MICHIGAN STATE
UNIVERSITY

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Letter of Intent to contribute to the Snowmass Instrumentation Frontier Micro-Pattern Gaseous Detector Topical Group

The Modular Neutron Array detector (MoNA) group (Paul Guèye, Thomas Baumann), the Active-Target Time-projection Chamber (AT-TPC) group (Wolfgang Mittig, Daniel Bazin), and the Detector System group (Marco Cortesi, Yassid Ayyad) of NSCL/FRIB (Michigan State University) are interested in participating in the activities promoted by the MPGD topical group of the Snowmass instrumentation frontier.

The NSCL/FRIB laboratory is highly engaged in the development of MPGD-based readout and new MPGD architectures for applications in the field of low-energy nuclear physics/astrophysics experiments with rare isotope beams (RIBs). Below, we outline the program area priorities that are most closely related to our submission:

-) The baseline option for scintillation-signal detection in a variety of large-area experimental configurations (solid/gas/liquid medium) is the photo-multiplier tube technology. The Detector system group of NSCL/FRIB, in collaboration with the MoNA group (FRIB), has been working on the development of alternative large-area photo-sensors: a Gaseous Photomultiplier (GPM) based on a hybrid MPGD. These are a cascade of hole-type (GEM-like) electron multipliers, the Multi-layer THGEM (M-THGEM), coated with light-sensitive solid photo-converter (photocathodes). A charge filter, based on mono-atomic layer of graphene, is incorporated in the M-THGEM structure to suppress ion-feedback effects. These flat-panel GPM of single-photon sensitivity (potentially extended down to visible light) can be highly pixelated and can be economically produced for large-areas. GPMs are immune to magnetic fields, have high photon detection efficiency over a large wavelength range, a few ns time response, high-rate capability (above a few kHz/mm^2) and they can work in a large variety of operational conditions (even in cryogenic conditions).

The primary, highly-ambitious goal is to develop a large-area, position sensitive GPM sensitive to visible light to serve as an optical readout for the next generation Modular Neutron Array (MoNA) detector. Moreover, the new concept is a potential choice for other applications at FRIB as well as in other future larger-scale experiments, beyond nuclear physics with RIBs.

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-) The past decade has seen a rapid increase of the number of active targets implemented in time projection chambers (AT-TPC) used in low energy nuclear physics experiments. They provide full solid-angle detection coverage,, excellent energy and angular resolutions and separation of charged particle tracks. This results in a high luminosity ideal for experiments with weak beam intensities, down to a few hundred particles per second, therefore extending the reach of nuclear studies to more than a thousand exotic and rare isotopes that can only be produced at such low intensities. To response and satisfy the demanding challenges of low-energy AT-TPC experiments with RIBs in terms of position-sensitive readout performance, new MPGD structures are studied and developed – multi-layer THGEM configuration with mesh imbedded as inner electrodes. In addition, we are currently focusing on the implementation of a new production technology, the additive manufacturing technology for large-scale fine gas avalanche structure, as well as the implementation of new substrate materials for hybrid MPGD configuration. The scope is to reduce discharge probability for operation of the AT-TPC readout in pure elemental gas at low pressure, at a reduced ion back-flow for high rate applications.

We firmly believe that results of the abovementioned research plan is expected to make a significant impact on the field of low-energy nuclear physics as well as particle/astroparticle physics - in particular in the class of exotic nuclear reactions. The activities lead and carried out by the FRIB detector lab and collaborators is in-line with the Snowmass instrumentation frontier topic group objectives. A strong collaboration with HEP groups of Snowmass and their feedback will certainly boost our R&D program and benefit a larger scientific community. Indeed, besides its importance for future experimental nuclear physics applications with RIBs, the proposed research is expected to provide new relevant scientific and technological information in the field of photon detection, with a broader impact and a much larger application portfolio.

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