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

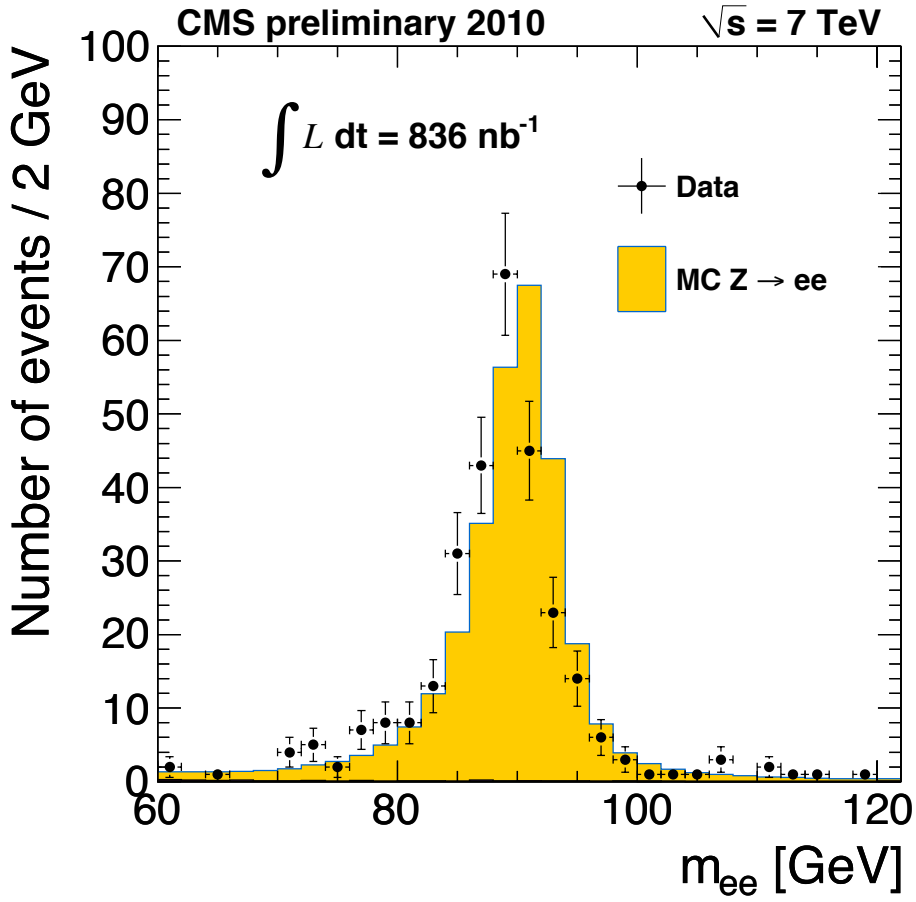
(August 20, 2010)

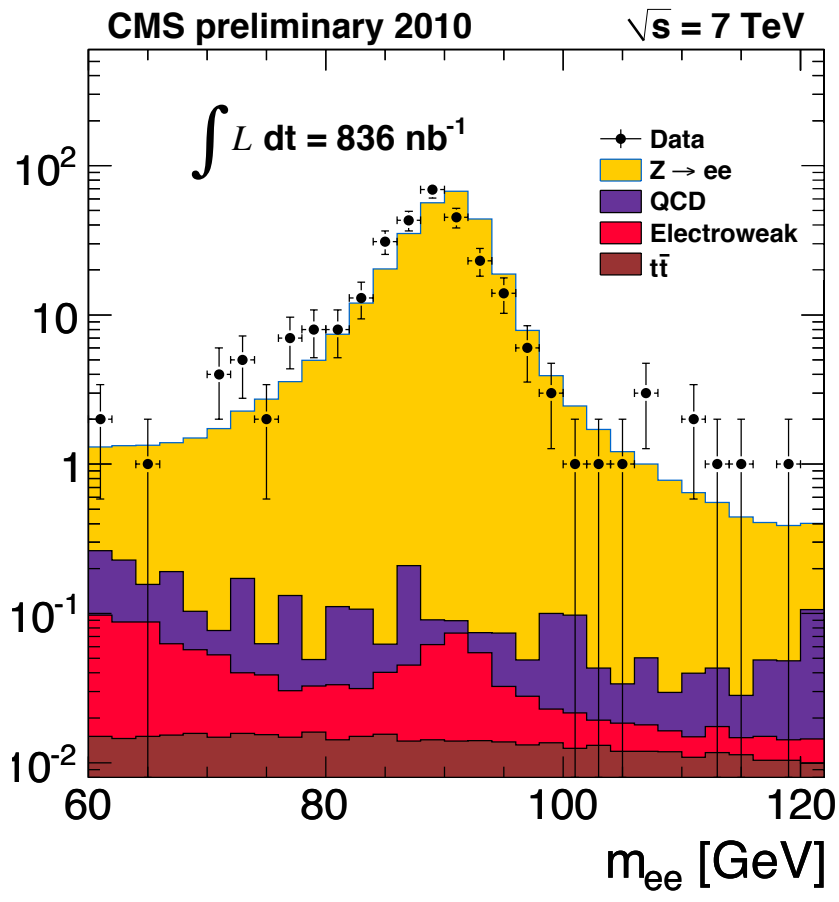
Overview

- PR plots with 836 nb^{-1} integrated luminosity (*i.e.*, last JSON)
- Cross section measurement update
- Status on specific topics:
  - Z signal yield vs time
  - Electron energy scale
  - Background subtraction
  - Electron efficiency

PR plots with 836 nb^{-1} data

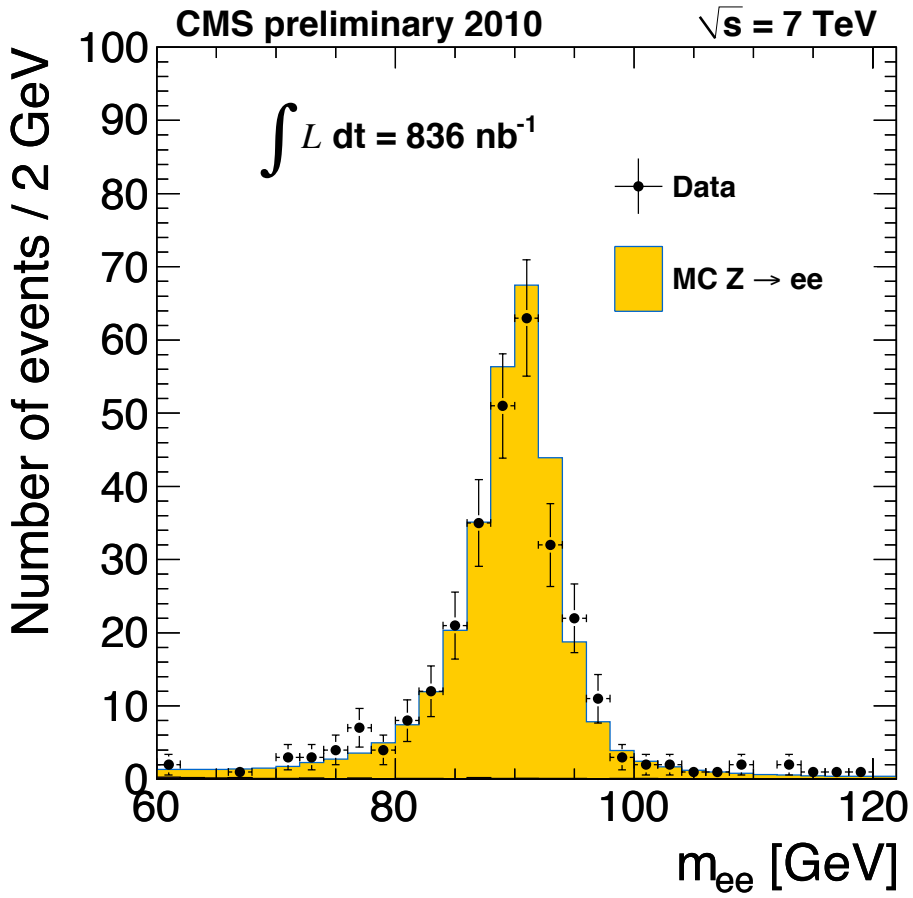
✦Have ~295 golden Z→ee candidates.

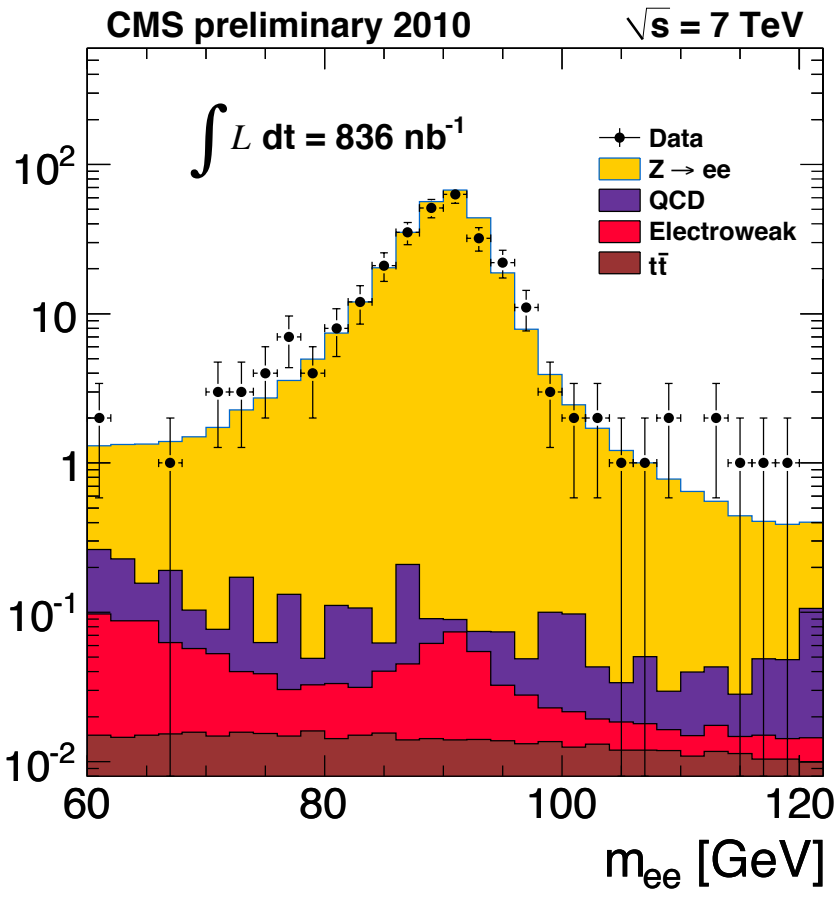




Z→ee mass after energy scale correction

Correcting for a −1.2% shift in mass everywhere in the detector gets it right for good e.



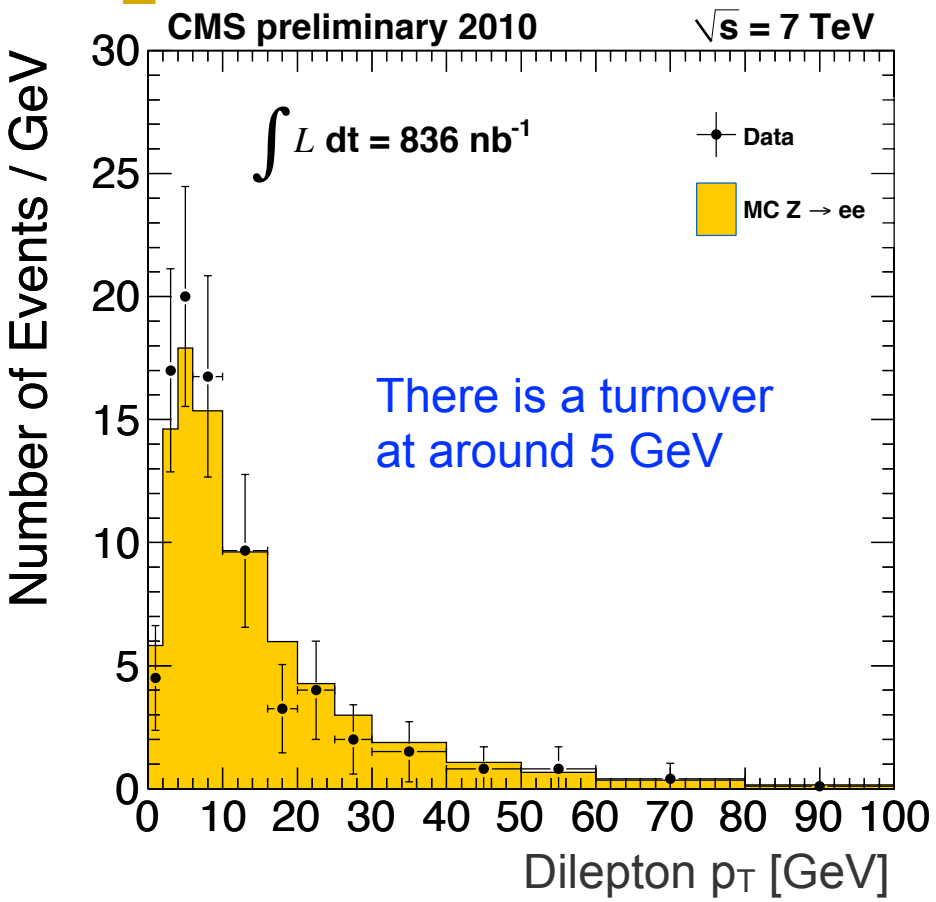


Mass shift in π^0, η:

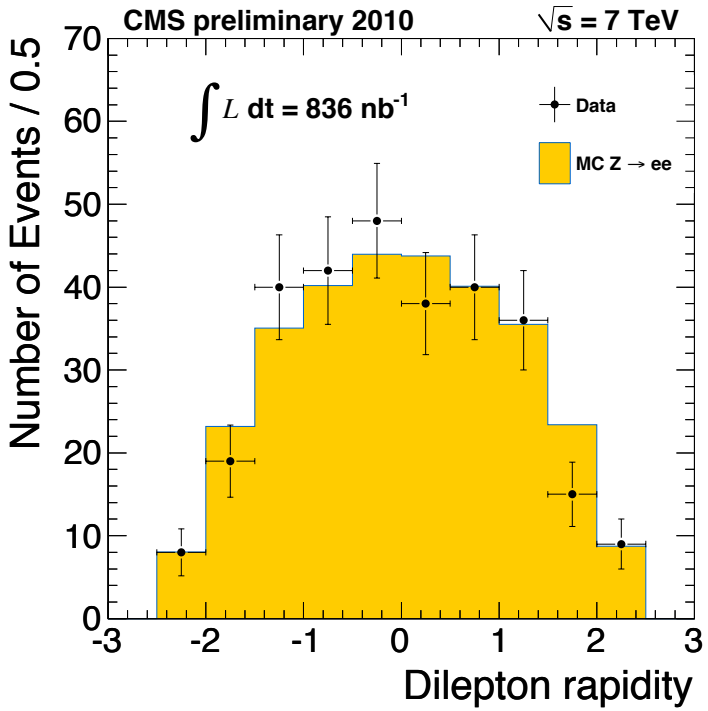
EB+EB	−0.7% ± 0.02% (stat.) ± 0.9% (syst.)
EE+EE	+2.5% ± 0.2% (stat.) ± 2.2% (syst.)

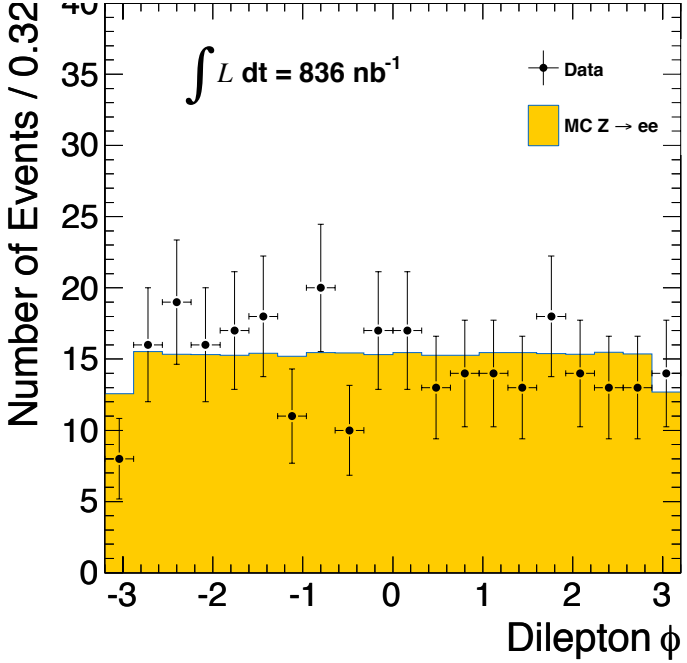
PAS: EGM-10-003

Z p_T, rapidity, azimuth

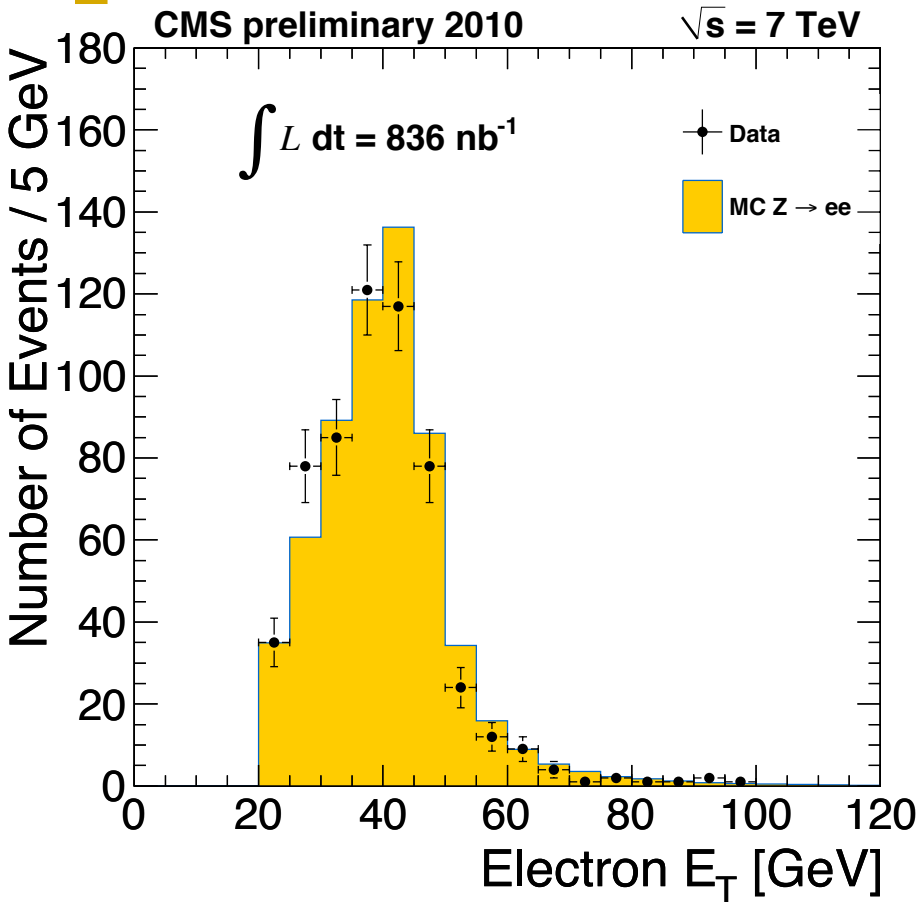


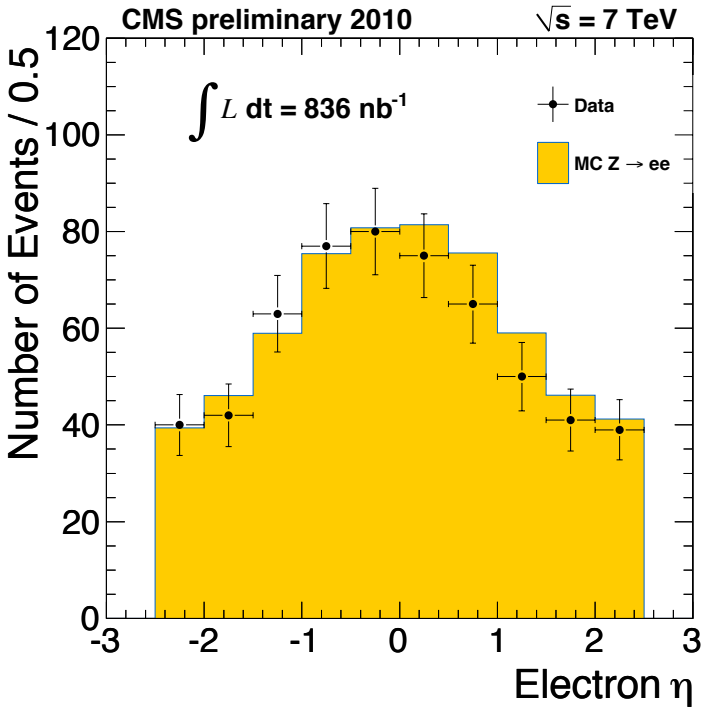
✦Distributions are in agreement with NLO predictions.

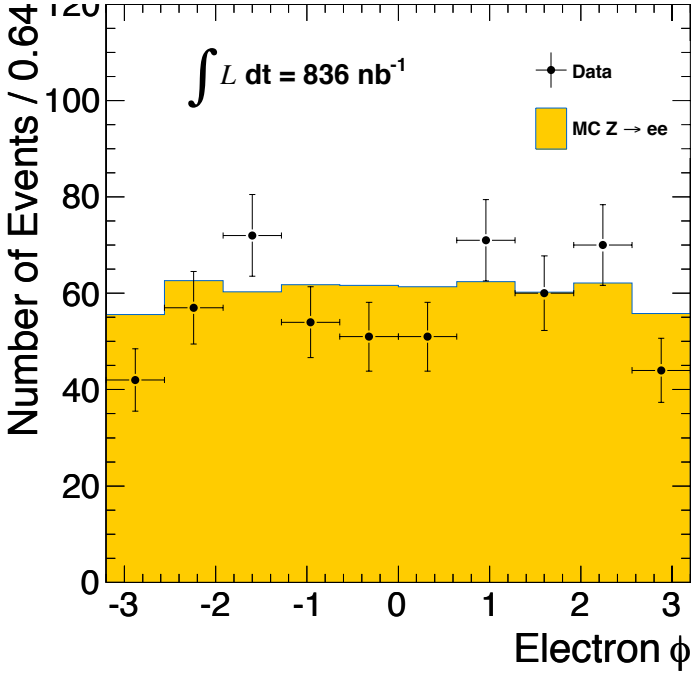




Electron P_T, rapidity, azimuth

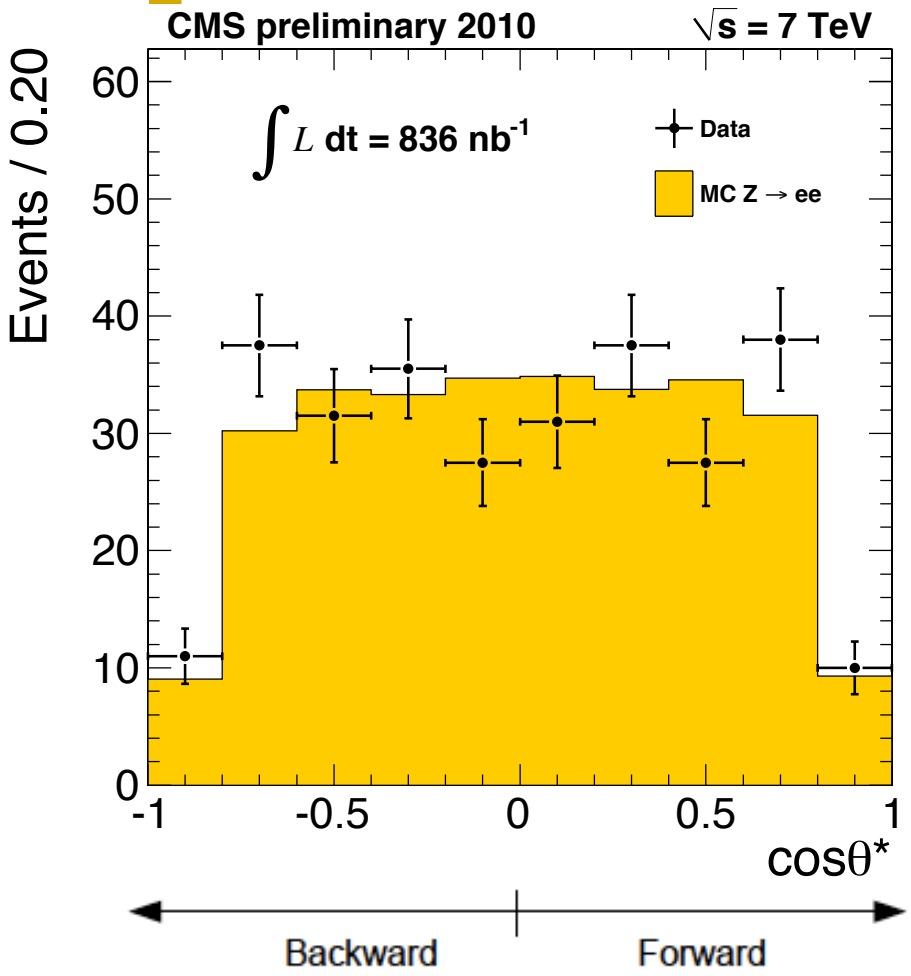




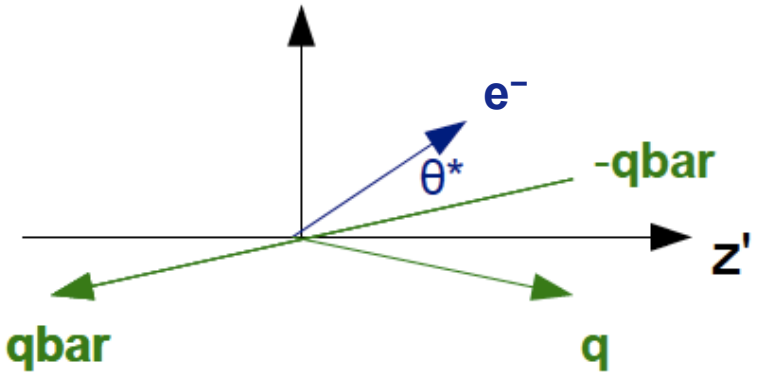


✦Distributions are in agreement with NLO predictions.

Z production topology: cosine θ*



Collins–Soper frame

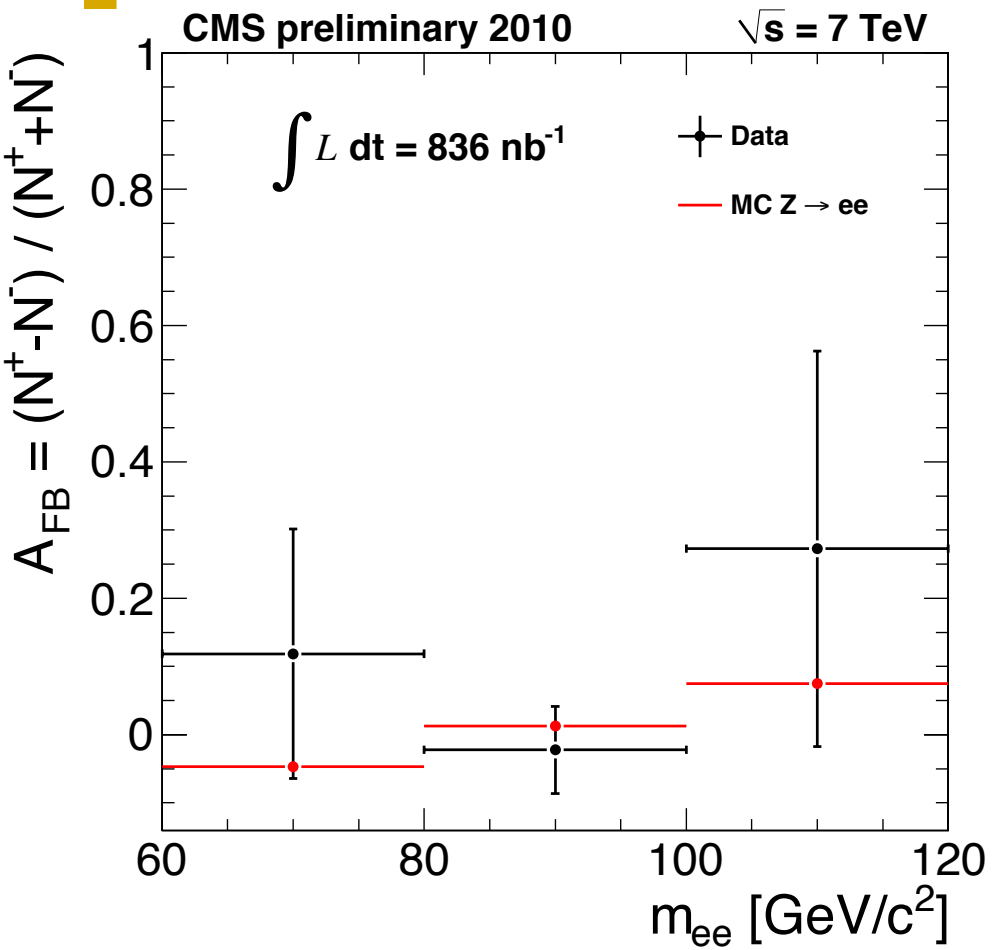


θ* is the angle between the electron momenta and the z' axis that bisects the angle between **q** and **−qbar**.

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 $\int L = 836\ nb^{-1}$

$N_{selected}$	295 ± 17.2
N_{bkgd}	3.1 ± 0.6 (from MC)
ε Acceptance Integrated Luminosity	0.8671 ± 0.0023 (MC stat.) ± 0.0867 (syst.) 0.4357 ± 0.0010 (MC stat.) ± 0.0131 (syst.) 0.836 ± 0.092 pb^{-1} (syst.)
$\sigma_{\gamma^*Z} \times BR(\gamma^*Z \to e^+e^-)$	924.2 ± 54.4 (stat.) + 71.9 (syst.) + 102.7 (lumi.)
Theoretical prediction	LO: 740 pb, NLO: 911 pb ($60 < m_Z < 120\ GeV$) LO: 1300 pb ($m_Z > 20\ GeV$), NLO: 1607 pb ($m_Z > 20\ GeV$)

dilepton efficiency

Acceptance = 43.6% ← from MC
Efficiency = 86.7 %
Cross section = 924 ± 54 pb ← our result
NLO prediction = 911 ± 27 pb

Breakdown of syst: 5⊕5% for efficiency ⊕ 3% for acceptance ⊕ 100% of bkg

Working on several data-driven background methods.

Simultaneous fit for cross section & efficiency

Parameter	Value	HiError,	LoError
1 TF Bkg Expo	-0.008	+0.007,	-0.007
2 $e^{\pm}$ Efficiency	0.928	+0.028,	-0.029
3 TF nBkg	77.1	+12.6,	-11.8
4 Cross section	943.1	+76.7,	-72.1

- Reconstructed Z line shape taken from NLO MC.
- The high purity sample assumed background-free,
  - we subtract the residual tiny background a posteriori.

Corr. matrix

NO.	GLOBAL	1	2	3	4
1	0.05441	1.000	0.052	0.042	-0.041
2	0.75267	0.052	1.000	0.600	-0.683
3	0.60553	0.042	0.600	1.000	-0.469
4	0.68686	-0.041	-0.683	-0.469	1.000

eff = 86.2% in data Vs. 86.7 % in MC

cross section after bkg subtraction

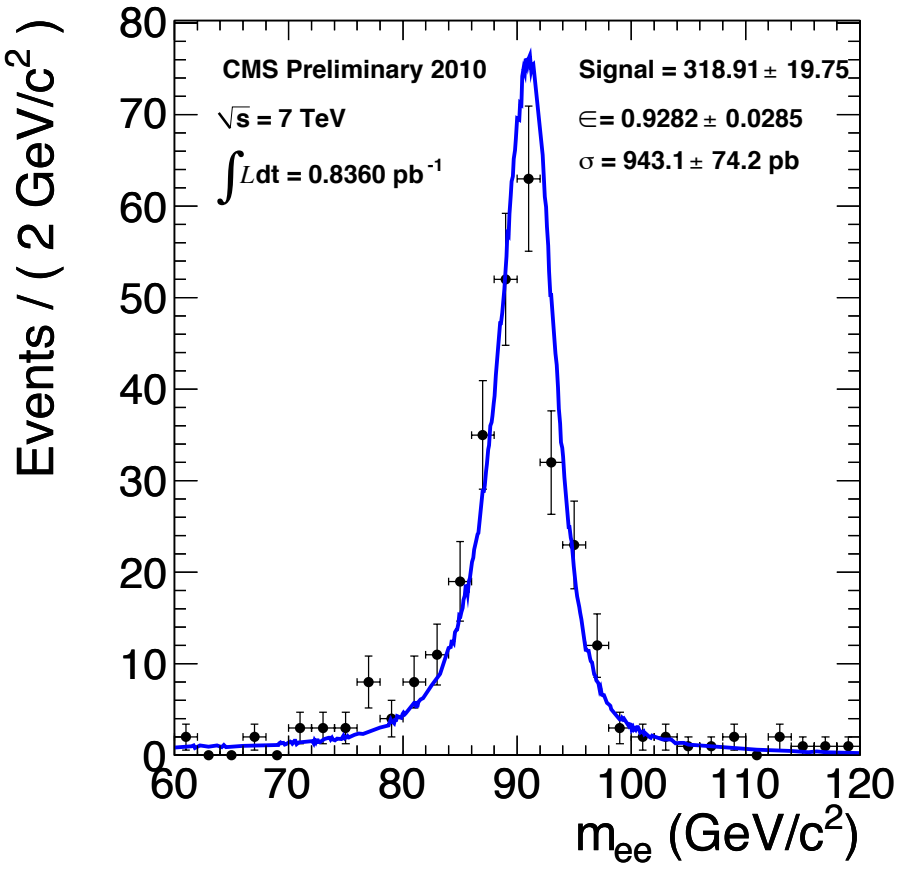
σ = 933.2 ± 74.1 (stat) ± 32.2 (syst) pb

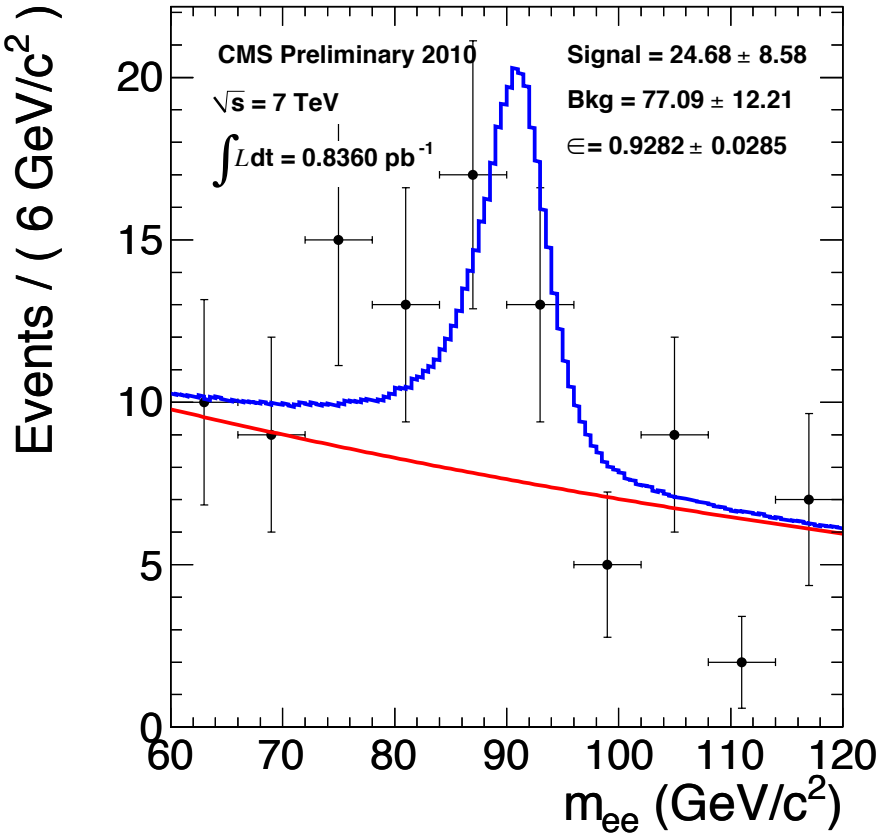
924.2 ± 54.4 ± 71.9 from simple counting

Small syst. uncertainty due to signal shape and $e^{\pm}$ energy scale yet to be included.
Also, working on improving some qualitative features of the fit.

Simultaneous fit now gives more precise result on cross section than simple counting !
The measurement is now gradually becoming systematics limited.

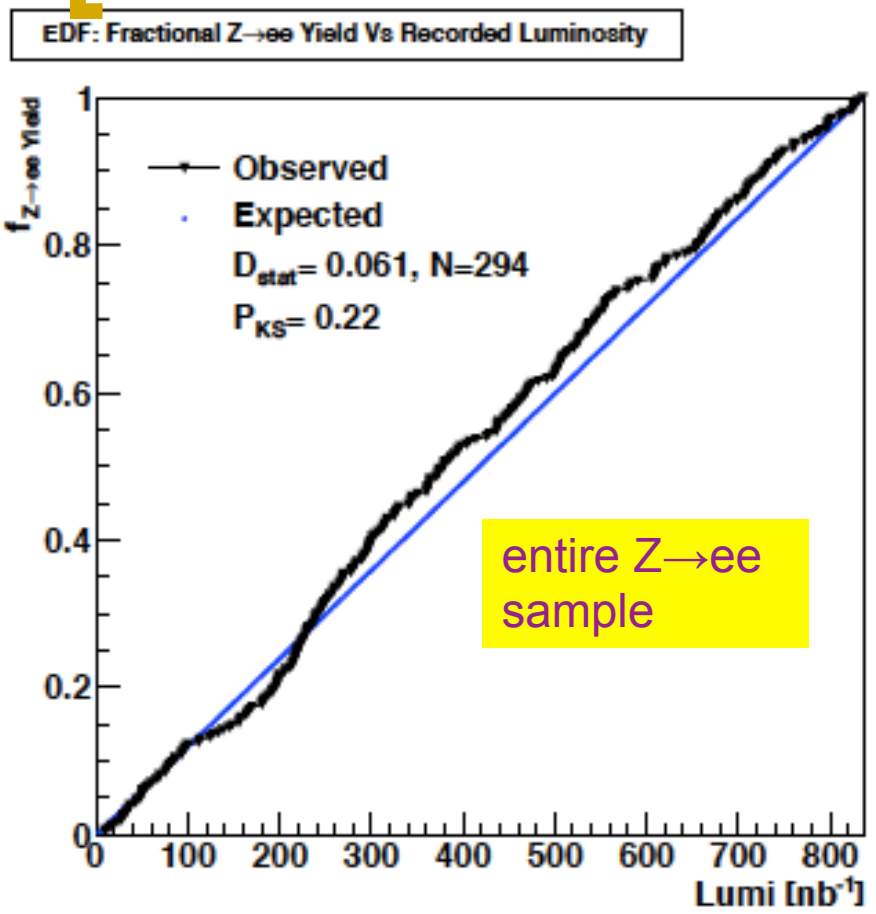
Simultaneous fit plots

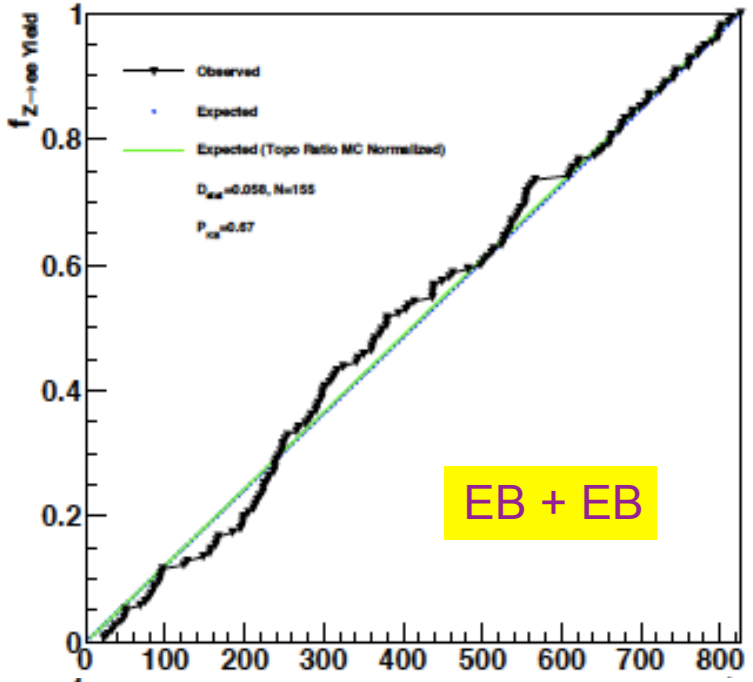


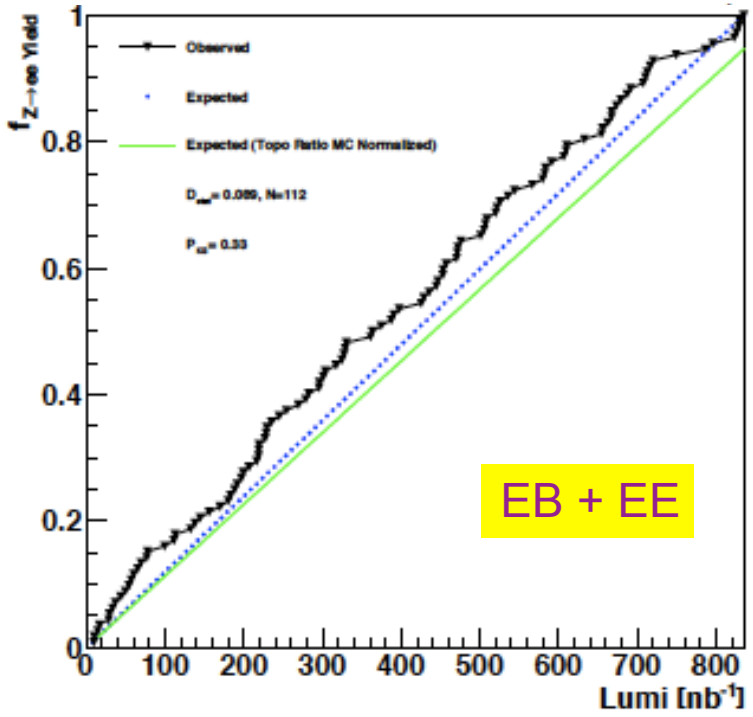


Result of the fit gives cross section and electron (reco⊗identification) efficiency directly from data.

Z→ee signal yield vs time







With more statistics now there is no evidence for any variation in Z signal yield with time.

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:

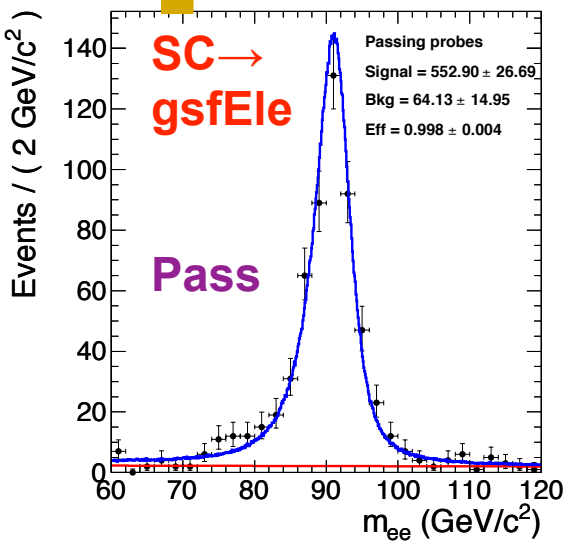
SuperCluster → GsfElectron → WP-95/WP80 → HLT

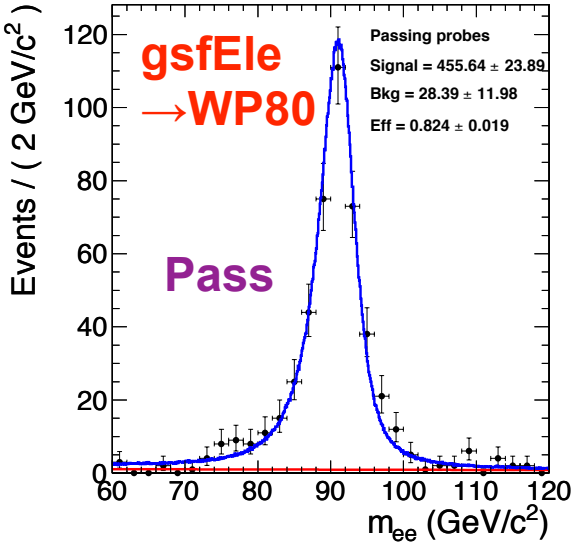
offline electron reconstruction efficiency with respect to acceptance

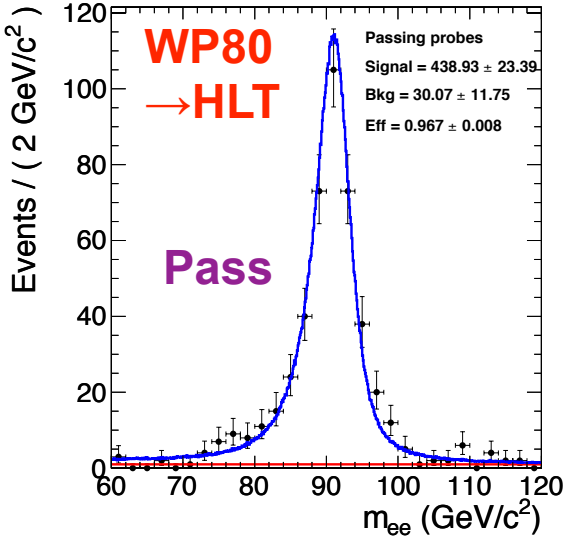
trigger efficiency w.r.t. offline selection

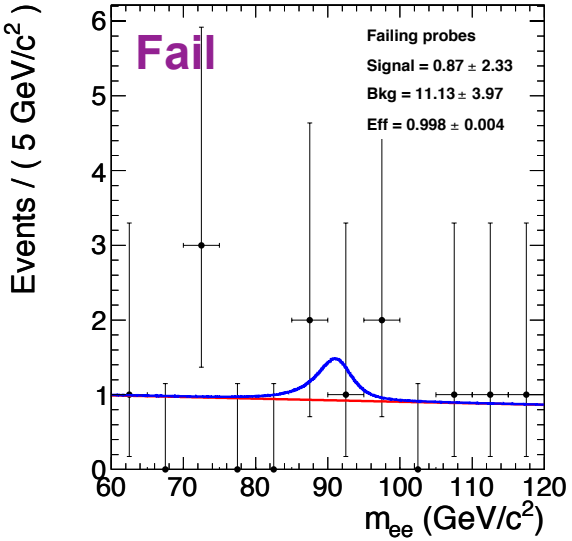
Compute each efficiency by performing simultaneous fit to passing and failing samples. The result of the fit gives efficiency and total # events.

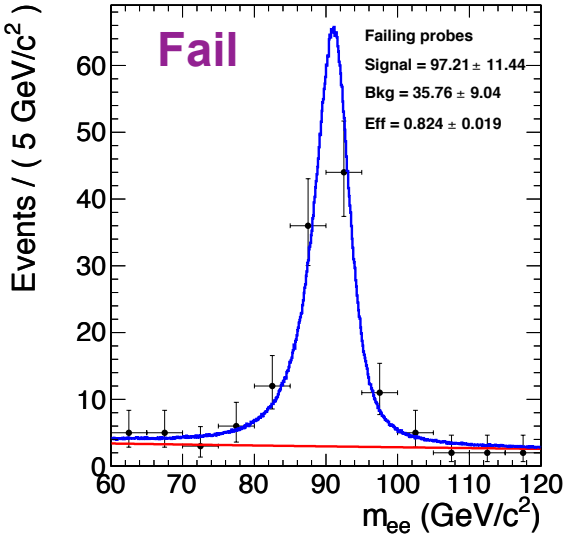
Simultaneous fit to passing and failing samples

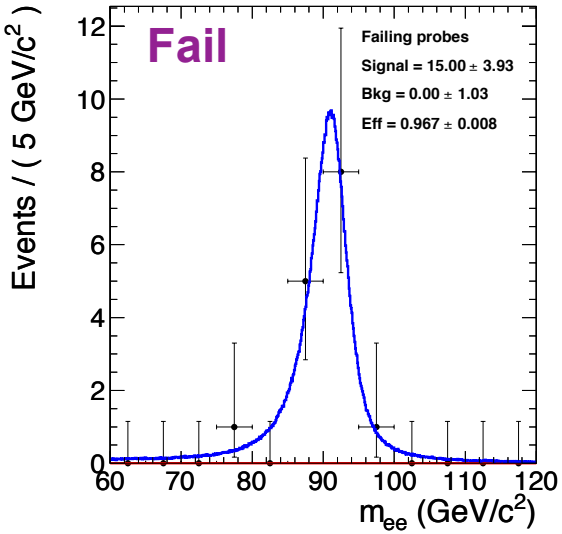












Data driven electron efficiency from Z

super cluster → gsfElectron

	Eff	σ_{stat}	N_{pass}	N_{fail}	MC
Total	99.8	0.4	552	1	98.6
Barrel	100.0	1.2	398	0	99.1
Endcap	98.6	1.3	154	2	97.4

gsfElectron → WP 95

Eff	σ_{stat}	N_{pass}	N_{fail}	MC
96.2	1.0	538	21	95.2
96.4	1.2	387	14	95.6
95.9	1.9	152	7	94.2

WP 95 → HLT

	Eff	σ_{stat}	N_{pass}	N_{fail}	MC
Total	97.2	0.7	518	15	98.6
Barrel	99.7	0.3	386	1	99.1
Endcap	90.4	2.5	132	14	97.4

gsfElectron → WP 80

Eff	σ_{stat}	N_{pass}	N_{fail}	MC
82.4	1.9	456	97	86.3
83.9	2.2	331	64	86.5
79.6	3.6	127	32	85.5

Except for WP80 efficiency, all other efficiencies are very close to MC expectation.

Summary

- PR plots: All look good
- Cross section measurement
  - Both simple counting and simultaneous fit performed
    - both give consistent results
    - in agreement with NLO predictions
- Status on specific topics
  - Z signal yield vs time: No significant variation observed
  - Electron energy scale: *ADC2GeV* scale is close to the ones obtained from π^0 and η. Can correct for it if needed.
  - Background subtraction: Work ongoing. Will be able to estimate residual background from data-driven techniques within 100% syst. uncertainty.
  - Electron efficiency: Efficiency in data is close to MC expectation. Detailed study using tag & probe ongoing.