MANAS based Readout of Avalanche Photodiodes for particle detectors

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Introduction

The Avalanche photodiode (APD) is a high sensitivity photodiode that operates at high gain under normal biasing conditions. They have been extensively preferred for radiation detection in particle physics over other devices because of their fast response and high quantum efficiency in visible region [1], insensitiveness to magnetic field unlike photomultiplier tubes. Also there are radiation hard APDs available for use in hostile radiation environment. APDs are small in size and compact which makes their handling better. This article reports the laboratory tests of APDs with pulsed light and sources such as cosmic muons and beta source to verify their suitability for the particle detectors.

Noise study and tests with Pulsed Light

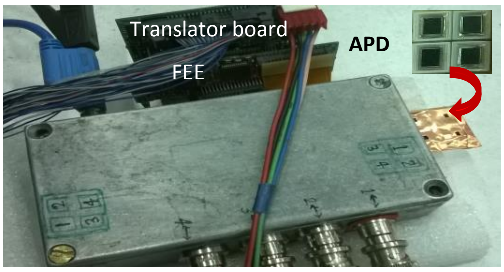

Fig. 1: Laboratory Test Setup

APDs S8664-55 from Hamamatsu with an active area of 5 Sq.mm was used with inherent avalanche gain. The APDs have been tested in an array of 2×2. To minimize the noise in the setup and to avoid possible ambient light leakage, the test assembly is put in a light tight box with proper shielding and grounding. The signal from the APDs has been coupled to a Front End Electronics (FEE) board consisting of MANAS ASIC [2] consisting of 16 channels along with Muon Arm Readout Chip (MARC) [3] is interfaced through a Translator Board (for translating LVDS to LVTTL and vice versa) to PCI CFD [4] card based DAQ system. A pulse generator was used for sourcing the pulse to the light emitting diodes. The standard deviation was 2.5 ADC channel in the bias voltage range of 200 to 425 volts.

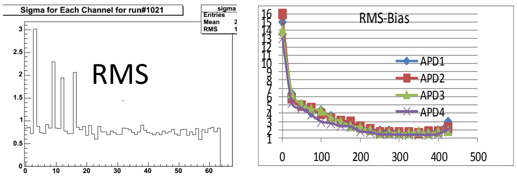

Fig. 2: Typical RMS values at 425Volts and variation of RMS with bias voltage

The evaluation of APD parameters such as spectral response, noise, response to charged particles etc. requires precise measurement of the APD gain at the operating bias voltage of photo diode. Kingbright LED'S, multi colored and blue have been used for tests with pulsed light. The variation of output with applied voltage is recorded for both blue and multi colored LEDs. It was observed that gain is almost constant up to about 200 volts, and increases at higher bias voltages. Four APDs under test have given higher ADC values with red followed by green and then blue as the gain is dependent on wavelength, as expected. The LEDs used, being multi colored; they require a higher forward voltage for blue in comparison with red and green and also the viewing angle also is more (30 to 60degree), so it was difficult to get a suitable intensity of light for all the 3 colors, at the same settings on pulse generator which switches on these LEDs. The relative radiant intensity was maximum for red and lowest for blue for the multi colored LED, hence for determining the gain of the APDs the standard blue colored LED (viewing angle is 20degree) is used.

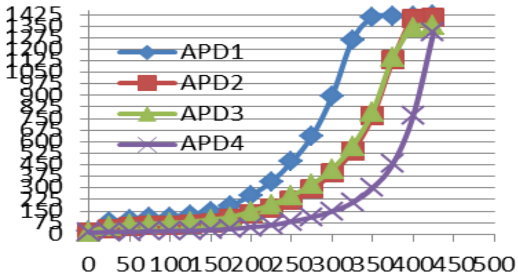

Fig. 3: ADC output vs bias voltage for different wavelengths

Tests with Cosmic muons and radioactive sources

For preliminary testing, the APDs without and with scintillator coupled to them were tested. The efficiency of the APDs was seen to be 50% with ^{90}Sr beta source and cosmic muons, whereas when tested with pulsed light the efficiency was found to be 98%. To investigate this, a single APD in different configurations like a) without any scintillator, b) with a scintillator on top of the APD and c) with a scintillator coupled orthogonally was assembled. Though we could see clear signals in both case a and b the efficiency is still about 50% only.

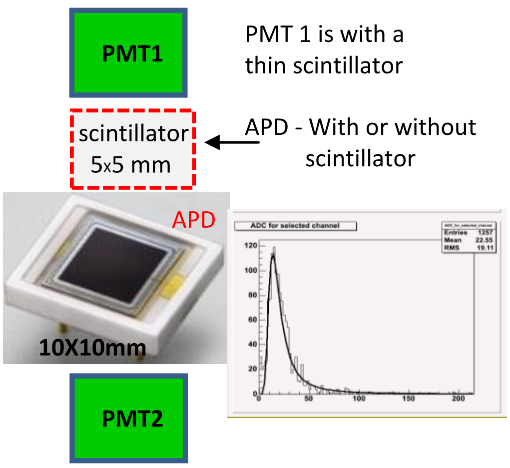

Fig. 4: Coincidence setup for tests with cosmics and Beta source

The active area of the APDs being only 5mm by 5mm and the actual size being 10mm by 10mm, the finger PMTs could not be aligned properly on the active region of the devices due to their size. To get a 2 fold trigger with Sr-90 beta source the source particles will have to pass through the PMT1, scintillator material (if coupled), the APD material and then reach PMT2 While for cosmic muons, material thickness is not a problem the geometrical alignment on a single APD is critical with such a small PMT the rates of 3 fold will be very less.

Fig. 4: Setup with APD coupled with Scintillator

To investigate further, a Scintillator is coupled to the APD orthogonally as shown in fig. 4. In this case the source particles do not pass through the APD material itself but will only pass through the PMT1, scintillator material and then reach PMT2. The efficiency in this case is improved to 85%.

Conclusion and Outlook

APD was tested with pulsed light, cosmic muons and ^{90}Sr beta source. The behavior observed confirms its suitability for the particle detector experiments. Further results will be presented.

Acknowledgement

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