In search of new excited states of ^{57}Cu*

A. Malinowski[1,2], P. Sekrecka[2], M. Palacz[2], A. Fijałkowska[1], G. Jaworski[2], and I. Kuti[3]
for the EAGLE-NEDA-DIAMANT collaboration

[1] *Faculty of Physics, University of Warsaw, Warsaw, Poland*
[2] *Heavy Ion Laboratory, University of Warsaw, Warsaw, Poland and*
[3] *HUN-REN Institute for Nuclear Research (HUN-REN ATOMKI), Debrecen, Hungary*

An experiment aiming to identify new excited states in ^{57}Cu was conducted in the Heavy Ion Laboratory of the University of Warsaw. This nucleus has only one valence proton outside the doubly magic self-conjugate N = Z = 28, ^{56}Ni core. Assuming a rigid core, its ground state and low lying excited states should thus be well described by very pure Shell Model configurations, with the valence proton placed in $p_{3/2}$, $f_{5/2}$, $p_{1/2}$ and $g_{9/2}$ orbitals, corresponding to states with spin and parity $3/2^-$, $5/2^-$, $1/2^-$, $9/2^+$, respectively. However, evidence is available that the N = Z = 28 core is relatively soft and its excitations are highly collective. Thus, an interplay of single-particle and collective effects should also be manifested in the excited states of ^{57}Cu. Currently, the ground state and the first two excited states are known and interpreted as configurations $p_{3/2}$, $f_{5/2}$, $p_{1/2}$, respectively [1-3]. A few high energy states were also observed as resonances in transfer reactions [4] or via spectroscopy of protons emitted after the ^{57}Zn β^+ decay [1]. The project aims to identify the $9/2^+$ single particle state and a possible collective negative parity cascade above $7/2^-$ (seen in the mirror ^{57}Ni nucleus).

An 82 MeV beam of ^{32}S was used to bombard a ^{28}Si target. In this reaction one proton and two neutrons (p2n) have to be emitted from the compound nucleus (^{60}Zn), to reach ^{57}Cu. The reaction is dominated by the channels associated with the emission of 2 or 3 protons, possibly together with 1 neutron. The cross section for the p2n reaction channel leading to ^{57}Cu is expected to be about $3 \cdot 10^{-4}$ of the total fusion cross section, thus a method to select events of interest is needed. For this purpose a setup was deployed, in which beside the high purity germanium detector array EAGLE [5], the neutron detector array NEDA [6] and the light charged particle detector DIAMANT [7] were included.

Analysis of the collected data is in progress. Preliminary tasks, like calibrations, stability corrections, and event building, are completed. Ongoing efforts focus on improving γ/neutron discrimination in the NEDA detectors as well as on the proper determination of the number of registered neutrons. This number is crucial for the selection of 1p2n events, but a single neutron can interact in multiple detectors, leading to a false 2n gating condition. The aim of the work is to reveal the desired ^{57}Cu lines or establish the detection limit for this isotope in the experiment.

[1] D. F. Sherman *et al.*, Phys. Lett. **B60** (1976) 261.
[2] X. G. Zhou *et al.*, Phys. Rev. **C53** (1996) 982.
[3] D. Kahl *et al.*, Phys. Lett. **B797** (2019) 134803.
[4] E. Stiliaris *et al.*, Zeitschrift für Physik **A326** (1987) 139.
[5] J. Mierzejewski *et al.*, Nucl. Inst. and Meth. **A659** (2011) 84.
[6] J.J. Valiente-Dobon *et al.*, NIM **A927** (2019) 81.
[7] I. Kuti *et al.*, Acta Phys. Pol. **B17** (2024) 3-A13, and references therein.

*This work is partly supported by the National Science Centre, Poland under Grant Agreement No. 2020/39/D/ST2/00466.