Test of prototype electromagnetic calorimeter (FOCAL) using large dynamic range ASIC ANUINDRA at CERN-SPS

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Introduction

A new sampling type electromagnetic calorimeter, FOrward CALorimeter (FOCAL), has been proposed for the ALICE experiment at CERN to boost its physics capabilities in the forward pseudorapidity region ($2.5 \leq \eta \leq 5.5$). A detailed GEANT-4 simulation was perfomed and an optimised geometry, with depth 20 X_R and transverse size with inner and outer radii of 6 cm and 80 cm respectively, at 8 m away from the interaction point was obtained. The absorber/ convertor and the detector were chosen to be Tungsten and Silicon repectively, to confine and tighten the electromagnetic showers along the longitudinal and transverse directions for better energy and position resolutions in the desired energy range (1–200 GeV). The calorimeter has longitudinal segmentation with 20 layers, each consisting of 1 X_R thick W and 300 µm Si pad sensors followed by associated electronics. Also, for better position resolution, 3 pixelised (1 mm^2) Si-sensor layers were used along with comparatively coarse segmentation for the other layers (1 cm^2).

A series of prototype detectors were fabricated and tested both with radioactive source and test beam to check the feasibility and functionality of the calorimeter. Initially, a mini-prototype was constructed and experimented at the CERN-PS using MANAS as the readout electronics [1]. A linear relationship between simulation and experimental results ensured satisfactory performance of the mini-tower. Following the successful test, a full-depth (20 X_R) FOCAL prototype was designed, developed and tested at CERN-SPS beam line using MANAS and ANUSANSKAR as the readout ASICs, whose details have been presented at the DAE Symp. On Nucl. Phys, 2016 [2]. Both the prototypes were tested with pions to study MIP-response and electrons (EM-shower) of different incident energies starting from 1 GeV to 60 GeV. Analysis shows performance of the prototype getting affected (saturation in ADC distribution) because of limited dynamic range (upto 600 fC) of the ASICs used.

Thus, a new ASIC, **ANUINDRA** with large dynamic range (~ 2.6 pC) has been designed to overcome the saturation in data taking for higher energies. This ASIC has been tested in the laboratory as well as with the full-depth prototype at the SPS beam line facility at CERN.

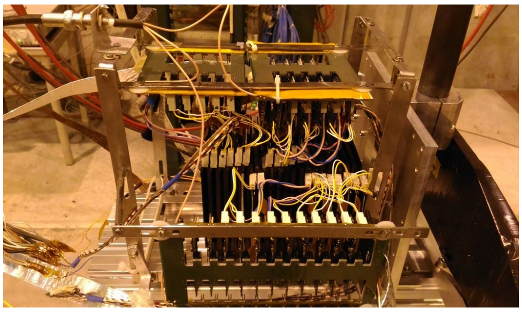

Fig-1: Full-depth prototype at CERN-SPS with ANUINDRA (8th to 12th layers) & MANAS (0th – 7th & 13th – 20th layers).

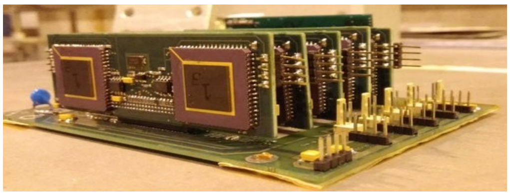

Fig-2: Large Dynamic Range (~2.6 pC) ASIC ANUINDRA mounted on a BP-PCB.

Fabrication and Test Beam

The test beam setup (July 2017), consisting of 21 layers of Si sensors and readout electronics sandwiched between by 20 tungsten layers, is

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shown in Fig-1. Each detector layer is a 6*6 array of 1cm*1cm Si-sensors on a single wafer fabricated at BEL, Bangalore. The readout electronics are taken out from the top and from one side of the mechanical frame, made of SS for FOCAL prototype, using different back plane PCBs for MANAS and ANUINDRA ASICs. Five detector layers (8^{th}–12^{th}) around the shower-max are read out using newly developed ANUINDRA ASICs, whereas MANAS chips have been used to read out signals from the other layers (0^{th}–7^{th} & 13^{th}–20^{th}). The trigger for positioning and selecting beam type during the test beam is provided by three scintillators, Presence (P), Horizontal (H) and Vertical (V) along with a cherenkov counter. The prototype has been tested at the T4-H8 beam line at SPS for a wide range of incident energies for different particles (20 =>150 GeV for e^-, 120 GeV π's and 180 GeV μ's).

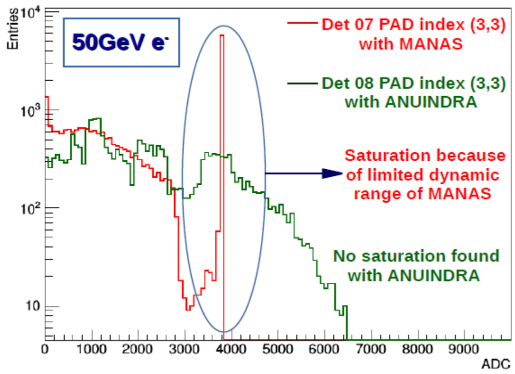

Fig-3: ADC distribution from a single pad with MANAS & ANUINDRA for 50 GeV e^-.

Results and Discussions

Analysis of the test beam data shows satisfactory calorimetric performances for the prototype with the new ASIC. As was expected ANUINDRA could resolve the saturation effect, found for 20 GeV e^- onwards as seen in the earlier test beam with MANAS ASICs, as shown in Fig-3. Development of EM-shower initiated by e^- of different incident energies have been analysed and plotted in Fig-4 which shows a reasonably good discrimination capability of the calorimeter over a wide incident energy range. The measured energy is found to behave linearly with incident energy as shown in Fig-5. A deviation from linearity has been observed beyond 100 GeV e^- and considered as an important input for further development.

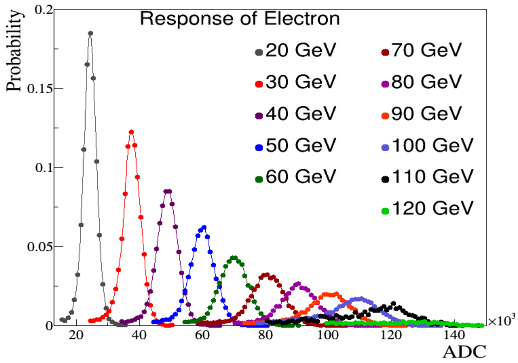

Fig-4: Response of electrons for different incident energies.

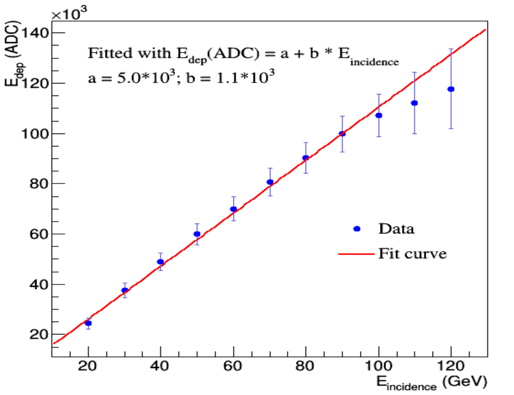

Fig-5: Calibration of measured energy deposition (ADC) with respect to incident energy.

The full-depth prototype was tested with different setups having both MANAS and ANUINDRA as well as ANUINDRA only. With available 5-ANUINDRA ASICs, scan of the full-depth was done for different incident energies. The data has been analysed in details to understand the calorimetric perdormance.

References

[1] NIMA, 764(2014) 24..**S.Muhuri et. al.**
[2] "Prototype tests of full-depth Si-W electromagnetic calorimeter for ALICE upgrade at CERN", **Sanjib Muhuri et. al.**, DAE Symp. On Nucl. Phys. 2016.

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