# Decay spectroscopy of fission fragments around $^{132}$Sn

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## Introduction:

Structure study of neutron rich nuclei around $^{132}$Sn, having few extra proton particle and few extra neutron particles (holes) compared to the double shell closure of Z=50, and N=82 is one of the most important research in recent time. The level structure of these nuclei enables us to understand the single particle energy as well as interaction matrix elements involving single particle orbitals around these shell closures. The odd-odd nuclei are of particular importance for studying the p-n residual interaction associated with the available single particle orbitals. Systematic information on the low lying states of these nuclei involving $\pi d_{5/2}$ orbital show an anomalous nature while studying both level energies and transition moments [1, 2]. There has been standing debate regarding the cause of such anomaly owing either to the change in single particle energy or interaction matrix element. The measured quadrupole moments of the $5/2^+$ and $7/2^+$ states of odd-A iodine nuclei also shows anomalous behavior when compared with the shell model calculations which has been explained with the configuration mixing associated with a modification of n-p interaction [2]. One of the most significant reasons for the scarcity of data for these nuclei is the difficulty to produce them with reasonable cross section and complexity of the experimental devices for selective γ-detection. The production of these nuclei as fission fragments, followed by the radiochemical separation, is one of the effective ways to study their low lying states [3]. The β-delayed gamma decay produced from the isotopes of radio-chemically separated nuclei can then be counted with an appropriate gamma array. This exploration requires the expertise in the field of both experimental nuclear physics as well as nuclear chemistry and has been initiated by developing an effective collaboration with the Radiochemistry group at VECC, Kolkata [4,5].

## Experimental Details:

In this particular work, the fission fragments have been produced with the $^{nat}$U ($^4$He,f) reaction at $E_\alpha$ = 40 MeV by using stacked foil irradiation followed by radio-chemical separation of Tellurium isotopes using carrier separation technique. Both short and long irradiations were carried out to produce the nuclei having different β-decay half-lives. The β delayed γ-rays has been detected with an ancillary array of eight $CeBr_3$ fast timing detectors coupled to the VENUS array of six Clover HPGe detectors. The Clover detectors were kept at angles 30$^o$, 90$^o$, 180$^o$, 260$^o$ and 310$^o$ with respect to one of them for which angular position is considered as 0$^o$. For the $CeBr_3$ detectors the angular positions were 67$^o$, 112$^o$, 136$^o$, 157$^o$, 207$^o$, 236$^o$, 282$^o$ and 337$^o$ with respect to the 0$^o$ Clover. Signal processing for the Clover HPGe detectors were performed using Mesytec sixteen channel amplifier whereas discrete NIM electronics were used for the processing of the signals from the $CeBr_3$ detectors. The data acquisition has been performed by using VME based data acquisition system consisting of high resolution (32 bit) VME ADCs, CAEN VME controller and VME LAMPS data acquisition software. The low lying spectroscopy of the daughter nuclei produced in the decay chain of neutron rich Te nuclei will be explored with the measurement of γ–γ coincidence, γ–γ angular correlation, and level lifetimes. For the measurement of decay half-lives, singles data was taken with a 50% HPGe detector. A coincidence setup with two thin window (100 μm Be) LEPS (Low Energy Photon Spectrometers) detectors have also been used for the measurement of low energy transitions in singles and coincidence mode. All the above measurements were carried out while keeping the separated Te nuclei in liquid media. The Generalized Centroid Shift technique [6] has been used for the measurement of level lifetime ~ps. The measurement of quadrupole moment for few long lived states of the nuclei in the Te decay chain was also performed by using Perturbed Angular Correlation (PAC) Technique. For this measurement coincidence data was gathered by using three $LaBr_3$(Ce) detectors in close configuration and while doping the active Te nuclei in Te metal matrix followed by annealing at a temperature of 300$^o$C for six hours.

## Data Analysis and Result:

The decay half-lives have been measured for both the long lived and short lived Te isotopes by following the activity of corresponding Iodine daughters by using the data gathered with the 50% HPGe and LEPS detectors. Fig.1 shows the half-lives of few such transitions showing the population of the excited states of different neutron rich Iodine nuclei. The γ–γ matrices have been generated from the data gathered with the Clover HPGe detectors in order to study coincidence relationships and angular correlation among different γ transitions. The γ–γ coincidence shows several new transitions in the decay scheme of the populated nuclei. Fig. 2 shows such a spectrum corresponding to the gated projection of 149keV transition in $^{131}$I. The prompt response time curve has been generated by using $^{152}$Eu source in order to measure lifetimes ~ps as described in ref. [6] using the centroid differences obtained with different γ–γ cascades involving 344 keV level of $^{152}$Gd and 366 keV level of $^{152}$Sm. The lifetime analysis is in progress to determine the lifetimes of the excited levels in picoseconds range. The shell model calculation has been planned to be initiated using OXBASH code for the interpretation of the level structure of these neutron rich nuclei which are mostly expected to have single particle structure.

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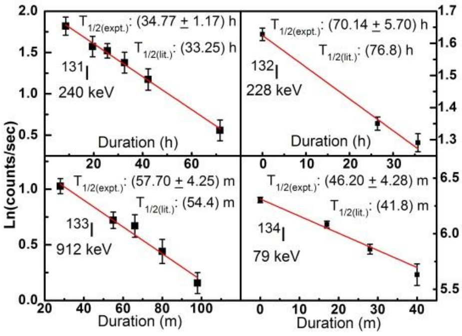


Fig. 1: Decay plots corresponding to the transitions de-exciting from the excited levels in neutron rich Iodine nuclei.

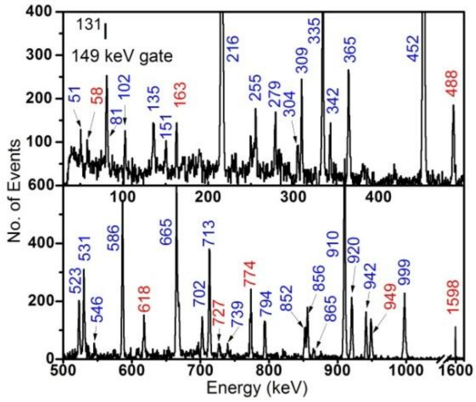


Fig. 2: The γ–γ coincidence spectrum, obtained by gating on 149 keV γ-transition of $^{131}$I. The new γ-rays are shown with red and the transitions marked in blue are known in $^{131}$I.

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