Search for short-lived uranium isotopes around N=126 *

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Production and decay of short-lived ^{221}U (previously unknown) and ^{222}U (only the half-life is known) were studied at the gas-filled separator TASCA. These two nuclei have only few neutrons more than the magic number N=126, which leads to high α decay Q-values and, therefore, to very short half-lives (< 10 μs). To explore this microsecond/sub-microsecond half-life region, digital electronics was implemented into a combined "ANalog" and "DIgital" (ANDI) data acquisition system [1].

A ^{50}Ti^{12+} beam was accelerated to energies E_{lab}=230 and 240 MeV and irradiated a rotating ^{176}Yb target wheel to produce ^{222}U and ^{221}U in 4n and 5n de-excitation channels of the complete fusion reaction, respectively.

The evaporation residues (ER) were separated from the primary beam by TASCA and implanted into the stop detector consisting of two double-sided silicon-strip detectors. Two signals, one from each side of the stop detector were processed in two different parts of the ANDI system with a common trigger and zero suppression [1]. The signals from 144 vertical front strips were processed by analog amplifiers connected to peak-sensing ADCs [2]. The preamplified signals from 48 horizontal back strips were processed by sampling ADC's (FEBEX2) with 60 MHz frequency. Traces with total length of 50 μs (7 μs before and 43 μs after) were recorded following an accepted trigger. The deadtime of the "analog" part was shorter than 43 μs. Therefore it was always ready to accept the next triggered event [1]. Further, both data were combined into single events by an event builder of MBS [1].

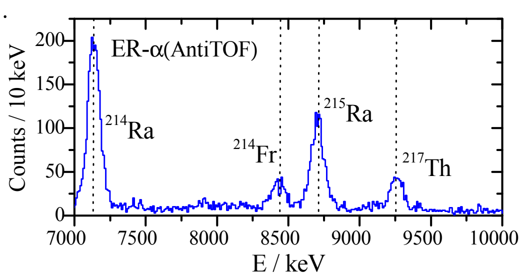

Fig 1: An energy spectrum of α-particles from the ER-α correlation up to 14 s, with both events occurring in the same pixel.

* Work supported by HI Mainz

An ER-α correlation analysis was performed to find recoiling nuclei and identify the measured α lines (Fig. 1). Only α-particle events were considered without a signal from the time-of-flight detector. Alpha decays of ^{214}Ra, ^{215}Ra, ^{214}Fr, and ^{217}Th were identified. From further analyses the decay of ^{214}Fr was found as a member of ER-α(7-18MeV)-α(^{214}Fr) chains. The second member of this chain is typically a pile-up of two α decays. These events were investigated using the data from the "digital" part. Clearly two signals were found in traces of them and α decays of ^{222}Pa and ^{218}Ac were unambiguously determined (see Fig. 2a).

The traces of the ER's from ER-α(^{214}Ra) were investigated in order to find "missing" α decays of mother ^{218}Th and grandmother ^{222}U nuclei. In most cases only single signals were found, pointing to the implantation of ^{214}Ra. However, traces with two and three signals were also found (see Fig. 2b). These data allow us to unambiguously assign α decays of ^{218}Th and ^{222}U.

The traces of the ER's from ER-α(^{217}Th) were investigated to find the α decay of the new nucleus ^{221}U. In most cases a single ER signal was seen. However, traces with two signals, which include the α decay of the new nucleus ^{221}U, were also found (see Fig. 2c). More detailed information will be provided in [3].

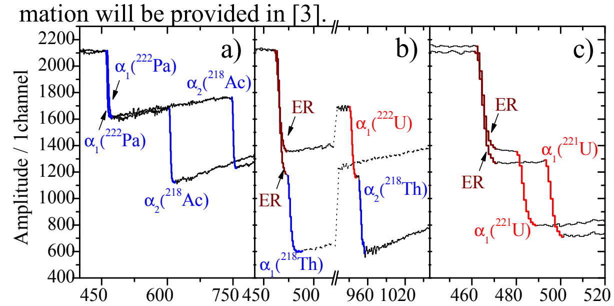

Fig 2: Example of traces of pile-up α-particles correlated with ^{214}Fr a), ER's correlated with ^{214}Ra b), and with ^{217}Th c).

[1] N. Kurz et al., this Scientific Report (2012).
[2] J.M. Gates et al., Phys. Rev. C. 83 054618 (2011).
[3] J. Khuyagbaatar et al., to be published.