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Novel Focal-Plane Detector Concepts for PID at the FRIB S800 Spectormeter

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The FRIB S800 superconducting spectrograph is used for studying nuclear reactions induced by high-energy radioactive beams. The spectrometer was designed for high-precision measurements of small scattering angles (within ±2 msr), combined with the large acceptance of the solid angle (20 msr) and momentum (6%). The high-resolution (1/10,000) is optimized for energies up to 200 MeV/u. The S800 has been an indispensable apparatus for the wide physics program of the NSCL with fast rare isotope beams, being the most heavily used experimental device at NSCL. The S800 spectrograph will continue to serve the nuclear physics/astrophysics community for experiments with rare isotope beams also during FRIB operation.
A crucial component for the performance of the S800 spectrometer is the focal plane detector system, which consists of an array of various detector technologies for trajectory reconstruction as well as particle identification (PID). This includes two x/y drift chambers for tracking, an ionization chamber for atomic number identification by energy loss measurement, and a plastic scintillator for timing (as well as energy loss). Downstream the plastic scintillator, a CsI(Na) hodoscope is deployed to identify atomic charge states of the implanted nuclei via total kinetic energy (TKE) measurement. In this work, the operational mechanism and performance of novel detector concepts planned for the upgrade of the S800 focal plane are described for the first time. In particular, we will present the design of the new drift chamber (DC) readout based on a hybrid Micro-Pattern Gaseous Detector structure. Performance evaluations under irradiation with small lab source (5.6 MeV alpha–particle emitted by an Am-241 source) as well as with test heavy-ion beams will be presented and discussed in detail. In the latter case we the detector was irradiated by a 78Kr36+ beam at around 150 MeV/u, as well as by a heavy-ion fragmentation cocktail produced by the 78Kr beam impinging on a Be target.
In addition, I will present the development of a heavy-ion particle identification (PID) device based on an energy-loss measurement (ΔE) within a novel optical scintillation scheme. The new instrument consists of a multi-segmented optical detector (ELOSS) filled with high-luminescence yield gas (e.g. pure Xenon). Its operational principle is based on recording the fast scintillation light emitted along an ion's track. This developing technology allows for high-resolution ΔE measurements at a high counting rate, unlike traditional ionization chambers. Both high energy resolution and high counting rate capabilities are needed to take full advantage of the future FRIB's rare-isotope beam portfolio and anticipated high intensity. The proposed detector presents a significant advance in both instrumentation and capabilities in the field of experimental nuclear physics, providing new opportunities for experiments with rare isotope beams.

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