Detection Of Multiple Radiation Sources Using Multi Anode PMT and CsI:Tl scintillator crystal

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Introduction

Multi Anode Photo Multiplier Tube (MAPMT) is multiple PM Tubes attached together in a single housing. This achieves a better spatial resolution for a radiation source than the conventional PMT. Typical applications include gamma ray imaging (gamma camera), positron emission tomography (PET), single photon emission computed tomography (SPECT), angular light scattering and radiation monitors for homeland security.

MAPMT is manufactured by many companies and available commercially [1]. It generally has a multianode bialkali photomultiplier tube, comprised of 8 × 8 pixels and having a 12-stage amplification of 1.5×10^6. The external size of the device is 52×52 mm^2, with an active area of about 49×49 mm^2 allowing a high packing fraction of 89 %. The pixels have a square cross-section with side lengths of 5.8 mm for centre pixels and 5.98 mm for edge pixels. This leads to a high spatially resolution.

To achieve the spatial resolution of any radiation source it is required to read the output of all the 64 PMT and plot them in a matrix. This requires sophisticated electronics. We have used IDEA make ROSMAP readout system to convert the signal from the MAPMT [2].

Here we report the use of multi-anode PMT with ROSMAP readout system for the spatial detection of multiple radiation sources.

Experimental

The multi-anode PMT (MAPMT) is mounted on a ROSMAP readout system. The scintillator used is CsI:Tl single crystal. The single crystal is grown in an indigenously designed and developed modified Bridgman Furnace. The as-grown ingot is about 55 mm in diameter and 70 mm long, as shown in Fig.1. For mounting on the MAPMT the crystal was cut and polished in two different ways. For the first set of experiment the CsI:Tl single crystal was cut into 64 pieces of size 5 mm x 5 mm x 6 mm. Each piece was polished on two sides and mounted in an SS grid of 8 x 8 so that each piece of scintillator corresponds to each pixel of the MAPMT. The SS grid also helps in collimation of the generated light and reduces cross talk among the various pixels.

In the second approach a single piece of CsI:Tl single crystal plate of size 49 mm x 51 mm x 6 mm is cut from the crystal ingot. The two sides are polished and mounted on the MAPMT using optical grease and covered with 10 layers of Teflon tape to ensure ~99% reflection of the generated photons to MAPMT.

In both the experiments the radiation source was detected directly using the detector setup (Scintillator+MAPMT+Readout) and also using a lead collimator of size 51 mm x 51 mm x 50 mm with each hole of size 3 mm x 3 mm. The collimator was used to collimate the incoming radiation such that only the gamma photon perpendicular to the crystal surface will be detected.

Experiments were carried out using various lab sources for calibrating the system so as to detect multiple sources with their spatial information.

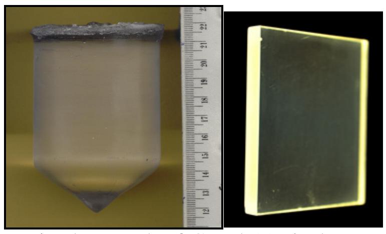

Figure 1: Photograph of CsI:Tl (a) single crystal ingot (b) plate of size 49 mm x 51 mm x 6 mm under UV illumination.

Results and Discussions

Initially the MAPMT voltage was optimized to obtain an acceptable resolution. A gamma source (^{137}Cs) of strength 2 micro Ci was used for this purpose. It was observed that with increase in the voltage the counts increases but the sharpness of image degrades. The best results were obtained at 720 V. In the next step keeping the MAPMT voltage fixed at 720 volts the dynode threshold voltage was varied. This threshold voltage is a global value and applies to all the 64 channels of the device. This decides the baseline and depends on the overall noise level. Depending on the experimental conditions it requires to be set for each experiment. Under the lab condition we observed that on increasing the dynode threshold value, the number of counts starts decreasing and the image gets diffused with some pixels stop detecting and hence give zero counts. The dynode threshold value is optimized at 1250 mV.

Using the parameters as optimized above the device was tested by varying the position of the source in the lateral as well as axial direction.

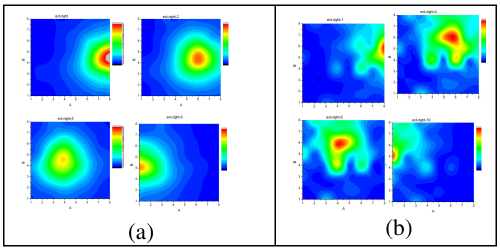

Fig. 1 MAPMT output showing the lateral displacement of radiation source without any collimator (a) by using pixilated crystals (b) using a single crystal.

The data shown in Fig.1 are recorded by moving the source position from right to left in a step size of about 1cm. It is observed that pixilated crystal shows a better spatial resolution when used without any collimator. The number of counts recorded in this case is also large as compared to those recorded with a single crystal slab. Thus for detection of a low strength source with better spatial resolution pixilated crystals should be used.

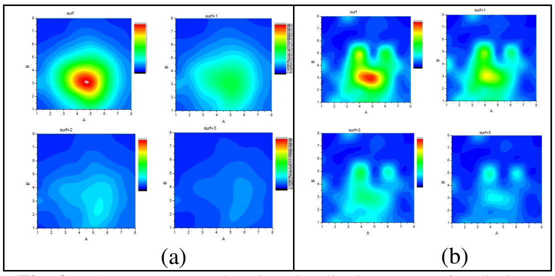

Fig. 2 MAPMT output showing the displacement of radiation source away from the MAPMT without any collimator (a) by using pixilated crystals (b) using a single crystal. (Top left data source at 2 mm distance from device, top left 5 mm, lower left 10 mm, lower right 20 mm)

In the second case data was recorded by moving the radiation source away from the device in a step size of 2 cm as shown in Fig.2. When the source is moved away from the MAPMT the counts decreases drastically in case of pixilated crystal where as in case of single slab we are able to locate the tentative position. In case of single slab we were able to detect the source at a distance of 10 cm. The spatial resolution was found to increase when the device was used with the lead collimator. But the mounting and proper correlation of the collimator holes with crystal pixel is found important.

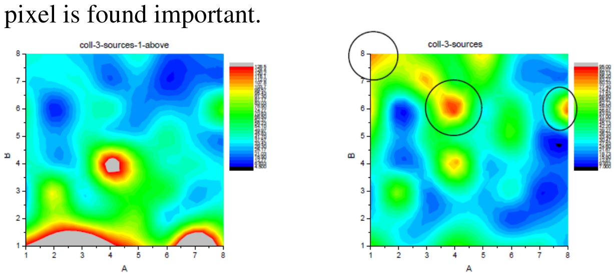

Fig. 1 MAPMT output showing the spatial position of three point source using a single slab of CsI:Tl crystal along with lead collimator.

Using the above setup we were able to detect three point sources of ^{137}Cs placed at different positions and at different distances from the device as shown in Fig.3. Thus the device is found useful to detect a radioactive source along with its position. Further experiments are underway to record the energy spectrum along with the source position.

References

[1] http://www.hamamatsu.com/resources/pdf/etd/H8500_H10966_TPMH1327E.pdf.

[2] http://www.ideas.no/products/rosmap-spectroscopy/.