Fast-timing studies of ^{133}Sn and ^{134}Sn excited states

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INTRODUCTION

During last decades a lot of effort has been devoted to gain experimental information about the region of nuclei around ^{132}Sn. This part of the nuclide chart with nuclei around the N=82 and Z=50 shell closures, therefore with a large N/Z ratio, is of great interest to test nuclear models and provide information about single particle states. Our experiment addresses the structure of Sn isotopes populated in beta-decay. The experiment was performed at the CERN-ISOLDE facility where Sn nuclei ranging from A=130 to A=134 were studied using gamma and fast-timing [1] spectroscopy. The use of the ISOLDE RILIS allowed for isobaric and even isomeric selection during ionization. In this work we report on the preliminary results of the study of the ^{134}Sn isotope.

MOTIVATION AND OBJECTIVES

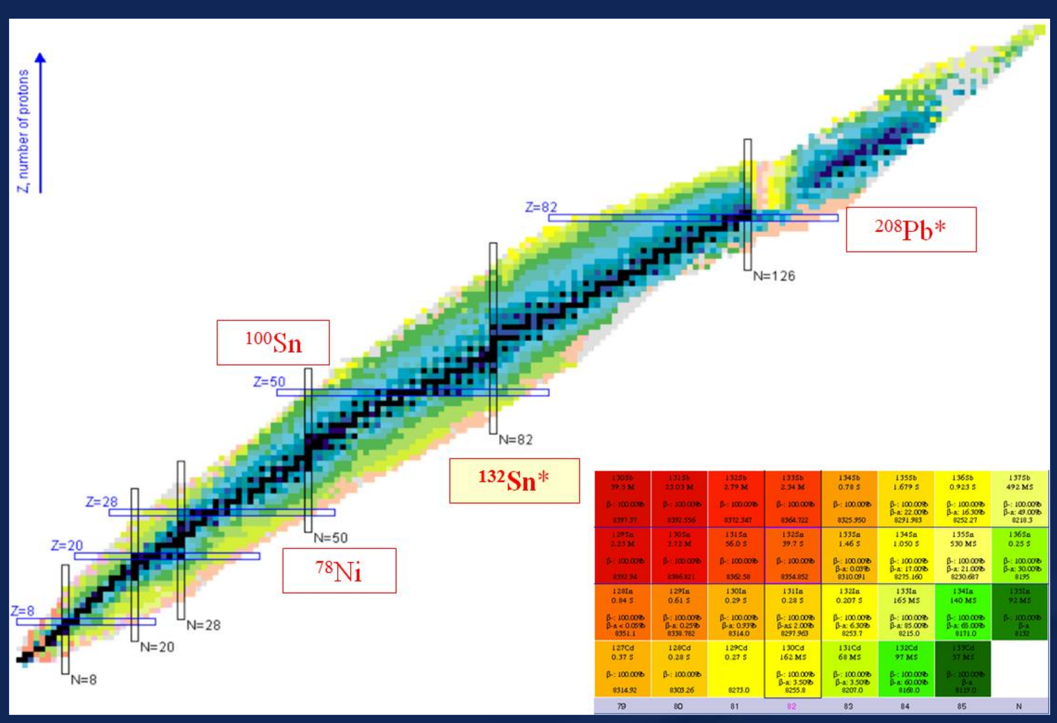


Figure 1. Chart of Nuclides and Nuclear map near ^{132}Sn. ^{132}Sn is the only medium-heavy doubly magic nucleus which along with most of its neighbours can be studied in some detail.

- **Main purpose:** Level-scheme of Sn nuclei using gamma spectroscopy, and lifetimes of excited states in the picosecond range with Fast-timing technique[1].
- **Experiment:** IS610, performed at ISOLDE(CERN)
- **Motivation:** Identification of single-particle and particle-hole states which remains unidentified. To obtain information about electromagnetic operators through half-life measurements.

EXPERIMENTAL DETAILS

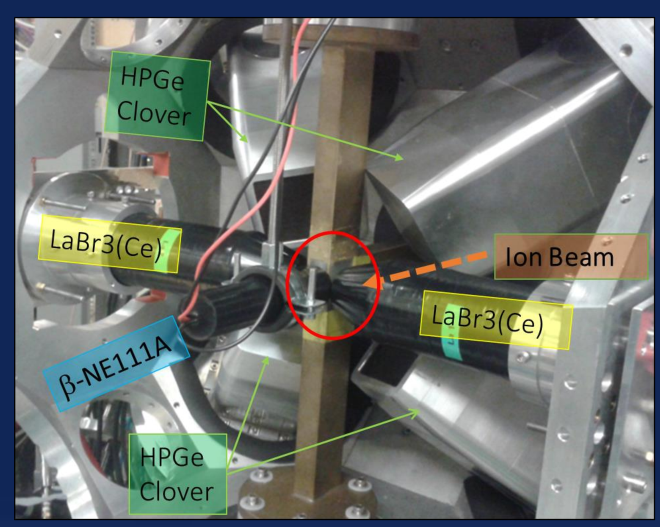


Figure 2. ISOLDE Decay Station(IDS). Detector setup used during the experiment IS610.

- A standard UC_x/Graphite target along with a neutron converter was used, which was bombarded with 1.4 GeV protons from the PS Booster at CERN.
- In isotopes were ionized with a laser ion source, RILIS.
- Ions are mass-selected, transported and implanted in a tape located in the center of the experimental setup.
- 7 detectors were used:
  - 4 Clover HPGe detectors with good energy resolution for spectroscopy information.
  - One fast plastic scintillator (NE111A) as β-detector.
  - 2 $LaBr_3$(Ce) scintillator crystals with good time resolution for timing information.

ISOLDE RILIS

- Resonant ionization of atomic structure.
- Highly selective ionization of desired isotope.
- Hyperfine structure gives the possibility of separating nuclear isomeric states.

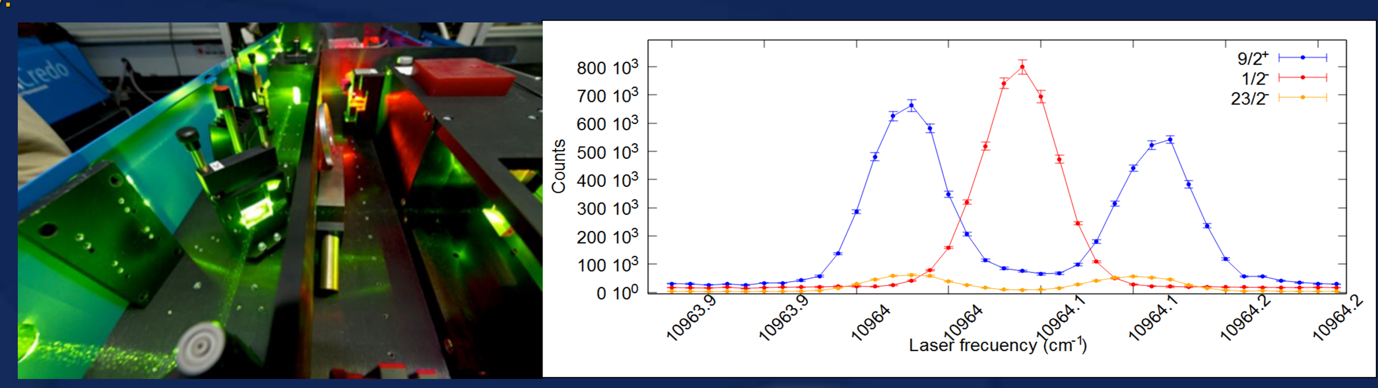


Figure 3. (Left) RILIS setup. (Right) Scan of ^{129}In isomer production, monitored by γ-rays in our experimental setup.

FAST-TIMING TECHNIQUE

- The fast-timing technique relies in the use of coincidences between fast scintillator detectors.
- The time difference measured between the detection of both particles carries the information about the lifetime of the levelst located in between the emission of those two particles.

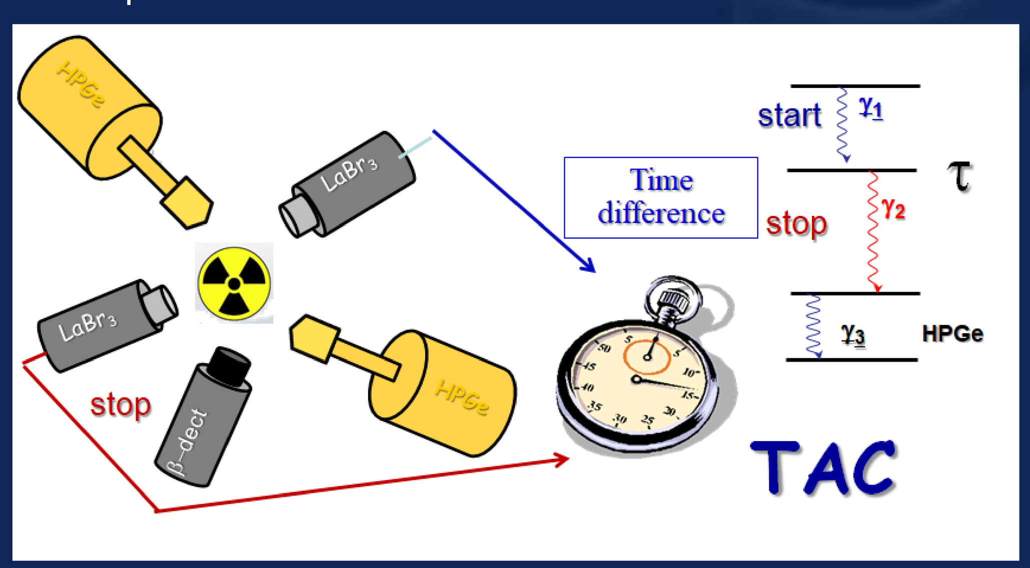


Figure 4. Schematic setup for the fast.-timing technique. Timing information by the fast-scintillator detectors because of their fast time response. Commonly HPGe are include to gain selectivity thanks to their excellent energy resolution.

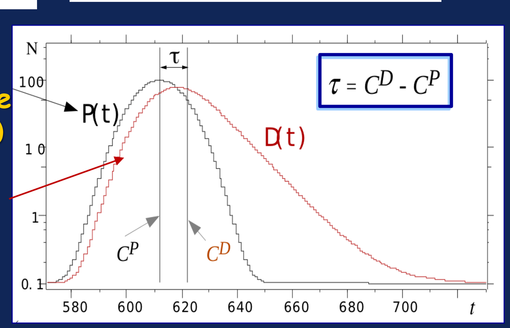
HPGe: BRANCH SELECTION	Plastic β scintillator: TIMING	$LaBr_3$(Ce)/BaF_2: TIMING
Good energy resolution	Fast response	Fast response γ-detectors
Poor time response	Efficient start detector	Stop detectors

De-convolution of slope:
- Slope = $T_{1/2}$
- Range: 100 ps to 30 ns (or longer)

P(t): Prompt Response
System resolution (PRD)

Centroid shift:
- Shift in centroid position = τ
- Range: down to ~5-10 ps

D(t): Time Distribution
TAC spectrum



PRELIMINARY RESULTS

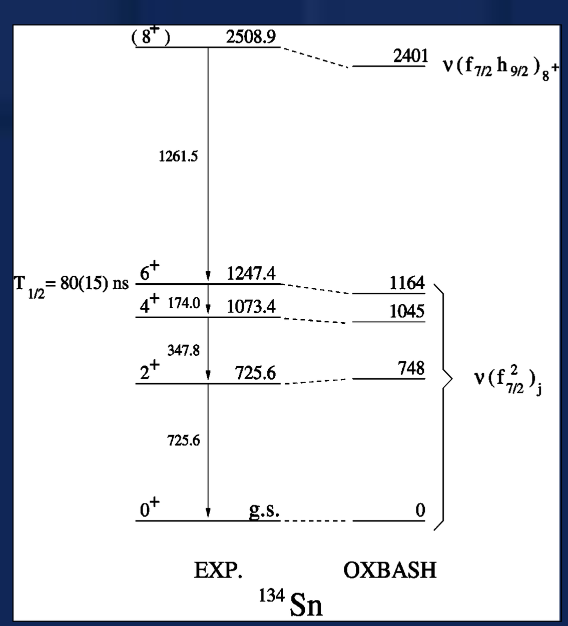


Figure 5. Level scheme of ^{134}Sn observed in ^{248}Cm spontaneous fission.[2]

- ^{134}Sn=^{132}Sn+2 neutrons.
- 2 particle states.
- Core excitations at high energies.
- Previously investigated in ^{248}Cm spontaneous fission.
- First investigation from β-decay studies.
- Information on B(E2) can prove proposed assignments.

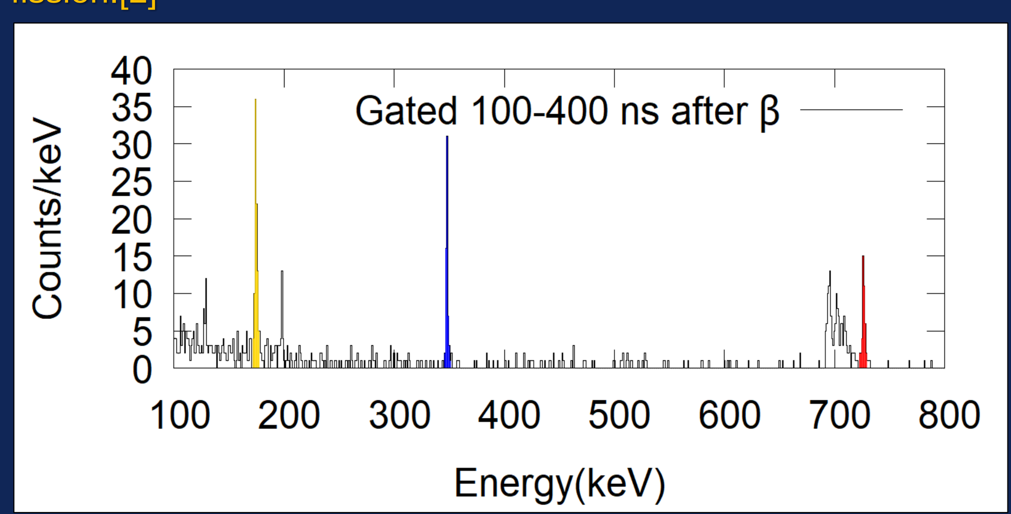


Figure 6. Gamma-ray spectrum recorded in HPGe detectors in a delayed coincidence with the beta-detector.

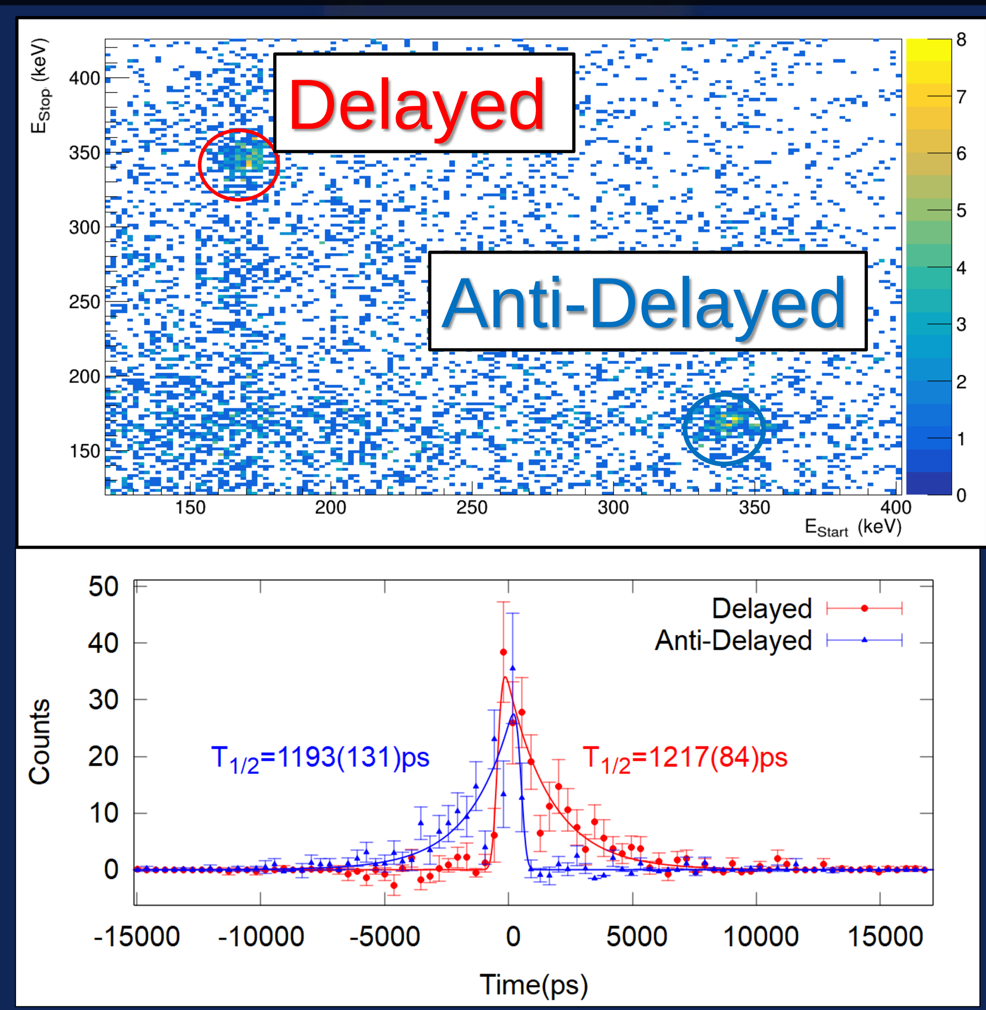


Figure 7. (Top) gamma-gamma coincidence matrix recorded in the LaBr3 detectors. (Bottom) TAC distribution for the 174-348 gamma-gamma coincidence. Lifetime is obtained from the fit of the slope.

$J_I \rightarrow J_F$	E(keV)	$T_{1/2}$	B(E2) W.u.
$6^+ \rightarrow 4^+$	174	73(5) ns	0.97(7)
$4^+ \rightarrow 2^+$	348	1.22(4) ns	2.19(7)
$2^+ \rightarrow 0^+$	726	53(31) ps	1.3(7)

CONCLUSIONS

- Investigation of excited Sn structure with combined gamma and fast-timing spectroscopy at ISOLDE
- Isomerically purified In beams help identification of low-lying structures.
- Use of a a set of 4 HPGe detectors in order to extract spectroscopic information.
- Lifetimes investigated from β-decay of ^{134}In.
- Complete set of B(E2) values for the $\nu(f_{7/2})^2$ states.
- New and more precise half-life measurement for 6^+.
- First measurements for the lifetimes of 2^+ and 4^+ levels.

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