CDF Looks Forward

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EWK process

$W \rightarrow e\nu$ x-section at large η (>1.1)

- Using tracking separately from calorimeter
  - ⇨ Excellent to test tracking capability
    - → Measure efficiencies on data, check MC
- Measurement interesting *per se* (unexplored rapidity region) and
  - ⇨ Path to other interesting physics processes (associated production, decays involving Ws etc)

CDF note 7023: Preliminary result on 72 pb^{-1} (blessed for spring conf. In 2004)

CDF 7594: Selection criteria and eff. Studies for 223 pb^{-1}

W→ eν x-sect

σ(W) is measured using electron at large η:

- ⇨Em clusters in *Plug*
- ⇨MET
- ⇨Clusters are matched to a 3D track *independently* reconstructed by the tracking system (i.e. no use of calorimetric info)
  - →Due to the η region this means using mostly silicon (SVXII, ISL) with or without COT
  - →This is very close to what is done in the central region

Data samples

Plug electron dataset collected in the first preshutdown period (March 2002-February 2004), equivalent to ~223 $pb^{-1(*)}$

- Require MET_PEM trigger fired
  - ⇨ Working plug and silicon ("Good silicon Run")
- Reconstructed using 5.3
  - ⇨ Good Run List V7

To measure efficiencies (trigger, ID etc)

- $Z \rightarrow ee$ (Central-Plug)
- JET20

All Gen5…

(*)factor 1.019 included

Ingredients

The recipe for cross section is always the same:

- $(N_{cand}-N_{back})/(\varepsilon \times L)$
  - $\varepsilon=\varepsilon_{sele} \times \varepsilon_{trigger}$

Measure efficiencies and background mostly using data

- $Z \rightarrow ee$ CP sample

Requirements

- calorimetric
  - EM clusters in plug region ($1.1<|\eta|<2.8$) with large E_T
  - Cluster to be consistent with being an electron *and* isolated (ID)
  - Large MET
- tracking
  - Require a match with a track extrapolated to the PES
  - Require track to have $E/p<2$

Selection

Trigger

- MET_PEM fired

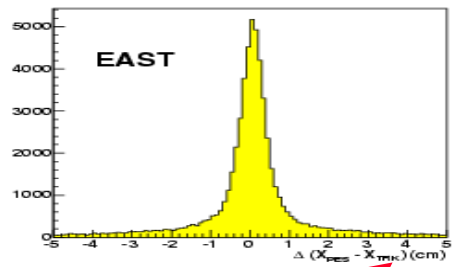
Electron

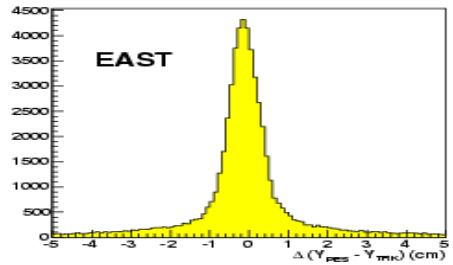
- E_T>20 GeV
- 1.1<|η|<2.8
- Electron ID
  - Had/Em <0.05
  - Relative Isolation<0.1

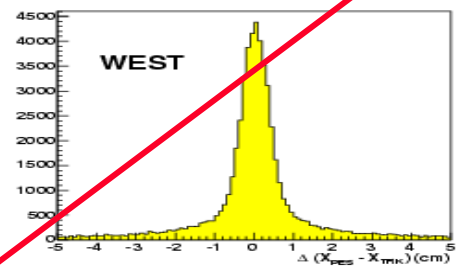
MET> 20 GeV

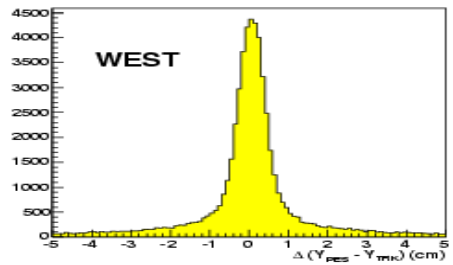
Require a track (P_T>1 GeV/c) to match:

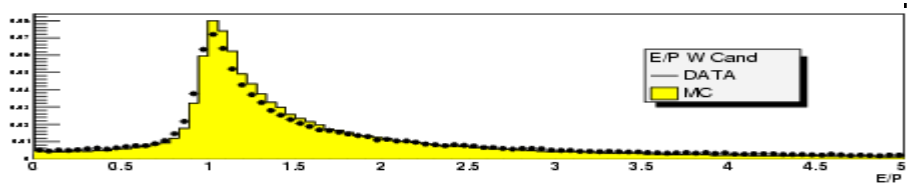
- |ΔX|<3cm ,|ΔY|<3 cm
- $|Z0_{trk}|$<60 cm
- E/p < 2

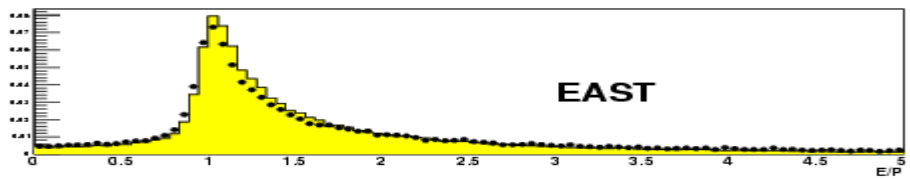


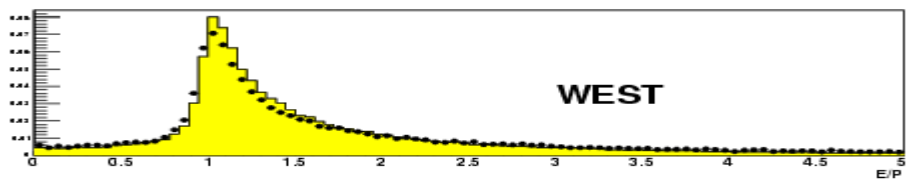






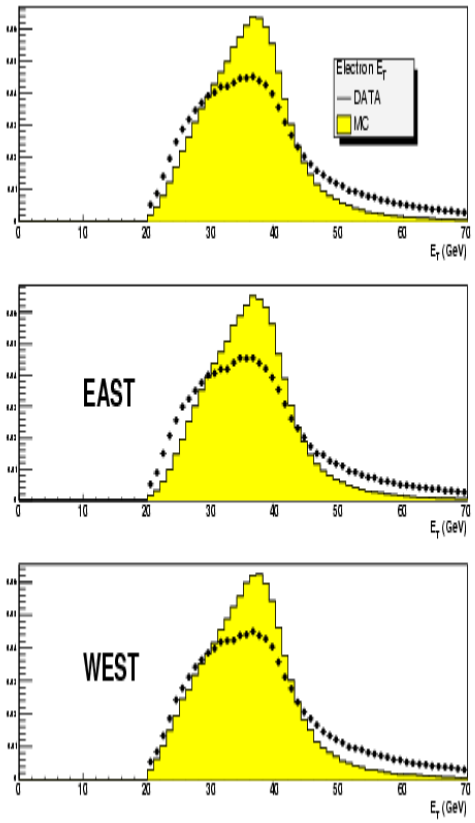




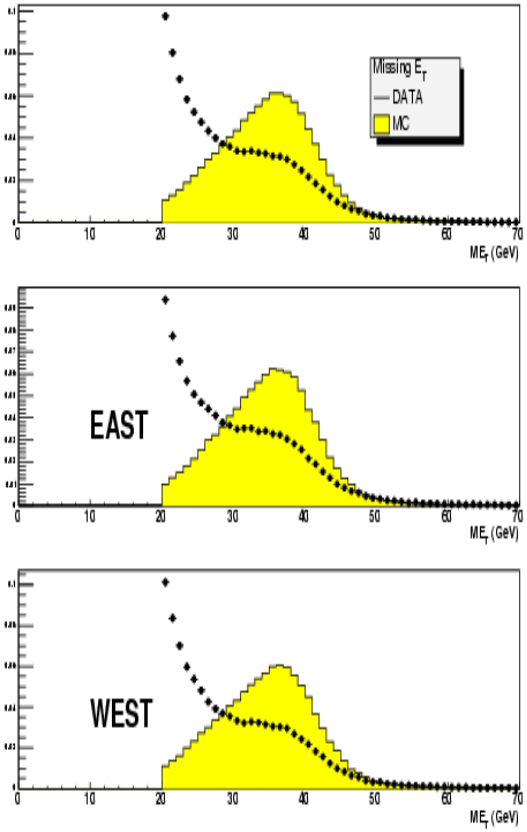


W->eν distributions after calorimetric cuts

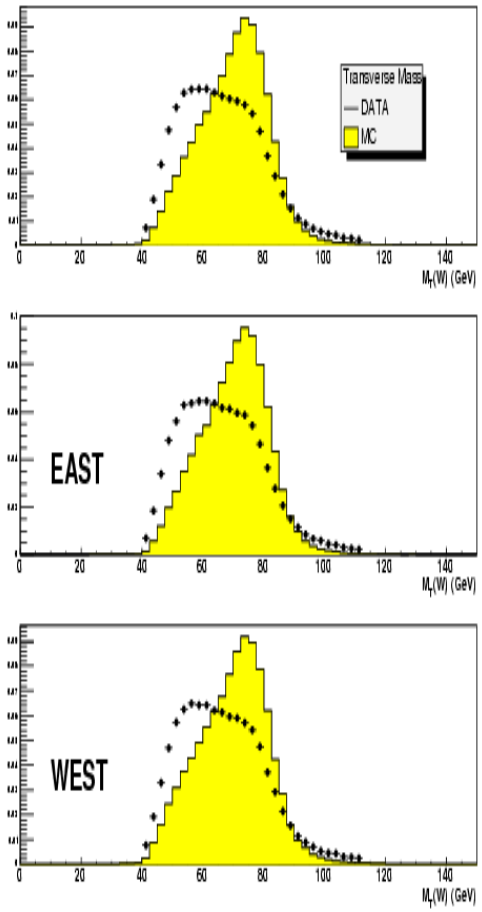
E_T



MET



M_T

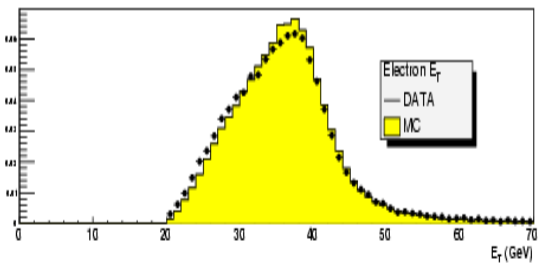


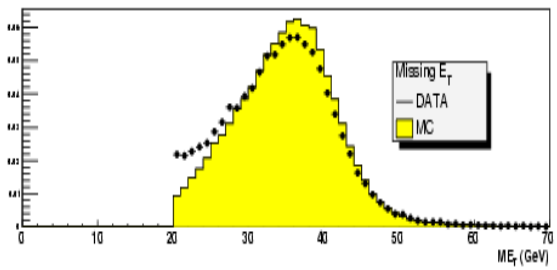
Large Background contamination. Use tracks to clean

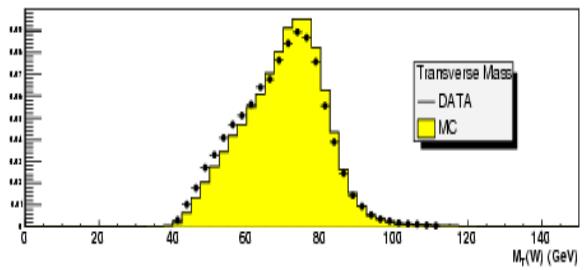
After track selection

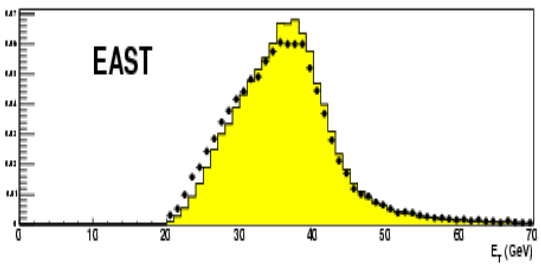
After track matching and E/p cut sample is clean:

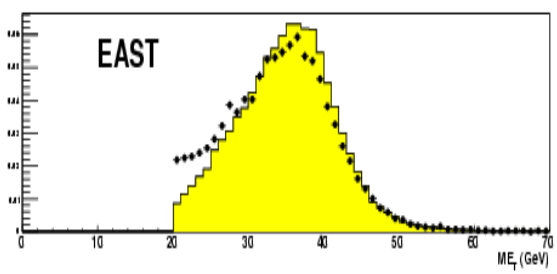
E_T MET M_T

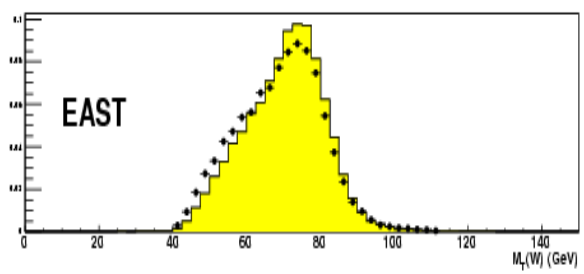


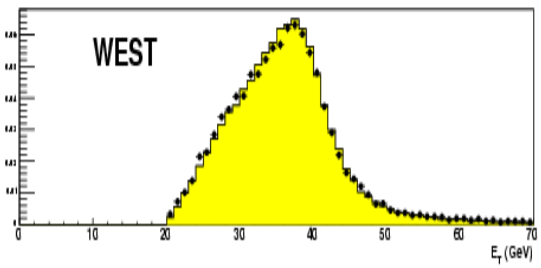


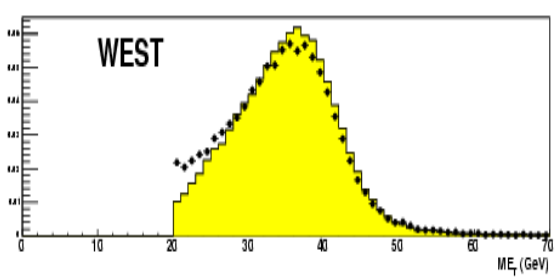


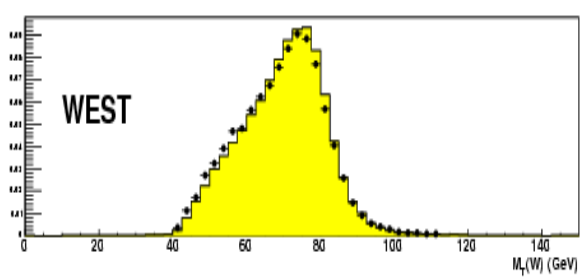








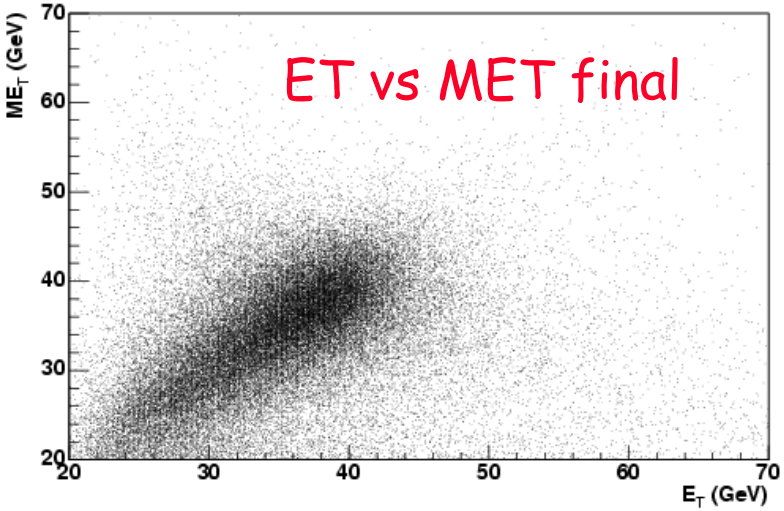




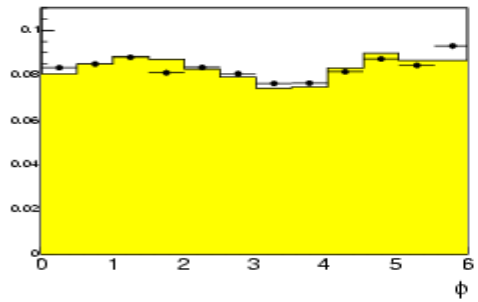
Top: All, Middle: East, Bottom: West

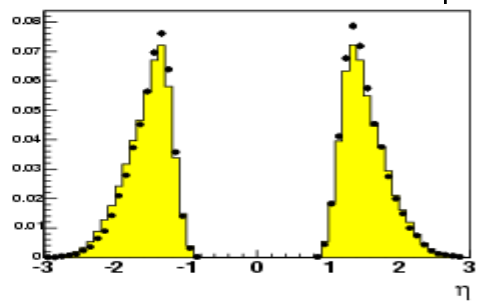
Selection Summary

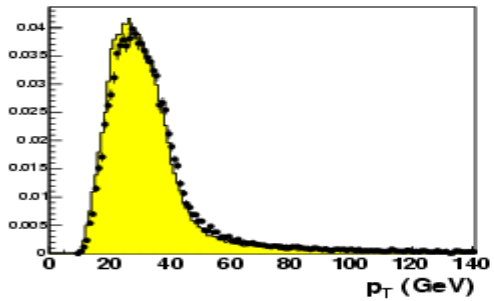
Requirement	# events
Em plug, ET>20	4.5 x 10^6
Ele ID	1.2 x 10^6
MET>20	402443
PES match	98756
E/p and Z0trk<60cm	58962

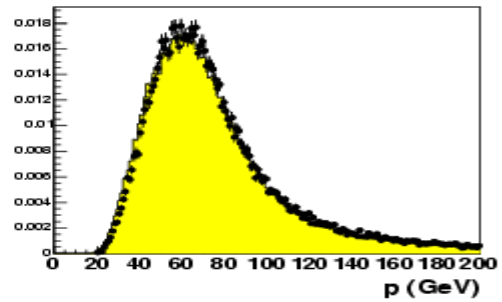


Cand. track parameters





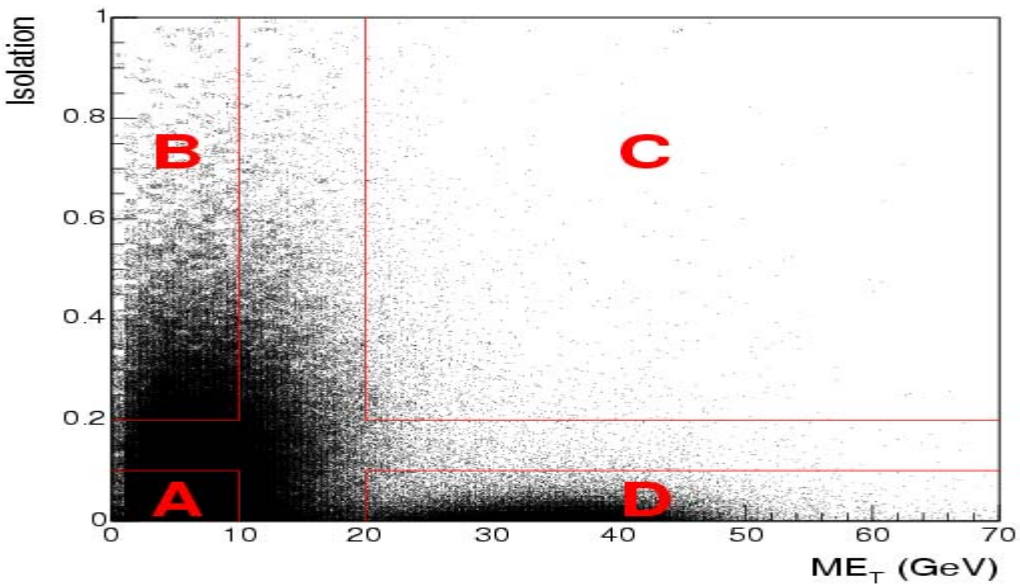




Background

Non W backg. is calculated using the MET vs ISO method.

- Corrections for $W\rightarrow\tau\nu$, $W\rightarrow e\nu$, $Z\rightarrow ee$ contributing to the different regions are applied.



$W\rightarrow\tau\nu$ and $Z\rightarrow ee$ backgrounds are estimated using MC and normalized to candidates

- Result is (stat. uncert. only):
  - ⇨ N(QCD)=3758±125
  - ⇨ N(Z)=527±5
  - ⇨ N($W\rightarrow\tau\nu$)=1946±43

Check of back.calculation using "anti-electron" method (CDF note 7760)

⇒result consistent

Acceptances and efficiencies

$\varepsilon = \varepsilon_{kin} \times \varepsilon_{id} \times \varepsilon_{pvz} \times \varepsilon_{track} \times \varepsilon_{E/p} \times \varepsilon_{trg}$

In red the ones measured using data

Geometrical and kinematical acceptance

⇨ET>20 GeV, 1.1<|η|<2.8, MET>20

→Computed using MC

Electron ID efficiency

⇨Had/EM<0.05, Isorel<0.1

→Measured using Z →ee (CP)

Track Matching

⇨ΔX,ΔY<3 cm

→Measured using plug leg of Z →ee (CP) events and MC

E/p requirement

⇨E/p<2

→Measured using plug leg of Z →ee (CP) events

Trigger efficiency

⇨MET_PEM fired

→Measured using backup trigger

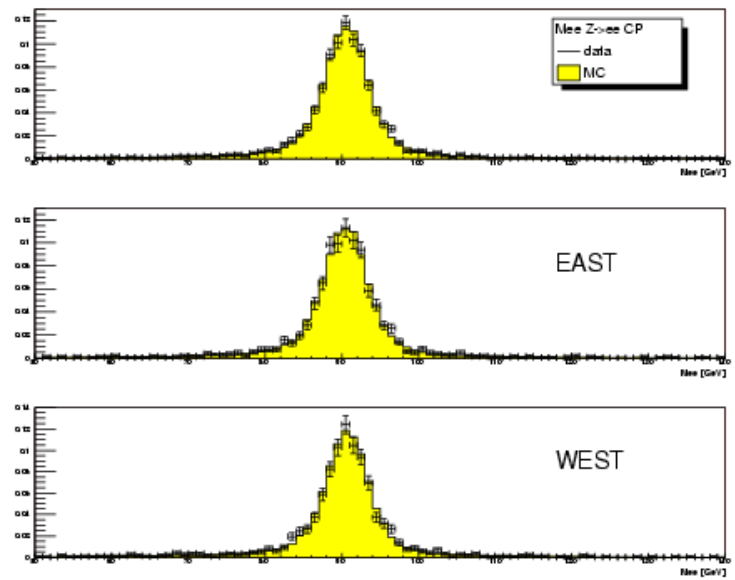
Z→ee, CP data sample

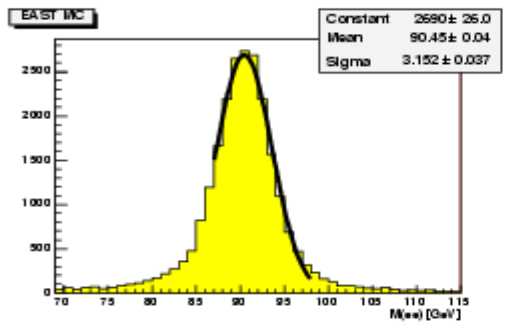
Central leg (tight)

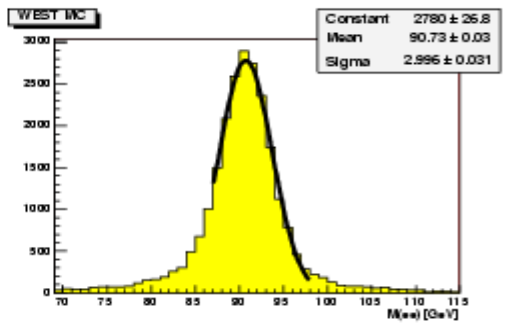
Plug leg:

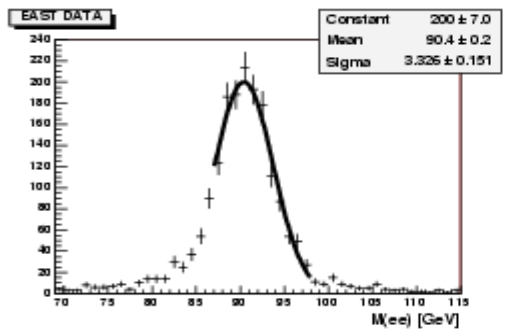
- E_T>20, 1.1<|η|<2.8
- Had/Em<0.125
- 80<Mee<100

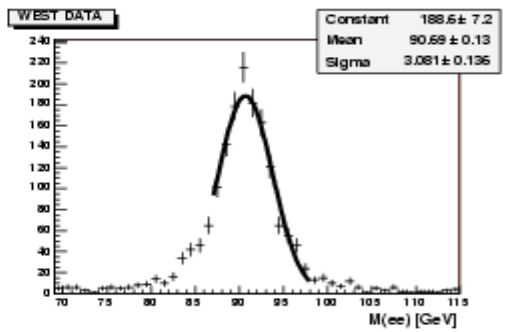
- Used to determine E scale and smear
- Used to measure efficiencies, check MC etc.





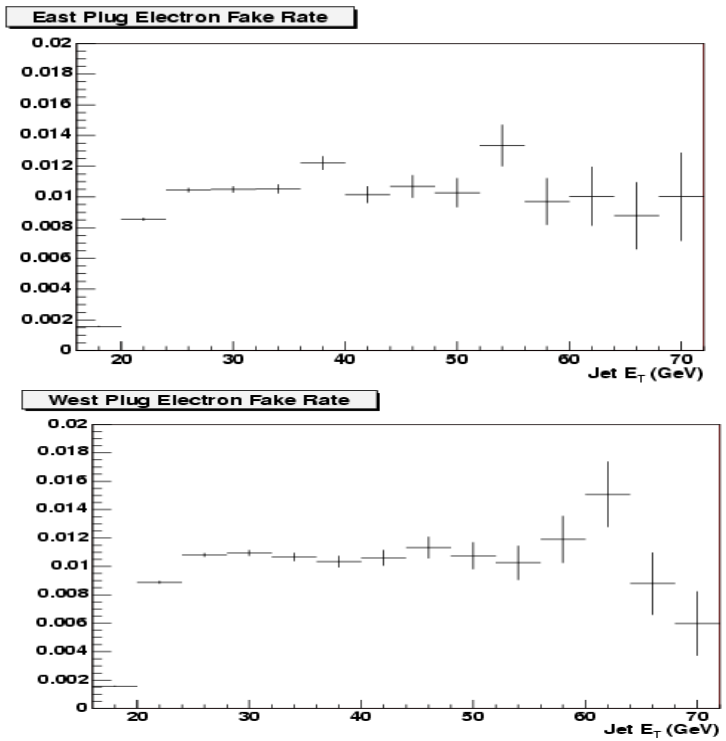






Z→ee, ε calculation

For ε calculations background computed as for the Z→ee CP sample (fake rate method using Jet20) and subtracted



Result:

- ε ID efficiency
  - ⇨0.951±0.0022±0.026
- track matching efficiency (combined with W MC)
  - ⇨0.462±0.0051±0.003
- E/p
  - ⇨0.721±0.0067±0.0006

Systematic uncertainties computed assuming 40% backg.unc. (x-checked)

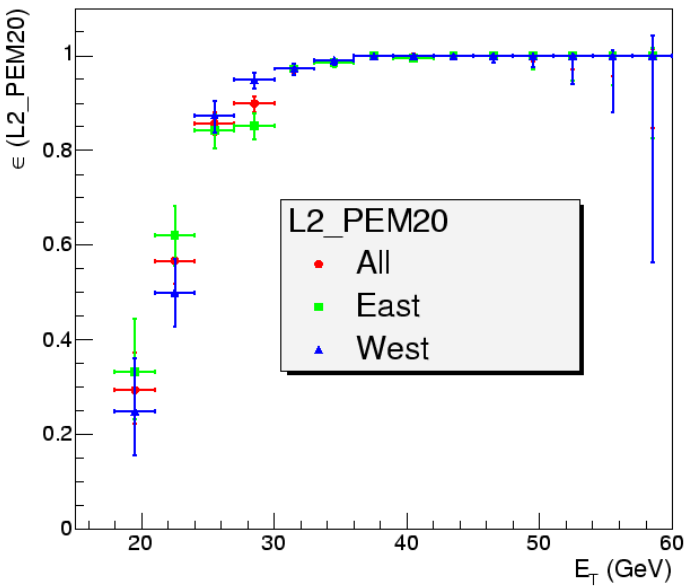
Trigger efficiency

Our trigger path is MET_PEM:

- L1= L1_EM8_MET15
- L2=L2_PEM20_L1_EM8_MET15
- L3=L3_PEM20_MET15

Efficiency is computed using backup trigger and (L2_PEM and L3_PEM20) using Zee(CP)*

- L1&L3_MET15= 0.9909±0.001
- L2_PEM20=0.9572±0.0036
- L3_PEM20=0.9975±0.0009
  - ⇨ε=0.946±0.004



(*) collected using an independent trigger

Kinematical Acceptance

Measured using EWK MC sample wtop1i processed using V 5.3.3

- $A = (0.31568 \pm 0.0004)$

Systematics:

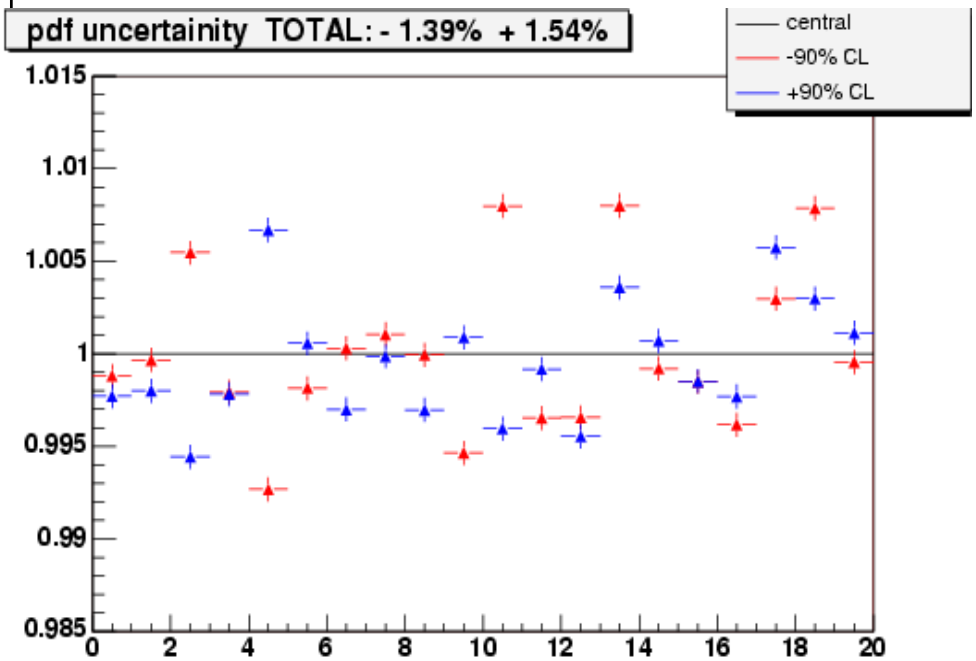
- Et Scale ✓
- Et Smearing ✓
- W Pt tuning
- U Recoil ✓
- Extra Material
- PDF ✓

Systematics summary

Source	Δ Acc/Acc (%)
Et scale…3σ (1σ)	0.45 (0.14)
Et smear …3σ (1σ)	0.09 (0.06)
Extra material	In progress
Pt tuning	In progress
U recoil …3σ (1σ)	0.21 (0.08)
PDF	+1.54 -1.39
Total	+xxx-yyy

Largest systematics: PDF

10 M events generated for each PDF eigenvalue.
90%CL value by CTEQ used to shift central value



Uncertainty estimate as by the W/Z PRD:

↳ (+1.54,-1.39)%

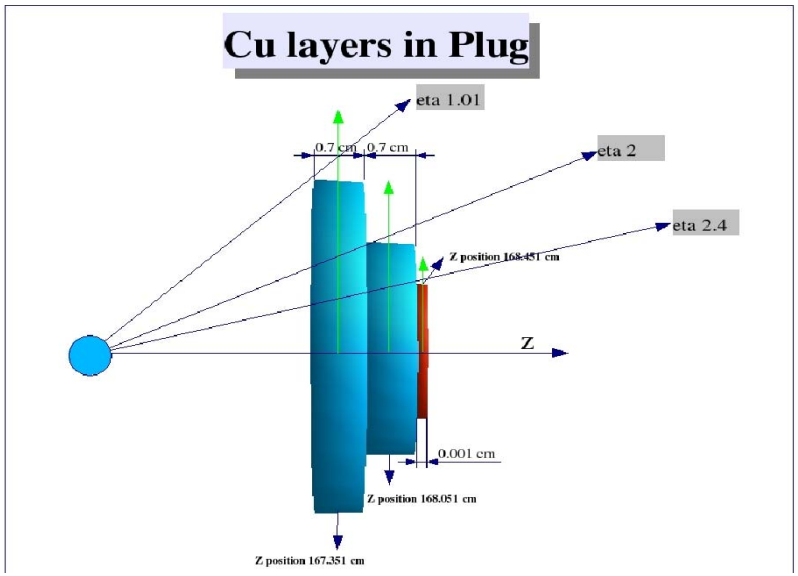
Direction of Acceptance Shifts	+ Uncertainty	– Uncertainty
$\Delta A^i_\uparrow > 0$ and $\Delta A^i_\downarrow > 0$	$\sqrt{(\Delta A^{i\,2}_\uparrow + \Delta A^{i\,2}_\downarrow)/2}$	0
$\Delta A^i_\uparrow > 0$ and $\Delta A^i_\downarrow < 0$	$\Delta A^i_\uparrow$	$\Delta A^i_\downarrow$
$\Delta A^i_\uparrow < 0$ and $\Delta A^i_\downarrow > 0$	$\Delta A^i_\downarrow$	$\Delta A^i_\uparrow$
$\Delta A^i_\uparrow < 0$ and $\Delta A^i_\downarrow < 0$	0	$\sqrt{(\Delta A^{i\,2}_\uparrow + \Delta A^{i\,2}_\downarrow)/2}$

Or, taking the largest shift if in the same direction:

↳ (+1.6,-1.65)%

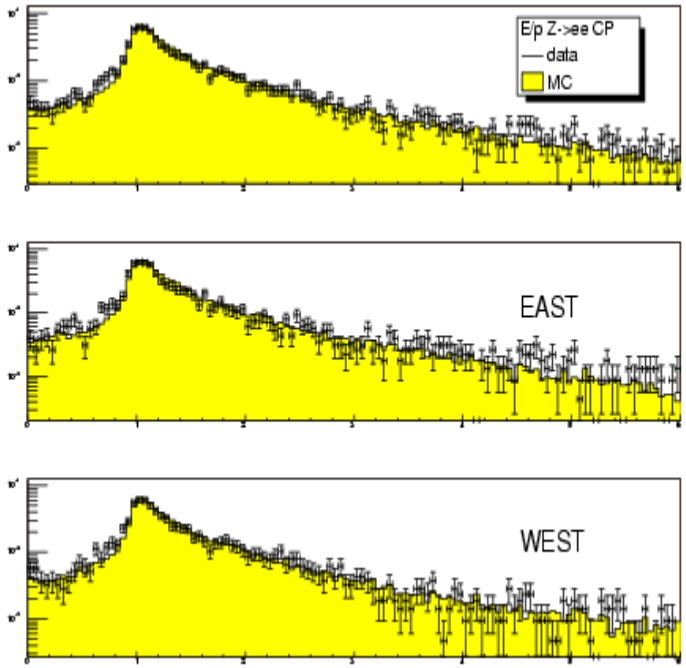
Other systematics: material

CDF simulation is tuned by adding material:



↳ Acceptance syst. is computed by varying amount (+-1/3 X0) and running full simulation and reconstruction

Good agreement data-MC (check with Zee)



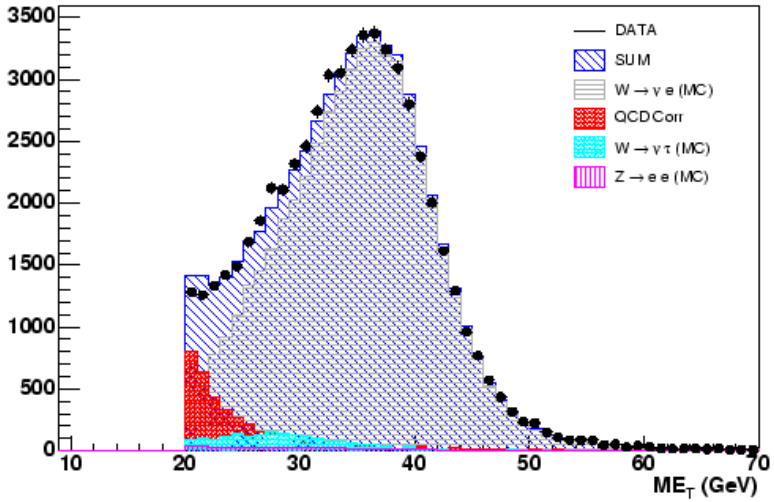
↳ Use Zee to check effect on Escale and avoid double counting

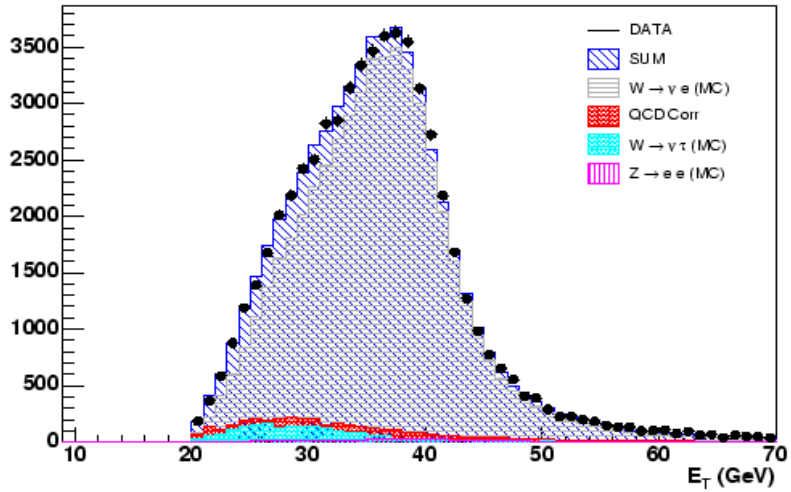
A few plots…

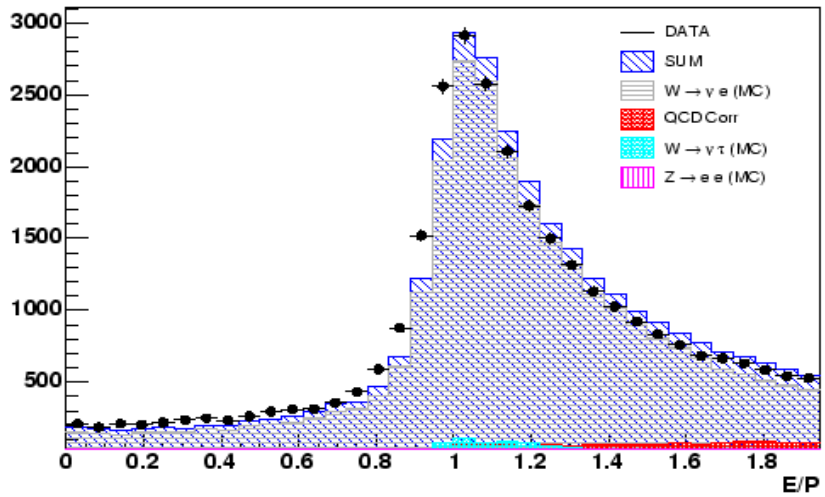
One can now look at kinematical plots after taking into account background contributions

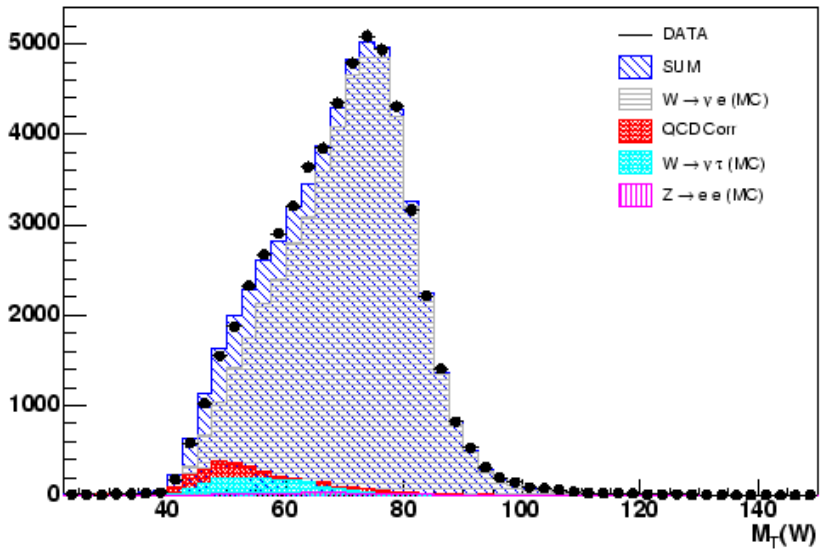
All the details in CDF note 7594

Kinematical distributions









Summary and result

$W \to e\nu$ cross section at $1.1 < |\eta| < 2.8$ in 223 pb^{-1}

- Acc=0.315168
- ε_{trigg}=0.946
- Lum.region(*)=0.947
- ε_{ID}=0.951
- ε_{trk}=0.462
- $\varepsilon_{E/p}$=0.721

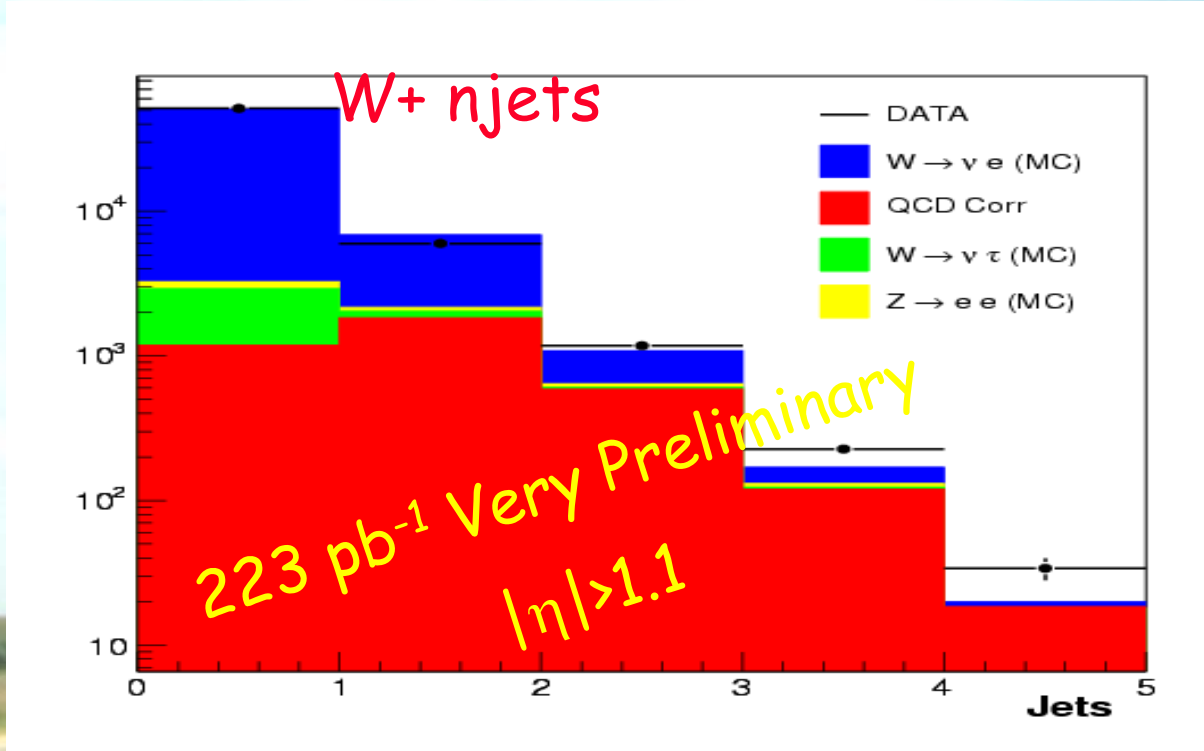
- σ=2643±12(stat)± (sys)±158(lum)

* a.k.a. Willis correction

Conclusion

CDF is looking (into the) forward region for physics.

Work in progress and keep working towards use of this info in $1fb^{-1}$…



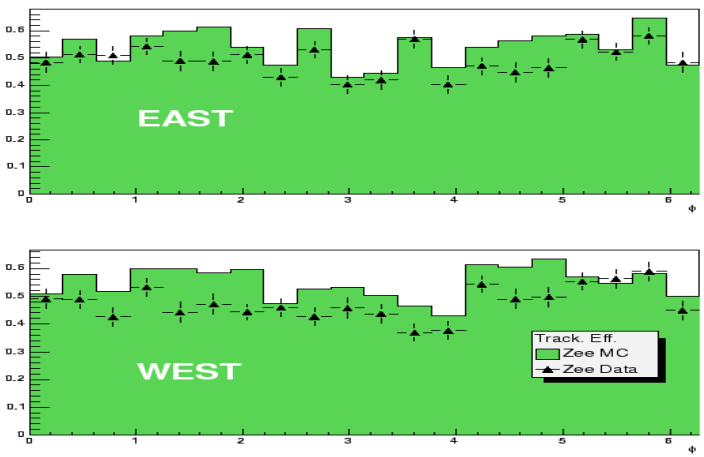
backup

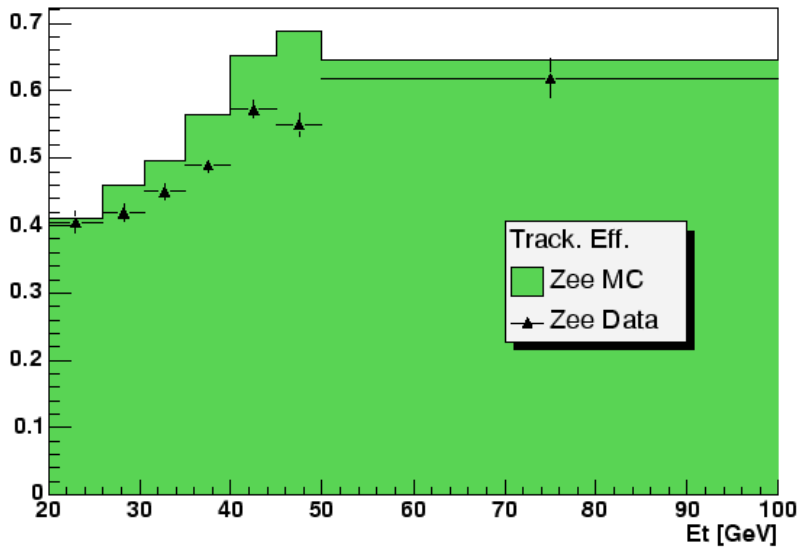
Track match efficiency

We do not want to rely on MC for ε_{match}

- Use $Z \rightarrow ee$ sample, measure how many plug *e* are matched ($\Delta X, \Delta Y < 3$ cm) by a track and define
- $\varepsilon_{mtch}(W_{data}) = \varepsilon_{mtch}(Z_{data}) \times \{\varepsilon_{mtch}(W_{MC}) / \varepsilon_{mtch}(Z_{MC})\}$
- ε_{mtch}(W data) = 0.462±0.005(stat)±0.003(sys)

This definition is instrumental to our measurement

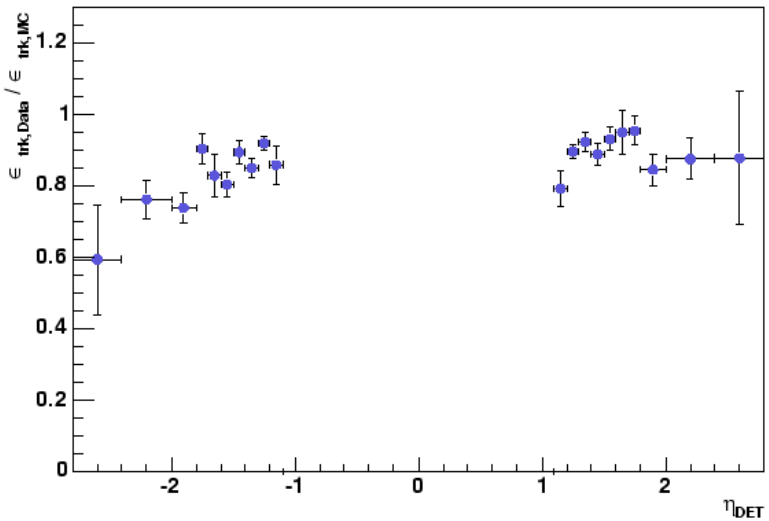


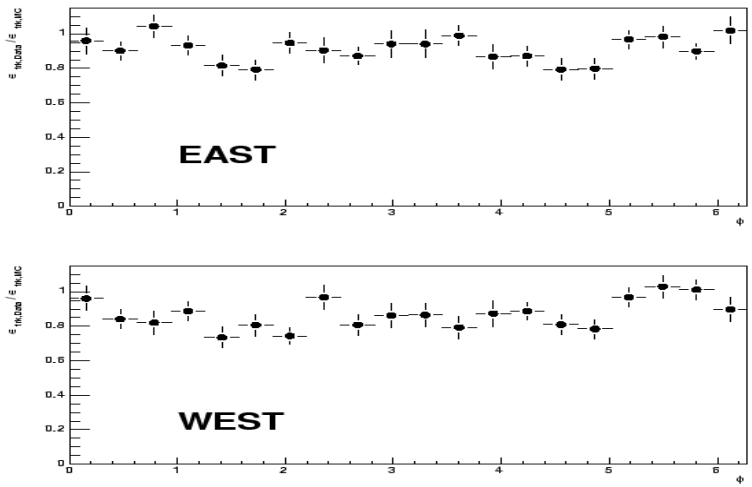


Tracking eff. SF

Results are:

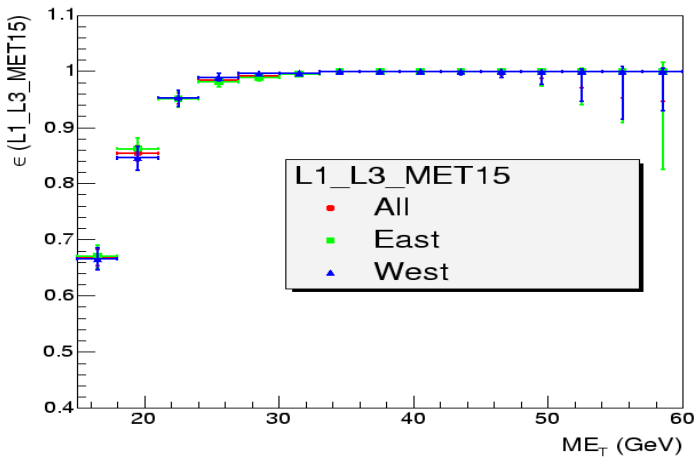
- ε_{mtch} (W MC)=0.5166±0.0009
- ε_{mtch}(Z data) = 0.489±0.005(stat)±0.003(sys)
- ε_{mtch}(Z MC) = 0.547±0.0015
- ε_{mtch}(W data) = 0.462±0.005(stat)±0.003(sys)
- Define scale factor= ε_{mtch}(Z data) / ε_{mtch}(Z MC)

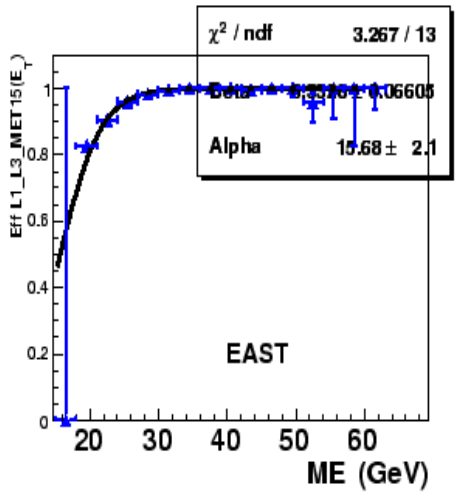


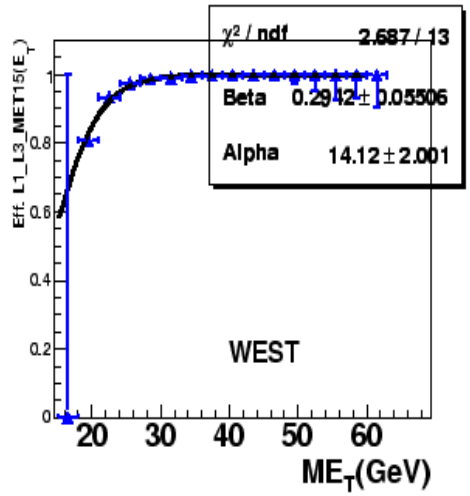


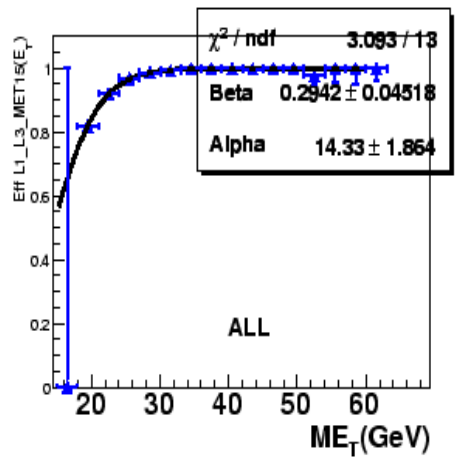
Trigger efficiency II

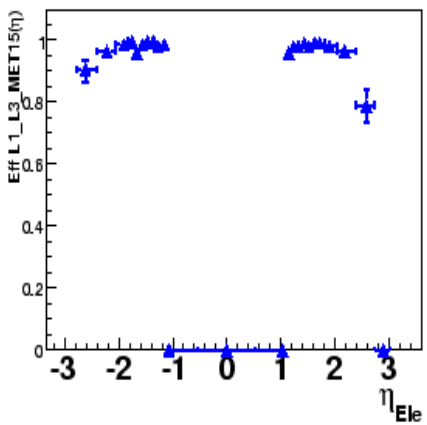
Here are some more plots:











PDF -II

Two prescriptions:

- Conservative

Direction of A shift	+ uncertainty	- uncertainty
$\Delta A^i_{up} > 0$ $\Delta A^i_{down} > 0$	$\mathrm{Max}(A^i_{up}, A^i_{down})$	0
$\Delta A^i_{up} > 0$ $\Delta A^i_{down} < 0$	A^i_{up}	A^i_{down}
$\Delta A^i_{up} < 0$ $\Delta A^i_{down} > 0$	A^i_{down}	A^i_{up}
$\Delta A^i_{up} < 0$ $\Delta A^i_{down} < 0$	0	$\mathrm{Max}(A^i_{up}, A^i_{down})$

$$\sqrt{\sum (+\text{ uncertainty})^2} \qquad \sqrt{\sum (-\text{ uncertainty})^2}$$

+1.60 % -1.65 %

- CTEQ:

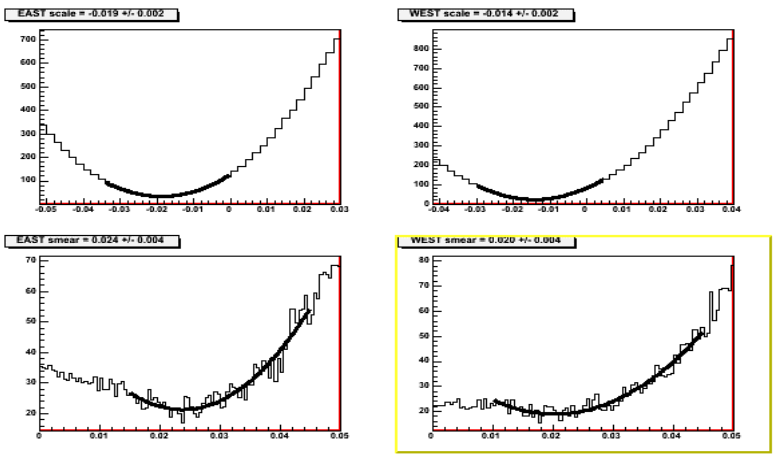
$$\frac{1}{2}\sqrt{\sum_i^{20} (\Delta A^i_{up} - \Delta A^i_{down})^2} = 1.22\ \%$$

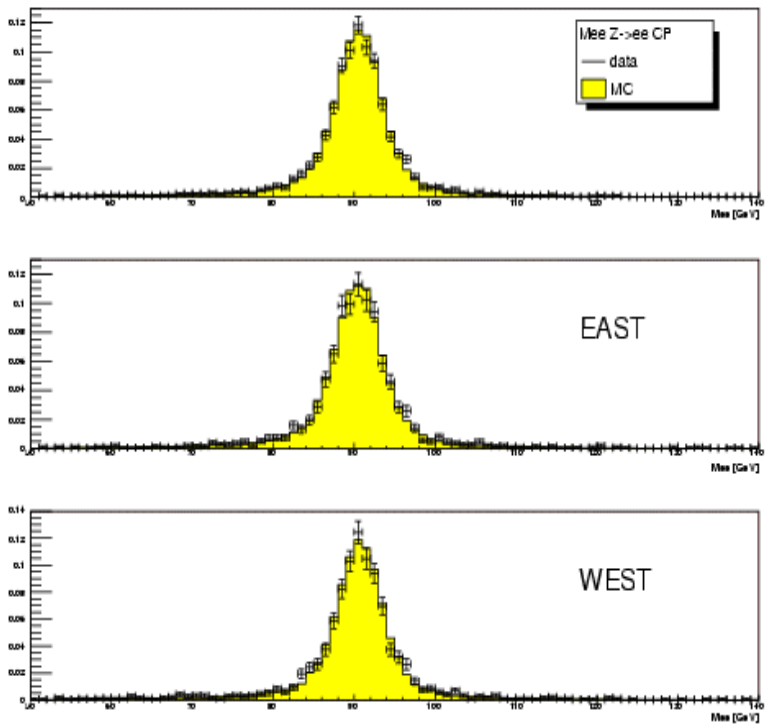
E Scale and smear

Energy scale is shifted in MC to match Zee data, also, smearing is applied

↳ $E_{scale\&smear}$ = Ex(1 + scale)x(1 + Gaus(0,smear)

	East	West
Scale	-0.019±0.002	-0.014 ±0.002
Smear	0.024±0.004	0.02±0.004





Recoil energy

$\vec{U} = -(\not{\vec{E}}_T + \vec{E}_T) \longrightarrow U_\perp \& U_{II} \longrightarrow$

$U'_{II} = K_{II}(U_{II} + C_{II})$

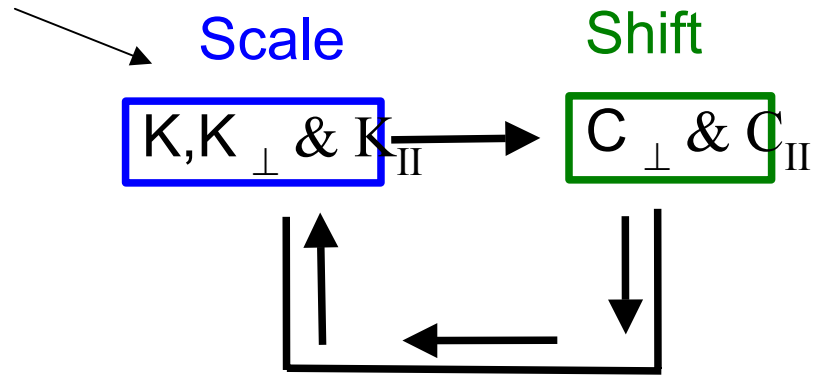
$U'_\perp = K_\perp(U_\perp + C_\gamma)$

$U' = K * \mathrm{sqrt}(U^2_\perp + U^2_{II})$

Parallel and perpendicular difined with respect of lepton direction

- Data and MC for different values of parameters were compared using χ^2 distributions

- Value of parameter for χ^2_{min} used to recalculate Met and acceptance
- Appropriate values of parameters of 3σ shift in χ^2 used for systematics study



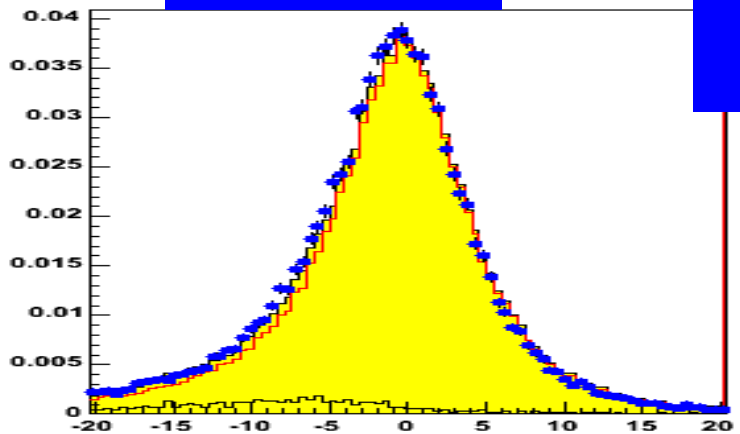
Evaluated in iteration

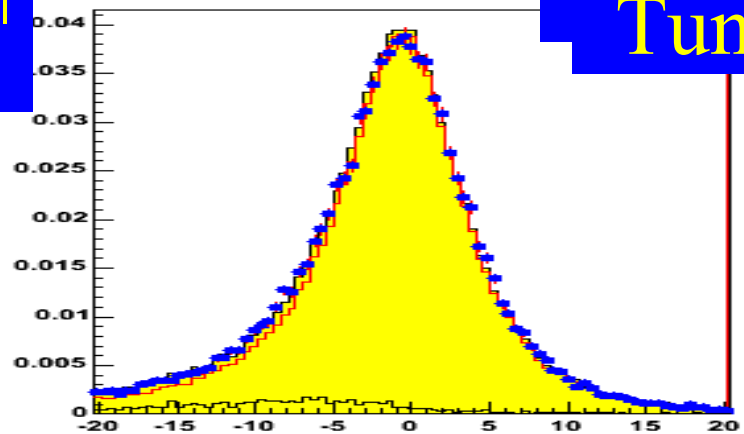
Recoil energy Perp & Par

No tune

$U_{\parallel}$

Tuned

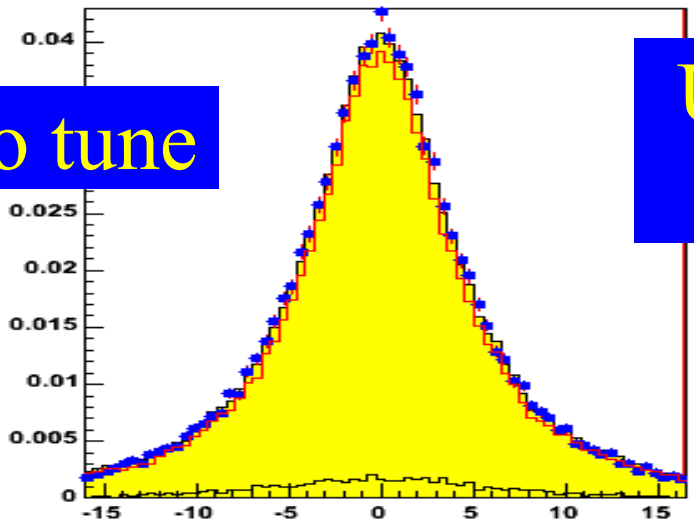


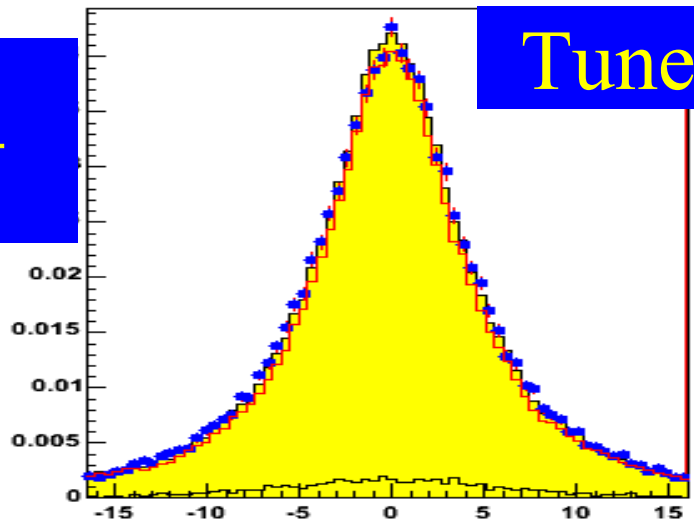


No tune

$U_{\perp}$

Tuned





Recoil systematics

Recoil syst.

↳ Standard +-3 σ

	Parallel Scale	Parallel Shift	Perpen Scale	Perpen Shift
Value	0.953	-0.332	0.965	0.006
$\Delta A/A$ [%]	0.178	0.120	0.051	0.007
$\Delta A/A$ [%]	0.182	0.119	0.061	0.004

Contribution to acceptance systematics:
$= \sqrt{(0.182^2+0.120^2+0.061^2+0.007^2)} = 0.226\%$

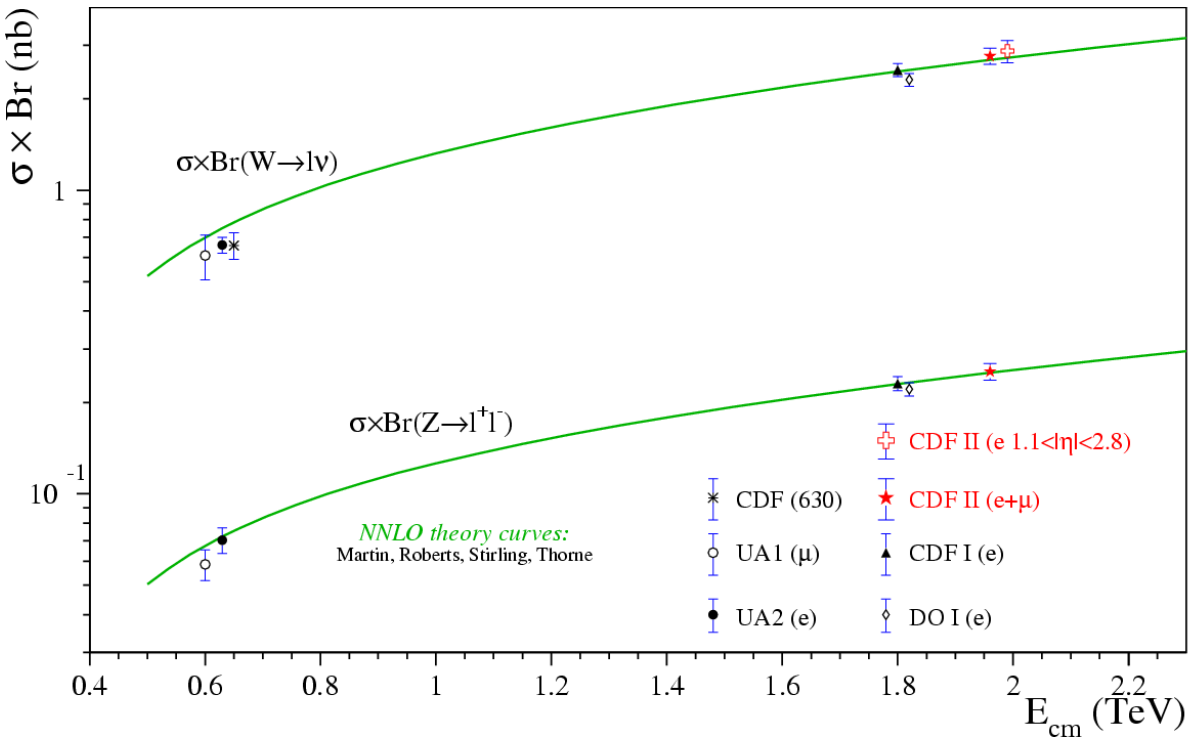
↳ Using 1 σ shift: contribution to $\Delta A/A = 0.211\%$

Conclusion 2004

Added one point to a 20 years old history…more to come

Work in progress:

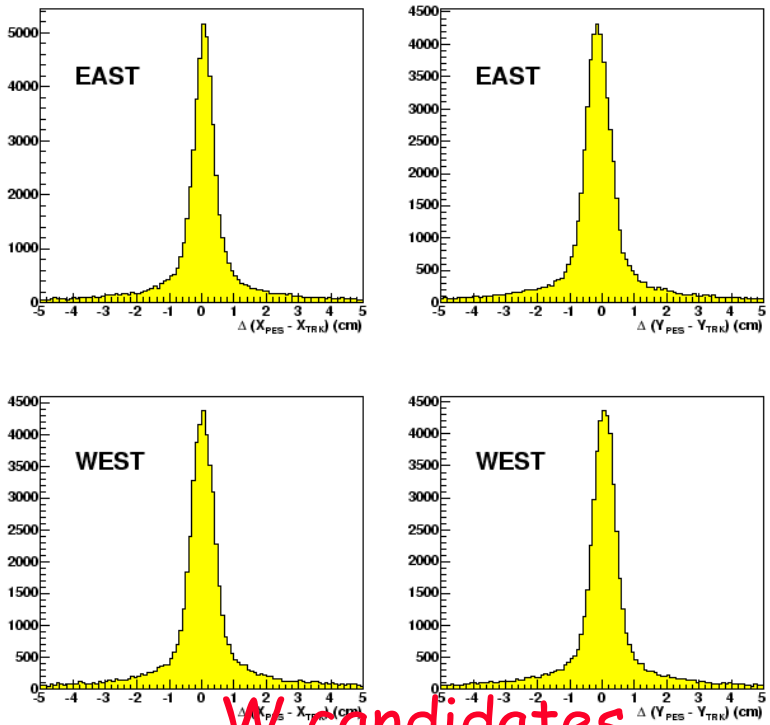
- 5.3.1: increase tracking efficiency, increase in candidates…

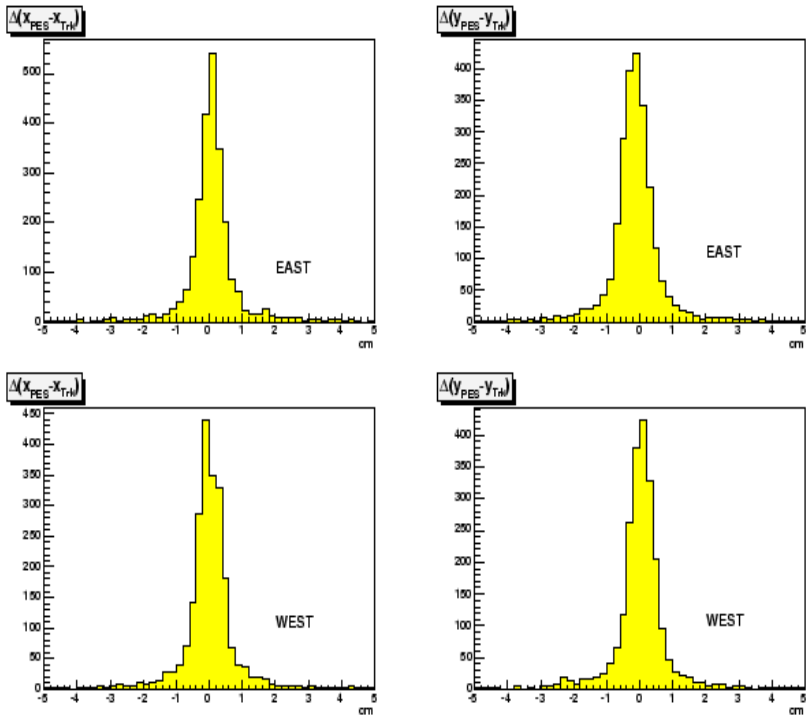


Track-PES matching

3D track found by tracking algorithm is extrapolated to PES location:

Correction for PES misalignment is applied,





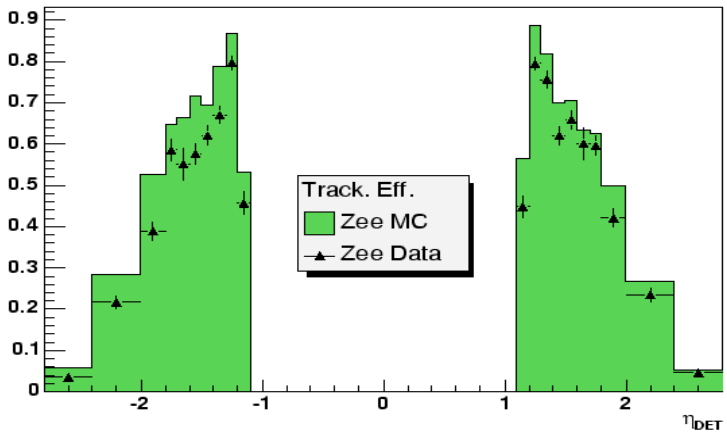
W candidates

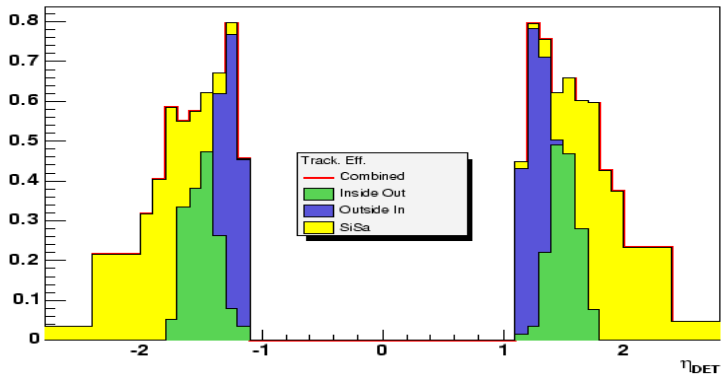
Plug leg of Z CP

Tracks

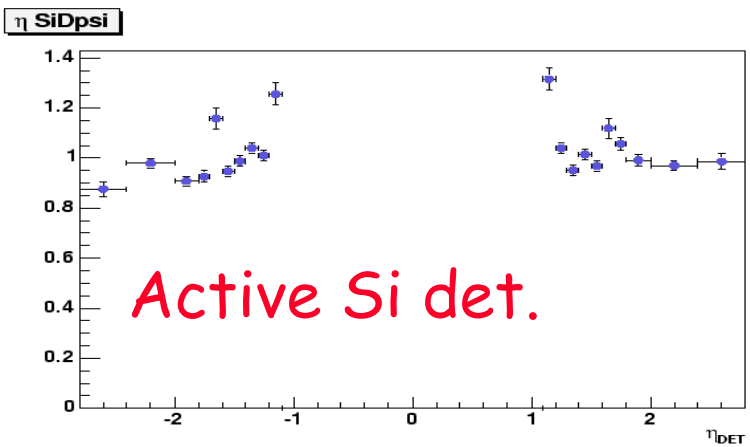
Tracking efficiency

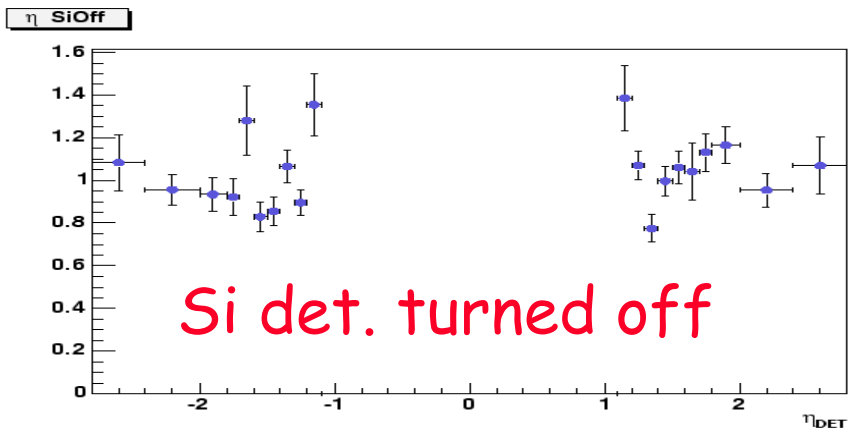
A few interesting plots: Zee CP eta study



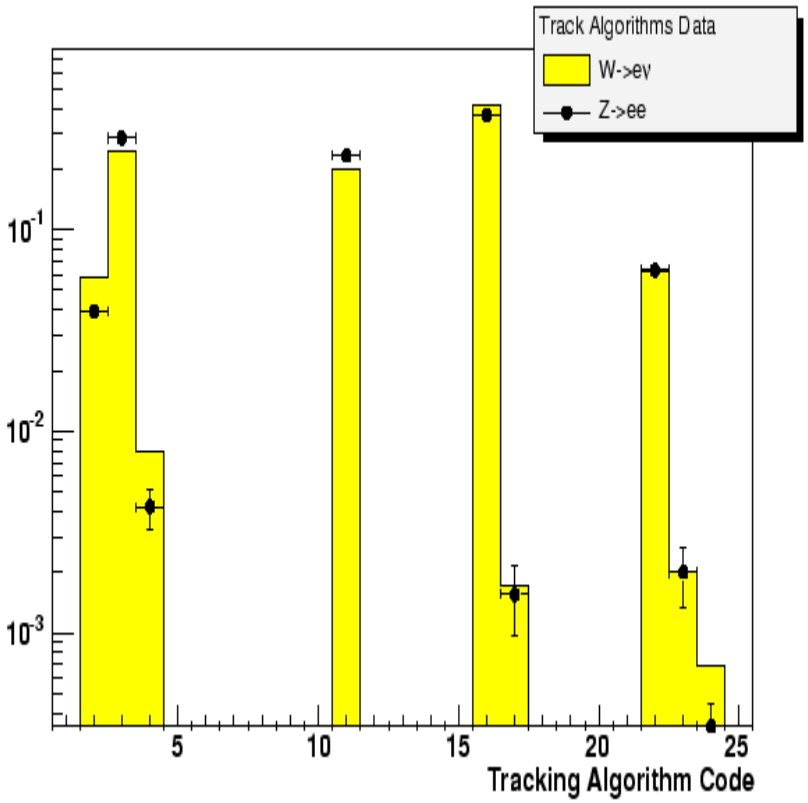


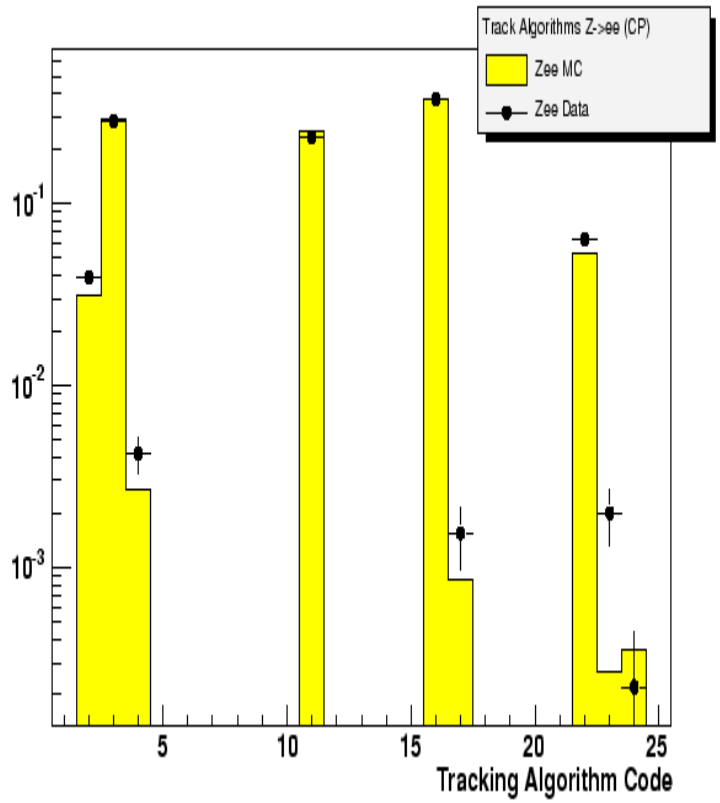
SF: MC/data ratio of





Track Matching





Tracks found by the different tracking algorithms

Tracking efficiency

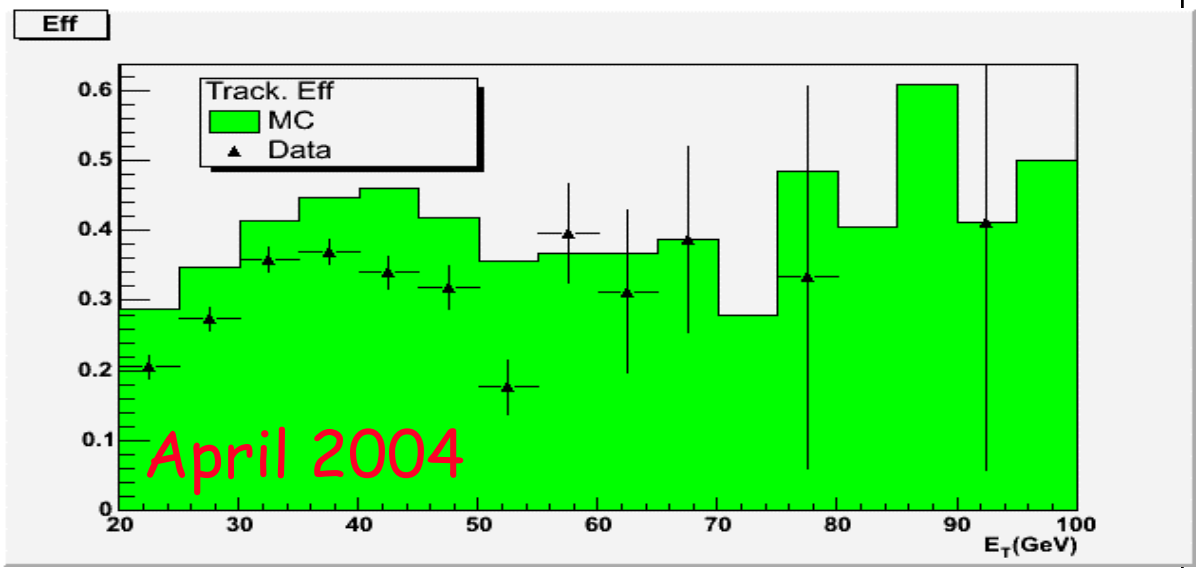
We do not want to rely on MC for $\varepsilon_{tracking}$

- Use $Z \rightarrow ee$ sample, measure how many plug *e* are matched ($\Delta X, \Delta Y < 3$ cm) by a track and define
- $\varepsilon_{tracking}(W_{data}) = \varepsilon_{tracking}(Z_{data}) \times \{\varepsilon_{tracking}(W_{MC}) / \varepsilon_{tracking}(Z_{MC})\}$

$Z \rightarrow ee$ (CP):

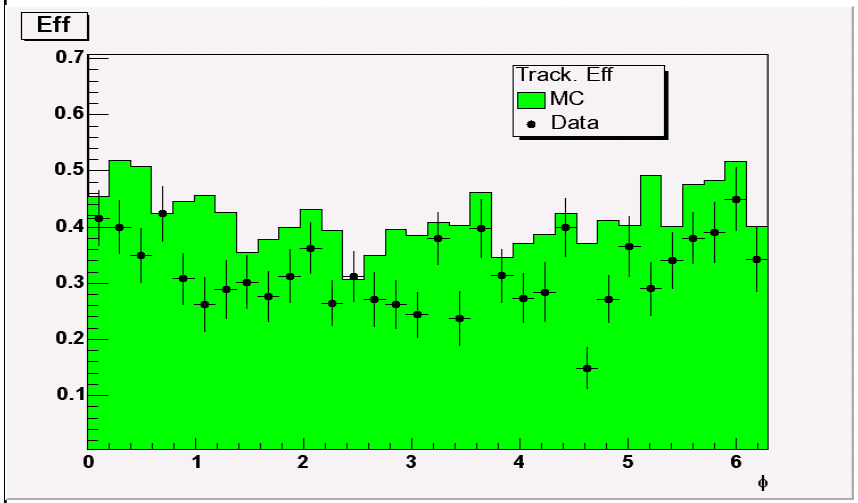
Data:

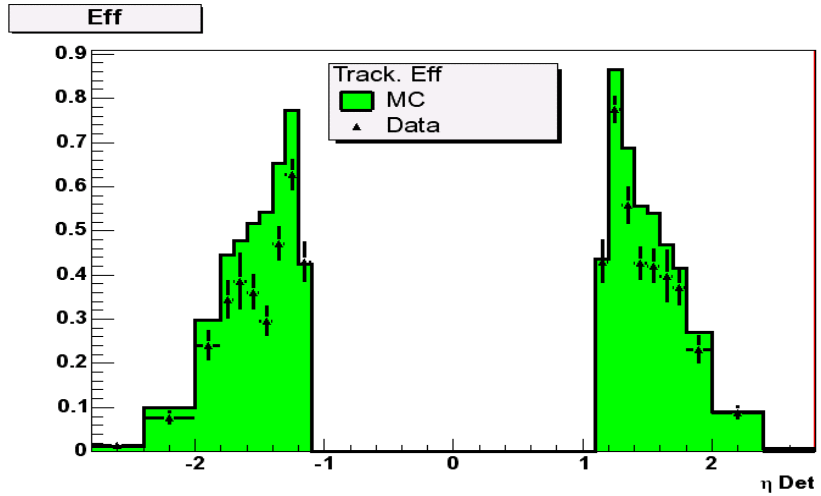
$\varepsilon_{tracking}(Z_{data}) = 0.32$



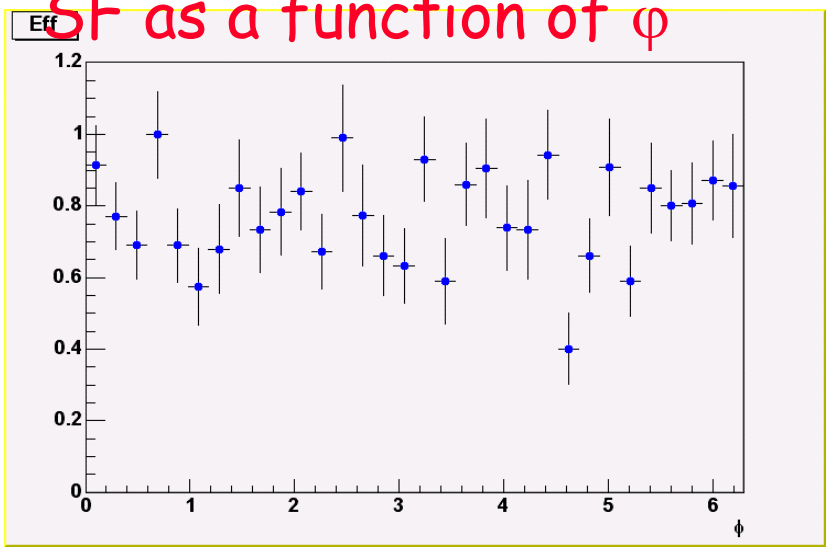
$$\varepsilon_{tracking}(W_{data}) = 0.322 \pm 0.009(stat)$$

SF and Tracking

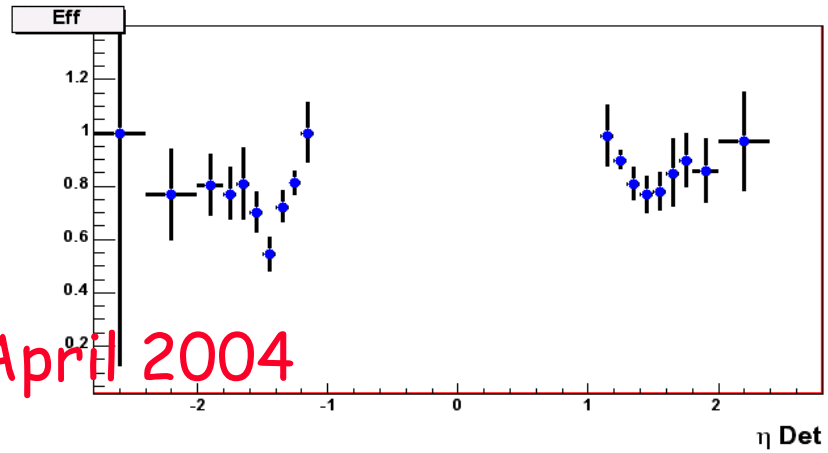




SF as a function of φ



SF as a function of η



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Scale Factor: Systematics

We define SF_0 as the average Scale Factor

Then we study what happens assuming that SF is a function of η or E_T

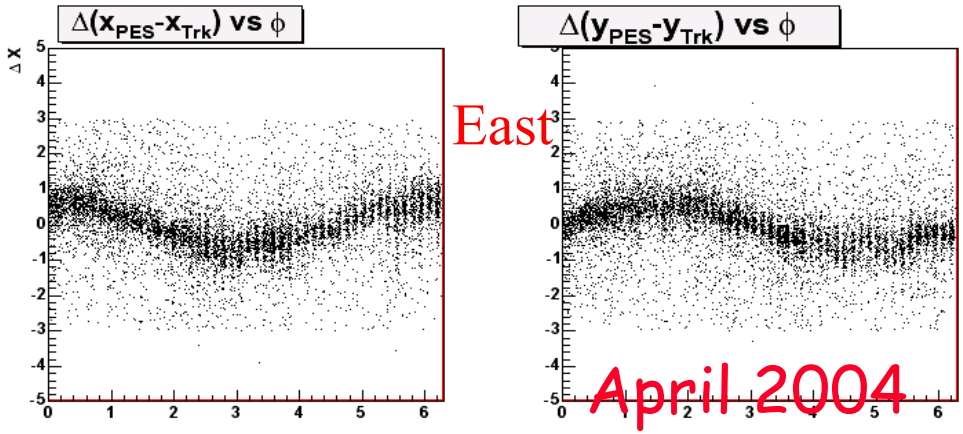
- We compute the difference between the number of events obtained using the average SF and the number of events obtained using SF function of η or E_T (Δ_{ET} and Δ_η)

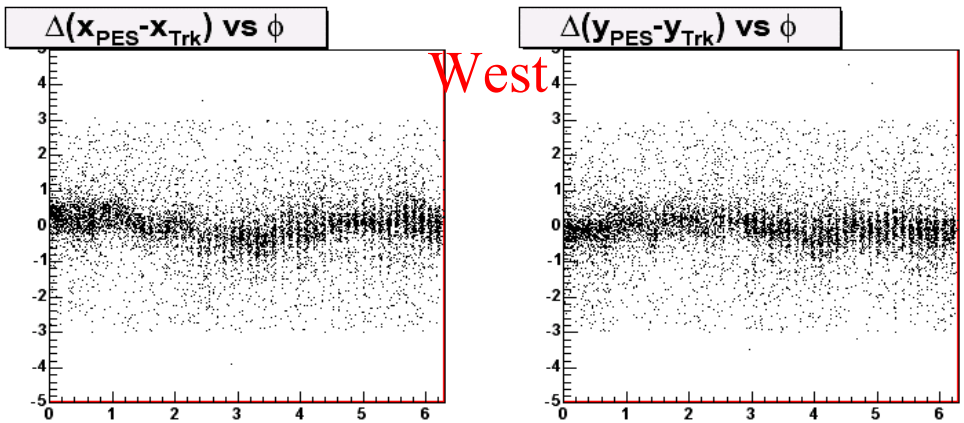
$$\Delta_{E_T} = \left(\int \left(\frac{\frac{dN}{dE_T}}{SF(E_T)} \right) dE_T \right) - \left(\frac{\int \frac{dN}{dE_T} dE_T}{(SF_0)} \right)$$

$$\Delta_\eta = \left(\int \left(\frac{\frac{dN}{d\eta}}{SF(\eta)} \right) d\eta \right) - \left(\frac{\int \frac{dN}{d\eta} d\eta}{(SF_0)} \right)$$

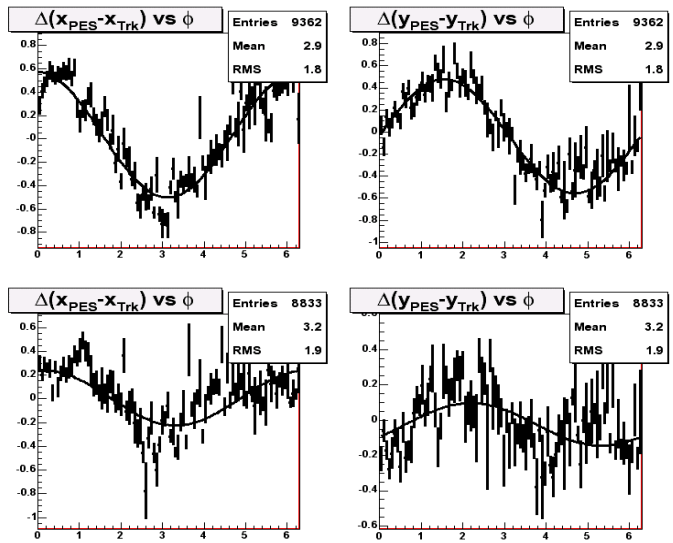
- We take the biggest of the two (Δ_{ET} and Δ_η) divided by the number of events obtained using a flat SF as the (fractional) systematic uncertainty due to the use of an average SF instead of a SF as a function of η or E_T

Track Matching- Wenu





Plug East Misalignement of ~0.7cm
Marginal impact since PES doesn't seed any track.
Just matching with 3cm window

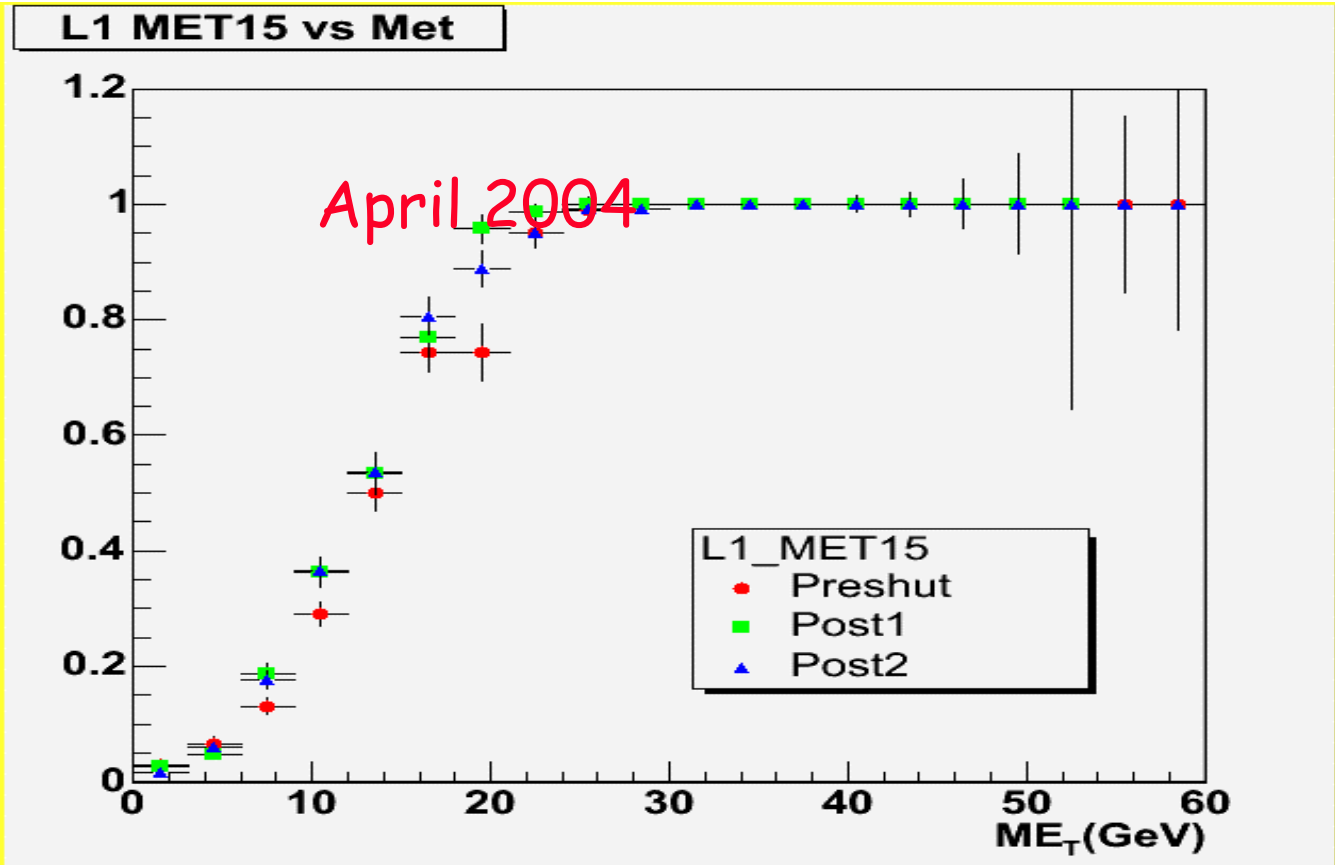


Residual misalignment

TRIGGER

L1 MET15

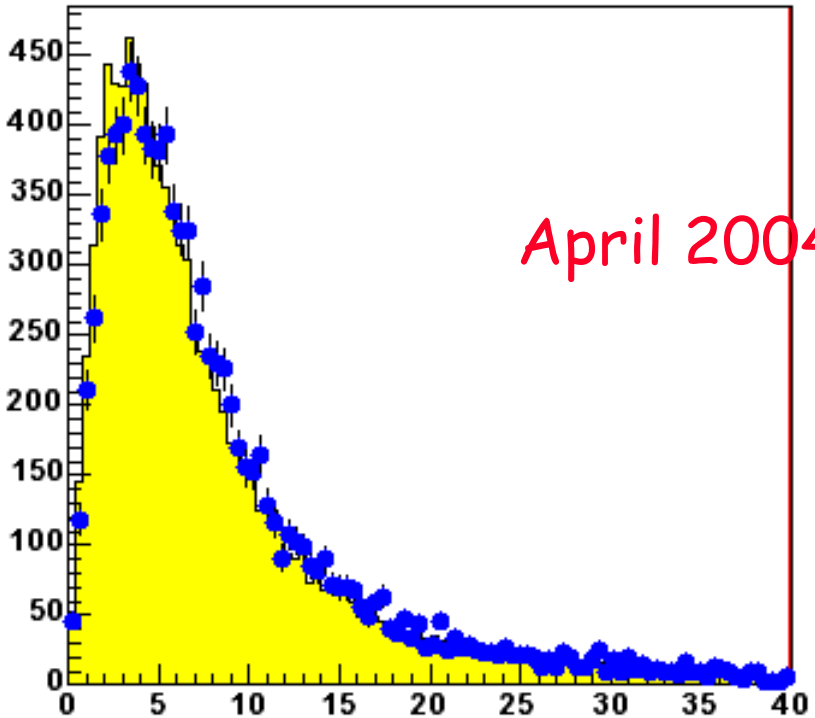
Trigger Eff for the three periods.



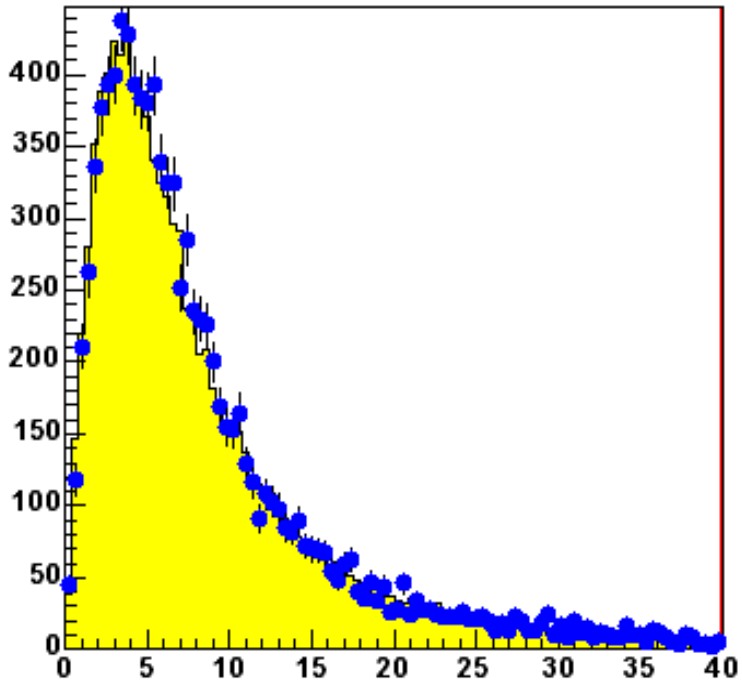
Recoil Energy: $\vec{U} = -(\vec{\not{E}}_T + \vec{E}_T)$

Before tuning

After tuning…



April 2004



U is decomposed into its // and ⊥ (to l direction). Then it is shifted and scaled.

Systematics is computed by changing shift and scale

Cross Section

N.candidate events	10461	
N.background QCD events	495 ± 62 (stat)	± 247 (sys)
N.background Z events	87 ± 13 (stat)	
N.background $W \to \tau\nu$ events	324 ± 23 (stat)	
Lumin.(pb^{-1})	64	± 4.3 (sys)
ϵ	0.052 ± 0.002 (stat)	± 0.002 (sys)

April 2004

	Value		Syst.error
ϵ_{Kin}	0.3112 ± 0.0007		0.0058
$\epsilon_{Pvz,Kin}$			0.0035
ϵ_{PVZ}	0.92 ± 0.005		
ϵ_{ID}	0.961 ± 0.004		0.022
ϵ_{trig}	0.958 ± 0.011		
$\epsilon_{E/p}$	0.64 ± 0.015		0.001
ϵ		0.170 ± 0.005	0.005
$\epsilon_{tracking}$		0.322 ± 0.009	0.006
ϵ_{Lum}		0.951 ± 0.001	0.005
Overall ϵ		0.052 ± 0.002	0.002

σ =2.874±0.034(stat)±0.167(syst)±0.172(lum) nb