Title: Long term aging studies of the new PMTs used for the HL-LHC ATLAS hadron calorimeter upgrade

Abstract:
The central hadron calorimeter (TileCal) of the ATLAS experiment at the Large Hadron Collider (LHC) is a sampling calorimeter made up of steel plates, as absorbers, and scintillating tiles, as active materials. It is read out by wavelength shifting fibers carrying light to about 10,000 photomultipliers (PMTs). Earlier studies of performance showed a degradation in PMTs response as a function of the integrated anode charge. At the end of the High-Luminosity LHC (HL-LHC) program, the expected integrated charge for PMTs reading out the most exposed cells is 600 C. A model of the evolution of the PMT response as a function of the integrated charge, based on the measured response during the Run 2 of the LHC, was built. The projected loss at the end of the HL-LHC is 25% for PMTs reading out the most exposed cells (these represent 8% of the total TileCal PMTs). These PMTs will be replaced with a newer version with the same geometry, in order to keep the global detector performance at an optimal level. A local test setup is being used in the Pisa laboratory to study the long term response of the new PMT model considered for replacement in TileCal. An integrating sphere equipped with four ports, used to mix and homogenize light, is installed in this setup. Three out of four sphere ports are used for receiving the incoming laser light, for injecting continuous light produced by a DC green LED, and for extracting with a fiber bundle the mixed light to be sent to the PMTs under test, located in a separated box. The large amount of PMT anode charge integration is obtained from the LED emission, while laser pulses are sent only for recording PMT responses with a DAQ system.
The performance of the new PMT model (which will be used for the replacement) is compared to the old PMT model, that is the version installed in ATLAS to readout TileCal cells. For the first time this new PMT model has been tested after integrating more than 800 C of anode charge. Preliminary results obtained from data collected in the Pisa laboratory over a period exceeding one year are shown in this presentation. We show also a preliminary study aimed to disentangle the contribution to the response degradation of the PMTs due to the loss of quantum efficiency and to the change in gain. This is the first time that the PMT response as a function of the integrated anode charge is studied, independently from the vendor tests.

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