PULSE HEIGHT DEFECT OF BaF_2 SCINTILLATOR FOR LIGHT CHARGED PARTICLES

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The intrinsic BaF_2 scintillator is becoming popular as charged particle detector as well. Although the properties of BaF_2 to gamma radiation have been measured by several authors data on the response to charged particles are scarce. For scintillators it is commonly observed that the light output at a given particle energy decreases for heavier particle (pulse height defect). We have measured pulse height defect and the ratio of fast component to total light output for proton and alpha particles independently using Van De Graaff accleralor at Trombay. The BaF_2 scintillator used for the present measurement was grown at TP&PED BARC and has a size of 10 mm dia and 5 mm thickness.

Protons of energy ranging from 1.5 MeV to 2.5 MeV and alpha particles of energy 2 MeV were obtained from the acclerator. The particles elastically scattered from gold target (50 $\mu gm/cm^2$) were detected using BaF_2 to study its response using gated and normal amplifiers . Alphas from ^{241}Am and ^{229}Th were also used. Proton and alpha pulse heights(total) were comparable in this energy range. Since at low energies (<20 MeV) the scintillator response is linear, the measured ratio will hold good up to about 20 MeV and meaningful extrapolation can be made to find the energy region in which the detector can resolve the two particles.

Experimental setup

A vacuum chamber with a quartz window was used for the experiment.The gold target was mounted inside the chamber in beam line. The BaF_2 crystal was mounted inside the chamber on the window at an angle of 74° w.r.t beam direction and at a distance of 13.5 cms from the target. A collimator of 5 mm dia limits the solid angle to 1 mSr. Quartz window PMT EMI 9558 QB was mounted outside the chamber on the quartz window. The face of the crystal through which the scattered particle were entering has a very thin (1 μm) coating of aluminum. This coating acts as a reflector for scintillation light as well as a seal for ambient light.

Electronics

The anode signal was bifurcated. One part was fed to a variable width gate generator (5 ns to 100 ns, NE 4667). The gate of width 50 ns thus generated was used to activate a gated amplifier. The other part of the anode signal was suitably delayed and fed as the input to the gated amplifier which integrates the charge within the gate (NE 4695). The timing of the gate and anode signals are critically adjusted such that the gate reaches 15 nsec before the anode signal. The delay of charge pulse was required to permit coincidence and logical decision to be made. The total light output was measured using the dynode signal using ORTEC 572 amplifier with 2 μsec shaping time, separeatly.

Results

The energy of the scattered particle at an angle of 74°

was calculated and corrected for energy absorbed in the Al coating and target thickness effect. The $1/\sqrt{E}$ behaviour of energy resolution was checked (see table 2) The energy calibration for proton and alpha gives the pulse height defect as 1 : 0.45. The pulse height defect for electrons and alphas were obtained as 1 : 0.302 in another measurement using ^{137}Cs, ^{22}Na and ^{235}U sources and this value is in good agreement with reference 1.

Table 1. Pulse height defect of BaF_2

Relative pulse height	electron	proton	alpha
	1	.66	0.302

Table 2

Proton energy	Energy resolution %	$\sqrt{E}$ * en res
1.70 MeV	10.87	14.17
1.95 MeV	10.60	14.82
2.20 MeV	9.77	14.49
2.45 MeV	9.30	14.55

The relative ratios of fast component to total light output for proton and alpha particles are found to be 1: 0.5. The plot energy (MeV) vs fast component (arb unit) is given in fig 1.

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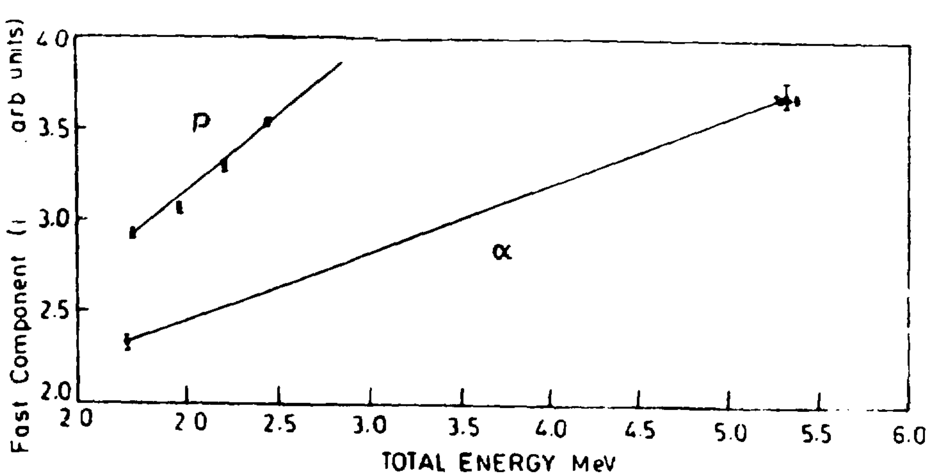

Fig1

Reference

1. S.Kubota, M. Suzuki,J.Ruan,F.Shiraiishi and Y.Takami Nucl Instr and Methods A(242) 291 (1986)