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Enhancing In-Beam Gamma-Ray Spectroscopy with Machine Learning: Study of Nuclear Structure and Shape Coexistence in Neutron-Rich Niobium Isotopes

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In-beam gamma-ray spectroscopy using the state-of-the-art Advanced GAmma Tracking Array (AGATA) provides unprecedented quality in Doppler correction for high-velocity recoil nuclei studies. The Pulse Shape Analysis (PSA) algorithm, crucial to AGATA's analysis, processes gamma-ray interaction signals by comparing them to a database of simulated signals. To improve PSA capabilities, experimental data is used to build databases instead of simulated ones. Although a database has been created in Strasbourg, the current algorithm used to analyze it is time-consuming. This work presents a new machine learning-based approach to enhance the existing analysis, improving precision in determining gamma-ray interaction positions within AGATA's high-purity higly-segmented germanium crystals.

Focusing on exotic nuclei, particularly neutron-rich Nb isotopes, AGATA is combined with the large acceptance VAMOS++ and EXOGAM spectrometers to investigate sudden shape transitions, shape coexistence, and nuclear deformation. Through transfer and fusion-induced fission experiments at GANIL, the level schemes of 99, 102, 104, 105, 106Nb have been substantially revised, and a level scheme for 107Nb is presented for the first time. The discovery of a novel spherical/deformed shape coexistence in 99Nb and the progression of nuclear deformation with increasing neutron number contribute to an improved understanding of complex nuclear structures in the island of deformation region.

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