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

Kalanand Mishra

Fermilab

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

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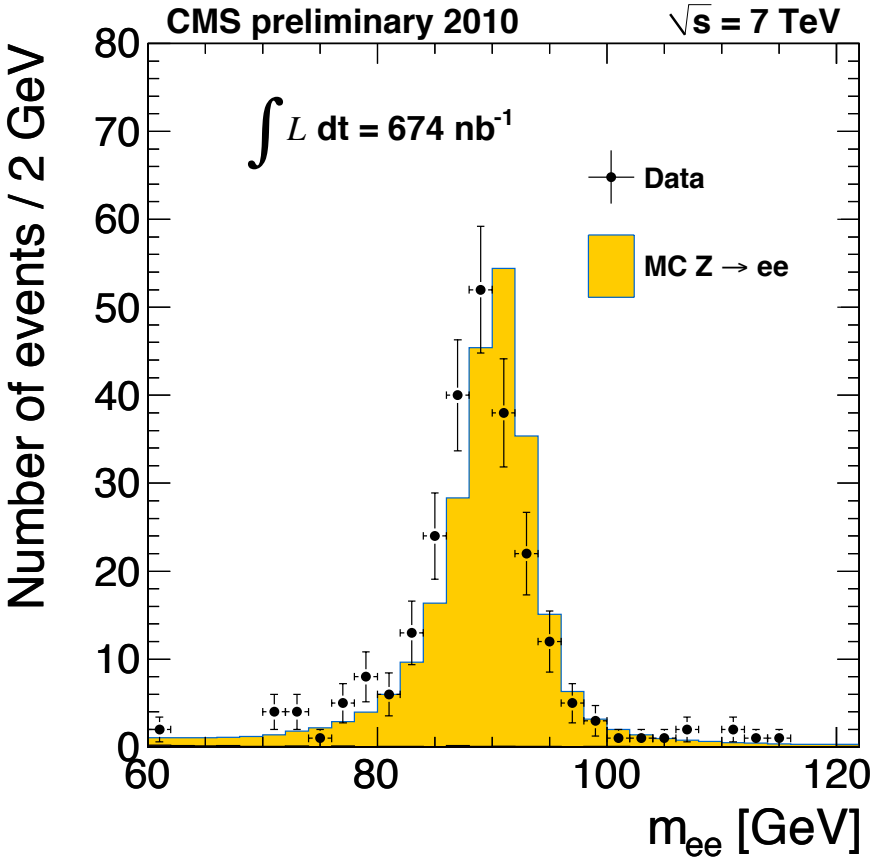
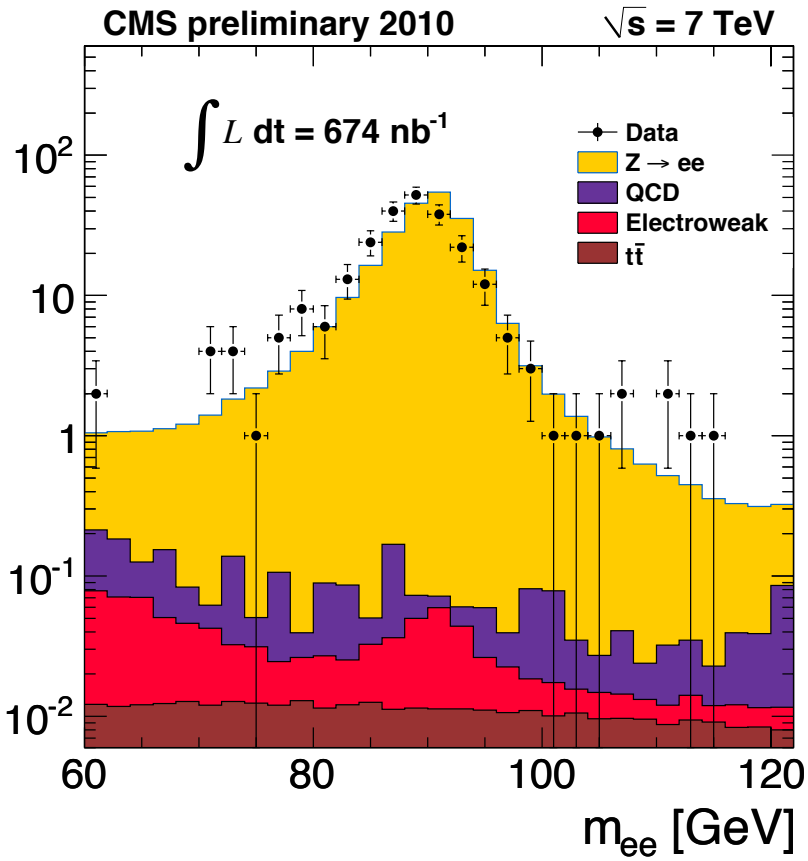
VBTF meeting

(August 13, 2010)

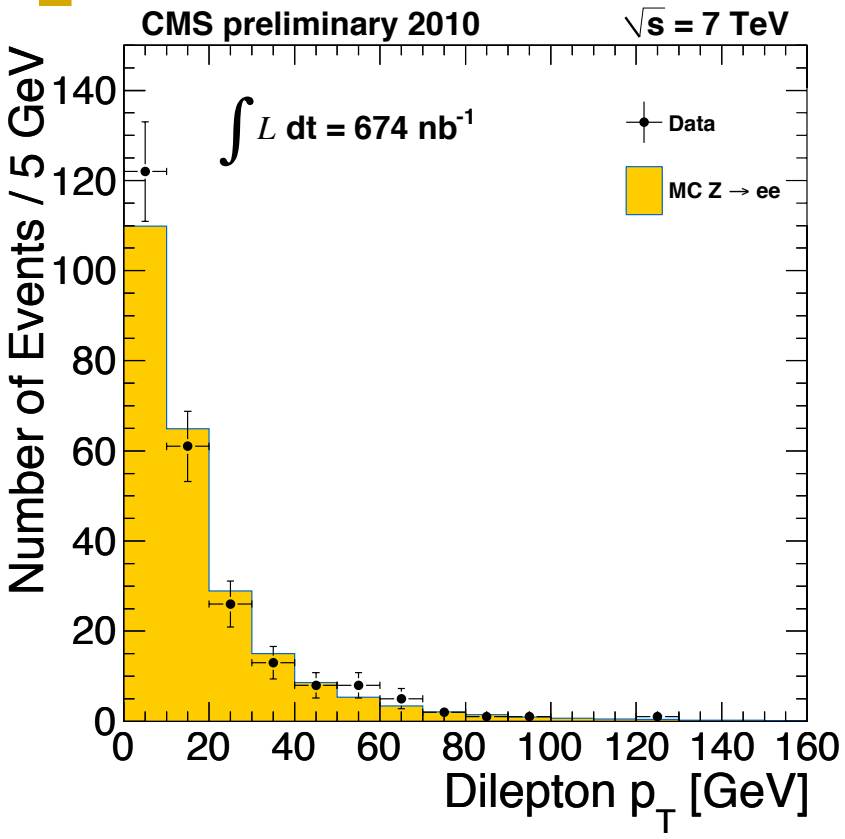
Z→ee snapshot at 674 nb^{-1}

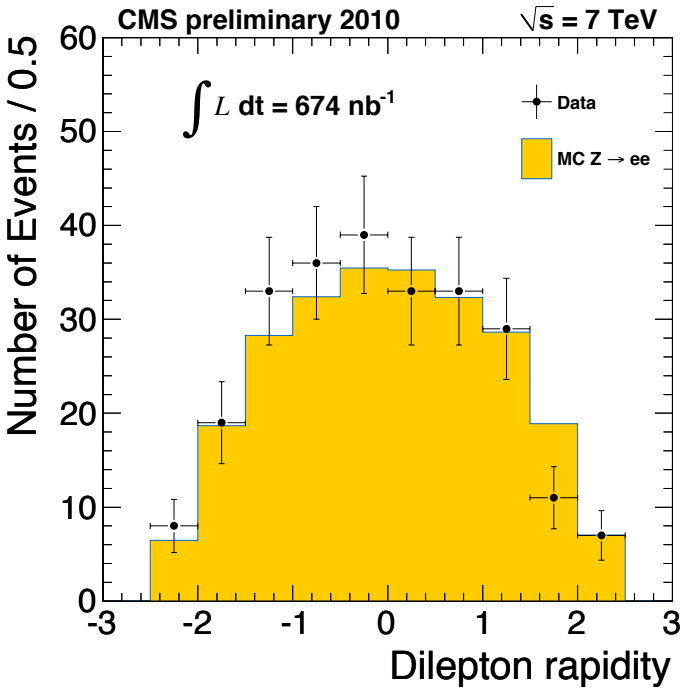
- Using Michele's private JSON good run list.
  - ➜to be superseded by today's official JSON from DQM
- Have ~250 golden Z→ee candidates.

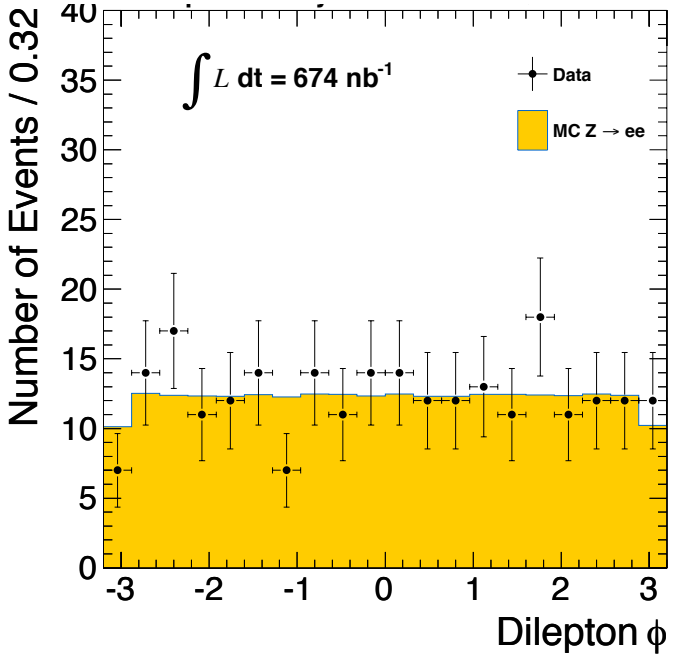




Z p_T, rapidity, azimuth

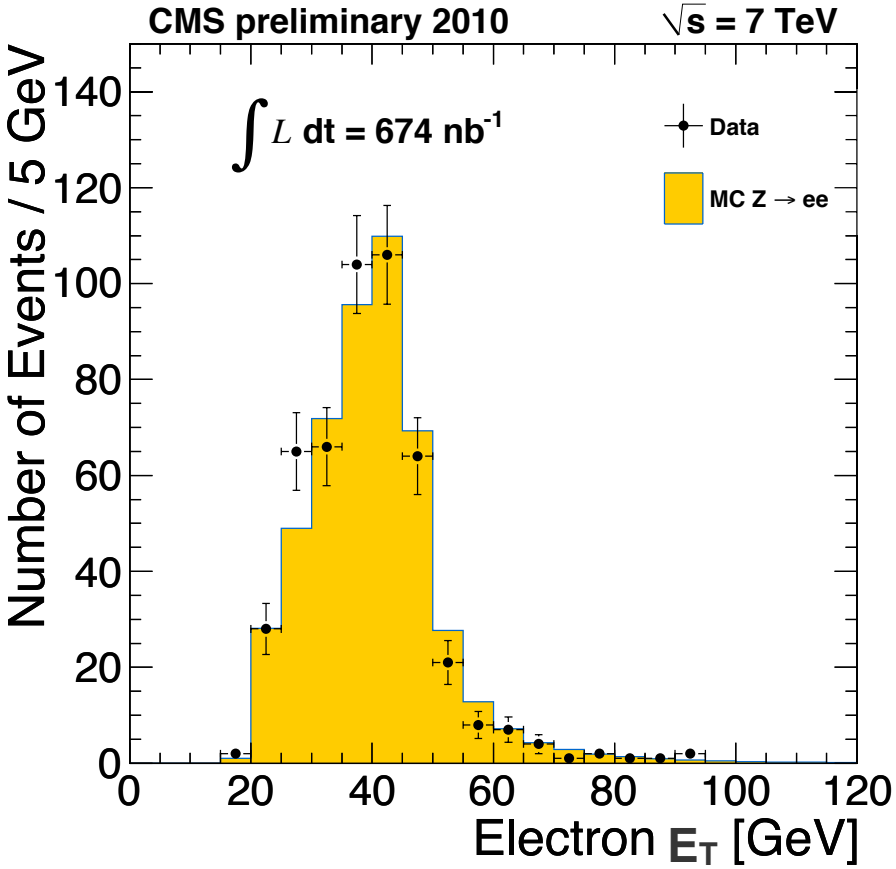


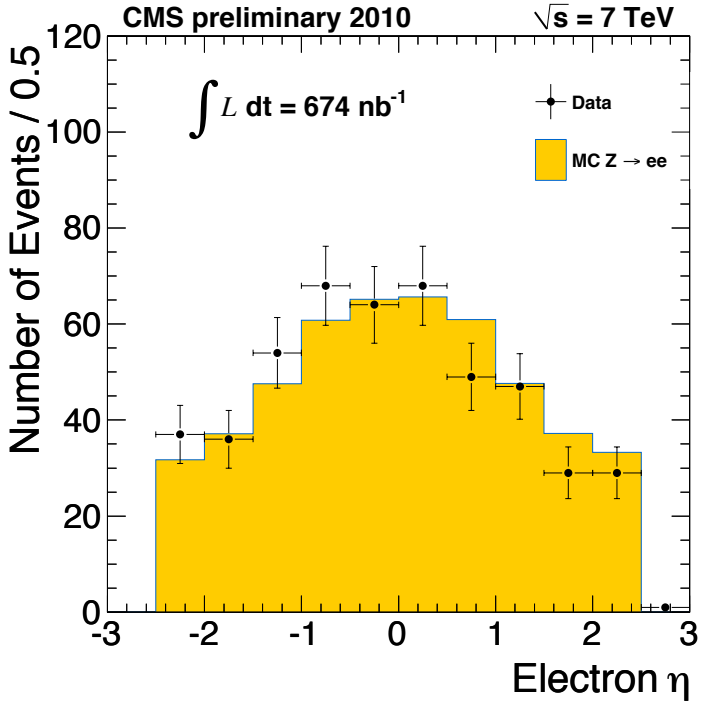


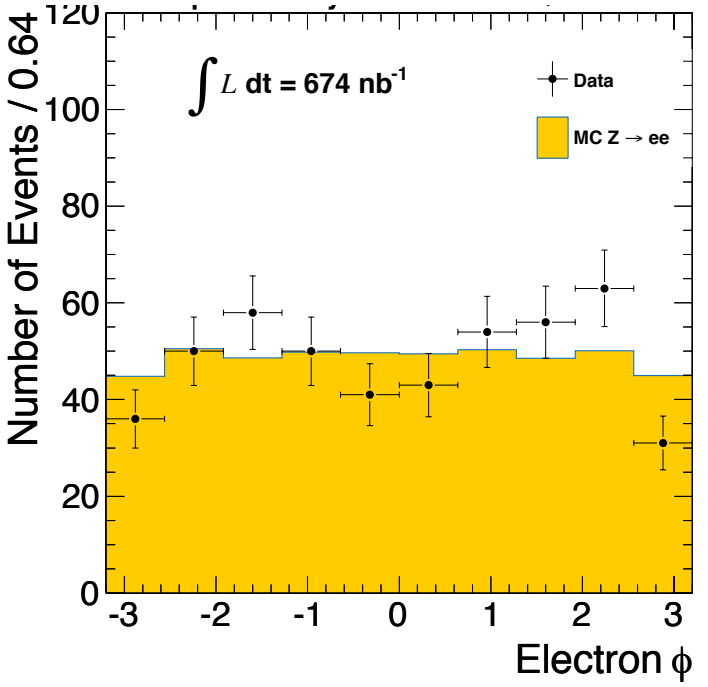


✦Distributions look very similar to NLO prediction.

Electron P_T, rapidity, azimuth

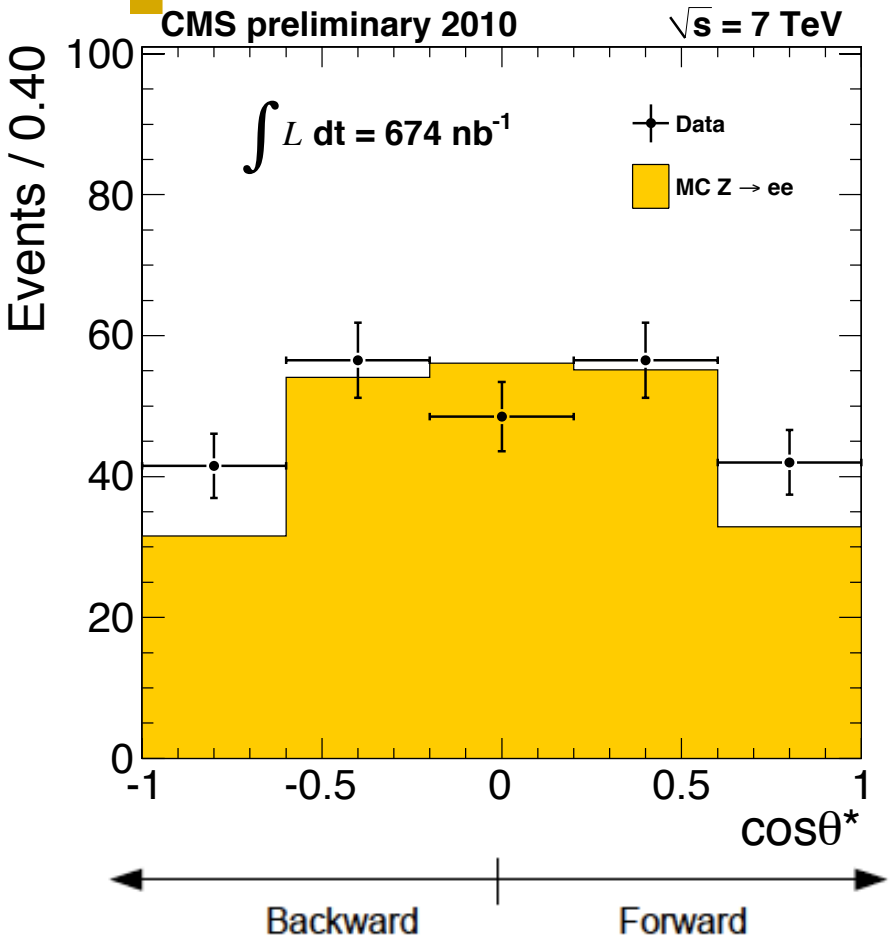




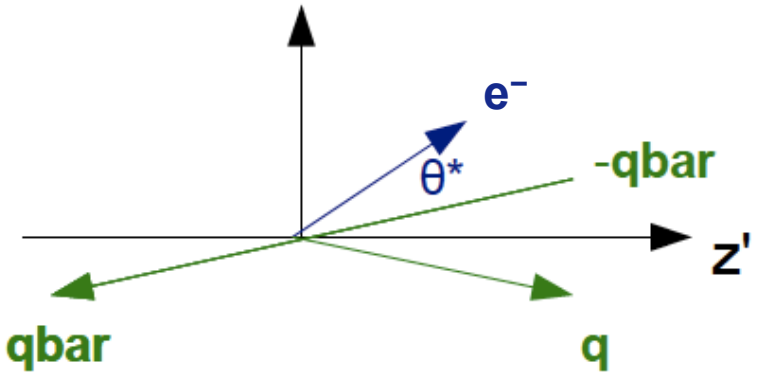


✦Perhaps an indication of small residual misalignment in ϕ.

Z production topology: cosine θ*



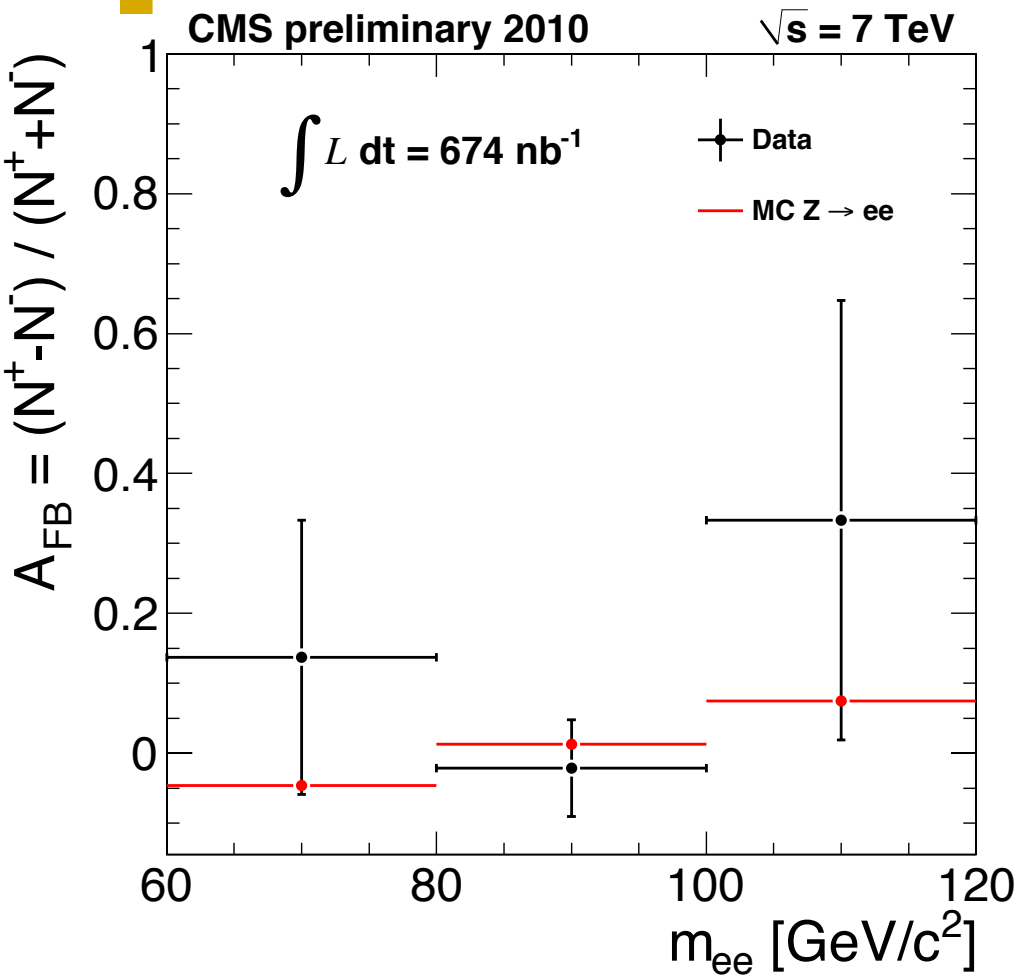
Collins–Soper frame



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→ee cross section using $\int L = 674\ nb^{-1}$

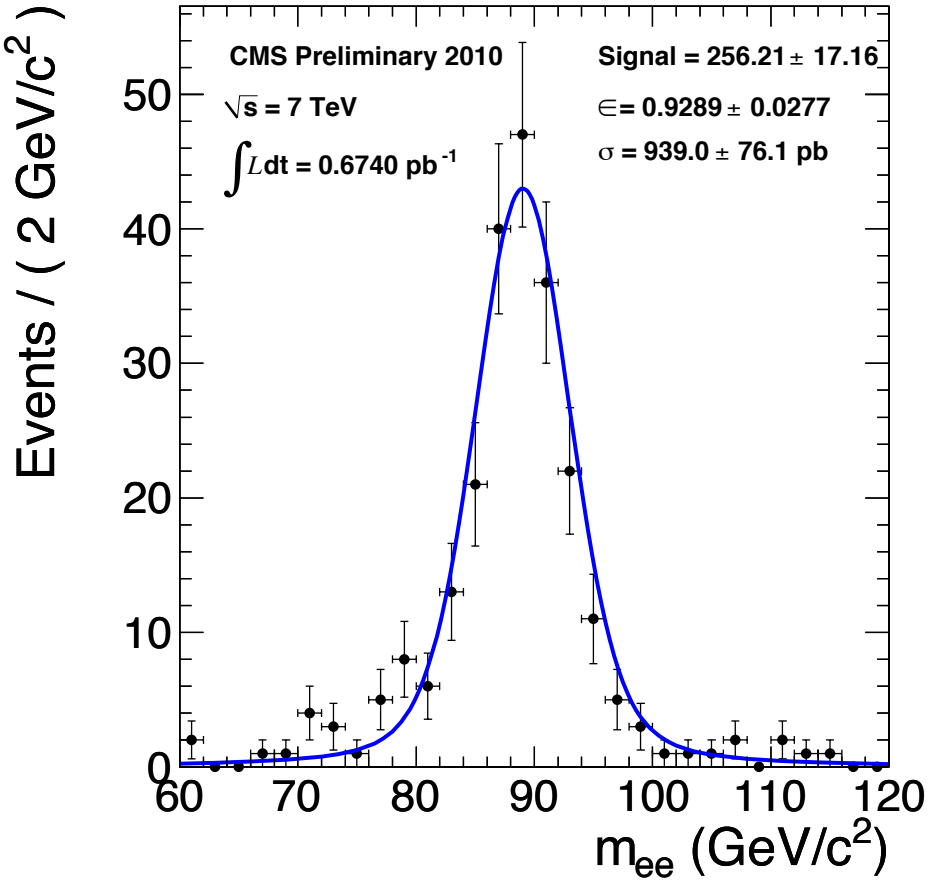
$N_{selected}$	252 ± 16
N_{bkgd}	2.5 ± 0.5 (from MC)
ε Acceptance Integrated Luminosity	0.8671 ± 0.0023 (MC stat.) ± 0.0867 (syst.) 0.4357 ± 0.0010 (MC stat.) ± 0.0131 (syst.) 0.674 ± 0.074 pb^{-1} (syst.)
$\sigma_{\gamma^*Z} \times BR(\gamma^*Z \to e^+e^-)$	979.8 ± 62.3 (stat.) + 58.0 (syst.) + 108.8 (lumi.)
Theoretical prediction	LO: 740 pb, NLO: 911 pb ($60 < m_Z < 120\ GeV$) LO: 1300 pb ($m_Z > 20\ GeV$), NLO: 1607 pb ($m_Z > 20\ GeV$)

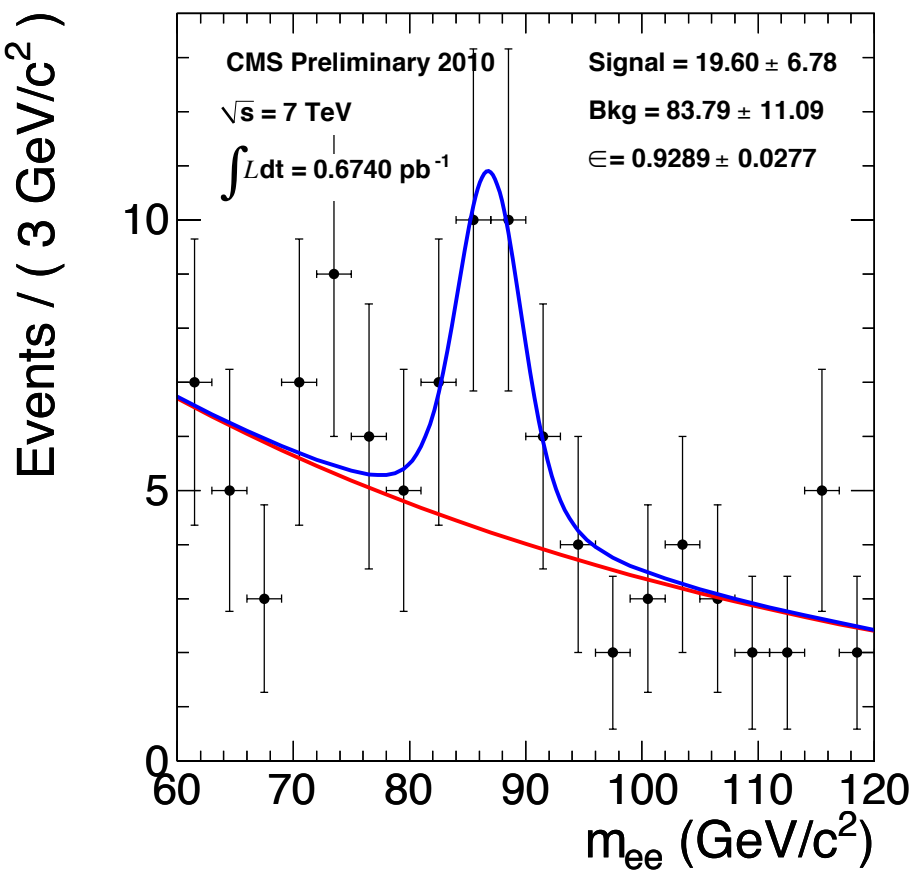
Acceptance = 44% ← from MC
Efficiency = 87 %
Cross section = 980 ± 62 pb ← our result
NLO prediction = 911 pb

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

Working on several data-driven background methods. On later slides.

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	89.03	+0.32, -0.33
2 Mean TF	86.86	+1.40, -1.52
3 Resolution	3.48	+0.39, -0.36
4 Resolution TF	2.28	+1.94, -0.00
5 TF Bkg Expo	-0.017	+0.006, -0.007
6 Efficiency	0.929	+0.026, -0.029
7 TF nBkg	83.8	+11.5, -10.7
8 Cross section	939.0	+79.3, -73.5

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

σ = 929.6 ± 79.3 (stat) ± 29.4 (syst) pb

979.8 ± 62.3 ± 58.0 from default method

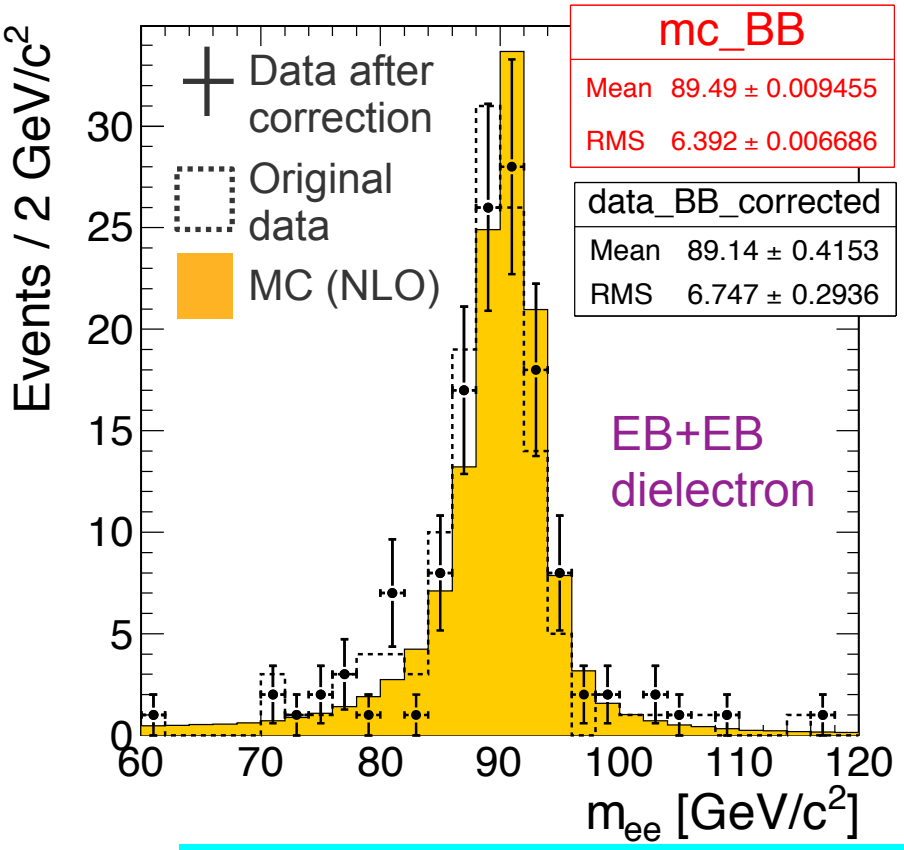
Corr. matrix

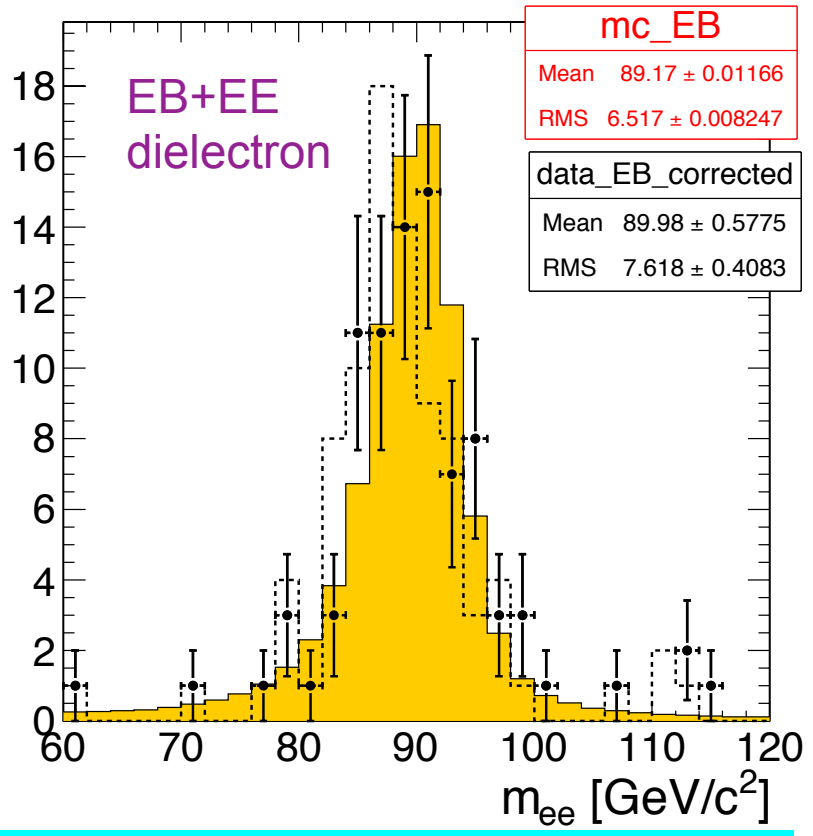
NO.	GLOBAL	1	2	3	4	5	6	7	8
1	0.17742	1.000	0.000	-0.177	0.000	0.000	0.000	0.000	0.000
2	0.18679	0.000	1.000	0.000	0.147	0.104	-0.095	-0.065	0.070
3	0.17742	-0.177	0.000	1.000	0.000	0.000	0.000	0.000	0.000
4	0.43468	0.000	0.147	0.000	1.000	-0.015	-0.405	-0.280	0.298
5	0.12039	0.000	0.104	0.000	-0.015	1.000	0.048	0.033	-0.035
6	0.69518	0.000	-0.095	0.000	-0.405	0.048	1.000	0.461	-0.614
7	0.47665	0.000	-0.065	0.000	-0.280	0.033	0.461	1.000	-0.340
8	0.61951	0.000	0.070	0.000	0.298	-0.035	-0.614	-0.340	1.000

Simultaneous fit now gives more precise result on cross section than our default method !

Z mass shift: Egamma prescription gets it right

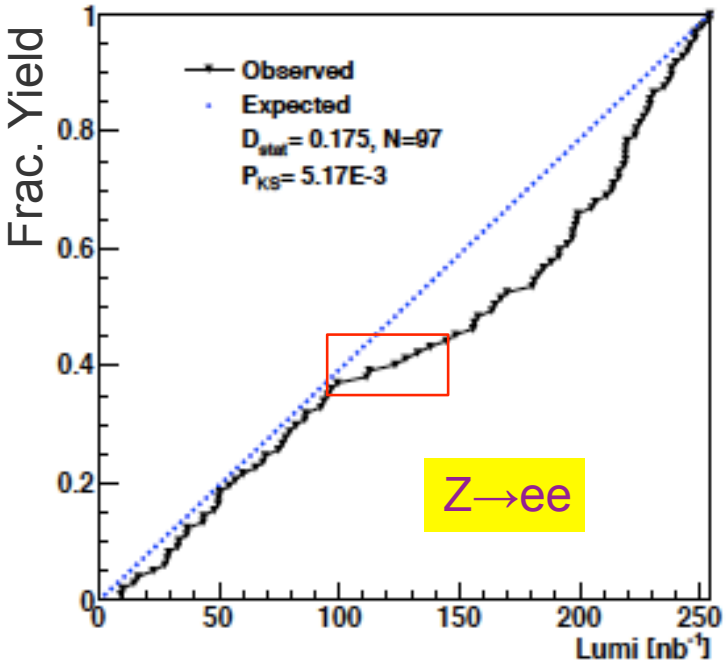
- Start with the WP95+WP95 invariant mass distribution in data
- Scale up electron energy by 0.7% in barrel and 2.5% in endcaps. [*Egamma* reco.]
- Get very good agreement between data and MC after this correction !

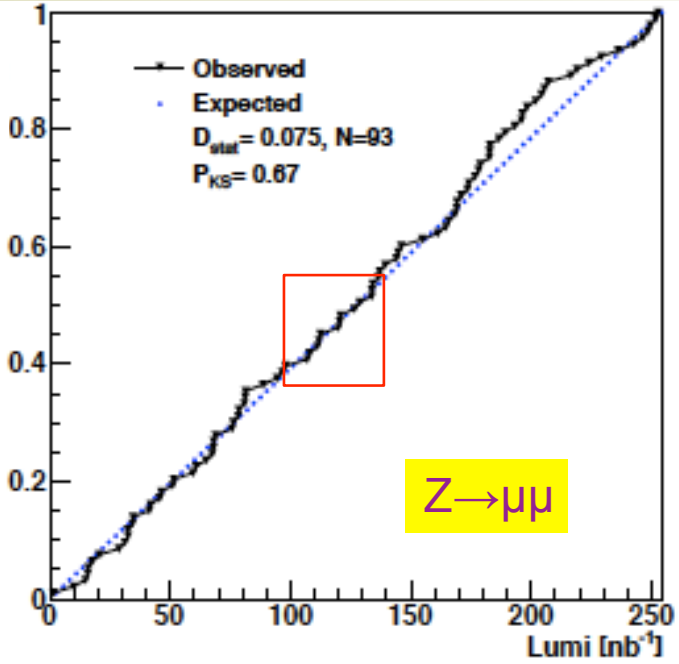




Question: Should we apply this correction to electron energy from now onwards by default ?

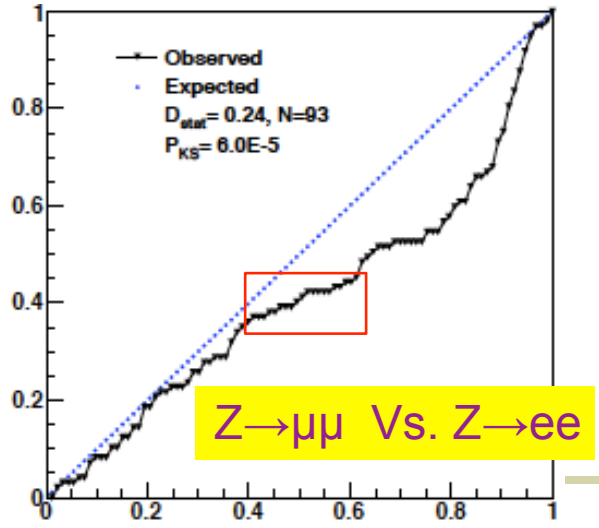
Z→ee signal yield vs time

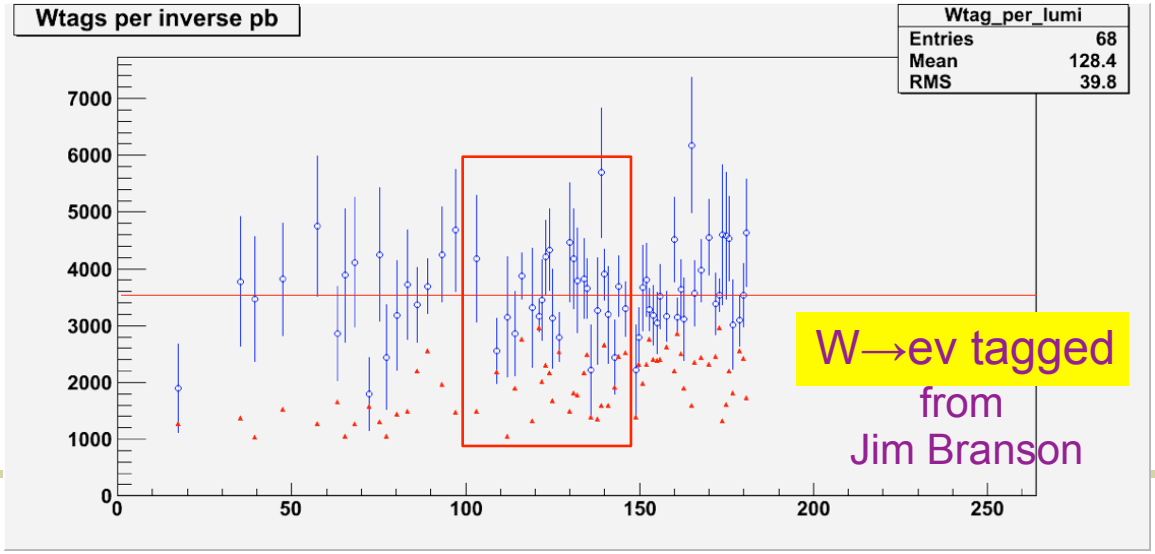




A downward fluctuation in Z→ee yield in a quantile of data, but caught up soon afterward.

Now this monitoring is part of our workflow.





Attempt at data-driven fake rate estimation

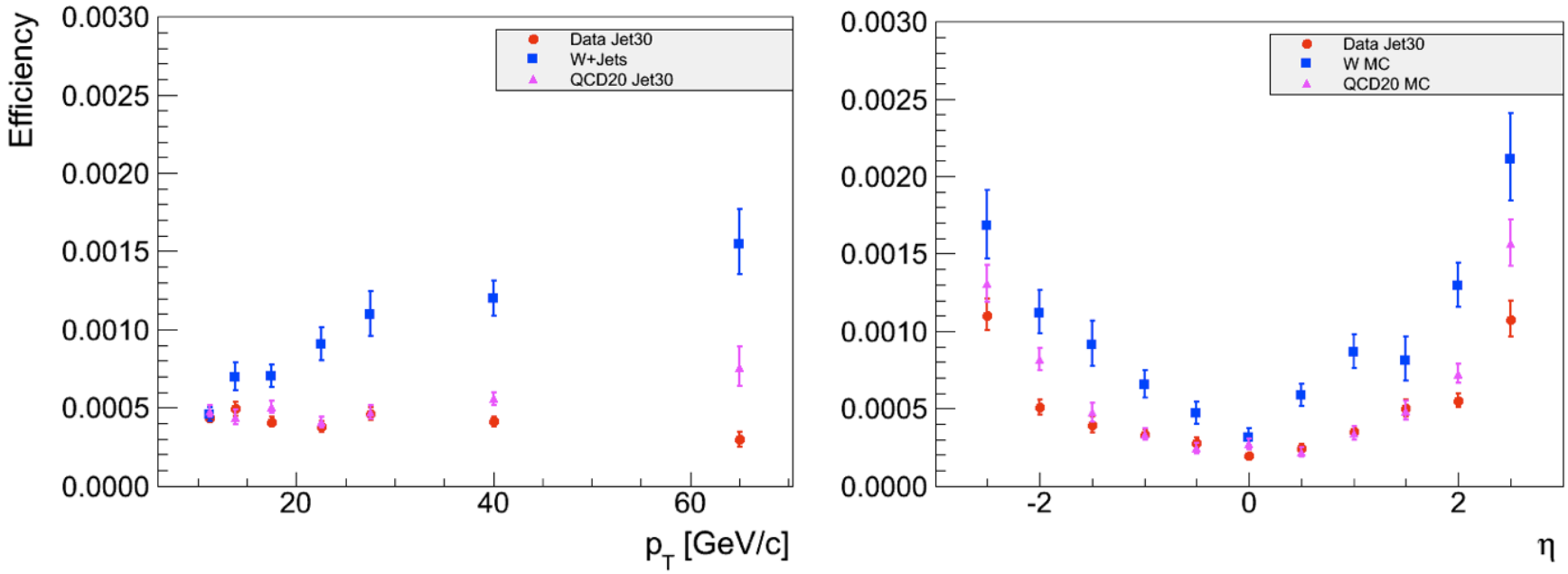
[from Si Xie]

jet →WP95 fake rate

- Measurement is performed with HLT_Jet30U trigger sample
- Measure ε_{fake} as a function of p_T and η

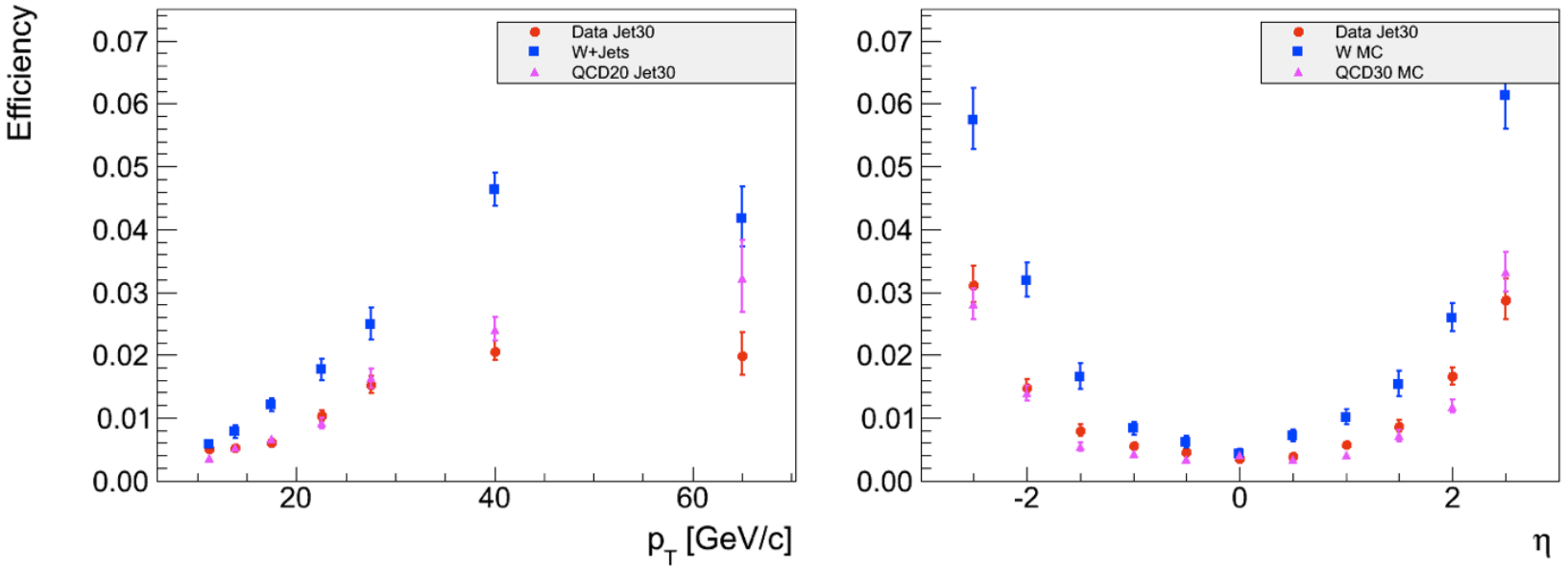
Will also try Jet15 trigger – to closely match the bkg kinematics

- **AntiKt 0.5 CaloJet -> VBTF95 fake rate :**
  - Denominator Definition: AntiKt 0.5 CaloJet
  - Numerator: VBTF 95% Working Point Electron ID+Isolation
  - Veto the leading trigger jet (remove any bias due to trigger requirements)



Reco electron→WP95 fake rate

- **Reco -> VBTF95 fake rate :**
  - Denominator Definition: ECAL Driven Reco Electrons
  - Numerator: VBTF 95% Working Point Electron ID+Isolation
  - Veto any electron candidates matching to the leading trigger jet (remove any bias due to trigger requirements)



- Agreement between QCD MC and Jet data is excellent
- W+Jets fake rate is a factor of 2-3 higher. (under investigation)

There are fewer W+jets & γ+jet background events, so this may not be a big problem.

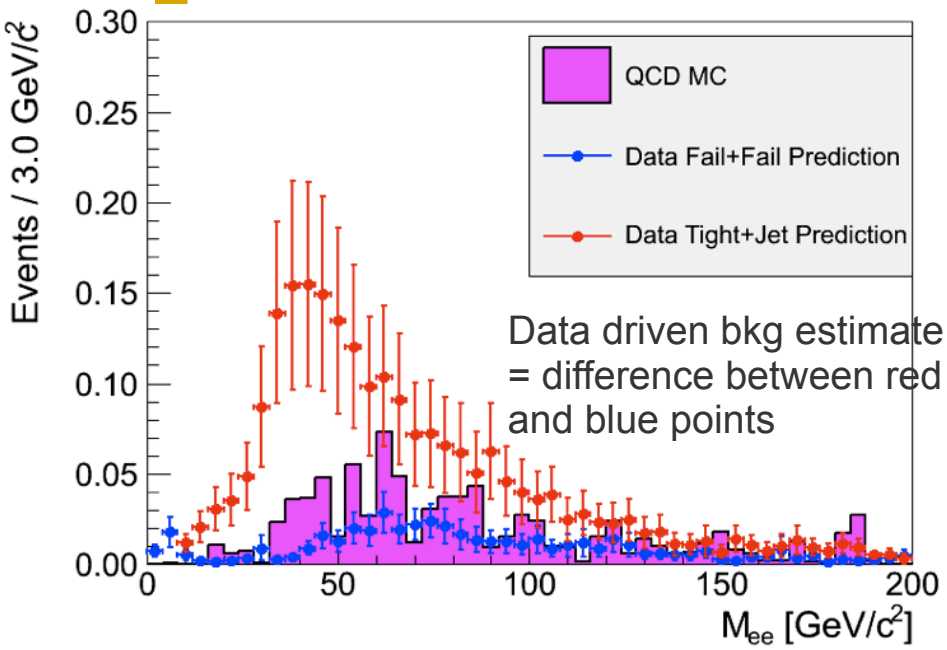
Methodology for background prediction

- Loose + Loose prediction
  - Select all loose+loose pairs, both failing the tight electron selection
  - Assign weight = fake rate electron1 * fake rate electron2
  - Predicts the QCD bkg.
  - Assumes both candidates are jets faking electrons, therefore ignores W+Jets & Photon+Jets bkg

- Tight + Jet prediction
  - Select all tight+jet pairs
  - Assign weight = jet -> electron fake rate
  - Predicts W+Jets & Photon+Jets bkg
  - Double counts the QCD bkg where both electrons are fake

- Final prediction = Tight+Jet prediction – Loose+Loose prediction
  - Tight+Jet prediction double counts QCD, but we subtract it using the Loose+Loose prediction

Background prediction in data: 200 nb^{-1}



Data driven bkg estimate = difference between red and blue points

Prediction Inside Z Mass Window

- Tight+Jet Prediction: 0.84 +- 0.35
- Loose+Loose Prediction: 0.25 +- 0.11
- **Final Prediction: 0.59 +- 0.37**
- Simulation Prediction: 0.42 +- 0.07

Signal contamination

- Tight+Jet:

Total Data :	2139
Expected Signal :	21.7 +- 0.06
Total Bkg Prediction :	0.84 +- 0.35
Expected Signal Contamination:	0.009 +- 0.004

1% signal contamination

- Loose+Loose:

Total Data :	1024
Expected Signal :	0.3 +- 0.01
Total Bkg Prediction :	0.25 +- 0.11
Expected Signal Contamination:	8e-5 +- 3e-5

Negligible signal contamination