

First campaign of the SEASTAR project

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The SEASTAR (Shell Evolution And Search for Two-plus energies At the RIBF) project aims to measure systematically 2_1^+ energies of neutron-rich nuclei via in-beam γ -ray spectroscopy. Its setup combines the DALI2 γ -ray spectrometer¹⁾ with the MINOS setup including a liquid hydrogen target system²⁾, as shown in Fig. 1, while exotic nuclei are produced with BigRIPS³⁾. In the first campaign 2_1^+ energies of ^{66}Cr , $^{70,72}\text{Fe}$, and ^{78}Ni were measured with three different secondary beam settings.

A ^{238}U primary beam was accelerated to 345 MeV/nucleon and impinged on a 3-mm thick Be target at the entrance of BigRIPS. The beam intensity varied between 13 to 15 particle-nA. The spectrometer was tuned for ^{67}Mn , $^{71,73}\text{Co}$, and ^{79}Cu ions to enable $(p, 2p)$ reactions and to populate 2_1^+ states in the above mentioned nuclei. Particle identification was performed with the $B\rho$ - ΔE -TOF method, employing standard BigRIPS detectors. Beam energies in front of the MINOS target were around 250 MeV/nucleon, beam purities in the order of 0.1–0.3 %, and total intensities of 4 to 6 kHz.

The MINOS and DALI2 setups were installed at the F8 focus. A reaction target thickness of 102 mm was employed for all three settings. A key feature of the MINOS system was its time projection chamber, which enabled to reconstruct vertex positions of $(p, 2p)$ (and also $(p, 3p)$) reactions with an accuracy of a few mm²⁾. DALI2 was employed in its standard configuration of 186 large-volume NaI(Tl) detectors. However, MINOS

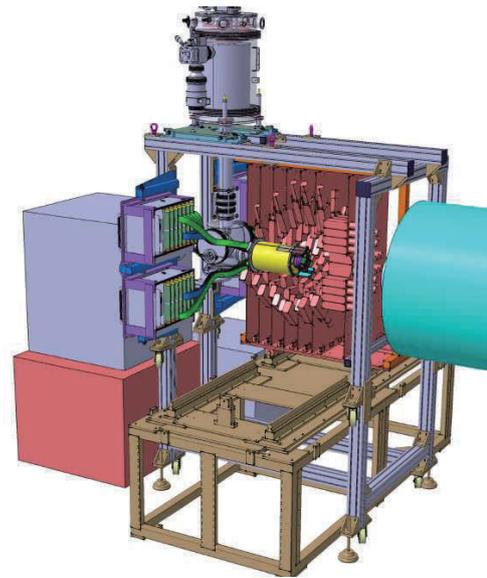


Fig. 1. Schematic view of the SEASTAR setup with the MINOS time projection chamber (yellow) mounted inside DALI2.

was installed further upstream than reaction targets are usually employed, resulting in an azimuthal angular coverage of DALI2 between 10° and 100° .

Reaction products were identified with the spectrometer ZeroDegree³⁾, providing again particle identification via the $B\rho - \Delta E$ -TOF method with standard detectors. ZeroDegree was tuned for the $(p, 2p)$ reaction channel in MINOS, resulting in total rates between 450 and 1200 Hz.

Data were collected for 7.5 days during the three settings in total, while secondary beam production with BigRIPS took 1.5 days and 1 day was used for user tuning. The 2_1^+ energies were observed on-line for the ^{66}Cr , $^{70,72}\text{Fe}$, and ^{78}Ni isotopes. Currently, these data as well as many by-products are under analysis by several groups belonging to the SEASTAR collaboration.

References

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