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Laboratoire national canadien pour la recherche en physique nucléaire
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On the decay of ^{102}Rb

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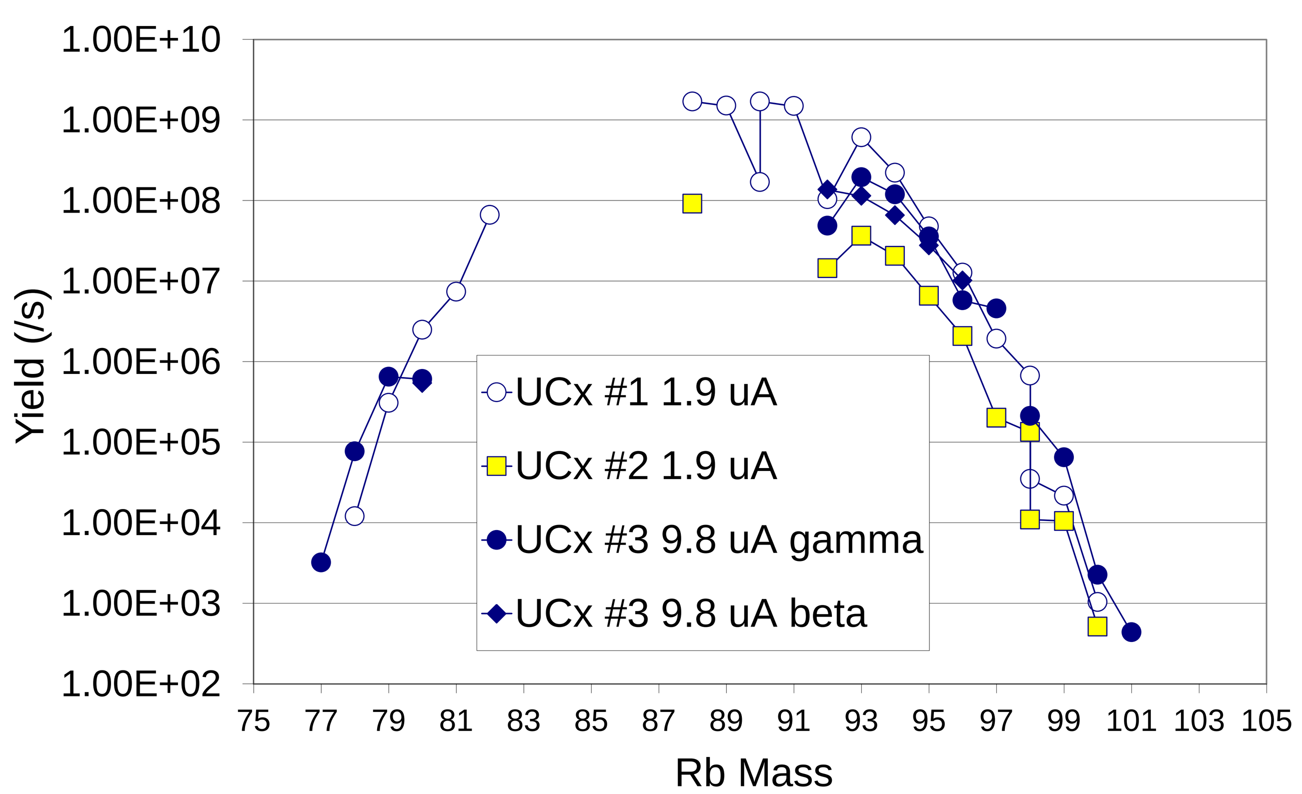
Motivations

Experimental investigations of the β-decay properties of nuclei which lie along the astrophysical r-process are becoming possible with modern facilities and detection systems [1]. The nuclear structure properties of these nuclei are also required to refine nuclear models in neutron-rich nuclei involved in the astrophysical r-process and improve the predictive accuracy for the properties of those nuclei which cannot be measured directly. ^{102}Rb is one of these nuclei at the boundary of r-process path, its decay properties and nuclear structure information have been investigated at TRIUMF-ISAC, an advanced ISOL facility [2,3]. In the present study, the β-decay half-life and β-delayed neutron emission branching ratio of ^{102}Rb have been measured and are presented here.

TRIUMF-ISAC

TRIUMF-ISAC (TRI-University Meson Facility – Isotopes Separator and ACcelerator) is a radioactive beam facility driven by a large cyclotron to deliver 500 MeV p+ primary beam impinging on multi-layer production target, i.e. UCx Actinide target with 10 μA in this case. Radioactive nuclei were surface ionized and mass separated before being delivered to the 8π spectrometer with ~ 26 keV beam energy.



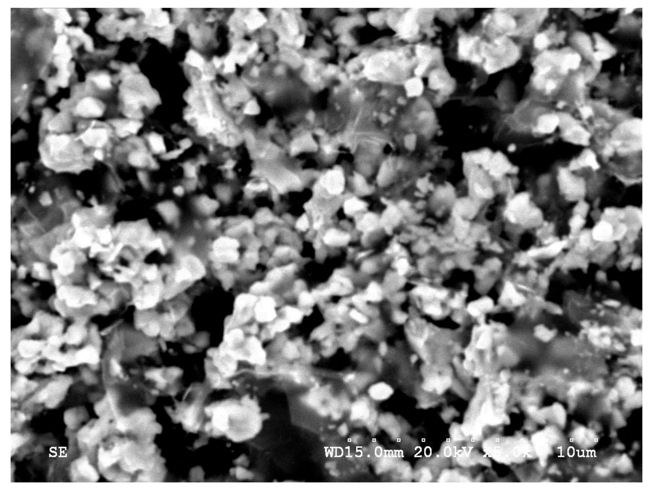


Figure 1. Measured yields of Rb isotopes at TRIUMF-ISAC with various intensities of primary p+ beam on UCx Actinide target.

Figure 2. UCx foil after carbonization and sintered procedures under Scanning Electron Microscope. Figures courtesy of P. Kunz, TRIUMF.

Experimental apparatus

The 8π spectrometer is composed of 20 Compton-suppressed HPGe detectors to measure γ rays emitted from excited states in daughter nuclei populated in β-decay and β-delayed neutron emission processes [2,3].

The radioactive beam is implanted onto a Mylar tape at the centre of the 8π spectrometer. The tape movement can reduce the build up of long-lived species from sight of the detectors, optimizing the signal-to-noise ratio.

Figure 3. 8pi spectrometer is composed of 20 HPGe detectors.

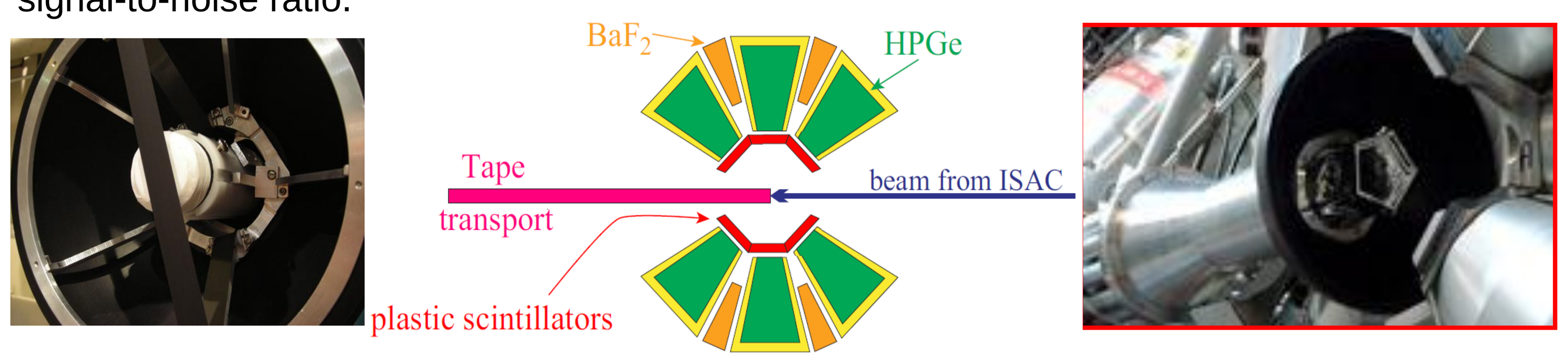


Figure 4. Schematic view of 8π spectrometer coupled with DANTE, ZDS, SCEPTAR and moving tape system.

SCEPTAR (SCintillating Electron Positron Tagging ARray) is a set of plastic scintillators to detect β particles which covers 80% of 4π solid angle in two hemisphere. When used in coincidence with the Ge detectors this dramatically increase sensitivity.

ZDS (Zero Degree Scintillator) replaces one hemisphere of SCEPTAR and is a single fast-timing response plastic scintillator that can be used for beta-tagging and fast β-γ coincidence timing.

DANTE (Dipentagonal Array for Nuclear Timing Experiments) is an array of 10 fast-timing response scintillators capable of β-γ and γ-γ coincidence timing down to 100 ps FWHM. 5 BaF_2 detectors and 5 $LaBr_3$ detectors (which give ~ 5% energy resolution with similar timing response) were used in this experiment.

Preliminary results

^{102}Rb β-decay half-life is achieved by fitting γ ray timing profile of beam cycles with maximum likelihood method. 126-, 112-, and 271-keV γ rays without interference with γ rays in other nuclei were selected from ^{102}Rb β-decay daughter ^{102}Sr and β-delayed neutron emission daughter ^{101}Sr, respectively. A half-life of 8 ms has been obtained in the present work is somewhat shorter than previously reported values, which are 37(3) ms [4] and 35(+15-8) ms [5].

β-delayed neutron emission branching ratio is also anomalously larger than previously reported value 18(8)% [4], 54% as of the lower limit of β-delayed neutron emission branching ratio is obtained by including an assumption of 5% β-decay branching ratio to ^{102}Sr ground state. Neutron branching ratio to ^{101}Sr ground state hasn't been considered [6].

β-γ-γ matrix was created to construct level schemes of daughter nucleus ^{102}Sr and β-delayed neutron emission daughter ^{101}Sr. Five new energy levels have been added to ^{102}Sr level scheme [7]. The low-lying level structure of ^{102}Sr appears to be very similar to the neighboring neutron-rich $^{98, 100}$Sr nuclei.

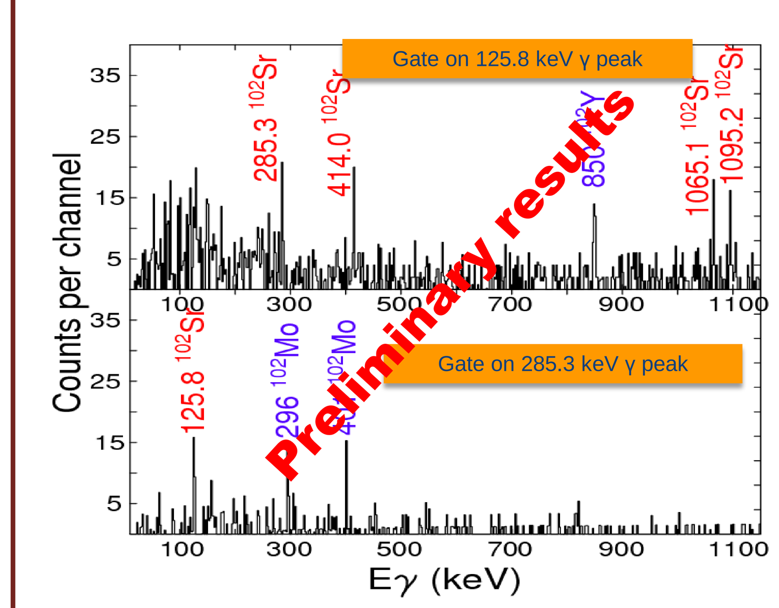


Figure 5. γ-ray spectra gated on 126 keV and 285 keV lines in ^{102}Sr. γ-ray labeled in purple color are from longer-lived daughter nuclei.

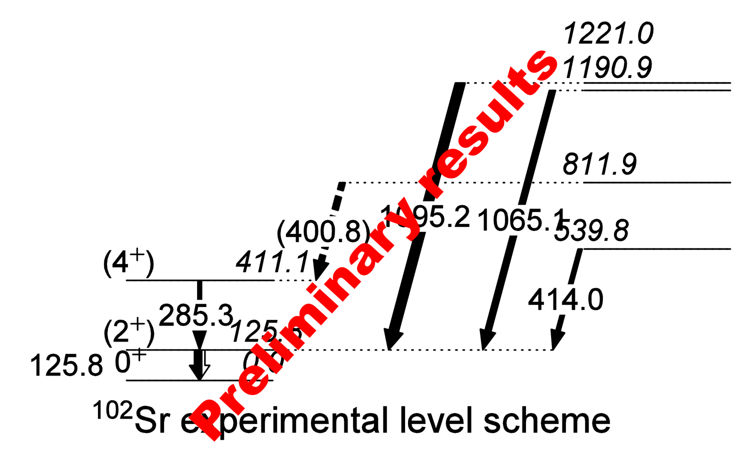


Figure 6. Level schemes of β-decay daughter ^{102}Sr from the present work.

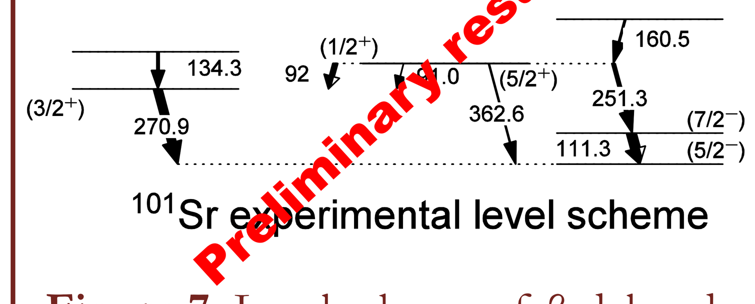


Figure 7. Level scheme of β-delayed neutron emission daughter ^{101}Sr.

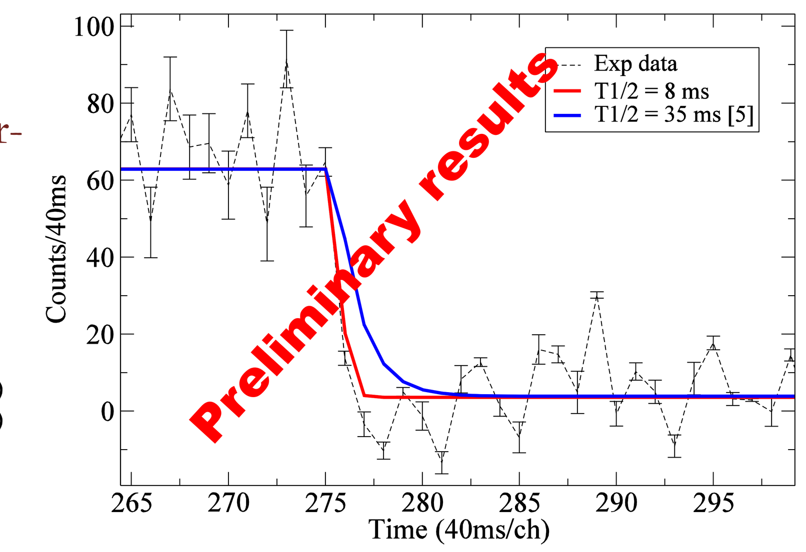


Figure 8. Decay period fit curves with previously reported value and best fit of current data.

The experimental level scheme of ^{101}Sr has been established by the β-delayed neutron emission process. The low-lying structure observed is not the same as the results from the previous β-decay study [8].

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Acknowledgments

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