Update on $Z \rightarrow e^+e^-$ analysis

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Fermilab

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

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VBTF meeting

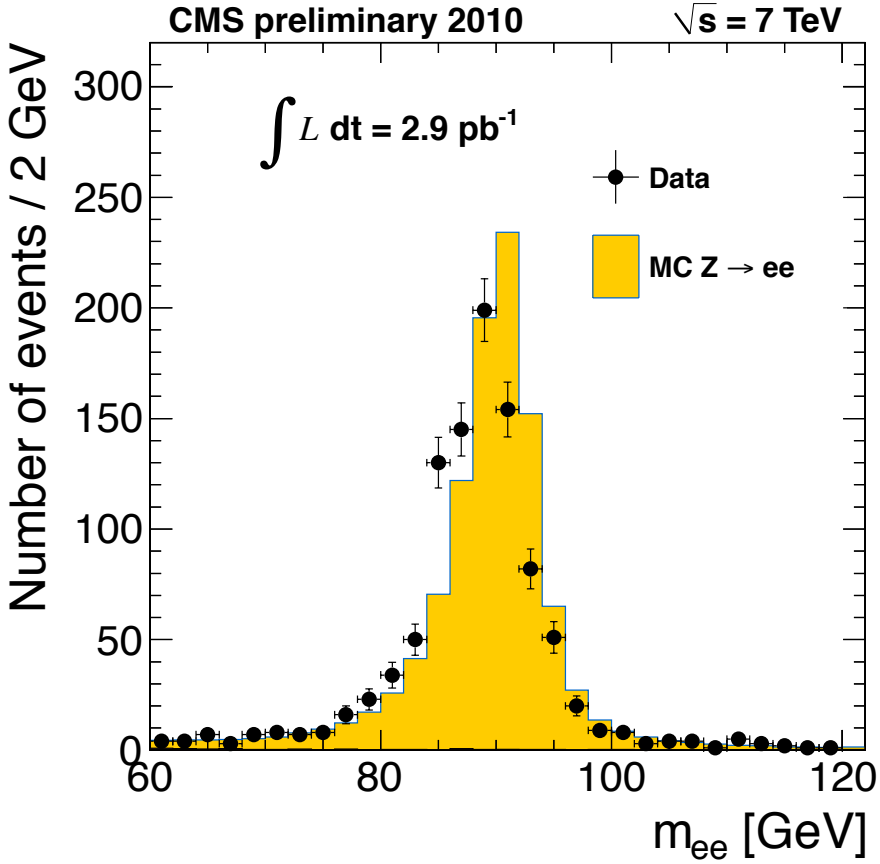
(Sept 10, 2010)

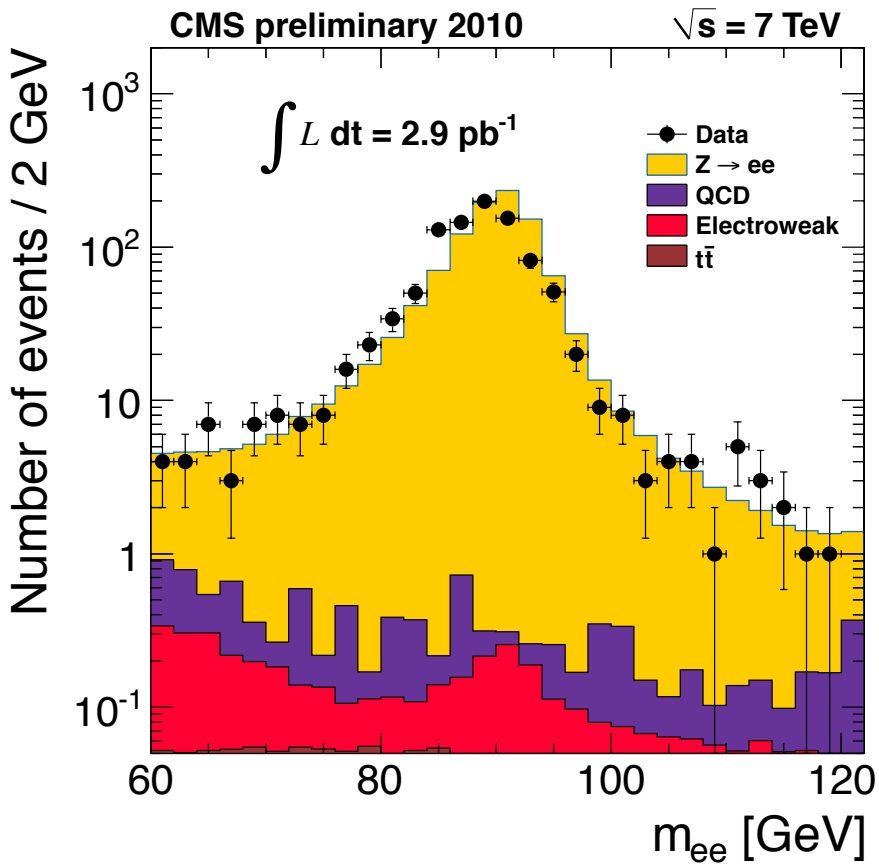
Overview

- PR plots with 2.9 pb^{-1} integrated luminosity (*i.e.*, last JSON)
- Cross section measurement update
- Status on specific topics:
  - Electron efficiency from tag & probe
  - A look at the 2.9 pb^{-1} data in CMSSW_3.8.2 preproduction

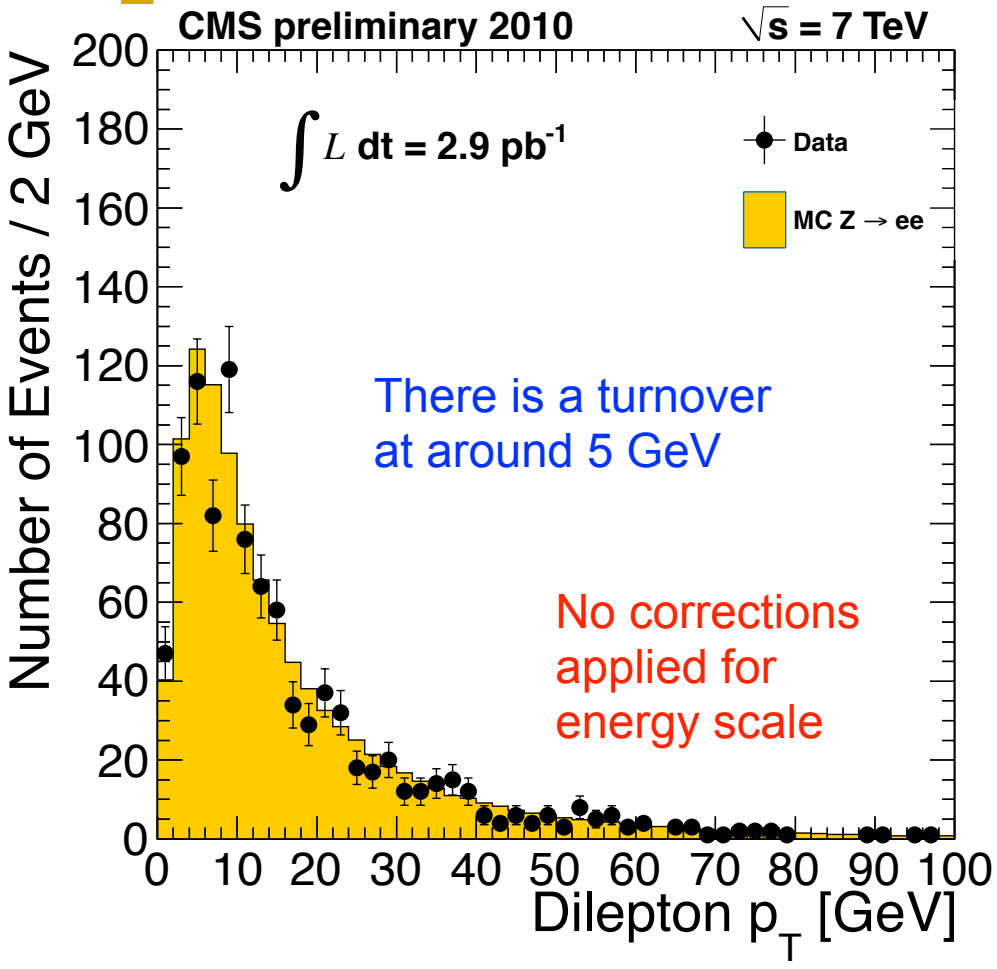
PR plots with 2.9 pb^{-1} data

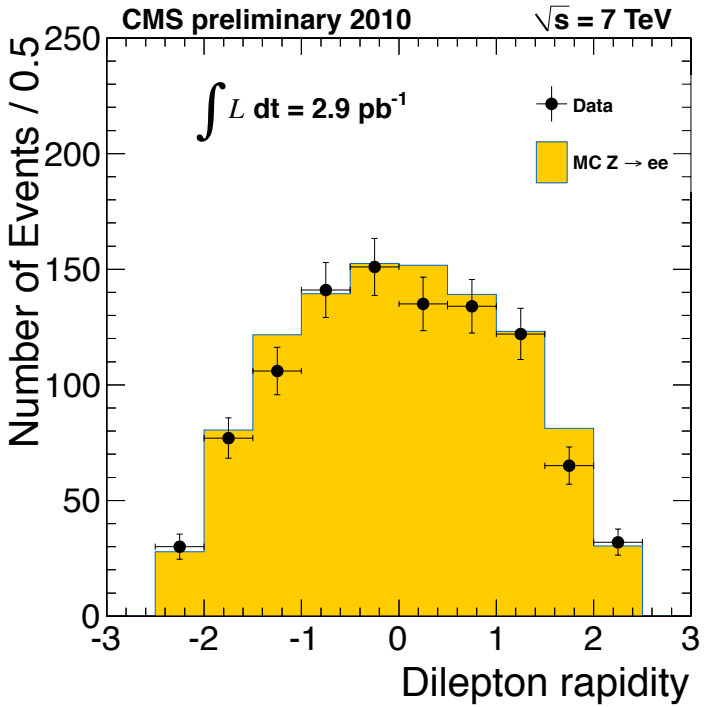
✦Have 993 golden Z→ee candidates.

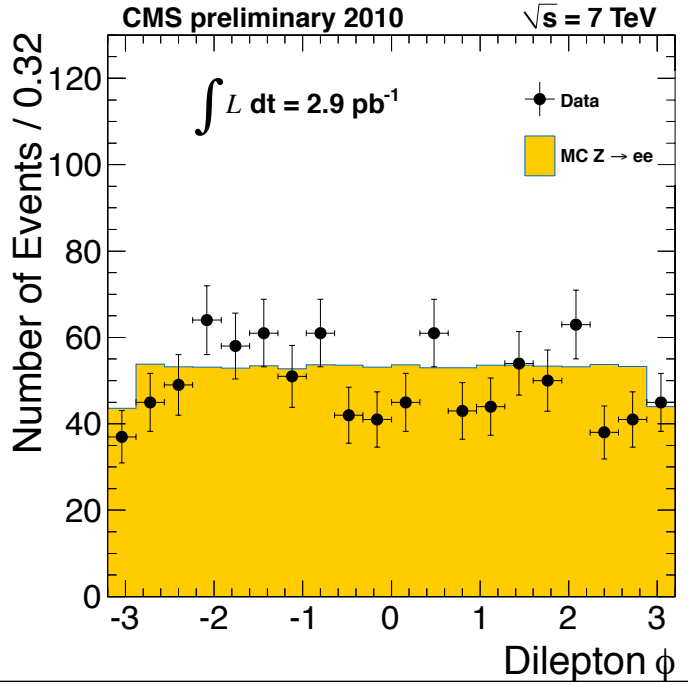




Z p_T, rapidity, azimuth

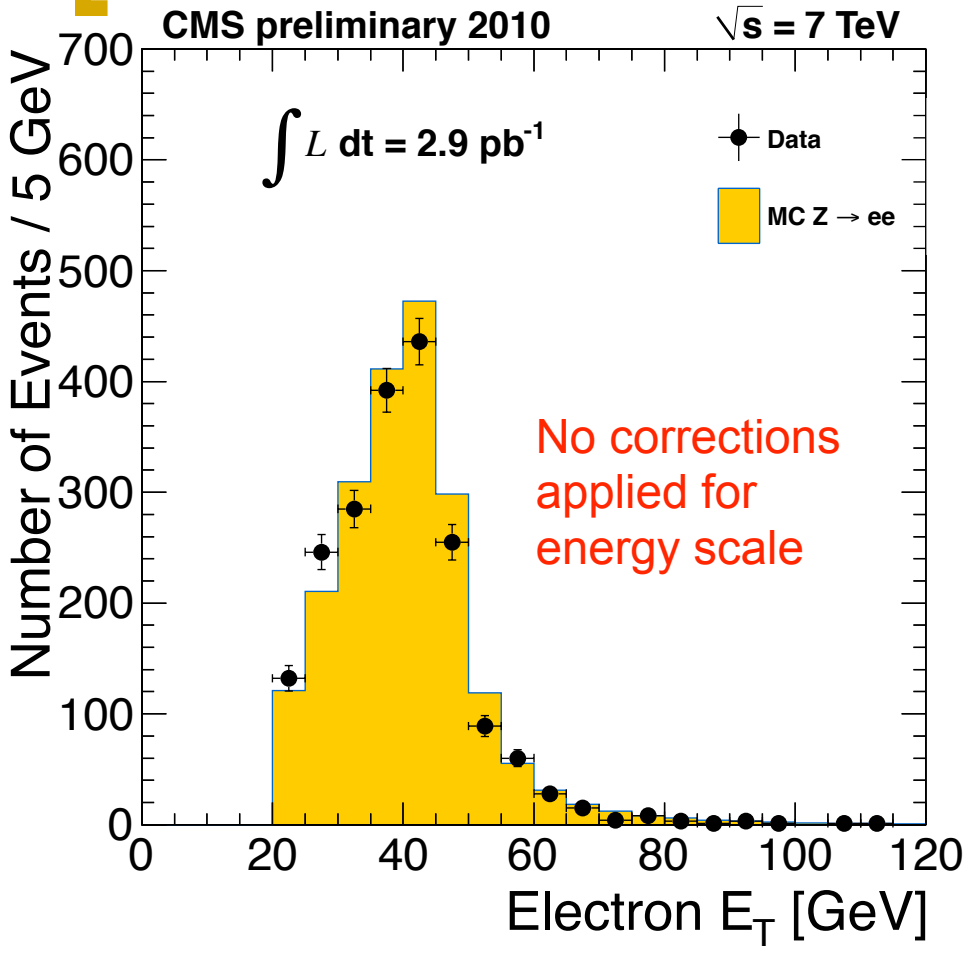


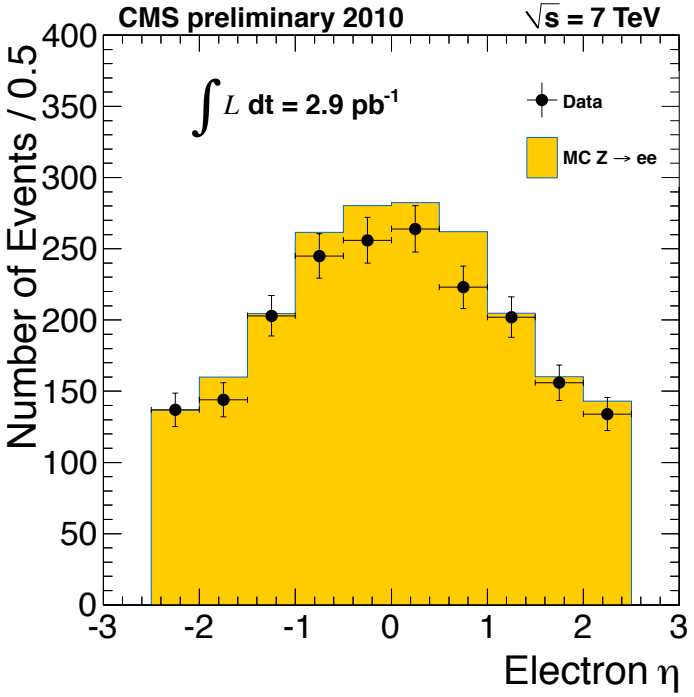


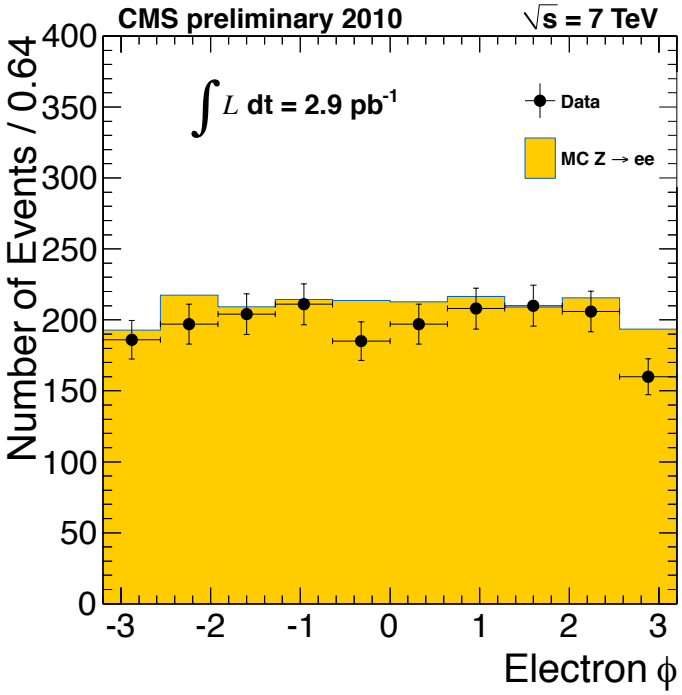


✦Distributions are in agreement with NLO predictions.

Electron P_T, rapidity, azimuth

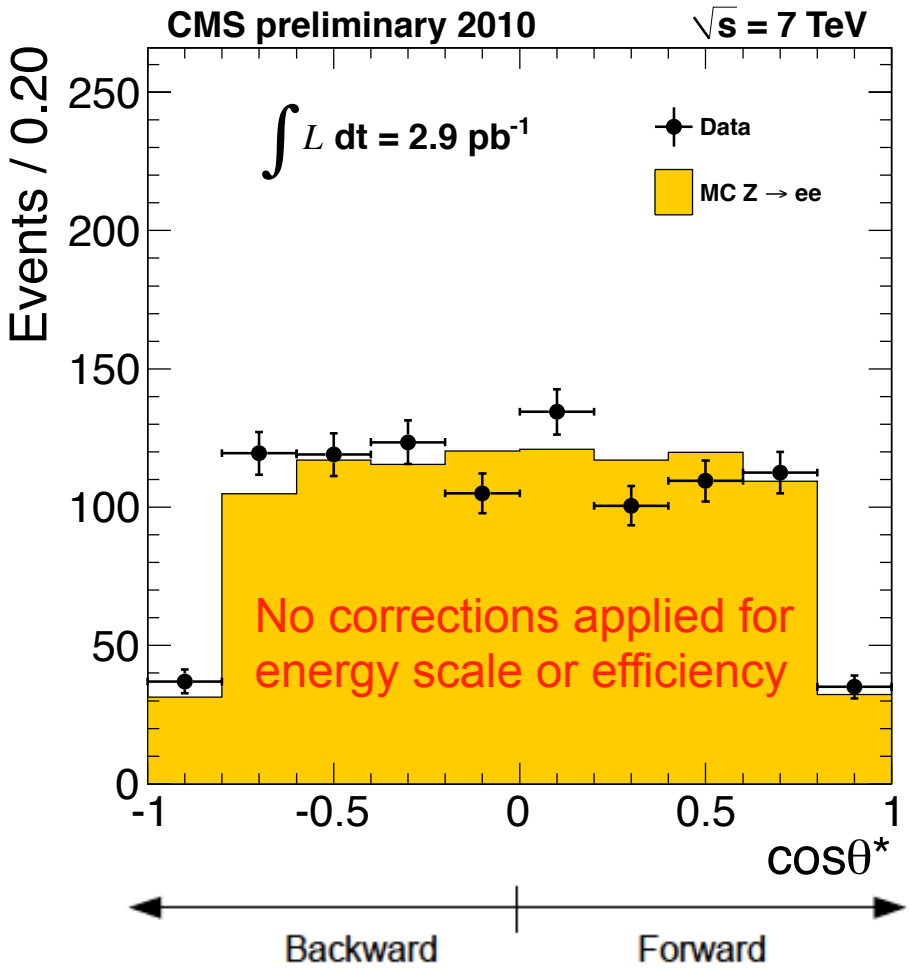




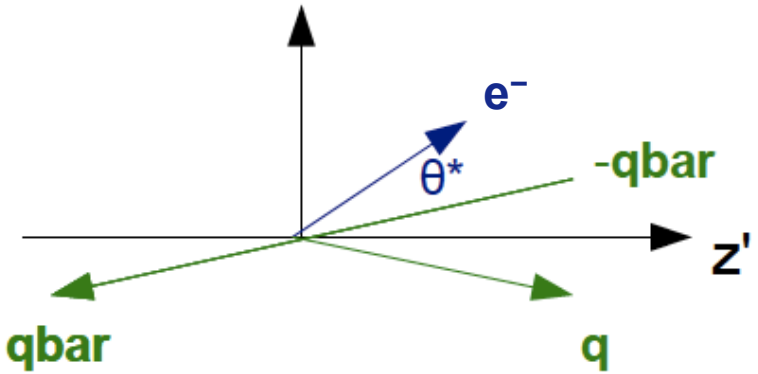


✦Distributions are in agreement with NLO predictions.

Z production topology: cosine θ*



Collins–Soper frame

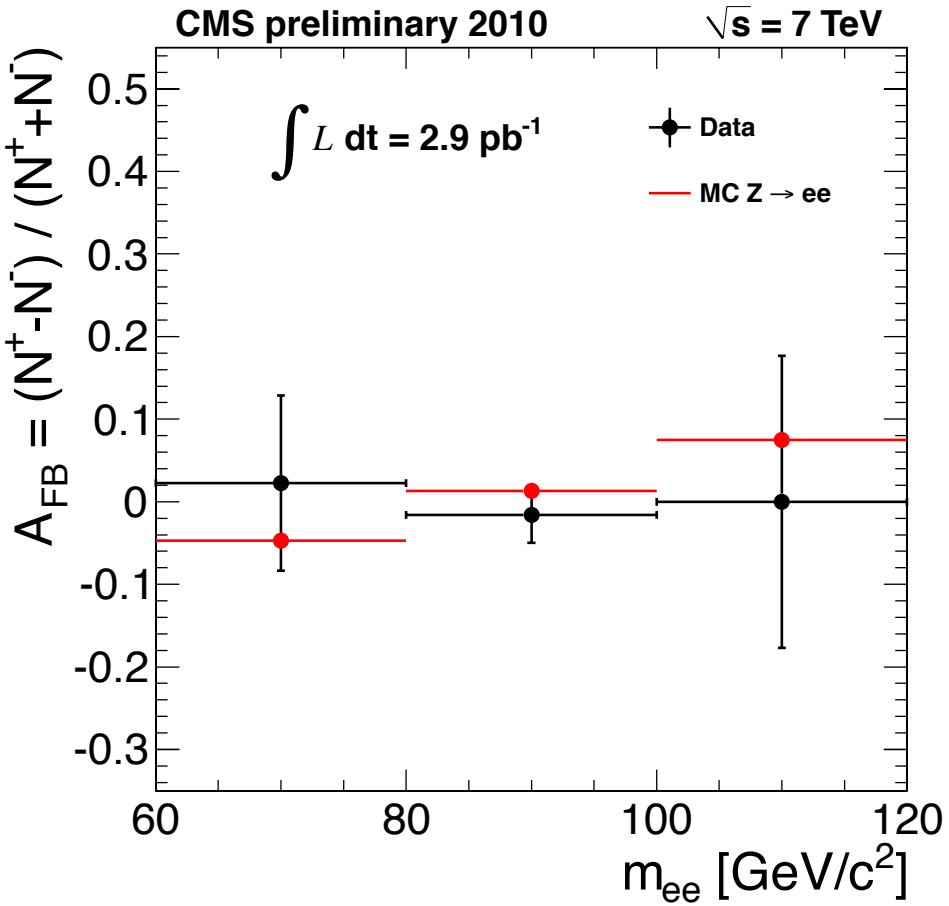


θ* is the angle between the electron momenta and the z' axis that bisects the angle between **q** and **−qbar**.

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

✦Good agreement with NLO prediction.

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→ee cross section using $\int L = 2.9\ pb^{-1}$

$N_{Selected}$ = 993 ± 31.5

$N_{Background}$ = 9.8 ± 11.8

Electron offline efficiency: from tag & probe

ε_{Reco}	=	1.0000 ± 0.0060 (stat)	± 0.0055 (syst)
$\varepsilon_{Reco \to WP95}$	=	0.9318 ± 0.0089 (stat)	± 0.0101 (syst)
$\varepsilon_{WP95 \to HLT}$	=	0.9895 ± 0.0026 (stat)	± 0.0131 (syst)

Work ongoing

includes syst due to signal and bkg shape, and energy scale

Dilepton efficiency = 0.8682 ± 0.0166 (stat) ± 0.0211 (syst)

Acceptance = 0.4357 ± 1.7% (theory) ± 1% (Energy scale) ← from MC

$\sigma_{\gamma^*/Z}$ x BR(Z→ee) = 902.5 ± 33.4 (stat) ± 30.2 (syst) ± 99.3 (lumi) pb

NLO prediction = 970 ± 20 pb, NNLO prediction = 972 ± 39 pb

Observed cross section is lower than prediction !

The only MC ingredient is acceptance.

Simultaneous fit for cross section & efficiency

Simultaneous fit to three samples: TT, TF(EBEB), TF(EBEE+EEEE)

1	bkg shape TF_BB	-0.033	+-	0.015	} Exponential bkg. shape for the two low purity samples
2	bkg shape TF_End	-0.025	+-	0.009	
3	eff_B	0.9639	+-	0.0143	Electron offline efficiency in the barrel and endcaps
4	eff_E	0.8936	+-	0.0334	
5	massShiftTF_BB	-0.309	+-	1.665	} Mass shifts due to electron energy scale
6	massShiftTF_End	-0.068	+-	0.014	
7	massShiftTT	-0.480	+-	0.102	
8	nBkgTF_BB	25.9	+-	8.1	} # background events in low purity sample
9	nBkgTF_End	56.3	+-	10.5	
10	resoTF_BB	2.59	+-	3.58	} Gaussian resolution widths
11	resoTF_End	0.032	+-	0.000	
12	resoTT	2.12	+-	0.21	
13	xsec	883.5	+-	32.6	Z signal cross section (contains ~1% residual bkg.)

Parameter Correlation Coefficients

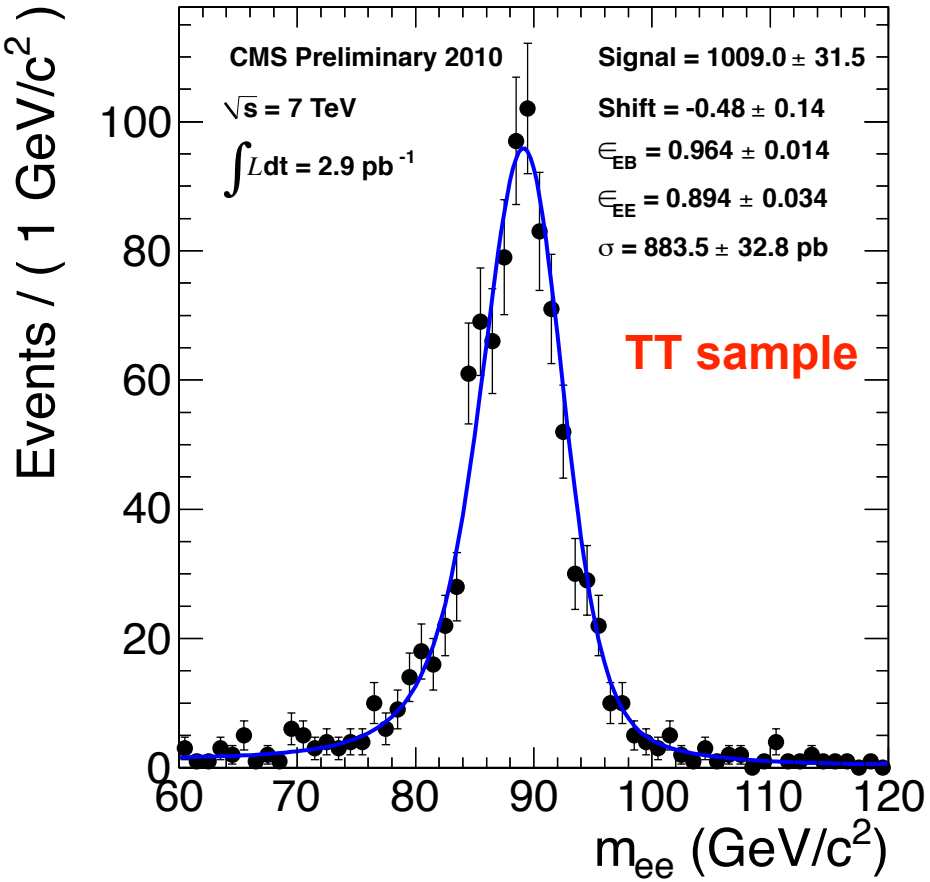
NO.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000	0.004	0.245	-0.078	-0.176	-0.031	-0.029	0.234	0.001	-0.237	0.173	-0.001	-0.101
2	0.004	1.000	-0.003	0.169	0.048	0.003	0.047	0.016	0.163	-0.018	-0.036	-0.000	-0.091
3	0.245	-0.003	1.000	-0.359	0.089	-0.005	0.008	0.638	-0.029	-0.394	-0.042	-0.002	-0.324
4	-0.078	0.169	-0.359	1.000	-0.031	0.001	-0.007	-0.206	0.506	0.123	0.014	0.001	-0.270
5	-0.176	0.048	0.089	-0.031	1.000	0.119	0.130	0.031	0.017	-0.006	-0.814	-0.007	-0.046
6	-0.031	0.003	-0.005	0.001	0.119	-1.000	0.030	-0.008	0.001	0.032	-0.136	-0.001	0.001
7	-0.029	0.047	0.008	-0.007	0.130	0.030	1.000	-0.043	0.019	0.042	-0.138	-0.156	-0.016
8	0.234	0.016	0.638	-0.206	0.031	-0.008	-0.043	1.000	0.003	-0.363	0.007	-0.002	-0.265
9	0.001	0.163	-0.029	0.506	0.017	0.001	0.019	0.003	1.000	-0.006	-0.016	0.000	-0.267
10	-0.237	-0.018	-0.394	0.123	-0.006	0.032	0.042	-0.363	-0.006	1.000	-0.081	0.002	0.164
11	0.173	-0.036	-0.042	0.014	-0.814	-0.136	-0.138	0.007	-0.016	-0.081	1.000	0.008	0.025
12	-0.001	-0.000	-0.002	0.001	-0.007	-0.001	-0.156	-0.002	0.000	0.002	0.008	1.000	0.001
13	-0.101	-0.091	-0.324	-0.270	-0.046	0.001	-0.016	-0.265	-0.267	0.164	0.025	0.001	1.000

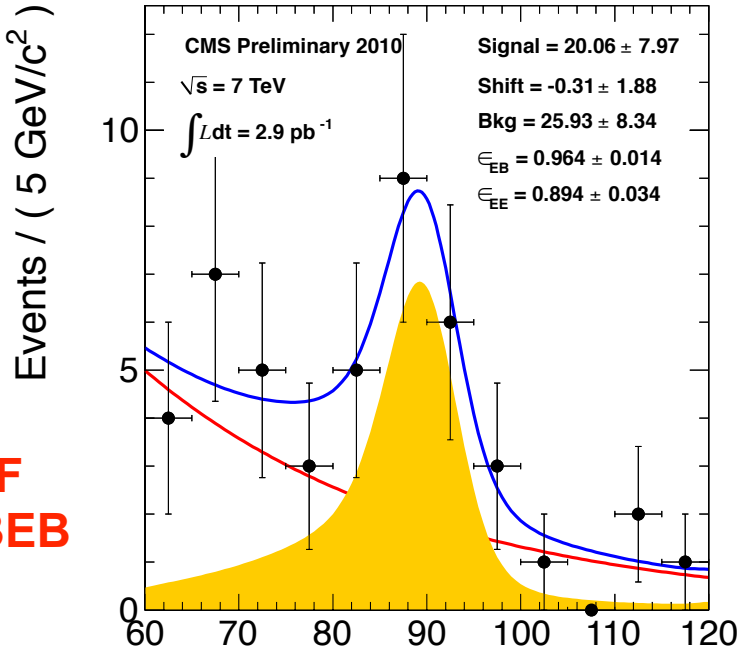
cross section after bkg subtraction

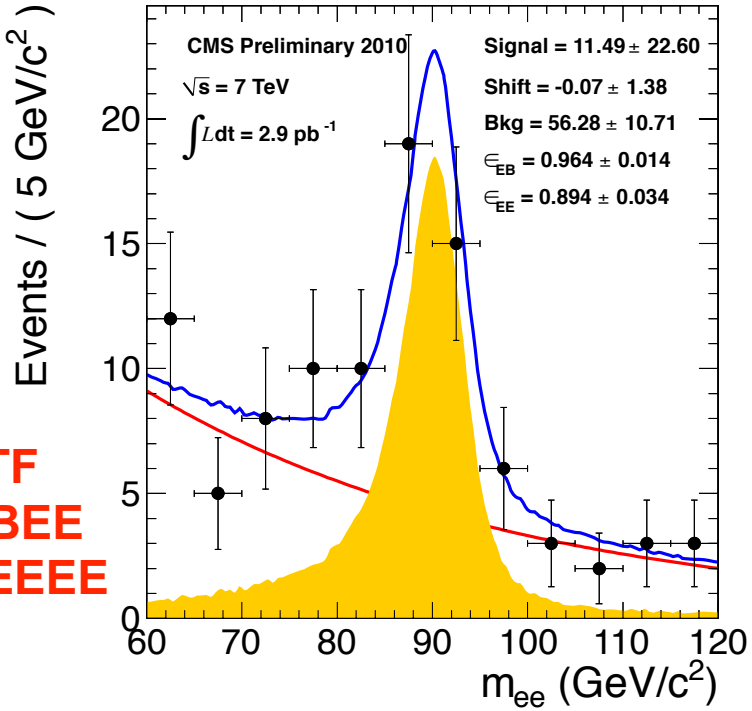
σ = 876.8 ± 32.6 (stat) ± 20.4 (syst) pb ➥Syst includes theory 1.9% ⊕ 1% EES ⊕ Bkg subtr.

902.5 ± 33.4 ± 30.2 from simple counting

Simultaneous fit plots







- ✦Signal shapes from NLO ⊗ CMS simu.
- ✦Convolve using Gaussian resolution.
- ✦Let the energy scale float.

Data driven electron efficiency from Z

super cluster → gsfElectron

	Eff (%)	σ_{stat}	σ_{syst}	MC
Total	100.0	0.6	0.6	98.6
Barrel	100.0	0.9	0.6	99.1
Endcap	98.6	1.3	0.6	97.4

gsfElectron → WP 95

Eff (%)	σ_{stat}	σ_{syst}	MC
93.2	0.9	1.0	95.2
93.0	1.1	1.0	95.6
93.3	1.7	1.0	94.2

WP 95 → HLT

	Eff (%)	σ_{stat}	σ_{syst}	MC
Total	99.0	0.3	1.3	98.6
Barrel	99.0	0.3	1.3	99.1
Endcap	98.9	0.4	1.3	97.4

gsfElectron → WP 80

Eff (%)	σ_{stat}	σ_{syst}	MC
79.2	1.2	1.0	86.3
80.8	1.4	1.0	86.5
74.9	2.3	1.0	79.8

✦MC tag & probe efficiencies are within 1% of the MC truth efficiency.

Systematic uncertainty in Efficiency

✦The impact of the energy scale on electron efficiency is marginal.

- super cluster → GsfElectron efficiency: 0.22%
- GsfElectron → WP95 efficiency: 0.10%
- GsfElectron → WP80 efficiency: 0.05%
- WP95 → HLT efficiency: 0.15%
- WP80 → HLT efficiency: 0.15%

✦The methodology to estimate this systematic is simple:

-We shifted the generator level energy scale by ± 3%.

-Compute MC tag & probe (and also truth-matched) efficiency for these two

- Take difference in the result between these 2 samples as the systematics.

✦Impact of the Z signal and background parametrization on efficiency computation is expected to ~1% or smaller

-try different background shapes: 1/ma, exponential, polynomial, ..

-try different signal shapes

- •signal template from data or MC
- •try different resolution functions

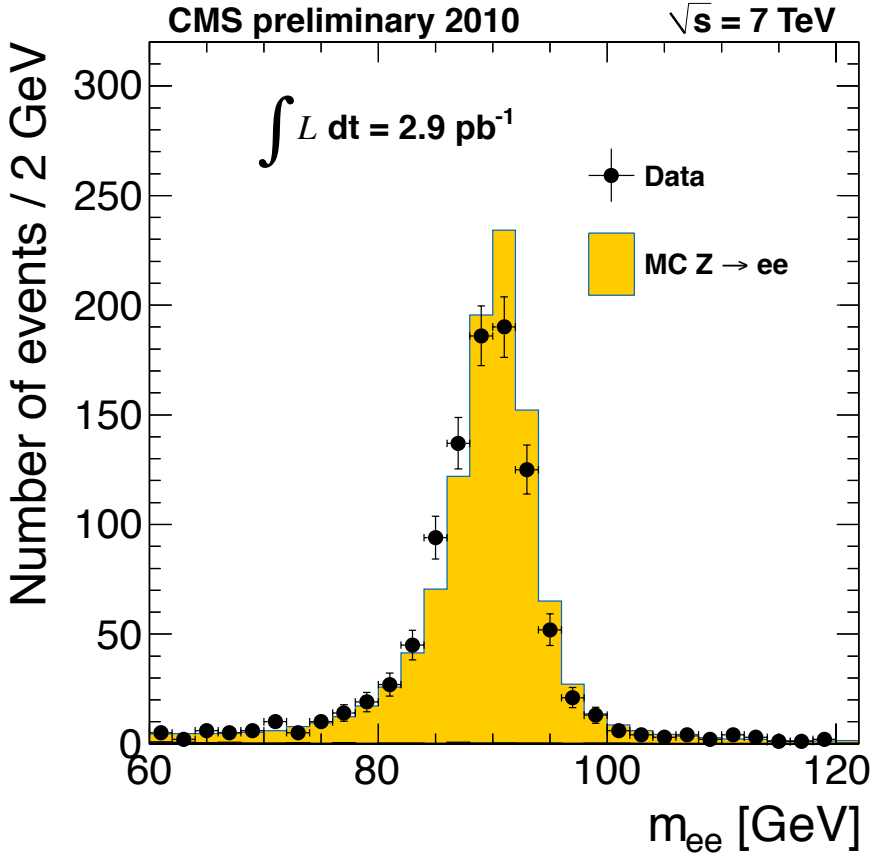
✦Currently we assign an ad hoc 0.5% systematics for these effects.

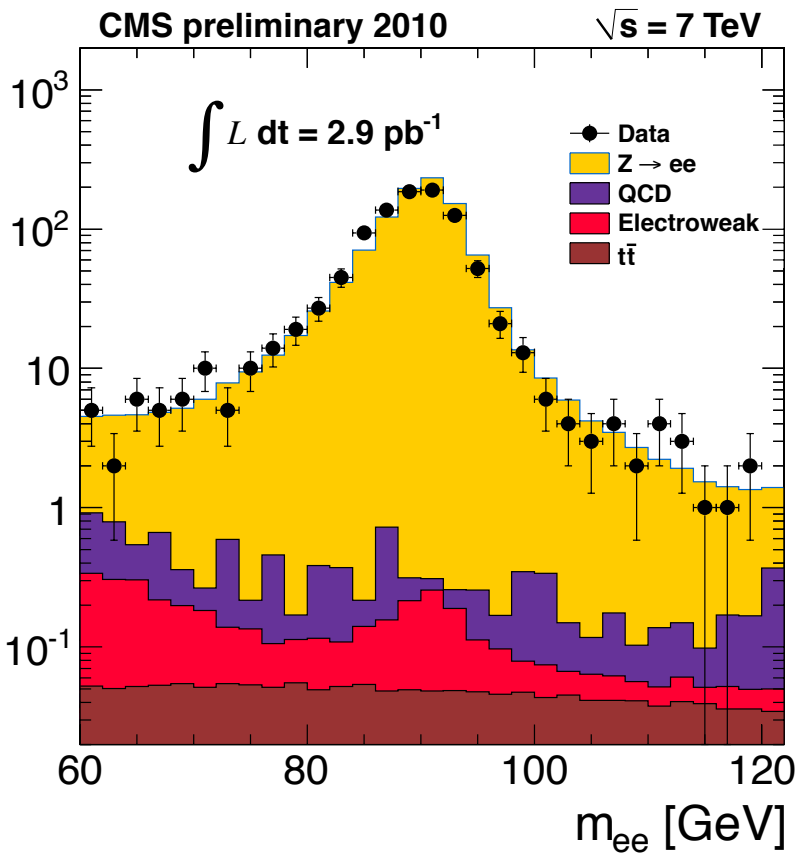
3.8.2 Reco: PR plots with 2.9 pb^{-1} data

Very Preliminary

✦Have 1002 golden Z→ee candidates.

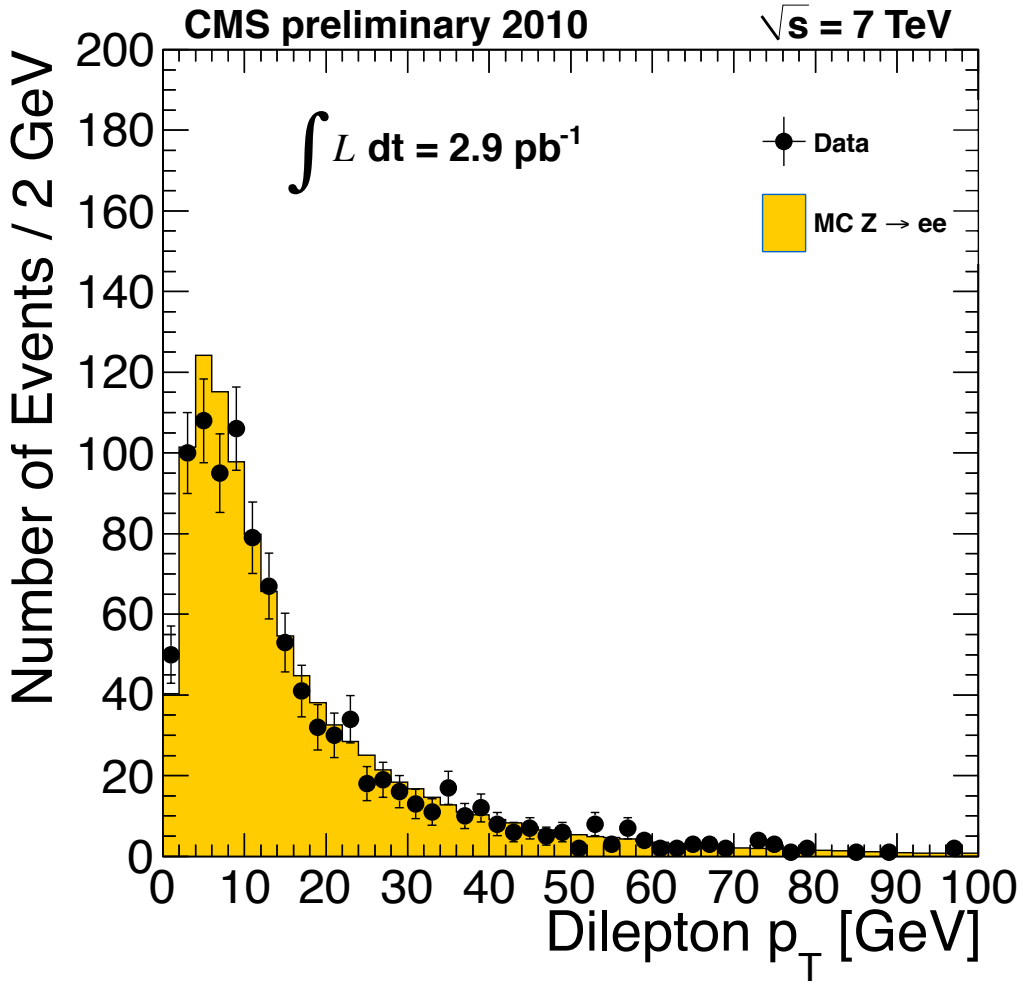
after applying Δη cut in EE

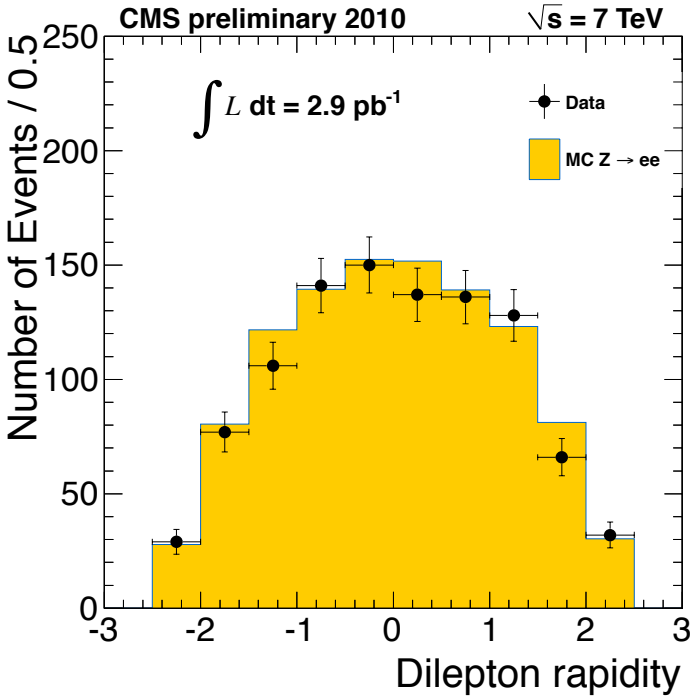


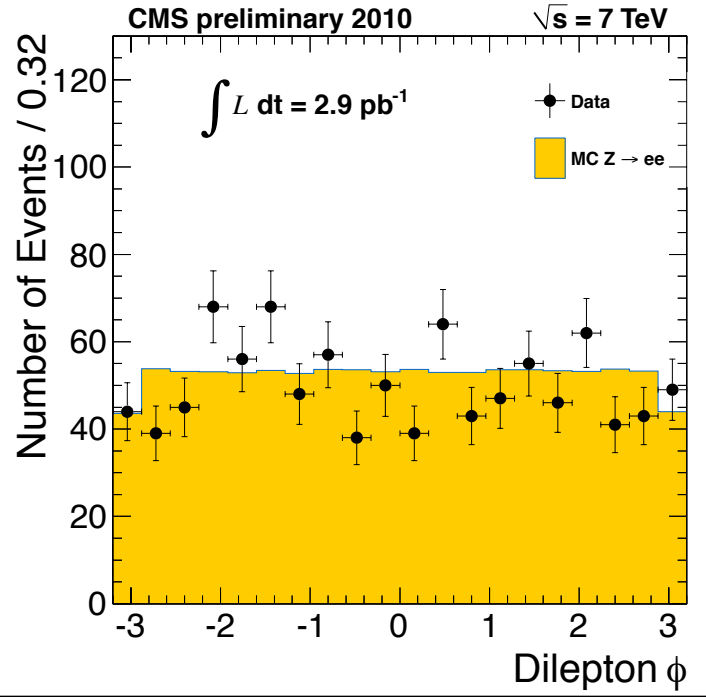


✦Peak seems to be at close to the right place now.

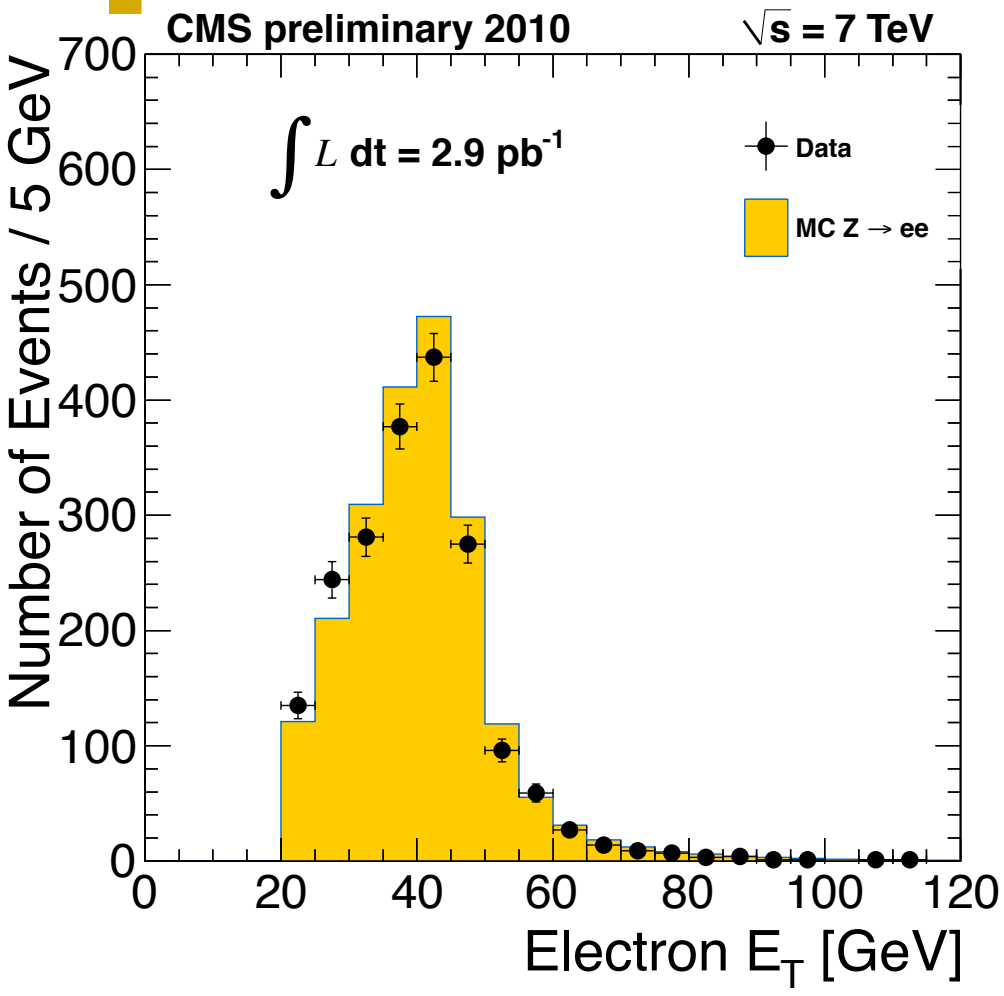
3.8.2 Reco: Z p_T, y, ϕ

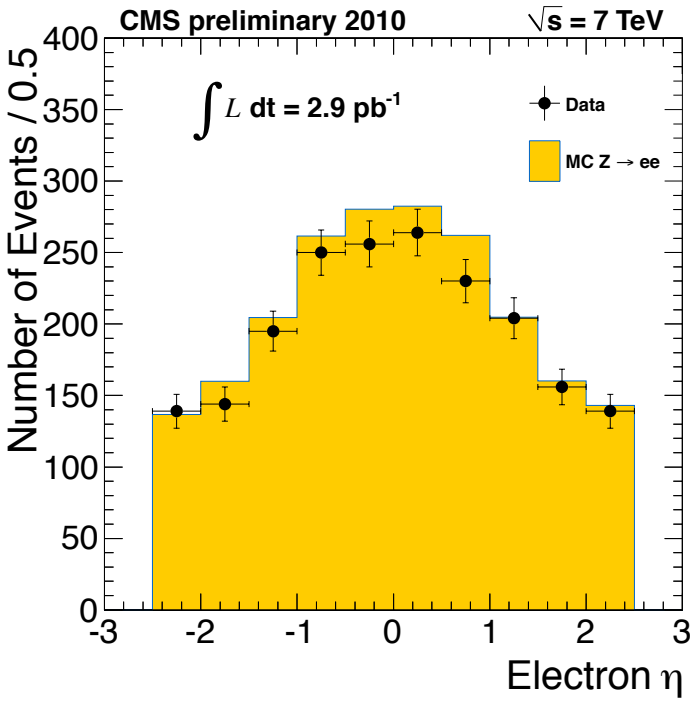


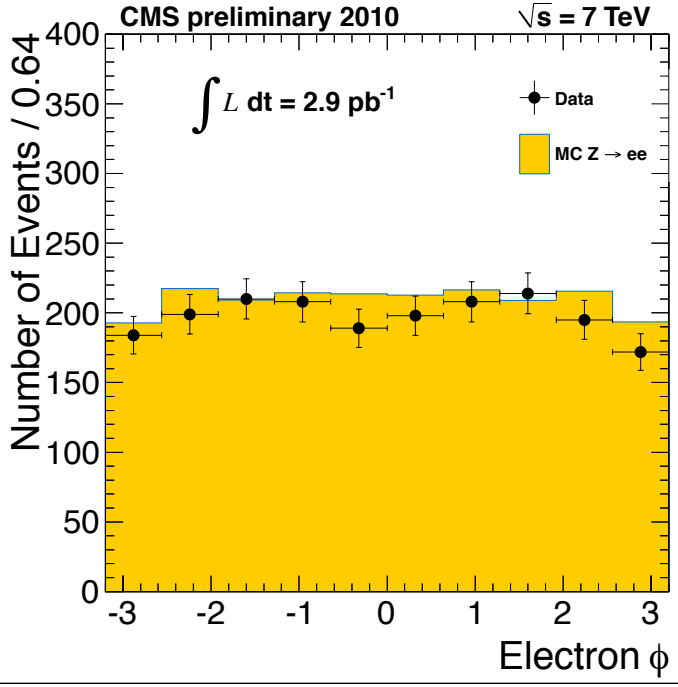




3.8.2 Reco: Electron E_T, η, ϕ

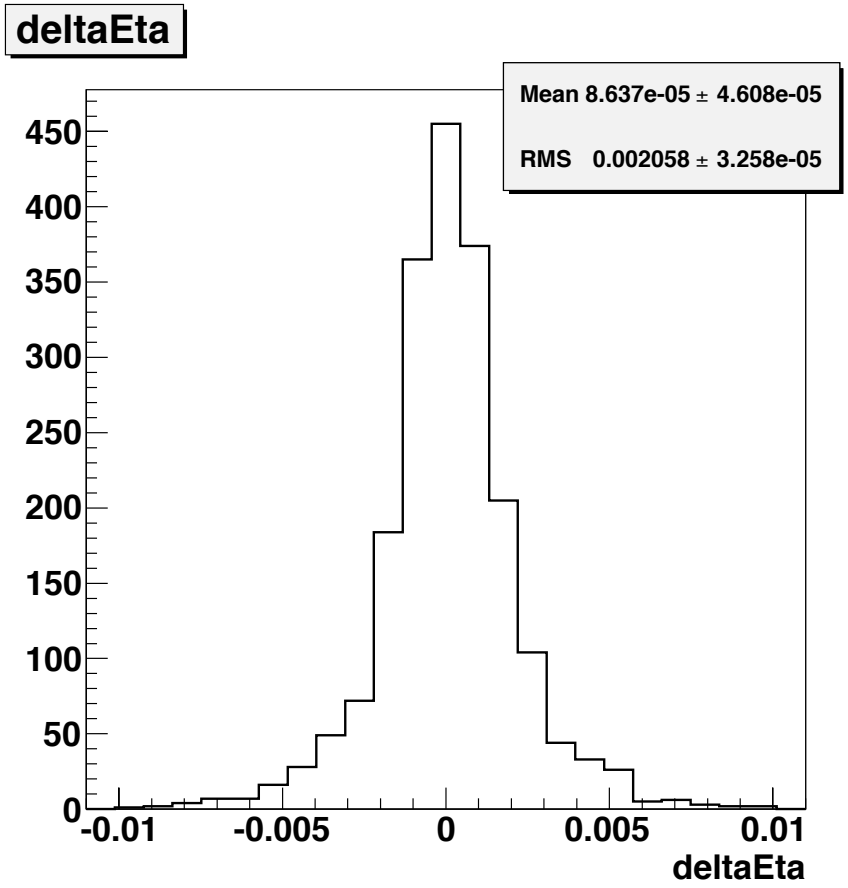


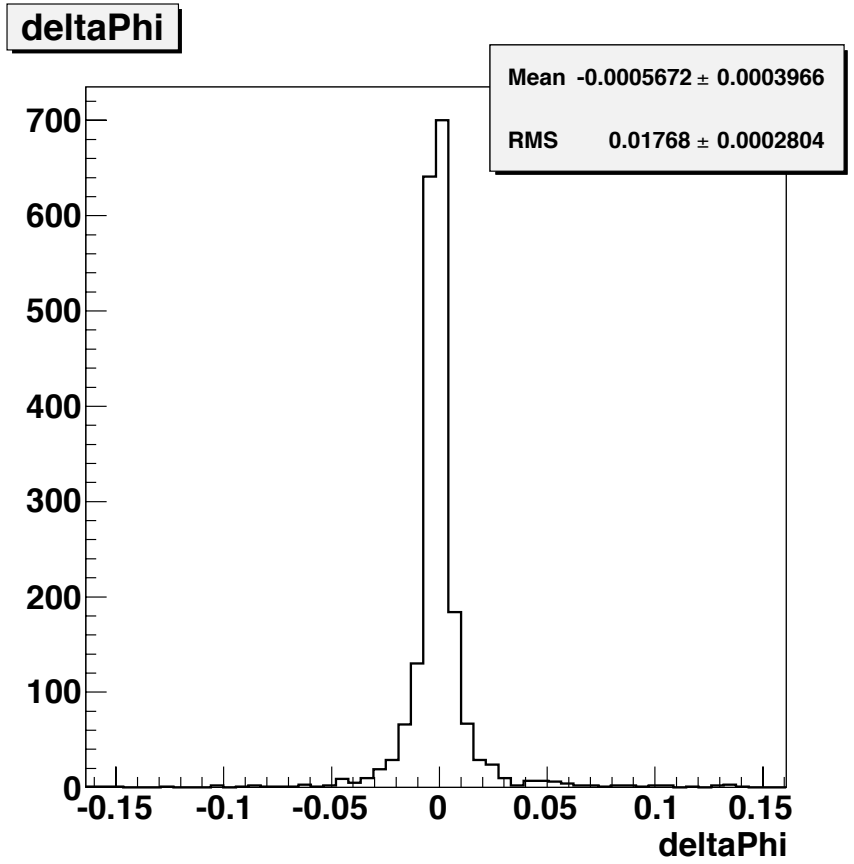




✦Better agreement in E_T distribution now

3.8.2 Reco: Electron Δη, Δϕ





✦Both centered at zero, both are symmetric.

3.8.2 Reco: Z→ee cross section, $\int L = 2.9\ pb^{-1}$

$N_{Selected}$ = 1002 ± 31.7

$N_{Background}$ = 9.8 ± 11.8

Electron offline efficiency: from tag & probe

ε_{Reco}	=	0.9928 ± 0.0037 (stat)	± 0.0055 (syst)
$\varepsilon_{Reco\rightarrow WP95}$	=	0.9535 ± 0.0088 (stat)	± 0.0101 (syst)
$\varepsilon_{WP95\rightarrow HLT}$	=	0.9889 ± 0.0024 (stat)	± 0.0131 (syst)

Dilepton efficiency = 0.8960 ± 0.0178 (stat) ± 0.0214 (syst)

Acceptance = 0.4357 ± 1.7% (theory) ± 1% (Energy scale) ← from MC

$\sigma_{\gamma^*/Z}$ x BR(Z→ee) = 882.5 ± 33.0 (stat) ± 29.3 (syst) ± 97.1 (lumi) pb

NLO prediction = 970 ± 20 pb, NNLO prediction = 972 ± 39 pb

Observed cross section is lower than prediction !

Essentially the same result as in 3.6.4path4 (prompt-Reco data)