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# Status of the ATLAS calorimeters: their performance during three years of LHC operation and plans for future upgrades

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The ATLAS experiment is designed to study the proton-proton collisions produced at the Large Hadron Collider (LHC) at CERN. Its calorimeter system measures the energy and direction of final state particles over the pseudorapidity range $|\eta| < 4.9$. Accurate identification and measurement of the characteristics of electromagnetic objects (electrons/photons) are performed by liquid argon (LAr)-lead sampling calorimeters in the region $|\eta| < 3.2$, using an innovative accordion geometry that provides a fast, uniform response without azimuthal gaps. This system played a critical role in the ATLAS analyses contributing to the Higgs boson discovery announced in 2012. The hadronic calorimeters measure the properties of hadrons, jets, and tau leptons, and also contribute to the measurement of the missing transverse energy and the identification of muons. A scintillator-steel sampling calorimeter (TileCal) is employed in the region $|\eta| < 1.7$, while the region $1.5 < |\eta| < 3.2$ is covered with a copper-LAr sampling calorimeter. The calorimetric coverage is extended to $|\eta| < 4.9$ by an integrated forward calorimeter (FCal) based on LAr with copper and tungsten absorbers and employing a novel electrode design.

In the first three years of LHC running, approximately 27 fb$^{-1}$ of data have been collected at centre-of-mass energies of 7 and 8 TeV. Results on the calorimeter operation and performance over this period will be presented, including the calibration, stability, absolute energy scale, uniformity, and time resolution. These results demonstrate that the calorimeters are performing well within the design requirements and providing reliable input to physics analyses.

Although LHC data-taking is expected to continue for a number of years, plans are already underway for operation at an instantaneous luminosity about 5 times the original design value of $10^{34}$ cm$^{-2}$s$^{-1}$. The calorimeter upgrade for this High Luminosity LHC (HL-LHC) involves two phases. In the first, upgrades to the LAr calorimeter electronics will provide more granular information to the trigger in order to reduce the effects of the high pile-up. The second phase will be devoted to the complete replacement of the front- and back-end electronics of both the TileCal and LAr calorimeters. In the case of the LAr calorimeter, additional complications may arise as a result of the increased instantaneous and integrated luminosities at the HL-LHC. These problems will be discussed along with a number of proposed solutions.

## Summary

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