# Call for FY24 R&D Proposals on May 8, 2023

Dear current and future R&D participants,

It is time to discuss the next steps in our path, i.e., the FY24 projects. We are trying to get the R&D program fully in sync with the FY boundaries.

Proposals

1. Please submit your proposals and progress reports (where applicable) to us by July 7, 2023. We aspire to have a DAC meeting well in time to prepare for contracts at the beginning of FY24.
2. We expect progress report from all ongoing projects eRD101 to eRD113. What milestones were achieved. How did our understanding improve. What is left to do?
3. eRD102, eRD103, eRD104, eRD106, eRD107, eRD108, eRD109, eRD110, eRD111, eRD112, and eRD113 may submit continuation proposals if and only if technical risk milestones remain.

These new proposals should be relatively straightforward to write. Keep them short and concise. List whatever technical risks remain, the milestones, deliverables, and two money matrices showing cost/item and funding/institution to close those remaining risks. Also list the representatives for each institution. List all participating members and institutions on the front page. Please also give, if applicable, an outlook for the years past FY24.

Be aware that R&D should not be mixed with PED. If you are not sure, talk to us. The proposals should concentrate on detector R&D tasks that mitigate project detector technical, risk.

DAC Review Meeting

With the project detector R&D expected to dwindle down at CD-2, we will limit the meeting to a two-day review meeting in the July-August period. The FY24 proposal goals of all continuation projects should be presented as well as a short status report of all FY22/FY23 proposals. More details on this meeting will be announced soon.

Best regards,
Elke, Rolf, and Thomas

# Upcoming Reviews

| | |
|---|---|
| • **Preliminary Design Status Review ePIC PID detectors** | **July 5-6, 2023** |
| • **DAC Meeting(s): R&D (2 days) and technical design review (2 days)** | **Late Summer/Fall 2023 (TBD)** |
| • **Final Design Review for LLPs of Detector** | **September 2023** |
| • **CD-3A Director's Review** | **October 10-12, 2023** |
| • **DOE CD 3A OPA Review** | **November 2023** |
| • **DOE CD 3A ESAAB Approval** | **January 2024** |
| • **Final Design Reviews for all ePIC subsystems** | **April – October 2024** |
| • **DOE CD 2/3 OPA Review and ICR** | **January 2025 (TBC)** |
| • **DOE CD 2/3 ESAAB Approval** | **April 2025** |

# AC-LGAD R&D FY23 Deliverables

- Sensor:
  - prototype with 30 ps time and spatial resolution match RPs and Tracker;
  - prototype with 20 ps time resolution for Forward ToF;
  - prototype with 20 ps time resolution for Barrel ToF.
- ASIC: EICROC FCFD SCIPP

  1st sensor + ASIC demonstrator for EIC applications and testing with particle beam;

  2nd ASIC prototype submissions with better performance and extended features
- Design and prototype of flexes
- Design and prototype of light-weight structure with embedded cooling tubes.

**eRD112**
- Sensor R&D
  - TCAD simulation
  - BNL, HPK productions
  - Lab/beam/irradiation
- Sensor/ASIC integration
  - Interposer
- Module structure
  - Light-weight structure

**eRD109**
- Frontend ASICs
  - EICROC
  - FCFD
  - SCIPP (FAST, ASROC, HP-SoC)
- Frontend electronics
  - Low-mass flexible PCB

**Project Engineering Design**
- Mechanical engineering
  - Mech. support, integration
  - Cooling system
- Electric engineering
  - Clock distribution system
  - Streaming readout
  - Service hybrid

# AC-LGAD R&D FY24 Goals

- Sensor
  - Optimize strip sensor design for better timing resolution (BNL/HPK)
  - Explore larger pixel size for FTOF for reduced number of channels (BNL/HPK)
  - Double metal layer strip sensor (BNL)
  - Determine the appropriate sensor size for detector module assembly (HPK)
  - Characterization (LANL, SCIPP, UIC/FNAL)
- ASIC
  - Testing of EICEICROC0, submission of EICROC0_1 (OMEGA/IJCLab/CEA-Irfu)
  - Submission and testing of FCFDv1, submission of FCFDv2 (FNAL)
  - Characterization of 1st ASROC, HPROCv2 and FAST3 (SCIPP)
- Sensor-ASIC integration
  - Interposer to connect pixelated ASIC with strip sensors or pixel sensor with different pitches (UIC)
- Flex
  - Produce module size functional prototype for bias sensor and reading out ASICs (ORNL)
- Mechanical structure
  - FTOF structure design and prototype (Purdue/NCKU)
- Electronics
  - Readout board and power board (BNL/Rice)

# BNL – eRD112

- FY23 (Labor 20k, MS 75k)
  - 08/2022-12/2022: 3rd production with pixels and strips 20-50 um thick
  - 02/2023-09/2023: 4th production with deep gain layer to increase signal amplitude
  - 05/2023-07/2023?: 5th production with normal gain layer design for pixels with different pitches
- FY24 (Labor 20k, MS 75k)
  - Production: fabrication of strip sensors with optimized geometry for timing; optimize geometry and process parameters to reduce the number of channels; fabrication of pixel sensors with optimized geometry for timing and crosstalk, compatible with the read-out ASICs being developed;
  - Production: introduce second metal for re-routing of signals.

# LANL – eRD112

- FY24 (20k)
  - travel to Fermi lab for the beam tests and basic M&S purchase for the sensor beam tests.)
  - Plan to characterize the irradiated AC-LGAD samples with the wired bounded 16-CH carrier boards.
  - Participate in future AC-LGAD beam tests at Fermilab.
  - If needed, will prepare and perform the irradiation tests at LANL LANSCE facility.

  - PED request (20k+10k): request funding to support part of Eric's time to work on the AC-LGAD ToF mechanical design: Plan to contribute to the AC-LGAD ToF mechanical design and focus on the cooling system design

# NCKU – eRD112

- FY23 (Labor 5k, MS 10k)
  - ?
- FY24 (?)

# Purdue – eRD112

- FY23 (Labor 15k, MS 5k)
  - 6/2023: first prototype and FEA of BTOF module CF structure, thermal test will follow
  - More advanced prototypes for BTOF?
- FY24 (Labor 30k, MS 5k)
  - Summer 2024: prototype FTOF no-pipe structure with reduced material budget (~2.5% X0)

# SCIPP – eRD112

- FY23 (Labor 15k, MS 0k):
  - Laser: Charge sharing: how it helps eRD112? non-uniformity: which BNL batch~~?~~
  - Capacitance: AC and interstrip: how it helps eRD112?
  - TCAD simulation: same content in FY22 report
- FY24 (Labor 31k, MS 4k):
  - Results within three months of delivery: Characterization of BNL prototypes, especially response uniformity
  - 12/2023: TCAD-based optimization of sensor characteristics, especially 20 μm bulk: how it helps eRD112?
    - Different gain layer design, 3D simulation of pad sensors with different pitch/metal
  - 2/2024: Characterization of EPIC run of HPK LGAD sensors
    - CV, IV, and laser and source
  - 3/2024: Execution and evaluation of radiation damage study
    - Before/after irradiation, NIEL using LANL on n+ layer, TID (dose from simulation)
    - https://wiki.bnl.gov/EPIC/index.php?title=Radiation_Doses
- Optional FBK Production in FY24 (Labor 15k, FBK production 70-100k for 5-15 wafers)
  - 3/2024: Design studies for and initiation of an AC-LGAD fabrication run at FBK

# UIC/FNAL – eRD112

- FY23 (Labor 15k, MS 10k)
  - 1/2023: laser and test beam results of 2nd BNL production sensors
  - 4/2023: laser and test beam results of 3rd BNL production sensors
  - 2/2023: 1st HPK production sensors from FY22 funds
  - 6/2023: laser and test beam results of 1st HPK production sensors
- FY24 (Labor 15k, MS 10k)
  - Q1 FY24: 2nd HPK production sensors (wider pitch, wider metal, 20/30/50um thickness) from FY23 funds
  - Q2 FY24: test results of 2nd HPK production sensors
  - Q3 FY24: test results of FCFDv2+2nd HPK sensors
  - Q4 FY24: 3rd HPK production sensors (module size sensor, “final” geometry) from FY24 funds
- Optional Interposer in FY24 (Labor 15k, MS 25k)
  - Q3 FY24: interposers to connect EICROC and strip sensors
  - Q4 FY24: characterization of EICROC+interposer+strip sensors

# IJCLab/Omega/CEA – eRD109

- FY23 (MS 75k)
  - EICROC0 testing
  - 1st quarter of 2024: EICROC0_v1 submission
- FY24 (MS 90k?)
  - 1st quarter of 2025?: EICROC1 submission

# Fermilab – eRD109

- FY23 (MS 40k)
  - 6/2023: charge injection, laser and test beam results of FCFDv0
  - 8/2023: FCFDv1 submission
- FY24 (MS 40k?)
  - Q1: Development of specifications for the FCFDv2.
  - Q2-Q3: Detailed characterization of the FCFDv1 performance
  - Q2-Q4: Design of the mixed-signal multi-channel FCFDv2 ASIC
  - Q4: Submission of the multi-channel FCFDv2

# ORNL – eRD109

- FY23 (Labor 32k, MS 12k)
  - Obtained several prototype flex foils with satisfactory high voltage capabilities and ohmic resistance but minor discrepancies in line impedance. Work will now focus on comprehensive characterization and integration into existing test benches to evaluate performance under various conditions
- FY24 (Labor 10k, MS 20k)
  - a functional full-size demonstrator of the flex PCB that connects at least one readout ASIC and sensor assembly on one end to a RDO prototype to be developed by BNL and Rice.

  - Interposer in the text?

# SCIPP – eRD109

- FY23 (Labor 29.7k, MS 3.3k):
  - ASROC:
    - designed a characterization board, waiting for chip
  - HPSOC:
    - ?
  - FAST2:
    - developed readout board, confirm large dynamic range and 1.5 ns risetime
- FY24 (Labor 38k, MS 7k):
  - ASROC:
    - 1/2024: characterization of first prototype
  - HPSOC: what is the power consumption?
    - 3/2024: characterization of the second, EIC-optimized prototype ASIC (HPSOCv.2)
    - 5/2024: specification of next version
  - FAST3: 1.5ns risetime, 2.4+5 mW/ch, suitable for EIC?
    - 3/2024: Characterization of the FAST3 analog amplifier with calibration and sensor inputs

# BNL/Rice – eRD109

- See slides in the following talk

- Put the detailed plan and request in the overleaf

| Institution | Contact | R&D Interest |
|---|---|---|
| Brookhaven National Laboratory | Alessandro/Zhangbu | Sensor prototyping, ASIC testing, Electronics development |
| Fermi National Accelerator Laboratory | Artur Apresyan | Sensor testing, ASIC prototyping |
| Los Alamos National Laboratory | Xuan Li | Sensor testing |
| Rice University | Wei Li | Sensor testing, Electronics development |
| Oak Ridge National Laboratory | Oskar Hartbrich | Sensor testing, ASIC testing, Electronics development |
| Ohio State University | Daniel Brandenburg | Electronics testing |
| Purdue University | Andreas Jung | Mechanical structure and cooling system prototyping |
| University of California, Santa Cruz | Matthew Gignac | Sensor testing, ASIC testing |
| University of Illinois at Chicago | Zhenyu Ye | Sensor testing, sensor-ASIC integration, ASIC testing |
| Hiroshima University | Kenta Shigaki | Sensor prototyping and testing |
| RIKEN | Yuji Goto | |
| Shinshu University | Kentaro Kawaide | |
| University of Tokyo | Taku Gunji | Streaming Readout |
| South China Normal University | Shuai Yang | |
| Univ of Science and Technology of China | Yanwen Liu | Sensor prototyping, Electronics development |
| Indian Institute of Technology, Mandi | Prabhakar Palni | Sensor testing |
| National Inst. of Sci. Education Research | Ganesh Tambave | Sensor prototyping and testing |
| National Cheng-Kung University | Yi Yang | Mechanical structure prototyping |
| National Taiwan University | Rong-Shyang Lu | Sensor prototyping, ASIC testing, Electronics testing |

# FY23 Report and FY24 Proposal Writing

As discussed last week, I suggest that we follow the same procedure as last year, namely to use overleaf to collect all the inputs, and consolidate into a single document for our FY23 report and FY24 proposal. I have created an overleaf project. Below is the link for viewing

https://www.overleaf.com/project/646c69b5b97ef76a1d135ed5

If you would like to contribute to writing (e.g. what your group did in FY23, what you would propose to do in FY24 etc), please let me know your overleaf account. Please complete the editing before June 20.

P.S. our proposals from the last two years can be found at

https://wiki.bnl.gov/conferences/index.php?title=Proposals

# FY23 Resource Requests by eRD112

| Vendor/ Institute | M&S Item | Cost per Item (k$) | N. Items | Tot. Cost (k$) | |
|---|---|---|---|---|---|
| **Sensor Production** | | | | **175** | |
| BNL IO | Sensor fabrication (incl. labor) | 50 (10 wafers) | 1.5 | 75 | → 75 |
| HPK/FBK | Sensor fabrication | 75+3-5/wafer | 1 | 100 | → 80 |
| **Sensor Characterization** | | | | **13.7** | |
| UIC | M&S for test beam setup | - | - | 5 | → 5 |
| LANL | M&S for irradiation test | - | - | 5 | |
| SCIPP | Fermilab 16-channel boards | - | - | 3.7 | |
| **Sensor/ASIC Integration** | | | | **30** | |
| UIC | Interposer fabrication and bump bonding | 30 | 1 | 30 | |
| **Mechanical Structure** | | | | **15** | |
| NCKU | Material for light-weight support structure | - | - | 10 | → 10 |
| Purdue | Material for light-weight support structure | - | - | 5 | → 5 |
| **Travel** | | | | **21** | |
| BNL | Trips to Fermilab testbeam | 2 | 2 | 4 | |
| UIC | Trips to Fermilab testbeam | 1 | 5 | 5 | → 5 |
| ORNL | Trips to Fermilab testbeam | 3 | 2 | 6 | |
| Rice | Trips to Fermilab testbeam | 3 | 2 | 6 | |
| **TOT.** | | | | **254.7** | → 180 |

Table 8: eRD112 resource request for M&S costs in FY23, excluding frontend ASIC and electronics.

# FY23 Resource Requests by eRD112

| Inst. | Task | Labor Type | FTE (%) | Tot. Cost (k$) | |
|---|---|---|---|---|---|
| **Sensor R&D** | | | | **172.3** | |
| BNL | Sensor+ASIC and test board assembly | El. Tech. | 10 | 20 | → 20 |
| UIC | Sensor+ASIC and test board assembly | El. Tech. | 10 | 15 | → 15 |
| | ~~lab/beam test for sensors and ASICs~~ | ~~Research Sp.~~ | ~~50~~ | ~~45~~ | |
| LANL | ~~Sensor irradiation test~~ | ~~Scientist~~ | ~~2.5~~ | ~~10~~ | |
| | ~~Sensor irradiation test~~ | ~~Student~~ | ~~5~~ | ~~5~~ | |
| Rice | ~~pixel sensor test~~ | ~~Postdoc~~ | ~~40~~ | ~~40~~ | |
| SCIPP | ~~Oversight and coordination~~ | ~~Project Scientist~~ | ~~5~~ | ~~9~~ | |
| | TCAD sim. and sensor design | El. Design Specialist | 10 | 16.5 | → 5 |
| | Prototype Assembly | EM Engineer | 5 | 11.8 | → 10 |
| **Sensor/ASIC Integration** | | | | **15** | |
| UIC | ~~interposer design and testing~~ | ~~El. Engineer~~ | ~~10~~ | ~~15~~ | |
| **Mechanical Structure** | | | | **20** | |
| NCKU | light-weight support structure R&D | Mech. Engineer | 10 | 5 | → 5 |
| Purdue | light-weight support structure R&D | Mech. Engineer | 10 | 15 | → 15 |
| **TOT.** | | | | **207.3** | → 70 |

Table 9: eRD112 budget request for labor costs in FY23, excluding frontend ASIC and electronics.

# FY23 Resource Requests by eRD109

| Vendor/ Institute | M&S Item | Cost per Item (k$) | N. Items | Tot. Cost (k$) |
|---|---|---|---|---|
| **Frontend ASIC** | | | | **118.3** |
| IJCLAB | EICROC1 submission | 65 | 1 | 65 |
| | EICROC test boards | - | - | 10 |
| FNAL | FCFDv1 submission | 25 | 1 | 25 |
| | FCFD test boards | - | - | 15 |
| SCIPP | ASIC service boards | - | - | 3.3 |
| **Frontend Readout Electronics** | | | | **31** |
| ~~BNL~~ | ~~Xilinx Dev Kit~~ | ~~4~~ | ~~1~~ | ~~4~~ |
| | ~~Timing chips and boards~~ | ~~15~~ | ~~-~~ | ~~15~~ |
| ORNL | Xilinx Dev Kit | 4 | 1 | 4 |
| | M&S | 8 | - | 8 |
| **TOT.** | - | - | - | **149.3** → 130.3 |

Table 10: eRD109 budget request for M&S costs in FY23 on frontend ASIC and electronics.

# FY23 Resource Requests by eRD109

| Inst. | Task | Labor Type | FTE (%) | Tot. Cost (k$) |
|---|---|---|---|---|
| **Frontend ASIC** | | | | **29.7** |
| SCIPP | Service board design layout | Electronic Design Specialist | 7.5 | 12.4 |
| | Board Assembly | Electro-Mechanical Engineer | 5 | 11.8 |
| | Board loading and lab msmt | Assistant specialist | 5 | 5.5 |
| **Frontend Readout Electronics** | | | | **88** |
| BNL | Readout and Timing Distribution | Research Associate | 20 | 38 |
| ORNL | Barrel TOF Low-Mass Service Hybrid | Electric Engineer | 10 | 32 |
| Rice | Endcap TOF Service Hybrid | Electric Engineer | 15 | 18 |
| **TOT.** | - | - | - | **117.7** |

→ 61.7

Table 11: eRD109 budget request for labor costs in FY23 on frontend ASIC and electronics.