# Determination of beta endpoint energy by scintillators and semiconductor (HPGe) detectors

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## Introduction

A key characteristic of a beta spectrum is its end-point energy. This end-point energy of beta particles can be measured using various detectors, including magnetic spectrometers [1], plastic scintillators, silicon detectors [2], and germanium solid-state detectors [3,4,5]. These detectors have varying efficiency and resolution. Among them, silicon-based detector is most widely used. Silicon detector has a limitation as this cannot be used for hard beta particles [1].

In the present experimental study, we have used NaI(Tl), $CeBr_3$, scintillators and HPGe [3,4] semiconductor detectors to access the end point energy of commonly found beta emitter, whose energy ranges from medium to high MeV, and has long half-life i.e., $^{204}$Tl and $^{90}$Sr-$^{90}$Y [6,7]. Precise measurement of the beta end-point energy is crucial in various fields of nuclear physics. The precision of the beta end-point energy is crucial for accurately interpreting the level structure of daughter nuclei. This can be achieved through beta-tagged gamma spectroscopy, employing scintillators with superior energy and time resolution. An example of such a scintillator is the $CeBr_3$ crystal, which has been used for this measurement.

Additionally, gamma counters in beta particle spectroscopy are also effective for assessing the beta end-point energy in complex beta decay processes.

## Experimental Details

We are using 2"x2" NaI(Tl), 1.5"x1.5" $CeBr_3$, 34% efficient and 31.5 mm thick HPGe for recording the beta decay spectrum. The calibration of the energy spectrum of NaI(Tl) (with a resolution of 7.6% at 662 keV) was done with the help of $^{133}$Ba, $^{60}$Co and $^{137}$Cs gamma sources. For CeBr3 and HPGe detectors, which had better energy resolution in comparison to NaI(Tl) scintillator, so, we have used $^{133}$Ba and $^{152}$Eu gamma sources for calibration. The events from background were collected for about 30 minutes, where the high energy gamma rays from U-Th series was taken into consideration as calibration points. The opening windows of both NaI(Tl) and $CeBr_3$ detectors was made up of 0.5mm thick aluminium, likewise HPGe had 0.6mm thick Carbon window. The source to detector distance was so chosen as to get least decrement in energy due to air. The events due to beta particles were collected for the same time as that due to background. The time normalized background spectrum was then subtracted from the events collected from beta spectrum, gathered with gamma counters. Two such background corrected beta spectrum are shown in Fig. 1.

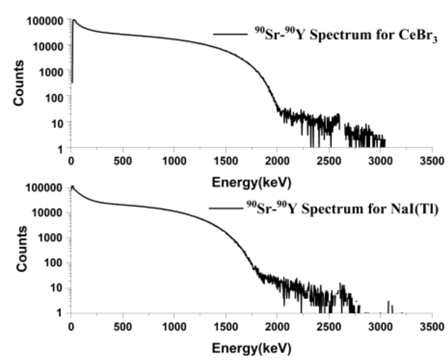


Fig.1 Beta spectrum collected using $CeBr_3$ and NaI( Tl) crystal

The procedure of extracting the beta spectrum using HPGe is shown in Fig. 2. The beta sources used in this experiment were $^{204}$Tl and $^{90}$Sr- $^{90}$Y which are pure beta emitter. $^{204}$Tl emits low energy beta particle, whereas $^{90}$Sr -$^{90}$Y emits both low and high energy beta particles.

## Result, Discussion and Future scope

Experiments using planar HPGe detectors have shown that the end-point energy can be accurately determined by fitting data points with energies greater than $0.8E_\beta$ where $E_\beta$ being the end point energy of beta particles [3]. This is applicable for scintillator detectors too. The fitting of experimental Fermi-Kurie (F-K) plots, if include lower energy data points, shows an upward curvature in the fitted line. This characteristic arises from the fact that the transitions are forbidden for both $^{204}$Tl and $^{90}$Sr-$^{90}$Y sources. The Fermi-Kurie plots were generated from the experimentally obtained beta spectrum using the 'F-K-Energy' routine Included in the spectrometer code LISE. [8,9].

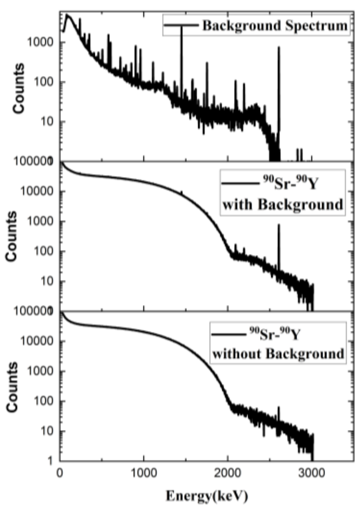


Fig2. Beta spectrum using HPGe crystal

The Fermi Kurie plots corresponding to $^{90}$Sr-$^{90}$Y is shown in Fig. 3.

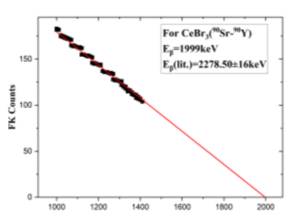


Fig 3: F-K plot for $^{90}$Sr-$^{90}$Y using $Cebr_3$ detector

The plot has been fitted with a linear function y=ax+b, with the relation of $E_\beta$ =b/a + d , where d is the correction factor for decrease in energy at the respective windows. It is seen that the end point energy determination from the F-K plot matches with that of experimental value when we add up the loss in energy in the respective window. Currently, we are in the process of simulating spectrum obtained by the gamma counters. The experimental work aims to be further validated by the simulation.

## Acknowledgements

The team is thankful to amity university -DTRA technical assistance program project code: AUUP/2021-22/576.

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