Expression of Interest (EOI) for the Electron Endcap Electromagnetic Calorimeter (EEEmCal)

Introduction: The EIC is a unique collider with diverse physics topics that impose unique requirements on the detector design. Nearly all physics processes require the detection of the scattered electron in the electron endcap (forward rapidities). The requirement of high-precision detection is driven mainly by inclusive DIS where the scattered electron is critical for all processes to determine the event kinematics. Excellent electromagnetic calorimeter resolution of better than 2%/√E is required at small scattering angles, while very good resolution is acceptable at larger angles. The highest resolution in electromagnetic calorimeters can be provided by homogeneous materials, e.g. PWO crystals and glass. We would like to collaborate with the project to help realize scattered electron detection in the electron-going direction covering pseudorapidity -3.5 to -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. This project is well-defined and could fit with any global effort to realize an EIC detector with high precision EM calorimetry at forward rapidities. The team welcomes additional groups in the consortium and is open for collaboration with other calorimetry efforts.

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

- Tanja Horn (CUA) – hornt@cua.edu

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

- CUA (contact: Tanja Horn, hornt@cua.edu)
- Lehigh U. (contact: Rosi Reed, rosijreed@lehigh.edu)
- MIT and MIT-Bates Research and Engineering Center (contact: Richard Milner, milner@mit.edu)
- U. Kentucky (contact: Renee Fatemi, renee.fatemi@uky.edu)
- AANL (contact: Ani Aprahamian, aapraham@nd.edu)
- FIU (contact: Lei Guo, leguo@fiu.edu)
- Charles University Prague, Czech Republic (contact: Miroslav Finger, miroslav.finger@cern.ch)
- IJCLab-Orsay (contact: Carlos Munoz-Camacho, munoz@jlab.org)

Please indicate the items of interest for potential equipment cooperation:

The item of interest of this EoI for potential equipment cooperation is: **Electron Endcap Electromagnetic Calorimeter (Crystal/Glass).** A list of specific items and tasks anticipated with the design, construction, and assembly of this equipment is shown below. The team's contribution to each of these items is listed in the next question below.

Radiator: crystal/glass fabrication and characterization

- *Develop EIC crystals quality specifications for fabrication*
- *Crystal quality assurance (visual inspection: shape, dimensions, cracks, etc.)*
- *Transmittance and Light attenuation length measurements*
- *Light yield measurements*

- Frame design/construction - to hold the crystal/glass bars
  - *Need a mechanical structure to hold the crystals/glass block*
  - *Investigate impact of structure on physics – resolution, e/p, etc.*
  - *Need to design the frame to split open in the middle for detector maintenance*
  - *Detector cabling and infrastructure*
- Readout: PMT or SiPM, plus shielding, cooling, etc. as required
  - *Includes studies of optimal readout configuration for large block sizes*
  - *Investigate (via simulations) impact of fractional coverage of block surface by photo-sensor (PMT or SiPM) on resolution*
- Electronics
- Prototype
  - *Mechanical construction/commissioning*
  - *Characterization of mechanical and optical properties of crystal/glass*
  - *AI-driven optimization of mechanical and optical properties*
  - *Testing behavior of functional parameters in radiation fields using Microtron accelerator facility in Prague*
  - *Testing behavior of functional parameters in radiation fields using 10-75 MeV Electron accelerator and 18 MeV proton Cyclotron in AANL*
  - *Reflector for crystal/glass blocks (MC and LED/beam studies of various reflector materials, such as Teflon, Mylar, Gore, etc.)*
  - *Beam tests*
  - *Calibration and monitoring of performance*
- Slow controls and online software
- Calorimeter assembly
- Simulations
  - *Monte Carlo simulation and comparison with test beam results*

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

This section discusses the potential contributions from current collaborators on this EOI. The major components are summarized in Table 1 below. CUA has extensive experience with building homogenous crystal electromagnetic calorimeters and testing detector components. In collaboration with AANL, IJCLab, and JLab, CUA is building a ~1100 $PbWO_4$ crystal-based calorimeter of which some crystals are owned by the universities, and has built lead glass-based calorimeters. It is possible that some $PbWO_4$ crystals and some lead glass in collaboration with

AANL could be reused. The Vitreous State Laboratory at CUA has extensive expertise in the design and optimization of properties of complex multicomponent glasses, modeling of property-composition relationships, structural characterization, and measurement of molten and solid-state properties of complex glasses. CUA's contribution is a cost-reduced radiator, as well as component characterization and prototype testing. Several institutions, including AANL, IJCLab and MIT-Bates have resources for the design and implementation of the frame. Lehigh will be able to test the electronics systems. Currently there is no institution intending to provide electronic readout design, construction, or slow controls. These are clear areas of opportunity for institutions that would like to join this effort.

This project will require an extensive R&D effort. AANL, Kentucky and MIT-Bates will be able to provide human resources for this effort. With the assistance of CUA and JLAB AANL will be able to lead the effort to clone prototypes, test for optical performance as well as radiation hardness using both electron and proton beams at AANL. Once the design is finalized and components in hand AANL, Kentucky, Lehigh and MIT/MIT-Bates will provide human resources for construction and assembly of the calorimeter.

Several of the collaborating institutions have extensive experience with simulations, which are critical not only for design, but also for understanding the results from prototyping tests and test-beam data. AANL, IJCLab, Kentucky, Lehigh and MIT/MIT-Bates can all contribute to this effort. MIT in particular has experience with AI-driven detector design, which can provide a strategy to optimize in a cost-effective way (e.g., with a fewer number of crystals) the resulting intrinsic resolution of the calorimeter, taking into account mechanical and optical properties as well as constraints like space limitations.

This consortium plans to pursue the reuse of existing $PbWO_4$ and lead glass ($0.5-$1Million) and further develop glass radiator, to be provided at reduced cost. The Science Committee of Armenia (Research and instrumentation ~< $50k) as well as IN2P3/France (~<$1Million) could contribute, pending further discussions. In addition, the Consortium plans to pursue several external funding sources including NSF-20-580 (Midscale instrumentation $4-15 Million), NSF Midscale instrumentation Program (>$15Million), and/or NSF MRI (Major Research Instrumentation <$2million).

Table 1: Major components and potential contributions (in kind)

Contribution	Description	Institution
Radiator	• Possible reuse of $PbWO_4$ and lead glass in collaboration with JLab. • Cost-shared glass • Labor for characterization of mechanical/optical properties and radiation hardness.	CUA, Charles U., AANL, IJCLab

Frame	Simulations for design	AANL
Frame	Design, engineering and construction	IJCLab
Frame	Design and engineering	MIT/ MIT-Bates
Electronics	Testing	Lehigh, Charles U., AANL, FIU
Slow Controls		AANL
Prototype	Human Resources for R&D at JLAB and CUA. Lead an effort to clone prototypes and test for optical performance and radiation hardness with beams at AANL.	AANL, CUA, IJCLab, MIT/MIT-Bates
Prototype	Manpower for prototype construction test beam operations.	Kentucky, FIU, MIT/ MIT-Bates, CUA, IJCLab
Calorimeter Assembly	Human resources	AANL, Kentucky, Lehigh U, MIT/ MIT-Bates
Simulation	Human resources	AANL, IJCLab, Kentucky, FIU, Lehigh, MIT/ MIT-Bates

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

The universities participating in this expression of interest have considerable experience, expertise, and resources. This will allow the preliminary design studies, simulations, and R&D for all aspects of an EIC electromagnetic calorimeter to be performed without extensive additional support. This includes collaborating with other forward sub-detector groups in the initial design of a future EIC detector. However, the final, detailed engineering design, material costs, infrastructure, electronics, etc. will require support from the EIC project and/or the national laboratories at a later stage.

EIC Project:

- Cost for glass material, $PbWO_4$ crystals, electronics, power supplies, infrastructure

- Detailed design/engineering, machining, fabrication, and assembly
- Integration/installation

Existing capabilities needed at the Labs:

- JLab: test space for crystal/glass testing; $PbWO_4$ crystals (NPS, FCAL, etc.)
- BNL: test space for prototype and later calorimeter assembly and testing
  - *need suitable interfacing with integration efforts including engineering, electronics, DAQ, slow controls, analysis software, etc.*
  - *need test space, assembly, and/or staging area – the details will be determined as more information becomes available. Possible models include those of the STAR and sPHENIX calorimeters*
- *Access to test beam facilities, e.g. JLab, BNL, Fermilab, DESY, etc.*

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

The following table shows the labor contributions for the EIC experimental equipment activities for the consortium. The individual tables can be found in Appendix B. Overall we estimate an annual average labor contribution of ~10 FTEs to carry out this activity.

Table 2: Overall table of time commitment of members of this EoI

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Under grad. student	Engineer	Designer	Technician	Total Sum
CUA	0.2			0.5	0.2	0.2			0.5	**1.6**
MIT+ MIT Bates	0.1		0.3	0.5	0.5	0.5	0.2	0.2	0.2	**2.5**
AANL	0.2	0.2	0.2	0.5	0.2	0.2	0.2		0.3	**2.0**
Lehigh U.	0.2				1.0	0.2				**1.4**

Kentucky U.	0.1			0.4	0.3	0.2				**1.0**
IJCLab			0.3	0.2	0.3			0.6	0.5	**1.9**
FIU	0.35			0.5	0.4	0.8			0.1	**2.15**
Charles U., Prague	0.1		0.4	0.2	0.1		0.4	0.1	0.2	**1.5**
TOTAL	1.25	0.2	1.2	2.8	3.0	2.1	0.8	0.9	1.8	**14.1**

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

Please indicate if there are timing constraints to your submission:

For the next ~5 years the team members of this EOI will be engaged in carrying out their research programs at facilities including BNL, Jefferson Lab, Fermilab, and DESY with three examples shown below. However, it is assumed that the team overall will have adequate resources available to pursue the design and construction of the EEEMCal in parallel.

- Kentucky: Installation of the forward detector at STAR and a first data taking run should be complete in 2022. Continued support of the detector may be required if STAR participates in Runs 23 and/or 24. The g-2 collaboration at FNAL expects to complete its last run by summer of 2022. Both the STAR and g-2 effort will require continued analysis efforts.
- Lehigh: Installation of potential sEPD into sPHENIX will be complete in 2023, support of the STAR EPD will be required throughout STARs running. RHIC running is scheduled through 2025 and will require some effort on analysis and shifts.
- FIU: There is a set of experiments approved to run at the Thomas Jefferson Lab in the mid-2020s to measure properties of hypernuclei which will involve a major installation of a spectrometer and dedicated PID detectors. However, the experiments have not yet been scheduled.

Please indicate any other information you feel will be helpful:

As mentioned above the group has considerable experience, expertise, and resources suitable for the preliminary design studies, simulations, and R&D for all aspects of an EIC electromagnetic calorimeter Comparable, large scale detector systems or sub-systems have been made in the past with every indication that this electromagnetic calorimeter for a future EIC detector can be successfully completed. A brief summary of some of the capabilities and past accomplishments of the group are itemized below. There is space at various institutes for fabrication and assembly before staging at BNL for installation into an EIC detector.

The team:

- *brings experience with developing and building large detectors. As an example, the team has a track record in the design, fabrication, commissioning and operation of EM calorimeters at Jefferson Lab, e.g. the TF-1 BigCal, the* $PbWO_4$ *-based CLAS inner calorimeter, HPS and the Hall C Neutral Particle Spectrometer, and the PbF2 DVCS calorimeter, the F-101 HERMES calorimeter, and the STAR ECal at BNL, as well as expertise with and vendor presence for glass scintillators.*
- *has access to students and senior staff, plus technical support at some institutions*
- *may be able to help with the smaller forward/backward calorimeters*

Specific skills/expertise/etc.:

- CUA:
  - Characterization facilities for glass/crystals
  - Prototypes for glass/crystals
  - Vitreous State Laboratory for glass scintillator production: expertise and use of specialized instruments required for production, characterization, and chemical analysis
  - Close connection to Scintilex, a small business for glass scintillator development and fabrication
    - Over the last year Scintilex, LLC has made tremendous improvements and progress in the formulation and production of transparent barium-silicate-based glass scintillators (SciGlass) using new formulation approaches that improve properties and solve the issue of macro defects that becomes even more acute upon scale-up. SciGlass has excellent radiation resistance - no damage up to 1000 Gy electromagnetic and 10^{15} n/cm^2 hadron irradiation, the highest doses tested to date. The SciGlass insensitivity to temperature is a clear advantage over PbWO4, which has a dependence of about 2-3%/°C and has to be continuously monitored.
    - Scintilex has demonstrated a successful scaleup method and can now reliably produce glass samples of sizes up to ~10 radiation lengths. Initial

beam test results suggest that Scintilex glass samples have an energy resolution comparable to $PbWO_4$ crystals, if comparable radiation lengths are used, for higher light yield, which is important for low energy particle detection. Scale up to ~15-20 X_0 long blocks is planned for late 2020.

- MIT and MIT-Bates Research and Engineering Center
  - Experience with detector design, construction, and operation (BLAST, OLYMPUS, Hermes, GlueX, etc.)
  - Very familiar with the DESY test beam facility for testing EM calorimeters
  - Monte Carlo simulation, AI optimized design, and analysis, several high performance computing clusters
  - Excellent graduate and undergraduate students
  - Engineering design, drafting, and fabrication capacity
  - Skilled technicians and space for assembly
  - Clean rooms
- AANL:
  - AANL: 10-75 MeV electron and 18 MeV proton beam
  - Cleanroom facility
  - Experience with detector design, construction, and operation
  - Monte Carlo simulation and analysis
  - Experience with the Jlab Hall A/C
  - Skilled technicians for assembly
- Kentucky
  - Experience with building and calibrating calorimeters
  - Experience with GEANT, both detector packages and beam guns
  - Experience with several Monte Carlo simulation packages
  - Experience with SLAC test beam facility
  - Machine shop and electronics engineer available for small fee
- IJCLab-Orsay
  - Engineering and construction capabilities (machine shop available)
  - Experience with simulation, construction and operation of calorimeters
  - Electronics department for readout design/fabrication
  - Gamma irradiation facility
  - Cleanrooms available
- FIU:
  - Design, build, construction of GlueX start counter
  - Construction and calibration of CLAS start counter
  - Experience with SiPM based detectors
  - Experience with SiPM testing

- Experience with monitoring and laser calibration for CMS calorimeter
- Experience with CLAS Drift Chamber and CLAS12 polarimeter
- Aerogel Cherenkov Detectors, design and construction (JR)
- EPICS Slow Controls and Alarm handlers (JR)
- Monte Carlo simulation packages (SIMC/A, GlueX)
- Machine and Electronics shop available for small fee

- Lehigh:
    - Experience with design, construction, commissioning of detectors including calorimeters
    - Access to a small machine shop and machinist
    - Experience with GEANT
    - Experience with several Monte Carlo packages
    - Experience with SiPM based detectors
- Charles U./Prague
    - Facilities for radiation hardness tests in Prague, at the Institute of Nuclear Research
    - Close collaboration and connection to CRYTUR, one of two manufacturers of $PbWO_4$ crystals worldwide
        - PWO production – CRYTUR qualifies a new batch (2 tons) of raw material for PWO crystals, manufactured by the original BTCP supplier from Russia.
        - Manufacturing - CRYTUR offers its construction/CNC/clean rooms manufacturing capabilities for crystal holder design, or for construction and manufacturing of any other mechanical assembly
        - Glass scintillator – CRYTUR follows the optimized scintillating glass composition, but starts with adding the Gd and Ce dopants into pre-made barium silicate glass, to make the process more robust and reliable.
        - New concepts – CRYTUR offers to test different detector concepts. CRYTUR can offer for testing, for example, shashlik detector made of YAG:Ce, LuAG:Ce of GaGG:Ce fibres with proprietary tungsten absorber. Other different concepts can also be developed
    - Electronic readout – Our team of electronics specialists can apply their experience in developing SiPM-based readout for the PWO/glass/new concept detector designs.
    - Data processing – Prague University can offer team experienced to process data from CERN

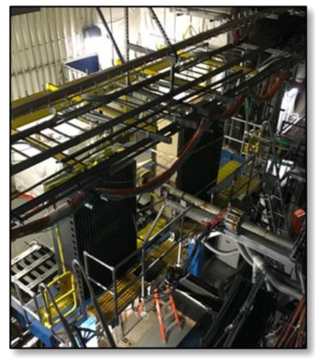
APPENDIX A:

Examples of Infrastructure and Expertise

Selected calorimeters

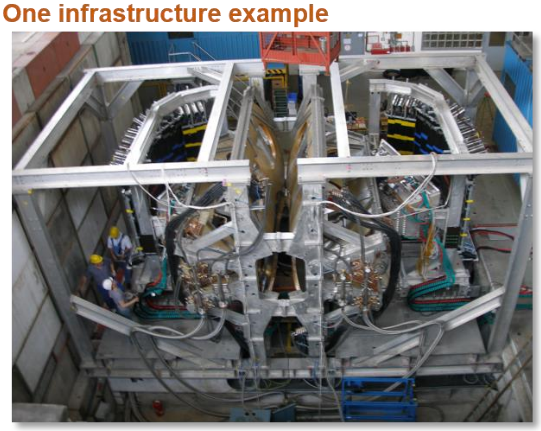
SHMS EMCal: 252 TF-1 blocks

NPS: 1080 $PbWO_4$ (CRYTUR, SICCAS)



STAR: installed ECAL of the forward upgrade

One infrastructure example



- Track record in the design, fabrication, commissioning, and operation of EMCals
- Access to students and senior staff, plus technical support at some institutions
- May also be able to help with the smaller forward/backward calorimeters

OLYMPUS (BLAST) spectrometer: designed, fabricated, commissioned and operated at Bates

APPENDIX B: Individual tables of time commitment of members of this EoI

The time commitment of members of the CUA group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum
CUA	0.1			0.5	0.2	0.2			0.5	1.5
	0.1									0.1
										1.6

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

It is anticipated that the collaborative effort of CUA to cooperate on the EIC Project is to include (at an annual basis) 0.2 full-time equivalent FTEs of a professor, 0.5 FTE of a postdoctoral researcher, and 0.2 FTEs of Ph.D. students, and 0.2 FTEs of undergraduate students. The technical collaborative effort contributed is to include up to 0.5 FTE of a technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of FIVE years.

The time commitment of members of the **MIT** group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum

MIT + MIT-Bates	0.1		0.3	0.5	0.5	0.5	0.2	0.2	0.2	2.5
										2.5

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

It is anticipated that the collaborative effort of MIT over five years to cooperate on the EIC Project is to include (on annual basis) 0.1 full-time equivalent FTEs of a professor, 0.3 FTE of a research scientist, 0.5 FTE of a postdoctoral researcher, 0.5 FTEs of Ph.D. students, 0.5 FTEs of undergraduate students. We plan to involve the staff of the Bates Research and Engineering Center and their contributed (average annual) effort is to include up to 0.2 FTE of an engineer, 0.2 FTE of a designer, and 1.0 FTE of a technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of about FIVE years.

The time commitment of members of the **AANL** group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum
AANL	0.1	0.1	0.1	0.2	0.1	0.1	0.1		0.1	0.9
	0.1	0.1	0.1	0.3	0.1	0.1	0.1		0.2	1.1
										2.0

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

It is anticipated that the collaborative effort of AANL to cooperate on the EIC Project is to include (at an annual basis) 0.2 full-time equivalent FTEs of a professor, 0.2 full-time equivalent FTEs of a research professor, 0.2 full-time equivalent FTEs of staff scientist, 0.5 FTE of a postdoctoral researcher, and 0.2 FTEs of Ph.D. students, and 0.2 FTEs of undergraduate students. The technical collaborative effort contributed is to include up to 0.2 FTE of engineer and 0.3 FTE of a technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of FIVE years.

The time commitment of members of the Lehigh U. group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum
Lehigh U.	0.2				0.5	0.2				0.9
					0.5					0.5
										1.4

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

It is anticipated that the collaborative effort of Lehigh U. to cooperate on the EIC Project is to include (at an annual basis) 0.2 full-time equivalent FTEs of a professor, 0.0 FTE of a postdoctoral researcher, and 1.0 FTEs of Ph.D. students, and 1.0 FTEs of undergraduate students. The technical collaborative effort contributed is to include up to 0.0 FTE of a technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of FIVE years.

The time commitment of members of the **U. of Kentucky** group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum
	0.1			0.4	0.3	0.1				0.9

U. Kentucky						0.1				0.1
										1.0

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

It is anticipated that the collaborative effort of U. of Kentucky to cooperate on the EIC Project is to include (at an annual basis) 0.1 full-time equivalent FTEs of a professor, 0.4 FTE of a postdoctoral researcher, and 0.3 FTEs of Ph.D. students, and 0.2 FTEs of undergraduate students. The technical collaborative effort contributed is to include up to 0.0 FTE of a technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of FIVE years.

The time commitment of members of the IJCLab group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum
IJCLab			0.2	0.2	0.3			0.3	0.25	1.25
			0.1					0.3	0.25	0.65
										1.9

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

It is anticipated that the collaborative effort of IJCLab to cooperate on the EIC Project is to include (at an annual basis) 0.2 full-time equivalent FTEs of a staff scientist, 0.2 FTE of a postdoctoral researcher, and 0.8 FTEs of Ph.D. students. The technical collaborative effort contributed is to include up to 0.1 FTE of an engineer and 0.2 of a designer. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of FIVE years.

The time commitment of members of the FIU group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum
FIU	0.1			0.5	0.2	0.2			0.1	1.1
	0.05					0.2				0.25
	0.1				0.2	0.2				0.5
	0.05					0.1				0.15
	0.05					0.1				0.15
										2.15

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

It is anticipated that the collaborative effort of FIU to cooperate on the EIC Project is to include (at an annual basis) 0.1 full-time equivalent FTEs of a professor, 0.5 FTE of a postdoctoral researcher, and 0.2 FTEs of Ph.D. students, and 0.2 FTEs of undergraduate students. The technical collaborative effort contributed is to include up to 0.1 FTE of a technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of FIVE years.

The time commitment of members of the Charles University group in the EIC efforts described in this EoI is anticipated to be as follows:

Institution Name	Professor	Research Professor	Staff Scientist	Postdoc	Graduate Student	Undergrad. student	Engineer	Designer	Technician	Total Sum
Charles University, Prague, Czech Republic	0.1		0.2	0.2	0.1		0.2	0.1	0.1	1.0
			0.2				0.2		0.1	0.5
										1.5

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

It is anticipated that the collaborative effort of Charles University to cooperate on the EIC Project is to include (at an annual basis) 0.1 full-time equivalent FTEs of a professor, 0.4 FTE of a staff scientist, 0.2 FTE of a postdoctoral researcher, and 0.1 FTEs of Ph.D. students. The technical collaborative effort contributed is to include up to 0.4 FTE of a (mechanical or electronics) engineer, 0.1 FTE of a designer, and 0.2 FTE of a technician. We anticipate the duration of this collaborative effort to cooperate on the EIC Project to start at the DESIGN/CONSTRUCTION phase and to be for a period of FIVE years.