

A New Isomer in ^{195}Bi Identified at the Focal Plane of HYRA

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Introduction

Due to the presence of high-j ($h_{9/2}$ and $i_{13/2}$) orbitals near the proton and neutron Fermi levels, high spin isomers are expected to occur for neutron deficient Bismuth nuclei ($Z = 83$) in $A = 190$ region. A 750 ns isomer has been known for a long time in ^{195}Bi [1] whose excitation energy and decay path have been reported recently [2]. A rotational band has been reported in this nucleus based on $13/2^+$ isomer, originated from the deformation driving $i_{13/2}$ orbital. This band reported to have prompt feeding through a 457 keV γ -ray apart from a strong feeding from the 750 ns isomer. In ^{193}Bi , the $29/2^-$ state is a $3\mu\text{s}$ isomer, another isomer with half-life $>10\mu\text{s}$ is also known in this nucleus but its excitation energy, spin and parity are not known [3]. Similar isomer has not yet been observed in ^{195}Bi . The aim of the present work was to find isomers and their decays in $^{193,195}\text{Bi}$.

Experimental set up

The experiment was performed at the HYRA beam line at IUAC, New Delhi using fusion evaporation reaction $^{30}\text{Si}(^{169}\text{Tm}, xn)^{193,195}\text{Bi}$ with $\sim 0.8 \text{ mg/cm}^2$ (mono-isotopic) target. The beam energy was between 155 - 179 MeV. The gas filled (Helium gas at 0.15 Torr) separator HYRA was used to separate the evaporation residues (ER) from the fission products and carried to the focal plane. A Ni foil (1.3 mg/cm^2) was used at upstream of the target to separate the He gas at HYRA from the beam line. Energy loss of the beam was $\sim 10 \text{ MeV}$ in this foil. The focal plane (FP) chamber consisted

of a MWPC followed by three Si pad detectors in which the ERs were stopped. A clover HPGe detector was placed outside the FP Chamber using a re-entrant cup to keep it close to the Si pad detectors to increase the efficiency. Another clover detector was placed near the target chamber. The target to focal plane time of flight of the ERs was estimated to be $\sim 1.5\mu\text{s}$. Multi-parameter data were taken in the list mode using the CANDLE software. The trigger was generated with 'AND' logic of MWPC and Si pad detectors. Times $\Delta T1$ between the MWPC and the clover (OR of all the four crystals) and $\Delta T2$ between master and the individual crystals were also recorded. $\Delta T2$ was used to generate γ - γ coincidence matrix between delayed γ -rays using the four crystals of the clover.

Results

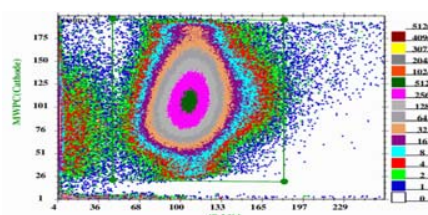


Figure 1: Si Vs. MWPC (Cathode) 2-D spectrum. Enclosed area is taken for ER gate.

It was for the first time such isomer decay study was carried out at the focal plane of HYRA. So, to establish the method the known $3 \mu\text{s}$ isomer in ^{193}Bi was studied using the same reaction at 169 MeV of beam energy at the target. The ERs were chosen from the two-dimensional plot of Si Vs. MWPC (Cathode), as

shown in Figure 1. All the known isomeric transitions from the isomers in ^{193}Bi have been observed in the addback spectrum of FP clover detector. The half-life of the isomeric state was obtained by fitting the time spectrum $\Delta T1$ gated by decay γ -line (or sum of γ -lines) from the isomer. We have obtained a half-life of 3.0(7) μs for the known 3 μs - isomer in ^{193}Bi [3].

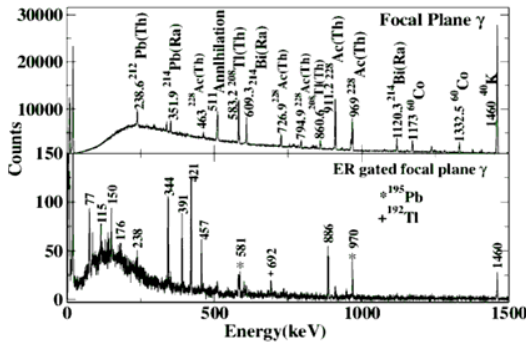


Figure 2: Addback spectrum in the focal plane clover detector with (bottom) and without (top) ER gate. Marked lines are from ^{195}Bi (bottom) or as stated.

The high spin states in ^{195}Bi were produced at 145 MeV of beam energy at the target. The addback γ - ray spectra in the FP clover detector are shown in Figure 2. The raw spectrum without ER gate in top panel is dominated by background lines. The spectrum with ER gate in the bottom panel is very clean and only the lines belonging to the ERs are seen. In this ER gated spectrum, apart from the isomeric decays in ^{195}Bi , there were some known lines from the isomeric decays in $^{194,195}\text{Pb}$ also which were produced in the same reaction. The 115, 150, 344, 391, 421 and 886 keV γ -lines in ^{195}Bi are known to feed from the 750 ns isomer. Observation of the 457-keV line, which was known to bypass the 750-ns isomer [2], in the bottom panel of Figure 2 indicates the presence of another isomer above the 750-ns isomer. The γ - γ matrix constructed from the four crystals of the focal plane clover detector indicates the possible presence of 238- and 176-keV γ rays decaying from the new isomer.

The time $\Delta T1$ has been projected with sum energy gate on the low-lying transitions and fitted assuming two isomers (as shown in Figure 3). It gives half-lives of T1 \sim 1.6(2) μs for the new isomer and T2 \sim 0.7(1) μs for the 29/2-

isomer, which is consistent with earlier measured value of 0.75 μs [1]. The time spectra gated by 238 & 457 keV γ are shown in Figure 4 and the fitted half-lives are consistent with new isomer.

Conclusion

Isomer decay studies have been successfully demonstrated at the focal plane of HYRA for the first time. A new isomer in ^{195}Bi has been identified. Detail analysis, results and the interpretation of the possible configuration of the new isomer will be presented.

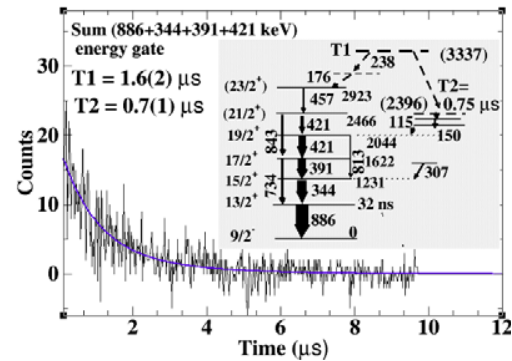


Figure 3: Sum energy gated time spectrum. Level scheme of ^{195}Bi , the new isomer T1 and its possible decay paths are shown in inset.

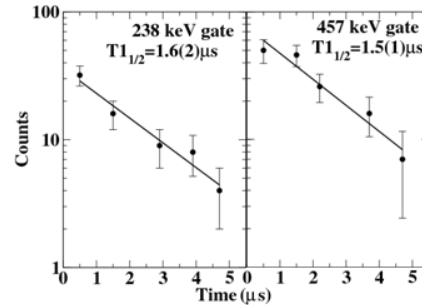


Figure 4: 238 & 457-keV γ gated time spectra.

Acknowledgement

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References

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