Lifetime measurements in neutron rich ^{129}Sn and ^{130,132}Te

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Introduction:

Electromagnetic transition rates provide one of the most sensitive probes of nuclear structure and they are of great value in probing the details of nuclear many-body wave functions in spherical and transitional nuclei around the closed shells ("magic nuclei") [1,2]. Such measurements in Sn and Te nuclei close to the double shell closure of ^{132}Sn are of substantial importance.

Study of ^{129}Sn, with three neutron holes with respect to neutron shell closure at N=82, is worth pursuing in detail as this provide important information on n – n interaction in the $d_{3/2}$, $s_{1/2}$ and the unique parity $\nu h_{11/2}$ orbitals that play significant roles in the development of low lying level spectra and the isomers in Sn isotopes. The low energy higher spin positive parity states like $23/2^+$, $19/2^+$ and $15/2^+$ are generated with spin contribution from two holes in $\nu 1h_{11/2}$. The evolution of B(E2) values corresponding to the decay of $19/2^+$ and $23/2^+$ isomers in odd-A Sn nuclei show the effect of gradual filling of the $\nu h_{11/2}$ orbital with the increase in neutron number [3]. The $\nu d_{3/2}$ orbital crosses the $\nu h_{11/2}$ orbital at ^{129}Sn, as observed from the nearly degenerate $11/2^-$ first excited level to the $3/2^+$ ground state [4]. The shell model calculation on the low lying negative parity excitations of ^{129}Sn shows that many of these levels have pure $\nu h_{11/2}^{-n}$ configurations with admixtures from the configurations involving $\nu d_{3/2}$ and $\nu s_{1/2}$ orbitals [5] and few among them are isomers having lifetime ~few hundreds nanoseconds to minutes [4]. Locating the candidates of pure multiplets of $\nu h_{11/2}^{-3}$ structure in ^{129}Sn and to estimate the possible configuration mixing can be probed with measurements of lifetimes in this odd-A Sn nucleus close to N = 82 shell closure.

The low lying excited levels (2^+ to 10^+ and 7^-) in the N = 78-82 Te nuclei are generated due to the coupling of either of two proton particles and/or two to four neutron holes with the neighboring Sn core. The particle-hole configurations of these levels are similar among themselves, however, with the addition of two protons in comparison to Z = 50, more proton contribution is found for the low spin levels while the neutron part of angular momentum is dominant in the higher lying levels (e.g. 10^+ and 8^+). The B(E2) values for the 10^+ to 8^+ decay in Te nuclei are observed to be anomalously and significantly high compared to those in both Sn and Xe nuclei [6] which was conjectured to be due to configuration mixing with increasing residual p-n interaction [6]. The same for the 0^+ to 2^+ excitation, however, was found to follow the expected behavior with increasing Z below N = 82 [7] but is of anomalous nature at or beyond N = 82 [8]. In order to probe the evolution of p-n interaction and configuration mixing, the lifetime measurements of all the low lying levels in N = 78, 82 Te would be of significance.

Experiment:

The lifetime measurements in ^{129}Sn and ^{130,132}Te were performed through γ–γ fast timing spectroscopy from the decay of microsecond isomers. The Te and Sn nuclei were produced from reaction ^{233}U(n_{th},f) using the research reactor at Institute Laue Langevin, Grenoble, France. The fission products were separated for A and its kinetic energy (E) by using the

Lohengrin mass spectrometer [10] associated with a gas ionization chamber (IC) at the focal plane of the spectrometer. Fast timing measurements were performed with separated fission product placed at the focal plane of the spectrometer surrounded by four $LaBr_3$ scintillator detectors. In addition, two Clover HPGe detectors were also placed in the setup for high resolution detection of the gamma rays emitted from the isomeric decay. Generalized Centroid Difference method with multiplexing electronics [9] was used for gathering the fast timing data using NIM electronics and Digital Data Acquisition.

Results:

Fig. 1 shows the IC gated Clover spectra for the A = 129,130 that clearly identify the gamma rays decaying from the isomers in Sn and Te nuclei. The delayed and anti-delayed time distribution spectra obtained for different cascades in ^{129}Sn and ^{130}Te nuclei are shown in Fig. 2 and Fig. 3.

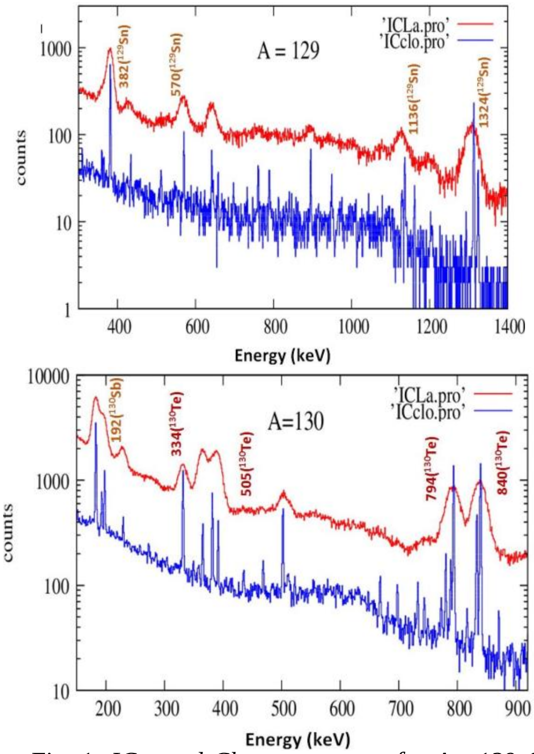

Fig. 1: *IC-gated Clover spectrum for A= 129 & 130, overlapped with the energy spectra from $LaBr_3$ detectors.*

Lifetimes are determined by comparing the measured centroid differences with the Prompt time response followed by appropriate background correction. The shell model calculation has been performed with NUSHELLX code [11] using sn100pn interaction. The experimental data obtained from preliminary analysis will be compared with these results.

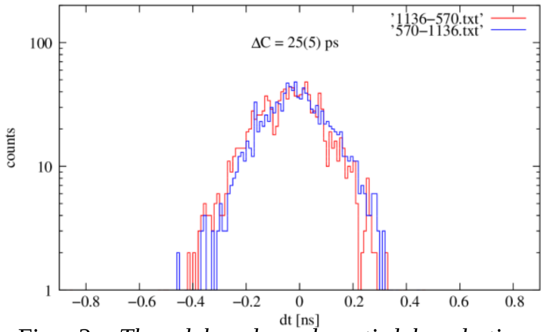

Fig. 2: *The delayed and anti-delayed time spectra obtained from $LaBr_3$-$LaBr_3$ coincidences for 15/2$^-$ level (570-1136 keV cascade) in ^{129}Sn.*

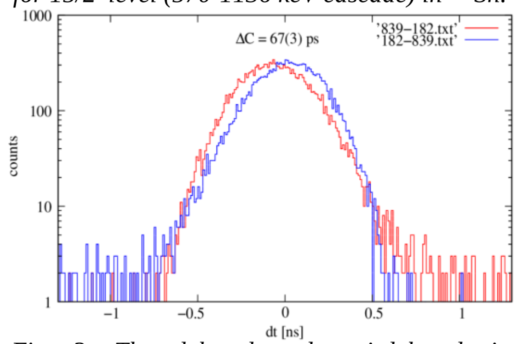

Fig. 3: *The delayed and anti-delayed time spectra obtained from $LaBr_3$-$LaBr_3$ coincidences for 4$^+$ level (839-182 keV cascade)in ^{130}Te.*

References:

[1] S. S. Alam et al., PRC **99**, 014306 (2019).
[2] S. Illieva et al., PRC **94**, 034302 (2016).
[3] J. Genevey et al., PRC **65**, 034322 (2002).
[4] www.nndc.bnl.gov/~ensdf
[5] R. L. Lozeva et al., PRC **77**, 064313 (2008).
[6] J. Genevey et al., PRC **63**, 054315 (2001)
[7] D. C. Radford et al., PRL **88**, 222501 (2002).
[8] J. Terasaki et al., PRC **66**, 054313 (2002).
[9] J.M. Régis, et al., NIM **A823** (2016) 72.
[10] P. Armbruster, et al., NIM **139**, 213 (1976).
[11] B.A. Brown and W.D.M. Rae, NDS **120,** 115 (2014).