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Diamond detectors for life-time measurements of exotic nuclei (the LISA project)

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The measurement of the lifetime of exotic nuclei requires high-resolution gamma energy detection and precise Doppler correction of the energy spectrum.
According to the Doppler shift relation, the uncertainty in the reconstructed energy is influenced by the velocity (β) and emission angle (α). While thin targets can reduce the uncertainties in both these quantities, thick targets are required to achieve higher luminosity in experiments with exotic nuclei at relativistic energies. However, in the case of thick targets, the energy spread and the uncertainty in the reaction vertex location become dominant contributors to the overall uncertainty (i.e. resolution), thereby reducing sensitivity to lifetime measurements.
The LISA project (LIfetime measurement with Solid Active targets) addresses these challenges by replacing conventional thick targets with pixelated layers of active targets. This allows for the measurement of energy loss in each layer and precise identification of the reaction vertex. Single-crystal CVD diamonds are identified as optimal candidates for these active layers because of their exceptional energy resolution, which supports event-by-event Z identification in each layer. Each layer is made of a 5x5 matrix of diamonds (4.5 x 4.5 mm^2, 500 µm thick), with a total active area of approximately 4.2 cm^2 per layer.
The first LISA prototype (2 layer of a 2x2 matrix –Figure 1) was tested at the GSI facility (Darmstadt, Germany) and the HIMAC facility (Tokyo, Japan) using heavy ion beams in the energy range of 200 AMeV to 1 AGeV. In-beam tests showed excellent energy resolution, approximately 1% at 1 GeV energy deposit. Such high resolution allowed for the discrimination of individual fission products by atomic number from a uranium cocktail beam, even using only a single diamond detector.
Further tests allowed for the calibration of the deposited energy and the comparison with ionization chambers enabled Z-discrimination within each layer and reaction identification between layers.
This presentation will provide an overview of the LISA array's current status, the results from experimental tests conducted in 2024, and plans for commissioning the final setup in 2025.

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