

## RDM plunger setup with clover detectors

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### Introduction

The knowledge of level lifetimes of the excited nuclear states provides deeper insight into the internal structure of the nucleus. The transition probabilities obtained from level lifetimes, give direct information about the wave functions of the two states involved in the electromagnetic decay of the nucleus. Therefore by measuring the level lifetimes, one can get information not only about the equilibrium shape of the nucleus, but also about the changes in the shape taking place at different excitation energy and spins during the de-excitation process. Due to this very reason, the method of lifetime measurement has been well exploited over the years and a number of structural issues in nuclei of different mass regions have been resolved. The recoil distance Doppler shift method (RDM) is one of the important methods of lifetime measurement [1]. For excited nuclear states having lifetime from  $10^{-9}$  –  $10^{-12}$  sec., this method uniquely determines the level lifetimes. For RDM lifetime measurements, the plunger setup at Inter University Accelerator Center (IUAC) Delhi has been extensively used with Gamma detector Array (GDA) [2] in the past. In the present work the test results of the plunger setup with a mix of normal HPGe and Clover detectors in the old GDA array are reported. The aim of the activity was two fold; one to check the consistency and precision of three DC motors of the plunger setup, the other was to compare quality of the data obtained with Compton suppressed HPGe detectors and unsuppressed clover detectors.

### Experimental Setup

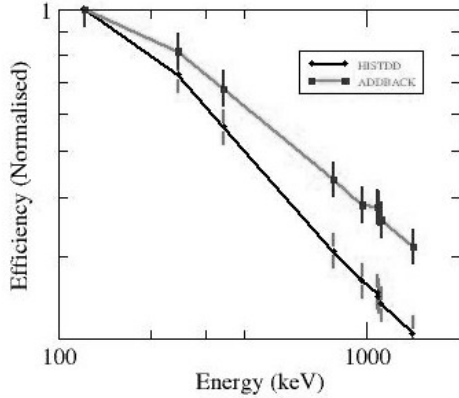
For the test experiment, the  $^{94}\text{Zr}$  ( $^{12}\text{C}$ ,  $4n$ )  $^{102}\text{Pd}$  reaction at a beam energy of 67 MeV was

used. The target foil consisted of a thin (thickness  $\sim 500 \mu\text{g}/\text{cm}^2$ ) layer of enriched  $^{94}\text{Zr}$ , evaporated on thick Ta foil (thickness  $\sim 4 \text{mg}/\text{cm}^2$ ). To protect  $^{94}\text{Zr}$  from oxidation, a very thin (thickness  $\sim 40 \mu\text{g}/\text{cm}^2$ ) layer of gold was also evaporated on Zr layer. A thick (thickness  $\sim 8 \text{mg}/\text{cm}^2$ ) stopper foil, made by rolling method was used in the experiment. A minimum target-stopper distance of  $\sim 8 \mu\text{m}$ , extracted with the capacitance method [3] was achieved in the experiment. For detection of de-excited  $\gamma$ -rays, in total five gamma detectors (two HPGe + three Clovers) in the old GDA structure were used. The three clovers and one HPGe were mounted in the four available slots of the backward ring ( $\theta = 144^\circ$ ) while the other HPGe detector was mounted in the forward ring ( $\theta = 51^\circ$ ) of the GDA structure. Since size of the anti-Compton shield (ACS) was not compatible with the GDA structure, clovers were used without ACS while the two HPGe detectors were used with ACS in the experiment. In total about 4 shifts of beam time was used and data from four target-stopper distances was recorded.

### Results and Discussions

The characterization of the setup, Energy resolution, full energy peak detection efficiency, addback factor, Peak to total ratio and Prompt to addback and background to addback are measured. The calibration were done using  $^{60}\text{Co}$  and  $^{152}\text{Eu}$  radioactive source. The peak to total ratio for the addback and direct mode are determined for the Clover detector. In addback mode we obtain a resolution of  $\sim 2.73 \text{keV}$  which is slightly large with respect to resolution of individual crystal  $\sim 2.51 \text{keV}$ . The normalised gamma detection efficiency for the addback and direct mode for a clover detector is shown in

fig.1. The detection efficiency in adback mode increases relative to that in direct mode with increase in gamma energy.

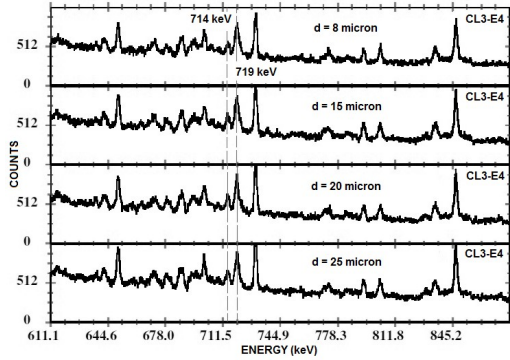


**Fig 1:** Shows the normalised efficiency plotted for the adback and direct mode for a clover detector. (logarithmic scale is chosen)

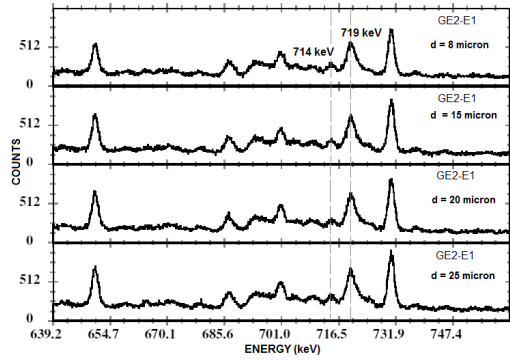
Some transitions like 332keV, 556keV, 719keV and 836keV for <sup>102</sup>Pd are observed in beam time of 4 shifts during facility test. Further analysis is in progress to extract the lifetimes. Spectrum obtained for 719keV peak showing shifted and unshifted peak is shown in fig.2(a) for a clover detector and for a suppressed HPGe detector is shown in fig.2(b).

**Summary**

The testing and characterization of the plunger setup comprising of three clovers and two HPGe detectors with anti-compton shield has been reported in this paper. The setup is planned to be used for the further experiments for lifetime measurement using RDM technique.



**Fig.2(a)**



**Fig.2(b)**

**Acknowledgement**

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**References**

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