Report of the 2022 EIC-related Generic Detector R&D Review Committee

June 1, 2023

FY22 marked the restart of the EIC-related generic detector R&D program. The equivalent of 30 proposals were received by the deadline of July 25, 2022. This was twice the number that was naively expected, reflecting tremendous interest in the EIC as well as unusually high demand for related R&D funds.

All proposals were assigned at least 2 readers. Complex or cross-disciplinary proposals were assigned 3 readers. Larger topical working groups within the committee of 16 members then discussed the proposals. Despite the committee's heavy workload, a process was followed which strived to respect the effort and expertise of all PI's. A total of 25 proposals were deemed possibly feasible/ready/affordable enough to merit a presentation. Talk slides and reviewer questions from the 2 day review committee meeting on November 15 and 16, 2022 are available at https://indico.jlab.org/event/658/ and https://indico.jlab.org/event/659/ .

Based on considerations of topical balance and priority, the review committee approved 15 proposals. Since most proposals were submitted by collaborations, this resulted in 38 awards to 23 institutions in 6 countries. As Chair, I'd like to thank the proponents for the generally high quality of their proposals. We stopped approving proposals when we ran out of money, not because we ran out of worthy proposals.

Many people helped with the restart of this program, from carefully thought out nominations for committee membership, to help with interpreting spreadsheets, to procurement and legal advice. If I tried to make a comprehensive list of all those who deserved thanks, I would surely fail, so I will limit myself to only a few:

The review committee members (whose names and institutions are listed on the next page) care very deeply about detector R&D, and I treasure them for their expertise, frankness, and patience. Each individual had a heavy load of 4 reading assignments, but as topical working groups formed and began discussions, some members ended up reading 6 or even 8 proposals. Thanks to Thomas Ullrich (BNL) for always sharing lessons learned from the previous BNL-managed version of this program, as well as providing his insights during the 2 day presentation meeting. David Dean (JLab) and Ivan Graf (DOE) always pointed me in the right direction. Regarding JLab support staff, I'd like to thank Stephanie Tysor for arranging the meeting rooms and Sadie Cherry for supporting us during the 2 intense days of the presentation meetings. Susan Brown and Tanya Stewart watched our finances, and Mitch Laney and Jessie Tenbusch and the rest of the Procurement and Legal teams have since gotten most of the awards into the hands of the successful PI's. I cannot thank all these people enough.

Sincerely,

Dave Mack (TJNAF)

Chair

The 2022 EIC-related Generic R&D Review Committee

Name	Institution	Reading Assignments
Nicolo Cartiglia	INFN Torino	6, 10, 20, 24
Gabriel Charles	IJCLab/IN2P3/CNRS, University Paris-Saclay	2, 3, 14, 23
Oleg Eyser	BNL	10, 13, 19, 27
Jin Huang	BNL	15, 21, 25, 26
Samo Korpar	U. of Maribor and Institute Jozef Stefan	6, 9, 12, 18
Ron Lipton	FNAL (retired)	5, 10, 12, 26
Clara Matteuzzi	INFN (retired)	7, 9, 20, 24
Ben Nachman	LBNL	15, 16, 17, 27
Daniel Pitzl	DESY	13, 22, 25, 26
Fabrice Retiere	TRIUMF	1, 2, 16, 18
Petra Riedler	CERN	5, 11, 20, 24
Stefan Ritt	PSI	5, 8, 11, 15
Bjoern Seitz	U. Glasgow	1, 11, 22, 27
Justin Stevens	College of W&M	4, 7, 17, 21
Maxim Titov	CEA	2, 3, 14, 23
Glenn Young	BNL	4, 8, 17, 19

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Note: On the following pages, the color green indicates a proposal which was at least partially funded.

EICGENR&D 2022 Proposal Number (1 thru 27)	Title And PI('s)	Institution(s) (abbreviated and only includes PI's)	Topical Area	Was a presentation requested?	Was the proposal at least partially funded?	If unfunded in 2022, is the proposal encouraged to resubmit in 2023?
1	**CSGlass for hadron calorimetry at the EIC**, T. Horn	CUA, Washington, DC, USA	Calorimetry	Yes	Yes	n/a
Discrimination between fast, short wavelength Cerenkov light versus slower, longer wavelength light could potentially be used to improve the energy resolution of jets in hadron calorimetry. The study will be done in an appropriately formulated scintillating glass.						
2	**A proposal for MPGD-based transition radiation detector/ tracker**, Y. Furletova, J. Velkovska	JLab, and Vanderbilt U., USA	PID (non-TOF)	Yes	Yes	n/a
Cleanly identifying electrons in the midst of orders-of-magnitude larger charged pion backgrounds is critical. The TRD being developed in this proposal could potentially provide significant e/pi discrimination beyond that provided by an EM calorimeter alone (thus reducing project risk), and help understand the EM calorimeter performance.						
3	**Precise Timing with a Micro Pattern Gaseous Detector**, K. Dehmelt	Stony Brook U., USA	Gaseous Precision Timing and/or Tracking	Yes	No	See comments below.
The PICOSEC technology could potentially offer an alternative to silicon options such as AC-LGAD in precision TOF applications. As the proposal outlined, there are many open areas for related R&D. However, the scope of this proposal was too broad given the small anticipated workforce. A resubmitted proposal should have a narrower focus selected to complement the world PICOSEC effort (mainly in Europe but also the approved JLab LDRD proposal 2023-LDRD-9 on which the PI is a collaborator).						

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4	**BeAGLE, a tool to refine IR and detector requirements for the EIC**, M.D. Baker	MDBPADS LLC, Miller Place, NY, USA	Software Supporting Electronics/ Detector Design or Physics Program	Yes	No	No
The BeAGLE Monte Carlo event generator was developed under the previous generic R&D program and has been instrumental in facilitating physics and detector studies for the EIC. The software is frequently referenced by experimentalists in their conference talk slides. However, given the even higher demand on the current program's funds, it is critical that the generic R&D committee focus on proposals which can have major impact over 1-3 years. We recognize the need for something resembling operations grants to support EIC R&D, but respectfully, we cannot provide them. In this context, further support for BeAGLE has been deemed a low priority for the generic R&D program.						
5	**Continued Development and Evaluation of a Low-Power High-Density High Timing Precision Readout ASIC for AC-LGADs (HPSoC)**, B. Schumm, L.Macchiarulo	UCSC, and Nalu Scientific LLC	Front End Electronics	Yes	Yes	n/a
Precision timing detectors require precision digitization of the fast signals. The committee agrees with the proponents that the future in this area lies in fast (10 GSamples/sec) waveform digitization with programmable feature extraction. Depending on the application, this would give experimenters the power to determine time, total charge, perform walk corrections, correct for baseline shifts and pile-up, utilize pulse shape discrimination, etc. A new 4-channel chip will be produced, interfaced to AC-LGAD's, and tested to demonstrate capability.						

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6	**A new radiation tolerant low power Phase-Locked Loop IP block in a 65 nm technology for precision clocking in the EIC frontend electronics**, D. Neyret, W. van Noije	IRFU, CEA Saclay, France, and U. de São Paulo, São Paulo, Brasil	Front End Electronics	Yes	Yes	n/a
If developed soon, a generic timing Phase Locked Loop IP block with ultra-low phase noise could be incorporated into upcoming ASICs for the EIC. The planned small footprint, low power consumption, and demonstration of sufficient rad hardness would increase the likelihood of its being adopted.						
7	**Refined Methods for Transfer Matrix Reconstruction Using Beamline Silicon Detectors for Exclusive Processes at the EIC**, A. Jentsch, M. Murray	BNL, Upton, NY, USA, and U. of Kansas, Lawrence, KS, USA	Software Supporting Electronics/ Detector Design or Physics Program	Yes	Yes	n/a
For the exclusive physics program, it is critical to be able to reconstruct the momentum and vertex angle of intact beam ions scattered at very small laboratory angles. A transfer matrix can relate downstream position measurements to the momentum and angle at the event vertex, however the matrix elements are themselves nonlinear functions of ion momentum. Several schemes for addressing this chromaticity will be explored, and the resulting software tools will be made available to the EIC community.						

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8	**TOMATO (end-TO-end siMulation fAst deTectOrs): An end-to-end simulation framework for fast detectors at the EIC**, D. Tapia Takaki	The University of Kansas Center for Research, Inc., Lawrence, KS, USA	Software Supporting Electronics/ Detector Design or Physics Program	No	No	No
This software development project appears to call for a multi-year effort by an experienced physicist, rather than one year by a relatively new graduate student. There are likely to be difficulties in linking Geant4 and Weightfield2 to a graphical interface program like LTSpice. Also, it takes enormous effort to make a system not only general but useful for others, and must include documentation and planning for support for users. With the proposed workforce, the chance of success appears to be very low.						
9	**Z-Tagging Mini DIRC**, C. E. Hyde	Old Dominion U., Norfolk, VA, USA	Other New Detectors	No	No	Yes
The identification of recoil ions is required to measure exclusive processes and could potentially extend the EIC physics program to include rare isotope spectroscopy. This proposal would detect Cerenkov light (proportional to Z^2) from a fused silica radiator near the downstream hadron beamline to identify the atomic number of ions up to 90. Ideally, the detector should be able to function over a signal dynamic range of nearly 10,000 (ie, with adequate S/N for protons). Most of the requested funds for Year 1 were for personnel for simulations. The committee would prefer that some of these background questions be started with the existing collaboration workforce before resubmitting this proposal.						

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10	**Implementation of a gain layer in Monolithic Active Pixel Sensor (MAPS) for high resolution timing application**, P. Schwemling, A. Camsonne, H.S. Jo	CEA IRFU Saclay, France, Jlab, Kyungpook National U., Korea	Silicon Detectors	No	No	See comments below.

Monolithic Active Pixel Sensors (MAPS) will be used in tracking and vertexing in EIC. Improving the multi-musec timing resolution of MAPS would potentially enhance PID via precision TOF, as well as enable the rejection of hits not associated with a given bunch crossing. (Note that while precision TOF would require resolution of roughly 25 ps, matching hits to bunch crossings would only require timing resolution significantly better than 10 ns.) We received two proposals which planned to add a gain layer to MAPS to dramatically improve S/N and hence their timing resolution.

In this proposal, precision timing capability would be added to an existing MAPS position detector by ion implantation of the gain layer.

The committee felt the risk was high that the device would not work as intended due to dislocation damage from the ion implantation. It was also the single most expensive proposal received, hence approval would have been unlikely unless the chance of success appeared very high. We note that the induced current from the buried gain layer may spread to several pixels depending on the aspect ratio. If used properly, this could be an advantage but must be considered in the electronics design. The proposal could be resubmitted if it can make convincing arguments that the R&D is much lower risk than it appears. And it would be helpful if the cost could be reduced.

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11	**Development of a Generic, Low-power and Multi-channel Frontend Readout ASIC for Precision Timing Measurements at EIC**, Z. Ye, A. Apresyan	U. of Illinois at Chicago, Chicago, IL, USA, and Fermilab	Front End Electronics	Yes	No	See comments below.
This proposal seeks to develop a 10-channel ASIC in Year 1 which will measure amplitude and have precision timing capability. A Constant Fraction Discriminator (CFD) on each channel inside the ASIC would mean no walk corrections are unnecessary. Although optimized for input signals from an AG-LGAD, with apparently straightforward modifications of the input stage, it could also be used for an MCP-PMT. Extensive bench testing would be needed in Year 2, followed by beam tests in Year 3. This proposal was rather expensive, and would require support at a similar level for a least 2 years to complete operability tests. The idea of incorporating a CFD into an ASIC seemed sound, but given the heavy demand on generic R&D funds in this category this year, the need to demonstrate this did not seem sufficiently compelling. However, a resubmitted proposal will be considered.						
12	**Development of a Novel Readout Concept for an EIC DIRC,** G. Kalicy (the submitter)	Catholic University of America, Washington, DC, USA	PID (non-TOF)	Yes	Yes	n/a
This proposal explores the potential advantages of a novel approach to transporting photons from the radiator bars to the plane of photo-sensors. A smaller total area would reduce photo-sensor cost. Indeed, a sufficiently small focal plane may even enable the use of relatively inexpensive SiPM readout with acceptably low noise levels. Thinner fused silica radiators and prisms would reduce the material before the EM calorimeters. It is a credible assertion in the proposal (though not demonstrated by simulations) that shower energy resolution and pi/e separation in affected EM calorimeters would improve. However, the advantages of thinner radiator bars will be offset by the proportionately larger number of internal reflections putting a greater premium on surface quality. The committee believes continuous refinement of barrel DIRC technology is relevant to Detector 2 and upgrades of Detector 1, and appreciates the opportunity in this proposal for greater dissemination of relevant knowledge from GSI.						

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13	**Simulations of the physics impact of a solenoid-based compensation scheme for the field of the main detector solenoid in IR8**, P. Nadel-Turonski, Wenliang Li, and V. Morozov	Department of Physics, Stony Brook U., Stony Brook, NY, USA, and ORNL, Oak Ridge, TN, USA	Studies to Support or Expand the Physics Program	Yes	No	See comments below.
The committee carefully considered this proposal to compensate for the Detector 2 solenoid at IR8 with an anti-solenoid rather than skew-quads. The detection of low P_T ion recoils is likely to be a key part of the Detector 2 physics program, and estimates suggest that the proposed option would offer larger acceptance, albeit with a constraint on the maximum length of the Detector 2 solenoid. However, the committee was informed by Project personnel that an anti-solenoid was off the table. If the Project changes its mind, this proposal is encouraged to resubmit.						
14	**Tracking and PID with a GridPIX Detector**, T. Hemmick, (P. Garg, contact person)	Department of Physics and Astronomy, Stony Brook University, USA	PID (non-TOF)	Yes	Yes	n/a
This proposal will use a TPC with a GridPix gas gain structure to achieve the counting of ionization clusters (which is the optimal way to implement dE/dx for PID of relatively low energy particles). The readout will be located on the high rapidity end of the barrel, hence minimizing material on the low rapidity end where the majority of scattered electrons are. Such a detector could potentially provide a relative low radiation length, cost-effective alternative to low energy PID by TOF. Furthermore, its dense track information could potentially help resolve ambiguities in higher resolution (but much more sparse) silicon tracking hits. Most of the funding goes toward a beam test.						

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15	**Particle identification and tracking in real time using Machine Learning on FPGA**, S. Furletov D. Romanov	Jlab, Newport News, VA, USA	Studies to Support or Expand the Physics Program	Yes	Yes	n/a
This proposal will demonstrate an FPGA-based machine learning algorithm for real-time PID, filtering, and data reduction. It will adapt this to streaming data acquisition, and apply it to actual data from a multi-detector suite consisting of a calorimeter, a Transition Radiation Detector, and a GEM tracker. The committee's response can be described as "warily enthusiastic". It considers streaming readout with filtering to be the future, but this is also the subject of extensive R&D world-wide. While the committee considers real-world tests with this rich detector suite to be worth funding, the proponents are strongly encouraged to collaborate with field-leading research projects such as the Fast Machine Learning Lab so that they can exploit synergies and complement other world-wide efforts.						

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16	**Development of High Precision and Eco-friendly MRPC TOF Detector for EIC**, Zhihong Ye, and Zhenyu Ye	Department of Physics, Tsinghua U., Beijing, China, and Department of Physics, U. of Illinois at Chicago, Chicago, IL, USA	Gaseous Precision Timing and/or Tracking	Yes	No	See comments below.

In precision TOF applications, MRPC's could potentially serve as an alternative to silicon options such as AC-LGAD's when lower cost is more important than better position resolution, for example. Previous work has achieved resolutions of O(20) ps by stacking many layers. However, this resulted in a 10% RL thickness for normal incidence which may be incompatible with achieving high performance in downstream EM calorimetry. Assuming a "sealed" MRPC design (which still requires low gas flow rates), the proposal's main goal is to see if similarly good timing resolution could be achieved with zero greenhouse gas emission. This would either be done with a non-greenhouse gas, or with a greenhouse gas with recycling. Other goals were to try to reduce the thickness, improve the position resolution, expand the set of simulations tools, and use machine learning to optimize the timing resolution. (There was a lot to unpack in this proposal.)

In this round of funding, committee members were supportive yet struggled to assign this a high enough priority for EIC-related detector R&D. A resubmitted proposal will certainly be considered.

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17	**Machine Learning for Detection of Low-Energy Photons in the EIC ZDC**, L. Wood	PNNL	Calorimetry	Yes	No	See comments below.
The goal of this proposal is to use machine learning (ML) to distinguish < 1 GeV photons from background neutrons in the Zero Degree Calorimeter (ZDC). The photons in question can be emitted with 2.6 MeV in the reference frame of a 208Pb nucleus, yet deposit ~500 MeV in the ZDC. This would tag a fraction of excited recoils, allowing one to disentangle this process from wholly coherent recoils in vector meson electro-production. The committee would have liked to have seen simulated distributions in several variables for neutrons and photons with similar, relevant energy depositions. However, segmented calorimeter reconstruction with ML has been done before, the chance of success seems high if neutron backgrounds are not overwhelming (the big question), and the relevance to EIC is clear. The proposal was expensive however, in a year where there was high demand for the funds we allotted to Calorimetry. This proposal is encouraged to resubmit.						
18	**Super-conducting Nanowire Detectors for the EIC**, W. Armstrong	ANL	Other New Detectors	Yes	Yes	n/a
Superconducting nanowire single photon detectors (SNSPDs) have high quantum efficiency, rapid time response, low dark rates, and ability to operate in multi-Tesla magnetic fields. This proposal will explore the potential suitability of SNSPDs for the detection of recoil ions very close to the hadron beam in the EIC. It is expected that the wires themselves will be quite rad-hard, in which case recoil ion coverage could potentially be extended to lower P_T than with existing silicon detector options. The major questions that will be answered are whether the superconducting signal readout chain is sufficiently rad-hard, and a better understanding of the wire recovery time in a flux of ionizing particles (which will each deposit much more energy in a wire than a single photon).						

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19	**EIC KLM R&D Proposal**, A. Vossen, M. Arratia, W.W. Jacobs	Duke U., Durham, North Carolina, USA, UC Riverside, IU Bloomington	Calorimetry	Yes	Yes	n/a
The K_{Long}+Muon (KLM) concept is a sampling hadronic calorimeter with mip sensitivity to detect neutral hadrons (K_{long} mesons and neutrons) and muons with high efficiency and purity. K_{long}'s are often a difficult-to-measure and non-negligible component of jets, while the detection of mu+mu- would enable measurements of continuum DDVCS and increase statistics for leptonic decays of the J/Psi and other vector mesons. In the elegant implementation of the KLM concept by Belle-II, the flux return of the solenoid was turned into a sampling calorimeter with good position and timing resolution. The latter is arguably an option for EIC Detector 2, could serve as its hadronic calorimeter some regions of rapidity, and may add unique physics capability. The committee supported this effort to extend the KLM concept beyond the state of the art (Belle-II) while taking into account significant size constraints present at the EIC. One goal of the R&D is to determine whether precision timing can be achieved in the scintillator strips using SiPM readout and waveform digitization (ie, without the use of MRPC layers). And if sufficiently good timing resolution can be achieved, then double-ended readout in a single layer of scintillator could provide hit position information both parallel and perpendicular to the long axis of the strip.						
20	**High Quantum Efficiency III-nitrides photocathodes and hybrid photon detectors for EIC**, L. Cultrera	BNL, Upton, NY, USA	Other New Detectors	No	No	See comments below.
The goal of this proposal is to build a hybrid single photon detector by combining a III-nitride photocathode with an LGAD as a gain stage. The concept would in principle have several nice features such as less ultra-high vacuum processing, high QE in the near-UV, and a potentially longer lived photocathode. The technology could potentially offer a lower-cost alternative to other technologies such as LAPPDs. The committee was interested in the concept, but felt the required effort (time and workforce) had been underestimated in spite of the proposal being one of the most expensive received. We regret that a properly resourced effort would almost certainly be too expensive for the generic R&D program at its current level of DOE funding.						

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21	**Exclusive and Semi-inclusive reactions in the muonic channel, and development of muon detectors in the far forward region**, M. Boer	Virginia Tech, Blacksburg, VA, USA	Studies to Support or Expand the Physics Program	No	No	See comments below.

This proposal was submitted to us in the spirit of a Letter of Intent requesting feedback.
Muon ID with high efficiency and purity could potentially expand the physics program. But the generic R&D program is too small to support a broad-ranging study; the funding for the workforce for such an effort would have to come from elsewhere. Given that the project Detector 1 and its cost are somewhat well-defined, questions similar to those raised in the proposal might include:

- What muon efficiency and purity can be obtained with the project Detector 1? If it is insufficient for a muon physics program, is there a realistic way to significantly improve it given constraints on space in the tunnel, for example?
- Perhaps the higher priority would be ensuring that Detector 2 has suitable muon ID to help complement the Detector 1 capabilities. Is there an alternative to applying the KLM concept in proposal #19 for muon ID to Detector 2 which reduces cost and/or improves performance? (Having an alternative technology for muon ID in Detector 2 would reduce risk.)

If the proponents identify a potential technical solution for improving muon ID, and if this in turn requires development or pushes the state of the art, that could become the basis for an EIC-related generic detector R&D proposal.

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22	**Injection Molding of Large Plastic Scintillator Tiles at Optical Quality**, O. Hartbrich	ORNL, Oak Ridge, USA	Calorimetry	Yes	No	Yes
Hadronic calorimeters often employ scintillating tiles with embedded wavelength shifting fibers. Machining of the trenches for the latter is expensive and time consuming. This proposal seeks to produce large scintillating sheets with fine trenches by injection molding. (Trenches along tile boundaries would be quite deep and filled with TiO2 to provide a high degree of optical isolation between tiles.) If this can be achieved with sufficiently good surface quality and acceptably low levels of cross-talk between tiles, it could reduce the lead time for fabrication and dramatically lower the cost of these intrinsically large detectors. The committee liked the idea, and exploring several different geometries seems like a good strategy. However, the committee received last minute news that one of the geometries was already funded and, given the tremendous competition this year in the Calorimetry category, decided to defer the proposal. The committee would welcome an updated proposal in the next call for proposals.						
23	**Development of Thin Gap MPGDs for EIC Trackers**, K. Gnanvo	Jlab	Gaseous Precision Timing and/or Tracking	Yes	Yes	n/a
The position resolution of Micropattern Gaseous Detectors (MPGDs) deteriorates at large track angles and high magnetic fields. Simulations indicate that resolution can be improved by decreasing the gap size, in a so-called Thin Gap MPGD. Several gas gain structures will be tested (GEM, Micromegas, muRWELL), along with several heavy gases to maintain high efficiency with the thinner ionization volume (n-Pentane, Xe, and Kr). Beam tests will be performed.						

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24	**Simplified LGAD structure with fine pixilation**, G. Giacomini	BNL, Upton, NY, USA	Silicon Detectors	Yes	Yes	n/a
This proposal will fabricate a new device called an "LGAD structure with fine pixelation"". It would retain the good timing and position measurement and 100% fill factor properties of the AC-LGAD, reduce cross-talk and capacitance due to its DC-coupled nature (which would provide higher rate capability and enable longer strip lengths), and in principle be easier to fabricate resulting in higher yields and lower costs.						
25	**Imaging Calorimetry for the Electron-Ion Collider**, M. Zurek, and Z.Papandreou	ANL, and U. Regina, Regina, Saskatchewan, Canada	Calorimetry	Yes	Yes	n/a
Improved resolution of longitudinal and transverse shower development in an EM calorimeter can provide better e/pi discrimination and better separation of the two photons from pi0 decays. Starting with the Pb-SciFi barrel calorimeter (BCAL) concept which originated in KLOE and was implemented in GlueX, this proposal would employ finer pixelization of the photosensors ($2x2cm^2$) at the ends of the bar, and sandwich Astropix silicon tracking between the inner radial layers. Initially, the collaboration will measure the energy resolution at high beam energy to constrain the constant term, and compare SiPM and MCP-PMT photosensor readout.						

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26 Topic 1	**Silicon Tracking and Vertexing Consortium, Topic 1: Embedded Monolithic Active Pixel Sensor R&D**, Nicole Apadula, Giacomo Contin, Nicolas Schmidt	LBNL, Trieste/INFN, ORNL	Silicon Detectors	Yes	Yes	n/a
Thinned Monolithic Active Pixel Sensors (MAPS) would in principle reduce multiple scattering, leading to improved momentum and angle resolution in an EIC detector. As this proposal emphasizes, a full assessment of multiple scattering must also include all necessary mechanical supports, cooling channels, and power and signal connections. The committee supported Topic 1 to investigate the mechanical and thermal properties of thin MAPS embedded in kapton. This R&D will also include alternatives to kapton, and research whether power and signal lines can be printed on the substrate.						
26 Topic 2	**Silicon Tracking and Vertexing Consortium, Topic 2: Aluminum Flexible Circuit Manufacturing Capability**, Yuan Mei	LBNL	Silicon Detectors	Yes	Yes	n/a
External flexible circuits are essential components of a MAPS-based detector. The radiation length of these can be significantly reduced if aluminum conductors are used instead of copper. In past experiments, these have been provided by CERN or the Kharkiv Institute, Ukraine. Topic 2 requested a small amount of funds to investigate the feasibility and/or quality of North American production. The committee supported Topic 2's modest request to potentially reduce supply chain risk in a likely future procurement of flexible aluminum circuits.						

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26 Topic 3	**Silicon Tracking and Vertexing Consortium, Topic 3: Functional Verification Model of EIC Tracking and Vertexing Detectors R&D**, Grzegorz Deptuch	BNL	Silicon Detectors	Yes	No	See comments below.

Topic 3 provides for the optimization of the full, near-final tracker design. The proposal expressed concerns not only regarding static IR drops, but also dynamic IR drops (eg, due to multiple, localized hits in a narrow time window). These concerns seem reasonable since, in light of Topics 1 and 2, one would presumably want to minimize conductor thicknesses to reduce multiple scattering.
Such a detailed simulation would appear to reduce risk in the project detector MAPS detectors, and we have passed this observation on to project personnel. But as presented, Topic 3 would have to develop such a fine-grained model of those detectors, it is not clear what the generic utility of such a model would be. For this reason, and because of the very high demand on program funds from the silicon categories, our generic R&D committee passed on this proposal. A proposal to address related, suitably generic issues would be welcome, keeping in mind that the silicon categories are very competitive.

EICGENR&D 2022 Proposal Number (1 thru 27)	Title And PI('s)	Institution(s) (abbreviated and only includes PI's)	Topical Area	Was a presentation requested?	Was the proposal at least partially funded?	If unfunded in 2022, is the proposal encouraged to resubmit in 2023?
26 Topic 4	**Silicon Tracking and Vertexing Consortium, Topic 4: Ultra-fast Timing Monolithic Active Pixel Sensors**, Yuan Mei	LBNL	Silicon Detectors	Yes	No	See comments below.

Monolithic Active Pixel Sensors (MAPS) will be used in tracking and vertexing in EIC. Improving the multi-musec timing resolution of MAPS would potentially enhance PID via precision TOF, as well as enable the rejection of hits not associated with a given bunch crossing. (Note that while precision TOF would require resolution of roughly 25 ps, matching hits to bunch crossings would only require timing resolution significantly better than 10 ns.) We received two proposals which planned to add a gain layer to MAPS to dramatically improve S/N and hence their timing resolution.

This proposal envisions the pixels consisting of moderate gain avalanche diodes, multiplexed to a slow (< 0.01c) transmission line which is read out by a TDC on each end. The sum of the two TDCs would yield a meantime with a resolution of O(10)ps, while the difference of the two TDCs would identify the hit pixel resulting in a resolution of O(10)mu.

This an interesting but complex new concept. Implementing each of the 3 stages (avalanche diode, transmission line, and TDC) would require a high level of sustained R&D effort over years. The committee will consider a resubmitted version of this proposal which addresses the following issues:

- A very accurate transmission line is envisioned with a factor of 100 delay. This seems VERY hard to do and may not be physically possible without destroying the time resolution of the pulse. This should be modelled using SPICE or other electrical simulation to show whether this scheme might work.
- Crosstalk could be a significant issue at 1 micron pitch and may be an issue with the pulse shape.
- 1 micron SPAD pitch is very hard. More typical is 2.5 micron in 65 nm technology.

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27	**Combined design of a projective tracker and PID system for the EIC Detector-1 with the assistance of Artificial Intelligence**, C. Fanelli	College of William and Mary, VA, USA	Software Supporting Electronics/ Detector Design or Physics Program	Yes	No	No
The application of machine learning (ML) techniques to the final optimization of Detector 1 performance seems to be a worthy topic for consideration for project detector R&D funding. As for future opportunities for funding by the generic detector R&D program, we anticipate there will be an appropriate time to support the ML optimization of the pre-project Detector 2 performance.						