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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Clarification to the ISOLDE and Neutron Time-of-Flight Committee related to INTC-P-579-ADD-1

Probing the magicity and shell evolution in the vicinity of $N = 50$ with high-resolution laser spectroscopy of ^{81,82}Zn isotopes Addendum: Laser-assisted decay spectroscopy of ^{75m,79m}Zn

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1 Introduction

The addendum to the original proposal was defended at the 77th meeting of the INTC held on November 12th, 2024, to study the decay spectroscopy of nuclear-state purified beams of ground state and isomer in ^{75,79}Zn to investigate shape coexistence in the $N = 50$ region using the CRIS Decay Spectroscopy Station. The purpose of this letter of clarification is to address the comments/issues raised by the INTC:

In the opinion of the INTC, the scientific motivation is strong, as little is known about the spins and parities of these states, which are key for understanding nuclear structure. However, the Committee requests a clarification on the requested shifts:

1. *The yield estimates are based on the 178 keV gamma-ray transition counts for* ^{75}Zn *and the 802.5 keV gamma-ray transition counts for* ^{79}Zn*. The Committee asks why these specific transitions were chosen.*

2. *The proponents should clarify the shift request based on an estimate of the isomeric yield ratio, which should be available from the first experiment.*

3. *Could you comment on whether it would be an option to measure the total (ground state + isomer) at the ISOLDE Decay Station with much higher statistics? Why is it necessary to measure both the ground state and the isomer separately at CRIS?*

2 Measurement at CRIS

The authors would like to thank the Committee for positively evaluating the strong scientific motivation of the experiment. Separation of the isomer from the ground state is required to measure the half-life of the β-decay of the two isomers ^{75m,79m}Zn with minimal contamination from the β-decay of the ground state, thus laser ionization is needed to separate the ground and isomeric state.
The measurements are proposed at CRIS because the atomic metastable state $4s4p\,^3P_2$ with favorable hyperfine splitting is populated after the Charge Exchange Cell (CEC) in the CRIS beamline [1, 2]. This splitting allows to separate the ground and isomeric state as shown in Fig. 1 for a $\sim 80\,\text{MHz}$ linewidth. A combination of RILIS and IDS would not be possible as this metastable state (at $\sim 32980\,/\text{cm}$) is not thermally populated in the target/ion source. The known ionization scheme for RILIS is $4s^2\,^1S_0 \rightarrow 4s4p\,^1P_1^0$ (0 $\rightarrow$ 46745 /cm) and has an unfavorable hyperfine splitting to separate the ground and isomeric states [3].

3 Shift request clarification

3.1 Isomeric yield ratio

The relative ratio between the implanted ground state and isomer in ^{75}Zn is estimated from the data collected during the previous campaign. In the hyperfine spectrum shown in

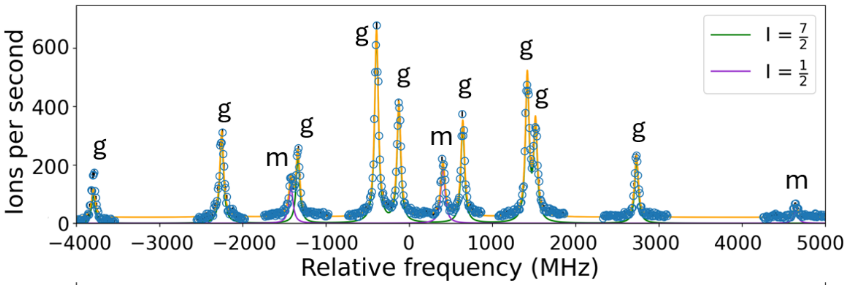

Figure 1: Hyperfine spectrum of ^{75g}Zn ($I = \frac{7}{2}$) and ^{75m}Zn ($I = \frac{1}{2}$) from the $4s4p\ ^3P_2 \rightarrow 4s5s\ ^3S_1$ transition. Data from our previous experimental campaign.

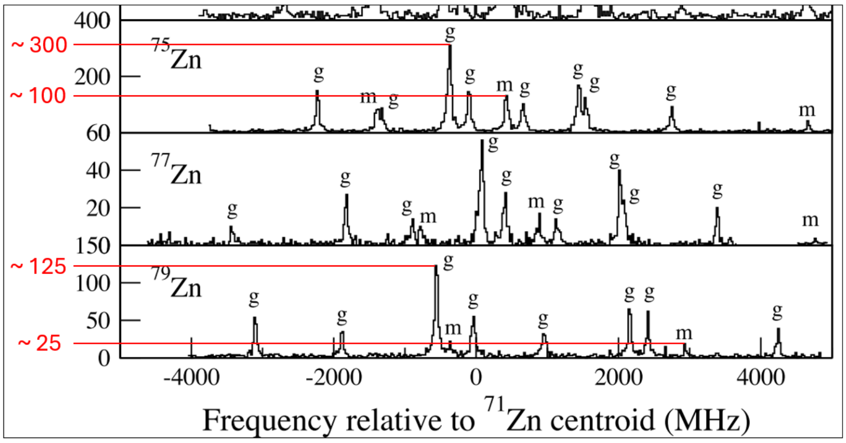

Figure 2: Hyperfine spectrum of $^{75-79}$Zn from the $4s4p\ ^3P_2 \rightarrow 4s5s\ ^3S_1$ transition, including isomeric structures. The most intense resonances for the ground state and the isomer are highlighted in red. Adapted from [2].

Fig. 1, the most intense resonances for the ground state and for the isomer yield about 600 ions per second and 200 ions per second, respectively. This corresponds to a relative yield of 75% for the ground state and 25% for the isomer. A previous experiment at COLLAPS measured the same hyperfine transition [2] and reported a similar ratio in ^{75}Zn, as can be observed from the top panel of Fig. 2. The same picture shows that a relative yield of 83% for the ground state and 17% for the isomer is expected for ^{79}Zn, which was not measured during our previous experiment. We shall thus use the observation from COLLAPS to scale our yield estimates on ^{79}Zn.

3.2 Yield estimates

The 178 keV gamma-ray transition for ^{75}Zn and the 802.5 keV gamma-ray transition for ^{79}Zn were chosen as examples of low-intensity transitions in the two isotopes.
Because of the limited amount of information available on the internal transitions, a total of 10^6 recorded β-decays is rather set as a benchmark for the shift request, as this would provide an area of about 500 counts in peaks with intensities of $\sim 1\%$ in β-gated single γ spectra, considering an average 5% single γ-efficiency of the HPGe detectors. This would

Table 1: Measured rates and requested shifts for the study of the decay of ^{75,79}Zn with the CRIS DSS.

Isotope	Rate	Shifts ground-state	Shifts isomer	Total
^{75}Zn	800 per s			1
^{79}Zn	60 per s	1.5	8.5	10
			Setup	3
			TOTAL	**14**

provide sufficient statistics to enable the detection of β-feeding intensities of 1% with a 5% uncertainty.

An estimate of the total implantation rates (ground state + isomer) is 800 ions per second for ^{75}Zn, deduced from the most intense resonances in Fig. 1, and 60 ions per second for ^{79}Zn, interpolated from the data of our previous experiment. Based on the simulated 70% β-detection efficiency and on the implantation rates, 1 shift is requested for both the isomer and the ground state in ^{75}Zn, where the shift is rather limited by setting up than by statistics, 1.5 shifts for the ground state of ^{79}Zn and 8.5 shifts for the isomer in ^{79}Zn. Finally, we require 3 shifts to set up the CRIS experiment to purify the Zn beams. The shifts are rounded to include possible downtimes and the setup time of CRIS and the DSS for each isomer. Based on these, we present the updated shift request in Table 1, for a total of **14 shifts**.

References

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