

Description

Name of spokesperson (Collaboration/Lab): S. Nandi¹, M. Fallot², (NA)²STARS collaboration, S3 collaboration and PIPERADE collaboration

¹ UGC-DAE CSR, Kolkata Centre, LB-8, LB Block, Sector III, Bidhannagar Kolkata 700098, India.

² SUBATECH, IMT Atlantique, Université de Nantes, CNRS/IN2P3, Nantes, France

Title: β -decay study of neutron deficient transitional Pt and Ir isotopes using (NA)²STARS

Abstract:

Atomic nuclei exhibit different shapes depending on their location in the nuclear landscape. The neutron-deficient region around $Z=82$ is known to display some of the most prominent shape-coexistence phenomena in the entire nuclear chart [1]. Nuclei in this region can exhibit axially deformed prolate and oblate shapes, non-axial (triaxial) deformation, and even octupole shapes [2–5]. Understanding the coexistence of these diverse shapes and/or evolution of one into another, as a function of excitation energy and spin, constitute an intriguing pursuit in nuclear structure studies.

There are two main approaches to studying nuclear shapes: qualitative and quantitative. The qualitative approach interprets nuclear shapes through level schemes or decay-scheme patterns. In contrast, the quantitative approach relies on measurements such as excited-state lifetimes, which provide more direct information about deformation parameters.

In addition to these methods, Total Absorption Gamma-ray Spectroscopy (TAGS) offers a unique and powerful way to determine nuclear ground state shapes, as it provides a complete and unbiased picture of the β -decay strength as a function of excitation energy, allowing direct comparison with theoretical calculations to extract the ground state nuclear shape of parent nucleus. Nuclear ground state shape determination using TAGS method primarily performed in the medium-mass $A\approx 80$ region [6–8]. However, recent TAGS studies of β decay in ^{186}Hg [9] and $^{190,192}\text{Pb}$ [10] have extended this approach to heavier nuclei, providing a broader framework for understanding the shapes of exotic systems by combining TAS data with shape-sensitive theoretical calculations. However the experimental data on TAGS measurement are very scarce for heavier nuclei.

Similar to the neutron-deficient $^{186,188}\text{Pb}$ nuclei [11,12], the neutron-deficient Pt isotopes ^{178}Pt , ^{180}Pt , and ^{182}Pt have been found to exhibit multiple 0^+ states within 500 keV of excitation energy, which are interpreted as signatures of shape coexistence [13]. This interpretation is further supported by theoretical calculations of deformation energy curves for even-even Pt isotopes. Constrained HF+BCS calculations employing the Skyrme interactions Sk3, SGII, and SLy4 [14] predict the coexistence of oblate and prolate minima in the Pt isotopes, similar to the behavior observed in Hg isotopes.

In this letter of intent we propose to determine the ground-state shape in neutron deficient ^{178}Pt , ^{180}Pt , and ^{182}Pt from the total β -decay strength from TAGS measurements using highly efficient

(NA)²STARS array. The present study is directed at facilitating our understanding of shape-dependent β decay, and also establishes a pandemonium-free decay scheme for neutron-deficient Pt isotopes.

Likewise, neutron-deficient odd–odd Ir isotope (^{178}Ir) suffer from a scarcity of β -decay data. Of particular interest is ^{178}Ir , which has a Q_{β} value of 7294(26) keV [15], while the highest known excited level in the daughter ^{178}Os is 1781.6(5) keV [15]. Lack of experimental data clearly indicates that existing decay data obtained with HPGe detectors are highly susceptible to the pandemonium effect.

The proposal requires the production of four nuclei of interest— ^{178}Pt , ^{180}Pt , ^{182}Pt , and ^{178}Ir —using four different targets and primary beams from the GANIL S3 chartbeams [16]. However, this setup still requires further development and is not yet available at S3.

To estimate the required number of shifts, a minimum of 10^5 β - γ coincidences with STARS is requested (assuming 70% efficiency for the TAS and 40% β efficiency). In these calculations, a transport efficiency of 50% and a laser ionization efficiency of 1% are assumed. The required intensities have been computed for all four nuclei of interest, corresponding to a maximum of approximately 11 UTs. In some cases, higher intensities may be required due to unknown ground-state-to-ground-state (GS→GS) branching ratios. The projected intensities available on the chartbeam website [chartbeam] [16] are close to these estimates, suggesting that the proposal could be realistic in the long term with further development. It is also possible that, in some cases, higher beam intensities will be achieved, in which case the required number of UTs would be reduced accordingly. When GS→GS branching ratios are unknown, we have conservatively assumed that 50% of decays proceed via β - γ transitions in our estimation on number of UTs.

Reference: -

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Requested beam availability in... 1-3 years 3-5 years 5-10 years

Beam (ion, energy, intensity, number of UTs – 1UT=8h) :

1+ for the DESIR beamline + PIPERADE		Energy	keV
		Intensity	Intensity for ¹⁷⁸ Pt : 1000 pps Intensity for ¹⁸⁰ Pt : 18800 pps Intensity for ¹⁸² Pt : 28000 pps Intensity for ¹⁷⁸ Ir : 6400 pps
Bunched beam (yes/no)		Freq / Length	Hz / μs
Purity	>95%	Estimated UTs	Decay Spectroscopy ¹⁷⁸ Pt : 8 UT ¹⁸⁰ Pt : 0.5 UT ¹⁸² Pt : 0.5 UT ¹⁷⁸ Ir : 2 UT

Production site:

SPIRAL1	S3-LEB
	x

Instruments to be used (please add instrument name if missing) :

MORA	LUMIERE	TAS	PIPERADE	MLLTRAP	OTHER
		x	x		

Other information (cooled / bunched beam, continuous beam / tape drive system / other request...) :

TAPE transport system is needed to address typical parent daughter problem.