Measurement of electron efficiency and energy scale from $Z \rightarrow e^+e^-$ analysis

Mikhail Makouski, Kalanand Mishra, Elizabeth Sudano, Jeremy Werner, Si Xie

*on behalf of VBTF **Z analysis** team*

Egamma meeting
(Sept 23, 2010)

Some details on golden Z→ee sample

- Zee yield from $\int L\,dt = 2.88\ pb^{-1}$
  - -By using the energy scale corrections from Zee (EB:1.0115 & EE:1.0292):
    - we have 994+7(in) - 1(out) = 1000 events.

- Acceptance (generated → gen level accepted)
  - A = 0.4584
  - A_EBEB = 0.2380
  - A_EBEE = 0.1713
  - A_EEEE = 0.0490

- Acceptance: A* (generated → super clusters accepted)
  - A* = 0.4345
  - A*_EBEB = 0.2257
  - A*_EBEE = 0.1612
  - A*_EEEE = 0.0476

Logistics and quality control

- ✦Four different groups of people run over the data and validate the event list
  - only when consensus is arrived we post the entire golden Zee candidate list in the EWK-VBTF hypernews.

- ✦Four different groups of people run tag & probe tool to compute efficiency
  - each group validates/ cross-checks the result from other groups.
  - make sure that we understand what we are computing: monitor the goodness-of-fit, keep an eye on the correlations etc.

- ✦Still use a common framework:
  - TagAndProbe utility as the baseline tool
  - Divide the task on computing various systematic uncertainties

- ✦Along the way to showing efficiency tables I will show you some typical fit plots/results.

Electron efficiency sequence using tag & probe

Tag Selection

- GsfElectrons.
- Super cluster within $|\eta|$ acceptance
- $E_T > 20$ GeV
- Isolation and Id cuts as in WP95
- Matched to lowest unprescaled electron trigger

Probe Selection

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

Obtain factorized efficiencies for passing probes:

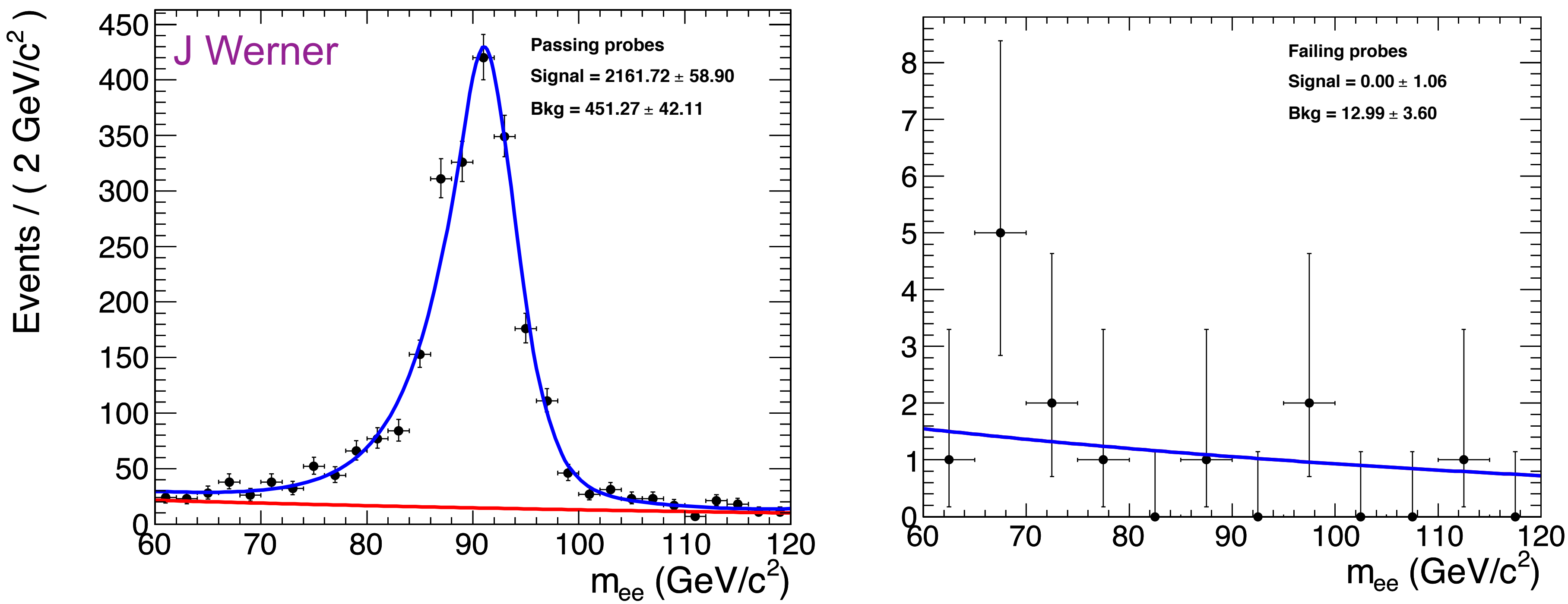
SuperCluster → GsfElectron → WP-95/WP80 → HLT

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.

Super cluster → GsfElectron efficiency



plot showing the simultaneous fit to the passing and failing samples

Methodology:

- Take signal lineshape in the passing and failing sample from NLO (Powheg) MC and CMS simulation. If needed we allow for additional smearing in data. The fit returns the efficiency directly.
- Use exponential background shape for nominal fits.

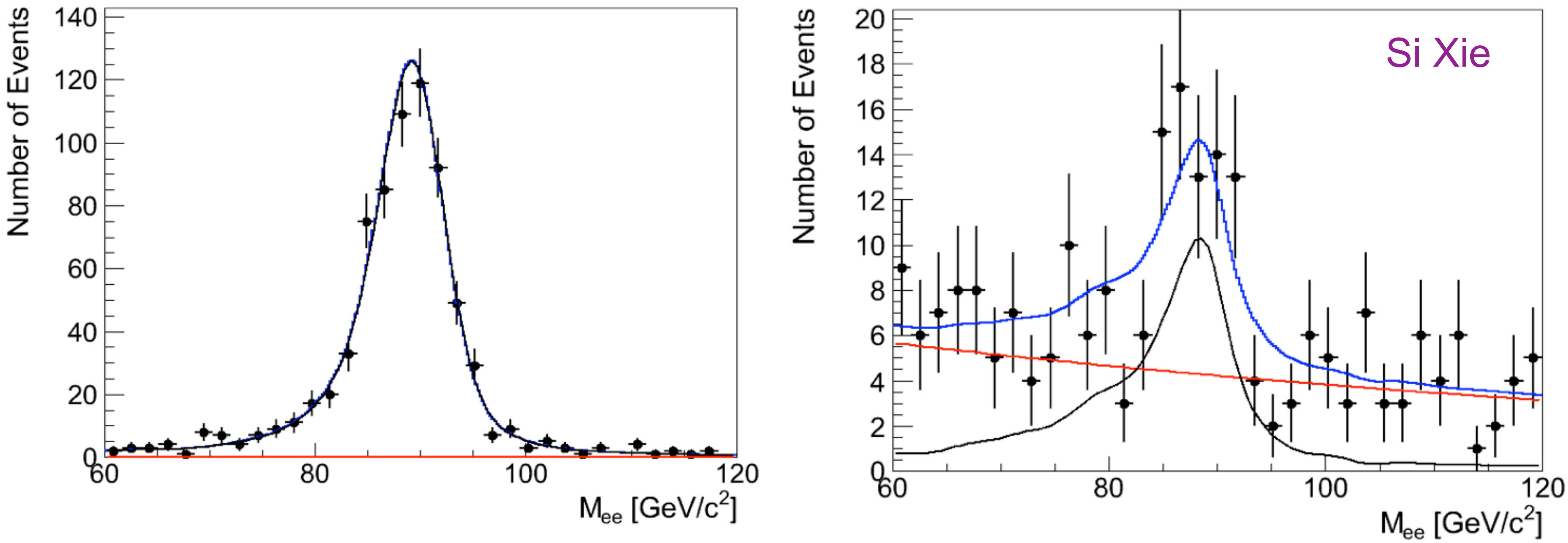
Super cluster → GsfElectron efficiency

	Efficiency (%)	σ_{stat}	σ_{syst}	MC
Total	**100**	**0.3**	**0.6**	98.7
EB	**100**	**0.6**	**0.6**	98.6
EE	**99.2**	**1.2**	**0.6**	97.0
e+ EB	**100.0**	**0.3**	**0.6**	
e+ EE	**100.0**	**0.2**	**0.6**	
e− EB	**100.0**	**0.5**	**0.6**	
e− EE	**100.0**	**0.7**	**0.6**	

Remarks:

1. The electron reconstruction efficiency is practically 100% in data.
2. In order not to get completely swamped by background, we apply following pre-selection to clean up the failing sample (i.e., “tag+ failing SC”): H/E<0.15, $\sigma_{i\eta i\eta}$ < 0.01 in EB and $\sigma_{i\eta i\eta}$ < 0.03 in EE. These are fully efficient in MC.

GsfElectron → WP-95 efficiency



plot showing the simultaneous fit to the passing and failing samples for e- in EB

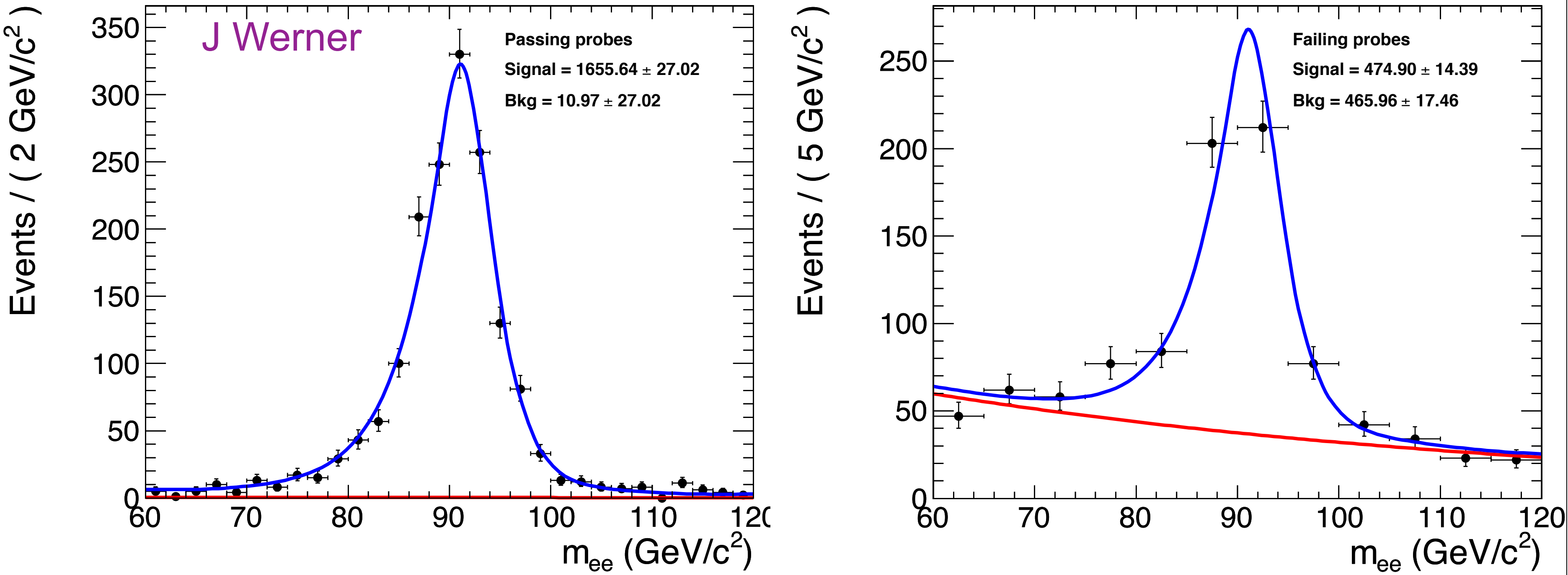
Methodology:
Fit procedure same as before

GsfElectron → WP-95 efficiency

	Efficiency (%)	σ_{stat}	σ_{syst}	MC
Total	**92.1**	**1.2**	**1.0**	95.2
EB	**92.0**	**1.3**	**1.0**	95.6
EE	**92.3**	**2.0**	**1.0**	94.7
e+ EB	**93.7**	**1.8**	**1.0**	
e+ EE	**93.0**	**4.2**	**1.0**	
e− EB	**90.3**	**1.8**	**1.0**	
e− EE	**91.6**	**2.8**	**1.0**	

Remarks:
The efficiency in data is a few percent lower than in MC.

GsfElectron → WP-80 efficiency



plot showing the simultaneous fit to the passing and failing samples

Methodology:
Fit procedure same as in the previous efficiency

GsfElectron→WP-80 + convVeto efficiency

	Efficiency (%)	σ_{stat}	σ_{syst}	MC
Total	**75.8**	**1.2**	**1.0**	82.8
EB	**79.0**	**1.3**	**1.0**	85.5
EE	**71.8**	**2.2**	**1.0**	77.0
e+ EB	**79.8**	**1.8**	**1.0**	85.5
e+ EE	**71.5**	**3.1**	**1.0**	76.8
e− EB	**78.1**	**1.7**	**1.0**	85.5
e− EE	**72.1**	**3.0**	**1.0**	77.2

Remarks:

1. The efficiency in data is a few percent lower than in MC.
2. Remember that efficiency in the above table for electrons with E_T, eta spectrum observed in Zee events. To compute the efficiency for Wenu events one needs to do the following: eff(W) = eff(Z) * eff(Wmc) / eff(Zmc).

WP-80 → ConvVeto efficiency

	Efficiency (%)	σ_{stat}	σ_{syst}	MC
Total	**98.0**	**0.01**		97.7
EB	**98.8**	**0.01**		98.8
EE	**96.9**	**0.05**		96.2
e+ EB	**98.5**	**0.02**		98.8
e+ EE	**96.4**	**0.07**		96.2
e− EB	**99.1**	**0.02**		98.9
e− EE	**97.4**	**0.07**		96.3

Remarks:

1. We computed this efficiency for the sake of cross check, and also to be able to compare with WP-95 (which does not have conversion veto).
2. The efficiency in data is remarkably close to MC efficiency.

WP-95 → HLT efficiency

	Efficiency (%)	σ_{stat}	σ_{syst}	MC
Total	**98.8**	**0.2**	**1.3**	98.8
EB	**98.7**	**0.3**	**1.3**	99.4
EE	**99.0**	**0.4**	**1.3**	97.7
e+ EB	**99.1**	**0.3**	**1.3**	
e+ EE	**98.7**	**0.6**	**1.3**	
e− EB	**98.6**	**0.4**	**1.3**	
e− EE	**99.3**	**0.5**	**1.3**	

✦Note that the Monte Carlo has a different trigger than data
✦In data, we used the lowest unprescaled electron/photon trigger available at the time

WP-80 + ConvVeto → HLT efficiency

	Efficiency (%)	σ_{stat}	σ_{syst}	MC
Total	98.9	0.3	1.3	99.4
EB	98.9	0.3	1.3	99.6
EE	98.9	0.4	1.3	98.9
e+ EB	99.0	0.4	1.3	99.6
e+ EE	98.8	0.7	1.3	98.9
e− EB	98.7	0.4	1.3	99.6
e− EE	99.1	0.6	1.3	98.8

- Note that the Monte Carlo has a different trigger than data
- In data, we used the lowest unprescaled electron/photon trigger available at the time

How did we estimate the systematics ?

✦The impact of the energy scale on electron efficiency is marginal. Here are the associated systematic errors we have computed:

- super cluster → GsfElectron efficiency: 0.22%
- GsfElectron → WP95 efficiency: 0.10%
- GsfElectron → WP80 efficiency: 0.05%
- WP-80/95 → HLT efficiency: 0.15%

✦The methodology to estimate this systematic is simple:

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

-Compute MC efficiency and take the difference in the result as systematics.

✦Systematics due to background parametrization is computed by generating events with alternative background hypothesis (say, linear, $1/m^{\alpha}$, polynomials of order 2,3) and performing the fit with nominal bkg shape (i.e., exponential).

-We estimate 0.6% systematic uncertainty in reco efficiency, 1% in WP80/95, and 1.3%in HLT efficiency.

✦SInce we float the resolution in signal modeling, in principle there is no systematics from signal shape. This and bkg systematics are under further study.

Electron energy scale

Electron energy scale: How we compute it ?

We can write the relation between the reconstructed Z→ee invariant mass in data and MC using the following equations:

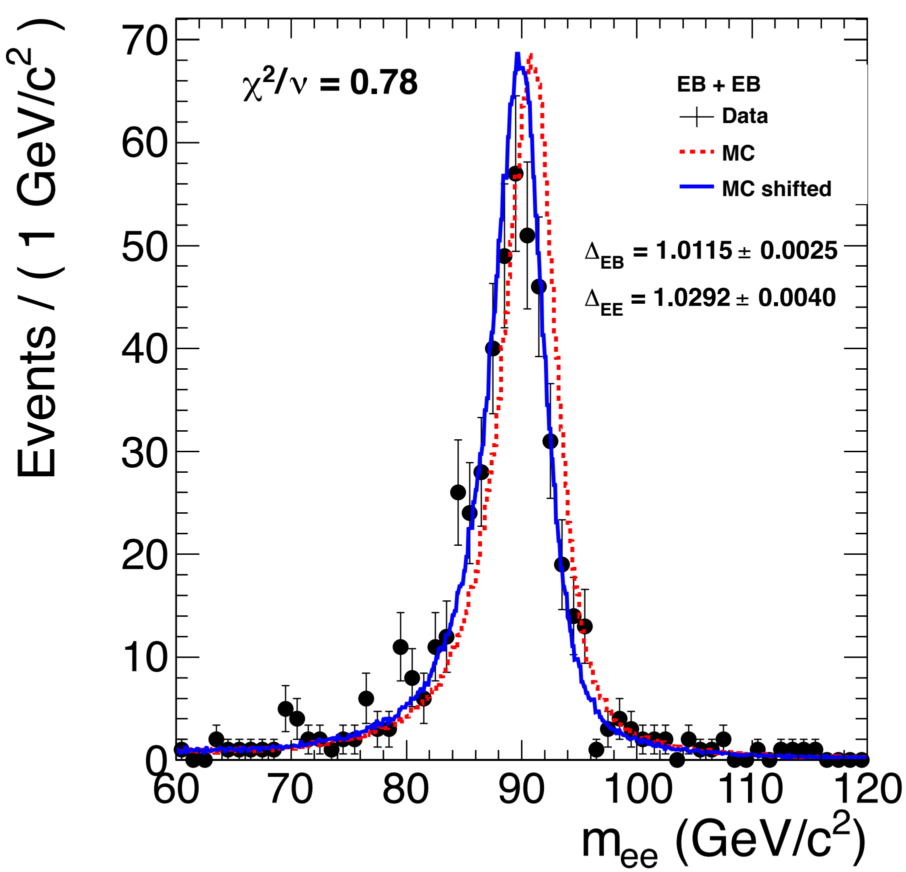
M_MC = a * M_data   for EB,EB
M_MC = b* M_data   for EE,EE
M_MC = √(a*b) * M_data   for EB,EE

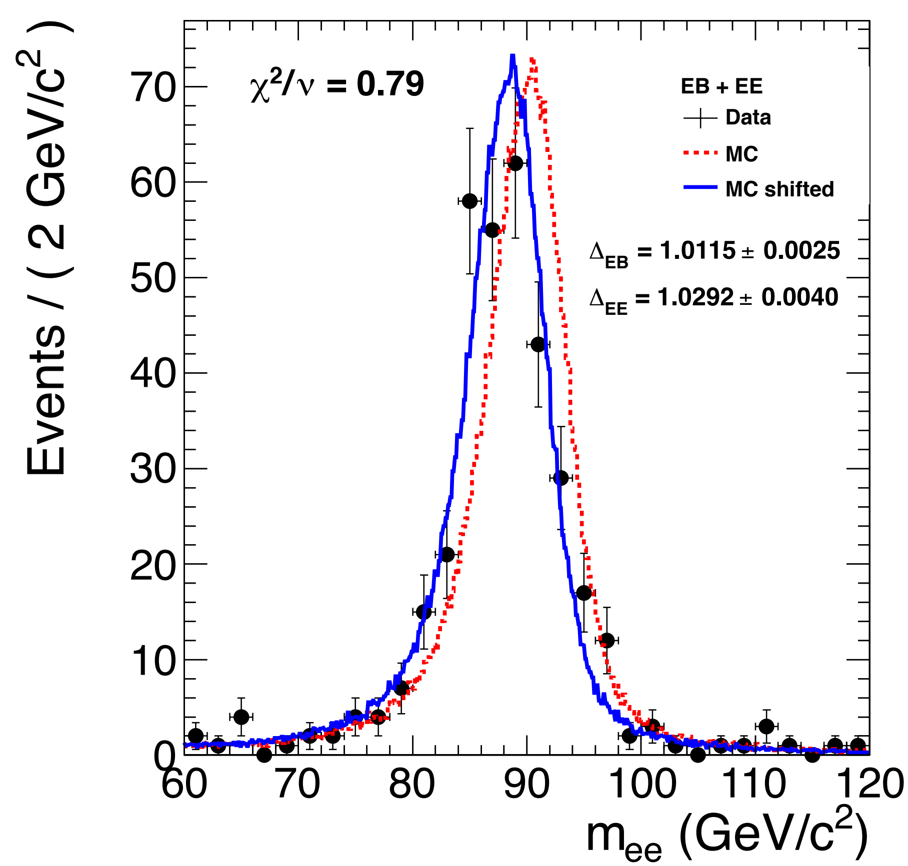
Here a,b are the energy scaling factors in the EB and EE respectively.

- Take the Z→ee events in data and rescale the electron energy such that we maximize the likelihood between M_data & M_MC.
This gives us an energy scale correction factor: A = xx ± yy

- Perform this fit simultaneously for both EBEB and EBEE samples.

Electron energy scale in data for WP-95



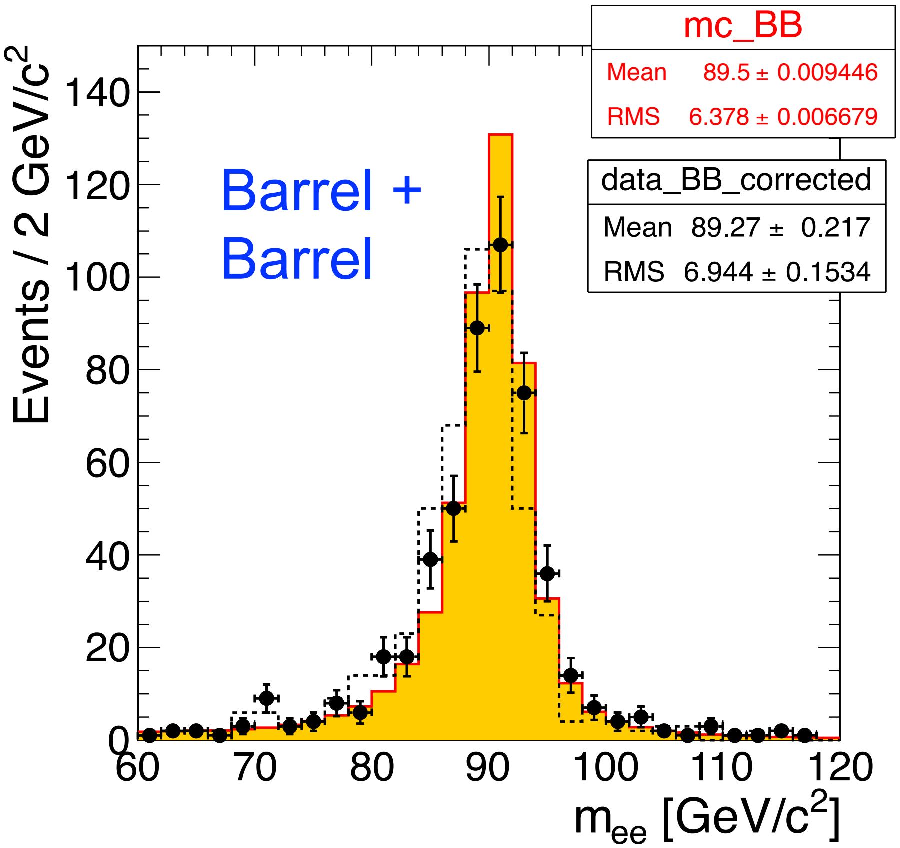


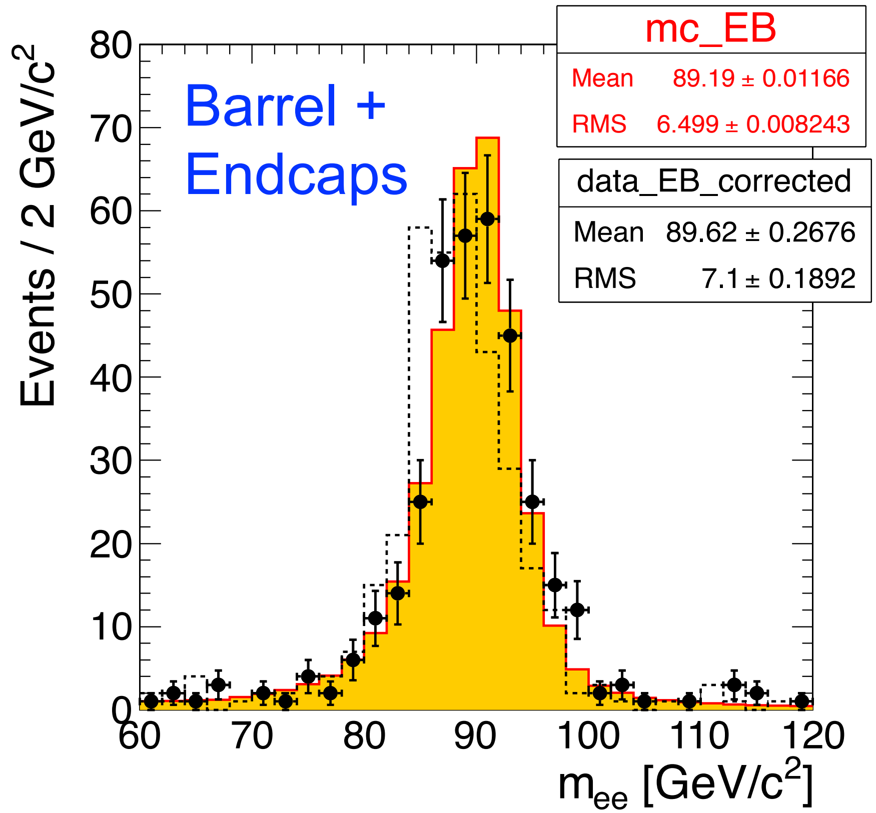
Electron energy scale (for WP95) is: 1.0115 ± 0.0025 (in EB)
1.0292 ± 0.0040 (in EE)

Practically the same for WP80

Electron energy scale: closure test

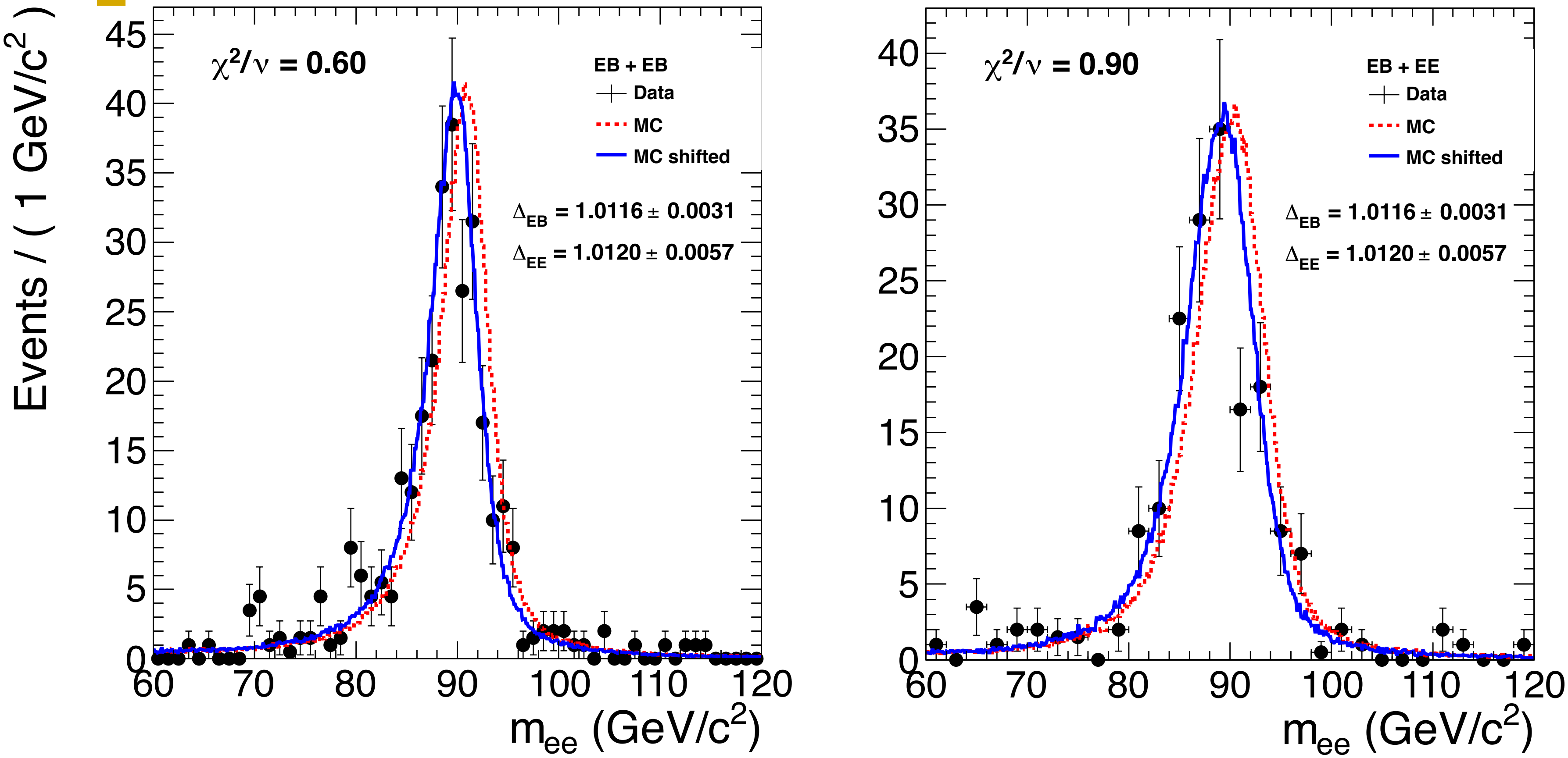
Apply the energy scale correction back to the Z→ee sample to see if data and MC agree now.





Conclusion: Closure test is successful and energy scale correction works.

Electron energy scale in data for WP-80



Electron energy scale (for WP95) is: 1.0116 ± 0.0031 (in EB)
1.0120 ± 0.0057 (in EE)

Same as WP95 for EB but smaller correction for EE.

Backup

Approximate signal yields by category

probe type	Npass	Nfail
SC->GsfEle	2162	0
EB	1509	0
EE	673	0
EB e-	761	0
EB e+	747	0
EE e-	333	0
EE e+	338	0
GsfEle->WP95	1960	163
EB	1374	112
EE	582	55
EB e-	693	68
EB e+	682	43
EE e-	276	22
EE e+	297	24
GsfEle->WP80	1656	475
EB	1189	298
EE	468	184
EB e-	591	160
EB e+	593	142
EE e-	225	96
EE e+	241	86

probe type	Npass	Nfail
WP95 -> HLT	1922	19
EB	1385	14
EE	567	5
EB e-	674	8
EB e+	676	5
EE e-	281	2
EE e+	291	3
WP80->HLT	1612	19
EB	1159	13
EE	447	5
EB e-	580	8
EB e+	579	5
EE e-	221	2
EE e+	232	3

Caveat: These yields have been computed using the fitted values of efficiency and total number of events in each case. They have been rounded off to the nearest integer values. These should not be used to compute efficiency.