Photon Efficiency Measurement Using Z Tag & Probe

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Introduction

- We have measured the efficiencies of different photon selections using the Z Tag and Probe method:
  - e.g. EGM-10-006, QCD-10-019...
- The very same methods will be used with electrons:
    - Electron Identification and Reconstruction efficiencies...
- We have compared and checked the consistency of the results obtained using three different methods:
  - Counting, Fit, Opposite Sign – Same Sign
- The results of this study are documented in the following analysis notes:
  - Electrons: CMS AN-2010/291 (in progress),
  - Photons: CMS AN-2010/292 (v6 is going to be uploaded)

Selection and Samples

- Numbers for different photon selections have been measured:
  - Egamma Loose/Tight, "Exotica", photon selection for H->γγ...
  - the following results refers to the "Exotica" selection:
    - σiηiη < 0.013 (0.03), H/E < 0.05
    - TkIso < 2.0 + 0.001*ET, ECALIso < 4.2 + 0.006*ET
    - HCALIso < 2.2 + 0.0025*ET
- Meaurements have been carried on using ~35 pb^{-1} of data using CMSSW_3_8_X.
- The MC samples used are:
  - Zee, Wenu, QCD_enriched, bc_to_e, Photon+Jet.

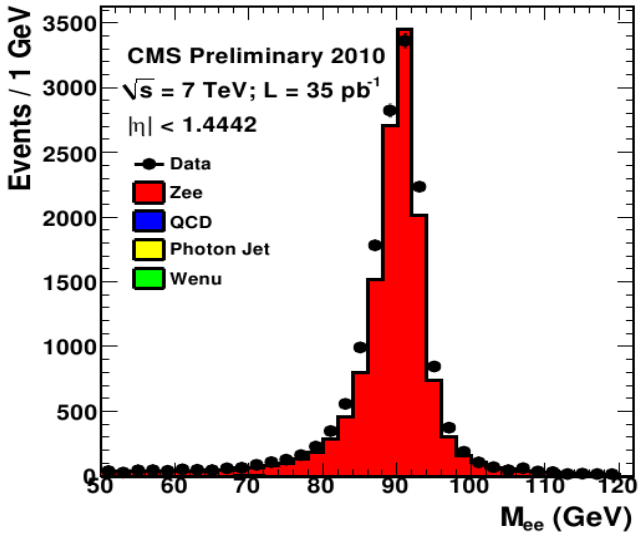
Counting (Overview)

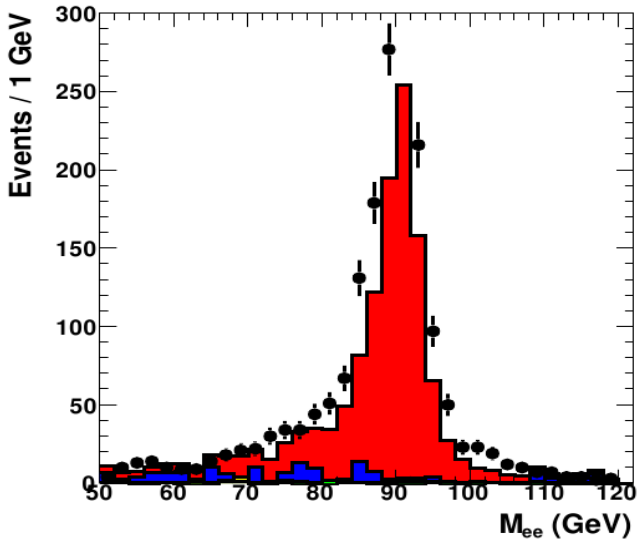
- Tag and Probe definitions:
  - Tag: CiC SuperTight electron with SC ET > 20 GeV
  - Probe: SC ET > 20 GeV
- To reduce the final uncertainty we have used factorization:
  - split the selection into two sets of cuts ($\sigma_{i\eta i\eta}$ + H/E – isolations):
    - compute ε counting events and performing MC bg subtraction
  - Combine partial efficiencies and correct for possible correlations: ($\varepsilon^{MC}_{TOT} - \varepsilon^{MC}_{fact}$)
- Statistical errors are binomial.
- Systematics: uncertainty on the background assumed 100% plus 50% of the estimated correlation between the measurements.

Counting (Isolation)

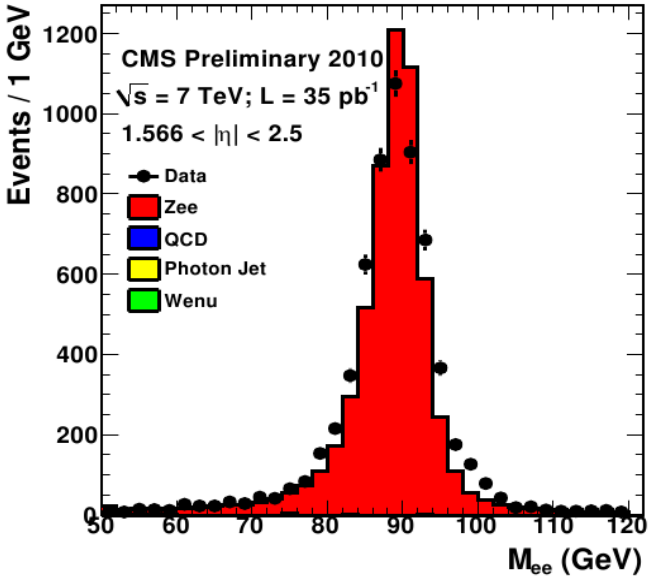
PASSING **FAILING**

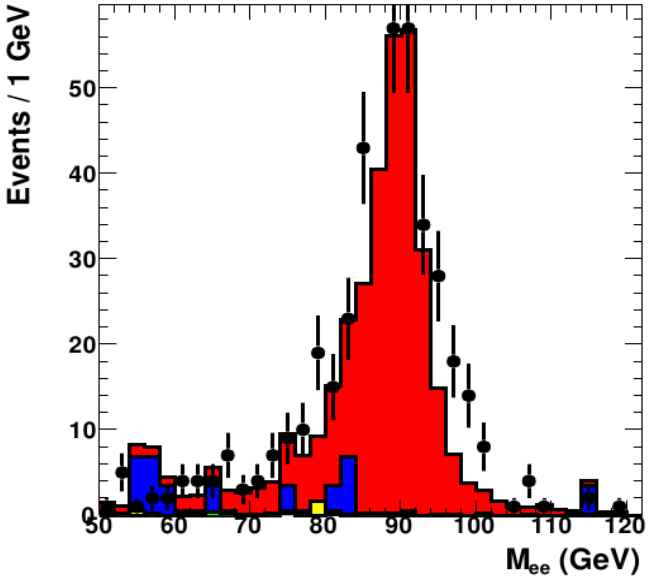
BARREL





ENDCAP





Electron energy scaled to match MC.

Counting (Results)

E_T	MC	DATA	R (DATA/MC)
Barrel			
20 - 35	86.97 ± 0.16 %	$86.49 \pm 0.45 \pm 1.95$ %	0.995 ± 0.023
35 - 45	92.21 ± 0.11 %	$90.05 \pm 0.33 \pm 0.16$ %	0.977 ± 0.004
45 - inf	93.61 ± 0.13 %	$90.98 \pm 0.43 \pm 0.02$ %	0.972 ± 0.005
Endcap			
20 - 35	88.54 ± 0.22 %	$88.28 \pm 0.55 \pm 1.07$ %	0.997 ± 0.014
35 - 45	93.20 ± 0.16 %	$92.36 \pm 0.49 \pm 0.35$ %	0.991 ± 0.007
45 - inf	94.94 ± 0.20 %	$94.18 \pm 0.62 \pm 0.16$ %	0.992 ± 0.007

Results available also as a function of eta, fBrem and R9.

Fit (Overview)

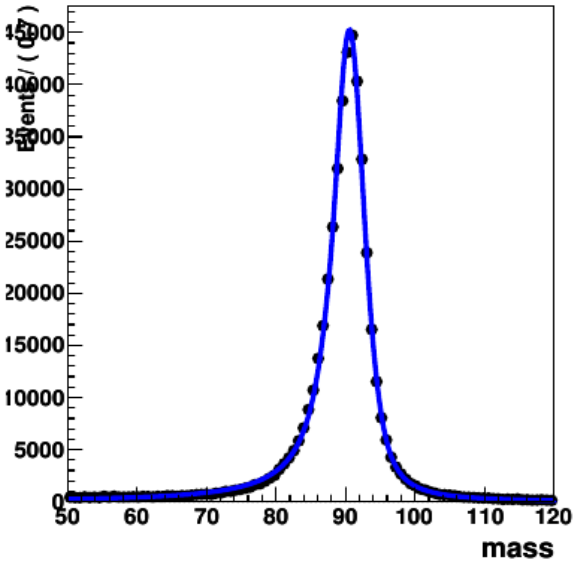
- Take signal shape from MC for passing and failing events:
  - Breit-Wigner (x) Modified Crystall-Ball (https://twiki.cern.ch/twiki/bin/view/CMS/ElectronTagAndProbe)
- Performed extended likelihood fit to data with signal + exponential (background) PDF:
  - tail parameters of signal PDF fixed from MC,
  - get signal and background yields from the fit.
- Systematics:
  - Background: tried different PDF for the background,
  - Energy scale: vary electron energy (by current energy scale uncertainty) and compute corresponding efficiency,
  - Signal: change tail of the PDF and check the contribution.

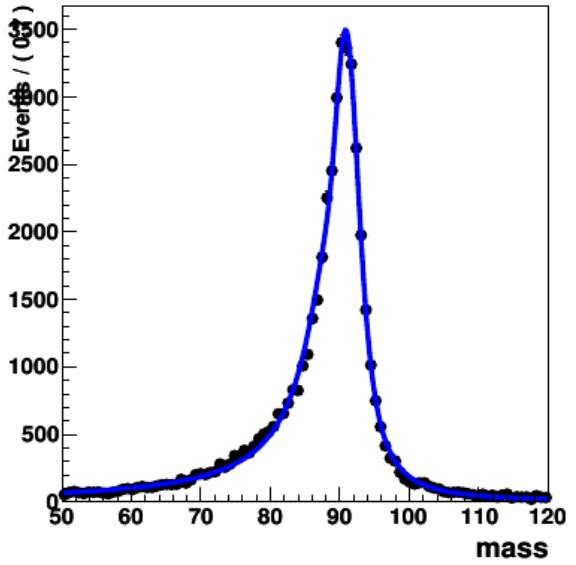
Fit MC signal only (PDF)

PASSING

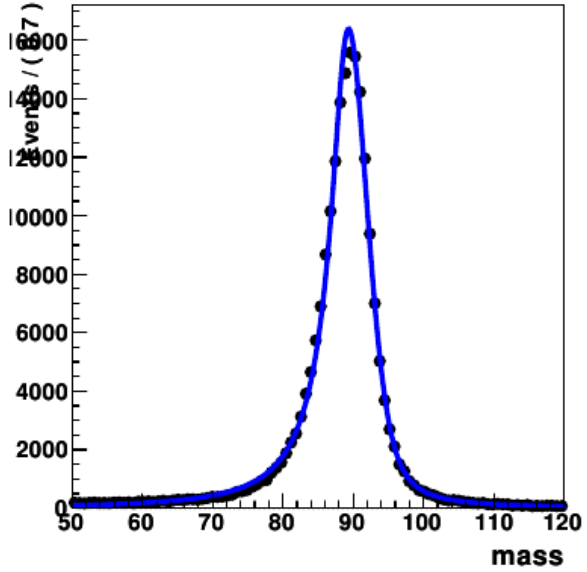
FAILING

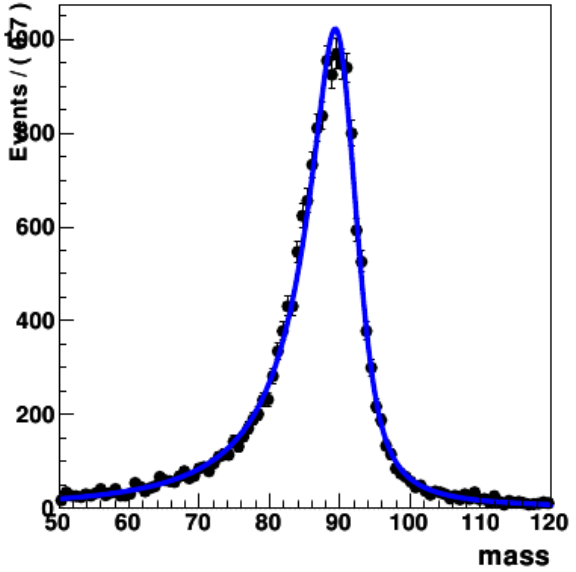
BARREL





ENDCAP



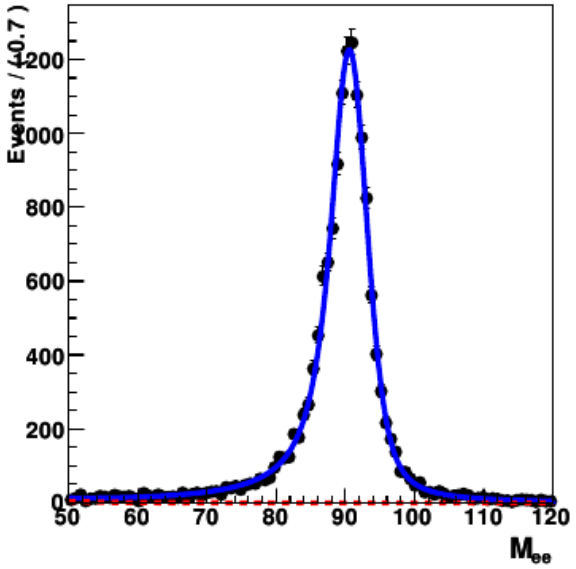


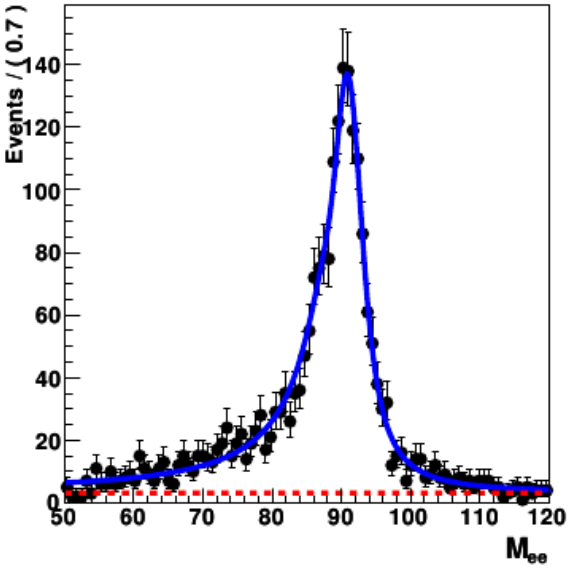
Fit (DATA)

PASSING

FAILING

BARREL





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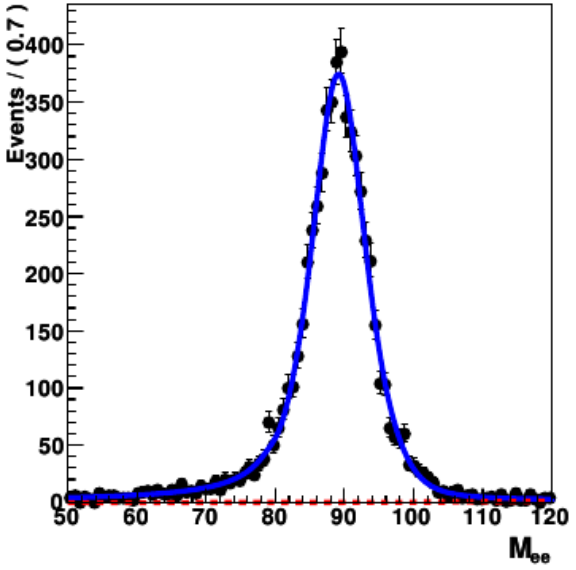
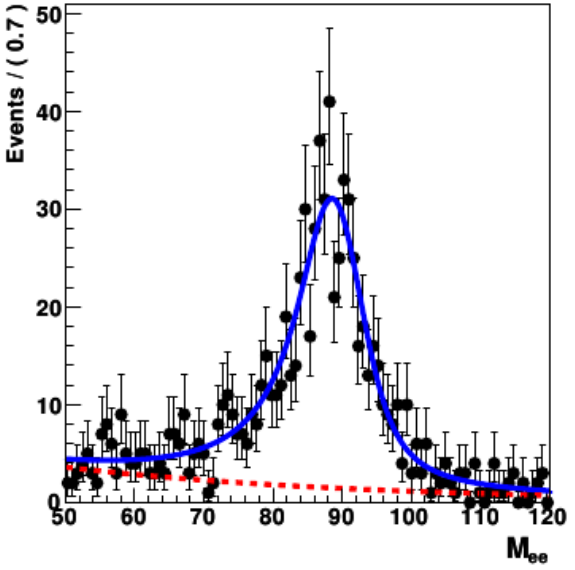




Fit (Results)

- No factorization is involved here, it has to be checked if factorization could help in reducing uncertainty.

E_T	**MC**	**DATA**	R (DATA/MC)
Barrel			
20 - 35	86.97 ± 0.16 %	$82.23 \pm 1.14 \pm 1.58$ %	0.945 ± 0.022
35 - 45	92.21 ± 0.11 %	$89.54 \pm 0.43 \pm 0.55$ %	0.971 ± 0.008
45 - inf	93.61 ± 0.13 %	$90.77 \pm 0.52 \pm 0.82$ %	0.970 ± 0.010
Endcap			
20 - 35	88.54 ± 0.22 %	$88.89 \pm 1.60 \pm 3.44$ %	1.004 ± 0.043
35 - 45	93.20 ± 0.16 %	$90.99 \pm 0.56 \pm 0.43$ %	0.977 ± 0.008
45 - inf	94.94 ± 0.20 %	$93.42 \pm 0.10 \pm 0.95$ %	0.984 ± 0.010

Results available also as a function of eta, fBrem and R9.

OS/SS (Overview)

- Given the number of OS and SS passing and failing events, the signal can be extracted from the following formula:

$$N = \frac{(N_{OS} - N_{SS})}{(1-2q)^2} - (B_{OS} - B_{SS})$$

  - q = charge mis-id (different for passing and failing events), taken from MC (for failing event can be hardly determined from data)
  - B_{OS} and B_{SS} number of OS/SS background events.

- Systematics:
  - Background events: 100% * ($B_{OS} - B_{SS}$)
  - Charge mis-id: assumed 50% error

	Passing	Failing
Barrel		
0 - 0.5	0.34%	0.98%
0.5 - 1.0	0.45%	1.25%
1.0 - 1.4442	0.81%	1.83%
TOT	0.52%	1.24%
Endcap		
1.566 - 1.8	1.87%	2.82%
1.8 - 2.1	2.00%	2.72%
2.1 - 2.5	2.67%	3.85%
TOT	2.21%	3.07%

OS/SS (Results)

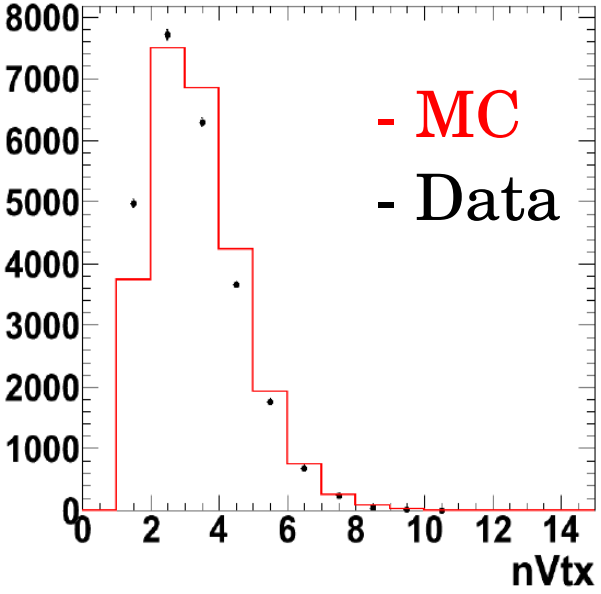
- No factorization is involved here, it has to be checked if factorization could help in reducing uncertainty.

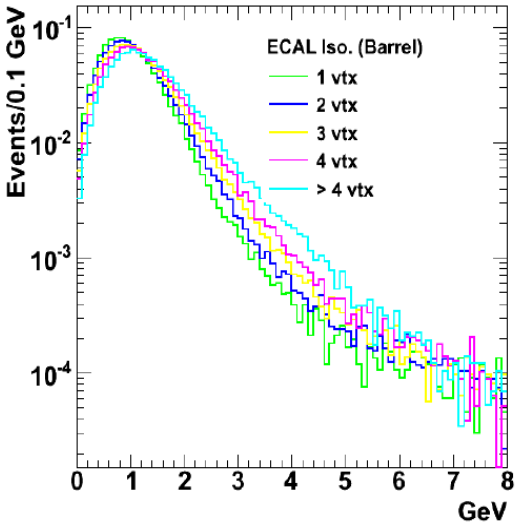
E_T	**MC**	**DATA**	R (DATA/MC)
Barrel			
20 - 35	86.97 ± 0.16 %	$86.22 \pm 0.48 \pm 1.59$ %	0.991 ± 0.019
35 - 45	92.21 ± 0.11 %	$90.53 \pm 0.34 \pm 0.59$ %	0.981 ± 0.008
45 - inf	93.61 ± 0.13 %	$91.08 \pm 0.44 \pm 0.17$ %	0.973 ± 0.005
Endcap			
20 - 35	88.54 ± 0.22 %	$88.98 \pm 0.60 \pm 2.17$ %	1.005 ± 0.025
35 - 45	93.20 ± 0.16 %	$93.04 \pm 0.48 \pm 0.99$ %	0.998 ± 0.012
45 - inf	94.94 ± 0.20 %	$94.26 \pm 0.66 \pm 0.21$ %	0.993 ± 0.007

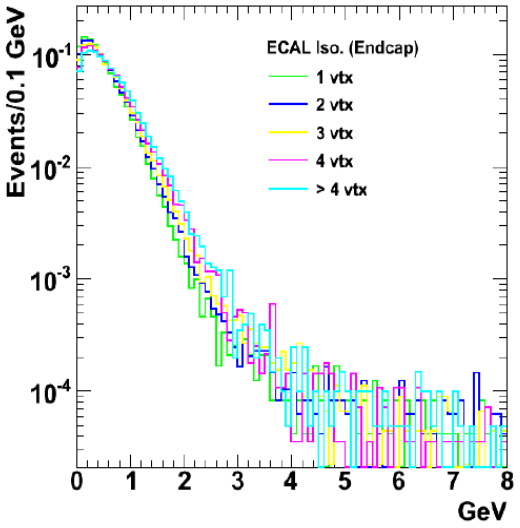
Results available also as a function of eta, fBrem and R9.

Pileup

- Recently MC samples with pileup have been simulated.

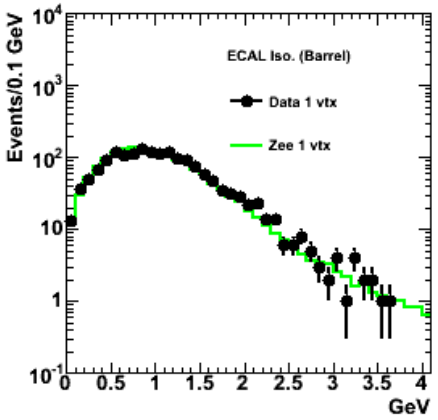


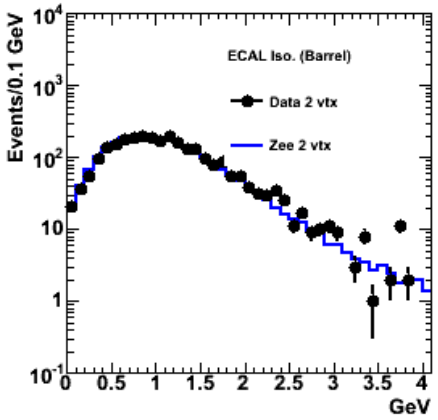


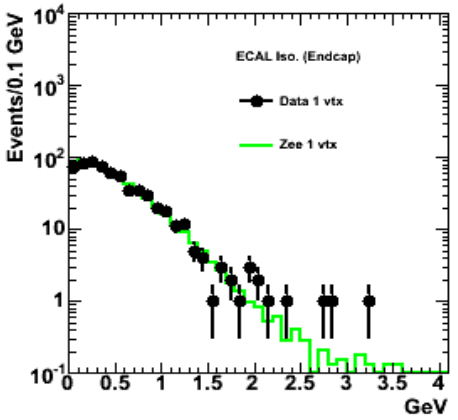


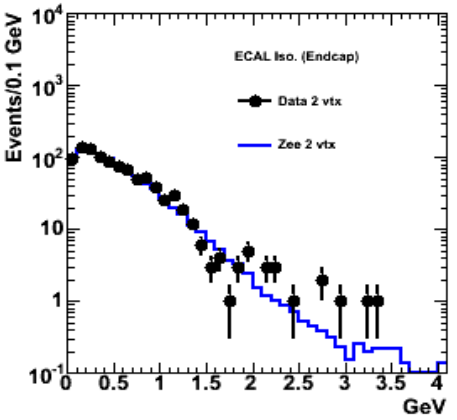
- We have compared signal MC with pileup to estimate the effect on the selection efficiency:
  - Exotica Selection: MC/MC_{PU} = 1.01 (BARREL), 1.001 (ENDCAP)
  - Hgg Selection: MC/MC_{PU} = 1.05 (BARREL), 1.01 (ENDCAP)

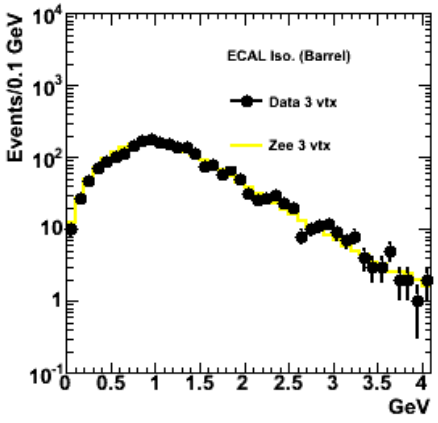
Pileup Data/MC Comparison

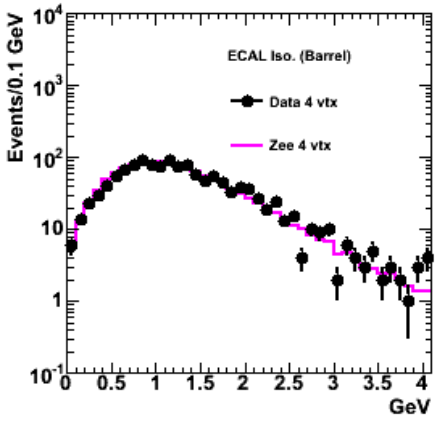


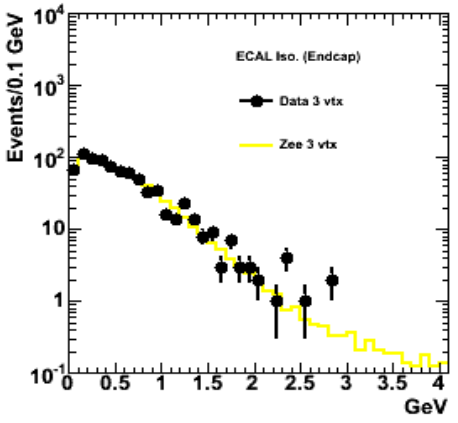


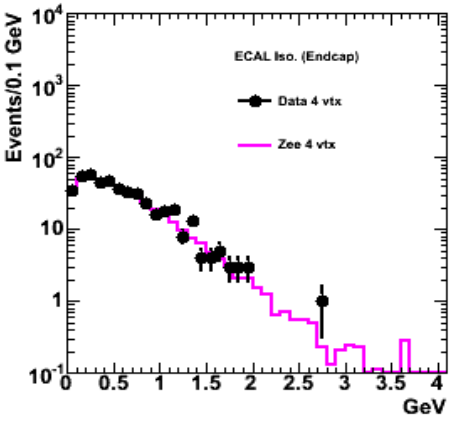












BARREL **ENDCAP**

Summary

- We have measured various photon selection efficiencies using Z Tag and Probe method using ~35 pb^{-1} of data.
- We have tested three different techniques: counting, fit and opposite sign-same sign:
  - the same methods will be used to measure electron efficiencies as well.
- The three results are in good agreement:

	COUNT	FIT	OS/SS
BARREL	0.981 ± 0.008	0.967 ± 0.011	0.982 ± 0.011
ENDCAP	0.991 ± 0.007	0.983 ± 0.016	0.994 ± 0.013

- We have also studied the selection efficiencies as a function of the number of reco vertices to check pileup effect.