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AI-Enhanced BEGe Detectors for Low-Energy X-ray Collapse Model Tests

Testing the foundations of quantum mechanics requires experiments with extremely high sensitivity to the detection of events, which, if they occur, would have an extremely low rate. The VIP collaboration at the Gran Sasso National Laboratory (LNGS) is performing tests on the spontaneous collapse of the wave function, where recent results indicate that different collapse models predict distinct photon emission features at low energies (<10 keV). Here, I introduce tests carried out at LNGS by VIP with a Broad-Energy Germanium Detector (BEGe) for probing spontaneous emission in collapse theories. In this talk, I will present recent results and describe the new methodologies and approaches being implemented to reach progressively lower energy ranges. Special emphasis will be placed on the development of a BEGe-based experimental setup, in which machine learning techniques are employed to classify event waveforms and enhance performance at low energies, where interference from microphonic noise makes classification challenging with conventional pulse-shape analysis techniques. These strategies represent a promising direction for extending sensitivity to rare events and improving the ability to test foundational models of quantum mechanics.

Author: MANTI, Simone (Istituto Nazionale di Fisica Nucleare)

Co-author: CURCEANU, Catalina Oana (Istituto Nazionale di Fisica Nucleare)

Presenter: MANTI, Simone (Istituto Nazionale di Fisica Nucleare)

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