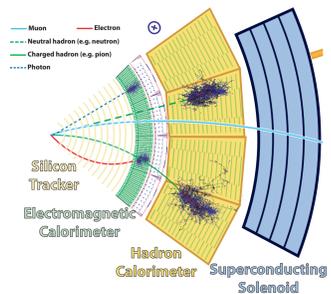
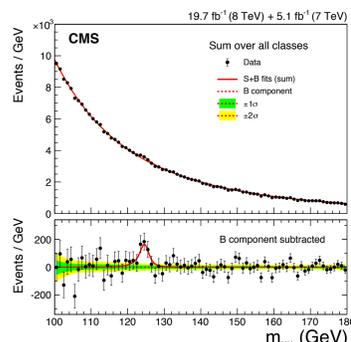
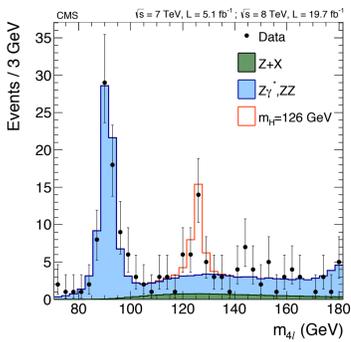


Marco Peruzzi (ETH Zurich), on behalf of the CMS collaboration

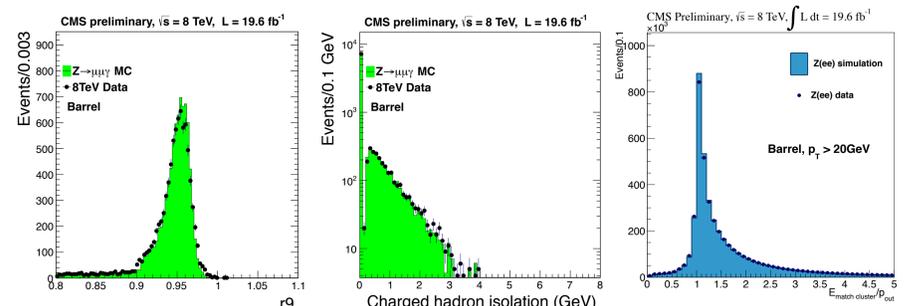
Performance of electron and photon reconstruction crucial for the physics reach of the CMS experiment



- Electron and photon reconstruction:
 - PbWO₄ crystal electromagnetic calorimeter, excellent energy resolution and granularity
 - Gaussian sum filter electron track reconstruction
 - e/γ selection relies on shape of energy deposit and surrounding energy flow (isolation)

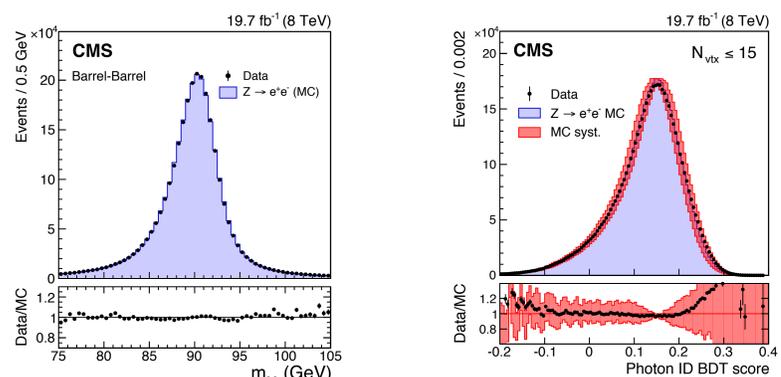
Data/MC agreement for discriminating variables

- Discriminating variables studied in high-purity electron and photon samples from $Z \rightarrow ee$ and $Z \rightarrow \mu\mu$ decays



[Left: ratio of energy in a 3x3 crystal square about the highest-energy crystal to the energy of the super-cluster; Right: charged hadron isolation sum at the nominal primary vertex, for pre-selected photons in data and Monte Carlo simulation of the $Z \rightarrow \mu\mu$ process for ECAL barrel. The r_9 shape in the Monte Carlo is corrected by a linear transformation derived from $Z \rightarrow ee$.]

- Excellent agreement in high-level quantities (reconstructed mass, MVA discriminants) used in analyses

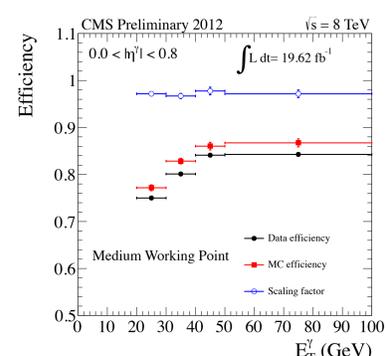


[Invariant mass of e^+e^- pairs in $Z \rightarrow e^+e^-$ events in the 8 TeV data (points), and in simulated events (histogram), in which the electron showers are reconstructed as photons, and the full set of photon corrections and smearings are applied.]

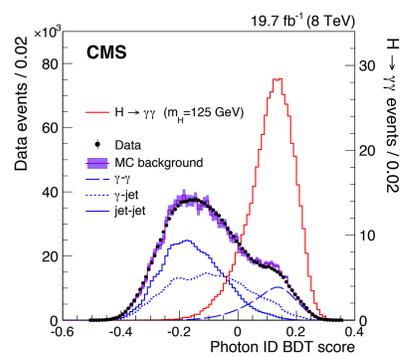
[Comparison of the photon identification BDT score for electron showers in the barrel in $Z \rightarrow e^+e^-$ events in the 8 TeV dataset and MC simulated events, for events passing the pre-selection, but with the electron veto condition inverted. The systematic uncertainty assigned to the photon identification BDT score is shown as a band.]

e/γ selection and background rejection

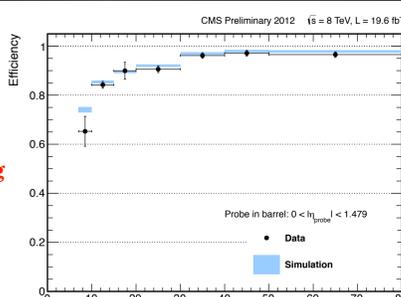
- Variables used for identification:
 - HCAL/ECAL energy deposit ratio
 - shower extension in the η direction
 - Particle-Flow isolation
 - track quality and cluster matching requirements for electrons



[The scale factor for the full photon selection efficiency in the ECAL barrel. The total scale factor is determined by the product of the scale factor calculated using the tag and probe technique and the scale factor of the electron veto. The electron veto scale factor is calculated in data and simulation by counting the number of passing and failing photons from $Z \rightarrow \mu\mu$ process, which is ~99.6% pure source of photons. Uncertainties are both statistical and systematic.]

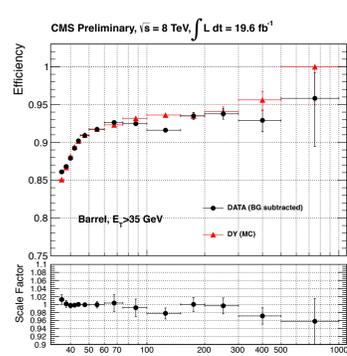


[Photon identification BDT score of the lower-scoring photon of diphoton pairs with an invariant mass in the range $100 < m_{\gamma\gamma} < 180$ GeV, for events passing the preselection in the 8 TeV dataset (points), and for simulated background events (histogram with shaded error bands showing the statistical uncertainty). Histograms are also shown for different components of the simulated background, in which there are either two, one, or zero prompt signal-like photons. The tall histogram on the right (right-hand vertical axis) corresponds to simulated Higgs boson signal events.]

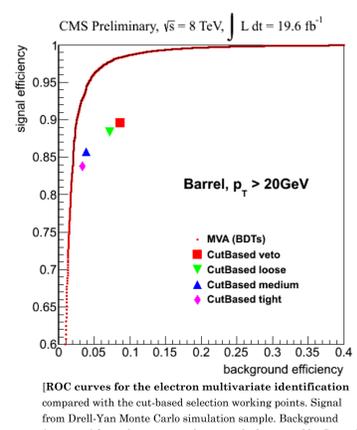


[Efficiency on data and on a Drell-Yan Monte Carlo sample for the isolation plus multivariate electron selection as a function of the electron p_T and the number of vertices. Both statistical and systematic errors are included.]

- Multivariate discriminants provide optimal background discrimination
- Efficiency stable as a function of pileup
- Dedicated high- p_T electron selection for searches



[HEEP selection efficiency on data and on a Drell-Yan Monte Carlo simulation as a function of the electron E_T . Only the statistical error is shown.]



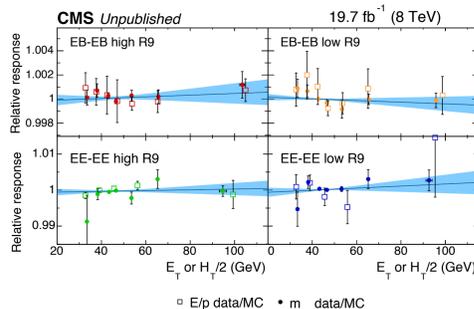
[ROC curves for the electron multivariate identification compared with the cut-based selection working points. Signal from Drell-Yan Monte Carlo simulation sample. Background from jets faking electrons in a data sample dominated by Z+jets.]

Energy scale and resolution

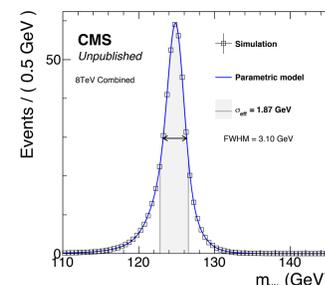
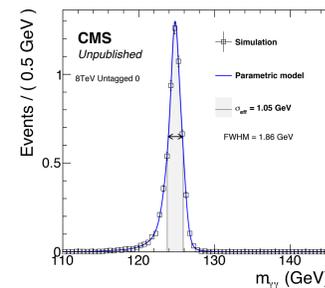
- Resolution optimized using multivariate technique for cluster energy estimation
- Energy scale constrained in data with electrons from Z decays
- Very small energy scale uncertainty, dominated by simulation of e/γ differences and linearity ($Z \rightarrow ee \rightarrow H \rightarrow \gamma\gamma$ extrapolation)

Source of uncertainty	Uncertainty in \bar{m}_H (GeV)
Imperfect simulation of electron-photon differences	0.10
Linearity of the energy scale	0.10
Energy scale calibration and resolution	0.05
Other	0.04
All systematic uncertainties in the signal model	0.15

[Magnitude of the uncertainty in the best fit mass induced by the systematic uncertainties in the signal model. These numbers have been obtained by quadratic subtraction of the statistical uncertainty. The statistical uncertainty includes all uncertainties in the background modelling.]

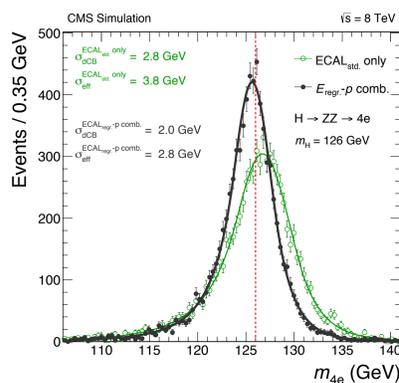


[Differential non-linearity in the four photon identification categories as derived from E/p and from the dielectron invariant mass. Each graph shows the ratio of the estimated position of the E/p (stars) or of the m_{ee} (dots) invariant mass peaks in data to the corresponding position estimated in MC simulation. On the abscissa, the E_T ($H_T/2$) of the electron is shown for the E/p (m_{ee} analysis).]

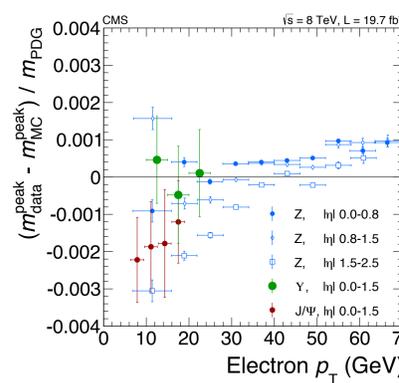
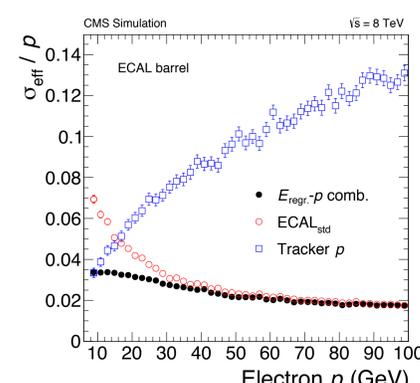


[Parametric $H \rightarrow \gamma\gamma$ signal model, for $m_H = 125$ GeV, in the untagged class 0 (top) and summed over all event classes (bottom).]

- Electron energy from regression-based combination of cluster energy and track p_T
- Simulation in agreement with data over a wide p_T range, within 0.1% - 0.3%



[Left: Expected four-lepton mass distribution for $H \rightarrow ZZ \rightarrow 4e$ for $m_H = 126$ GeV using ECAL-only electron momentum estimation (green open points: ECAL_{std} only), and using the method employed in this analysis (black full points: $E_{reg} - p$ combination). The fitted standard deviation, σ_{ECAL} , of the double-sided Crystal-Ball function and effective width σ_{eff} are indicated. Electrons with $p_T > 7$ GeV in the full η -range are used. Right: Expected effective momentum resolution σ_{eff} for electrons in the EB as a function of the momentum for the ECAL-only, the tracker-only, and the combined estimates.]



[Left: Relative difference between the mass peak positions in data and simulation as obtained from Z, J/psi and Y(nS) resonances as a function of the transverse momentum of one of the electrons regardless of the second. Right: Relative difference between the dilepton σ_{eff} in data and simulation, as measured from $Z \rightarrow e^+e^-$ events, where the electrons are classified into different categories (B: barrel, E: endcaps, G: golden, S: showering).]