FIRST FULL BETA-STRENGTH MEASUREMENT WITH DTAS ACROSS N=126 AT FAIR PHASE-0

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Abstract. An experiment was performed at GSI with the objective of measuring the β-intensity distribution in the decay of Hg, Au and Pt isotopes around N=126 using the total absorption gamma-ray spectroscopy technique. The aim is to benchmark theoretical models used to make predictions of half-life and neutron emission probabilities of exotic nuclei involved in the rapid neutron capture process, leading to the synthesis of very heavy elements. This paper presents some experimental details and the current status of the analysis.

1 Introduction

Our current understanding of the production of the heaviest elements in the Universe remains incomplete, especially with regards to the contribution of the rapid neutron capture (r-) process to the observed abundances of elements with A>180 and the astrophysical site responsible for this process. To shed light on this puzzle, a combination of astronomical observations, including gravitational wave detection, nuclear physics laboratory experiments and theoretical modelling is necessary.

From the point of view of the nuclear data, the situation is challenging, as the abundance distribution in the heavy mass region peaks at A $\sim$ 195, the so-called 3rd abundance peak, which is related to the N=126 shell closure in very neutron-rich nuclei. There is a lack of experimental information in this remote region, and it is impossible at current facilities to fill the gap. As a result, we must rely on theoretical predictions, particularly for the important macroscopic quantities of half-life ($T_{1/2}$), neu-

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tron emission probability (P_n), and mass. P_n and $T_{1/2}$ are extracted from the calculated β-strength distribution, which depends on nuclear structure. However, the existence of a number of theoretical calculations providing largely conflicting results for both quantities when crossing N=126, see for example [1, 2], calls for additional studies to understand the origin of these differences.

To address this issue, we aim to contrast calculated and measured β-strength distributions, rather than $T_{1/2}$ and P_n, for the first time in this region. Total Absorption Gamma-ray Spectroscopy (TAGS) [3] is the most suitable technique to provide β-strength distributions in the decay energy window. This technique relies on the use of large calorimeters that are sensitive to γ cascades rather than individual γ rays, and a suitable analysis method [4] to extract feeding intensities as a function of daughter excitation energy E_x.

2 Experiment

The experiment, the first with the Decay Total Absorption Spectrometer (DTAS)[5] at the GSI facility, was performed in June 2022 as part of the FAIR Phase-0 DESPEC campaign. We measured the decay of ^{207}Hg, $^{204-206}$Au and ^{203,204}Pt produced in fragmentation and relativistic charge-exchange reactions [6, 7] of a 1 GeV/u ^{208}Pb beam on a 1625 mg/cm^2 ^{9}Be target. The beam intensity was 10^9 pps with a time structure of 1.6 s spill every 3.8 s. The isotopes were selected using the FRagment Separator (FRS) and identified by the $B\rho - \Delta E - B\rho$ method [8].

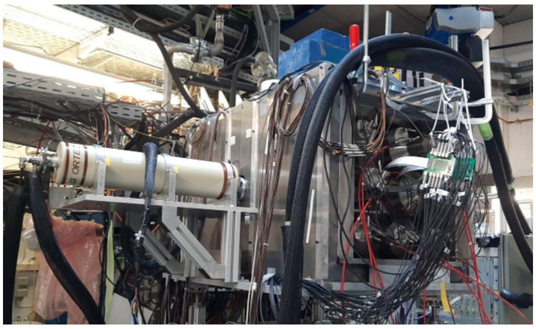

Figure 1. Experimental set-up installed at the end of the FRS.

The Advanced Implantation Detector Array (AIDA) [9] was used to measure ion implantation and decay particles. In our experiment we employed two 1-mm thick silicon Double-Sided Strip Detectors (DSSD) separated 10 mm, each with 128 strips in X and Y direction and a strip pitch of 0.56 mm. Two position sensitive plastic scintillation detectors (βPlast [10]) were placed within the AIDA snout ~15 mm upstream and downstream from the DSSDs. With an area of 80 mm × 80 mm and a thickness of 3 mm, they were used as subsidiary ion/β detectors. Isomeric and β-delayed γ-ray cascades were measured with DTAS surrounding AIDA. It consisted of 16 independent NaI(Tl) modules with crystals of size 150 mm × 150 mm × 250 mm. The setup was completed with two X-ray sensitive HPGe detectors (LOAX), each 30 mm thick and 70-mm diameter. They were inserted in DTAS to the left and right of the beam.

Up to five independent Data ACQuisition (DACQ) systems were used (FRS, AIDA, DTAS, βPlast, LOAX) all integrated into a Multi Branch System (MBS) using the White Rabbit (WR) common synchronization signal. For DTAS DACQ [11] this required encoding WR time information following developments made at Chalmers Technical University and GSI [12]. The progress of the measurement was controlled via Go4 based near-line analysis. Further details and references can be found in [10].

3 Status and outlook

The analysis of the data is at an early stage. Currently, we are working on the calibration of the FRS detectors in order to improve the identification of the nuclei of interest. At the same time, we are analysing DTAS data obtained from the measurement of several radioactive sources and comparing the results with detailed Monte Carlo simulations to benchmark the calculated spectrometer response. Next we will address the calibration of AIDA data and the reconstruction of ion and β events. Then the information from the three systems will be merged to obtain ion-γ and ion-β-γ correlations from which we will obtain the spectra to be analyzed.

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