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β^--DELAYED AND ISOMER SPECTROSCOPY OF NEUTRON-RICH Ta AND W ISOTOPES* **

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Decays of neutron-rich $A \sim 190$ nuclei have been studied following projectile fragmentation of a ^{208}Pb beam on a ^{9}Be target at the GSI Fragment Separator. Gamma-ray decays from previously reported isomeric states in ^{188}Ta, ^{190}W and ^{192,193}Re were used as internal calibrations for the particle identification analysis, together with the identification of previously unreported isomeric decays in ^{189}Ta and ^{191}W. The current work also identifies β-delayed γ rays following the decay of ^{188}Ta to ^{188}W for the first time.

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1. Introduction

Little spectroscopic information is currently available on the structure of heavy neutron-rich nuclei with $A \sim 190$ due to the difficulties in populating such systems for experimental study. Relativistic-energy projectile fragmentation reactions [1,2] can however provide a means by which such nuclei can be accessed in the laboratory. Structural studies can then be made using the high efficiency gamma-ray detection available with the Stopped RISING gamma-ray spectrometer array [3]. This device enables the measurement of spectroscopic information from the decays of both isomeric states and β^--delayed decays [4] of ions which have been synthesised in projectile fragmentation reactions at the GSI facility in Darmstadt, Germany. This short conference paper presents some preliminary results from β^--delayed γ-ray spectroscopic study of heavy projectile fragments to investigate the low-lying states of neutron-rich W isotopes.

2. Experimental setup

A primary beam of ^{208}Pb at an energy of 1 GeV/nucleon from the SIS-18 synchrotron at GSI was fragmented on a 2.45 g/cm^2 Be target with the resulting ions being separated and identified using the GSI Fragment Separator (FRS) [5]. Two MUlti Sampling Ionization Chamber detectors were used at the final focal plane of the FRS to measure the energy loss of the individual ions. This, together with the time-of-flight of the ions enabled an event-by-event particle identification for the ions transmitted through the FRS. The ions of interest were brought to rest at the end of the FRS in an array of three 5 cm $\times$ 5 cm $\times$ 1 mm Double-Sided Silicon Strip Detectors (DSSSDs) each segmented into 16 strips in both the horizontal and vertical directions [4]. The DSSSDs used logarithmic preamplifiers [6] to enable the measurement of both the total implantation energy *and* the energy deposited by the subsequent β^- particle for each decay event for each pixel. This was used to determine the implantation positions of the transmitted secondary ions and correlate them with their subsequent β-decay signals in the same or neighbouring pixels of the DSSSDs. Coincident γ-rays following either isomeric decays or β-delayed emission were measured using the 15 germanium cluster detectors of the RISING γ-ray array [3].

3. Experimental results and summary

The fragment particle identification was achieved by creating standard two dimensional spectra of the energy loss in the MUSIC chamber detector (which is related to the atomic number, Z, of the ions) *versus* the time-of-flight, TOF (which is related to the mass-over-charge ratio of the transmitted ions), on an event-by-event basis for each ion. Reference [5] provides more details on the particle identification used in the current work.

Fig. 1 shows gamma-ray spectra associated with decays from previously reported [2] isomeric states in ^{188}Ta, ^{190}W and ^{192,193}Re as observed in the present work. These isomers were used as checks for the particle identification analysis and provided an independent validation for the γ-ray energy and timing setups. Decays from two previously unreported isomers were observed associated with the ^{189}Ta and ^{191}W nuclei. Fig. 2 shows the β-delayed gamma-ray spectra for ^{188}W following decays from the parent nucleus ^{188}Ta. The γ-ray transitions observed in ^{188}W have been reported previously from in-beam studies using deep-inelastic [7] and two-neutron transfer reactions [8]. Three discrete transitions were identified at energies of 143, 297 and 434 keV. These correspond to the decays from the yrast 2^+, 4^+ and 6^+ states, respectively. The transition from the previously identified [8] yrast 8^+ state ($E_\gamma = 554$ keV) is not observed here, suggesting that the β^- decaying state has a tentative spin of ($I = 5$).

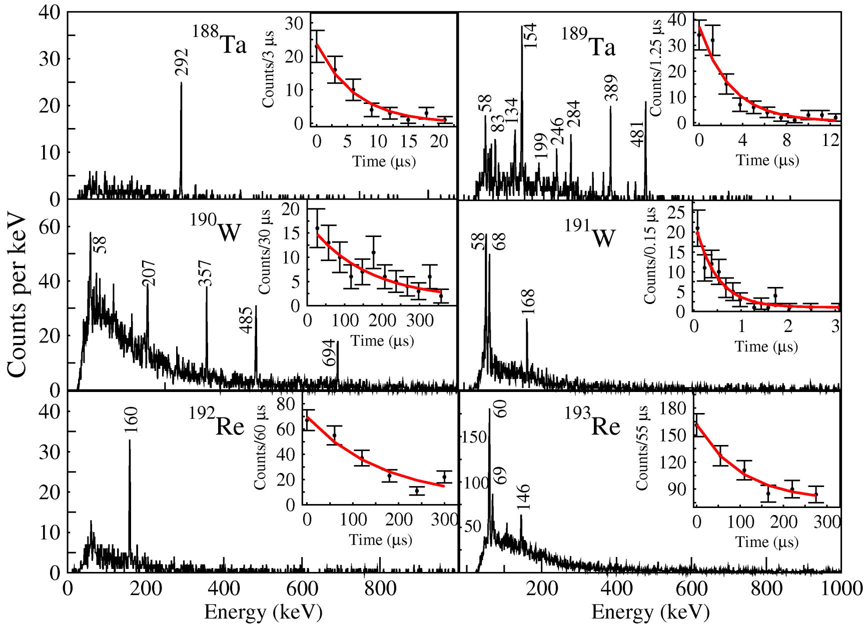

Fig. 1. Gamma-ray energy and decay time spectra for decays from isomeric states observed in the current work.

In conclusion, the RISING active stopper has been used to obtain spectroscopic information on heavy neutron-rich nuclei around $A \sim 190$ which were populated following projectile fragmentation reactions using a 1 GeV per nucleon, ^{208}Pb primary beam. Isomeric and β-delayed γ-ray spectroscopy have both been used to provide new spectral information on the

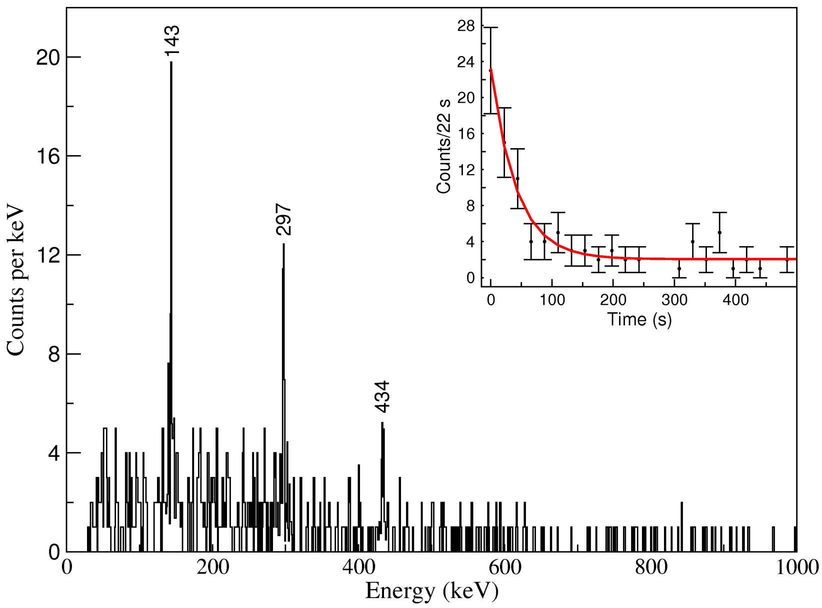

Fig. 2. Beta-delayed γ-ray spectrum following decay events associated with ^{188}Ta primary fragments which populate ^{188}W. A time condition that the β-particle must be measured within 120 seconds of the secondary beam implant in the active stopper has been applied to this spectrum. The inset shows the decay time spectrum associated with this decay half-life obtained by projecting the decay times of β-delayed gamma-ray coincidence events relative to the ^{188}Ta implantation time.

low-lying internal states in Ta and W nuclei. The spectra for the β^--decay of ^{188}Ta show the previously reported γ rays associated with decays of levels in the ^{188}W daughter nucleus up to a spin-parity of 6^+. Data on heavier Ta $\rightarrow$ W decays, which were studied in the same experiment, are currently under analysis and the preliminary results are reported elsewhere [4].

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