Avalanche Photodiodes for the ALICE Forward Calorimeter

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To enrich the physics program of the ALICE experiment at CERN, an Electromagnetic Calorimeter is being proposed as a possible upgrade in the Forward pseudorapidity region. The calorimeter will be installed at a distance of about 4 meters from the vertex and cover a region of 2.5 to 5.0 in pseudorapidity. Two different sampling calorimeters are being studied: (1) Tungsten-scintillator design, and (2) Tungsten-silicon strips and silicon pad design. Our study concerns the design consisting of scintillator readout.

The tungsten-scintillator design of the calorimeter comprises of 40 layers of Tungsten (3mm thickness) and Scintillator (3 mm thickness) sandwich as shown in Fig. 1. Tungsten is used as the converter material and scintillator as the sensitive medium. When the electrons or photons fall on the tungsten an electromagnetic shower is produced. The shower particles while passing through the scintillator produces visible light. Each scintillator pad (of 1cm x 1cm) is connected by four fibers which collect light from the scintillators as shown in the figure. The light at the end is read out by Avalanche Photo Diode (APD) [1] with its front-end electronics board. This signal is processed by the front end board connected to the sensor and sends the digitized data to the Data Acquisition system for further analysis.

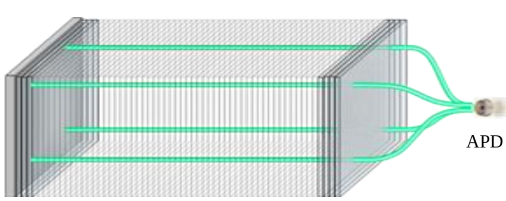

Fig.1 Layout of Tungsten and Scintillator Calorimeter with APD at the end

The APDs are preferable over conventional devices like Photon Multiplier Tubes (PMT) because of their insensitiveness to magnetic field, fast response, and high quantum efficiency in visible region. These are radiation hard detectors and can be used in hostile radiation environment. APDs are also small and compact which makes the handling better. Here we report laboratory tests of Hamamatsu S8664-55(S8148) APDs in terms of its gain variation with applied bias voltage, wavelength, temperature sensitiveness and response to cosmic rays.

A test setup for characterizing APDs in the laboratory is shown in fig 2. In this setup APD is mounted over a Charge sensitive preamplifier (CSP) [6] and a tricolor king bright LED (LF5WAEMBGMBW) is sourced to APD. To avoid any ambient light APD-CSP assembly with LED is put in a light tight box along with a LM35 temperature sensor that is calibrated directly in degree Celsius. Output from the preamplifier is fed to the Amplifier for pulse shaping and finally its output is observed on Multichannel analyzer. Gain variation with the bias voltage, and temperature sensitiveness is established as shown in fig. 3

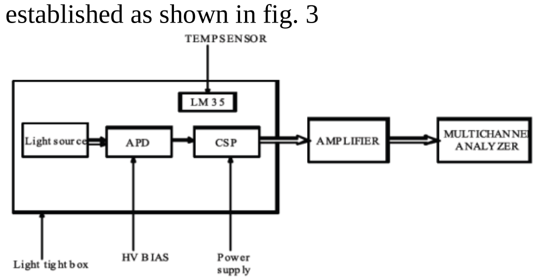

Fig.2 Setup for APD Testing

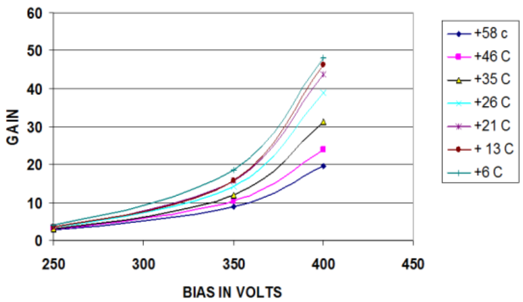

Fig.3 Gain variation as a function of APD bias voltage for different temperatures

There is not much change in gain till 250 volts, but the increase in gain is much faster thereafter and higher gains can be achieved at higher bias voltages. Also gain goes up by the decrease in temperature because of the decrease in the mean free path of electrons between the ionizing collisions which are temperature dependent, so for getting higher gains, we have to operate it at the lower temperatures. From the characteristics study [2] of photosensor with temperature and bias voltage it is concluded that the temperature and Bias voltage stabilization are essential to get the consistent results from Front End Electronics.

In the actual readout system it is not possible to have a dedicated Charge sensitive Preamplifier [3], amplifier and Multichannel Analyzer for each Readout channel. For the actual Readout we have used ASIC MANAS[4][5] with 16 channels, each channel comprising of Charge Sensitive Preamplifier, Deconvolution filter, Semigaussian shaper, Track and hold and Multiplexer. A Front End Board has been used which consists of four MANAS and a MARC (Muon Arm Readout Chip) as shown in fig. 4

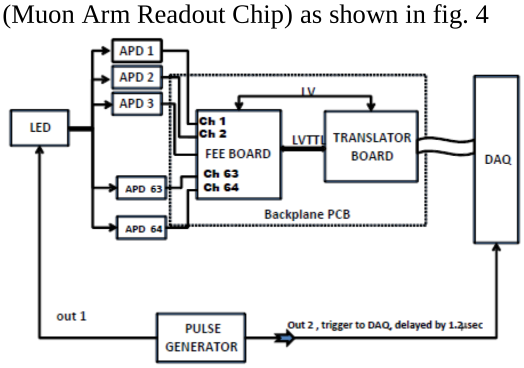

Fig.4 Readout Setup with ASIC MANAS

After 420 volts MANAS gets saturated because of its low dynamic range, so to increase the dynamic range we have used the charge division technique and with that we are able to operate the photosensor till 465 volts with charge division in three channels.

Also a cosmic ray set up is made by coupling APD with a scintillator through a light guide and reading the cosmic signal taking the APD with scintillator as the three fold.

The studies are made by varying the Bias voltage of the sensor and observing the MPV value after Landau fit as shown in fig.5.

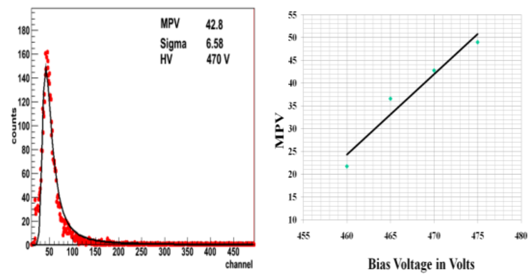

Fig.5 Landau Fit and Linear Variation of MPV with Bias voltage

Details of the different setup, results and performance status will be presented.

References

[1] Hamamatsu Silicon APD S8664 series

[2] Characterization of avalanche photodiodes (APDs) for the electromagnetic calorimeter in the ALICE experiment *by A.Badala et.al.* Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers Detectors and Associated Equipment Volume 596, Issue 1, 21 October 2008, Pages 122-125

[3] ALICE EMACL TDR CERN-LHC-2008-014 ALICE-TDR-014 1 September 2008

[4] P. Bhattacharya et.al. *PRR MANAS*, Private Communication.

[5] The Long-Time Performance of MANAS Chip by S. DAS et. al. *Proceedings of the International Symposium on Nuclear Physics (2009)*

[6] PHOS Basics for the Users Revision 2.1, 4 January 2007