The ATLAS liquid argon calorimeter:
upgrade plans for the HL-LHC

Abstract submitted by the ATLAS LAr speakers committee
Speaker to be nominated later

Contact: Peter Krieger (Peter.Krieger@cern.ch)

The ATLAS detector was designed and built to study proton-proton collisions produced at the LHC at centre-of-mass energies up to 14 TeV and instantaneous luminosities up to \(10^{34}\) cm\(^{-2}\)s\(^{-1}\). Liquid argon (LAr) sampling calorimeters are employed for all electromagnetic calorimetry in the pseudorapidity region \(|\eta|<3.2\), and for hadronic calorimetry in the region from \(|\eta|=1.5\) to \(|\eta|=4.9\). Although the nominal LHC experimental programme is still in progress, plans for a High Luminosity LHC (HL-LHC) are already being developed for operation of the collider and associated detectors at luminosities of up to \((5-7)\times10^{34}\) cm\(^{-2}\)s\(^{-1}\), with the goal of accumulating an integrated luminosity of 3000 fb\(^{-1}\).

The proposed instantaneous and integrated luminosities are both well beyond the values for which the detectors were designed. The electromagnetic and hadronic calorimeters will be able to tolerate the increased particle flux, but the performance of the forward calorimeter (FCal) will be affected. Two solutions for this are under study: one option is to build and install a replacement FCal with smaller LAr gaps. A second approach, which does not require the opening the cold volume of the cryostats, involves the installation of a small MiniFCal calorimeter in front of the FCal, in order to reduce the particle flux into the existing device to levels at which it can operate normally. The currently preferred MiniFCal option is a LAr/Cu sampling calorimeter for which detailed design and performance studies are underway.

The electronics readout, originally qualified for an integrated luminosity of only 700 fb\(^{-1}\), will also potentially be affected. This concerns especially the hadronic endcap calorimeter (HEC) that employs cold GaAs preamplifiers located inside the endcap cryostats. The properties of these devices have been further investigated in recent proton and neutron irradiation tests to determine whether they must be replaced. The measured gain and linearity degradation is used to determine the performance expected for calorimetric measurements in HL-LHC conditions.

Beside the specific HEC radiation concerns, the entire front-end readout system is not expected to survive the integrated luminosity at the HL-LHC. Furthermore, the requirements of long-latency data buffering and multi-level hardware triggering by the future ATLAS trigger system are not compatible with the current front-end electronics. As these electronics are much more accessible than the HEC preamplifiers, a decision has been taken to replace the complete readout chain. The new read-out system must be able to process about 180000 channels at 40 MHz in real time, with 16 bit dynamic range and a total data rate of about 140 Tbit/s. To meet these challenging environmental and performance parameters, dedicated ASICs for low-latency, low-power analog-to-digital conversion and for fast, low-latency optical transmission are being developed, along with FPGA-based high-bandwidth online data processing modules.
The talk will cover the problems associated with operation of the LAr calorimeter at the HL-LHC and discuss the various upgrade solutions and the associated technological developments.