Stability of the ALICE FoCal-E prototype for hadrons

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Development of the ALICE FoCal-E detector[1)] is underway for operation in 2029–2032 at the LHC. The main purpose of FoCal-E is to study the gluon structure in a regime where the fraction of the proton momentum is down to $\sim 10^{-6}$ by measuring direct photons, neutral hadrons, and jets at forward pseudorapidity range of $3.4 < \eta < 5.5$. An essential ability of the FoCal-E is to identify the direct photons from the ones decayed from neutral pions.

FoCal-E is an electromagnetic sampling calorimeter comprising 20 tungsten absorbers, each with 1 radiation length, followed by a silicon pad layer with a granularity of 1×1 cm^2 or a silicon pixel layer with a granularity of 30×30 μm^2. The silicon pixel layer is located after the 5th and 10th tungsten absorbers for spatial resolution to identify the direct photons. The pad layer is placed after the other tungsten layers for energy measurement. A prototype of FoCal-E was constructed, and its performance has been tested using hadron and electron beams at CERN-SPS. In this article, we report an analysis result on the stability of the prototype for hadrons under various beam energies. See Ref. 2) for more details on the other analysis results.

The transverse size of the prototype is 9×8 cm^2, which is covered by 72 low-granularity cells in the pad layers. The pad layers use the HGCROC application-specific integrated circuit (ASIC)[3)] for dual-range readout. It provides ADC up to 100 minimum ionizing particles (MIPs) and time-over-threshold (ToT) for larger energy deposits. The ToT is a signal processing technique that allows us to obtain large signals by measuring pulse width of the digital output.

In order to study the stability of the prototype for hadrons, pedestals and common noises were subtracted from each channel. The pedestals were measured by a dedicated pedestal run and the common noises were estimated by each physics run. In a given layer, ADC values of 72 cells were arranged in ascending order and an average of three middlemost values was considered as a common noise of that layer. After subtracting the pedestal and common noise, a clear MIP distribution was observed mainly in the 52nd cell, because it included the beam center. Pedestals on the first and last layers in the 52nd cell were fitted by a Gaussian function, and events where the ADC values of those two channels exceeded the Gaussian means by three times of the standard deviation were selected, which will be called coincidence cut hereafter, to enhance the signal events. Figure 1 shows the MIP distribution before and after the coincidence cut. The pedestal around 0 was mostly removed by requiring the coincidence cut.

The MIP distributions were fitted by a Landau distribution convoluted with a Gaussian to estimate the stability of the prototype for hadrons. Figure 2 shows the estimated most probable values and widths depending on the beam energy and pad layers (ASICs). They exhibit no significant variation (approximately or less than 10%), which is stable enough to calibrate the detector.

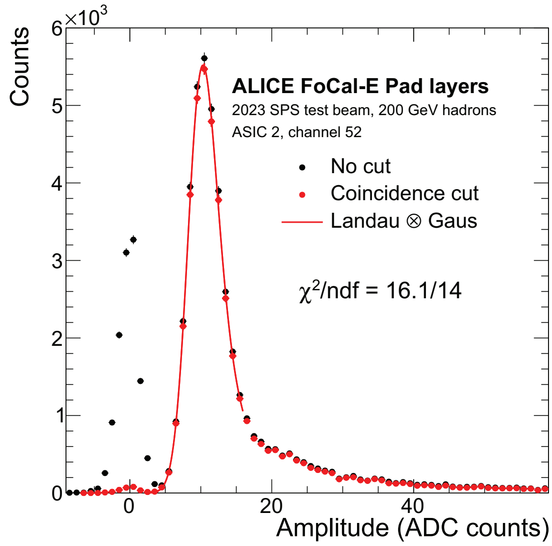

Fig. 1. MIP distribution for 200 GeV hadrons before (black) and after (red) the coincidence cut.

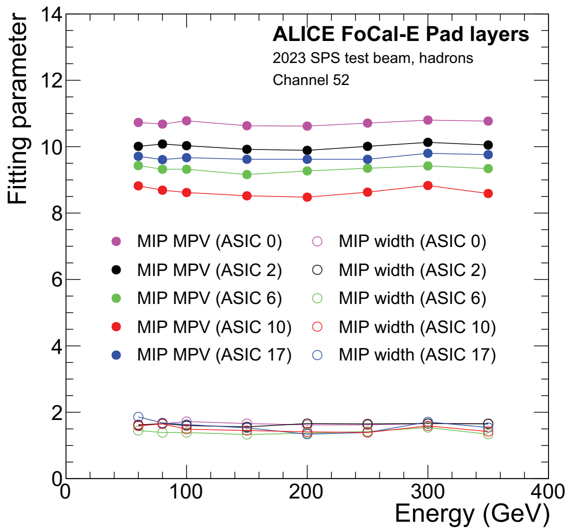

Fig. 2. Estimated MPVs and widths of the MIP distribution depending on the beam energy and pad layer.

References
1) ALICE Collaboration, CERN-LHCC-2020-009 (2020).
2) T. Chujo *et al.*, arXiv:2311.07413 [physics.ins-det], submitted to J. Instrum.
3) CMS Collaboration, J. Instrum. **15**, C04055 (2020).

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