Electroweak and Top Physics at CDF in Run II

XVII Rencontres de Physique de la Vallée d'Aoste

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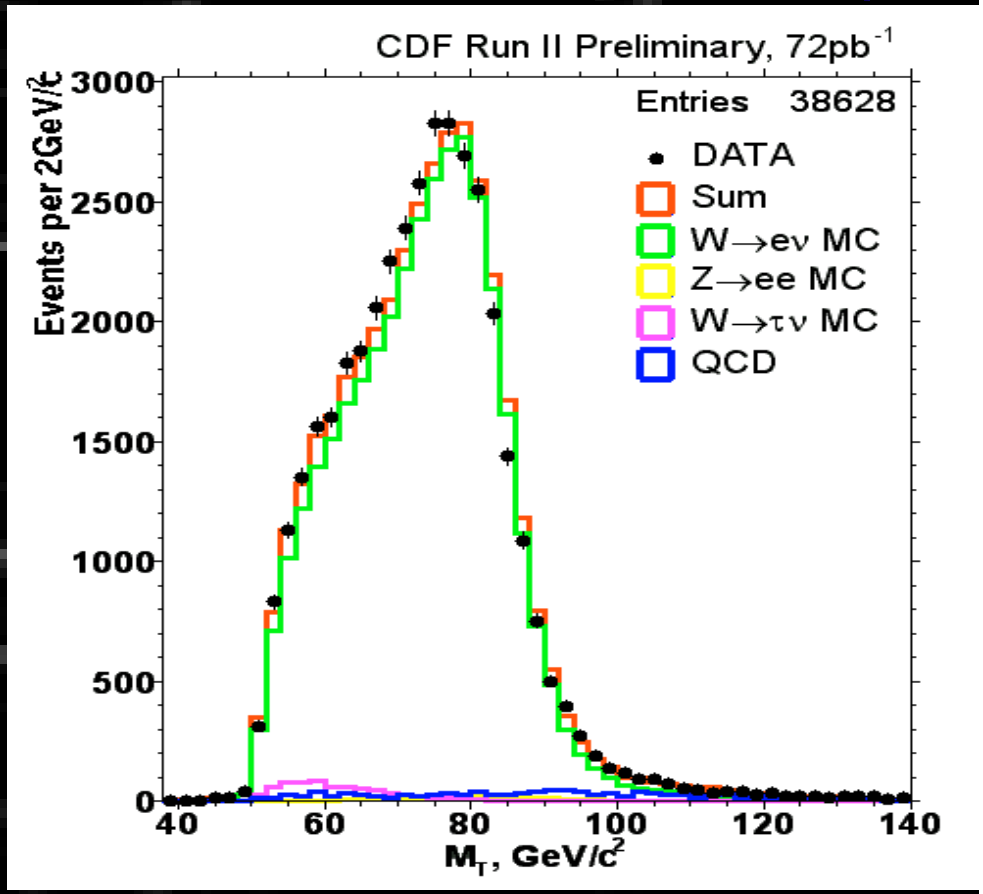
Electroweak Physics

- Cross section measurements
  - ✔$W \rightarrow l\nu$ (e,μ,τ)
  - ✔$Z^0 \rightarrow l^+l^-$ (e,μ)
- Forward-Backward asymmetry: A_{FB}
- Diboson: $W^+W^- \rightarrow ll\nu\nu$
- Standard Model consistency checks
  - ✔$R = \sigma(W \rightarrow l\nu)/\sigma(Z^0 \rightarrow l^+l^-)$ (e, μ)
    - ➤ extract $\Gamma(W)$
  - ✔$\sigma(W \rightarrow \tau\nu)/\sigma(W \rightarrow e\nu)$
    - ➤ extract g_τ/g_e

$\sigma.BR(W\rightarrow e\nu_e)$

- Event selection
  - ✔ One isolated high p_T central e
  - ✔ $\not\!\!E_T$>25 GeV
- 38628 candidates in ~72 pb^{-1}
- Backgrounds ~ 6%
  - ✔ dominated by QCD



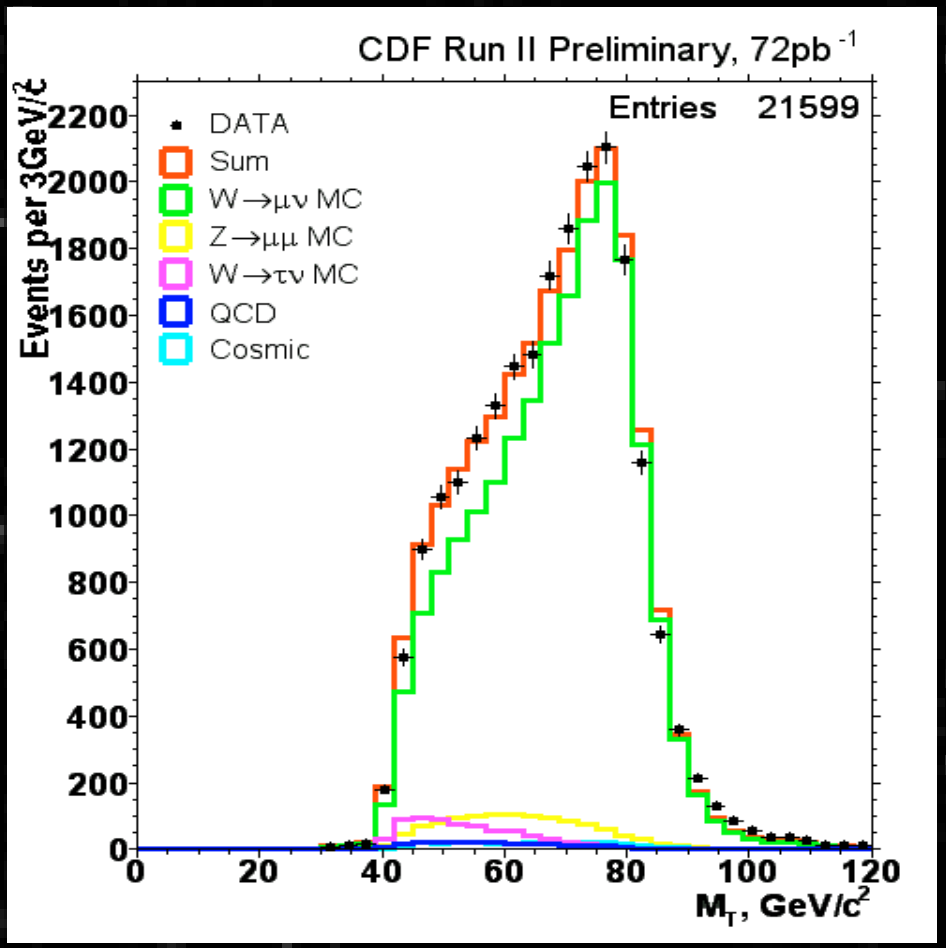
$\sigma \cdot BR(W\rightarrow e\nu) = 2.64 \pm 0.01_{stat} \pm 0.09_{sys} \pm 0.16_{lum}$ nb

NNLO @ $\sqrt{s}$=1.96 TeV[‡]: 2.69 ± 0.10 nb

[‡] Nucl. Phys. B359,343 (1991)
Phys.Rev. Lett. 88,201801 (2002)

$\sigma.BR(W\rightarrow\mu\nu_\mu)$

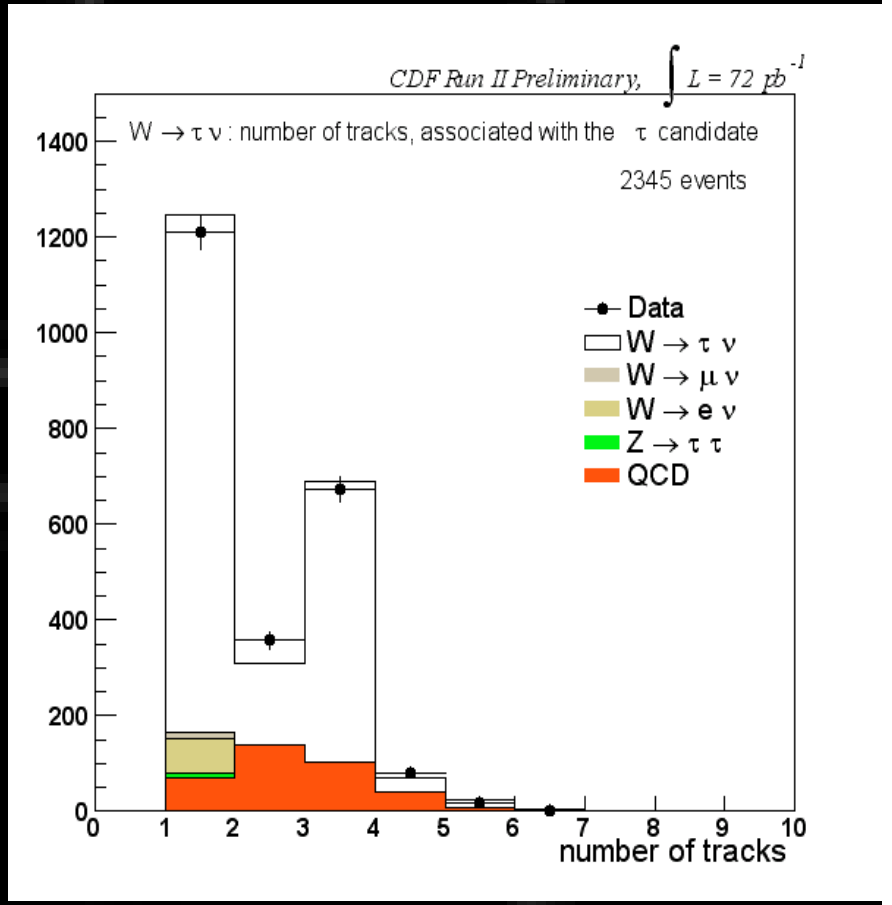
- Event selection
  - ✔ Isolated high p_T central μ
  - ✔ $\not{E}_T$>20 GeV
  - ✔ Z veto
  - ✔ Cosmic veto
- 21599 candidates in ~72 pb^{-1}
- Backgrounds ~ 11%
  - ✔ dominated by $Z\rightarrow\mu^+\mu^-$:



$$\sigma\cdot BR(W\rightarrow\mu\nu) = 2.64\pm0.02_{stat}\pm0.12_{sys}\pm0.16_{lum}\ nb$$

$\sigma.BR(W\rightarrow\tau\nu_\tau)$

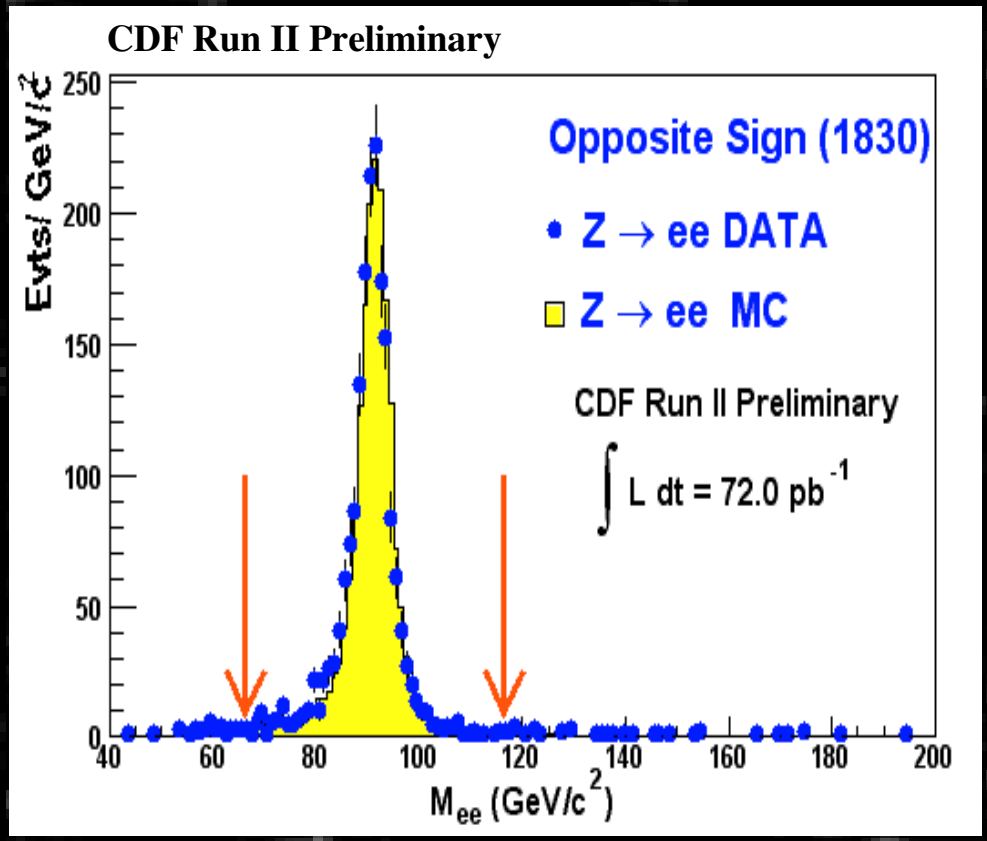
- Event selection
  - ✔ One isolated (calo+track) central τ
  - ✔ $\not\!\!E_T$>25 GeV
  - ✔ e removal
- 2345 candidates in ~72 pb^{-1}
- Backgrounds ~ 26%
  - ✔ dominated by QCD & W→eν



$$\sigma\cdot BR(W\rightarrow\tau\nu) = 2.62\pm0.07_{stat}\pm0.21_{sys}\pm0.16_{lum}\ nb$$

$\sigma.BR(Z^0 \rightarrow e^+e^-)$

- Event selection
  - ✔ Two isolated high p_T central e
- 1830 candidates in ~72 pb^{-1}
- Backgrounds ~ 0.5%



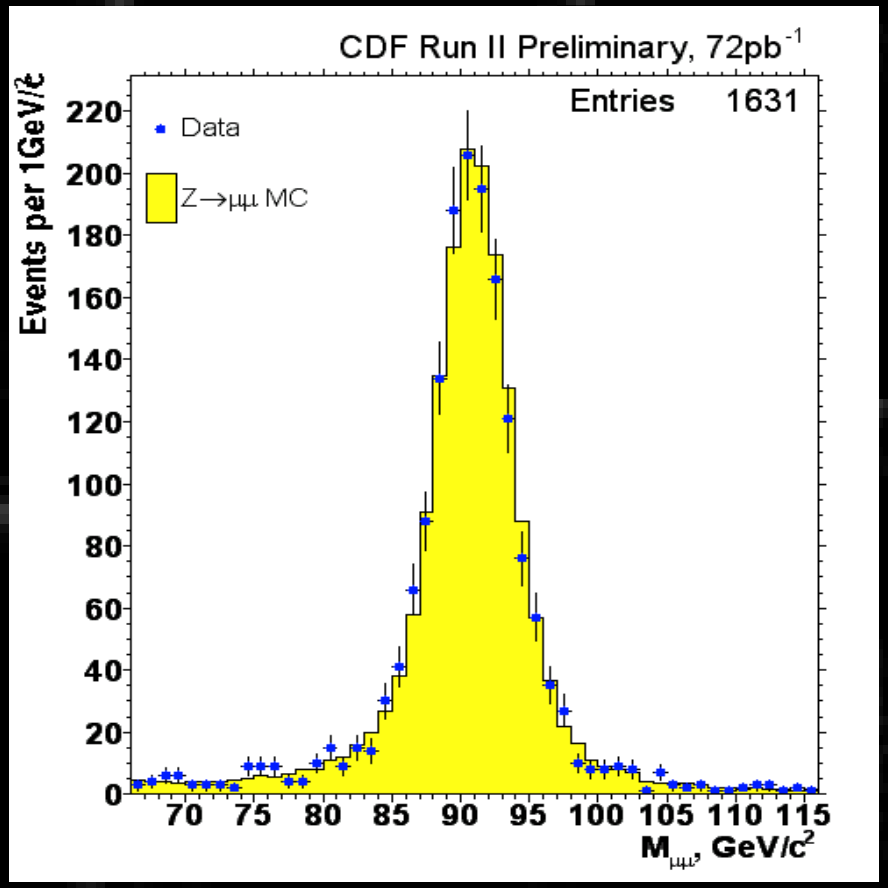
$\sigma \cdot BR(Z^0 \rightarrow e^+e^-) = 267 \pm 6_{stat} \pm 15_{sys} \pm 16_{lum}$ pb

NNLO @ $\sqrt{s}$=1.96 TeV‡: 252 ± 9 pb

‡ Nucl. Phys. B359,343 (1991)
Phys.Rev. Lett. 88,201801 (2002)

$\sigma.BR(Z^0 \rightarrow \mu^+\mu^-)$

- Event selection
  - ✔ One isolated high p_T central μ
  - ✔ A second isolated high p_T track:
    - ➤ E_{em} <2 GeV & E_{had}<6 GeV
  - ✔ Cosmic veto
- 1631 candidates in ~72 pb^{-1}
- Backgrounds ~ 0.5%

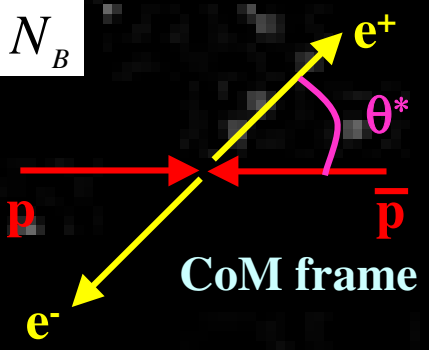


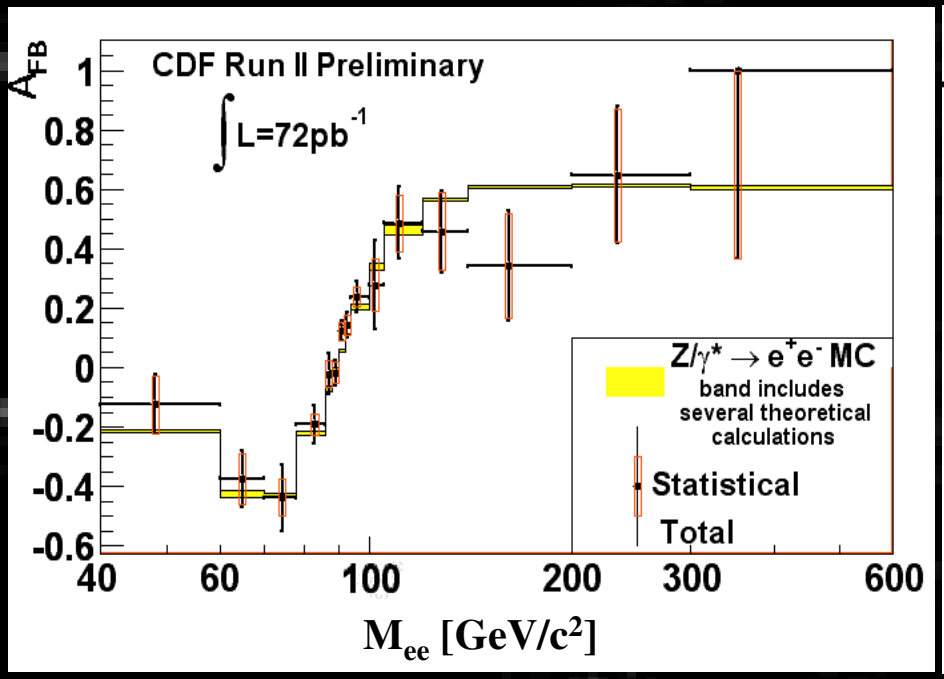
$$\sigma \cdot BR(Z^0 \rightarrow \mu^+\mu^-) = 246 \pm 6_{stat} \pm 12_{sys} \pm 15_{lum}\ pb$$

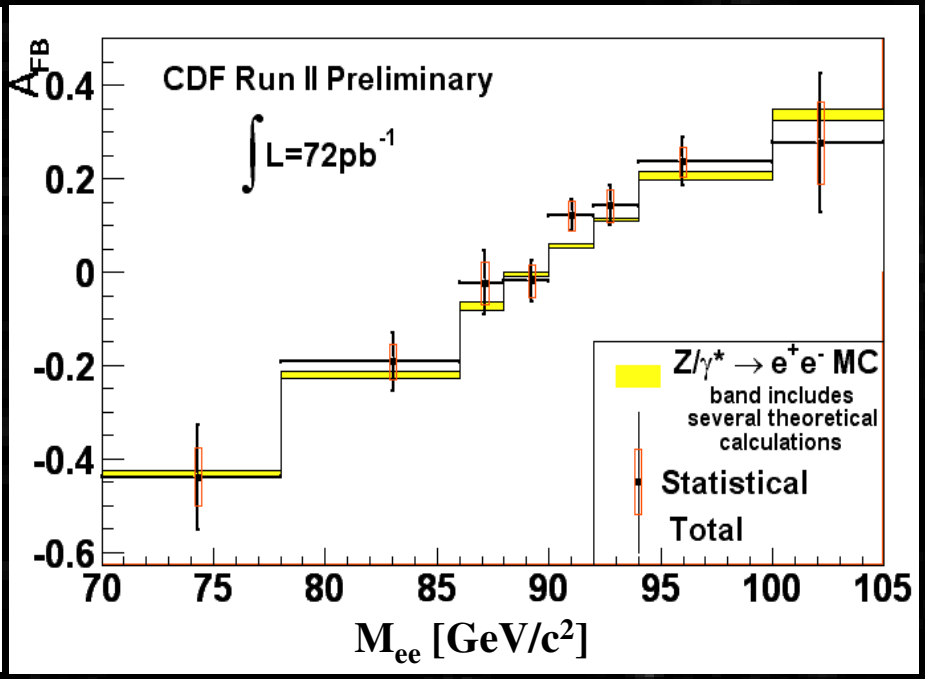
A_{FB} with $Z^0 \rightarrow e^+e^-$

- Forward-Backward asymmetry A_{FB}:
  - ✔ Direct probe V,A ⇨ Extract $\sin^2\theta_W$
  - ✔ Constrains the properties of any hypothetical heavy neutral gauge boson not in SM (e.g. Z')

$$A_{FB} = \frac{N_F - N_B}{N_F + N_B}$$







SM Consistency Checks

• electron • muon

$\mathcal{R}$	$9.88 \pm 0.24_{stat} \pm 0.47_{sys}$ $10.69 \pm 0.27_{stat} \pm 0.33_{sys}$
$\Gamma(W)$ [GeV]	$2.29 \pm 0.06_{stat} \pm 0.10_{sys}$ $2.11 \pm 0.05_{stat} \pm 0.07_{sys}$

Measure *Theoretical prediction* *PDG SM* *PDG combined Exp*

$$\mathcal{R} = \frac{\sigma(pp\to W)\,\Gamma(W \to e\nu)\,\Gamma(Z)}{\sigma(pp\to Z)\,\Gamma(W)\,\Gamma(Z \to ee)}$$

Extract

$\mathcal{R}$ = 10.67 ±0.15 NNLO(1.96 TeV) [Nucl. Phys. B359,343 (1991)] [Phys.Rev. Lett. 88,201801 (2002)]

Γ(W) : 2.118 ± 0.042 GeV [Phys. Rev. D66, 2002 (PDG fit)]

Γ(W) : 2.067 ± 0.021 GeV [Phys. Rev. D49, 2002]

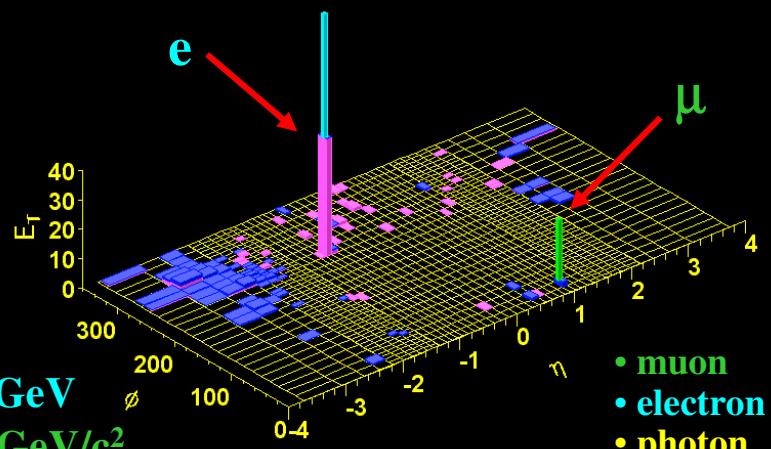
$$\frac{BR(W\to\tau\nu)}{BR(W\to e\nu)} = 0.99 \pm 0.04_{stat} \pm 0.07_{sys} \Rightarrow \frac{g_\tau}{g_e} = 0.99 \pm 0.02_{stat} \pm 0.04_{sys}$$

Diboson: $W^+W^- \rightarrow l\nu l\nu$

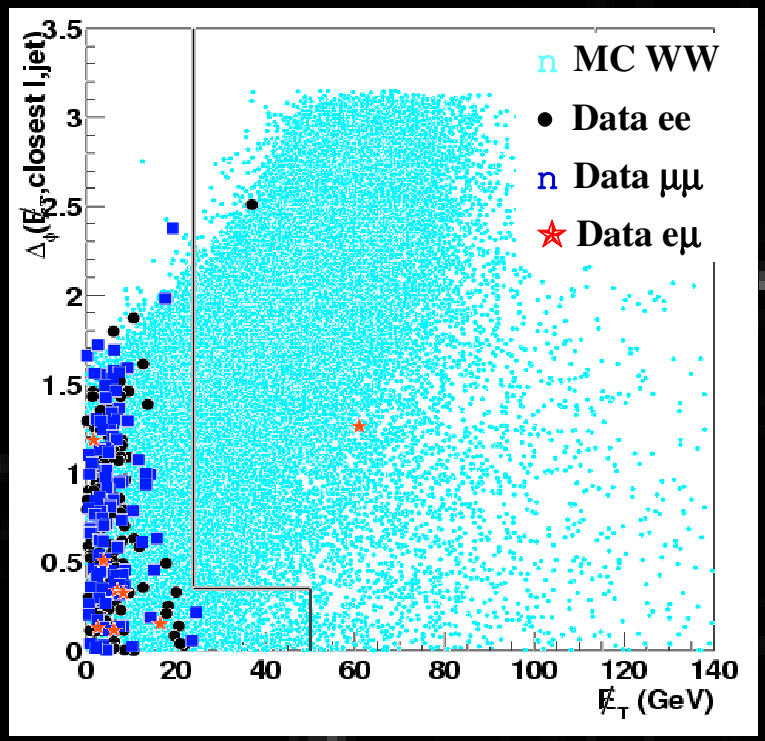
Event selection

- ✔ Two high p_T isolated μ or e with opposite charge
- ✔ $\not\!\!E_T$>25 GeV
- ✔ $\Delta\phi(\not\!\!E_T, l/j)>20^0$
- ✔ Z veto
- ✔ Jet veto to reject $t\bar{t}$

Source	ee	μμ	eμ	ll
Background	0.29±0.13	0.46±0.18	0.77±0.60	1.52±0.64
WW→llνν	0.54±0.12	0.65±0.14	1.55±0.34	2.74±0.59
Data	1	0	1	2



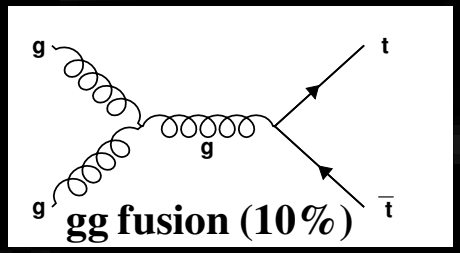
$E_T(e)$=41.8 GeV
$P_T(\mu)$=20.5 GeV/c^2
$\not\!\!E_T$=60.2 GeV

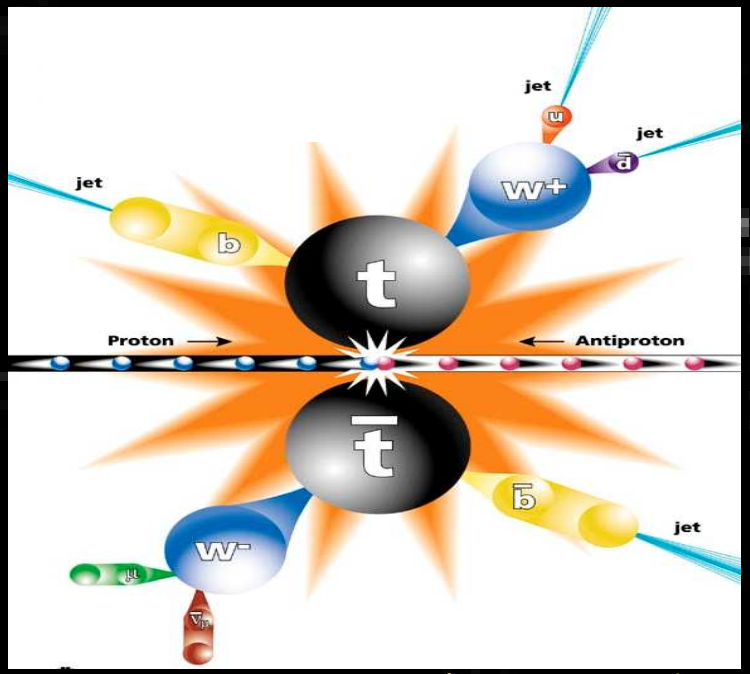


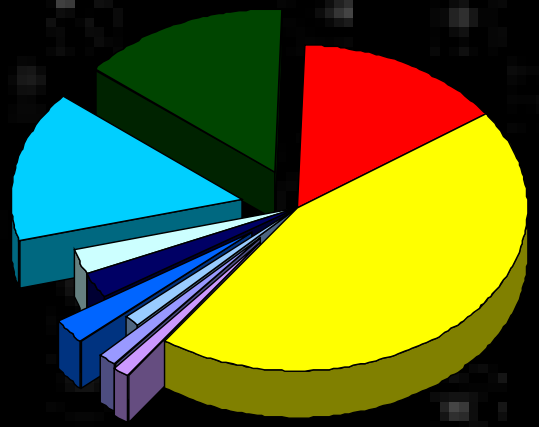
Cross section to come with more statistics

Top Production & Decay

- BR(t→Wb)≈ 100 %
  - ✔ Both W's decay via W→lν (l = e or μ; 5%)
    - ➤ final state lν lν $b\bar{b}$: dilepton
  - ✔ One W decays via W→lν (l = e or μ; 30%)
    - ➤ final state lν $q\bar{q}$ $b\bar{b}$: lepton+jets
  - ✔ Both W decays via W→$q\bar{q}$ (44%)
    - ➤ final state: $q\bar{q}$ $q\bar{q}$ $b\bar{b}$: all hadronic





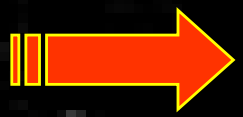


- e-e (1/81)
- mu-mu (1/81)
- tau-tau (1/81)
- e -mu (2/81)
- e -tau (2/81)
- mu-tau (2/81)
- e+jets (12/81)
- mu+jets (12/81)
- tau+jets (12/81)
- jets (36/81)

Top Physics

- $\sigma_{t\bar{t}}$ measurement
  - ✔Precision test of QCD
  - ✔Probe for physics beyond SM:
    - Non-SM production:
      - $X \rightarrow tt$
      - $X \rightarrow ll+jets+\not{E}_T$
    - Non-SM decay: $t \rightarrow Xb$

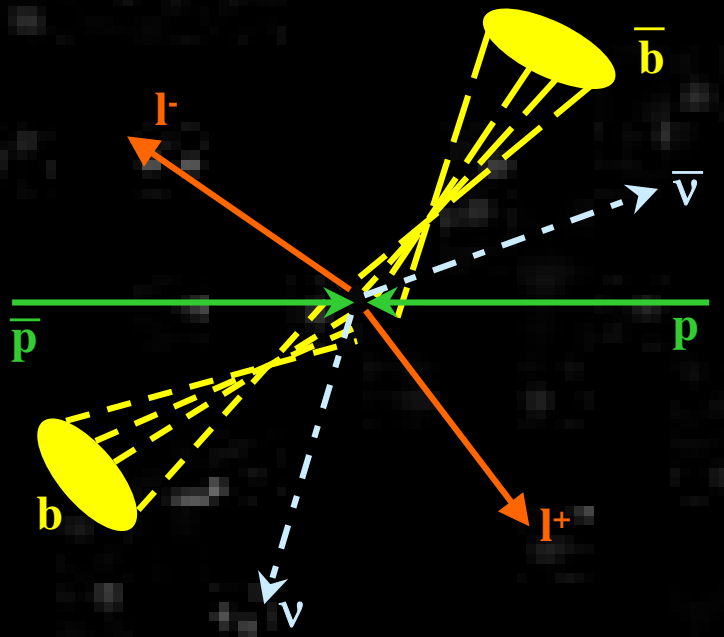
- Channels:
  - ✔dilepton channel ($l\nu\ l\nu\ b\bar{b}$)
    - Good S/B≈7:1
    - Low statistics
    - More difficult to measure M_{top} accurately
  - ✔l+jets channel ($l\nu\ q\bar{q}\ b\bar{b}$)
    - Lower S/B≈1:6 for W+≥ 3 jets
      - b-tagging improve S/B≈3:1
    - Higher statistics
    - Essential for M_{top}(2 b-tags jets)



Top mass ?

Dilepton Channel

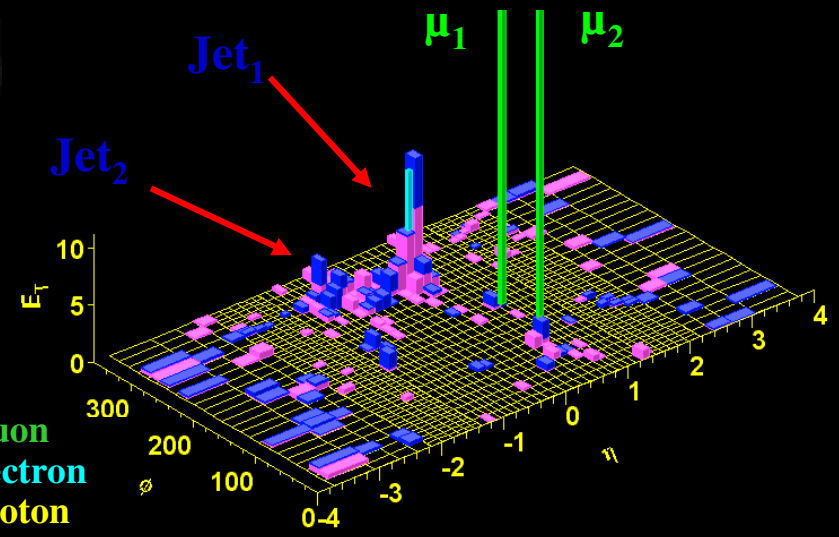
- Event selection (similar to Run I)
  - ✔ Two high p_T isolated μ or e with opposite charge
  - ✔ $\Delta\phi(\not\!\!E_T, l/j)>20^0$
  - ✔ Z veto
  - ✔ $\not\!\!E_T>25$ GeV
  - ✔ Jets $\not\!\!E_T>10$ GeV & $|\eta|<2.0$ use $\geq$2 jets for $\sigma_{t\bar{t}}$
  - ✔ $H_T>200$ GeV ($\Sigma\ \not\!\!E_T, E_T^l, E_T^j$)
- Backgrounds
  - ✔ WW/WZ,
  - ✔ $Z\rightarrow\tau\tau$, Drell-Yan
  - ✔ fake lepton



72 pb^{-1} : 5 candidates in $\geq$ 2 jets bin (1 ee, 1 $\mu\mu$, 3 eμ)

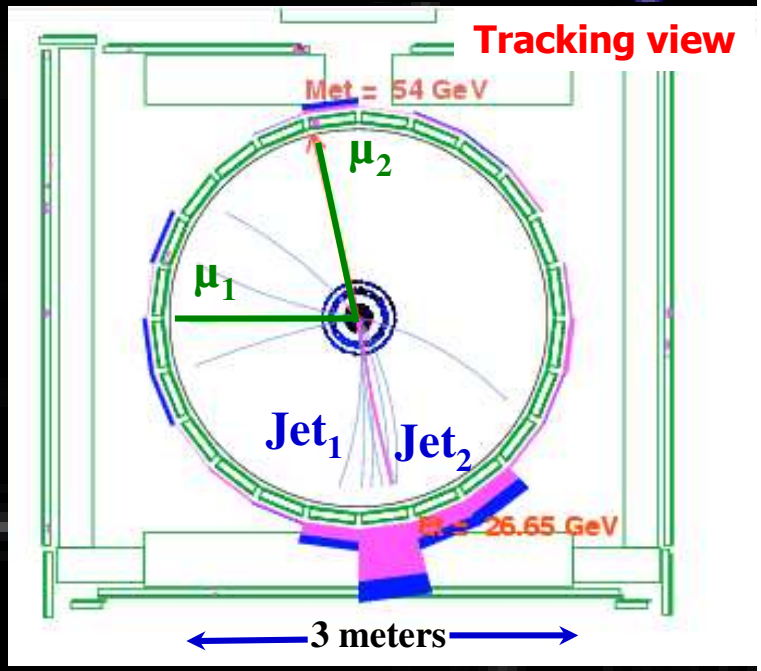
$t\bar{t}$ Dilepton Candidate

$t\bar{t}$ dilepton candidate:
Nov 26 2002 run: 154654 event: 7344016
$\mu^+\mu^-$ (CMUP-CMX) + 2 jets

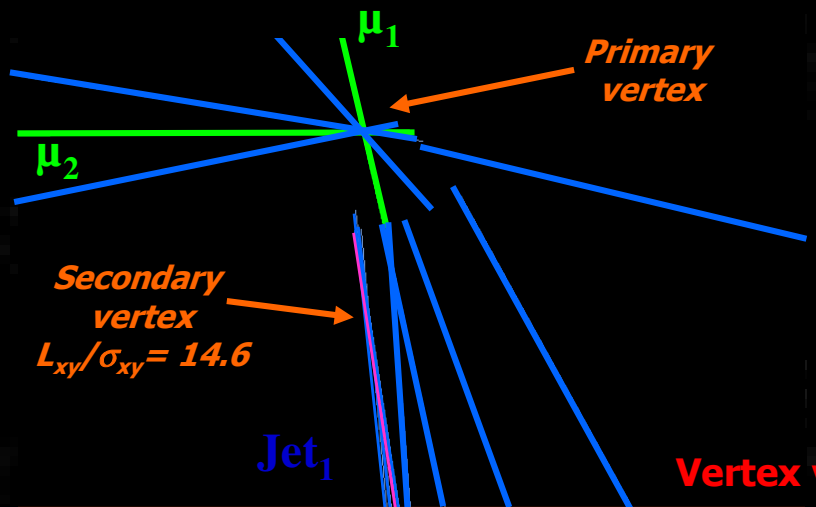


- muon
- electron
- photon

Lego view



- muon
- electron
- hadron

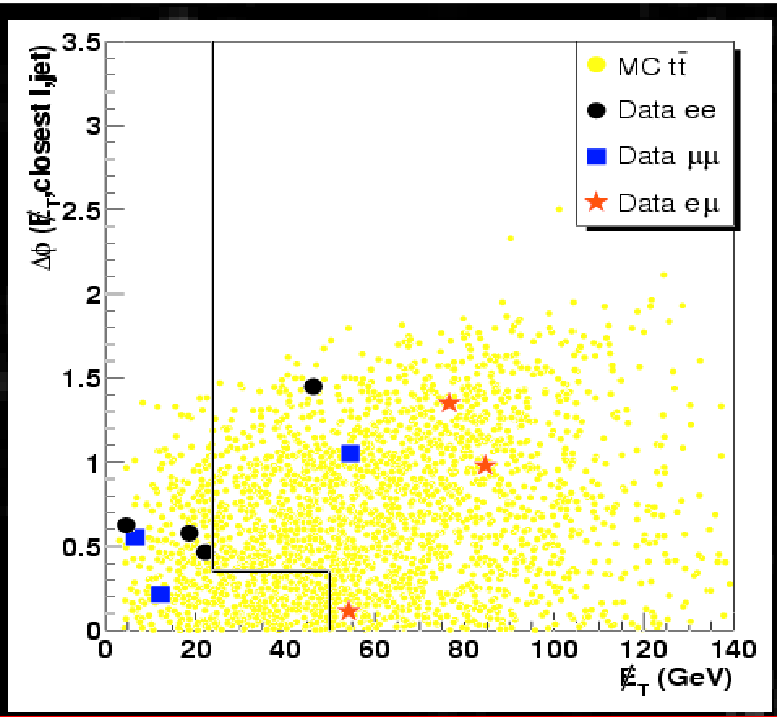


Vertex view

$p_T(\mu_1) = 57$ GeV/c²
$p_T(\mu_2) = 53$ GeV/c²
$M_{\mu\mu} = 69$ GeV/c
$E_T^j = 32{,}15$ GeV
$\not{E}_T = 54$ GeV
$H_T = 212$ GeV

$\sigma_{t\bar{t}}$ in Dilepton Channel

Source	ee	μμ	eμ	ll
Background	0.103±0.056	0.093±0.054	0.100±0.037	0.30±0.12
tt→lνlνbb	0.47±0.05	0.59±0.07	1.44±0.16	2.5±0.3
SM expectation	0.57±0.08	0.68±0.09	1.5±0.2	2.8±0.3
Data	1	1	3	5



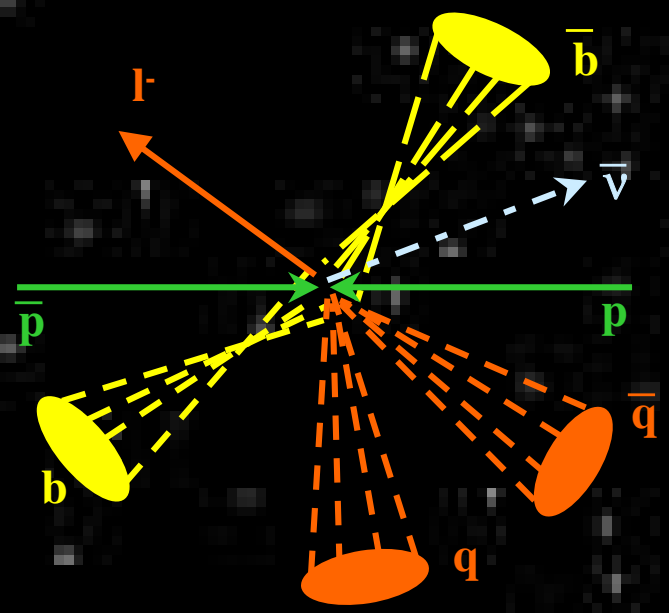
$\sigma_{t\bar{t}} = 13.2 \pm 5.9_{stat} \pm 1.5_{sys} \pm 0.8_{lum}$ pb

NLO @ $\sqrt{s}$=1.96 TeV for M_{top} = 175 GeV‡: $6.70^{+0.71}_{-0.88}$ pb

‡ MLM

Lepton+Jets Channel

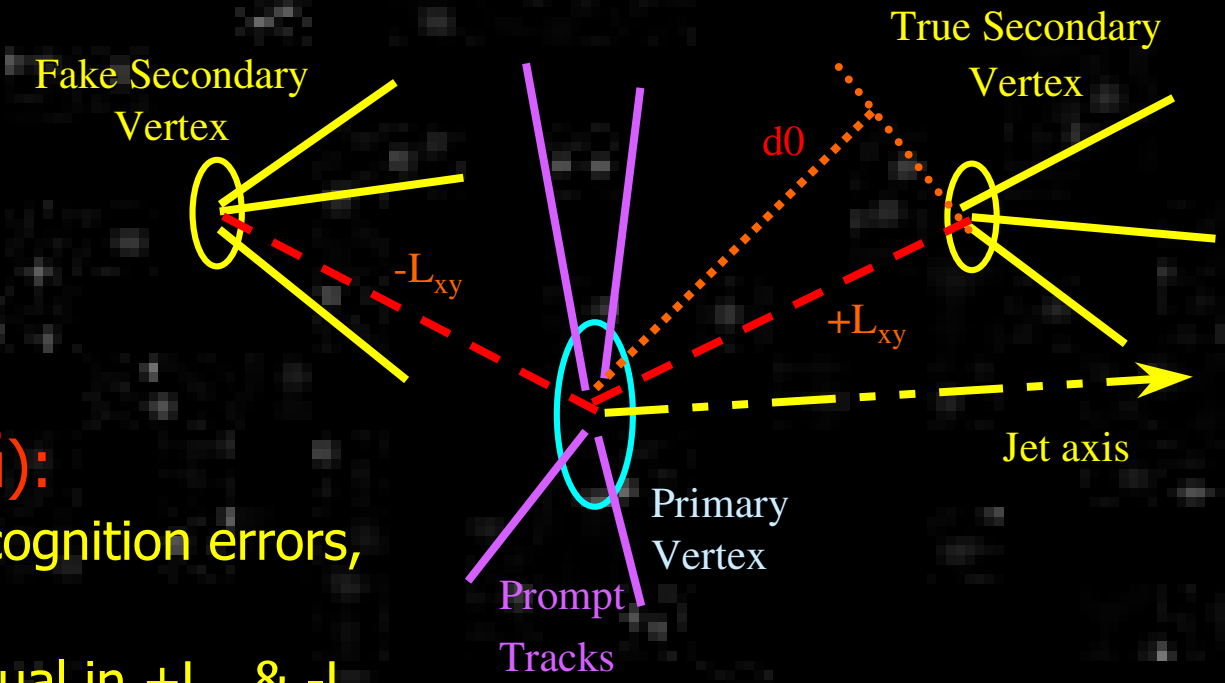
- Event selection (same as Run I)
  - ✔ One isolated high p_T central e or μ
  - ✔ $\not\!\!E_T$>20 GeV
  - ✔ Jets E_T>15 GeV & $|\eta|$<2.0
  - ✔ Z veto
  - ✔ use W+≥ 3 jets for $\sigma_{t\bar{t}}$



- Reduce background with b-tagging
  - ✔ Secondary Vertex Tagging (SECVTX)
    - ➤ Only 2% W+jets expected to have b quarks
- Backgrounds
  - ✔ W+jets ($g \to b\bar{b}$, $c\bar{c}$)
  - ✔ Mistags from light quarks and gluon jets
  - ✔ W+charm
  - ✔ Non W background (fake lepton), diboson, Drell-Yan, single top (small)

Lepton+Jets: b-tagging

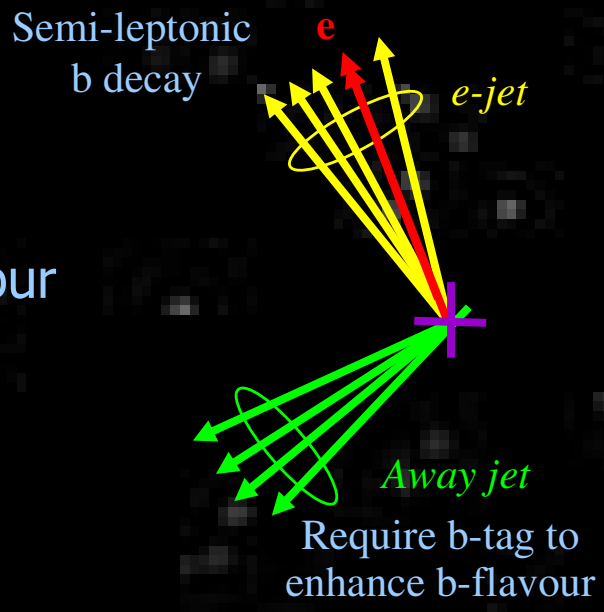
- b-quarks have a long lifetime: $c\tau \sim 450\ \mu m$
  - ✔ B hadrons travel L_{xy}~3mm before decay
- Jet is tagged as b-jet if $L_{xy}/\sigma_{xy} > 3$ (typical σ_{xy}~150μm)



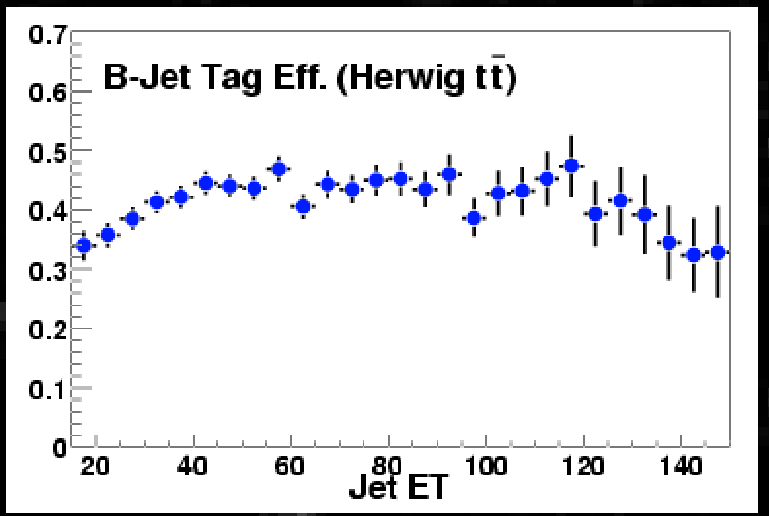
- Mistags ($g \to d\bar{d}, u\bar{u}$):
  - ✔ Due to pattern recognition errors, resolution etc...
  - ✔ Assume mistag equal in $+L_{xy}$ & $-L_{xy}$

b-tagging Efficiency

- Jet b-tagging efficiency
  - ✔ $\varepsilon_B = r/F_B$
    - Tagging rate: $r = (N_+ - N_-)/N_{tot}$
    - F_B: Fraction of e-jets containing heavy flavour
  - ✔ Done with few different methods:
    - results all consistent with each other
  - ✔ Measured in data & $b\bar{b}$ MC
    - Determine Scale Factor



ε (Data)	ε (MC)	Scale Factor
0.20±0.01	0.22±0.01	0.89±0.07



- Efficiency of b-tagging a $t\bar{t}$ event
  - ✔ measure in $t\bar{t}$ MC, apply SF

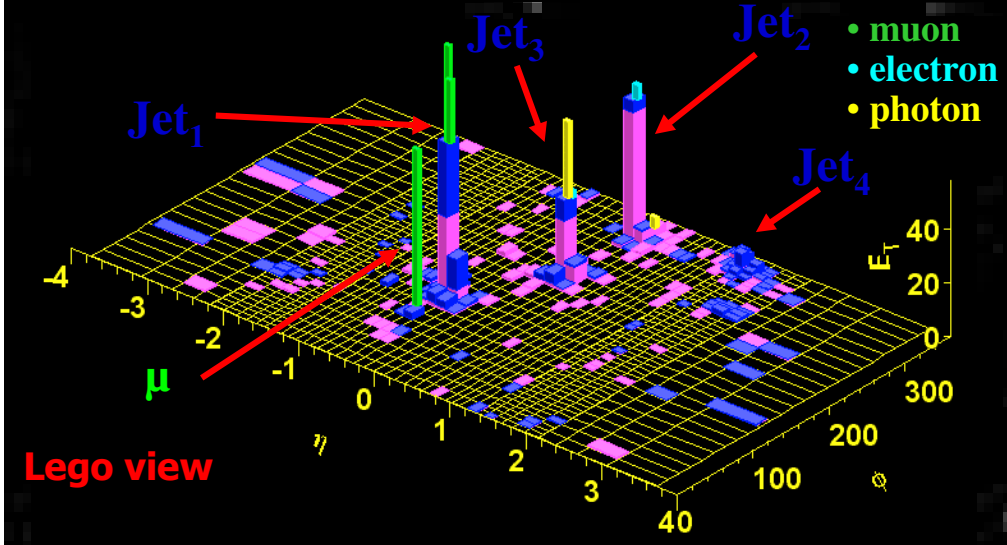
ε(event tag) = 45 ± 1 ± 5 %

l+jets: Main Backgrounds

- Mistags measured from data
- $Wb\bar{b}$ & $Wc\bar{c}$ measured from MC
  - ✔ Relies on simulation of heavy flavour content
  - ✔ For now take $b\bar{b}$ & $c\bar{c}$ fraction in $Wb\bar{b}$ & $Wc\bar{c}$ from Run I
    - ➤ RunI & Run II fractions agree within uncertainties
  - ✔ b-tagging efficiency from Run II corrected with SF

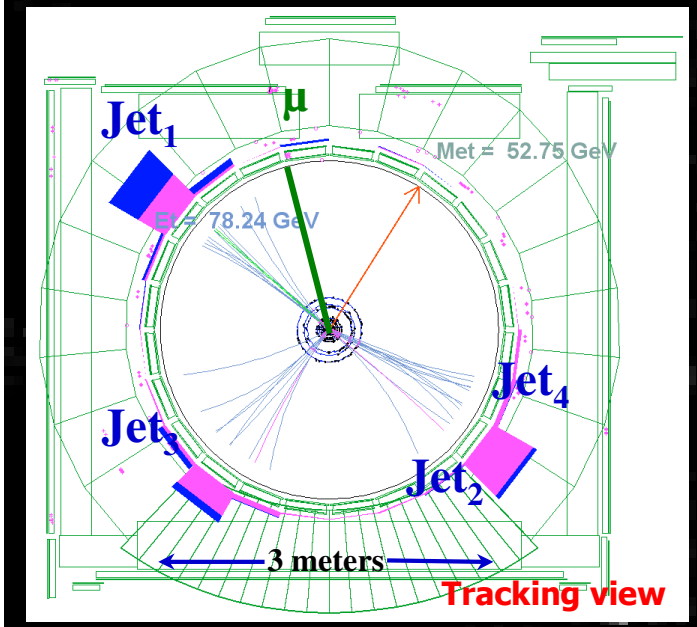
Njet	1	2	3	≥ 4
$-L_{xy}$	7.4 ± 0.77	2.9 ± 0.33	0.7 ± 0.1	0.25 ± 0.046
$Wb\bar{b}$	6.3 ± 2.3	3.9 ± 1.3	0.8 ± 0.3	0.30 ± 0.11
$Wc\bar{c}$	2.3 ± 1.0	1.5 ± 0.7	0.2 ± 0.1	0.07 ± 0.03
Total	16.0 ± 3.4	8.4 ± 2.0	1.7 ± 0.4	0.6 ± 0.2

$t\bar{t}$ l+jets Candidate

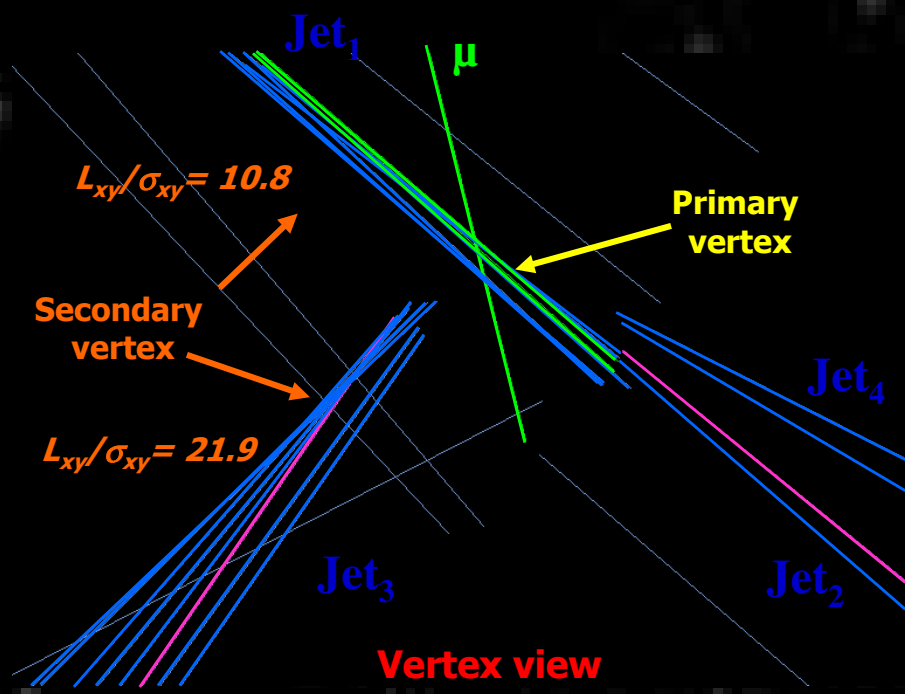


$\bar{t}t$ l+jet candidate:
Nov 02 2002 run: 153693 event: 799494
μ (CMUP) + 4 jets

$p_T(\mu) = 54.4$ GeV/c^2
$E_T^j = 96.7, 65{,}8, 54.8, 33.8$ GeV
$\not\!\!E_T = 40.8$ GeV

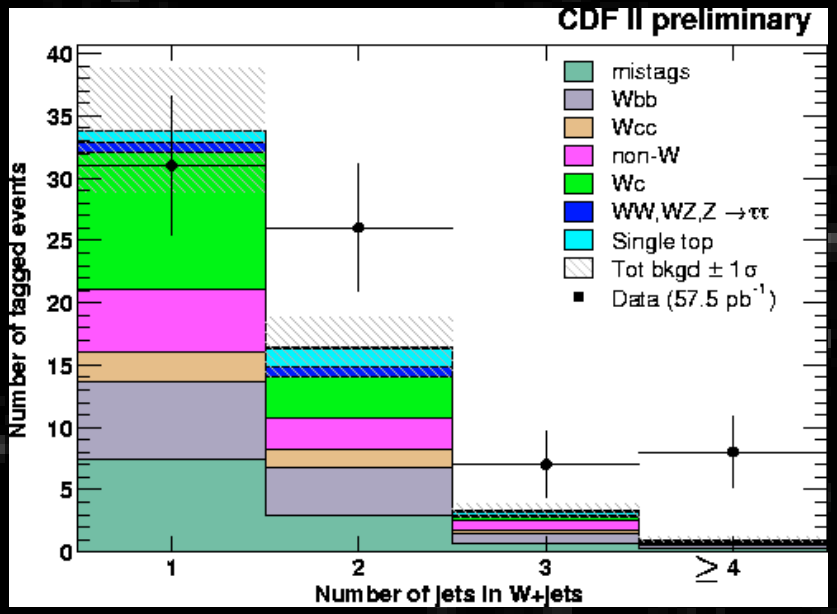


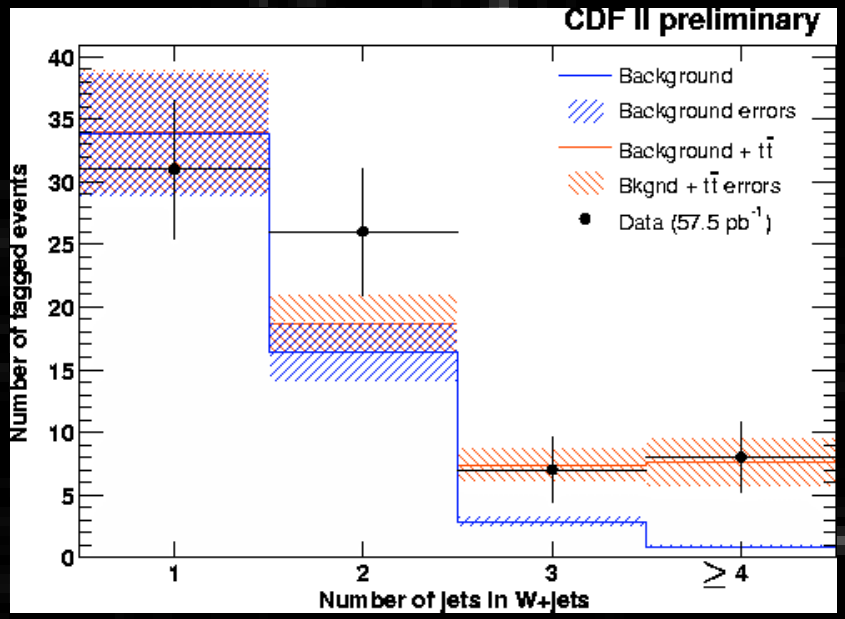
• muon
• electron
• hadron



$\sigma_{t\bar{t}}$ Measurement: l+jets channel

Source	W+ 1jet	W+ 2jets	W+ 3jets	W+ ≥4jets
Background	33.8±5.0	16.4±2.4	2.88±0.05	0.87±0.2
SM Bkgnd + $t\bar{t}$	34.0±5.0	18.65±2.4	7.35±1.4	7.62±2.0
Events before tagging	4913	768	99	26
Events after tagging	31	26	7	8



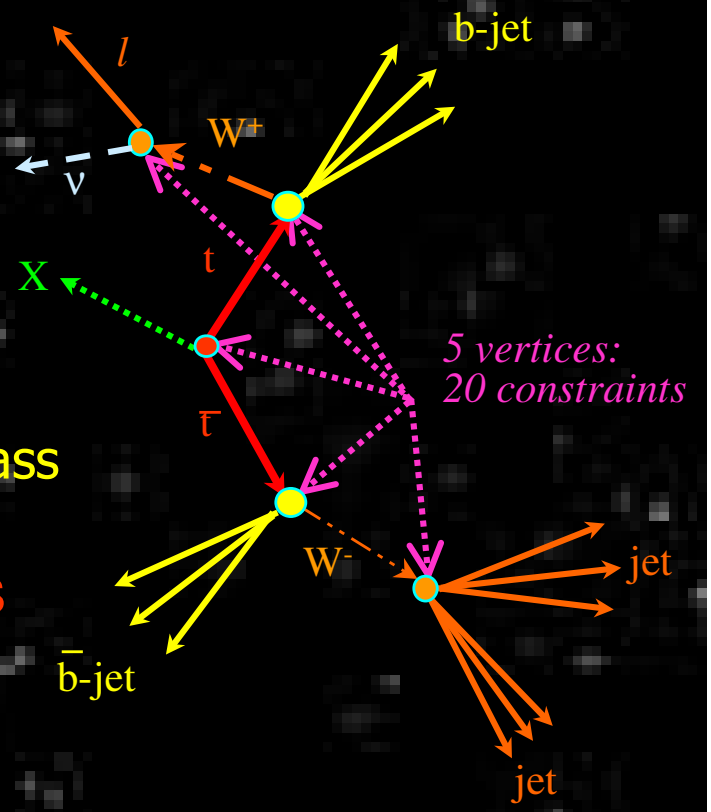


$\sigma_{tt} = 5.3 \pm 1.9_{stat} \pm 0.8_{sys} \pm 0.3_{lum}$ pb

NLO @ $\sqrt{s}$=1.96 TeV for M_{top} = 175 GeV‡: $6.70^{+0.71}_{-0.88}$ pb

Top mass

- Sample: l+jets
  - ✔ 24 combinatorics
    - ➤ 12 correspond to the jet-parton match
    - ➤ every combination has two solutions for p_z^ν
  - ✔ with 1 b-tagged jet goes down to 12
  - ✔ with 2 b-tagged jets to 4
  - ✔ Impose $M_t=M_{\bar{t}}$, $M(j,j)=M(l,\nu)=M_W$,
    - ➤ PDG: M_W, Γ_W, Γ_t
  - ✔ 2-C fit applied, lower χ^2 is chosen for top mass



- Model the shape of reconstructed mass distribution for $t\bar{t}$ & background events
- Extract top quark mass using maximum Likelihood

Run II Top Mass uncertainties

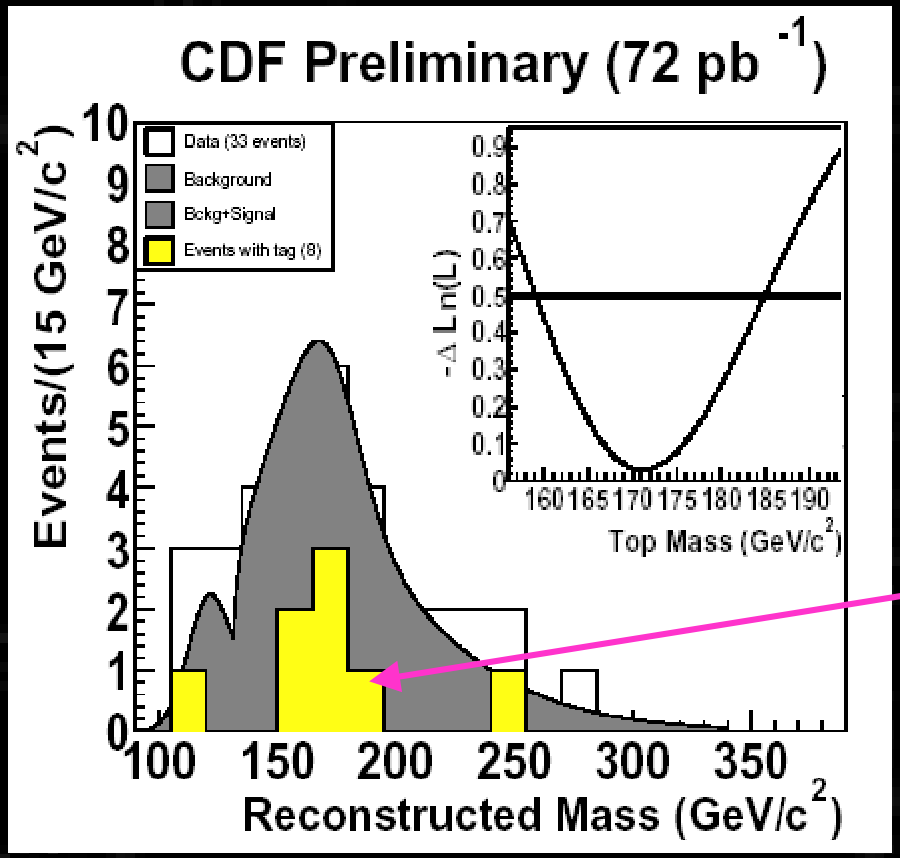
Run I uncertainty was 4.4
Need to understand CDF calorimeter better.

Run II Systematic uncertainties on M_{top}

Source	Uncertainty (GeV/c^2)
Jet Energy Measurement	9.3
Initial and Final State Radiation	2.4
Background Shape	0.3
Parton Distribution Functions	1.8
Monte-Carlo Generators	1.8
Total	9.9

We know how to do it !

How does it look ?

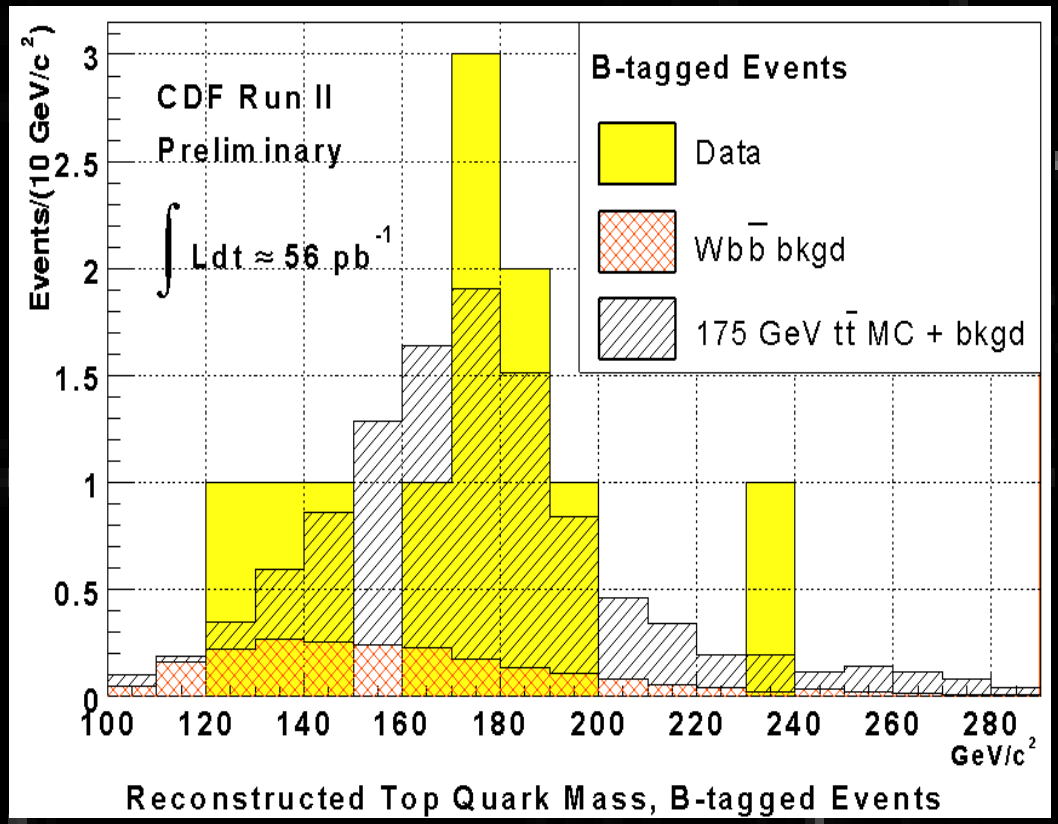


- No b-tag requirement on the jets ...
  - ✔≥4 jets with E_T>15 GeV

Event with at least 1 b-tagged jet
Not used in the fit!

$$M_{top} = 171.2^{+14.4}_{-12.5\ stat} \pm 9.9_{sys}\ GeV/c^2$$

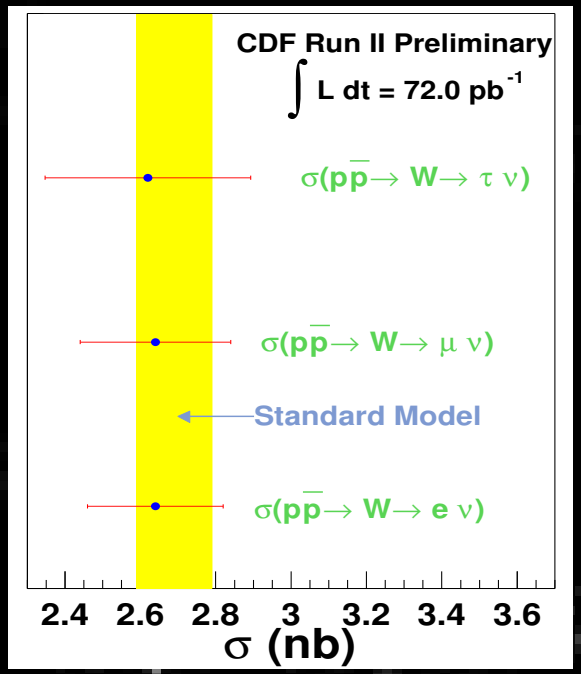
What about using b-tagging ?

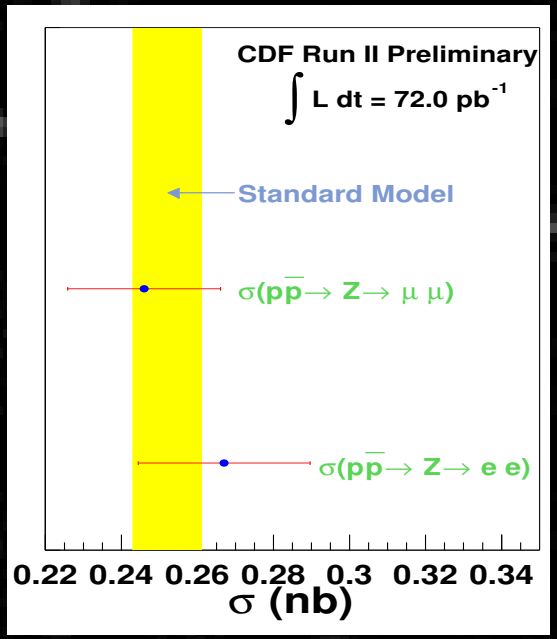


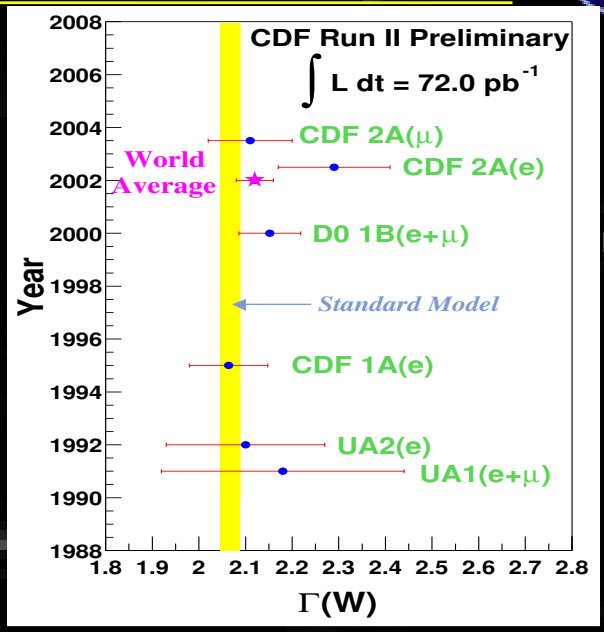
- **4** jets with $|\eta| < 2.0$,
  - ✔**3** with $E_T > 15$ GeV
  - ✔Require at least 1 b-tagged jet

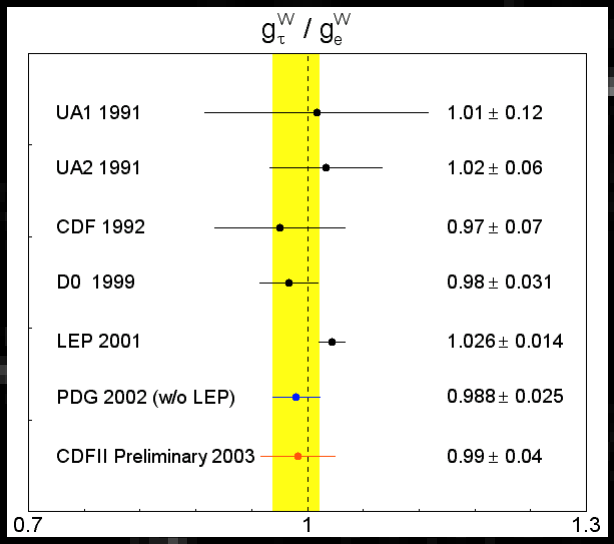
M_{top}= ??? soooonnnn

EWK summary



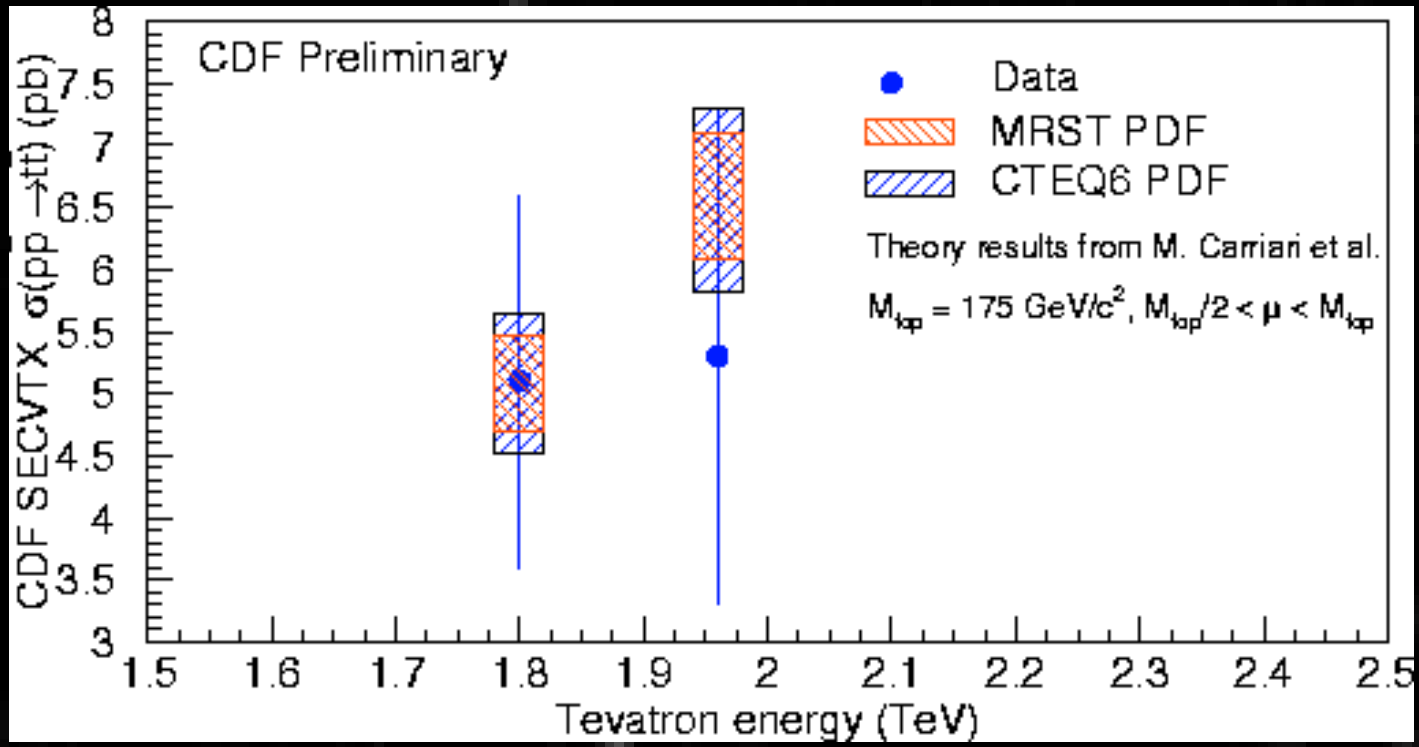






Many new results already competitive

Top summary



Run I like cross section analyses in good shape

Top mass measurement on its way...

Stay tuned for exciting results from CDF ...

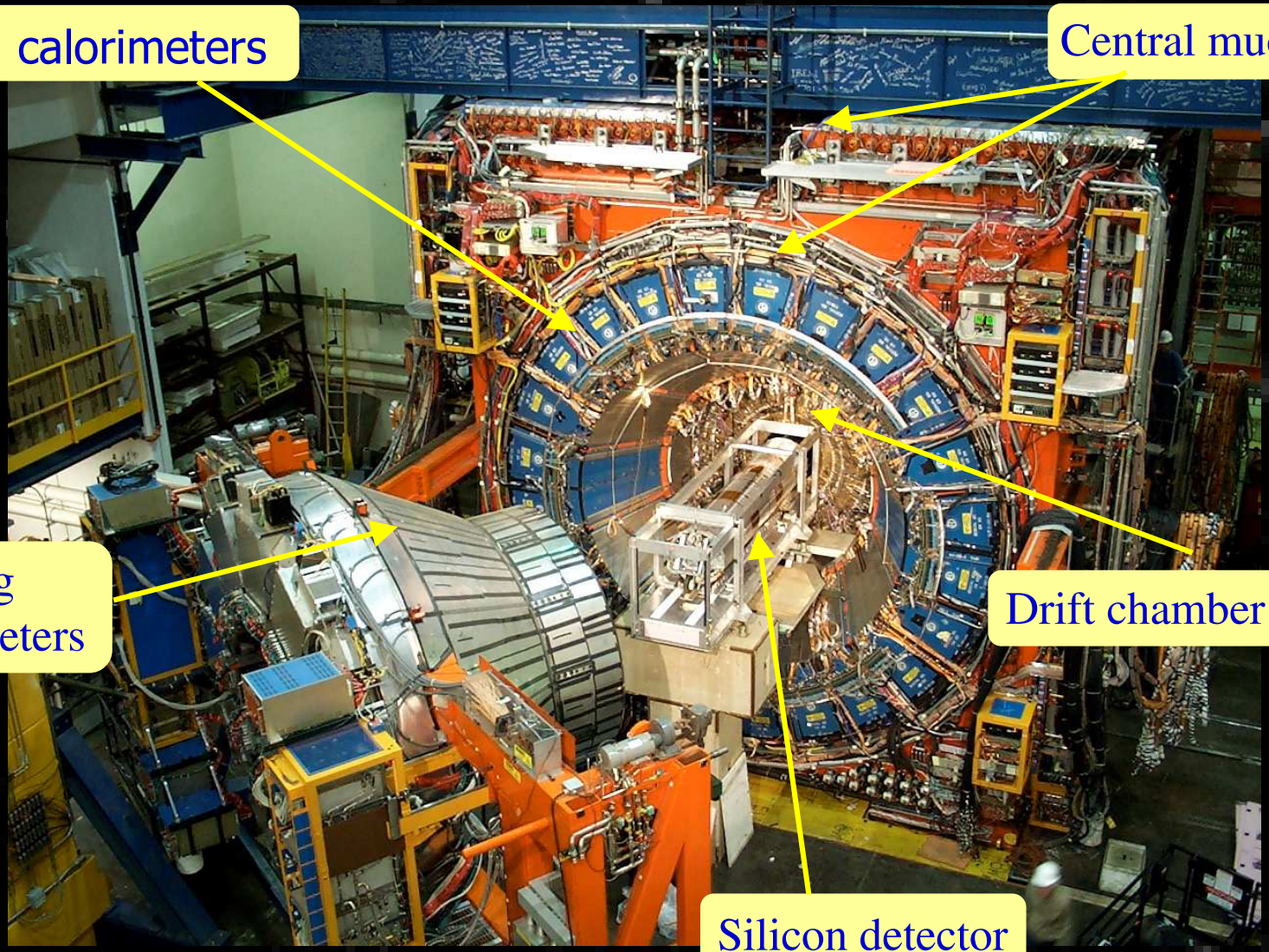
La suite au prochain episode...

BACKUP SLIDES

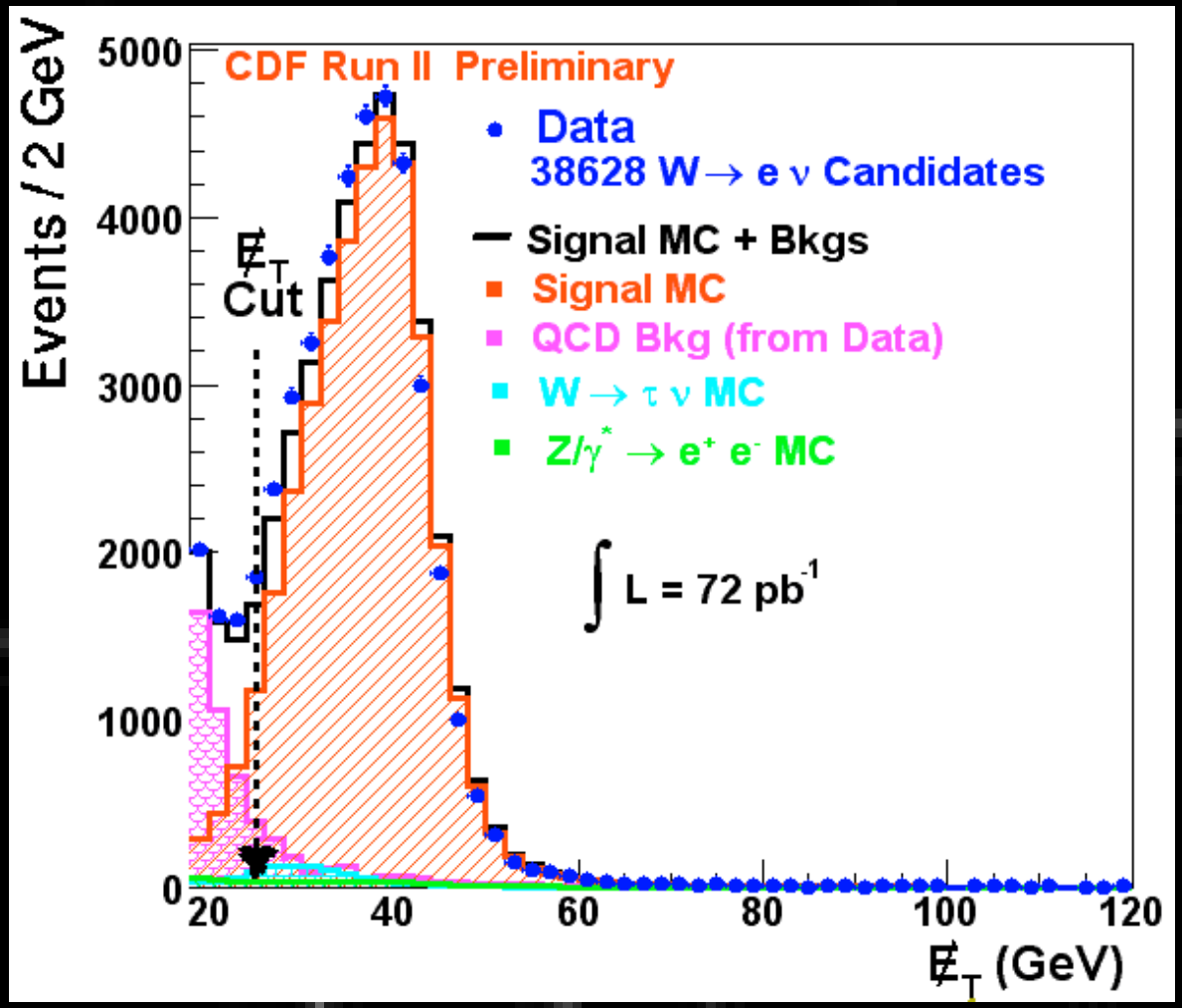
BACKUP SLIDES

- CDF detector
- MET, EoP
- MET
- A_{FB} 1 2
- Tau reconstruction
- Dilepton summary, kinematics
- b-tagging: efficiency, SF, bckg, M1, M2, other bckg, kinematics
- Top mass
- MW
- data

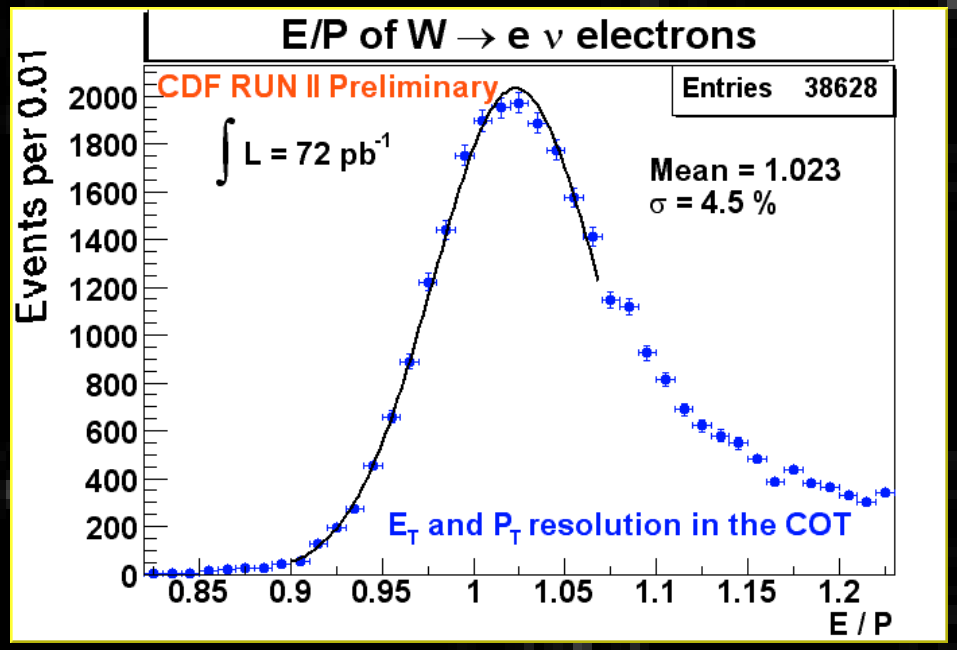
CDF Run II detector

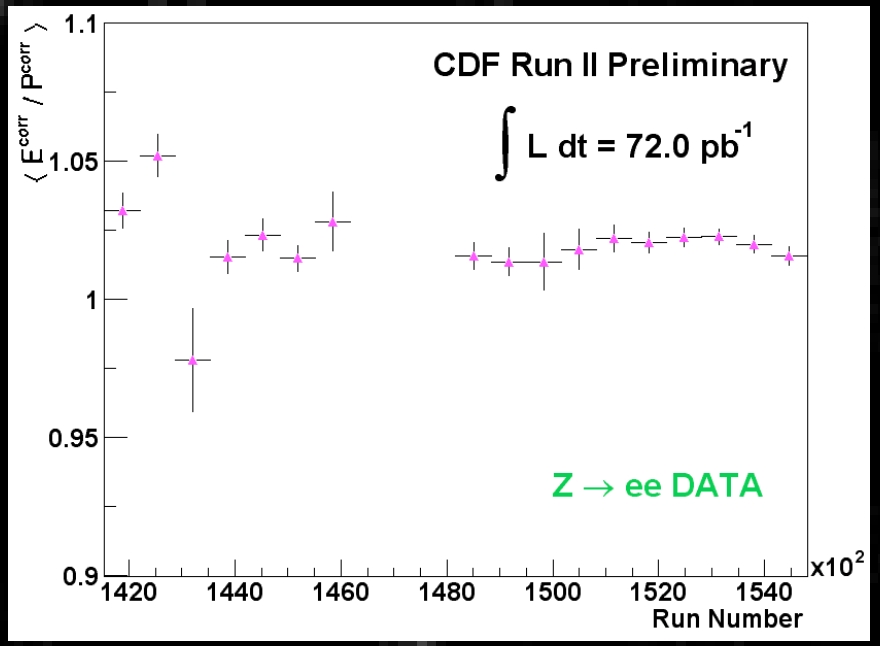


Missing E_T in $W \rightarrow e\nu_e$

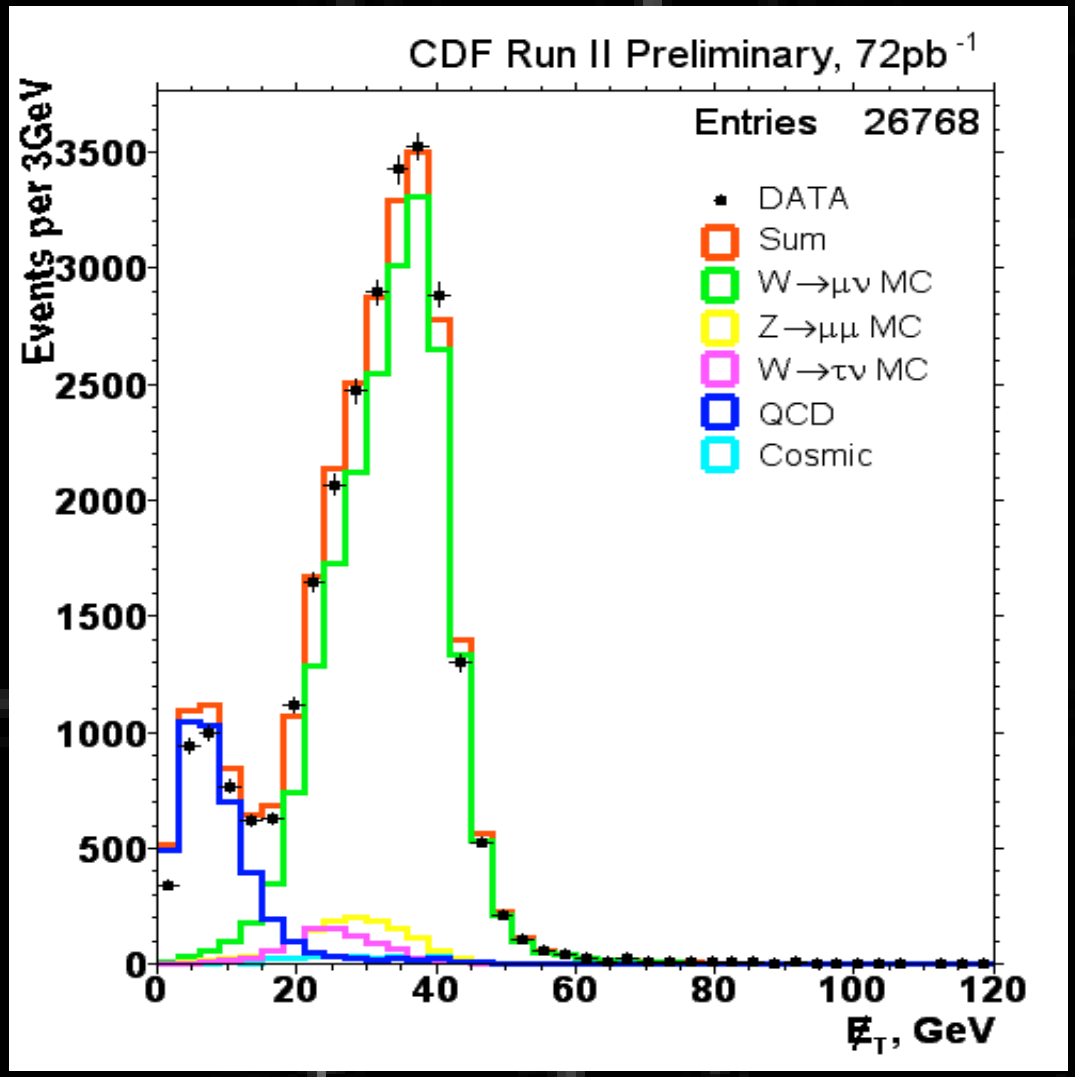


EoP

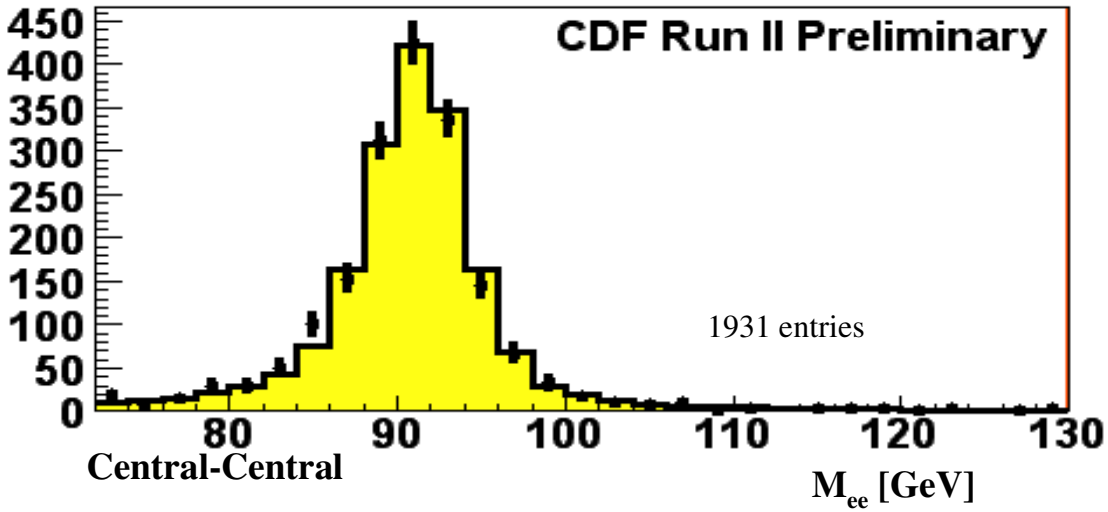

E/P of W → e ν electrons
CDF RUN II Preliminary
Entries 38628
∫ L = 72 pb-1
Mean = 1.023
σ = 4.5 %
ET and PT resolution in the COT
Events per 0.01
E / P

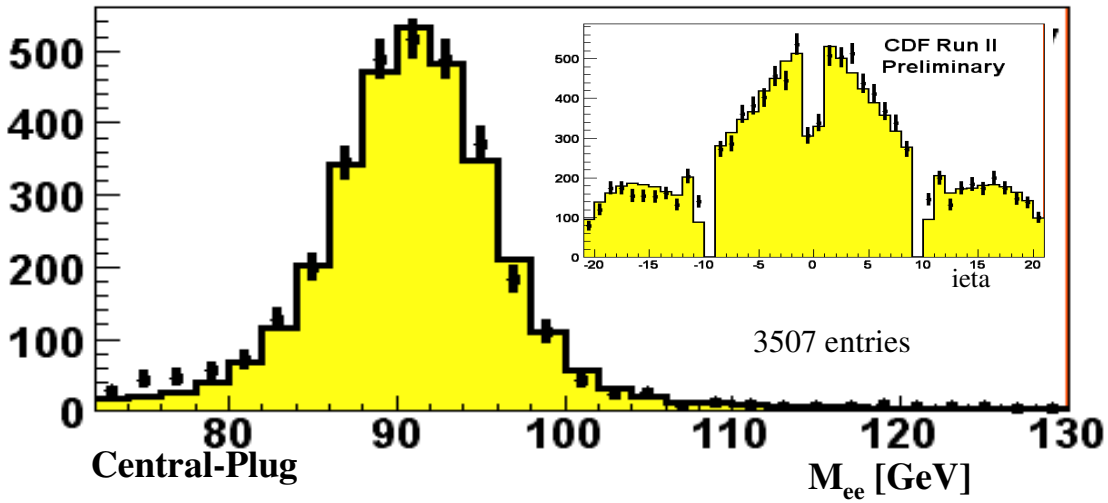

CDF Run II Preliminary
∫ L dt = 72.0 pb-1
Z → ee DATA
Run Number
x10²

Missing E_T in $W \rightarrow \mu \nu_\mu$

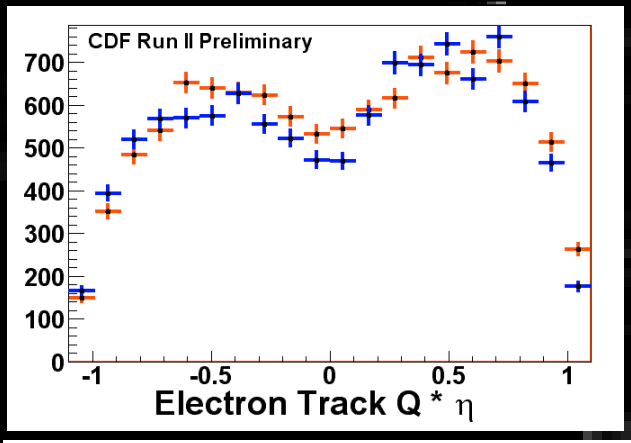


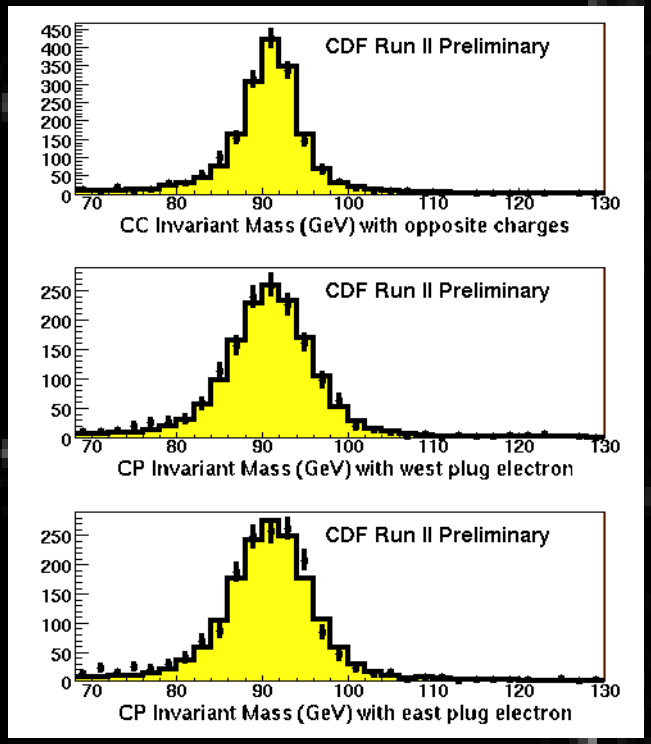
A_{FB}

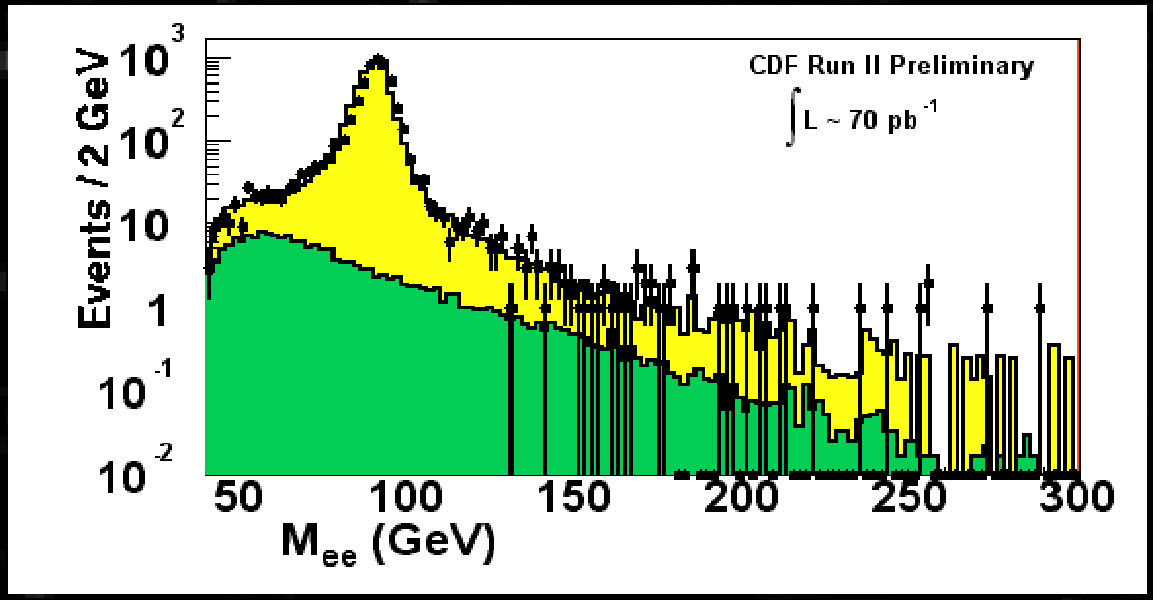

CDF Run II Preliminary
1931 entries
Central-Central
M_{ee} [GeV]

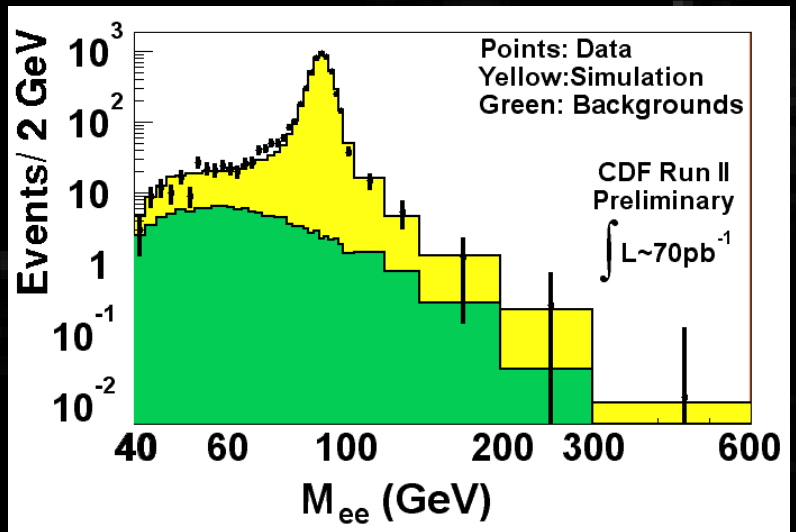

CDF Run II Preliminary
ieta
3507 entries
Central-Plug
M_{ee} [GeV]

A_{FB}


CDF Run II Preliminary
Electron Track Q * η


CDF Run II Preliminary
CC Invariant Mass (GeV) with opposite charges
CDF Run II Preliminary
CP Invariant Mass (GeV) with west plug electron
CDF Run II Preliminary
CP Invariant Mass (GeV) with east plug electron


CDF Run II Preliminary
∫L ~ 70 pb-1
Events / 2 GeV
Mee (GeV)

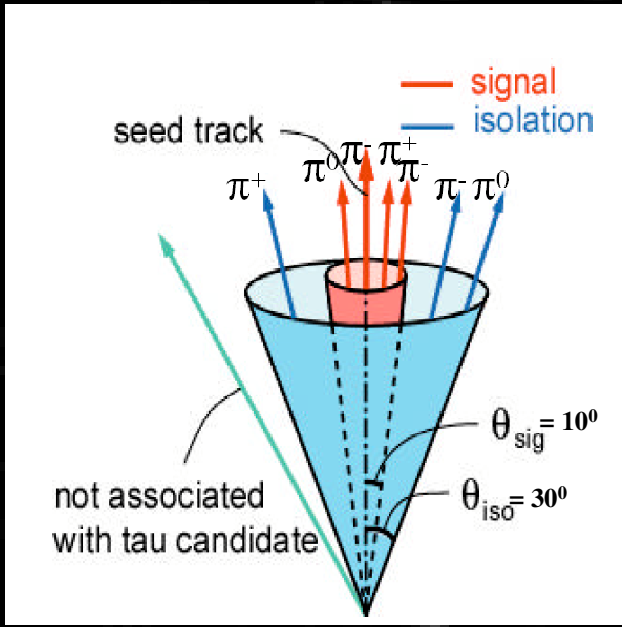

Points: Data
Yellow:Simulation
Green: Backgrounds
CDF Run II
Preliminary
∫L~70pb-1
Events/ 2 GeV
Mee (GeV)

τ reconstruction

- τ reconstruction at hadron collider is hard
- Little used in Run I (5/200 CDF publications were using τ's)
- Important for searches and Supersymmetry
  - ✔ Popular phenomenological scenarios
    - ➤ Charged Higgs: $H^+ \rightarrow \tau\nu$, Neutral SUSY A/H/h $\rightarrow \tau\tau$, Stau
- Can trigger on hadronic τ decay

- *τ identification*:
  - ✔ Start from narrow cluster in central calorimeter (E_T^{seed}>6 GeV)
  - ✔ Search for a energetic track pointing to it
  - ✔ No tracks within 10^0-30^0 annulus,

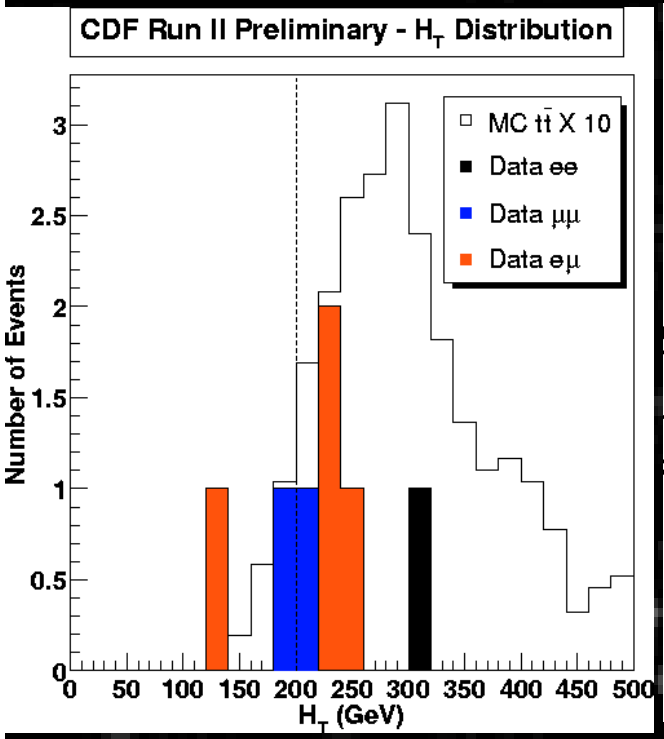
  allow more within $\theta<10^0$ ($N_{twr}\leq 6$)
  - ✔ Reconstruct energy cluster and make π^0
  - ✔ $M_{trk+\pi 0}$ 1.8 GeV/c^2

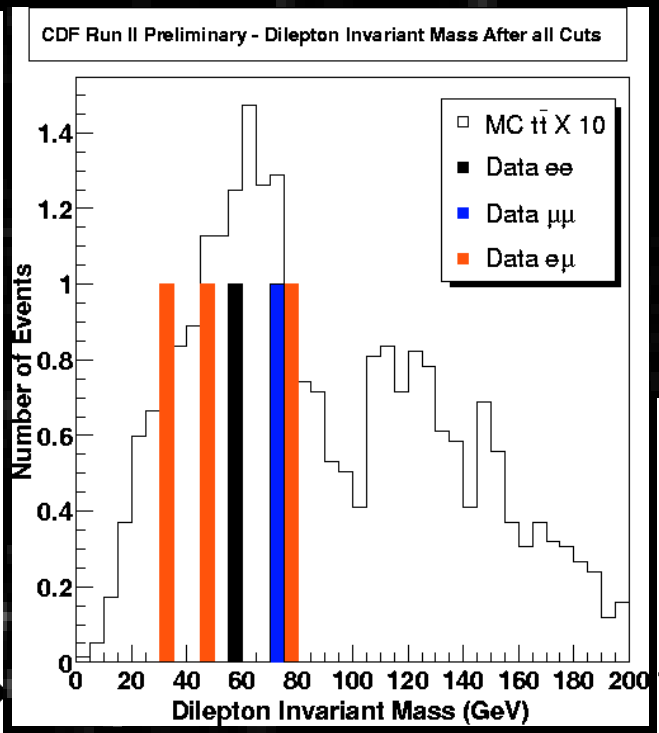


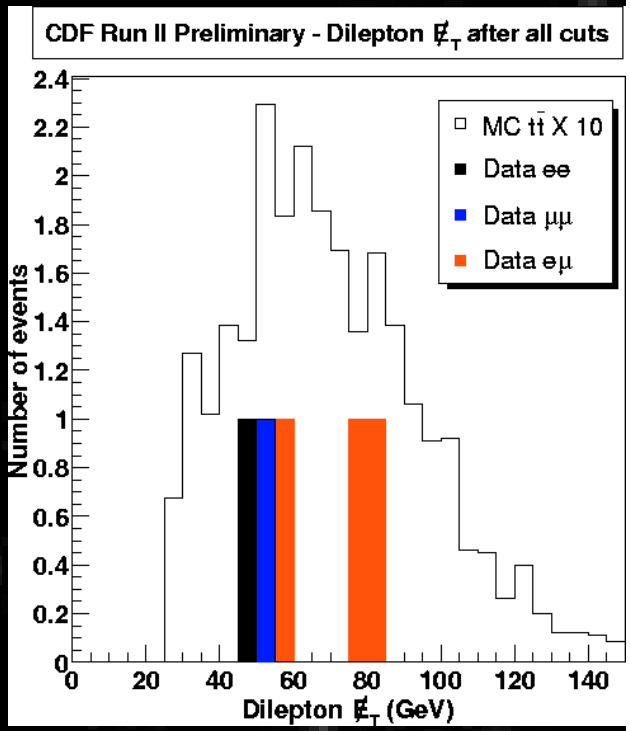
Dilepton Summary

	CDF Run II Preliminary			
Source	ee	$\mu\mu$	$e\mu$	$\ell\ell$
Drell-Yan e^+e^-	0.15 ± 0.08	0	0	0.15 ± 0.08
Drell-Yan $\mu^+\mu^-$	0	0.33 ± 0.15	0.15 ± 0.08	0.49 ± 0.17
Drell-Yan $\tau^+\tau^-$	0.010 ± 0.004	0.012 ± 0.005	0.033 ± 0.012	0.056 ± 0.014
WZ	0.010 ± 0.001	0.017 ± 0.002	0.029 ± 0.003	0.056 ± 0.003
Fake	0.11 ± 0.10	0.095 ± 0.111	0.54 ± 0.59	0.74 ± 0.61
$t\bar{t}$	0.0038 ± 0.0025	0.0033 ± 0.0021	0.015 ± 0.006	0.022 ± 0.007
Total Background	0.29 ± 0.13	0.46 ± 0.18	0.77 ± 0.60	1.52 ± 0.64
$WW \rightarrow$ dileptons	0.54 ± 0.12	0.65 ± 0.14	1.55 ± 0.34	2.74 ± 0.59
Run 2 Data	1	0	1	2

Dilepton kinematics



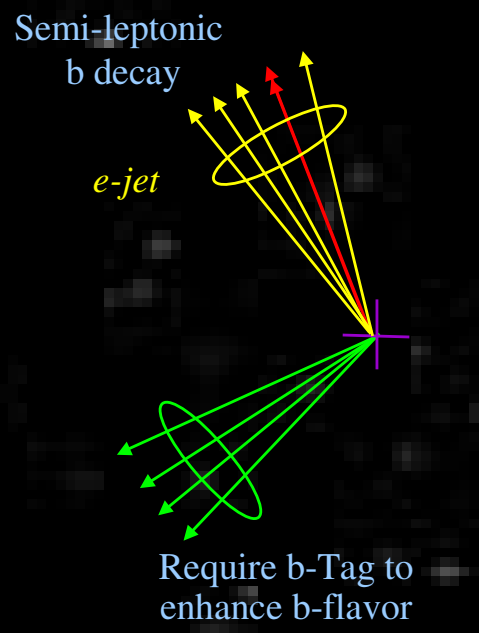




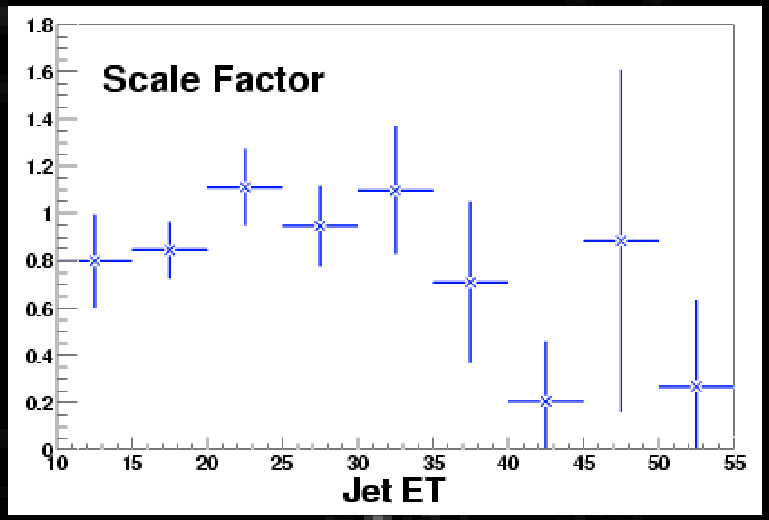
b-tagging efficiency

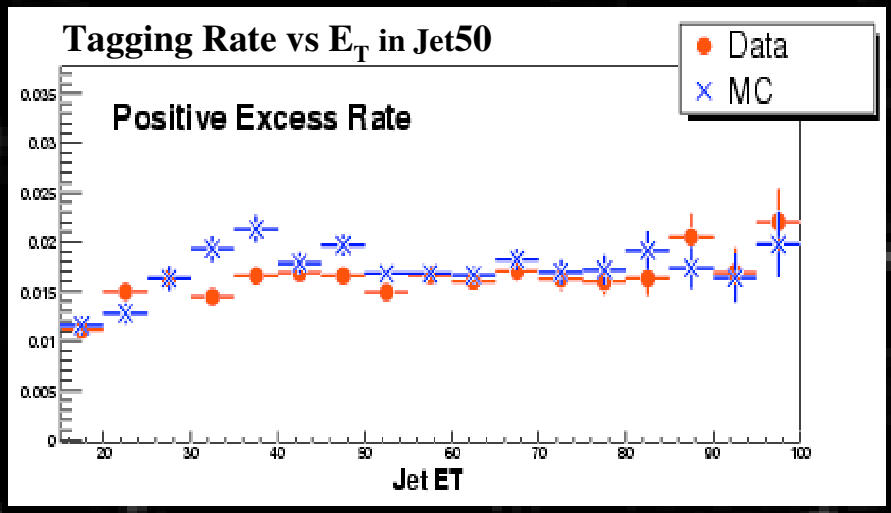
- Sample:
  - ✔ e-jet (E_T^e<9 GeV, $\Delta R(e,j) < 0.4$)
  - ✔ Away jet (E_T^j> 12 GeV, $|\eta| < 1.5$, $|\phi_{ejet}\phi_{ajet}|$ >2 rad)

- To measure Efficiency:
  - ✔ $\varepsilon_B = (N_+ - N_-)/N_{Tot} / F_B$
    - ➤ Fraction of e-jets containing heavy flavor, F_B
  - ✔ Measure F_B with:
    - ➤ $D^0 \rightarrow K\pi$
    - ➤ secondary muon in e-jet ($b \rightarrow c \rightarrow \mu$)
    - ➤ convergence electron in e-jet
      - ❖ (effectively measure light flavour)



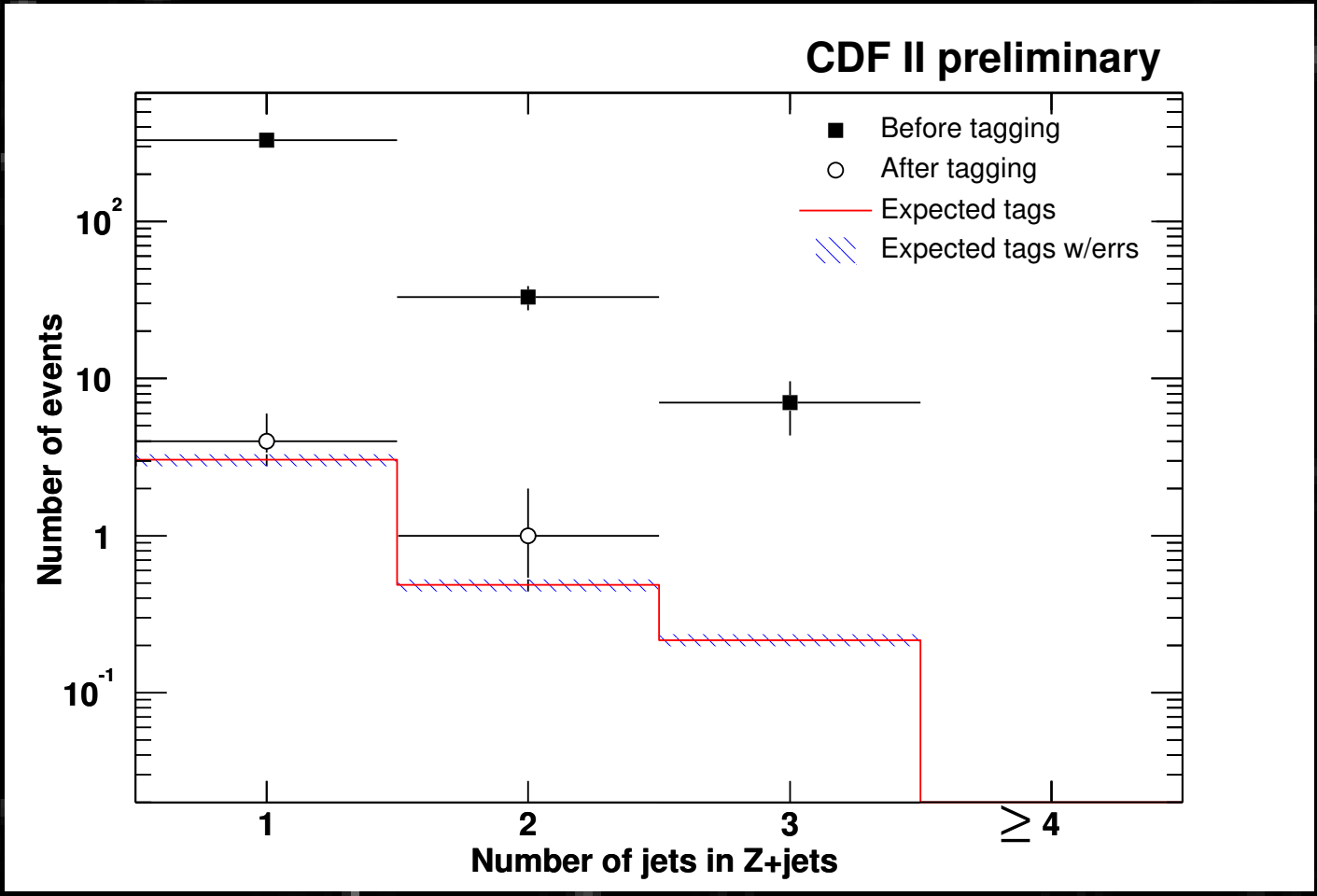
b-tagging: efficiency SF





l+jets backgrounds

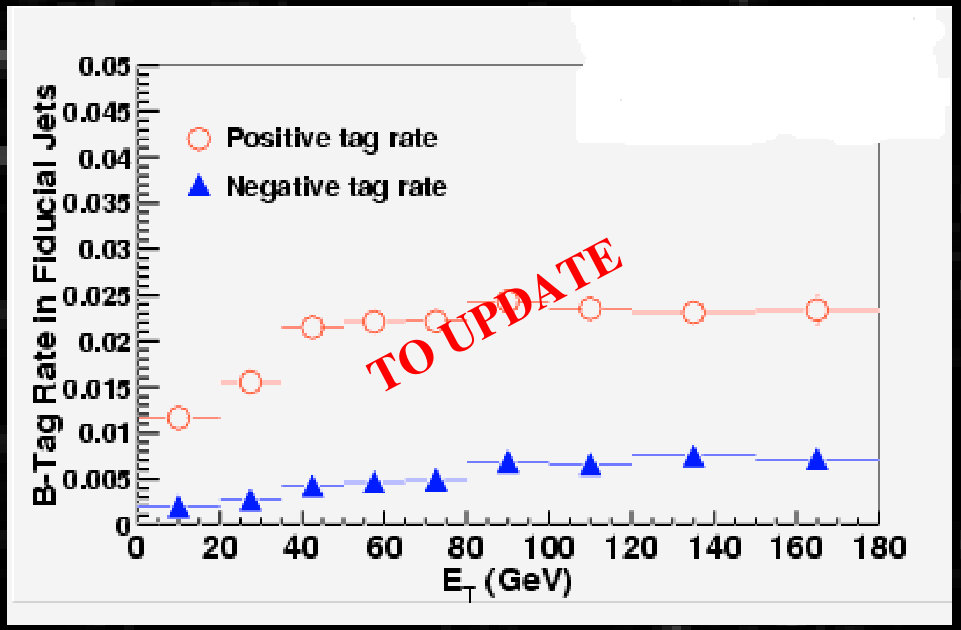
- Before - After b-tagging



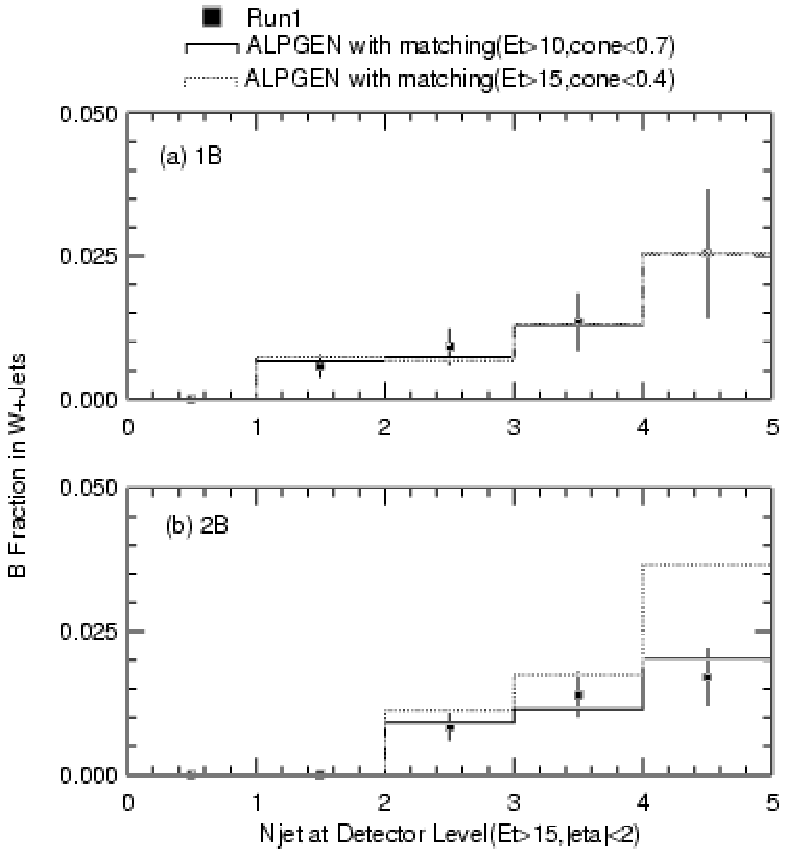
Method 1 background estimate

- Method 1 (data driven)
  - ✔ Combine mistags, $Wb\bar{b}$ & $Wc\bar{c}$
  - ✔ Assumption: heavy flavour content is the same for W+jets & for generic jets
  - ✔ Overestimate since W+jets admixture of gluon & light jets
  - ✔ Measured from POS tag rate in generic jet samples

Jet multiplicity	1 jet	2 jets	3 jets	$\geq$ 4jets
electrons	20.1 $\pm$ 2.7	7.1 $\pm$ 1.1	1.9 $\pm$ 0.4	0.6 $\pm$ 0.2
muons	15.0 $\pm$ 1.8	5.3 $\pm$ 0.7	1.0 $\pm$ 0.2	0.3 $\pm$ 0.1
TOTAL	35.1 $\pm$ 3.6	12.4 $\pm$ 1.4	2.9 $\pm$ 0.4	1.0 $\pm$ 0.2



Method 2 background estimate



Fiducial jet

ϵ_{tag}(%)	1B Run I	1B Run II	2B Run I	2B Run II
W+1jet	23.5 ± 0.7	28.4 ± 0.7		
W+2jet	21.3 ± 1.5	28.1 ± 0.7	39.0 ± 3.4	50.0 ± 1.6
W$\geq$ 3jet	21.1 ± 3.9	30.0 ± 1.0	44.0 ± 7.0	50.0 ± 2.0
Average	23.1 ± 0.6	28.6 ± 0.4	39.9 ± 3.0	50.0 ± 1.2

Table 5: The b-tag efficiencies for $Wb\bar{b}$ events in Run I and Run II.

ϵ_{tag}(%)	1C Run I	1C Run II	2C Run I	2C Run II
W+1jet	5.7 ± 0.3	4.6 ± 0.2		
W+2jet	4.7 ± 0.5	6.4 ± 0.6	9.6 ± 2.0	11.0 ± 1.5
W$\geq$ 3jet	4.4 ± 1.3	4.2 ± 1.1	14.0 ± 4.0	10.0 ± 1.7
Average	5.4 ± 0.3	4.8 ± 0.2	10.0 ± 2.0	10.5 ± 1.0

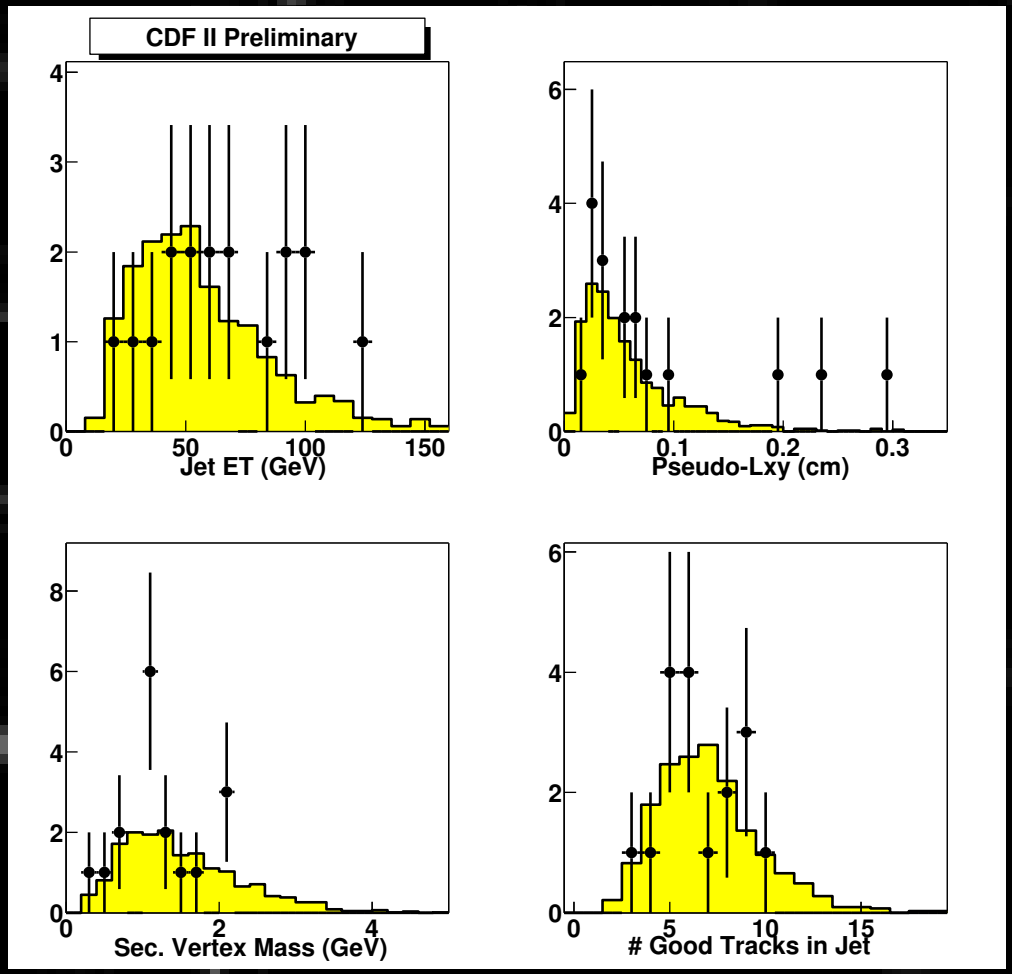
Table 6: The b-tag efficiencies for $Wc\bar{c}$ events in Run I and Run II.

Lepton+Jets: Other backgrounds

- Non-W background (Data)
  - ✔ Method: Isolation vs $\not\!\!E_T$
- Wc (Monte Carlo)
  - ✔ Subs tract Non-W fraction from W+jets
  - ✔ Fraction of Wc events in W+jets from Run I
  - ✔ Use Run II charm tagging efficiency & SF
- WW, WZ (MC)
  - ✔ Use $\varepsilon_{RunII}/\varepsilon_{RunI}$ & RunI acceptance.
  - ✔ Calculate for e then normalise μ contribution from 1 jet bin data
- $Z \rightarrow \tau^+\tau^-$ (Monte Carlo)
  - ✔ Run I acceptance scale efficiency to Run II
- Z + heavy flavour (Monte Carlo & Data)
  - ✔ $Zb\bar{b}$ same as $Wb\bar{b}+g \rightarrow Zb\bar{b}$

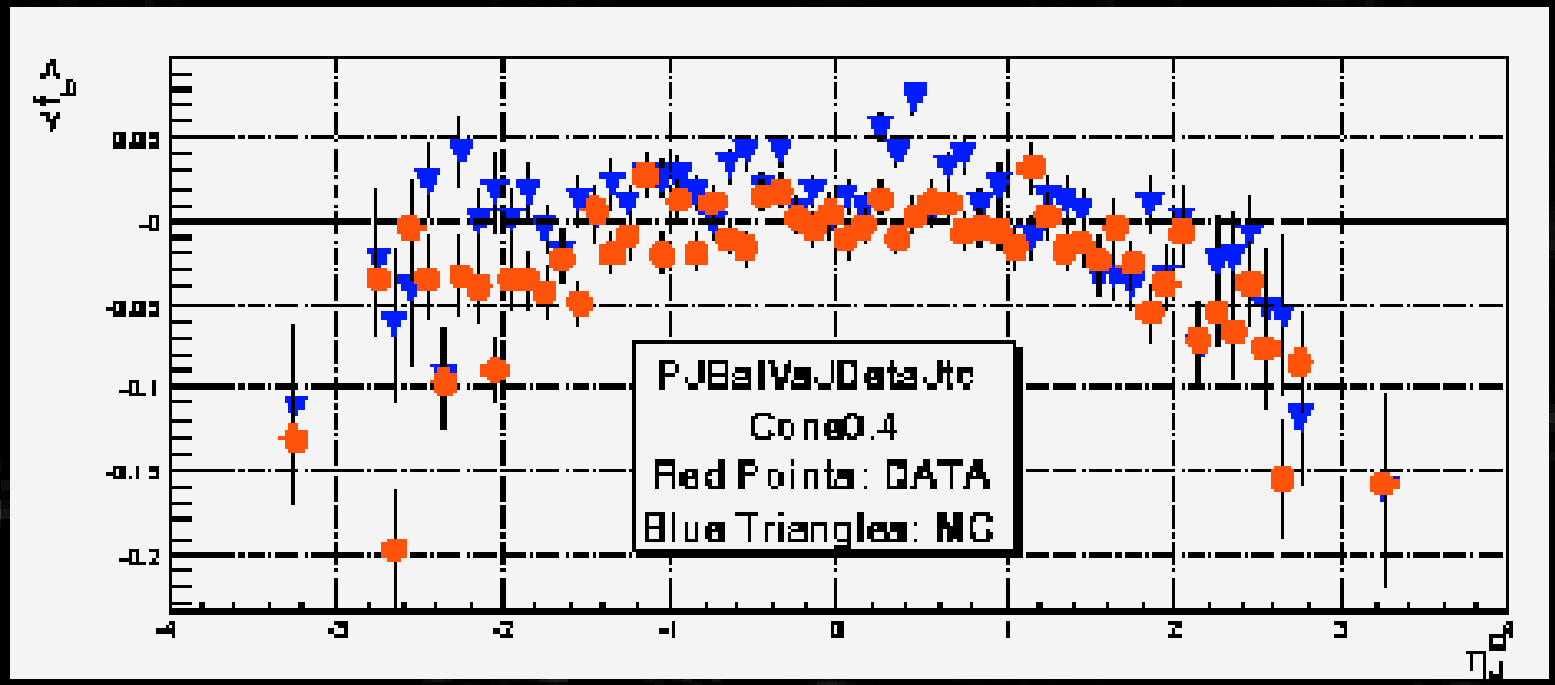
  RunI: HF fraction estimated to be 2x as large as for W
  - ✔ $Zc\bar{c}$ same as $Wc\bar{c}$
  - ✔ Fraction of Z in W+jets from MC (mostly from $Z \rightarrow \mu^+\mu^-$) & normalise to data
- Single Top (Monte Carlo)
  - ✔ Produced via off mass shell W production or W-gluon fusion process
  - ✔ Use theoretical cross section & MC to calculate expected single top contribution

1+jets kinematics

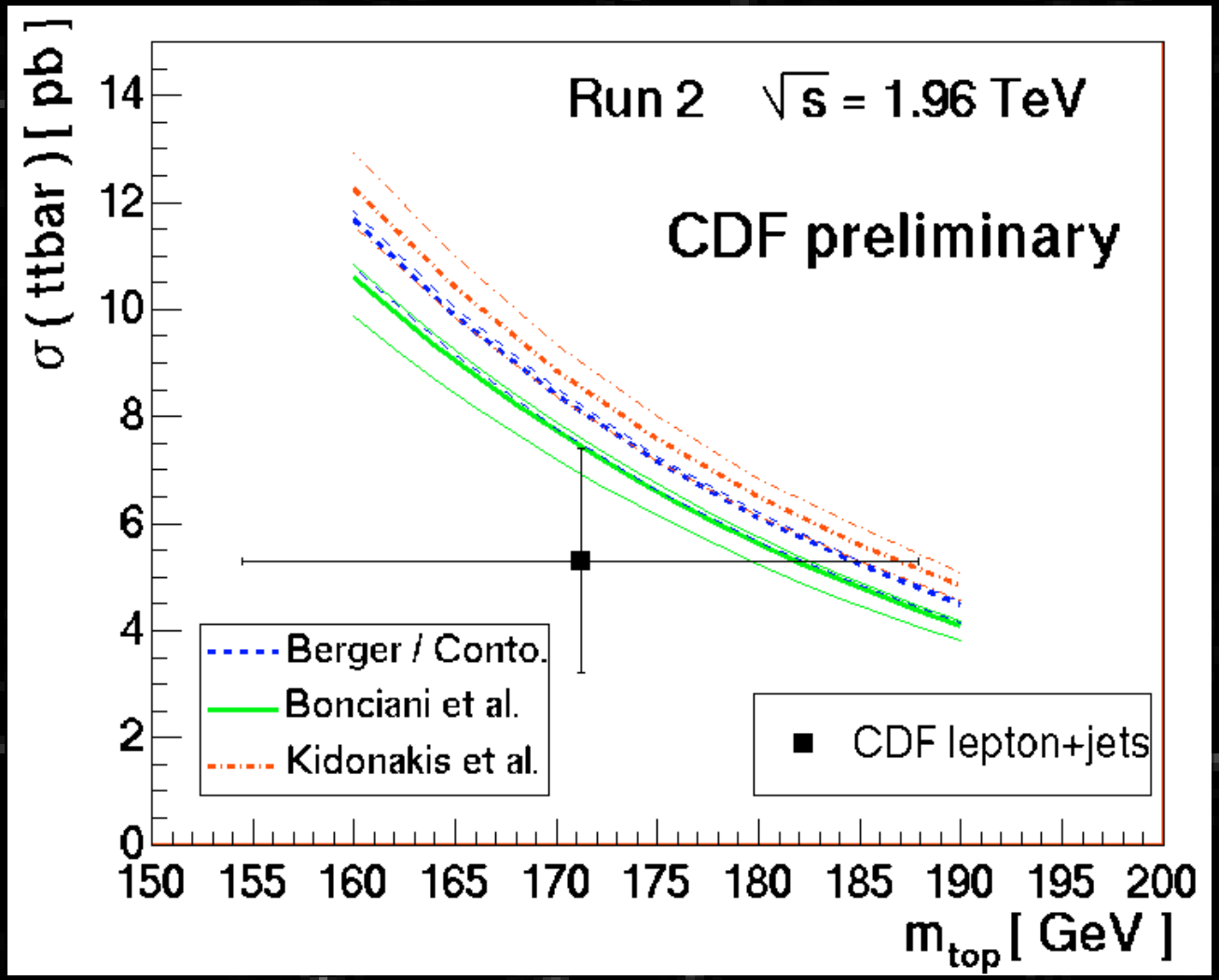


Top Mass

- Photon-Jet balancing: uncertainty 5%

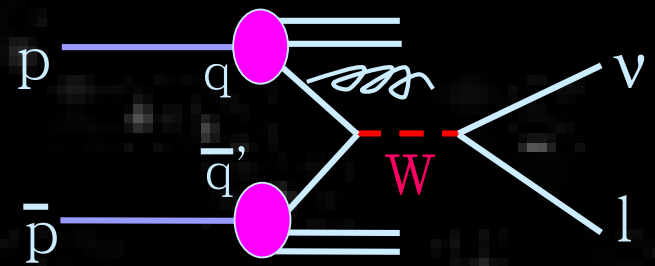


Summary top

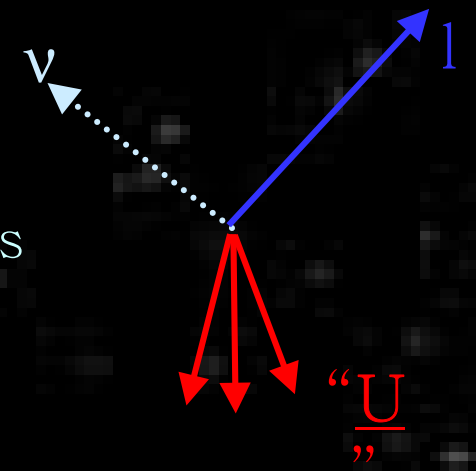

Run 2 $\sqrt{s}$ = 1.96 TeV
CDF preliminary
σ (ttbar) [pb]
14
12
10
8
6
4
2
0
150 155 160 165 170 175 180 185 190 195 200
m_{top} [GeV]
Berger / Conto.
Bonciani et al.
Kidonakis et al.
CDF lepton+jets

Measuring M_W

W production at the TeV:



which looks like this in the detectors:



- Calculate transverse mass
  - understand E and P scales and resolutions
- Calculate missing transverse momentum
  - must model *U*nderlying event and recoil distributions, etc.
- From M_T distribution extract measure of Mw
  - sensitive to PDFs (use forward calorimeters)

Data

- Data taking March 2002-January 2003
  - ✔Record initial luminosity!
    - ➤ 3.8×10^{31} $cm^{-2}s^{-1}$ (Nov 2002)
  - ✔Record integrated Luminosity
    - ➤ 7.1 pb^{-1} in a week
- Data sample used
  - ✔72 pb^{-1} (58 pb^{-1} with Silicon)
- At $\sqrt{s}$=1.96 TeV
  - ✔$\sigma(W)$ & $\sigma(Z)$ 10% higher
  - ✔$\sigma(t\bar{t})$ 35% higher