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Predicting the performance of the CMS precision PbWO4 electromagnetic calorimeter in the HL-LHC era from test beam results on irradiated crystals

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The harsh radiation environment in which detectors will have to operate during the High Luminosity phase of the LHC (HL-LHC) represents a crucial challenge for many calorimeter technologies. In the CMS forward calorimeters, ionizing doses and hadron fluences will reach up to 300 kGy (at a dose rate of 30 Gy/h) and 2E14 cm-2, respectively, at the pseudorapidity region of |η|=2.6.

To evaluate the evolution of the CMS ECAL performance in such conditions, a set of PbWO4 crystals, which had previously been exposed to 24 GeV protons up to integrated fluences between 2.1E13 cm-2 and 1.3E14 cm-2, has been studied in beam tests.

A degradation of the energy resolution and a non-linear response to electron showers are observed in damaged crystals. Direct measurements of the light output from the crystals show the amplitude decreasing and pulse becoming faster as the fluence increases. The evolution of the performance of the PbWO_4 crystals has been well understood and parameterized in terms of increasing light absorption inside the crystal volume.

A double-sided readout configuration, in which two identical photodetectors are coupled to the opposite ends of each crystal, has also been tested. The separate and simultaneous readout of the light from the two sides of the crystal allows us to correct for longitudinal shower fluctuations and to mitigate the degradation of energy resolution in highly damaged crystals. The non-linear response to electromagnetic showers, arising from high non-uniformity of light collection efficiency along the longitudinal axis of irradiated crystals, can also be corrected by means of the double-sided readout technique.

Has accepted

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