YAP(Ce) as focal plane detectors

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Introduction

YAP(Ce) has been known to be one of the commercially available new scintillators that can be used for several applications. It has a good timing response and a very high value for the radiation hardness, compared to other known inorganic scintillators. Several studies have been reported on the properties of the scintillator, viz., light yield, decay time constant, gamma and charged particle response, pulse shape discrimination and timing characteristics [1–3]. The YAP(Ce) crystals has a very good response to the energetic heavy ions [3, 4] and attempts have been made to employ it as a viable alternative to the Si detectors for the detection of heavy ions. As a part of the experimental facilities, being developed for the upcoming Superconducting cyclotron at VECC, the possibility is being explored for using the YAP(Ce) as an E detector, preceded by a position sensitive MWPCs as ΔE counterpart, at the focal plane of the proposed superconducting solenoid spectrometer. The selection of Photo Multiplier Tubes (PMT) has been very crucial in such cases in order to have good timing response and energy resolution for energetic heavy ions. As the peak emission wavelength of YAP(Ce) is $\sim$ 350 nm, the UV sensitive PMTs, viz., Hammamatsu R4141 and Philips XP2020Q have been used by different groups. With this background, the YAP(Ce) crystals have been studied with fast UV sensitive Philips XP2978 PMT which can be used also in high vacuum. The spectral response of this PMT is in the range from 150 nm to 650 nm with a maximum at 400 nm. At the peak emission wavelength of YAP(Ce), the cathode radial sensitivity of the tube is of the order of 80 mA/W. The γ response and timing characteristics have been studied with a 25 mm $\phi \times$ 5 mm crystal and the response to the energetic heavy ions has been studied with a 25 mm $\phi \times$ 1 mm crystal. The responses have been tested for different bias voltages of the tube and the best values have been reported here.

Results

FIG. 1 shows the γ energy spectra taken with ^{137}Cs γ source which gives an energy resolution $\sim$ 6% at 661.7 keV. The timing measurements for YAP(Ce) were carried out on the γ rays emitted from a ^{60}Co source and with a reference counter consisting of a 3.5 cm $\times$ 3.5 cm $\times$ 5 mm BaF_2 crystal coupled to XP2978 PMT. The measurement has been repeated by replacing the BaF_2 with another YAP(Ce) detector of same thickness. FIG. 2 shows the BAF_2-YAP(Ce) and YAP(Ce)-YAP(Ce) timing spectra. The time resolution for the YAP(Ce) comes out to be $\sim$ 465 ps from the BAF_2-YAP(Ce) measurement, when corrected for the contribution from the reference counter which is $\sim$ 450 ps for the used BaF_2 detector. The result is also corroborated with the other measurement. The energy resolution of energetic heavy ions were measured with a 25 mm $\phi \times$ 1 mm thick crystal coupled to XP2978 PMT. An elastic scattering experiment has been car-

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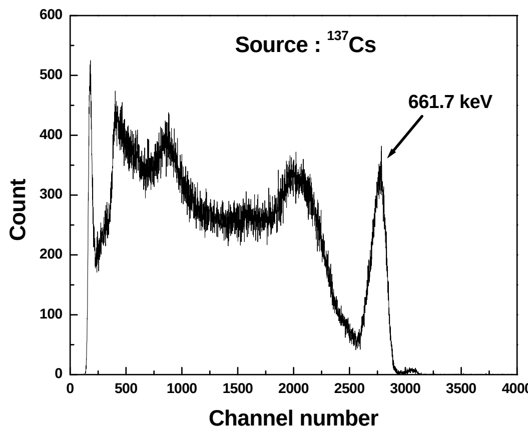

FIG. 1: Energy spectrum obtained with ^{137}Cs source.

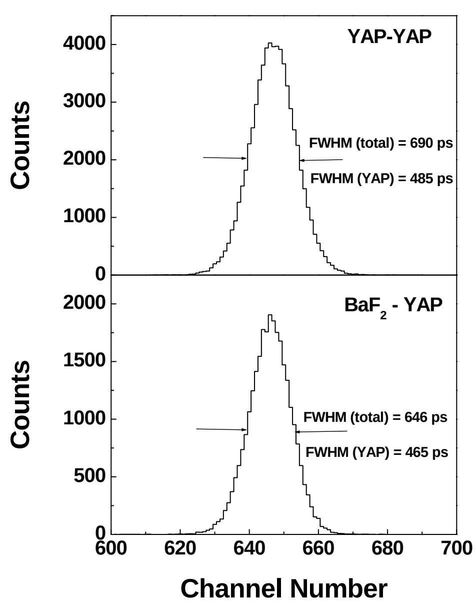

FIG. 2: Timing response of YAP(Ce) when measured with BaF_2 and self.

ried out with ^{20}Ne (145, 160 MeV) and ^{16}O (116, 145 MeV) beams from Variable Energy Cyclotron, Kolkata and with ^{197}Au and ^{nat}Ag targets. The elastiacally scattered ions were detected by a ΔE-E detector, consisting of a thin Si detector as ΔE and YAP(Ce) detector as E. The data were taken at various angles ranging from 15° to 60° for studying the response at different energies of the ions. The energy of the ions detected by the YAP(Ce) crystal have been determined by subtracting the energy degradation in the ΔE Si detector. The resolution has been measured for the elastic peaks obtained at different angles. In FIG. 3 the energy resolutions for ^{20}Ne and ^{16}O ions have been plotted with respect to the energy of the scattered ions. The development of the prototype of a compact array is being planned with four numbers of 25 mm $\phi \times 5$ mm YAP(Ce) crystals.

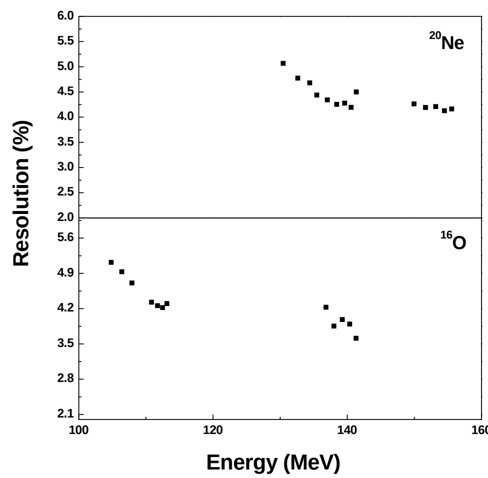

FIG. 3: Energy resolution as a function of energy for the ^{16}O and ^{20}Ne ions.

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