First Tests of High Resolution Silicon Pad Detectors for the ALICE Forward Calorimeter

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To enrich the physics program of the ALICE experiment at CERN, a newly designed Electromagnetic Calorimeter is being proposed as a possible upgrade in the Forward pseudo rapidity region. The calorimeter will be installed at a distance of about 3.5 meters from the vertex and cover a region of 2.5 to 4.8 in pseudo rapidity. The detector will be a novel silicon-tungsten design, which will be used for the first time in any high-energy physics experiment.

For full containment of photon energy up to 200GeV it has been found that 24 radiation lengths (layers) of material is sufficient. For this purpose a sampling type calorimeter with tungsten (absorber) and silicon (active material) has been considered.

The requirement of the design of the calorimeter is to have 3 planes of $1mm^2$ silicon detectors and 22 planes of $1cm^2$ silicon pad detectors. The three pixel layers (1mm *1mm silicon pads) will be at 4^{th}, 8^{th} and 12^{th} layer for good position resolution and tracking of incoming particles. Other active layers are composed of silicon pads of 1cm x 1cm.The design of the pad detectors is underway in collaboration with CMEMS Centre, Electronics Division of BARC. We plan to fabricate the detector at Bharat Electronics Limited (BEL), Bangalore.

To get a firsthand knowledge of the working of the silicon detectors, we have obtained two different detectors from BEL: (1) 32 channel strip detectors, (2) arrays of $1mm^2$ silicon pad detectors. These two detectors are tested in the laboratory. In this article, we present the first results of the working of these two sets of detectors.

The 32 channel silicon strip[3] detector of 1.9 mm pitch on a 4 inch wafer and 320 um thick with detector size of 63mm x 63mm and resistivity of 10KOhm-cm, each strip is 60mm x 1.78mm as shown in Fig 1 were tested by measuring leakage current of the strips and it is less than $10nA/cm^2$ as specified by the manufacturer, BEL Bangalore.

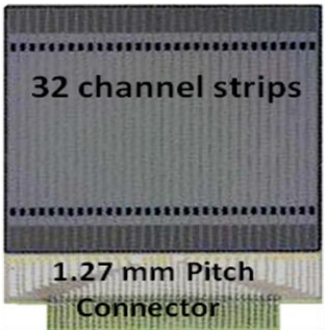

Fig.1 A 32 channel Silicon Strip Detector

This detector was also tested with alpha sources in vacuum using conventional electronics and observing the ADC, MeV plots during the preliminary tests as shown in Fig 2. The individual peaks are clearly visible, and the ADC-MeV relationship is quite linear.

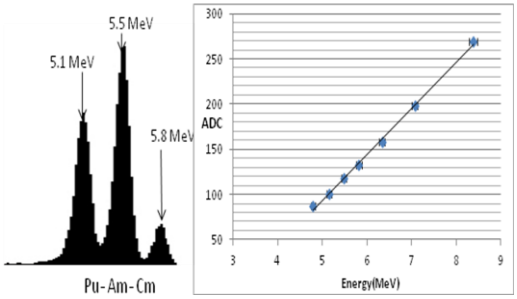

Fig.2 Response of silicion strip detector to the Alpha Sources

1 mm^2 pad detectors of 320 um thick silicon with full depletion voltage of about 100 volts and full depletion capacitance of $40pF/cm^2$ was

designed, fabricated and mounted on a Printed Circuit Board (PCB) by BEL.

Six such arrays have been mounted on three PCBs at BEL Bangalore, in such a way that two such PCBs can be mounted back to back, with minimum dead space between the detector active areas, thus making total 324 readout channels. The leakage current for few pads is measured and it is in the range of 2nA to 3nA for 1 sq mm pad.

The tests of the 27 element, 1 sq mm Silicon pad detector array with alpha sources have been done by conventional electronics with the detector kept in vacuum chamber and connecting one of the pad to the preamplifier, amplifier and finally to the Multichannel Analyzer. Fig 3 shows the part of the PCB on which the 6 numbers of 27 elements $1mm^2$ arrays have been mounted along with the Thorium spectra from the detector.

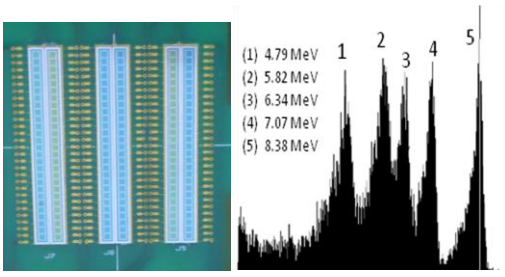

Fig.3 27 x 6 detector array and Thorium Spectra from the detector

We have tested the detector with two different radioactive sources (a) Pu-Am (b) Thorium, figure 4 shows the ADC Vs Energy plot.

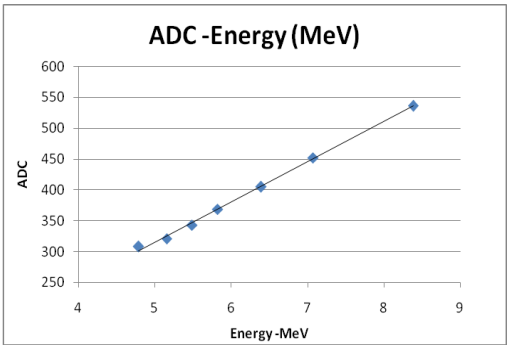

Fig.4 ADC-MeV plot

Further tests are being carried out by varying the bias voltage of the detector, varying the gain of the amplifier and with different radioactive sources.

These detectors will also be tested during the November test beam time at CERN, Geneva in PS area to study the behavior and characteristics of the detector and requirements of front end electronics with regards to dynamic range and the results will be presented.

For the Readout of all 324 channels it is not possible to use a dedicated Charge sensitive Preamplifier, amplifiers and Multichannel analyzer for each readout channel. The readout PCB on which the detectors are mounted is designed to connect all 324 signals to frontend electronics Board via flexible kapton cables. The front end boards are readout by ASIC like GASSIPLEX [1]/MANAS [2]/INDIPLEX

By switching off the deconvolution filter in GASSIPLEX the dynamic range can be extended from 280fC to 500fC for negative signals and from 500fC to 900fC for positive signals with sensitivity of 2.2mV/fC. A Test pulse is injected test from a pulse generator through a charge injector and looking at ADC values of the channel output, there is no saturation up to a charge of 500 fC for negative signals.

More rigorous test of detector at different bias voltages, different gain is underway. The detailed response of the one square mm silicon pad would be presented and discussed.

References:

[1] The ALICE HMPID on-detector front-end and readout electronics NIMs A 518 (2004) 498–500 Gassiplex by J. C. Santiard

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