
# Current status of $Z \rightarrow e^+e^-$ analysis

Kalanand Mishra

*Fermilab*

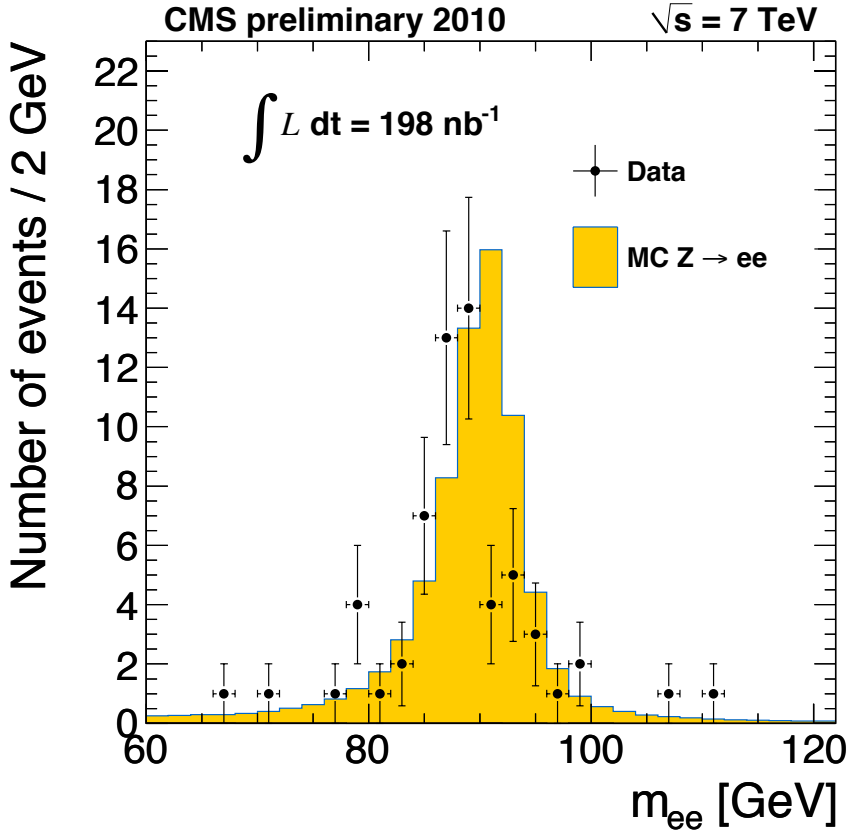
*on behalf of **Z Signal Extraction** team*:

D Bandurin, J Berger, C Broutin, Y Chung, A De Cosa, F Fabozzi, M De Gruttola, V Halyo, J Han, N Heracleous, O Hindrichs, I Kravchenko, C Lazaridis, L Lista, M Makouski, K Mishra, P Paganini, D Piccolo, D Piparo, R Rodrigues, Y Roh, A Schorlemmer, K Sung, J Werner, S Xie, A Zabi, M Zeise

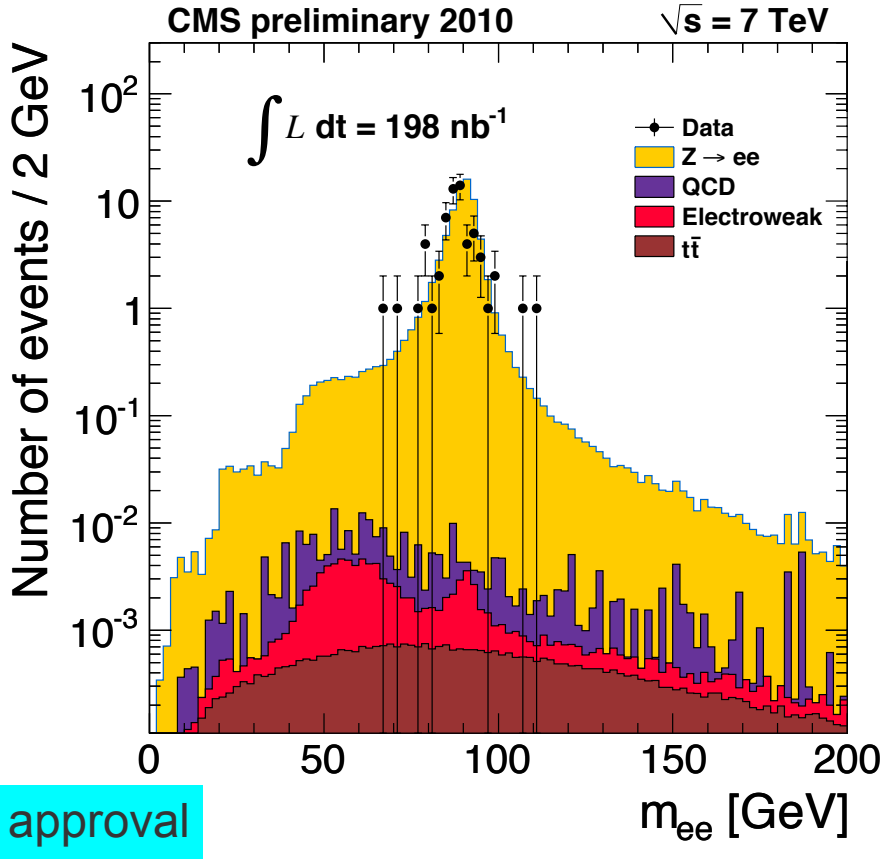
*Electroweak special meeting*

(July 19, 2010)

# Z→ee snapshot for ICHEP: 198 nb$^{-1}$



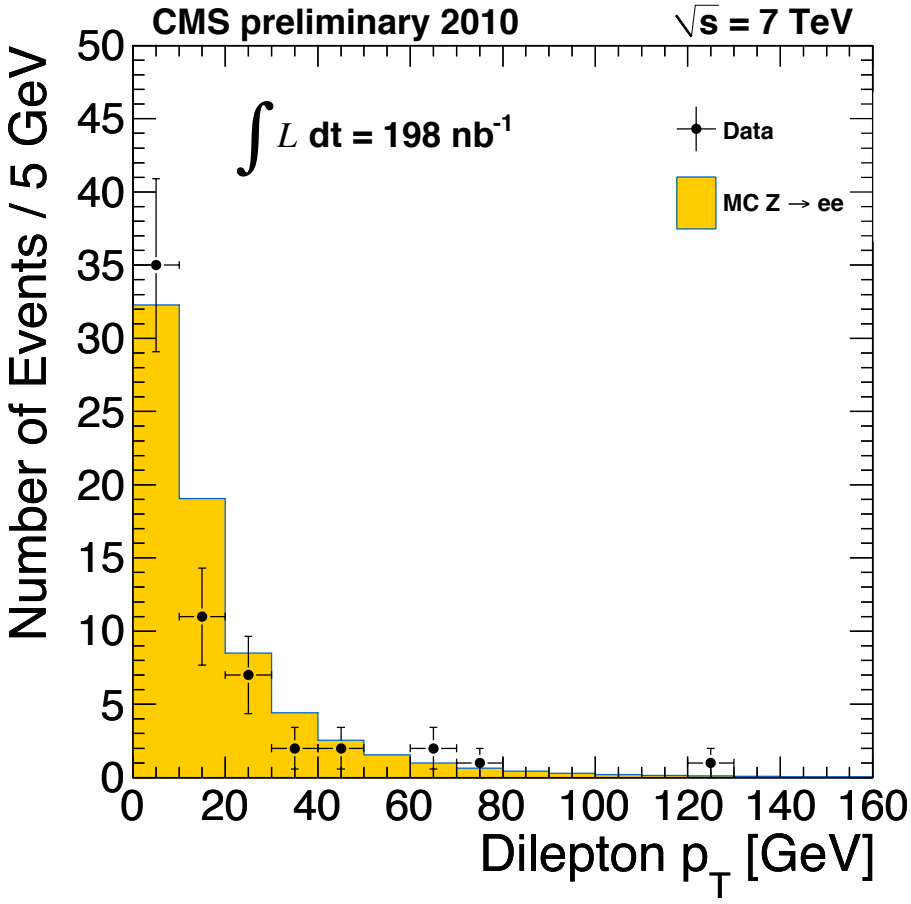

**Official count:**
- We have 61 golden Z→ee candidates.
- 28 BB, 30 BE, 3 EE combinations.
- Posted the list on VBTF hypernews.

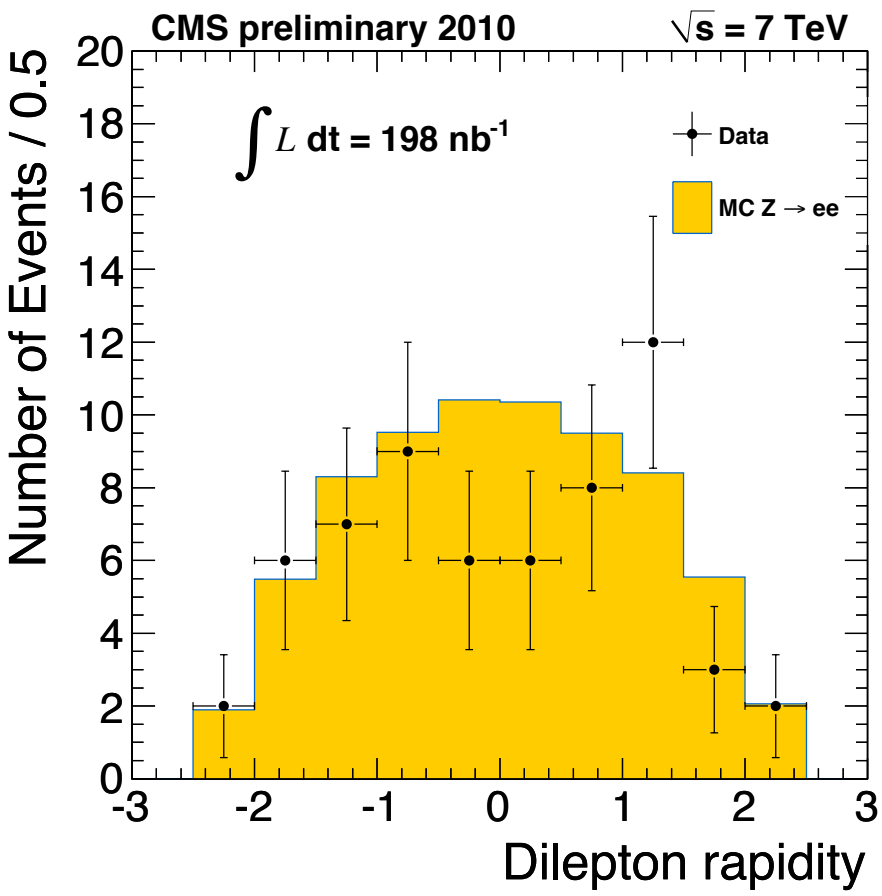



Expect about 50% BB, 40% BE, and 10% EE events. So far more or less consistent with the expectation.

These plots will go for ICHEP approval

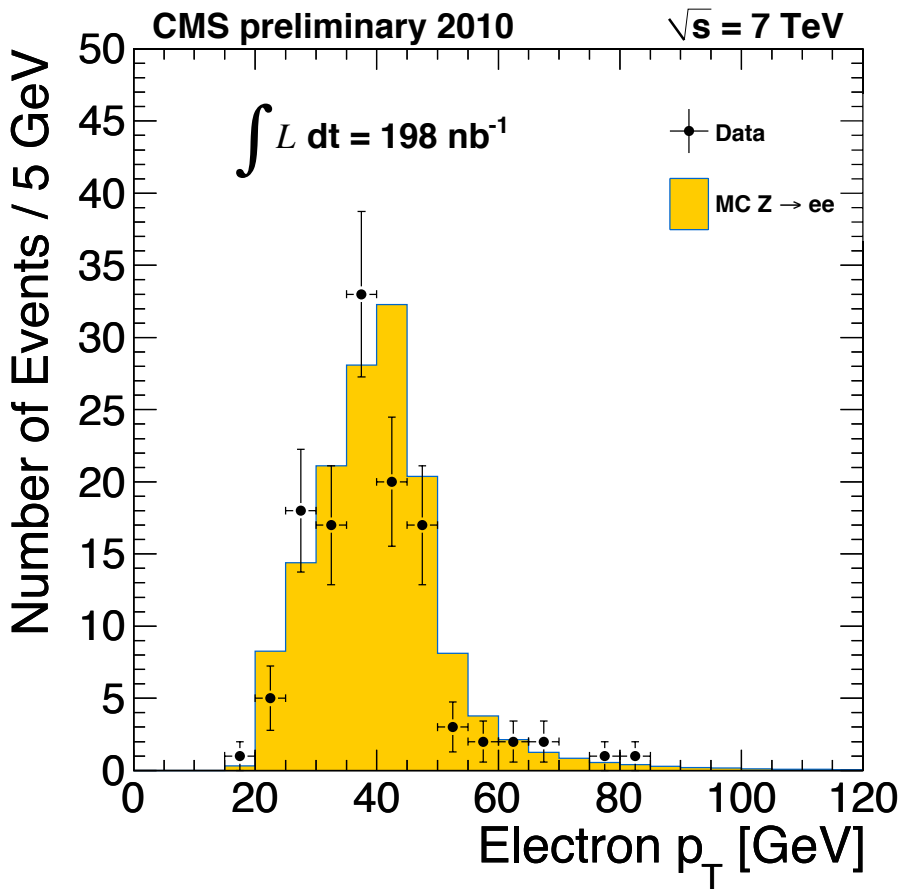
# Z $p_T$ and rapidity

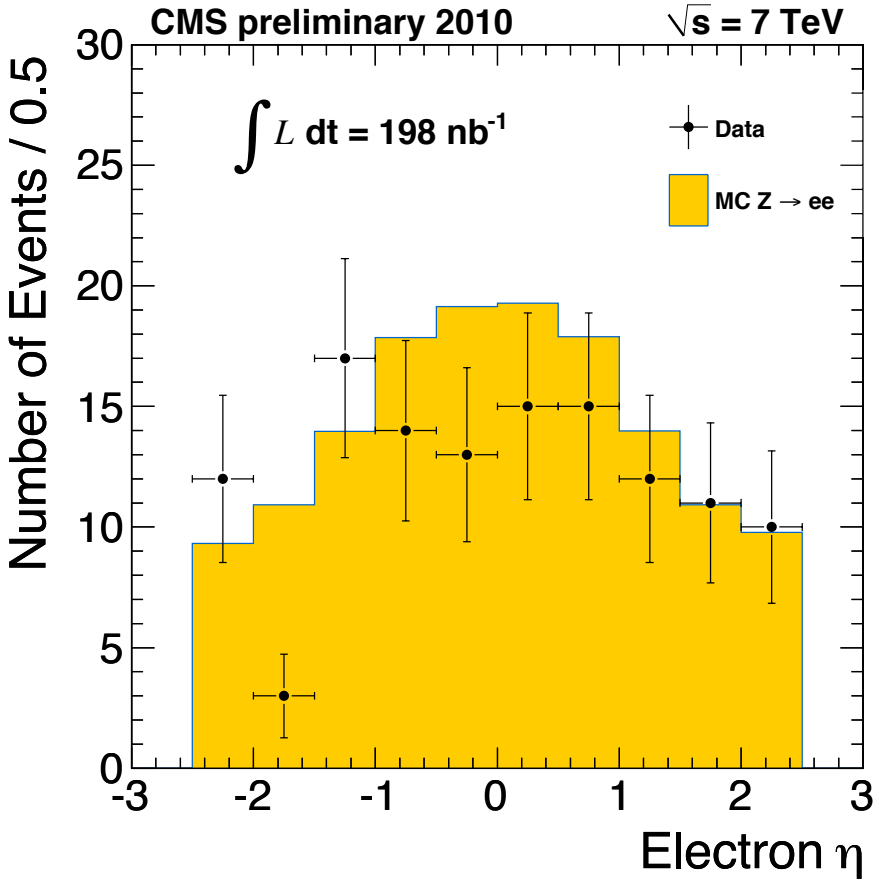



Both distributions look very similar to NLO prediction.

# Electron $P_T$ and rapidity

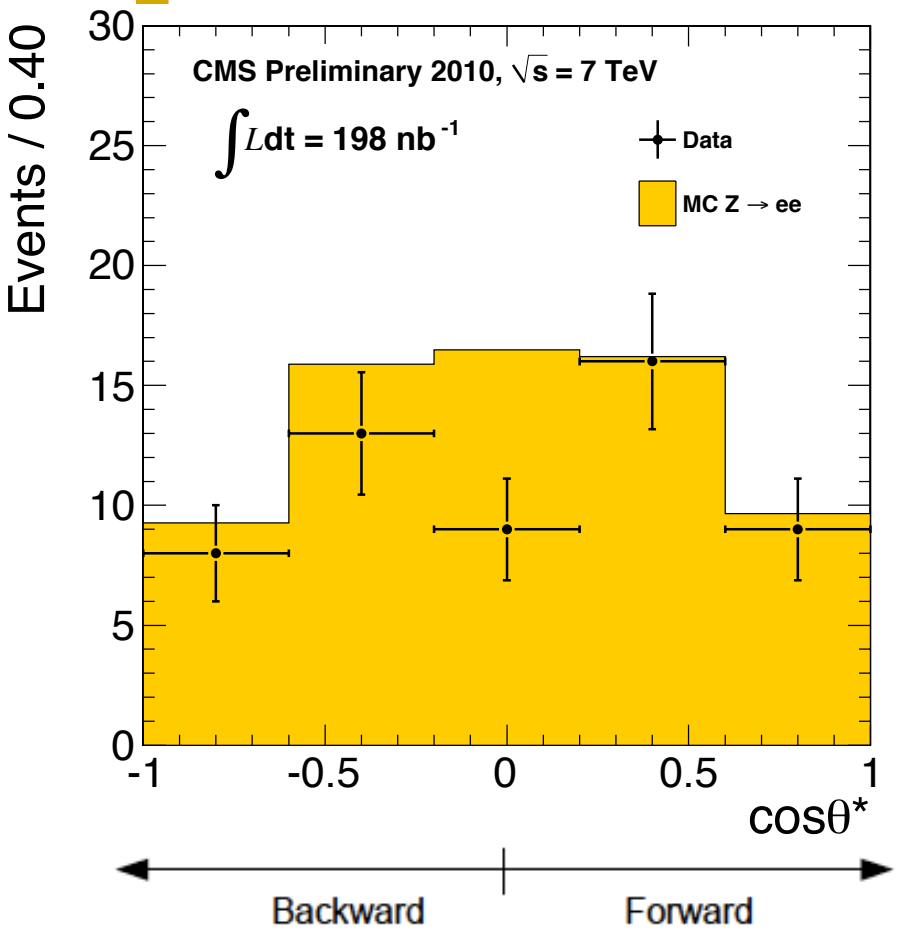


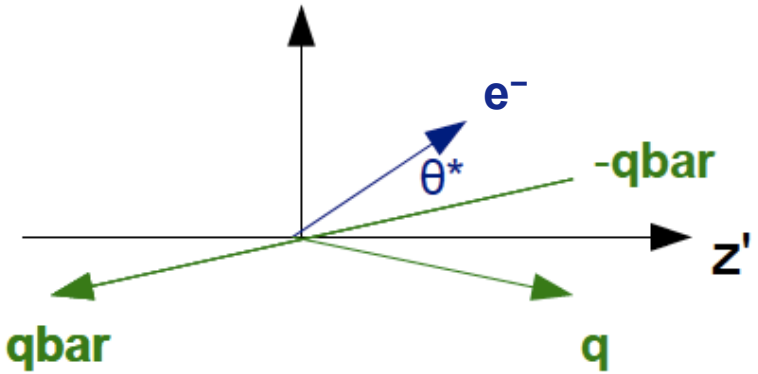

We have a 82 GeV electron now from Z decay.

No deficit in the endcaps.

# Z production topology: cosine θ*



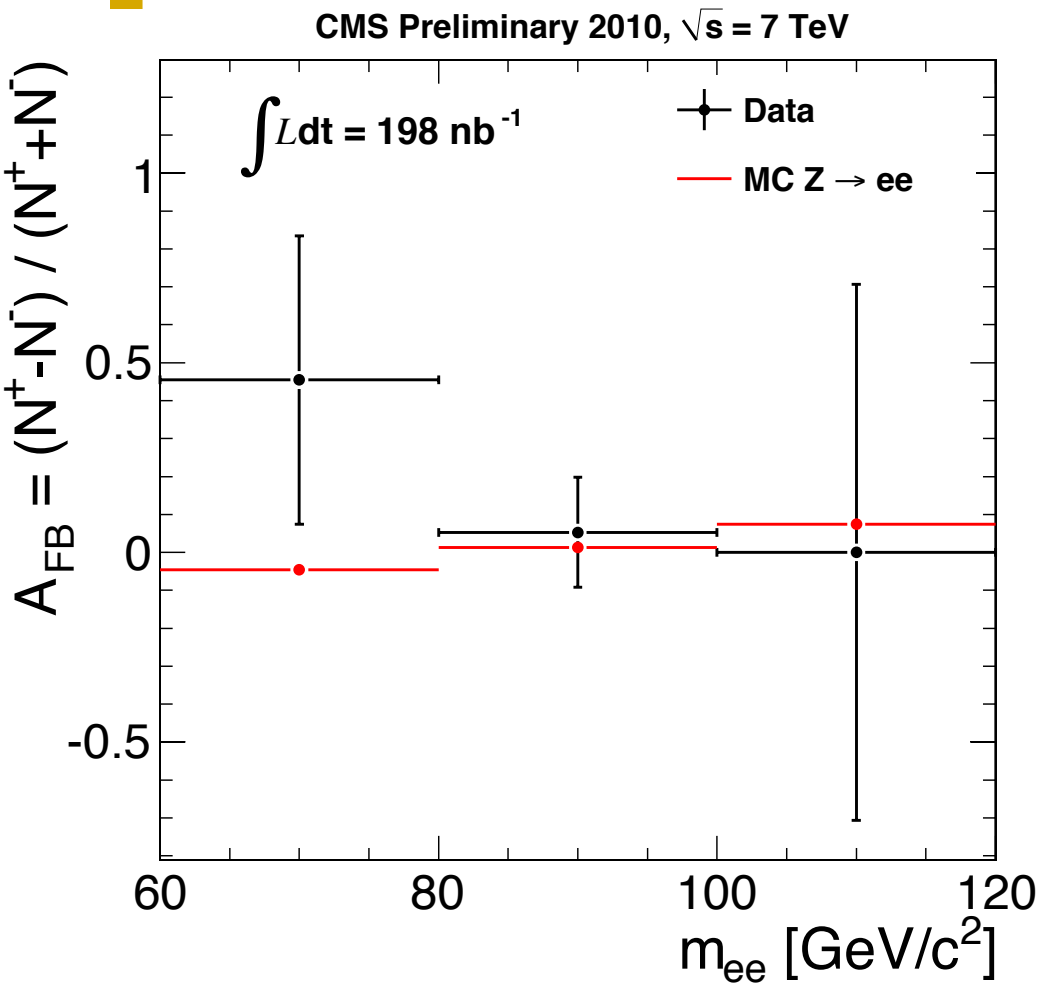

**Collins–Soper frame**




θ* is the angle between the electron momenta and the z' axis that bisects the angle between **q** and **−qbar**.

*J.C. Collins and D.E. Soper, Phys. Rev. D 16, 2219 (1977)*

# Z forward–backward asymmetry




- **Forward** events (cosΘ*>0)
- **Backward** events (cosΘ*<0)

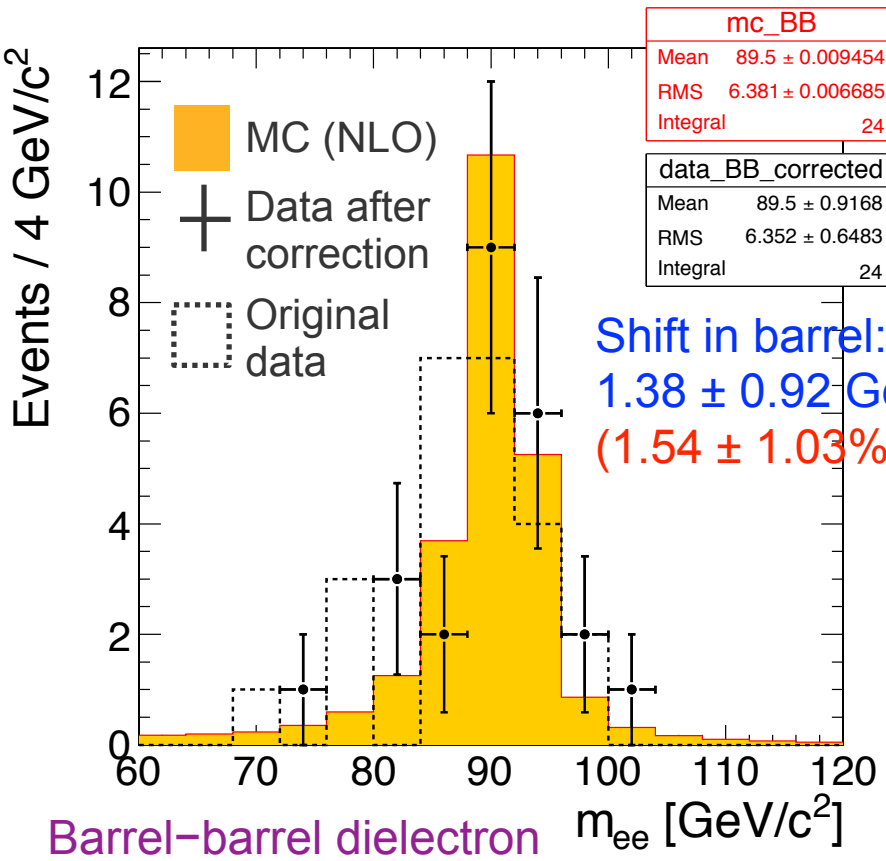
For each Z mass bin, we compute the asymmetry given by

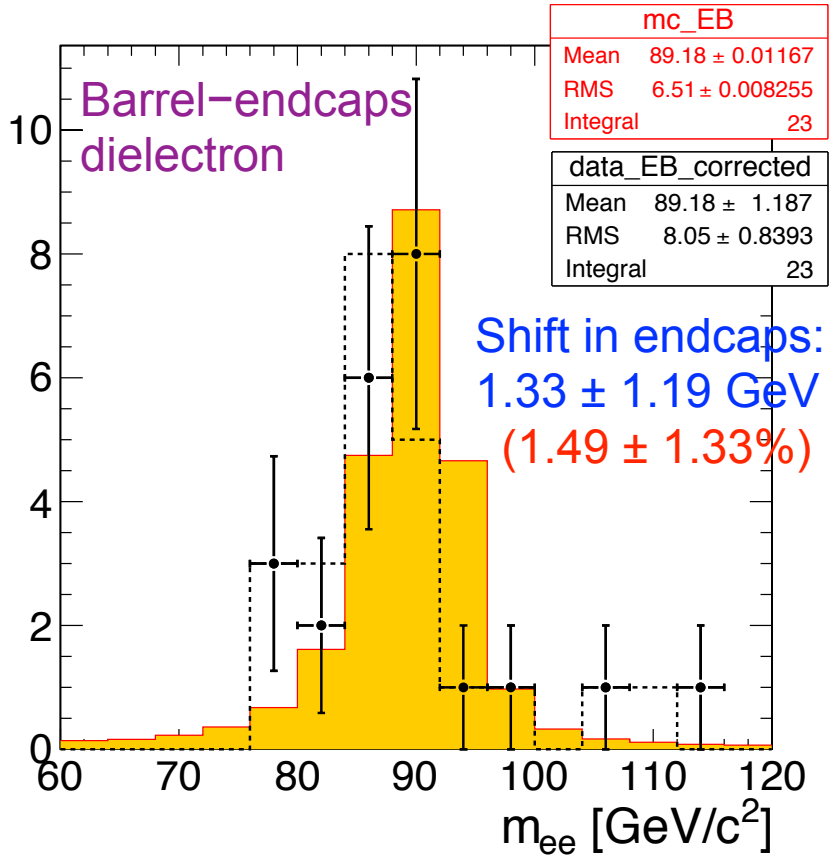
$$A_{fb} = \frac{(N_f - N_b)}{(N_f + N_b)}$$

Observed asymmetry is consistent with NLO predictions.

# Z mass shift scan: from naive attempt

- Start with the WP95+WP95 invariant mass distribution in data
- Iteratively scale up each electron energy until agreement with MC is reached
- Find energy shift of 1.54 ± 1.03% in barrel and 1.49 ± 1.33% in endcaps.



# Z→ee cross section using ∫L = 198 nb$^{-1}$

| | |
|---|---|
| $N_{selected}$ | 61 ± 7.81 |
| $N_{bkgd}$ | 0.73 ± 0.13 |
| $\varepsilon$ | 0.8671 ± 0.0023 (MC stat.) ± 0.0867 (syst.) % |
| Acceptance | 0.4357 ± 0.0010 (MC stat.) ± 0.0131 (syst.) % |
| Integrated Luminosity | 0.198 ± 0.022 $pb^{-1}$ (syst.) |
| $\sigma_{\gamma^*Z} \times BR(\gamma^*Z \to e^+e^-)$ | 805.7 ± 104.4 (stat.) + 47.0 (syst.) + 88.6 (lumi.) |
| Theoretical prediction | LO: 740 pb, NLO: 911 pb ($60 < m_Z < 120$ GeV)<br>LO: 1300 pb ($m_Z > 20$ GeV), NLO: 1607 pb ($m_Z > 20$ GeV) |

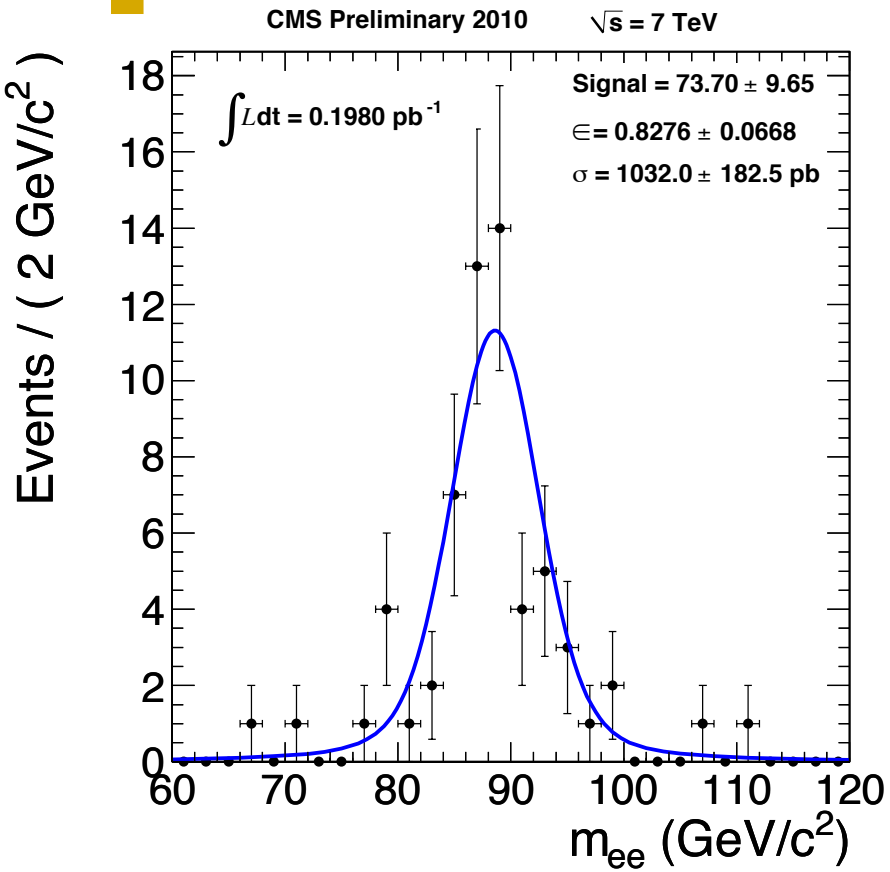
Acceptance = 44%
Efficiency = 87 %
Cross section = 806 ± 104 pb
NLO prediction = 911 pb

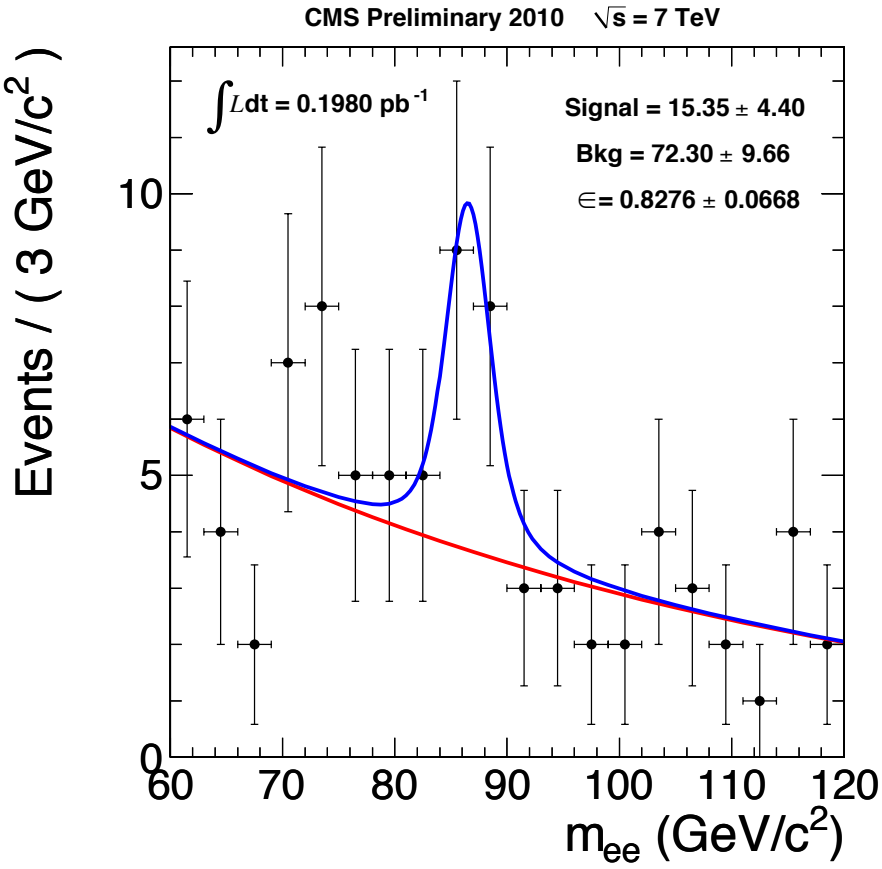
from MC

our result

This is our default method up to this point. Alternative method on next slide.

# Simultaneous fit for cross section & efficiency




The result of the fit gives cross section and electron (reconstruction⊗identification) efficiency directly from data.

# Simultaneous fit results

| Parameter | Value | +HiError,-LoError |
|---|---|---|
| 1 Mean | 88.60 | +0.63, -0.64 |
| 2 Mean TF | 86.53 | +1.15, -1.39 |
| 3 Resolution | 3.36 | +0.86, -0.97 |
| 4 Resolution TF | 1.41 | +1.65, -0.00 |
| 5 TF Bkg Expo | -0.018 | +0.007, -0.007 |
| 6 Efficiency | 0.828 | +0.066, -0.069 |
| 7 TF nBkg | 72.3 | +10.0, -9.3 |
| 8 Cross section | 1009.0 | +201, -171 |

Z line shape parametrized using Breit Wigner times a Gaussian resolution function. The high purity sample is background free, we subtract the residual tiny background posteriori.

87 % in MC

806 ± 104 ± 47 from normal method

**Correlation matrix**

| NO. | GLOBAL | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.58623 | 1.000 | -0.000 | 0.586 | 0.000 | -0.000 | -0.000 | -0.000 | 0.000 |
| 2 | 0.15413 | -0.000 | 1.000 | -0.000 | -0.137 | -0.065 | 0.051 | 0.032 | -0.047 |
| 3 | 0.58623 | 0.586 | -0.000 | 1.000 | 0.000 | -0.000 | -0.000 | -0.000 | 0.000 |
| 4 | 0.25365 | 0.000 | -0.137 | 0.000 | 1.000 | -0.000 | -0.206 | -0.129 | 0.189 |
| 5 | 0.07591 | -0.000 | -0.065 | -0.000 | -0.000 | 1.000 | 0.033 | 0.020 | -0.030 |
| 6 | 0.73722 | -0.000 | 0.051 | -0.000 | -0.206 | 0.033 | 1.000 | 0.361 | -0.723 |
| 7 | 0.37794 | -0.000 | 0.032 | -0.000 | -0.129 | 0.020 | 0.361 | 1.000 | -0.331 |
| 8 | 0.72793 | 0.000 | -0.047 | 0.000 | 0.189 | -0.030 | -0.723 | -0.331 | 1.000 |

# Electron efficiency from tag & probe in Z→ee

## Tag Selection

- GsfElectrons.
- Super cluster within |η| acceptance
- $E_T$ > 20 GeV
- Isolation and Id cuts as in WP95

## Probe Selection

- $E_T$ > 20 GeV, |η| in acceptance
- Fit the tag-probe invariant mass to get the number of signal events.

Obtain factorized efficiencies for passing probes:

SuperCluster → GsfElectron → WP-95/WP80 → HLT

offline electron reconstruction efficiency with respect to acceptance

trigger efficiency w.r.t. offline selection

**Compute each efficiency by performing simultaneous fit to passing and failing samples. The result of the fit gives efficiency and total # events.**

# Data driven electron reco efficiency from Z


**super cluster → gsfElectron**

| | Eff | $\sigma_{stat}$ | $N_{pass}$ | $N_{fail}$ | MC |
|---|---|---|---|---|---|
| Total | 98.4 | 1.8 | 97.3 | 1.6 | 98.6 |
| Barrel | 98.6 | 2.1 | 71.0 | 1.0 | 99.1 |
| Endcap | 97.0 | 3.9 | 32.2 | 1.0 | 97.4 |
| e− | 97.0 | 3.2 | 51.1 | 1.6 | 98.6 |
| e+ | 100.0 | 3.1 | 46.9 | 0.0 | 98.6 |
| $e^-$ EB | 97.7 | 2.3 | 41.8 | 1.0 | 99.1 |
| $e^+$ EB | 100.0 | 2.4 | 33.6 | 0.0 | 99.1 |
| $e^-$ EE | 94.7 | 5.1 | 17.8 | 1.0 | 97.4 |
| $e^+$ EE | 100.0 | 3.3 | 14.9 | 0.0 | 97.5 |
| EE+ | 100.0 | 4.8 | 20.7 | 0.0 | 97.9 |
| EE− | 90.7 | 8.6 | 9.8 | 1.0 | 96.8 |

**gsfElectron → WP 95**

| Eff | $\sigma_{stat}$ | $N_{pass}$ | $N_{fail}$ | MC |
|---|---|---|---|---|
| 95.1 | 3.0 | 92.8 | 4.9 | 95.2 |
| 96.8 | 3.2 | 68.4 | 2.3 | 95.6 |
| 88.5 | 6.1 | 31.0 | 4.0 | 94.2 |
| 99.0 | 3.6 | 51.1 | 0.5 | 95.2 |
| 90.8 | 4.0 | 42.3 | 4.3 | 95.2 |
| 97.4 | 4.0 | 37.8 | 1.0 | 95.6 |
| 94.2 | 4.2 | 34.8 | 2.1 | 95.6 |
| 92.8 | 9.0 | 17.0 | 1.3 | 94.3 |
| 86.4 | 8.8 | 12.7 | 2.0 | 94.2 |
| 89.6 | 7.9 | 20.6 | 2.4 | 94.2 |
| 87.0 | 8.2 | 8.7 | 1.3 | 94.2 |

- The reconstruction efficiency is close to 100%.
- Working Point 95 selection is about 95% efficient.
- Efficiencies in data and MC agree with each other within a few percent.

# Data driven electron HLT efficiency from Z

**WP 95 → HLT Photon-15**

| | Eff | $\sigma_{stat}$ | $N_{pass}$ | $N_{fail}$ | MC |
|---|---|---|---|---|---|
| Total | 98.6 | 1.4 | 70.1 | 1 | 98.6 |
| Barrel | 98.0 | 1.9 | 50.1 | 1 | 99.1 |
| Endcap | 100.0 | 2.1 | 23.6 | 0 | 97.4 |
| e− | 100.0 | 1.4 | 35.1 | 0 | 98.6 |
| e+ | 97.2 | 2.7 | 35.1 | 1 | 98.6 |
| $e^-$ EB | 100.0 | 1.7 | 29.0 | 0 | 99.1 |
| $e^+$ EB | 96.4 | 3.5 | 26.7 | 1 | 99.1 |
| $e^-$ EE | 100.0 | 3.8 | 13.0 | 0 | 97.4 |
| $e^+$ EE | 100.0 | 4.1 | 11.9 | 0 | 97.5 |
| EE+ | 100.0 | 2.8 | 20.6 | 0 | 97.5 |
| EE− | 100.0 | 7.3 | 8.5 | 0 | 97.4 |

- Trigger efficiency is almost 100% both in data and in MC.
- There is no evidence of charge dependence of any of the efficiencies.
- A 5% systematic assignment for efficiency is adequate (I think).