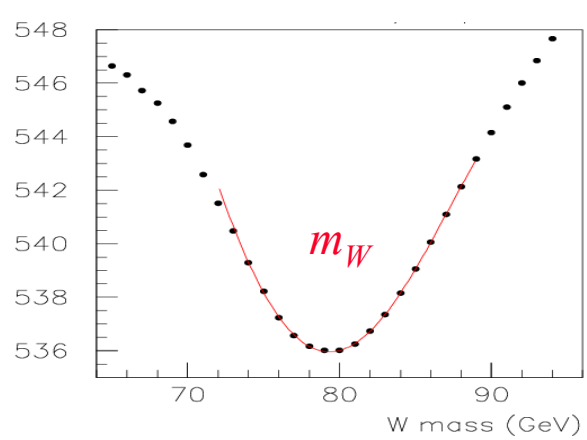


$$m_{top} = 179.9 \pm 3.6 \quad (stat)\ GeV/c^2$$

(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

A measurement of the tt cross section at $\sqrt{s}$=1.96 TeV was 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 mass measurement:

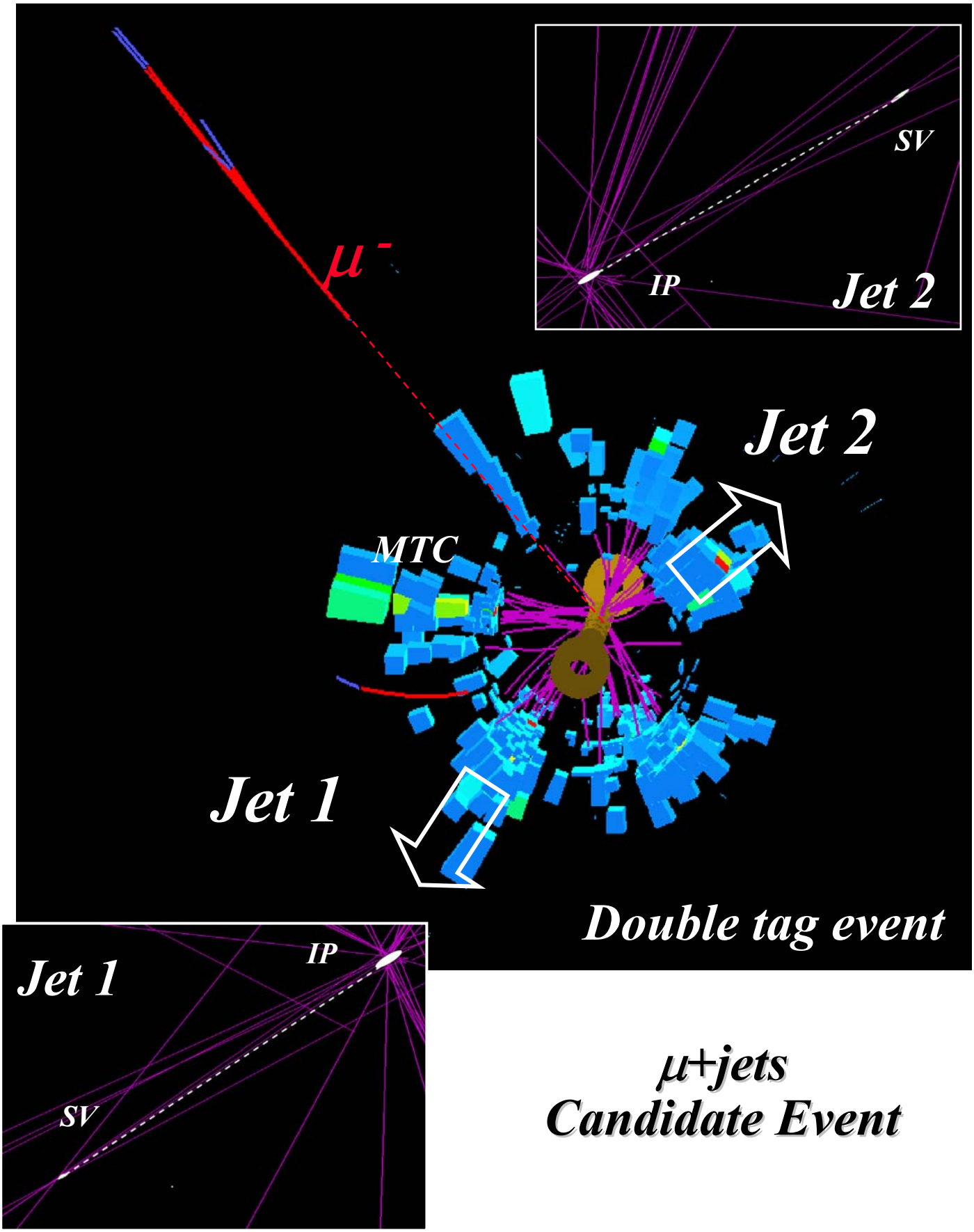
$$m_{top} = 179.9 \pm 3.6\ \ (stat)\ \pm 6\ \ (syst)\ \ GeV/c^2$$

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