EEEMCal Action Items from 11/23/2020 meeting

- Collect existing EMCal simulations into github
  - NPS
  - TPEX

- Prepare slides for discussion with NSF
  - EEEMCal in context of full detector design
  - Bottom line plus R&D effort for next few years to get to EEEMCal design
  - Unique physics enabled by EEEMCal
  - Experience of the team with photon/electron detection – broad expertise including hadron and heavy-ion physics

- Try to arrange meeting with NSF before Holidays

- Collect information for Hall D beam tests in 2021

- Collect information for discussion of prototype concepts and questions to address for one of next EEEMCal meetings

Recap EIC EOI

- Received: 47 EOIs – good representation, a number of universities and countries seem still missing

Experimental Program Preparation

BNL and TJNAF Jointly Leading Process for Defining Detector(s)

Call for Expressions of Interest (EOI) for "Potential Cooperation on the EIC Experimental Program"	May 2020
EOI responses	November 2020
Assessment of EOI Responses	On-going
BNL/TJNAF to organize a committee to advise on initial EIC experimental program	
Call for Detector Proposals	March 2021
Decision on Detector(s)	December 2021

EEEMCal path forward – near term activities

- Major items
  - SciGlass development and radiator characterization
  - Crystal/glass prototypes and beam tests
  - Simulations for performance optimization
  - Setup technical infrastructure
  - Engage with the forming detector proposals/consortia
  - Explore off-project funding, e.g. NSF

- Upcoming beam test opportunities – contributions?
  - Jlab 2021, June++
  - DESY 2021

- Simulations
  - Determine best configuration of crystal/glass (performance and cost)
  - Choice of reflector, fractional coverage of radiator with SiPM

Example CUA:

- SciGlass fabrication and characterization on test bench
  - 2x2x20cm^3 with improved formulation, 40cm long bars for beam tests, larger scale production
  - Dimensions, surface characteristics, light yield, timing, transmittance
- Crystal/SciGlass prototype and beam tests Jlab 2021:
  - 3x3 prototype with PMT and SiPM (different configurations), streaming readout
- Monte-Carlo simulation studies in collaboration with ….:
  - Setup and optimization of the 3x3 prototype simulation for quick investigations
  - Investigation of optimal shared forward rapidity crystal/glass

Example AANL:

- Monte-Carlo simulation studies of calorimeter resolution:
  - Effect of fractional coverage of blocks by PMT or SiPD, effect of reflector (wrapping) material
  - Optimal resolution for different configurations of crystals in the inner and another material in the outer regions, (e.g. scintillating glass). (To determine the optimal number of crystals for the physics performance and lowest possible cost).
- R&D studies of EIC EC, crystals optical properties, EC prototyping:
  - crystals inspection and QA, transmittance and attenuation length, light yield measurements
  - In 2021-2022 we can design and prepare setup to test radiation resistance of calorimeter components and prototypes using 10-75 MeV energy electron and 18 MeV proton beams at AANL.

Example MIT

- Preparations for beam tests at DESY in 2021:
  - 5x5 prototype with PMT – standalone system
  - Plan to test different radiators, cooling system, and different readout systems including streaming readout
  - Positive TPEX review – anticipate to test ten 5x5 calorimeter configurations over the next few years
- Monte-Carlo simulation studies in collaboration with ….:
  - GEANT4 simulations including shower simulator developed at Mainz
  - Tuned with data from earlier beam test – good agreement

Example IJCLab Orsay:

- Monte-Carlo simulation studies of calorimeter:
  - Build on NPS simulation developed
- R&D studies of radiator and prototyping:
  - Irradiation with Co-60 source, transmittance, LY, etc.
  - Resources for prototype design and construction

Example Lehigh U.:

- R&D studies of SiPM and electronics:
  - SiPM single vs. array and noise control if combining multiple channels in readout
  - Testing electronics components
  - Help with prototype test beams programs

Example FIU:

- Monte-Carlo simulation studies of calorimeter:
- Help with prototype test beam programs

EEEMCal path forward – funding exploration (US)

- Cost bottom line for all new EEEMCal – **estimate: ~$12M**

In context of the EIC call for detector proposals a submission of an MSRI LOI on January 5th may be needed

- Matching funding opportunities
  - NSF MidScale Research Infrastructure (MSRI) R1 program (<$20M)
    - The MSRI R2 program is for >$20M
  - NSF Major Research Instrumentation (MRI) program + something else
    - Track 1: <$1M (competition within PHY)
    - Track 2: <$4M (competes with all of NSF)

- Next steps:
  - Discussion with NSF – prepare a few slides identifying the unique physics enabled

EEEMCal path forward – funding exploration (US)

- Cost bottom line for all new EEEMCal – **estimate: ~$12M**

- Major items

  - Scintillator material - $5.5M + labor + IDC
  - Readout electronics - $1.2M + labor + IDC
  - Mechanics and integration - $1.4M + ?
  - Calibration and monitoring - <$1M?
  - Performance studies - <$1M?
  - Quality control and assembly - <$1M

Mechanics and integration	
	EEEMCal mechanical structure
	Thermal aspects/calculations
	Sub module structure
	Sub module mounting and tests
	Support structure
	Electronics integration
	Cooling design (heat sources and transfer, cooling layout)
	Monitoring system and integration
	PCB, cables, connectors
	Design maintenance access options
	Prototype tests (mechanical, thermal, readout, assembly)
	Scintillator geometry and housing (arrangement, light collection, carbon fiber alveoli, etc.)
	Pitch between scintillator elements
	Radiation hardness of materials

Item	Task	Facilities
Scintillator material		
	SciGlass fabrication/optimization	VSL
	SciGlass characterization (dimensions, light output, kinetics, radiation hardness)	Jlab NPS cleanroom, university instrumentation
	SciGlass prototype tests	Test beam facility (Jlab, BNL, Fermilab, DESY)
	Crystal procurement	
	Glass procurement	
	Scintillator radiation damage and recover	X-ray 160 keV (CUA), Co-60 (IJCLab, Charles U.), university instrumentation
	Scintillator quality of mass production	Jlab NPS cleanroom, university instrumentation
	Scintillator prototype beam tests	Test beam facility (Jlab, BNL, Fermilab, DESY)

Readout Electronics	
	Readout procurement
	SiPM calibration
	SiPM selection (array vs. single)
	SiPM screening (temperature, radiation) and matching
	Streaming readout tests
	Preamplifier prototype tests (noise, dynamic range, etc.)
	Digitization
	Feature extraction
	Front End prototyping and testing
	PCB, cables and connectors
	Detector control systems

Calibration and monitoring	
	Precalibration with cosmic muons
	Monitoring
Performance studies	
	Prototype for endcap
	Beam test program (readout, cooling, monitoring, energy resolution, spatial resolution)
Quality control and assembly	
	Scintillator
	Readout electronics
	Mechanical

EEEMCal – enables [PHYSICS PROCESS] at the EIC

The EEEMCal enables key physics process(es) allowing to investigate XXXX [EXAMPLES]

- The EIC is a unique *electron*-ion 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.

EEEMCal – key for electron detection at the EIC

The EEEMCal provides excellent electromagnetic particle detection in the electron endcap

- For successful [PHYSICS MEASUREMENTS] 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.

EEEMCal – proposal

- We would like to design and construct the 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.