Study of Radiative Z^0 Decay

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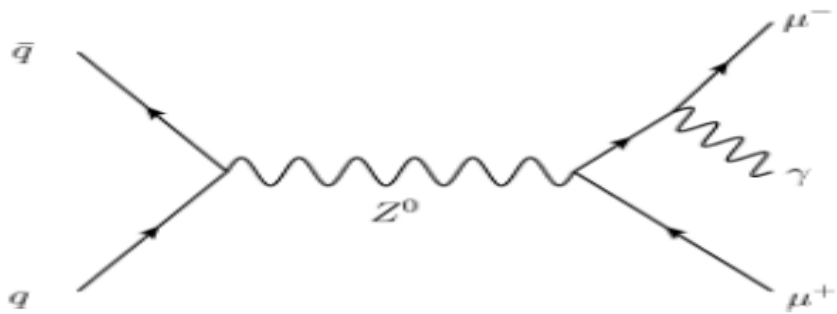
The $z \to \mu\mu\gamma$ channel

- Final State Radiation event(FSR)
- Precise measurement on Z^0 boson mass and width from LEP
- Precise muon momentum scale using specified methods
- Three-body decay: photon kinematics fully determined by the rest of the event
- Purely EWK process: clear signal in hadronic collisions

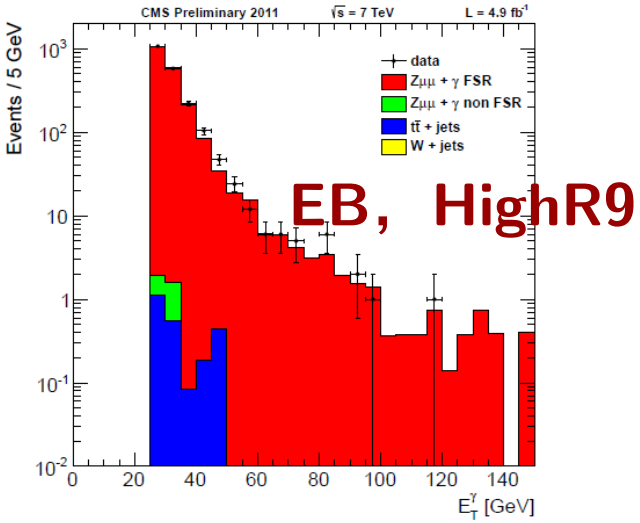


Note:

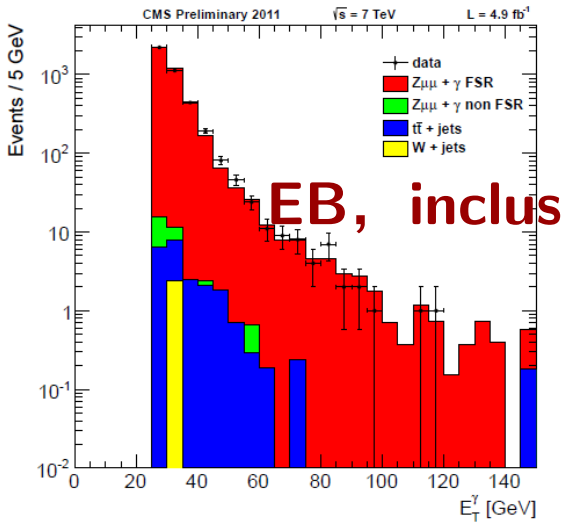
This channel is source of "certified" unbiased photons with very high purity and relatively high P_T compared to photons from π^0 or η decays

Selection strategy

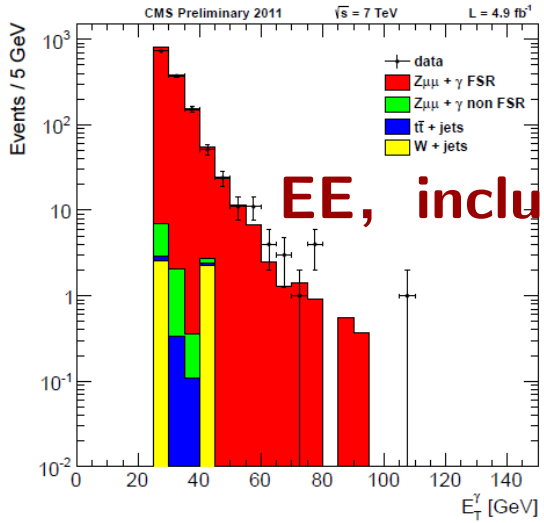
- In order to select the $Z \to \mu\mu\gamma$ events in the real data, the events should pass the double muon trigger, also muon ID, as well as photon ID and some FSR selections.
- R9 is the ratio of energy within 3x3 array of crystals to the total energy of supercluster.



EB, HighR9



EB, inclusive



EE, inclusive

Data/MC agrees well

Definition

- We call photon energy scale for DATA and simulation:

$$S_{RECO} = \frac{M^2_{\mu\mu\gamma,R} - M^2_{\mu\mu,R}}{M^2_Z - M^2_{\mu\mu,R}} - 1$$

- Assumptions:
  - The reconstructed muon momenta have been perfectly corrected.
  - We can replace $M_{\mu\mu\gamma.G}$ by Z^0 PDG value $M_Z = 91.187$.
- Plots are shown for EB with R9 > 0.94, inclusive EB and inclusive EE categories.
- Our energy-scale extraction method is one of the two approved methods within CMS.

Note:

We published our results in CMS-DP-12-024, CMS-DP-2011/008

`http://cds.cern.ch/record/1490641?ln=en`,

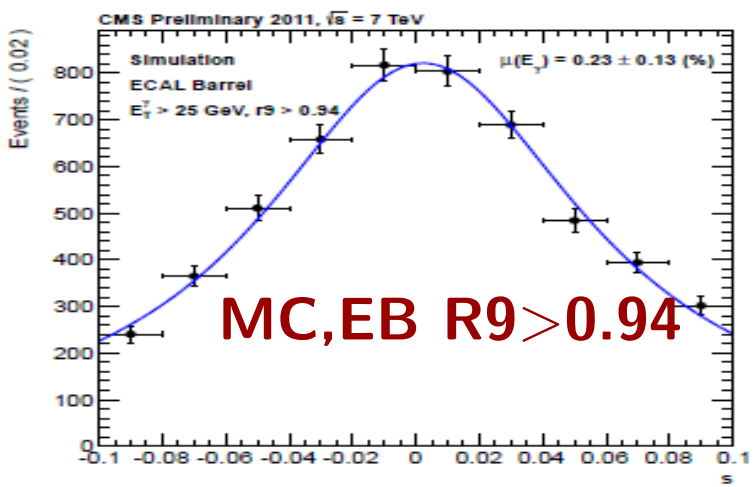
`http://cds.cern.ch/record/1373389?ln=en`

Fit method and results

- The purity of the selection is in excess of 99% for photons with Et>25 GeV.
- The "S" distributions are fitted(unbinned) with Voigtian(convolution of a Breit-Wigner with a Gaussian) functions, and the fit ranges optimised so as to produce as uniform a distribution of P-values as possible, with a mean ideally equal to 0.5.
- We show statistical errors and the fit range systematic error in our results, that errors from the muon momentum corrections have been estimated for MC and have been found to be insignificant.

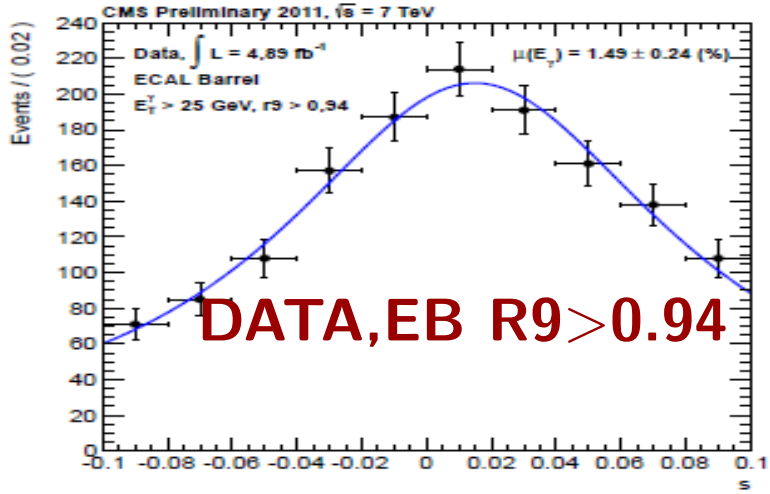
Fit method and results

SRECOMC



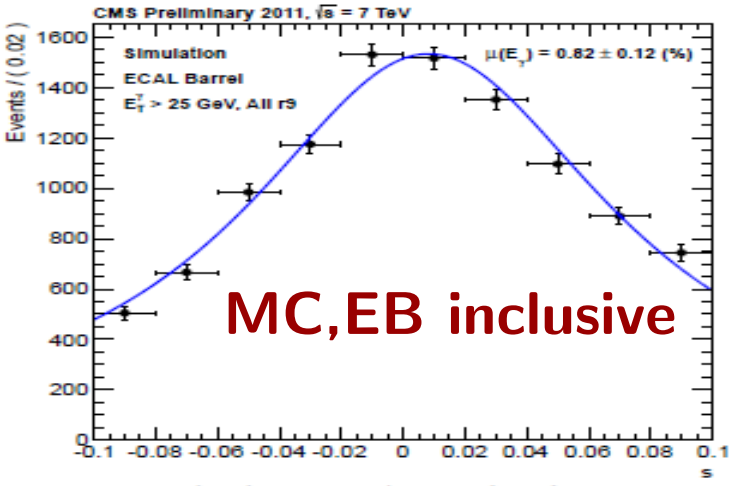
$\mu(E_\gamma) = 0.23 \pm 0.13$ (stat)
$\pm$ 0.15 (fit range) $\pm$ 0.03 (muons) %

SRECOData



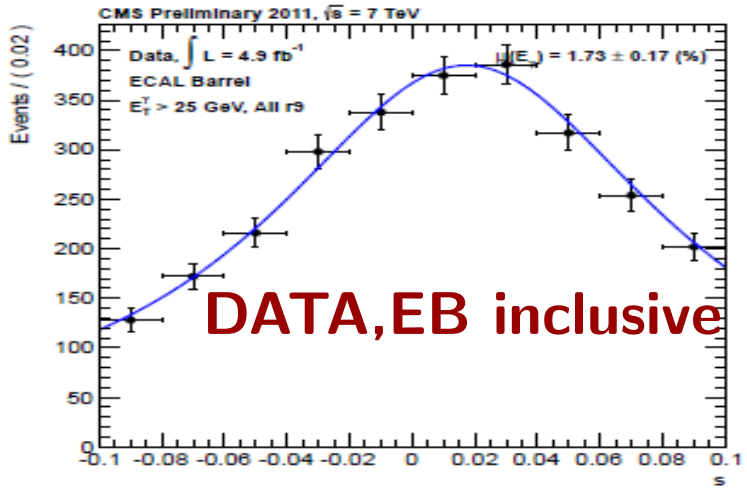
$\mu(E_\gamma) = 1.49 \pm 0.24$ (stat)
$\pm$ 0.05 (fit range) %

SRECOMC



$\mu(E_\gamma) = 0.82 \pm 0.12$ (stat)
$\pm$ 0.10 (fit range) $\pm$ 0.02 (muons) %

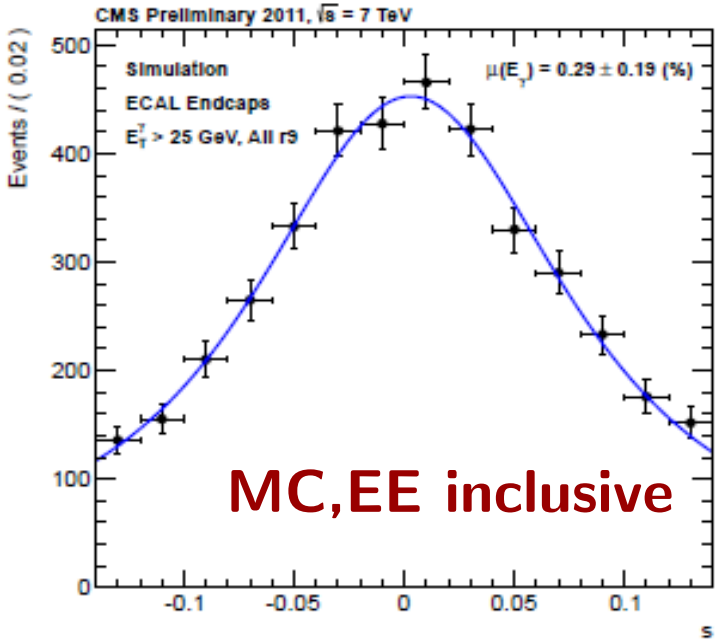
SRECOData



$\mu(E_\gamma) = 1.73 \pm 0.17$ (stat)
$\pm$ 0.16 (fit range) %

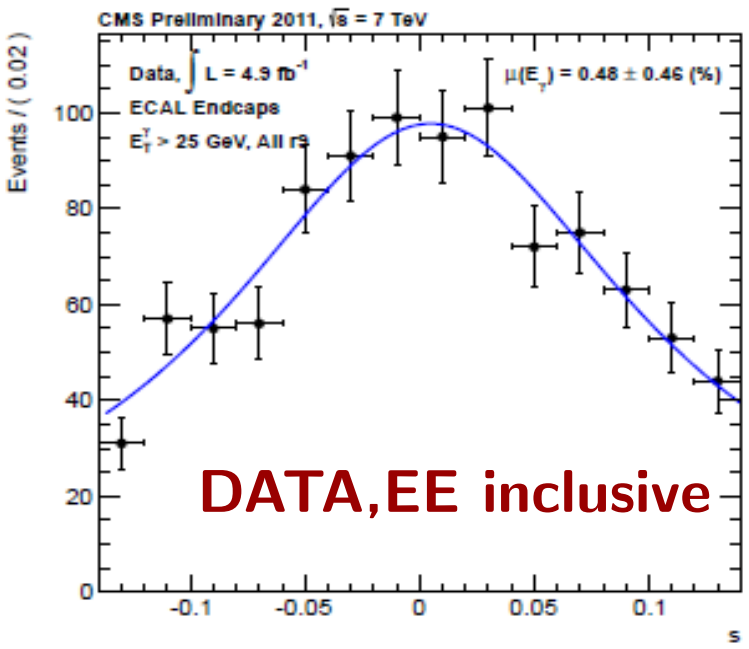
Fit method and results

s_{RECOMC}



$\mu(E_\gamma) = 0.29 \pm 0.19$ (stat)
$\pm$ 0.05 (fit range) $\pm$ 0.03 (muons) %

$s_{RECOData}$



$\mu(E_\gamma) = 0.48 \pm 0.46$ (stat)
$\pm$ 0.10 (fit range) %

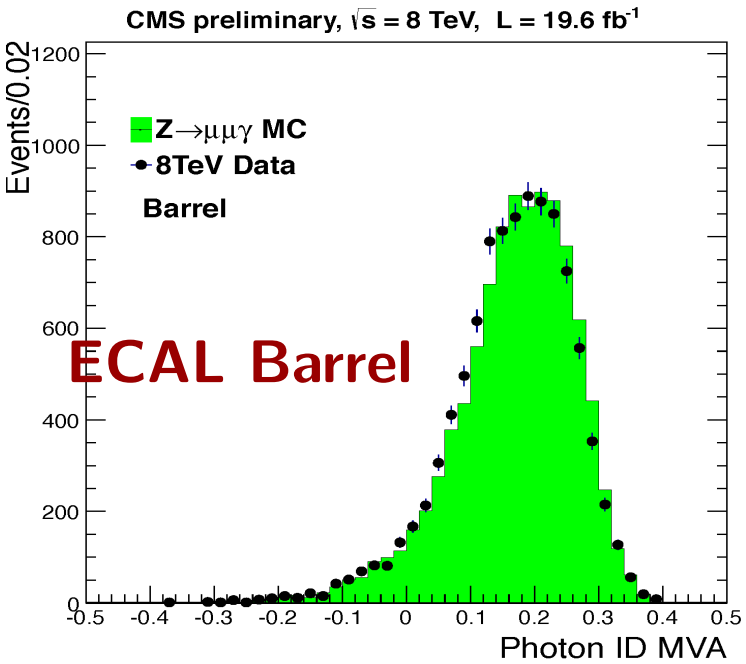
Conclusion:

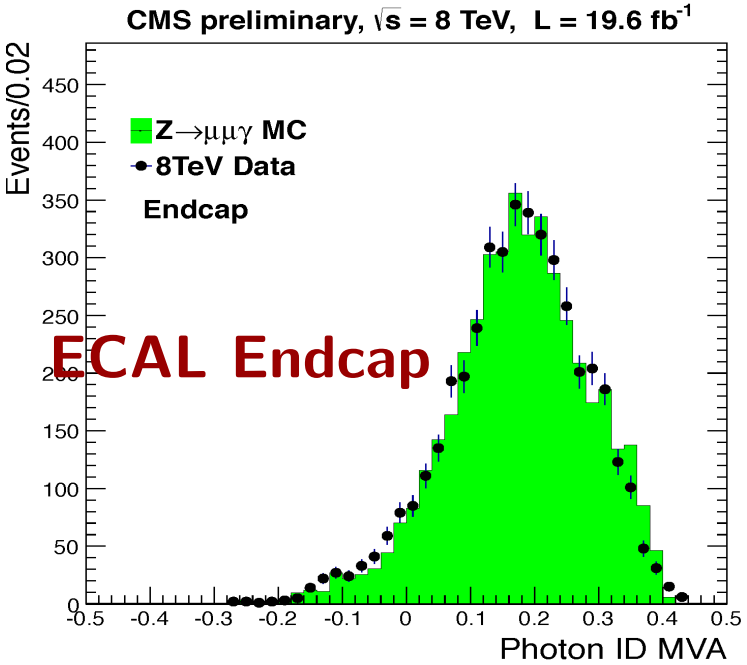
The photon energy scale agrees to within 1.3% between DATA and MC. The energy scale agrees to better than 0.5% with that obtained using the other approved method.

Photon ID MVA validation

- In the $H \to \gamma\gamma$ analysis, we uses Boosted Decision Trees (BDT), a multivariate analysis method, to distinguish prompt photons from non-prompt photons, primarily from high momentum neutral mesons decaying to two photons.
- A validation of the extent to which the MVA inputs and output in data are well modeled by Monte Carlo (used in the analysis to construct the signal model) can be performed using $Z \to \mu\mu\gamma$ events selected in data with photon purity in excess of 99%.

Photon ID MVA validation





Conclusion:

A comparison of the photon ID MVA score obtained with barrel photons from $Z \to \mu\mu\gamma$ events in data and MC simulation. DATA and MC agrees very well when using selected $\mu\mu\gamma$ events.

CMS-HIG-13-001

Electron veto efficiency

Tag and probe

- We can use the selection to "tag" the FSR event.
- The selected photon is "probe".
- The statistics at high-Pt is still limited, but unique way to check electron veto efficiency in data.
- The efficiency is nearly 96.1% for DATA and 97.4% for MC.

Estimate systematic uncertainties in Vgamma

- In Vgamma production measurement, $\mu\mu\gamma$ study can be used to estimate the photon energy scale uncertainty. CMS-EWK-10-008

Table 1: Summary of systematic uncertainties.

	$W\gamma \to e\nu\gamma$	$W\gamma \to \mu\nu\gamma$	$Z\gamma \to ee\gamma$	$Z\gamma \to \mu\mu\gamma$
Source	Effect on $A \cdot \epsilon_{MC}$			
Lepton energy scale	2.3%	1.0%	2.8%	1.5%
Lepton energy resolution	0.3%	0.2%	0.5%	0.4%
Photon energy scale	4.5%	4.2 %	3.7%	3.0%
Photon energy resolution	0.4%	0.7%	1.7%	1.4%
Pile-up	2.7%	2.3%	2.3%	1.8%
PDFs	2.0%	2.0%	2.0%	2.0%
Total uncertainty on $A \cdot \epsilon_{MC}$	6.1%	5.2%	5.8%	4.3%
	Effect on $\epsilon_{data}/\epsilon_{MC}$			
Trigger	0.1%	0.5%	$< 0.1\%$	$< 0.1\%$
Lepton identification and isolation	0.8%	0.3%	1.1%	1.0%
E_T^{miss} selection	0.7%	1.0%	N/A	N/A
Photon identification and isolation	1.2%	1.5%	1.0%	1.0%
Total uncertainty on $\epsilon_{data}/\epsilon_{MC}$	1.6%	1.9%	1.6%	1.5%
Background	6.3%	6.4%	9.3%	11.4%
Luminosity	4%			

Conlusion and prospects

- Method developed for measuring photon energy scale, one of two approved methods for photons with Et $>$ 25 GeV.
- Used for photon commissioning and validation, including for the $H \to \gamma\gamma$ analysis.
- Used for photon identification efficiency, including for the $H \to \gamma\gamma$ analysis.
- Used for estimating systematic uncertainties in Vgamma analysis.
- Results for the full 2012 dataset and corresponding MC will be available soon.

Merci 谢谢!

Backup

Photon scale