Superconducting Nanowire Detectors for the EIC:
eRD28 One-page summary

The superior metrics of superconducting nanowire detectors, such as sub-20 ps timing resolution, 100-nm position resolution, zero dark counts, and robustness against radiation or magnetic fields up to 5 T make them uniquely capable to cover many areas of EIC detection that do not require large area coverage, such as (extreme) far-forward detectors, Compton polarimeters, superconducting magnet cold-bore trackers and others.

As this technology has not yet found its way into application in nuclear physics, eRD28 aims to demonstrate that this technology is capable and mature enough to be part of the EIC detector portfolio.

Accomplishments to date: The group finished groundwork necessary for testing and fabrication of superconducting nanowires as particle detectors, where we commissioned a portable cryostat compatible with vacuum systems of accelerator beam pipes capable of 3 K operation independently of the accelerator system cooling. We carried out simulations of energy deposition in our nanowires and their detailed response to particle crossings.

Assessment of technological readiness: The authors have previously demonstrated operation and good performance of these detectors as single-photon counters in magnetic fields up to 5 T and have experience in deployment of large-scale superconducting device systems for other projects.

Given the much relaxed size requirements of particle detectors, when compared to photon counting, the limiting factor for deploying these detectors on day-1 is the availability of readout which can match the timing metrics and density of the sensor itself. This is a problem shared across all EIC detector-related R&D projects. Given the extremely low-noise, low-power operation of the devices and trivial readout of individual detector pixels (comparatively to semiconductor detectors), successful development of high-speed, high-density readout for conventional detector technologies means automatic elimination of this bottleneck also for eRD28, where only engineering constraint becomes the interfacing between the devices at liquid helium temperatures and room-temperature electronics.

The problem of many-channel readout of superconducting devices is also investigated by the much larger quantum computing and communication communities (with which the authors are in active collaboration), where large amount resources are devoted to multi-institutional and multinational projects focused specifically on this topic.

Assessment of work remaining for a TDR plus ballpark cost estimate and timeline: Design of first generation of individual pixel of few-pixel array detectors can be completed within next 6 months, depending on when the institutions lift their current work restrictions. After another 6 months to a year, results gathered during that period can be integrated and a process will be developed to fabricate optimized detectors at relevant scales.

Thus, after 2 years, the sensor modules of Roman Pot-like superconducting nanowire particle detectors or Compton polarimeter components can be available, and readiness by CD-4a will depend on availability of appropriate readout electronics, which is not within purview of this project.