Prototype tests of full-depth Si-W electromagnetic calorimeter for ALICE upgrade at CERN

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Introduction

A silicon-tungsten electromagnetic calorimeter has been designed, fabricated in India and tested at CERN for the FOCAL (with rapidity coverage $2.5 \leq \eta \leq 5.5$)detector as an upgrade of the ALICE experiment at CERN. The sampling type electromagnetic calorimeter will boost physics capabilities of ALICE experiment specifically in low Bjorken-x limit in terms of Particle production mechanisms, Gluon saturation, parton energy loss etc. An extensive GEANT4 simulation [1] was performed both for geometry optimization and to study physics performances. 20 layers, consist of $1X_R$ thick Tungsten and 300μm silicon sensors followed by associated electronics and PCB both to hold detectors and electronics, were found as an optimized configuration for the calorimeter to contain full energy deposition for electrons or gamma of incident energy range 1 to 200 GeV. Each detector layers had to have transverse segmentation either with 1mm*1mm (few specified layers 4, 8, 12) or with 1cm*1cm (rest all layers) to handle very high particle (dominantly gamma for FOCAL) flux and shower produced by them coming from pp or pPb collisions which get manifold in case of PbPb collision at LHC energies. Along with simulation an rigorous effort was invested in developing the si sensors and ASICs to fabricate the calorimeter. A series of prototypes are being produced and tested both with laboratory set up and PS/SPS test beam facilities. A full-length FOCAL prototype, as latest development and successor of mini-prototype [2], was fabricated and tested at SPS beam line at LHC.

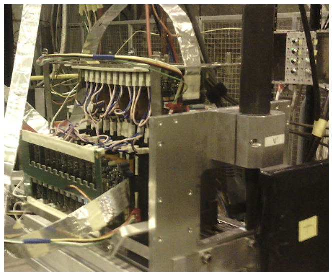

FIG. 1: Complete experimental arrangement for Full-Length FOCAl Prototype at SPS.

Fabrication and Test

A mechanical arrangement(Fig-1) was designed and machined with in-house facility at VECC for the prototype with SS. Four longitudinally movable segments, each holding 5 layers of detector array and and 10cm*10cm tungsten plates, are arranged on SS super base. Options for taking out electronics are kept both from top and two sides of the frame. A 6*6 array of 1cm*1cm silicon detectors are developed for each layer on a single wafer unlike mini-prototype detectors and tested using Sr^{90} β-source before test beam at SPS. Limited dynamic range of the read out ASICs (MANAS and ANUSANSKAR) seems to affect data taking with increase in incident energy of electron or gamma specially arround shower-max region and taken care for the next ASIC development. A devoted triggering unit consist of X-Y scintillator, finger scintillator

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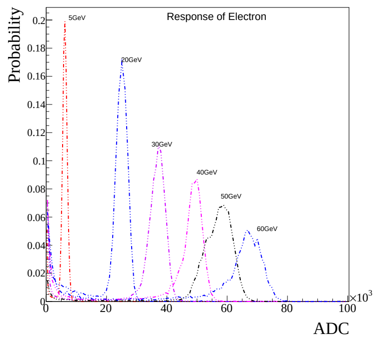

FIG. 2: Response of electron for different incident energies.

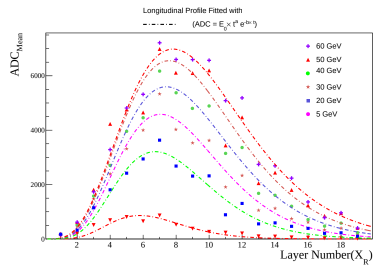

FIG. 3: Longitudinal Shower Profile showing development and energy deposition of EM shower.

and a Cherenkov counter was used both in positioning and selecting beam type during data taking. The full experimental set up at SPS was shown in figure-1. The prototype was experimented with H6 beam line at SPS for a wider range of incident energies starting from 5GeV to 60GeV for electron and 120GeV for pion with reasonably good statistics (20K events each).

Results and Discussion

High energy pion served the purpose of minimum-ionizing particle response whereas electron helped in understanding behavior to electromagnetic shower within the calorimeter. Electron with different incident energies (Fig-2) helped to understand development and propagation of electromagnetic shower within the calorimeter. The prototype response to MIP was found to be 26ADC. Electron responses for different $E_{incident}$ have been analyzed and found distinctively separated (Fig-2) from each other. Longitudinal Shower profileas (Fig-3), Response of electron (ADC) at each layer for particular incident energy, reconstructed from data and have been fitted with phenomenological profile which shows a nice shift of the shower maximum with increase in incident energy towards deeper along depth. Resolution, efficiency of the calorimeter in measuring energy precisely and expressed as $\frac{\sigma}{E} = a(compactness) + \frac{b}{\sqrt{E}}(Stochasticity) + \frac{c}{E}(ElectronicNoise)$, reconstructed from calibrated data and to be 8.5% as shown in Fig-4 assuming contribution from different sources in output ADC are independent. A immediate scope in develop-

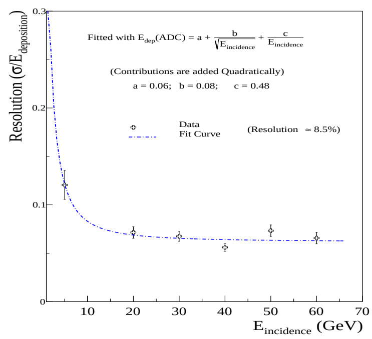

FIG. 4: Resolution reconstructed from electron data for different incident energies .

ing large dynamic range ASIC was well taken as a carefull investigation of saturation found around shower max region with increase in incident electron energy. All these results and discussion along with fabrication of the full prototype will be present in the conference in details.

References

[1] NIMA,681(2012)34.,**R.Sandhir,S. Muhuri,T.K. Nayak**

[2] NIMA,764(2014)24.,**S.Muhuri et. al.**