Outline

Some Comments on Electron Monte Carlo

- Introduction
- Object ID and Event Selection
- W and Z Samples in Data and MC:
  - Had/Em
  - E/p
  - ΔX and ΔZ
  - Isolation Corrections
  - Calorimeter Edge Effects
  - Plug ID Variables

Introduction

- I'm doing a search for new physics in Dileptons
- Recently, I've been trying to nail down comparisons for W's and Z's in MC and Data
- The Electron MC looks good – I get appropriate predictions for yields...
- ...But there are some shapes which disagree significantly between Data and MC.
- Many of these are surely known, but it might be useful to itemize them here.
- I'll try to be as specific as I can for this talk to be as useful as possible
- Finally, I'm happy to help in ways I can be most useful – mostly in refining and making new plots to help specify exact problems.

Object ID and Event Selection

- Event selection:
  - Looking for W's and Z's
  - Pick events with one tight lepton and either a second loose lepton or $\not\!\!E_{\mathrm{T}} > 20$ GeV.
- Want to maximize acceptance:
  - Use 'or' of likelihood (CDF Notes 5934, 5902, 6083, 6721) and standard (Joint Physics Group) cuts.
  - A loose lepton can have $\mathrm{p_T} > 12$ GeV.
  - Loosen Fiducial requirements.

Object ID and Event Selection

- $\not\!\!E_T$ is corrected for all objects in the event including:
  - Tight and loose electrons with $E_T > 12$ GeV
  - Tight and loose muons with $p_T > 12$ GeV
  - Jets with $E_T > 8$ GeV at Level 4.
- H_T is the scalar sum of the p_T of all objects in the event as well as $\not\!\!E_T$.

Object ID and Event Selection

Table 1 summarizes the cuts for central electrons.

Variable	Tight	Loose
E_T	$>$20 GeV	$>$12 GeV
$\|X_{CES}\|$	—	$<$ 21 cm
$\|Z_{CES}\|$	—	9 $<$ $\|Z_{CES}\|$ $<$ 230 cm
Track P_t	$>$ 10 GeV	$>$ 10 GeV
Track $\|z0\|$	$<$ 60 cm	$<$ 60 cm
E/p	$< 2.0 \,\|\|\, p_T > 50GeV$	
charge signed Δx	-3.0$< q_{trk} * \Delta x <$ 1.5 cm	
$\|\Delta z\|$	$<$ 3.0 cm	
Track quality cuts	3 SL $>$ 5 hits	3 SL $>$ 5 hits
Conversion Filter	$! = 1$	$! = 1$
Had/Em	$< 0.055 + 0.00045 * E$	$< 0.055 + 0.00045 * E$
Lshr	$<$ 0.2	
χ^2_{strip}	$<$ 10	
Frac. Cal. Iso (corrected)	$<$ 0.1	$<$ 0.1

Table 1: Summary of the cuts for tight and loose electrons. When the selection is likelihood-based, the last four cuts are replaced by the likelihood.

Object ID and Event Selection

Table 2 summarizes the cuts for plug electrons.

Variable	Cut
E_T	$>$12 GeV
$\|\eta_{det}\|$	$1.2 < \|\eta_{det}\| < 2.5$
Track Type	Phoenix
$\|z0\|$	$<$ 60 cm
SVX Hits	≥ 3
Had/Em	< 0.05
χ^2_{three}	< 10
Frac. Cal. Iso (corrected)	< 0.1
PES 5$\times$9 U	> 0.65
PES 5$\times$9 V	> 0.65
PEM Fit Towers	$! = 0$

Table 2: Summary of cuts for plug electrons. When the selection is likelihood-based, the last six cuts are replaced by the likelihood.

Data: W and Z Control Samples

- Using 5.3.3 inclusives bhel0d
- Data has been ntupled with the UCNtuple:
  - CVS Directory: FlatNtuple
  - CVS Tag:
  - Web Page:
    $http://hep.uchicago.edu/cdf/flatntuple/index.html$
- Using the latest good run list from the DQM group (version 7), requiring the calorimeter, all muon detectors, and the silicon to be good.
- This narrows the data range to runs from 150145 to 186598 and dates from August 20, 2002 to August 22, 2004.
- The integrated luminosity for this inclusives is 496.8 pb^{-1}.
- With the goodrun list, the luminosity shrinks to 298.4 pb^{-1}.

MC: W and Z Control Samples

- Using the following Top Group samples:

Process	Dataset	Cross Section (pb)	k-factor	# of events	Luminosity (pb^{-1})
$Z \to ee$	ztop2i	256	1.3	1062012	3191
$W \to e\nu$	wtop1i	2780	–	1304237	469

- Except where noted, All MC plots are absolutely normalized using the above cross sections (with appropriate scale factors and trigger efficiencies).

Electron Info

-
- Electron scale factors and trigger efficiencies:
  - Set the central electron scale factor to 1.
  - Take the phoenix scale factor to be 0.949.
  - Take the L3 CEM trigger efficiency to be $1 - 2.784 \times \exp(-1.749 \times (\mathrm{E_T} - 17.86))$

Central-Central $Z \rightarrow ee$

- As a sanity check, require the following:
  - Standard Cuts
  - One electron tight central; the other tight or loose central.
  - fidele==1 & $\mathrm{E_T} > 20$ GeV for both e's
  - 66 GeV$< M_{ee} <$ 116 GeV
  - Opposite Sign
- Numbers:

# of MC events	# Predicted in Data	# Seen in Data
79038	7382	7365

- Quick Note: This goes up by 34% if we use the 'or' of the likelihood and standard cuts!
- Extensively compared electron ID variables and physics quantities. Some look good. Some look not so good...

Had/Em in Central-Central $Z \rightarrow ee$

- Had/Em gotten by: $EmCluster- > hadEm()$
- In Appendix A of CDF Note 5934, Bruce Knuteson paramaterizes the expected hadronic energy fraction. It appears that some constants are wrong in the paramaterization.
- When we fit the tail to an exponential, the data has a decay rate of 95.7, while the MC has a decay rate of 69.4.

Had/Em in Central-Central $Z \rightarrow ee$

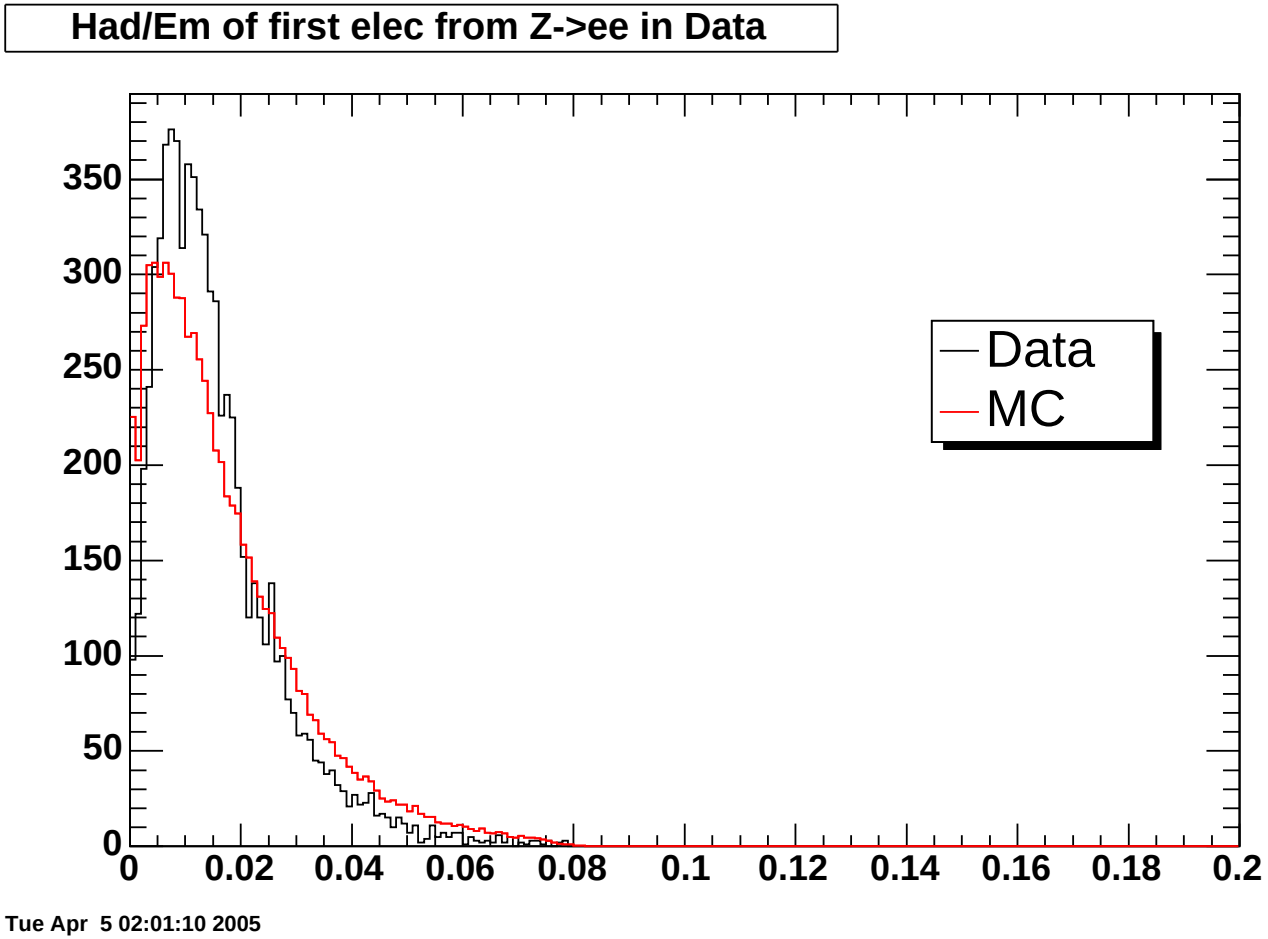

Figure 1: Had/EM in $Z \rightarrow ee$

E/p in Central-Central $Z \rightarrow ee$

- Energy is the corrected two tower energy.
- Uncorrected 4-momentum comes from: $emobj_alg$ :: $CEMFourMomentum$ :: $TwoTower(CdfEmObject, false)$
- Correction factor from: $CemCorrAlg$ :: $GetCemCorr(CdfEmObject, "USETRACK", correction)$
- This corrects for:
  - CEM mapping corrections,
  - CEM tower-to-tower corrections
  - Global E energy scale correction
- Momentum is the corrected (with Larry's 5.3.3 curvature corrections) momentum.

E/p in Central-Central $Z \rightarrow ee$

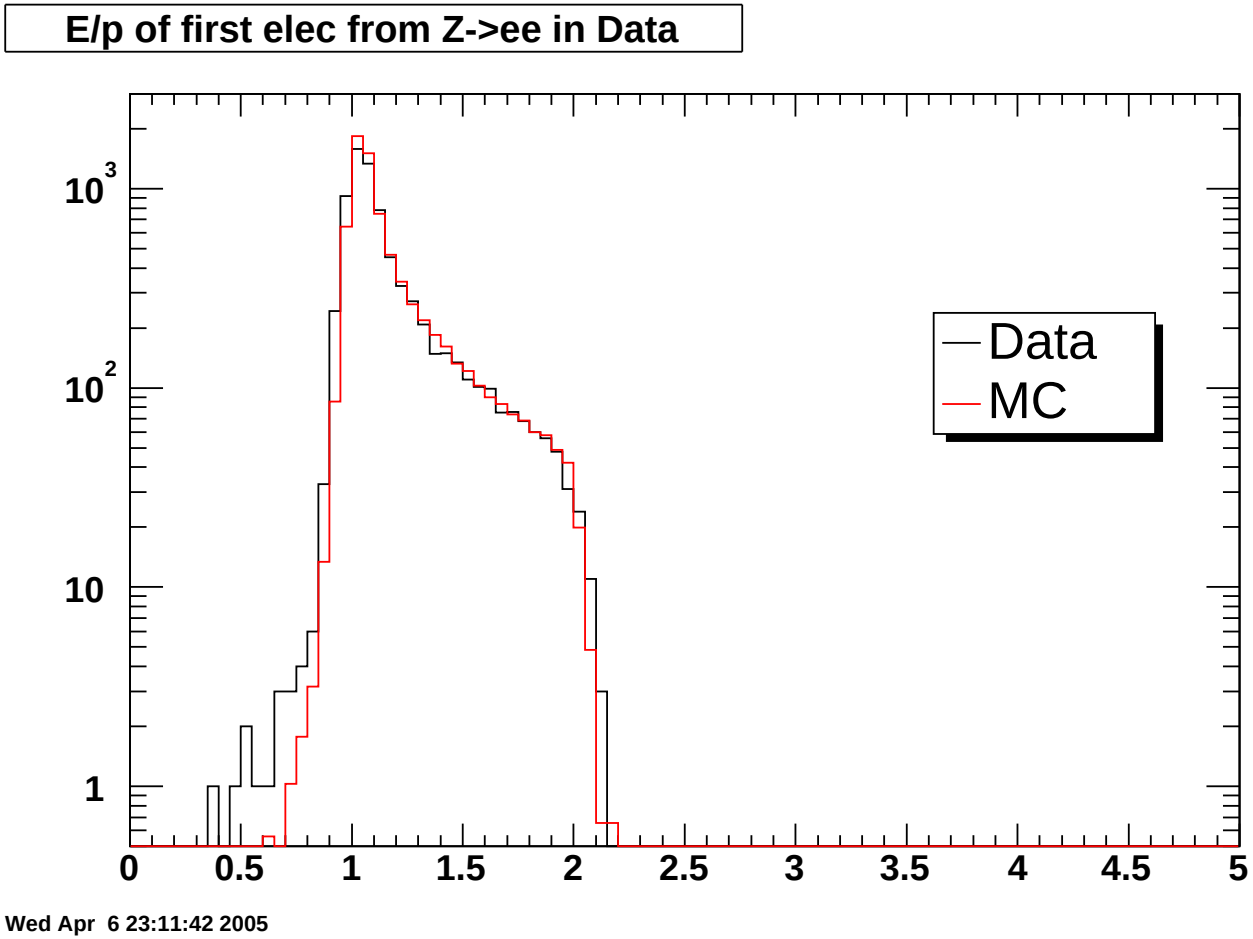

Figure 2: E/p in $Z \rightarrow ee$

Iso in Central-Central $Z \rightarrow ee$

- Total isolation energy in a cone of 0.4 (in GeV).
- $EmCluster->totalIsolationEt4()$
- Correction is PJW leakage correction, documented in CDF Note 4170.
- Correction coded in Electron/src/IsoCorrAlg.cc
- The correction is a function of CES X position times Em Et.

Iso in Central-Central $Z \rightarrow ee$

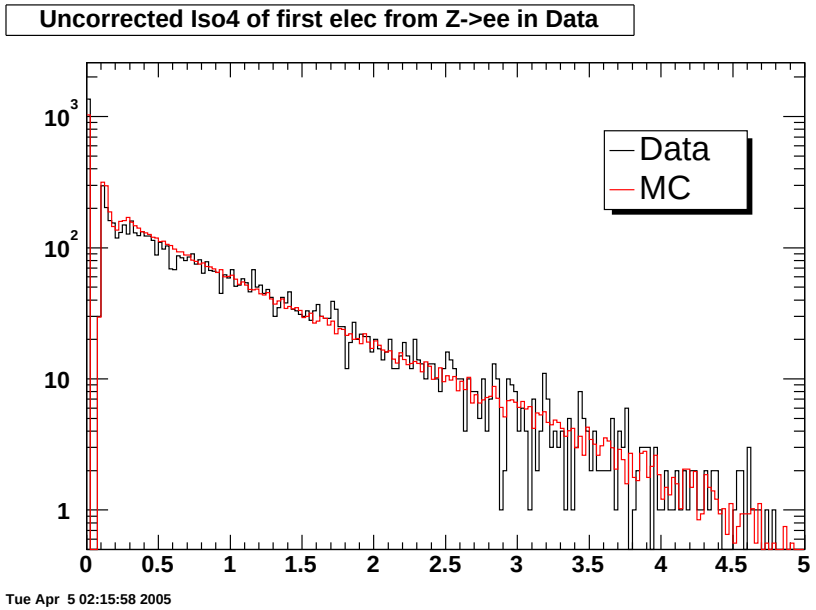

Figure 3: Uncorrected Isolation in a cone of 0.4 from $Z \rightarrow ee$

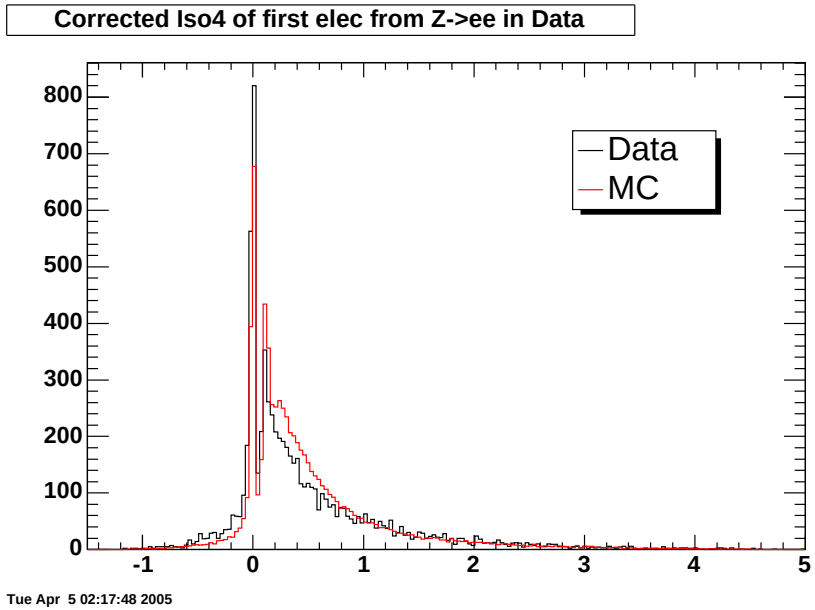

Figure 4: Corrected Isolation in a cone of 0.4 from $Z \rightarrow ee$

CES-Track Matching in Central-Central $Z \rightarrow ee$

- For completeness, these are the $\Delta X(CES - Track)$ and $\Delta Z(CES - Track)$ variables.
- This is apparently due to wrong calibrations in the data.

CES-Track Matching in Central-Central $Z \rightarrow ee$

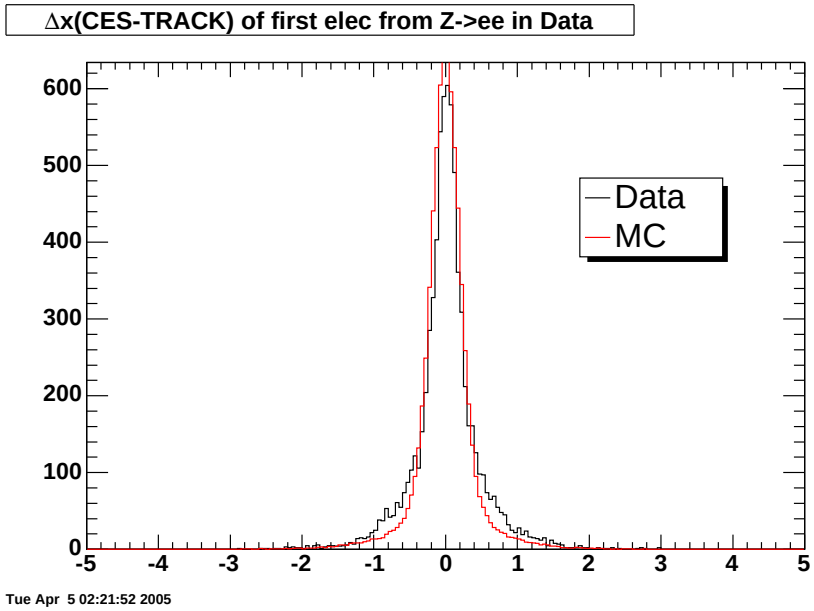

Figure 5: $\Delta(XCES - Track)$ in $Z \rightarrow ee$ events

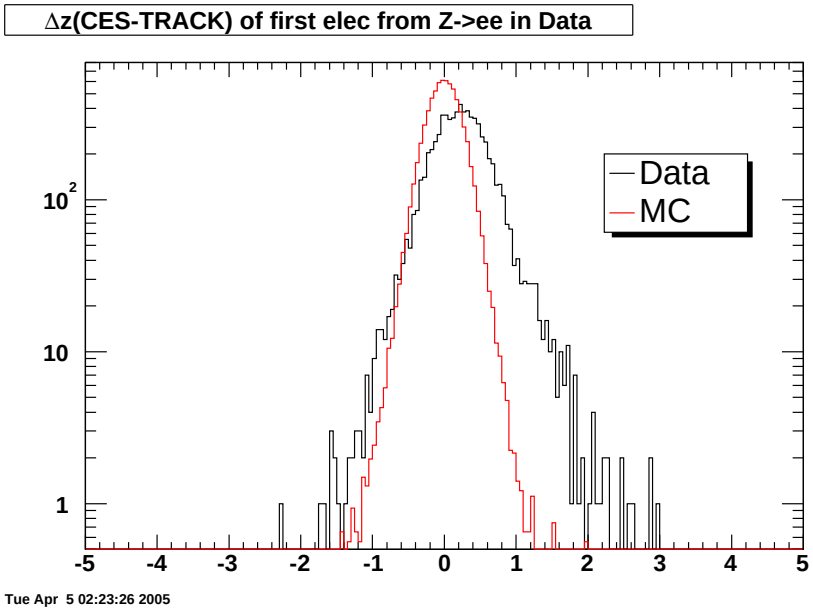

Figure 6: $\Delta(ZCES - Track)$ in $Z \rightarrow ee$ events

Central-Central $Z \rightarrow ee$ (Analysis Cuts)

- Move on to our analysis cuts:
  - 'Or' of the likelihood and standard cuts
  - One electron tight central with $\mathrm{E_T} > 20$ GeV.
  - The other tight or loose central with $\mathrm{E_T} > 12$ GeV.
  - No fidele requirement
  - No requirement on M_{ee}
  - Opposite Sign
- Numbers:

# of MC events	# Predicted in Data	# Seen in Data
120252	11232	11666

Central-Central $Z \rightarrow ee$ (Analysis Cuts)

- Maybe we know what we're doing:

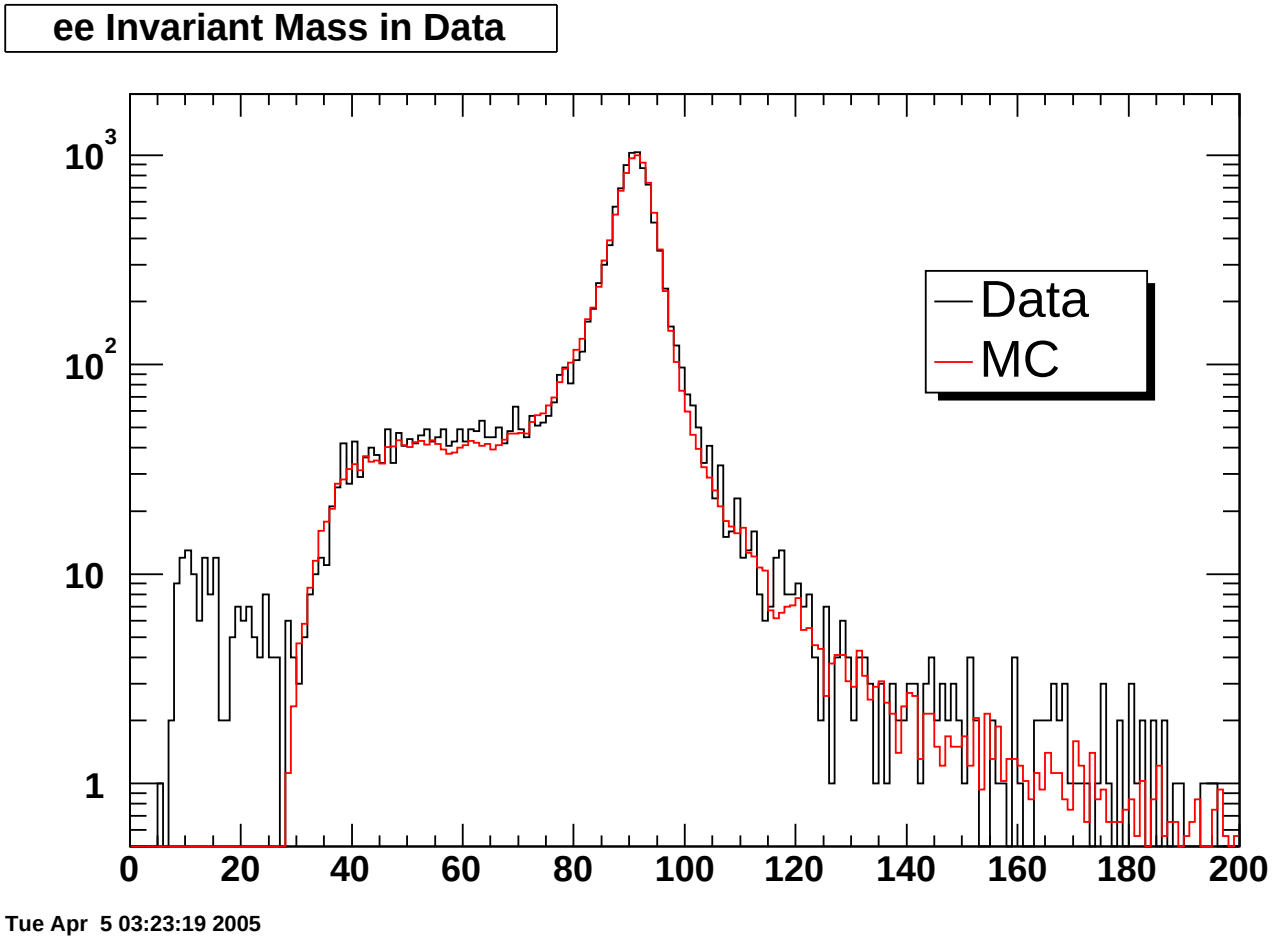

Figure 7: Invariant Mass of e^+e^- events.

Central-Central $Z \rightarrow ee$ (Analysis Cuts)

- But then again...

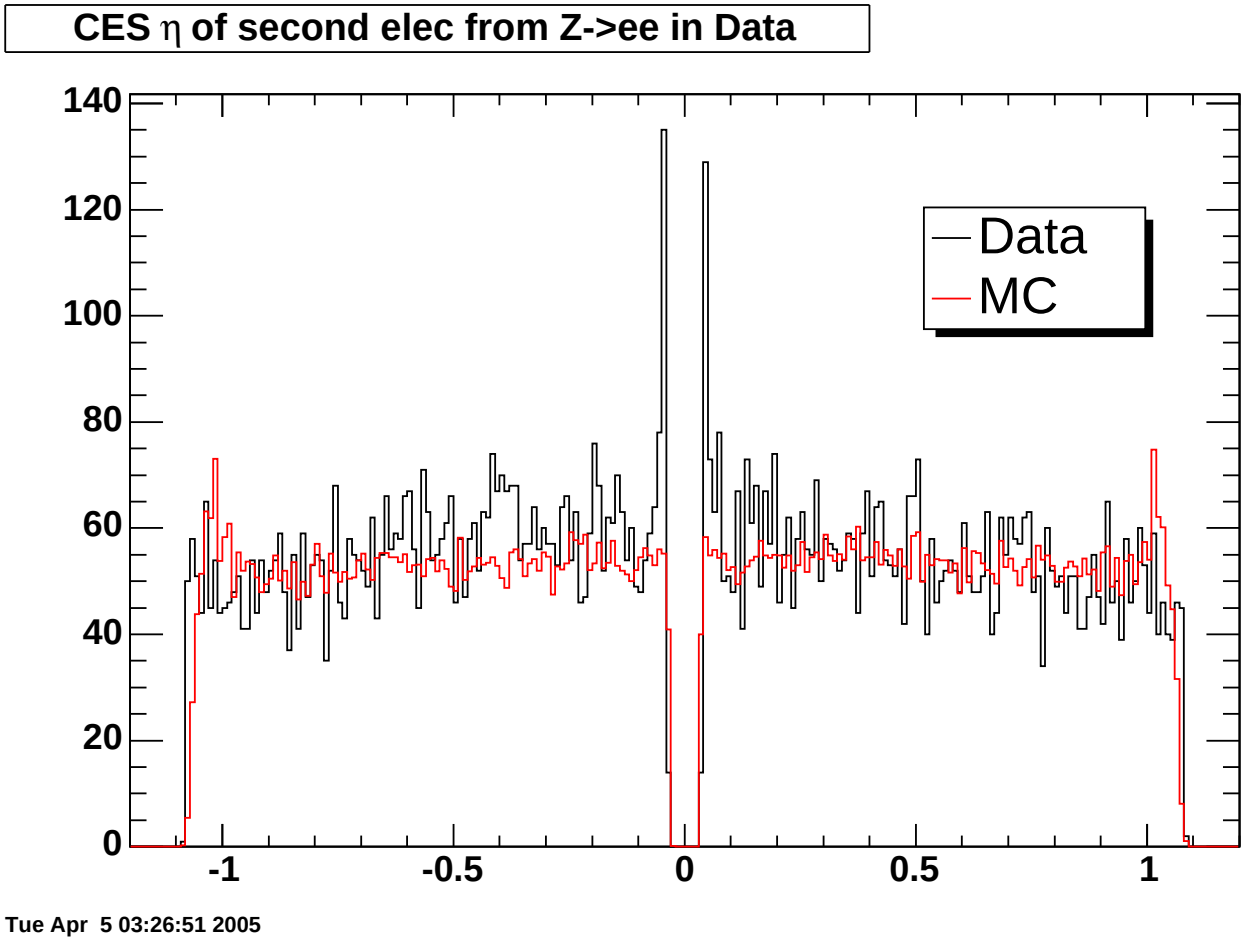

Figure 8: Ces η of electrons from $Z \rightarrow ee$

Central-Plug $Z \rightarrow ee$

- As a sanity check, require the following:
  - Standard Cuts
  - One electron tight central; the other loose plug.
  - fidele==1 for central e
  - $\mathrm{E_T} > 20$ GeV for both e's
  - 66 GeV$< M_{ee} <$ 116 GeV
  - Opposite Sign
- Numbers:

# of MC events	# Predicted in Data	# Seen in Data
109311	9215	8902

Central-Plug $Z \rightarrow ee$

- While the numbers work out ok, most plug ID variables in MC do not match the data.
- I've been told that the PES Profile variables match better in 6.1.

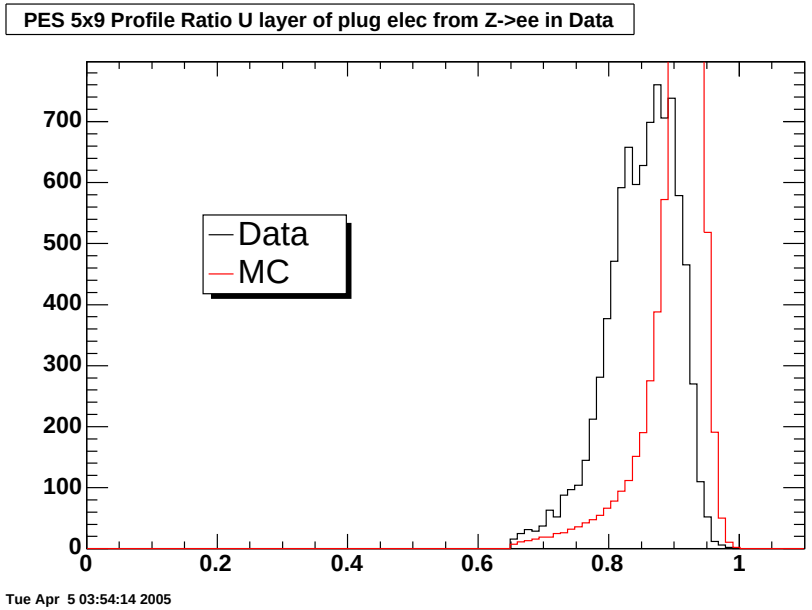

Figure 9: PES 5x9 U in $Z \rightarrow ee$ events

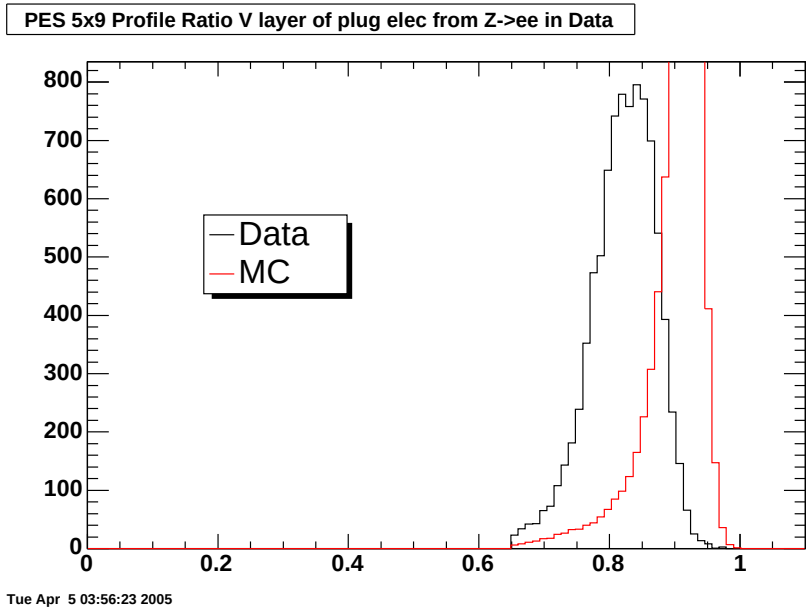

Figure 10: PES 5x9 V in $Z \rightarrow ee$ events

Central-Plug $Z \rightarrow ee$

- PEM 3x3 χ^2 gotten by:
  $emObject.matchingEmCluster() -> pem3x3Chisq()$

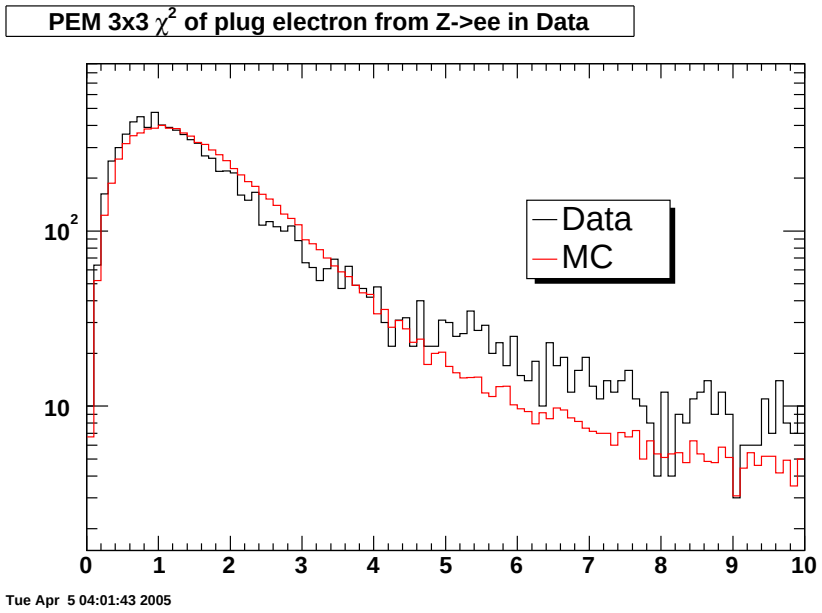

Figure 11: PEM 3x3 χ^2 in $Z \rightarrow ee$ events

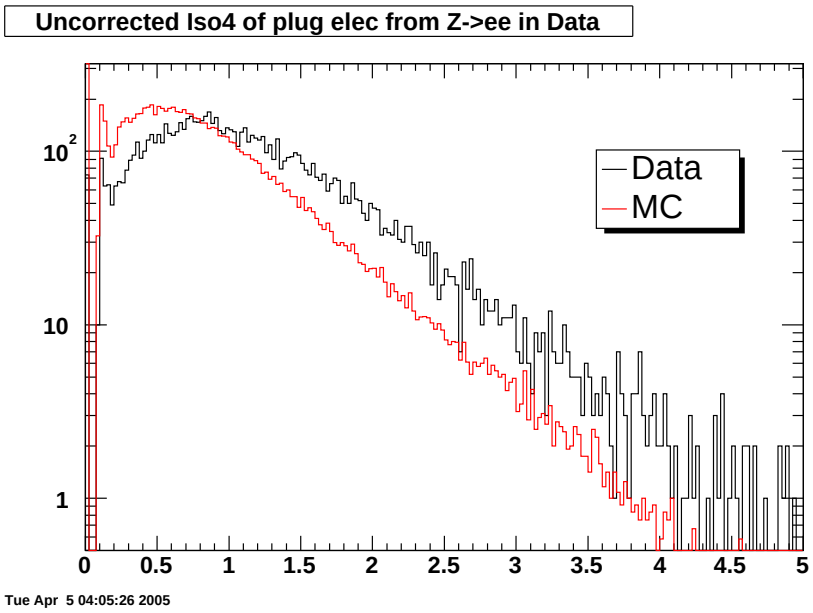

Figure 12: Isolation in Plug in $Z \rightarrow ee$ events