Fast Scintillator Detectors for Nuclear Spectroscopy, Medical Imaging and Hadrontherapy Monitoring *

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Fast scintillators, new photodetectors, and readout electronics with fast timing response and high-rate capabilities are driving significant progress across various research domains. Halide-based inorganic scintillator crystals, combining fast time response, high energy resolution, and relatively high effective atomic number are particularly advantageous for radioactive ion beam experiments, where they enable lifetime measurements of nuclear states down to tens of picoseconds. On the other hand, faster scintillators allow replacing the present generation of LSO or LYSO-based PET scanners, and improving the achievable time resolution for TOF-PET imaging. Furthermore, the ability to sustain high rates enhances the sensitivity of modern preclinical scanners.
This presentation will focus on the instrumentation, readout electronics, and digitization strategies developed for fast-timing applications. We will showcase experimental results on the time and energy response of various inorganic scintillators, highlighting materials with strong potential for both nuclear spectroscopy and medical imaging. Comparative data will be presented for large scintillator crystals coupled to silicon photomultipliers (SiPMs) and traditional photomultiplier tubes (PMTs).
We will illustrate the versatility of ultrafast scintillator-based detectors. Examples will include decay spectroscopy measurements in the exotic region around ^{132}Sn and the development of HISTARS, a high-performance detector for nuclear excited-state lifetime measurements of nuclei populated in reactions at HIE-ISOLDE. A novel imaging approach that combines gamma-ray detection with MRI by detecting the anisotropic emissions from hyperpolarized radioactive species following magnetic resonance excitation, will be presented. Finally, real-time dose monitoring in hadrontherapy via activation and in-beam PET will also be discussed.

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