Singles time stamped data in In-beam spectroscopy

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Introduction

The advancement in technology has stimulated the path of evolution in digital signal processing. It has offered experimentalists to substitute the analog electronics by real time digital acquisition technique by using a complete, compact system - Digitiser. This can be used in in-beam or off- beam measurements. In the present work, we shall demonstrate the advantage of using singles time-stamped data from a detector acquired by a digitiser to monitor beam characteristics. Minute details of beam intensity and beam tuning variations can be monitored continuously with such data. In the study of nuclear isomers, having half-lives around a few seconds or minutes, the reaction products are carried out to a low background detection site using Recoil transport technique [1]. But this method is quite involved [2] and needs several mechanical arrangements. Usage of time stamped singles data using a digitiser can be useful to measure these half-lives also.

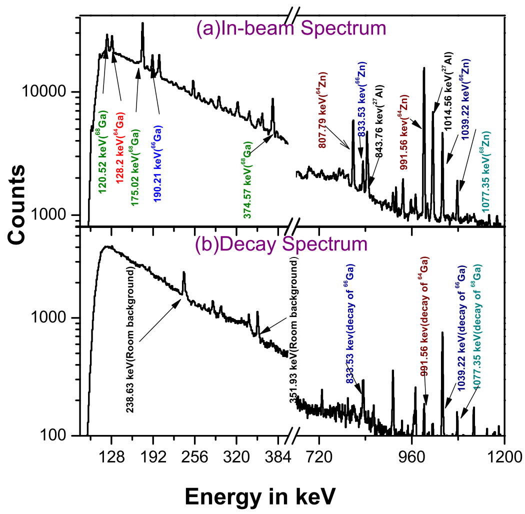

FIG. 1: a)In beam and b) decay spectra obtained from proton irradiated Zn target using HPGe detector and digitiser .

Experimental details

An in-beam experiment has been performed at the Variable Energy Cyclotron Centre, Kolkata using light-ion proton beam delivered from the K-130 cyclotron. The natural Zn(^{64}Zn : 49.17%, ^{66}Zn : 27.73% and ^{68}Zn : 18.45%) target was irradiated by 10 MeV proton beam. It mainly populates ^{65,67,69}Ga nuclei that decays via 1n channel producing the residual nuclei ^{64,66,68}Ga that further decays via electron capture to ^{64,66,68}Zn. An HPGe detector (20% relative efficiency) in singles mode with CAEN 5780 digitiser (14 bit, 16k channel and 100 MS/s, minimum time bin of 10 ns) was used. Data were acquired in List mode that generates a sequential list of incoming energy along with temporal information expressed in terms of time stamp (1 unit=10 ns). This list mode data can be sorted using

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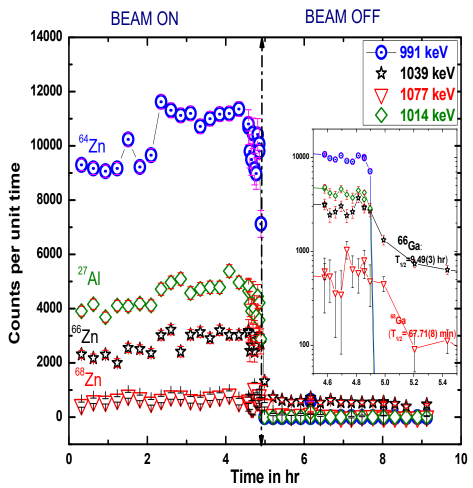

FIG. 2: Variation of area of different gamma transitions in beam-on and beam-off situation.

simple programming language for a particular time window sequentially to follow the in-beam yields or decay as a function of time(Fig. 2).

Results and Discussion

Typical in-beam and decay γ-ray energy spectra are shown in Fig 1. To study the in-beam effect, the time evolution of area under the strong photo-peaks was studied. Strong photopeaks at 991 keV, 1039 keV and 1077 keV correspond to 2^+ to 0^+ transition for ^{64,66,68}Zn isotopes, respectively[3]. These gammas are arising out of proton inelastic scattering as well as decay of corresponding Ga isotopes populated via (p,n) reaction. In Fig. 2, the yield of these gamma rays is almost proportional to the abundance ratio of these isotopes in natural Zn, if we assume same efficiency of the detector for these similar energy gammas. In addition, the area of 1014 keV which corresponds to the target holder material ^{27}Al is considered as a background event induced by proton beam hitting the target frame.

In beam-on situation, the absolute area under the peak is not only dependent on the abundance of that material, but also on beam parameters such as beam current, beam focusing, etc. For a particular target material, such parameters can be monitored via List mode data. The higher area of real peaks as well as of background peaks, will indicate increase in beam current. If in any situation, there is larger increase in area of background peak than real peaks, that will be an indication of deterioration of beam focusing. From Fig 2, the beam on and beam off situations have been differentiated by a dotted line. From beam - off portion, the yields of these gamma rays are only arising from the decay of Ga isotopes, which can be used to determine the halflives of different Ga isotopes. The halflives of these isotopes range from $\simeq$ 3 min to 9 hr[3]. The area of 1014 keV of Al falls off sharply with the stopping of the beam as the half-life of (p,n) reaction product ^{27}Si has a half-life of 4.15 s[3].

Thus it is evident that time stamped data in singles mode acquired in List mode can be utilised for various purposes.

Acknowledgments

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