

Intruder configurations toward the Island of Inversion

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In the previously accepted proposal we aimed to study the transition into the $N = 20$ Island of Inversion by multi-nucleon transfer reactions using a ^{26}Mg beam on a ^{238}U target. The proposal was evaluated by the PAC in December 2022. The experiment was scheduled and performed in April 2023.

In our original submission, we proposed to use a ^{26}Mg beam at 7 MeV/A and a 1 mg/cm² thick ^{238}U target. Multi-nucleon transfer reactions populate states in nuclei with $N > 14$. The combination of PRISMA for reaction product identification and measurements of ejectile momenta with AGATA for γ -ray spectroscopy would allow us to measure excited state lifetimes on the order of 1 ps. The main goals of the proposed experiment were:

- to establish negative parity states in Mg isotopes arising from the promotion of an odd number of particles across the $N = 20$ gap to the fp shell and
- to study quadrupole and octupole collectivity in Ne isotopes.

In addition we aim to perform spectroscopic studies of Na and F nuclei. Since this experiment is part of a proposed campaign to use multi-nucleon transfer reactions with light projectiles we will also benchmark GRAZING calculations which are needed to plan future experiments.

The beam time in April 2023 was not successful due to problems with the beam delivery. The ion source was unable to provide ^{26}Mg , probably because the source material was prematurely evaporated. In discussion with the local team, the AGATA physics campaign spokesperson, the PAC chair, and the LNL directorate, we decided to switch the beam to ^{22}Ne . This case was similarly to the original plan presented in the context of the LNL mid-term plan and endorsed by the PAC. Unfortunately, the beam current was highly unstable, and frequent re-tuning and adjustments significantly reduced the effective beam intensity on target.

Nevertheless, we were able to collect important data. Population of Ne isotopes up to $N = 16$ was observed which gives us confidence that in this proposed experiment we can achieve lifetime measurements in the 4n channel ^{30}Mg . During the run, we gained experience to optimize the PRISMA settings to compensate for the low efficiency of the spectrometer for these light ions. In particular, we successfully tested an alternative way to perform particle identification by correlating the time of flight of the ions with their kinetic energy (E-ToF). The Z reconstruction and the mass separation achieved with this method are shown in Fig. ??.

In summary, we believe that our physics case to study nuclei toward the $N = 20$ island of inversion is still of high interest and therefore request 7 days of beam time. We will also consider proposing the follow-up experiment using the ^{30}Si beam during the AGATA- PRISMA campaign at LNL once both the AGATA scheduling and beam availability are released.

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