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Irradiation tests and expected performance of readout electronics of the ATLAS hadronic endcap calorimeter for the HL-LHC

At the proposed high-luminosity LHC (HL-LHC) the readout electronics of the ATLAS Hadronic Endcap Calorimeter (HEC) will have to withstand a much harsher radiation environment than is present at the LHC design luminosity. The heart of HEC read-out electronics is the pre-amplifier and summing (PAS) system, which is realized in GaAs ASIC technology. These PAS devices are installed inside the LAr cryostats, directly on the detector. They have been proven to operate reliably in LHC conditions up to an integrated luminosity of 1000 fb^{-1}, including safety factors. However, at the HL-LHC a total integrated luminosity of 3000 fb^{-1} is expected, which corresponds to an increase of a factor of 3-5 in the expected radiation levels. On top of this, a safety factor of at least 2 needs to be accounted for to reflect our confidence in the background rate simulations.

Samples of the GaAs ASIC have therefore been exposed to neutron and proton radiation with integrated fluences in excess of $4x10^{15}$ n/cm^2 and $2.6x10^{14}$ p/cm^2, several times the levels expected for ten years of HL-LHC running. In-situ measurements of S-parameters allow the evaluation of frequency-dependent performance parameters, like gain and input impedance. The non-linearity of the ASIC response has been measured both at warm and at cold, i.e. at LAr temperatures. This allows an improved estimation of the expected degradation of the HEC performance. The measured gain and non-linearity of the ASIC response have been applied to Monte-Carlo simulations in order to understand their effects on jet measurements in HL-LHC conditions.

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