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Optimising the performance of the CMS Electromagnetic Calorimeter to measure Higgs properties during Phase I and Phase II of the LHC

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The CMS Electromagnetic Calorimeter (ECAL), is a high granularity lead tungstate crystal calorimeter operating at the CERN LHC. The original design placed a premium on excellent energy resolution. Excellent energy resolution and efficient identification for photons are essential to reconstruct the Higgs boson in the H->gg decay channel, for measurements of the self-coupling of Higgs bosons and other related parameters.

The ECAL performance has been crucial in the discovery and subsequent characterisation of the Higgs boson. The original ECAL design considerations, and the actual experimental energy reconstruction and calibration precision will be reviewed.

The improvements to the energy reconstruction and energy calibration algorithms for LHC Run II are described. These are required to maintain the stability of the ECAL energy scale and resolution for the higher LHC luminosities that have been experienced compared to Run I. The precision measurement of the Higgs decay modes is central to the HL-LHC physics program. In addition, the search for di-Higgs production is important to understand the details of the vacuum potential. The crystals in the barrel region will be retained for HL-LHC. The decrease of operating temperature and upgrades to the readout electronics that are needed to maintain the required performance of the barrel region from 2026 onwards will be described.

These upgrades will ensure that radiation-induced noise increases will not dominate the energy resolution for photons from Higgs boson decays, and will preserve the ability of CMS to trigger efficiently on these signals. They will also permit precision time measurements (30 ps rms error on the arrival time of photons from Higgs boson decays) which will improve the determination of the location of the production vertex for di-photon events. Time measurement performance of the new readout electronics has been characterized in beam tests.

The predicted electron and photon energy resolution and identification efficiencies expected for HL-LHC will be described, and the performance relevant to a number of key Higgs decay channels will be presented.

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