

Expression of Interest (EOI) for the EIC Collider Detector (“ECCE”) Consortium



Contact persons for this submission:

Or Hen (hen@mit.edu)

Tanja Horn (hornt@cua.edu)

John Lajoie (lajoie@iastate.edu)

Institutions collectively involved in this submission of interest:

AANL/Armenia, Academia Sinica/Taiwan, BGU/Israel, BNL, CU Boulder, CUA, Charles U./Prague, Columbia, FIU, GWU, GSU, IJCLab-Orsay/France, ISU, JLab, Kentucky, LANL, LLNL, Lehigh, MIT, National Cheng Kung University/Taiwan, National Central University/Taiwan, National Taiwan University/Taiwan, National Tsing Hua University/Taiwan, ODU, Ohio University, ORNL, Rice, Rutgers, SBU, TAU/Israel, UConn, UIUC, UNH, UVA, Vanderbilt, Wayne State, and WI/Israel.

Items of interest for potential equipment cooperation:

The EIC enables an exciting research program which will advance our understanding of the structure of hadronic matter. A state-of-the-art collider detector for the EIC, which is needed to realize its physics program, will be extremely complex. It will require extensive infrastructure, and will need to be integrated into the operation of the accelerator to a very high degree. The technically driven reference schedule for the EIC project is aggressive and presents a significant challenge for an EIC detector to be designed, built, commissioned, and ready to start delivering science when the machine begins to deliver collisions. The substantial resources needed to construct a state-of-the-art detector for the EIC present an additional challenge. Time-tested strategies for addressing such challenges include the reuse of existing infrastructure where suitable and leveraging the hard-won expertise gained through previous successful projects.

The EIC Collider detector (ECCE) consortium comprises 36 institutions assembled around the idea of building on the foundation of existing infrastructure available at RHIC IP8 and experimental equipment available there and elsewhere at JLab and RHIC. The consortium includes institutions with wide-ranging world-class detector expertise, strong familiarity with the EIC-suitable characteristics of IP8, and an understanding of the approach to DOE project management. Appropriate use of existing infrastructure will help mitigate several technical and schedule risks of an EIC detector project. The technical expertise in the consortium can build on and extend upon the base provided by existing equipment to provide a complete detector with capabilities mandated by the EIC science requirements as defined by the recent EIC Yellow-Report community effort. The substantial project management experience of the involved institutions provides credible “out of the box” know-how for realizing such a sophisticated detector.

Our working principles in developing this consortium have been:

- To follow the guidance provided by the Yellow Report detector design study.

- Explore utilization and/or upgrades of existing detectors and infrastructure that would enable EIC science by meeting the Yellow Report performance requirements.
- To assemble the talent and expertise to develop and build new equipment when required.

Our collective experience spans a wide range of activities including detector development and construction, mechanical support and infrastructure, readout electronics and computing, algorithm development, etc. for RHIC (sPHENIX, STAR, PHENIX, etc.), JLab (Hall A, Hall C, CLAS, GlueX, etc.), the LHC experiments, and more. The discussions below are informed in part by a prior design study¹.

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

Below we detail the specific equipment we would like to help realize and the relevant experience members of our consortium have in realizing such/similar equipment. This list is extensive but does not cover the full ECCE, leaving room for additional contributions.

We note that individual EOIs were submitted by several consortia groups and/or for various equipment elements. These contain additional details that go beyond the scope of the current consortia EOI and are cross-referenced in an appendix at the end of this document.

● **Central Barrel Detector:**

- Hadronic Calorimetry (Rutgers, ISU, GSU)
 - We would like to realize a hadronic calorimeter, possibly based on the existing sPHENIX magnet flux return. The Rutgers, ISU and GSU groups had a leading role in the R&D, test beams, design and construction of the hadronic calorimeters for the sPHENIX detector.
- Electromagnetic Calorimetry (UIUC)
 - The UIUC group is manufacturing the W-fiber EMCAL towers for the sPHENIX central barrel and have a wealth of experience and significant factory capabilities. While the existing sPHENIX EMCAL will not be adequate for an EIC detector, their expertise will be key in realizing a barrel ECAL for the ECCE detector.
- Central Tracker
 - Silicon timing detectors for tracking and TOF (MIT, Rice, ORNL)
 - Rice University, MIT, ORNL and others are involved in the R&D for fast timing silicon detectors that can be used for time of flight measurement with good spatial granularity. They can be part of a four-dimensional tracker where both the position and time are measured. Low Gain Avalanche Detectors (LGAD) are presently being developed for applications in the LHC experiments and are being considered for various sub detectors of ECCE, including tracker and forward spectrometer.
 - Rice, MIT, and ORNL are part of a dedicated consortium of institutes developing fast timing silicon sensors.
 - Vertex (LANL, ORNL)
 - The LANL group has a long history successfully leading the R&D, construction and operation of major tracking detectors at RHIC, including the PHENIX forward muon trackers and forward silicon tracker upgrade, and is currently leading the sPHENIX

¹ <https://indico.bnl.gov/event/5283/attachments/20546/27556/eic-sphenix-dds-final-2018-10-30.pdf>

MAPS-based silicon pixel (MVTX) upgrade effort. For the EIC the group would like to develop a silicon vertex detector possibly based on the latest MAPS technology. As an alternative, we also consider the possibility of recycling MVTX sensor staves (ITS-II, ALPIDE) and readout electronics for the Day-1 EIC central inner most silicon detector to provide precision vertex measurements.

The ORNL group has decades of experience developing detector subsystems in large existing and previous ONP experiments at the AGS, CERN SPS, RHIC, and the LHC. ORNL is seeking to develop a multi-layer silicon tracking subsystem with excellent resolution for vertex and secondary vertex identification and tracking. (See the dedicated ORNL EOI referenced below for details.)

- GEMs (UVA, GWU, MIT-BATES, Vanderbilt, Wayne State)

The UVA group is currently running a world-class GEM development and construction laboratory. They recently successfully built GEMs for the PRad and SBS experiments at JLab and will build GEMs for MOLLER, SOLID and others. The GWU group is currently working with MIT-BATES to realize a sister lab to UVA in order to enhance manufacturing capabilities. Vanderbilt and Wayne State are both GEM factories for the sPHENIX TPC and Wayne State also built & tested GEMs for the ALICE Barrel Tracking Upgrade. This combined expertise will be put to use for GEM trackers for the ECCE.

- TPC (SBU, ORNL, WI/Israel, Wayne State)

Stony Brook is manufacturing the TPC for the sPHENIX experiment and has a wealth of expertise with GEMs and gaseous detectors. Vanderbilt, Wayne State, and WI/Israel are presently GEM factories for the sPHENIX TPC construction. ORNL had a leading role in the recent upgrade of the ALICE TPC, and Wayne State also participated in this project. These groups intend to use their expertise and existing lab infrastructure towards realizing a TPC for the ECCE detector.

- Pre-shower (Taiwanese groups)

The Taiwanese groups have vast experience building collider detectors. The IPAS group worked on the LEPS2 RPC detector and COMPASS DC construction. NCKU worked on the AMS UTTPS project and is working on the STAR forward tracking detector. NTHU group is working on the ATLAS phase-2 upgrade. NTU group worked on the Belle EFC and SVD2 project, and CMS Phase-1 upgrade Pixel detector. Both of NTU and NCU group worked on the CMS Preshower detector. Both of NTU and NCU group are working on the sPHENIX INTT detector and CMS Phase-2 upgrade HGCal detector. NCU group worked on the silicon sensors for WA98, and PHOBOS silicon tracker. The groups are interested in using their expertise to lead the development and construction of the ECCE pre-shower system.

- **Hadron Endcap**

- Forward Calorimetry - HCal and ECal (ISU, Ohio University)

ISU participated in design studies for forward instrumentation in sPHENIX and R&D for different forward calorimetry designs. A hadronic calorimeter similar to the UCLA design for the STAR forward upgrade has been considered, as has repurposing the PHENIX EMCal or E864 calorimeter blocks². Ohio University will participate in the design, simulation, and calibration of forward calorimetry by employing its experience with

² https://indico.bnl.gov/event/3867/attachments/10442/12745/sPH-cQCD-2017-001_draft_2017_06_02.pdf

calorimetry in multiple experiments at both RHIC and JLab. These groups will use their experience with calorimetry in sPHENIX and other experiments to develop a solution for forward calorimetry in the ECCE detector.

○ Particle ID:

■ mRICH (GSU)

GSU has developed a Modular Ring Imaging Cherenkov (mRICH) detector (NIMA 871, 13 (2017)). It is a modular and compact RICH detector that provides hadron PID capability from 3 to 10 GeV/c for p/K separation and electron PID for e/p separation below 2 GeV/c. It uses Aerogel as radiator and Fresnel lens for focusing which allows a sharper ring image than the proximity focusing RICH detector design and shifts the ring image by the lens to the central region of the focal plane. The mRICH is ideal for PID at backward rapidity (lepton arm) since it provides p/K separation for maximum hadron momentum (for jets and SIDIS physics) and complement the EMCAL with e/ p separation up to 2 GeV/c.

■ DIRC (ODU)

ODU has participated in the eRD14 PID consortium since its inception in 2011. Particular work at ODU includes DIRC simulations, magnetic field tests of prototype sensors, beam tests of prototype DIRC detectors (in collaboration with PANDA R&D, S.L. Allison PhD 2017), and ongoing measurements of optical properties of lenses for DIRC imaging.

■ TOF (MIT, Rice, ORNL, Wayne State):

We expect to use similar technology as described above for the silicon timing detectors in the Central Tracker. We will also examine the possible use of MRPC detectors. Members of the Wayne State group are heavily involved in the prototyping through final operation of the STAR MRPC-based fast-timing systems (STAR TOF, MTD, and VPD).

■ High momentum reach RICH (SBU, UConn)

The SBU group are investigating the use of gaseous RICH technology to cover the high momentum reach for PID, building on experience from BNL. The UConn group has experience with the CLAS12 RICH which they will also apply for the ECCE detector.

○ Forward Tracking:

■ Vertex Trackers (LANL)

The LANL is currently working on a forward silicon detector R&D and design supported by a LANL LDRD program (FY2020-2022, \$5M) with focus on sensor technology evaluation and detector optimization, as well as heavy flavor physics program development. With the LDRD support, the group are working on the R&D and development of a Forward Silicon Tracker (FST) by evaluating two new sensors, AC-LGAD and HV-MAPS (MALTA), for possible application in fast timing and precision vertex measurements at EIC. Further developments for the ECCE detector will follow from the results of these studies.

● **Lepton Endcap:**

○ Electromagnetic Calorimetry (MIT, CUA, Lehigh, FIU, Kentucky, AANL/Armenia, Charles U./Prague, IJCLab-Orsay/France, ODU)

We would like to collaborate with the project to help realize scattered electron detection in the electron-going direction covering pseudorapidity $-3.5 < \eta < -1$ with an electromagnetic calorimeter. The team has a long-standing track record with the

- construction of homogeneous EM calorimeters based on high-resolution crystals and glass. Our collective experience spans a wide range of activities including detector design and construction, technical support and infrastructure, readout electronics, crystal/glass fabrication and characterization, etc.
- Hadronic Calorimeter (ORNL, Ohio University)

ORNL has extensive relevant experience developing calorimeter subsystems for multiple experiments. Ohio University will participate in the design, simulation, and calibration by employing its experience with calorimetry in multiple experiments at both RHIC and Jefferson Lab.
 - Particle ID:
 - mRICH (GSU)

See the description for the Hadron Endcap.
 - TOF (MIT, Rice, ORNL, Wayne State)

We expect to use similar technology as described above for the silicon timing detectors in the Central Tracker.
 - eID with HBD (SBU)

If needed SBU will be contributing to electron-ID with a HBD detector. SBU was one of the leading groups in realizing the HBD for the PHENIX experiment.
 - **Far Forward Detectors:**
 - ZDC (BGU/Israel, MIT, ORNL, UIUC, TAU/Israel)

The Nuclear Physics Lab at UIUC has built the EMC for E821 at BNL, a pair of forward EMCs in PHENIX (the MPC) and currently is working on the construction of the sPHENIX EMC as well as R&D for the LHC High Luminosity ZDCs. Illinois leads the joint CMS-ATLAS R&D for developing the radiation hard CMS&ATLAS ZDCs and RPDs for LHC run 4. Illinois will contribute general knowledge of calorimetry to the EIC ZDC and new radiation hard technology developed for the operations of ZDC during HL LHC operations. Illinois also will be able to contribute the project management needed for the ZDC subproject.

The MIT, TAU and ODU groups have vast experience in spectator neutron measurements at JLab and most recently built the CLAS12 Back Angle Neutron Detector (BAND). The groups are interested in contributing to high performance neutron calorimetry for spectator tagging in light nuclei, and near 0 degree detection of boosted photons.

The BGU group are currently collaborating with UIUC on the sPHENIX EMC and expect to be able to contribute ~1/2 of a full ZDC for the EIC (in collaboration with TAU).

ORNL has extensive relevant experience developing calorimeter subsystems for multiple experiments.

The groups are interested in combining their expertise for realizing an ZDC for the ECCE detector.
 - Off-momentum tracking (GEMs: UVA, GWU, MIT-BATES, HUJI/Israel)

Tracking is foreseen to use either GEM or Straw tube detectors. As mentioned above, the GEMs can be built by the UVA, GWU and MIT-BATES groups, building on the proven leadership of the UVA group in manufacturing and operating such detectors. For the straw tubes the group at the Hebrew University (HUJI) who recently built such detectors for the MUSE experiment at PSI. Based on past experience the HUJI can provide such a detector in full.

- Roman pots (ODU)
 - ODU has past experience commissioning, operating, and analyzing the Si trackers of the pp2pp experiment at RHIC (later merged with STAR) and is interested in contributing to similar activities in ECCE.
- **Far backward (low-Q2):**
 - Luminosity monitor (ODU).
 - ODU are interested in contributing to the design studies for a luminosity monitor to allow integrated measurement of Bremsstrahlung flux and differential measurement of pair conversion.
- **Polarized Beam and polarimetry (MIT, UNH, SBU)**

The MIT group, in collaboration with BNL, are currently leading the development of a polarized ^3He ion source for RHIC. The project has been funded since 2012 by the DOE ONP R&D program for Next Generation Nuclear Physics Facilities. The MIT-LNS group led the development of high field optical pumping which takes place in the 5 Tesla field of the existing EBIS at BNL. The goal is to extract polarized, fully stripped ^3He ions by 2022 and subsequently inject them into RHIC. The group is also working on development of polarimetry in RHIC/EIC for polarized ^3He beams. These developments will go into the ECCE to allow polarized ^3He measurements.

SBU has initiated a collaborative effort (together with JLab and UVA eRD26) towards development of a polarimeter laser system that will meet the lepton polarimetry requirements at the EIC. In addition, we are interested in the overall design, operation (and eventual analysis of data) of the polarimeter and detectors to ensure the needed precision can be reached.
- **Electronics:**
 - Electronics (Columbia, ORNL)
 - The Columbia group has a long history of providing state-of-the art front-end electronics and data acquisition components, first for PHENIX and now sPHENIX, using the resources of Columbia's Nevis Laboratory. The group has worked with the Iowa State group and the Colorado group on interfacing electronics for the beam-beam counters and calorimeter read-out into the Level-1 trigger system. ORNL collaborated with Columbia on various electronics projects for multiple PHENIX subsystems over the years.
 - DAQ / Trigger (ISU, CU Boulder, Ohio University)
 - The CU Boulder group is leading the effort on the sPHENIX Level-1 Trigger electronics, with one PI serving as the relevant Project Level-3 Manager, and is involved in the Electromagnetic and Hadronic Calorimeter front-end electronics, for the sPHENIX Experiment. The ISU group designed and built the Global Level-1 trigger for the PHENIX experiment as well as multiple Level-1 trigger systems. ISU has access to electronics design and testing facilities through the EE Department, and has collaborated with EE on electronics design as well as wafer-probing and sensor testing. Ohio University will participate in the design and infrastructure development of the DAQ system employing its DAQ experience from multiple experiments at both RHIC and Jefferson Lab.
 - Streaming Readout (SBU, ORNL)
 - The SBU group has been leading the efforts for streaming readout as a general EIC R&D project (eRD23). The group, in close cooperation with the sPHENIX DAQ group at BNL, are very involved in driving the hybrid DAQ design for sPHENIX. The hybrid DAQ

integrates the readout of classical triggered detectors with a streaming readout of the tracking detectors in an overall streaming-readout oriented design. This approach allows sPHENIX to extend the heavy flavor physics program of sPHENIX beyond what is currently possible with a triggered readout alone. The SBU group has extensive expertise in electronics design. A streaming readout is the YR recommendation for the EIC readout philosophy. With the experience at sPHENIX and other experiments, the SBU group is in an excellent position to play a major role in the design and realize a high-performance streaming readout solution for ECCE.

ORNL has decades of experience developing advanced readout systems for many experiments including recent ones with state-of-the art continuous readout systems. ORNL is responsible for the sPHENIX MVTX (continuous) readout electronics. ORNL seeks to develop an optimized experiment-wide common back-end continuous readout system using an integrated systems management approach to significantly improve performance and reliability, while reducing overall integrated costs.

- **Computing:** (LLNL, ORNL, UConn)

Simulations will be performed using existing High Performance Computing Facilities available at LLNL and ORNL as a supplement to resources provided by the SDCC at BNL. Both facilities provide support for containers (singularity or docker) which eliminate any concerns porting to generic CPUs. Additional support will be provided for porting selected codes to hybrid and GPU architectures in cases where significant speed-up is likely. In addition the UConn group has vast experience from their work on CLAS12 on high-performance computing, both locally and using the open science grid. This expertise will be put to use for the ECCE computing needs.

- **Project Management**

Many of the institutions in the ECCE consortium have significant experience working on large DOE/NSF projects and would bring that experience to the ECCE project. This experience varies from the upper level of project management to experience at L2/3 in detector projects.

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

For this EOI we assume the availability of the IP8 interaction point at RHIC, along with the corresponding mechanical, electrical, safety and cryogenic infrastructure, as well as the availability of certain components of the sPHENIX detector.

The IP8 hall is 17.4m in length and 18.6m in width and includes an overhead crane with a 12-ton capacity. The width of the assembly hall to the exterior of the RHIC ring could be expanded without substantial civil construction as it is a standard metal building that extends out of the RHIC berm. The opening to the interaction hall from the assembly area is 9.3m x 10.2m. The height of the beamline above the floor is 5.2m. The IP8 area is already equipped with a safety system that includes radiation monitoring, ODH monitors and smoke alarms.

In support of new RHIC experiments, the DOE has recently invested a total project cost (TPC) of \$33.4M in IP8 infrastructure, including:

- Superconducting solenoid magnet
- Cryogenic support for solenoid
- Detector carriage and structural components, including the magnet flux return
- Electronics racks with power, cooling and safety systems

The existing superconducting solenoid, inherited from the BaBar experiment at SLAC, is 3.5m long with a 1.4m inner bore radius, and generates a 1.4T inner field in the sPHENIX configuration. A higher inner field (up to ~1.5T) is possible with appropriate modifications to the flux return design. The magnet and power supply have been transported to BNL and refurbished, including a new valve box and cryogenic interface. It has successfully undergone both low-current and high-current testing in preparation for RHIC running and plans are underway to fully map the magnet with the current flux return in 2022. Operational procedures and limits have been established by the BNL Superconducting Magnet Division to safely operate the solenoid. By the time the ECCE is realized, the solenoid will have three or more years of operational experience at RHIC. Last, it should be noted that the solenoid cryostat and chimney will fit through the existing opening between the interaction and assembly halls. We believe that leveraging the existing solenoid enables the possibility to free up resources for detectors and instrumentation. We do, however, recognize that using an existing solenoid carries its own set of risks and the solenoid may require additional refurbishment before use in ECCE to ensure reliable operations during the EIC era.

The detector carriage and structural components support part of the solenoid flux return and solenoid both in IP8 and in its assembly hall. Currently the barrel solenoid flux return is instrumented to provide an outer layer of hadronic calorimetry; this could be upgraded or replaced to provide the same functionality for the ECCE. Additional investments have also been made in IP8 to reinforce the rails used to move the detector between IP8 and the assembly hall. The sPHENIX detector will require electronics racks that include power, cooling, fire suppression and safety interlock systems. When sPHENIX is decommissioned these racks will be available for reuse.

The institutions of the consortium will also contribute their world-class project management experience toward the challenge of realizing a fully capable EIC detector, ready to start the EIC science program when the accelerator first delivers collisions. The successful experiences of the sPHENIX MIE, MVTX, inner HCal, and IP8 infrastructure upgrade projects, and the ALICE EMCAL upgrade have resulted in an extremely capable project management team. This is a workforce that is experienced with current DOE management practices and expectations and will be indispensable in realizing a complex EIC detector project.

The use of the existing supporting infrastructure at IP8 will reduce the technical and schedule risk of an EIC detector project substantially. We emphasize that the “ECCE” detector concept is not *driven* by the reuse of equipment. Our focus is on delivering an EIC detector that is fully capable of realizing the EIC scientific program, but this approach has broader implications for the EIC program as a whole. We support a complementary approach to the physics program enabled by two detectors. The savings and risk reduction realized through the appropriate reuse of IP8 infrastructure could be used to invest in a second EIC detector in IP6.

Finally, As detailed in BNL's EOI, the laboratory has a wide array of facilities, equipment and expertise relevant to an EIC detector. The consortium also expects to make extensive use of facilities such as electronics facilities, clean rooms, high-bay areas for detector assembly, computing, etc., made available through the EIC Center at Jefferson Lab. These facilities will be essential to realizing the ECCE detector.

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

The time commitment of members of the ECCE groups in the EIC efforts described in this EOI is anticipated to be as follows. As this EOI cross-references a large number of EOIs, we added notes to indicate where commitments are also counted in different EOIs (see appendix). The entries in the table below are in annual fractional full time equivalent (FTE).

It is intended that the collaborative effort of the “ECCE” consortium will start at the detector design phase and continue for a period of five years or more (through the detector construction period).

Please indicate if there are timing constraints to your submission:

The ECCE consortium members are involved in multiple ongoing experiments at JLab12, BNL and others. We anticipate that this will not have a major impact on our ability to realize our interests in the ECCE.

Please indicate any other information you feel will be helpful:

It should be mentioned that SBU’s contribution, in particular FTEs, applies to any effort toward any EIC experimental realization.

Five Taiwanese groups belong the Taiwan instrumentation detector consortium (TIDC) under the support of a special grant from the Taiwan funding agencies. The most important facility, Taiwan Silicon Detector Facility (TSiDF) is located in NTU. TSiDF is equipped with a class-10000 clean room, an automatic gantry, an automatic bonder, a climate chamber, a 6-inch probe station and several important instruments for silicon detector assembly and tests. Right now the assembly of the STAR forward tracking detector, the sPHENIX INTT detector and CMS HGCal detector are being conducted in TSiDF. TSiDF is one of the six module assembly centers for the CMS HGCal project around the world and one of two sPHENIX INTT assembly centers. IPAS is equipped with a high precision machine shop that has been providing high precision tools for the detector assembly in TSiDF. NCU is equipped with a class-10000 clean room and a 8-inch probe station. The silicon sensors of the CMS preshower were characterized and the silicon sensors of the sPHENIX INTT and CMS HGCal are being characterized in NCU. NCU worked on the silicon sensor production with the industrial partners. NCKU also has a 10000-class clean room and a 6-inch probe station which can provide the basic silicon sensor QA. NCKU group also has capability to design mechanical structure and conduct thermal analysis for detector module. In addition, a crystal growth group in NSYSU in Taiwan can offer good quality of LYSO crystals to the particle physics experiments.

As detailed above, the Israeli groups expect to be able to contribute to the construction of straw tube detectors, half of the ZDC, and GEMs, building on their successful past experience building such detectors for experiments at JLab, BNL, PSI, and the LHC.

Institution	Prof.	Res. Prof.	Staff Scientist	Postdoc	Grad.	Ugrad.	Engineer	Design	Tech.	Sum
AANL/Armenia	0.2	0.2	0.2	0.5	0.2	0.2	0.2	0	0.3	2.0*
AS/Taiwan	0.2	0	0	0.5	0	0	0	0	0	0.7
BGU/Israel	0.1	0	0	0.4	0.5	0.1	0	0	0	1.1
Boulder	0	0	0	0.3	0.2	0	0	0	0	0.5
CUA	0.2	0	0	0.5	0.2	0.2	0	0	0.5	1.6*
Charles U./Prague	0.1	0	0.4	0.2	0.1	0	0.4	0.1	0.2	1.5*
Columbia	0.1	0	0.5	0	0	0	0.5	0.2	0.2	1.5*
FIU	0.35	0	0	0.5	0.4	0.8	0	0	0.1	2.15*
GWU	0.2	0.3	0.0	0.3	0.4	0.2	0	0	0	1.4
GSU	0.5	0	0	0.5	0.5	1	0	0	1	3.5

HUJI/Israel	0.15	0	0	0	1	0	0	0	0.5	1.65
ISU	0.4	0.4	0	1.5	1	0.4	0	0	0	2.8
Kentucky	0.1	0	0	0.4	0.3	0.2	0	0	0	1.0*
LANL	0	0	2	2	1	0	0.25	0	0	5.25*
LLNL	0	0	0.2	0.5	0	0	0	0	0	0.7*
Lehigh	0.2	0	0	0	1.0	0.2	0	0	0	1.4*
MIT	0.6	0	1	0	1.5	2	1.5	1.5	1.5	9.6*
NCU/Taiwan	0.2	0	0	0	1	0	0	0	0	1.2
NKCU/Taiwan	0.7	0	0	0	2	0	0	0	0	0.9
NTU/Taiwan	0.3	0	0	0.3	0.5	1	0	0	0	1.1
NTHU/Taiwan	0.2	0	0	0	0.5	0	0	0	0	0.7
ODU	0.2	0	0	0.5	0.5	0	0	0	0.5	1.7*

Ohio University	0.3	0.2	0	0.4	0.4	0.4	0	0	0	1.7*
ORNL	0	0	5.7	2.0	0.7	0	2.7	0.6	1.2	12.9*
Rice	0.2	0	0	0.5	1	0	0.5	0	0	2.2*
Rutgers	0.4	0	0	0	1	0.4	0	0	0	1.8
SBU	0.8	3.0	0	9.9	6.2	4.8	0	0	0	24.7
TAU/Israel	0.2	0	0	1	1	0	0.5	0	0	2.7
UIUC	0.2	0.2	0	0.5	1.5	1.0	0.5	0	2	4.1
UNH	0.2	0	0	0.5	1.5	0	0	0	0	2.2
UVA	0.2	0.4	0	0.5	1.0	0.2	0	0	0	2.3
Vanderbilt	0.2	0.5	0	1.0	2.0	2.0	0	0	0.2	5.9
WI/Israael	0.15	0	0	0.5	0	0	0	0	0	0.65
IJCLab-Orsay/France	0.2	0.2	0.8	0	0.1	0.2	0	0	0	1.5*

Wayne State	0.6	0	0	0.5	2.0	2.0	0	0	0.2	5.3
-------------	-----	---	---	-----	-----	-----	---	---	-----	-----

*Indicate commitment also listed in a separate, dedicated, EOI.

Appendix A: Related Expressions of Interest

- Electron Endcap Electromagnetic Calorimeter (EEEMCal), Tanja Horn (contact).
- Fast Time silicon sensors for EIC detectors, Wei Li (contact), Alessandro Tricoli (contact).
- Expression of Interest in Contributions to the Electron Ion Collider (LANL), Xuan Li (contact).
- Georgia State University, Murad Sarsour (contact)
- High Performance DIRC, Gregorz Kalicy CUA (contact)
- ZDC Consortium, Michael Murray UK (contact)
- Precise central silicon tracking and calorimetry with integrated parallel and continuous readout for an EIC detector, submitted by ORNL with multiple collaborating institutes, Kenneth Read (contact)
- Fast Time Silicon Sensors for EIC detectors, submitted by Rice Univ. with multiple collaborating institutes
- Ohio University EOI, Justin Frantz (contact)
- Stony Brook University EoI, Klaus Dehmelt (contact)
- Old Dominion University EOI, Charles Hyde (contact)