Development of a compact 25-channel preamplifier module for Si-pad detectors of the BARC-CPDA

A.Inkar, Bency John*, R.P.Vind, L.Kinage, R.V.Jangale, D.C.Biswas and B.K.Nayak
Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA
email: bjohn@barc.gov.in

The BARC Charged Particle Detector Array modules use indigenously developed Si-pad detectors as their first element[1]. Total number of charge sensitive pre-amplifiers required for the Si-pad detectors is 250. In Ref.[1], we demonstrated a low cost solution for implementing pulse shape based particle discrimination technique with the Si-pad detectors. One of the main ideas here is a layout of five pre-amplifiers connected with one Si-pad detector (called a bank of preamplifiers). In the present work, a 25-channel pre-amplifier module that can cater to 5 independent Si-pad detectors, or a five-bank module, has been developed. This module uses pre-amp hybrid chips A1422H from CAEN S.p.A.[2] and is housed in a double width NIM standard box. The module has been tested for performance using proton and ^{7}Li beams from FOTIA facility, Trombay.

The pre-amp hybrid chip A1422H has been selected after a few iterations. It was felt that compactness should be one of the criteria for the selection for the pre-amplifiers and we started with 8-channel chips from LeCroy (HQV-810) and a 16 channel assembly from single-compact-chips from Cremat (CR-110). Soon it was realized that procurement of these chips in large numbers would be a problem and shifted attention to CAEN A422 hybrids and assembled a bank of preamplifiers and carried-out several tests. A better hybrid (A1422H, also from CAEN) that having low noise characteristics, fast response and low power consumption compared to A422 was opted for the CPDA Si-pad array when these chips became available in the market. The sensitivity chosen was 5 mV/MeV and the detector capacitance factors chosen were 200 pF and 1000 pF. Since the pulse shape discrimination is a must for the Si-pad array, timing output should be available to the user. The ASIC developed by BARC (BARC-P-127) was also tested. However the shaper circuit integrated in this chip made the timing filter signal unavailable, therefore these ASICs could not be used.

The hybrid A1422H is in a SIP package and has been realized using a Cold Discharge Mechanism by the manufacturer. The main issue in the mounting of these ultra sensitive pre-amplifier chips (very sensitive to noise pick up) in large numbers in a compact space like that of a NIM box is the tough task of minimizing electronic noise entering into it through the sources of common channels. Major sources of noise are : (1) Different ground loops created on the PCB wiring (2) Ripples of ±Vcc power supplies for the pre-amplifier. To minimize the noise from aforesaid two sources, we have made the circuit of all 25 channels physically isolated with each other on a mother board. Separate ground wires of equal length were run to the clean ground of NIM Bin power supply. One pre-amplifier bank was given ± 12 V through L-C π-filter deriving power from the NIM Bin. Thus all 5 banks were provided separate L-C π-filter for ± 12V. Detector I/Ps are connected to pre-amp through a panel mounted 25-pin D-type male connector mounted on the front panel of the module. The O/P of each pre-amp is available on the rear panel of the module on LEMO-00 connectors. HV bias for Si-pad detectors are given through 5 LEMO-00 connectors mounted on front panel of the module. HV bias circuits for all 5 Si-pad detectors are also isolated from each other and are mounted on a separate PCB having separate ground wires running to clean earth of the NIM Bin and are realized on a PCB mounted on the back face of the front panel of the module.

The tests were carried out using the general purpose scattering chamber of the FOTIA facility. The pad detector was 'reverse' mounted on a movable arm in the chamber at a distance of 30 cm from the target. The preamplifier module was set outside in a NIM bin close to the chamber. Pre-amplifier signals were connected to inputs of a CAEN 16-channel spectroscopy amplifier (N568B) that is equipped with a timing filter section. For the FOTIA tests, common signals from the Si-pad detector were processed and the capacitance factor for the pre-amplifier used was 1000 pF. The energy and timing outputs of N568B were sent to the counting room where the timing signals were processed using a Si-Array Pulse-Shape-Discrimination NIM module[3]. The PSD module provides time to amplitude (TAC) pulses that correspond to relative rise-times of the original pre-amplifier signals. The energy and PSD-TAC outputs were recorded using the multi-parameter data acquisition system LAMPS.

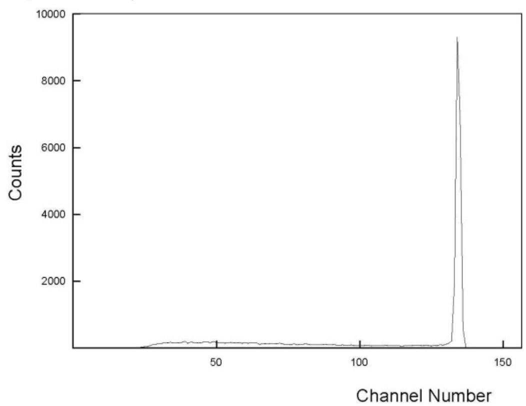

Fig. 1 Pulse height spectrum of scattered protons

Elastic scattering of 4 MeV protons from a self supporting thin gold target was measured at 45° laboratory angle using the Si-pad detector. The pulse height spectrum of scattered protons is shown in Fig.1. In order to study the timing characteristics through the PSD-TAC, more than one type of particles are required. Therefore (8 MeV) ^{7}Li beam was bombarded on a thin ^{27}Al target and fusion-evaporation reactions were populated that produce protons and alphas in addition to scattered ^{7}Li. Since elastic scattering dominates at forward angles the detector was moved to 135° lab angle where scattered Li ions are far less dominant. The relative rise-time versus energy deposited in the detector for ^{7}Li+^{27}Al reaction at 135° is given in the 2-D scatter plot (Fig.2). To help identification of event groups in the 2-D spectrum, scatter plots obtained with an Am-Pu alpha source and the gold-proton elastic scattering were superimposed on this spectrum. Accordingly, the groups were identified as shown by the arrow marks in Fig.2. Lithium and alphas are not well discriminated in this energy region. The circle shown indicates the position of proton peak in 4 MeV proton-gold elastic scattering. With the same detector settings, a 2-D spectrum with a blank-target frame were also recorded. Perhaps due to scattering and reactions from the target frame, significant number of low energy events were present in this spectrum, very similar to the low energy group seen in Fig.2. Thus the low energy group from frame scattering has also been identified.

Summarizing, the energy and timing characteristics of the 25-channel preamplifier module is suitable for the BARC-CPDA Si-pad detectors. Pulse shape discrimination has been achieved for protons of energy above 4 MeV from rest Z>1 particles. Further work is in progress for full-test and use of the module in the BARC-CPDA, Pelletron LINAC facility, Mumbai.

The authors wish to thank the FOTIA team for providing the beams.

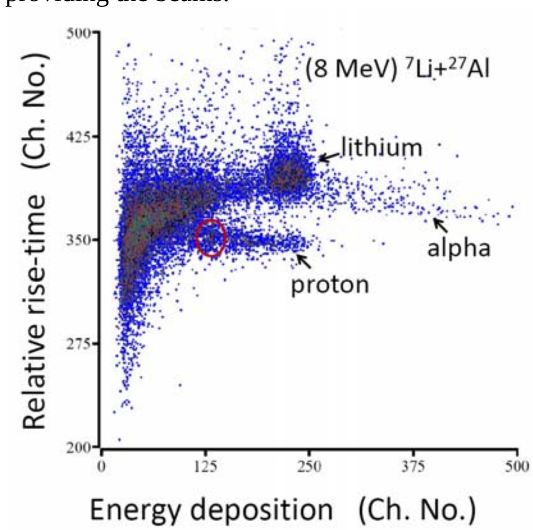

Fig. 2 Pulse shape discrimination 2-D plot

References

[1] Bency John, A.Topkar, R.P.Vind *et al.*, Nucl. Instr. and Meth. A 609, 24 (2009)

[2] Electronic Instrumentation 2012 Products Catalog, CAEN

[3] Bency John, S.Venkatramanan, R.P.Vind *et al.*, DAE Symp. On Nucl.Phys. 52, 633 (2007)