**Expression of Interest (EOI) in the Electron Ion Collider From Ohio University, Athens, Ohio USA**

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**Contact: Justin Frantz** **frantz@ohio.edu**

**Executive Summary:** The medium- and high- energy nuclear experimental groups of Ohio University are excited for new exploration with the Electron Ion Collider and are therefore interested in contributing effort and resources to the EIC project. Our current multiple groups which include 4 faculty members, three currently primarily participating at Jefferson Lab and one currently primarily participating at RHIC anticipate nearly full participation in the EIC. This includes anticipation of ~5 graduate students eventually, and at least one postdoc potentially (with new funding). We expect this to be a unified effort across all our groups to a single EIC detector-collaboration. We expect to contribute DAQ and calorimeter software support along with the possibility of participation in hardware construction projects.

*Please note EoI questionnaire responses are included in the Appendix*

**Ohio University Dept of Physics and Astronomy and Institute for Nuclear and Particle Physics (INPP)**

Ohio University is located in Southeastern Ohio in Athens, Ohio and has around 20,000 students, 16,000 Undergraduate and 4000 Graduate students. The Ohio University Department of Physics and Astronomy is primarily focused on Nuclear and Particle Physics, Astrophysics, Condensed Matter Physics, and Biophysics; these endeavors are funded at a level of approximately $3 million/year. There are currently 27 tenured or tenure-track faculty members. At present there are ∼70 graduate students; the Department has granted over 200 Ph.D.s since the doctoral program began in 1959 including the winner of the 2009 **Nobel Prize** in Chemistry Venkatraman Ramakrishnan. The Nuclear and Particle Physics research efforts at Ohio University are organized under the Institute of Nuclear and Particle Physics (INPP). INPP research is supported by DOE and NSF grants totaling approximately $1.5 million/year. Also, the INPP receives funding from Ohio University, which is a percentage of the overhead generated from nuclear and particle physics research grants. This money is used to support and enhance the infrastructure of the Institute, as well as to, occasionally, directly support some of the research projects. The Department maintains a machine shop (milling, lathe and other machines) with two-full time machinists and electronic shop with one full-time computer/electronic engineer; shop services are made available to research groups at highly subsidized rates. Also, one accelerator engineer is among full time staff members of the Department.

 One aspect of the INPP is the operation of the Accelerator Laboratory, which includes 4.5 MV tandem Van de Graaf accelerator. This facility has multiple beam lines and experimental areas. The accelerator is extensively used for diverse projects in nuclear physics, astrophysics, materials science, etc. The Lab has such resources as a computer farm, hardware assembly rooms, electronics testing rooms, and a stockroom. The Department has a library of licensed software packages, which include mechanical engineering and electronics design tools.

**Medium and High Energy Nuclear Physics at Ohio University**

Research in medium energy at Ohio University focuses on the understanding of hadronic matter made up of quark and gluons. It currently involves the research of 5 faculty members, comprising 4 independent research groups. However only 4 of these faculty and 3 of the groups are included in this Expression of Interest. In the past years, the Ohio University faculty members in this area have typically worked with, 6 graduate Ph.D. students 9 undergraduate students total. Each of faculty, (Julie Roche, Paul King, Justin Frantz and Chaden Djalali) and their current groups are described below along with their potential interest and expertise areas for expected EIC contributions. These faculty members are leaders of the experiments they participate in and in some cases are spokespersons which means they propose the project and lead it on all aspects. For example, King is the spokesperson of the upcoming JLab-TDIS experiment, Roche is the spokesperson for two JLab-DVCS experiments, and Frantz is currently leading the sPHENIX EMCal Calibration software development efforts. Similarly, they are all PI's on grants that fund the development and/or acquisition of equipment necessary to perform their experiments. Roche is a co-PI of a Major Research Instrument NSF award for the building of a photon detector. King is a co-PI on a Mid-Scale Research Infrastructure NSF proposal with a focus on data acquisition equipment for the Moeller experiment. Finally, these faculty members are also leaders in their nuclear physics communities. For example, in 2018, Roche

organized the Photonuclear Gordon Conference. King is the chair of the JLab-Hall A collaboration. Frantz periodically serves as Hard Scattering convener and Correlations topical group convener of the large PHENIX Heavy Ion working groups, task forces for sPHENIX, and has served as User’s Executive Committee Chair for RHIC.

**Julie Roche and Paul King**

For their research, Roche and King use the electron beam at JLab in Virginia. Roche is a spokesperson of two DVCS experiments which aim at building a simultaneous map of the position and momentum of quarks inside the proton. King is a spokesperson for the upcoming TDIS experiment which aims to measure the quark momentum distribution inside pions. King is also the software manager of the larger upcoming Moller experiment which will test the limits of our most profound understanding of particle interaction. King and Roche are funded by the National Science Foundation.

Interests of King and Roche in EIC Detector construction efforts and eventual collaboration goals are primarily in the areas of DAQ and Calorimeter Design, Simulation and Reconstruction. Some of these efforts are expected to be made within the context of ECCE consortium and also within the EIC Users Group Software Working Group consortium (see these related EoI submissions). King in particular is interested in aspects of streaming readout.

**Justin Frantz**

Frantz's research uses the Relativistic Heavy Ion Collider (RHIC) facility at BNL which

collides mostly Au nuclei at ultra relativistic energies. Frantz is involved in two collaborations at RHIC and was briefly a part of the LHC-ATLAS Heavy Ion Working Group. The first experiment at RHIC is the PHENIX Collaboration which will continue to analyze large datasets taken until the PHENIX Experiment finished in 2016. The second is the upcoming sPHENIX Experiment, currently under construction in the former PHENIX Experimental Hall. Frantz has involved in the EMCal systems of both PHENIX and sPHENIX. In PHENIX he served in the DAQ group and as the Operations Manager/Detector Council member for the PHENIX PbGl Calorimeter as well as Photon and Hard Scattering Working Group Convener, among other leadership roles. In sPHENIX he has active in EMCal Reconstruction Software and Simulation work and currently is coordinating the calorimeter calibration software efforts. Frantz is funded by the Department of Energy.

Interests in EIC Detector construction efforts and eventual collaboration goals are primarily in the areas of DAQ and Calorimeter Design, Simulation and Reconstruction. This will include related jet reconstruction algorithms, as one of Frantz’s primary physics interests are EIC jet-related observables. Some of these efforts are expected to be made within the context of ECCE consortium especially the parts of sPHENIX that may be reused by the efforts surrounding the ECCE consortium. Frantz is also interested in several of the goals the EIC Users Group Software WG such as development as common EIC Users tools for Monte Carlo Generators and developing modular reconstruction software.

**Chaden Djalali**

Djalali started in Fall 2020, joining INPP research from his former position as Provost and following a semester of Faculty Fellowship Leave. Djalali does research at both Jefferson Lab, Virginia, and the Japan Proton Accelerator Research Center (J-PARC) located in Tokai, Japan. Djalali is a part of the Run Group A, E and G at CLAS12, and was co-spokesperson on previous CLAS experiments on modifications of vector-meson properties in nuclei. At J-PARC, Djalali is part of experiments E06 and E36, using the TREK detector. The former has the goal of searching for time reversal violation in rare decays of kaons, and the latter one is a test of lepton universality of the standard model.

Main interest in the “The Nucleus as a Laboratory for QCD” topics in the EIC white paper. Studying the effects of gluon saturation on nuclear structure functions, hadronization and color transparency will be a natural extension of currently approved experiments with CLAS12. The production of vector mesons in the medium is of particular interest to study the properties of saturated gluon matter.

**Participation in Small Hardware Projects**

Although we expect our primary contributions amongst our unified efforts to be mostly in EIC software and DAQ, some of our groups here at Ohio University have participated in unit testing of hardware and other small hardware related projects. This kind of work can be aided by our small INPP engineering staff and technicians. For example, as a participant of an NSF MRI where our institution takes some detector component testing or even unit development most likely related to calorimeter technology, like scintillating fiber selection, testing.

**Summary**

**and Other Related Expressions Of Interest Submissions.**

Despite diverse EIC-physics interests of the group, we expect that the detector development and collaboration efforts of all of the Ohio University groups will be unified as a single effort on a single detector-collaboration, possibly together with some common funding requests, such as for a post-doc. It is expected that some of these efforts will be in the context of the ECCE consortium as well as the EIC Software consortium. Ohio University is a participating institution in both of these consortia. Please see the ECCE EoI, as well as the EIC Software WG Expression of Interest, for further details. Note that the FTE estimates in those documents are a time-averaged subset of those listed in the appendix questionnaire below, and would have similar time distribution as indicated below.

**Appendix : Questionnaire**

**Please indicate the name of the contact person for this submission:**

Justin Frantz *frantz@ohio.edu*

**Please indicate all institutions collectively involved in this submission of interest:**

*Ohio University*

**Please indicate the items of interest for potential equipment cooperation:**

*N/A*

**Please indicate what the level of potential contributions are for each item of interest:**

*N/A*

**Please indicate what, if any, assumptions you made as coming from the EIC Project or the labs for your items of interest:**

*N/A*

**Please indicate the labor contribution for the EIC experimental equipment activities:**

The time commitment of members of the Ohio University groups in the EIC efforts described in this EoI is anticipated to be as follows on the table starting on the next page. Two version of the table are given. First a time-averaged one (with time-averaged FTE’s from FY22 to FY28, then another indicating some information about the distribution over time of these FTE’s.

First time averaged FTE’s between FY22 and FY28:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Institution Name | Professor | Research Professor | Staff Scientist | Postdoc | Graduate Student | Undergrad. student | Engineer | Designer | Technician | Total Sum |
| Ohio University | 0.4 | 0.3 |  | 0.5\*  | 0.9 | 0.4 | 0.1 |  |  | 2.5 |

This version contains more details about the time distributions and specific faculty groups of the expected EIC participation.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Institution Name | Professor | Research Professor | Staff Scientist | Postdoc | Graduate Student | Undergrad. student | Engineer | Designer | Technician | Total Sum |
| Ohio University | 0.1FY22 increasing to 0.5FY27(Frantz and Roche) | 0.1 FY23 to0.4FY28(King) |  | 0.1FY25\* to0.9FY28(1 person) | 0.1FY22to1.5FY28(3 students) | 0.2FY22To0.6FY28(3 students) | 0.1 |  |  |  |
| 0.1Djalali |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 0.4FY22to4.1FY28 |

FOR BOTH TABLES:

\*postdoc subject to new funding availability

Note: Here we use the maximums suggested below, ie 0.25 Professor FTE = 25% of absolute work time equals 100% of research time = MAX for a professor.

NOTE: FTE in the above table represents the annual fractional full time equivalent (FTE).

(In other words) It is anticipated that the collaborative effort of Ohio University to cooperate on the EIC Project is to include (at an annual basis with a time distribution as indicated in the table ) the ranges in the table above totaling on average 0.4 full-time equivalent FTEs of our professors, 0.3 FTE of a research professor, 0.5 FTE of a postdoctoral researcher, and 0.9 FTEs of Ph.D. students, and 0.4 of undergraduate students. 0.2 full-time equivalent FTEs of a professor, 0.3 FTE of a research professor, 1.0 FTE of a postdoctoral researcher, and 0.9 FTEs of Ph.D. students. Some small technical collaborative efforts may be possible for now we list up to 0.1 FTE of a an engineer/technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the CONSTRUCTION phase and to be for a period of MORE THAN FIVE years, with the effort levels increasing from FY22 and beyond reaching its steady state for EIC participation soon after that time. At that point we expect to increase the number of graduate students working on EIC physics, probably to at least five beyond FY28, however we list a slightly smaller FTE contribution reflecting FY28.

**Please indicate if there are timing constraints to your submission:**

*N/A.*

**Please indicate any other information you feel will be helpful:**

*None.*