Letter of intent: proposal template

Please specify an acronym, a project title and the name(s) of the project leader(s):

Electron-ion collider luminosity (EICL), Luminosity detectors for future electron-ion colliders
Project leaders:
Prof. Dr. Tyler Kutz (Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, DE)
Dr. Nick Zachariou (University of York, UK)

In the sections below, please provide details on *(2 pages max.):*

1. Research objectives

Deep inelastic scattering (DIS) is a fundamental method for studying the structure of hadronic matter, and a typical element in physics programs using hadronic physics infrastructure. The rich DIS dataset from HERA in Germany (which ceased operation in 2007) continues to be actively analyzed, while many collaborations exist for current and future DIS experiments at Jefferson Lab (JLab) and the electron-ion collider (EIC) in the USA, and an electron-ion collider in China (EicC). The physics programs of these facilities focus on the emergence of nuclear matter from QCD, including the origin of nucleon mass and spin, 3D imaging of the nucleon, nuclear medium modification, and gluon saturation effects. Precise measurements of cross sections and asymmetries are essential to achieving these physics goals. These observables demand high-precision determinations of the luminosity. Future collider facilities such as the EIC and EicC aim to achieve precisions of $\leq$1% in absolute luminosity and $\approx 10^{-4}$ in relative luminosity.

HERA demonstrated the use of bremsstrahlung in determining luminosity in electron-hadron colliders. The cross section (given by the Bethe-Heitler formula) is large and precisely calculated in QED, making it an ideal process for determining luminosity from photon rate measurements. This approach, while applicable at future facilities, is complicated due to the wide anticipated ranges of electron energies and ion species (bremsstrahlung $\propto Z^2$), necessitating measurements across a wide range of photon energies and rates. Also, in order to achieve the required relative bunch-to-bunch precision in luminosity, the signals must be extremely fast ($<$ 10 ns) with high readout rates ($\geq$ 100 MHz). The systematics associated with this can be reduced with a multi-detector luminosity monitor. At higher rates, a pair spectrometer calorimeter (PSCal) can be used to detect converted e^+e^- pairs. At lower rates, a direct photon calorimeter detector (DPD) can be used to directly measure the bremsstrahlung photons.

We propose here the development of high-precision photon calorimetry for luminosity monitoring at the EIC. Previously, the group at University of York has begun developing and fabricating scintillating-fiber calorimeter modules for use in PSCals. This proposal aims to take advantage of the expertise and setup developed in York to produce a test module of a quartz-fiber calorimeter suitable for the DPD. This module could then be tested in the A2 (real photon) beam line at MAMI, to ensure adequate timing resolution. This test data would also be critical for benchmarking simulations, which will then be

used for optimizing the design of the full detector. Developing high-precision luminosity detectors is essential to the services provided to EIC users.

The research objectives of this LOI are:
- Develop and fabricate a DPD test module using the setup at York
- Test the module with real photon beams at Mainz
- Use test data to benchmark DPD simulations
- Optimize design of full DPD

2. Connection to Transnational Access infrastructures (TAs) and / or Virtual Access projects (VAs)

The EIC is planned for construction at Brookhaven National Lab in close partnership with Jefferson Lab. This proposal will improve the service and quality for BNL/EIC's international user community.

3. Estimated budget request

We request 96.000€ to partially fund a PhD position (0,75 FTE) for three years. This amounts to 0,4 FTE (approximately half of the required funding). Note that it may be possible to obtain the remaining funding from Center for Frontiers in Nuclear Science (CFNS) at Stony Brook University.

Direct cost:	96.000,-€
Total cost (+25% overhead):	**120.000,-€**

4. Participating and partner institutions

Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, DE
University of York, UK
Center for Frontiers in Nuclear Science, Stony Brook University, USA
Czech Technical University Prague, CZ
Brookhaven National Laboratory, USA
Jefferson Laboratory, USA