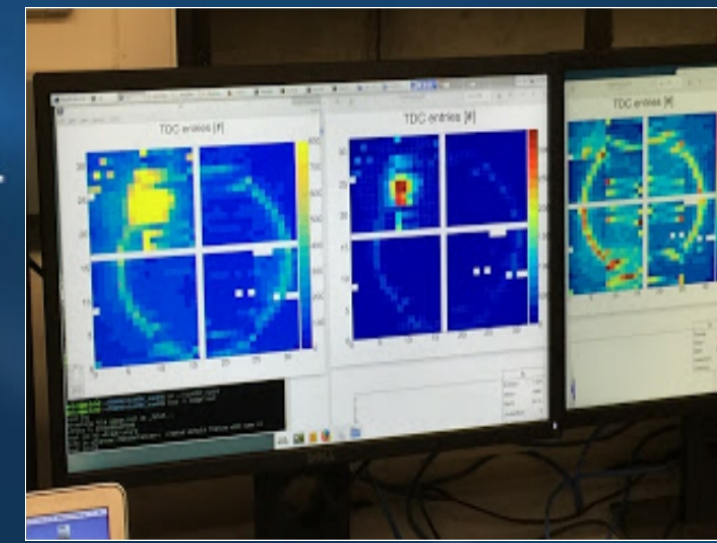
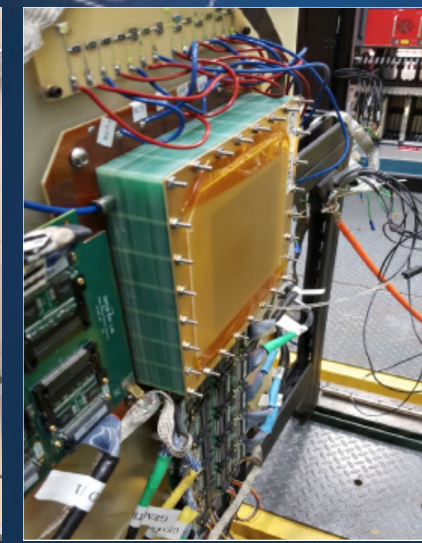
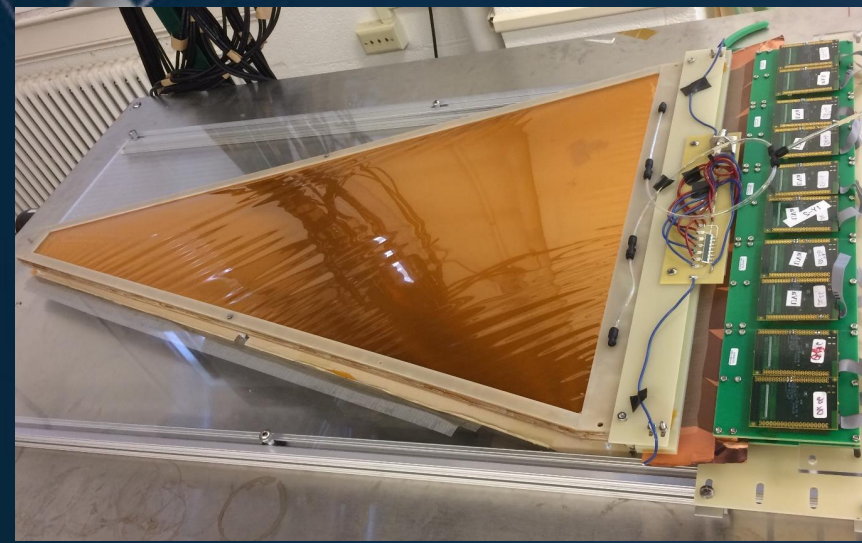
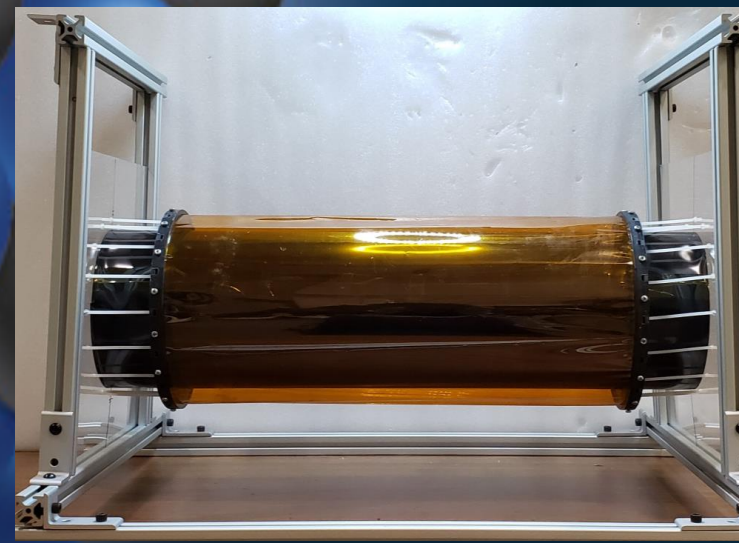
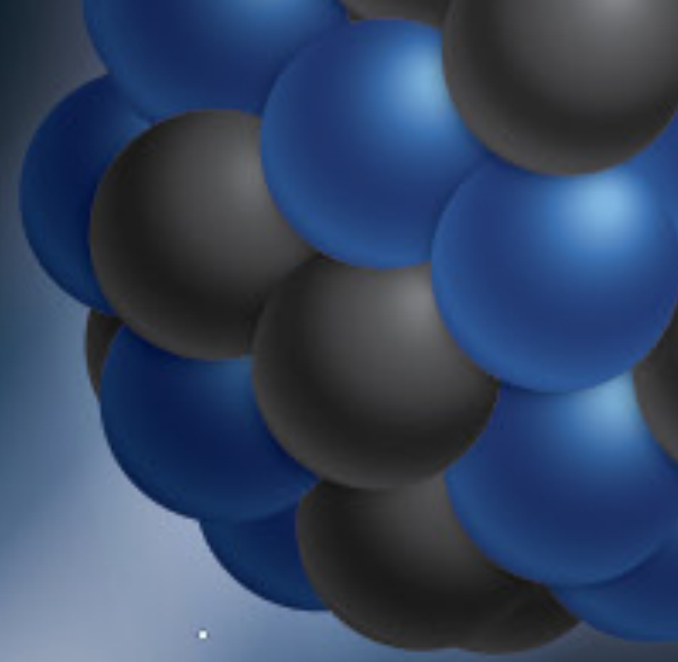


6.10.02



# Detector R&D Status and Milestones

EIC Detector Comprehensive  
Design Review

August 29-30, 2023

*Rolf Ent & Thomas Ullrich*

Electron-Ion Collider



# Recall FY22

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- Project R&D launched based on R&D Plan that included most likely baseline compiled from CD-1/CDR and overlapping design choices by proto-collaborations (ATHENA & ECCE)
- Timeline 2021
  - ▶ Early August: **Call to existing R&D groups** and wider community to form groups around selected projects (see next slide).
  - ▶ End August: **Deadline for submission of proposals** with clear milestones and timelines as well as manpower and funding
  - ▶ September: **Meeting with groups** individually.
  - ▶ Early October: Receive updated proposals and **initial decision on FY22 program**
- Issues
  - ▶ Continuing Resolution (> 6 month) and other funding issues delayed launch
  - ▶ First round of contracts requires steep learning curve for participating institutions and us dealing with procurement regulations. R&D not your typical procurement item.

# FY22 Program

ID	R&D Subject	Funding (R&D plan)	Funding (requested)	Funding (actual)
eRD101	mRICH	\$140,000	\$170,000	\$60,000
eRD102	dRICH	\$260,000	\$220,000	\$210,000
eRD103	hpDIRC	\$450,000	\$525,000	\$155,000
eRD104	Service reduction (Si)	\$42,840	\$47,000	\$47,000
eRD105	SciGlass	\$90,000	\$90,000	\$90,000
eRD106	Forward EMCAL	\$90,000	\$198,700	***
eRD107	Forward HCAL	\$100,000	\$351,900	***
eRD108	Cylindrical MPGD	\$140,000	\$210,905	\$86,000
	Planar MPGD		\$26,914	\$27,000
eRD109	ASICs			***
eRD110	Photosensors	\$180,000	\$323,000	\$185,000
eRD111	Si-Tracker (no sensors)	\$340,160	\$381,000	\$240,800
eRD112	AC-LGAD (incl. ASIC)	\$235,000	\$416,000	\$200,000
eRD113	MAPS/ITS3			***
		\$2,068,000	\$2,960,419	\$1,300,800

- \*\*\* postponed until technical decisions for project detector baseline (ePIC) finalized and/or funding limitations
- Launch of contracts delayed (end FY22)
- Many groups benefiting from left-over generic R&D funding
- Burden of handling the contracts shared between BNL and JLab
- Milestones were adjusted according to delays
- Progress and Status reported at DAC Meeting October 19-21, 2022

# Ongoing FY23 Program

---

- ePIC now fully formed and baseline defined - still open questions on some technologies
- Still somewhat out-of-sync with FY boundaries but catching up
- Timeline 2022
  - ▶ July: Request to submit proposals and status reports, deadline October 1, 2022 in time for DAC meeting
  - ▶ DAC Meeting October 19-21, 2022
  - ▶ November: Discussion with groups and updates to proposals
  - ▶ December 2022: Final decisions and response letters to participating groups
- Remarks
  - ▶ First time funded: eRD106/107 (Fwd Cal), eRD109 (ASICs), eRD113 (MAPS)
  - ▶ Si sensors (eRD113) moved from an assumed generic detector R&D to a project R&D and took some time to sort out
  - ▶ In several proposal substantial mix of PED and R&D that needed to be separated
  - ▶ In practice, it still takes several months to get contracts in place



# FY23 Program

ID	R&D Subject	Funding (requested)	Funding (actual)
eRD101	mRICH	\$113,500	\$60,000
eRD102	dRICH	\$190,000	\$190,000
eRD103	hpDIRC	\$230,000	\$230,000
eRD104	Service reduction (Si)	\$87,300	\$87,300
eRD105	SciGlass	\$60,000	\$60,000
eRD106	Forward EMCAL	\$99,100	\$99,100
eRD107	Forward HCAL	\$150,500	\$94,800
eRD108	MPGDs	\$189,785	\$93,905
eRD109	ASICs	\$569,700	\$569,700
eRD110	Photosensors	\$314,500	\$203,000
eRD111	Si-Tracker (no sensors)	\$628,300	\$86,000
eRD112	AC-LGAD (incl. ASIC)	\$462,000	\$250,000
eRD113	MAPS/ITS3	\$1,416,000	\$976,000
		\$4,510,685	\$2,999,805

- Careful coordination/synchronization with generic program to avoid overlap
- Details of main tracker still not fully settled
- Fwd HCAL design modified during decision process
- Specification of AC-LGAD/ToF finalized (barrel = strips, fwd = pixel)
- eRD110 more emphasis on LAPPD/HRPPD less on SiPM
- Awarded \$601K to eRD111 as PED, and for eRD110 awarded separately \$50K as PED (for the SiPMs mechanical design for in situ annealing).



# Preview FY24 Program

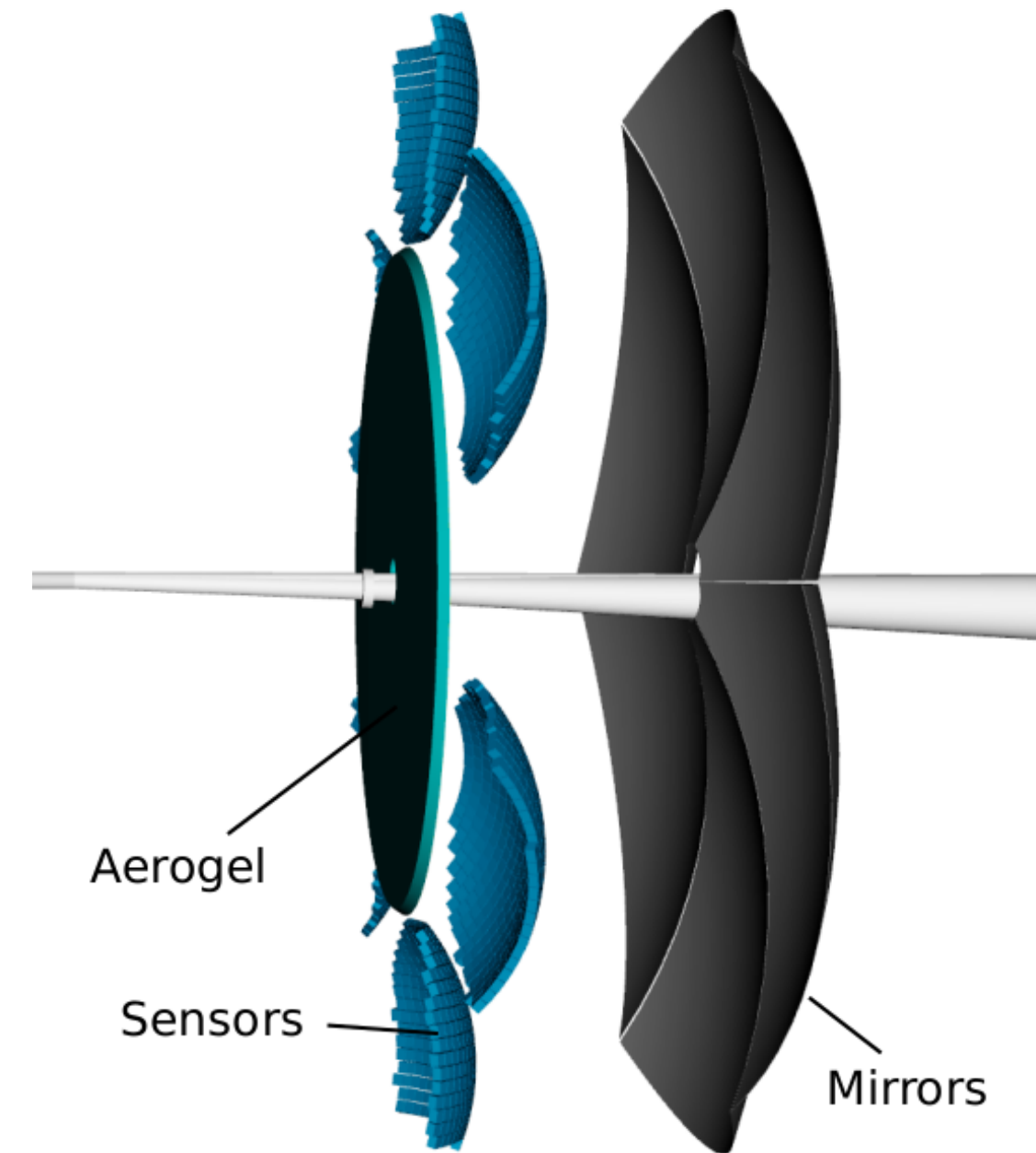
ID	R&D Subject	Comments
eRD101	mRICH	<i>ended</i>
eRD102	dRICH	
eRD103	hpDIRC	
eRD104	Service reduction (Si)	
eRD105	SciGlass	<i>ended</i>
eRD106	Forward EMCAL	<i>no funds requested</i>
eRD107	Forward HCAL	
eRD108	MPGDs	
eRD109	ASICs	
eRD110	Photosensors	
eRD111	Si-Tracker (no sensors)	
eRD112	AC-LGAD (incl. ASIC)	
eRD113	MAPS/ITS3	
eRD114	pfRICH	<i>new</i>
eRD115	Imaging Cal	<i>new</i>

- Ongoing review August 28 & 31, 2023
- Collaboration decided to change two baseline technologies
  - ▶ mRICH  $\Rightarrow$  pfRICH
  - ▶ SciGlass EM Cal  $\Rightarrow$  Imaging Cal
- We have ~\$3M funding available for FY24, with the requests surpassing this.
- Some requests again may not qualify as project R&D.
- eRD113 request is (too) large. Will need non-R&D solution to handle it.
- Talk includes slides (some in backup) for project status w.r.t FY23 P6 milestones for baseline technologies were applicable, i.e., those marked in green in the table.



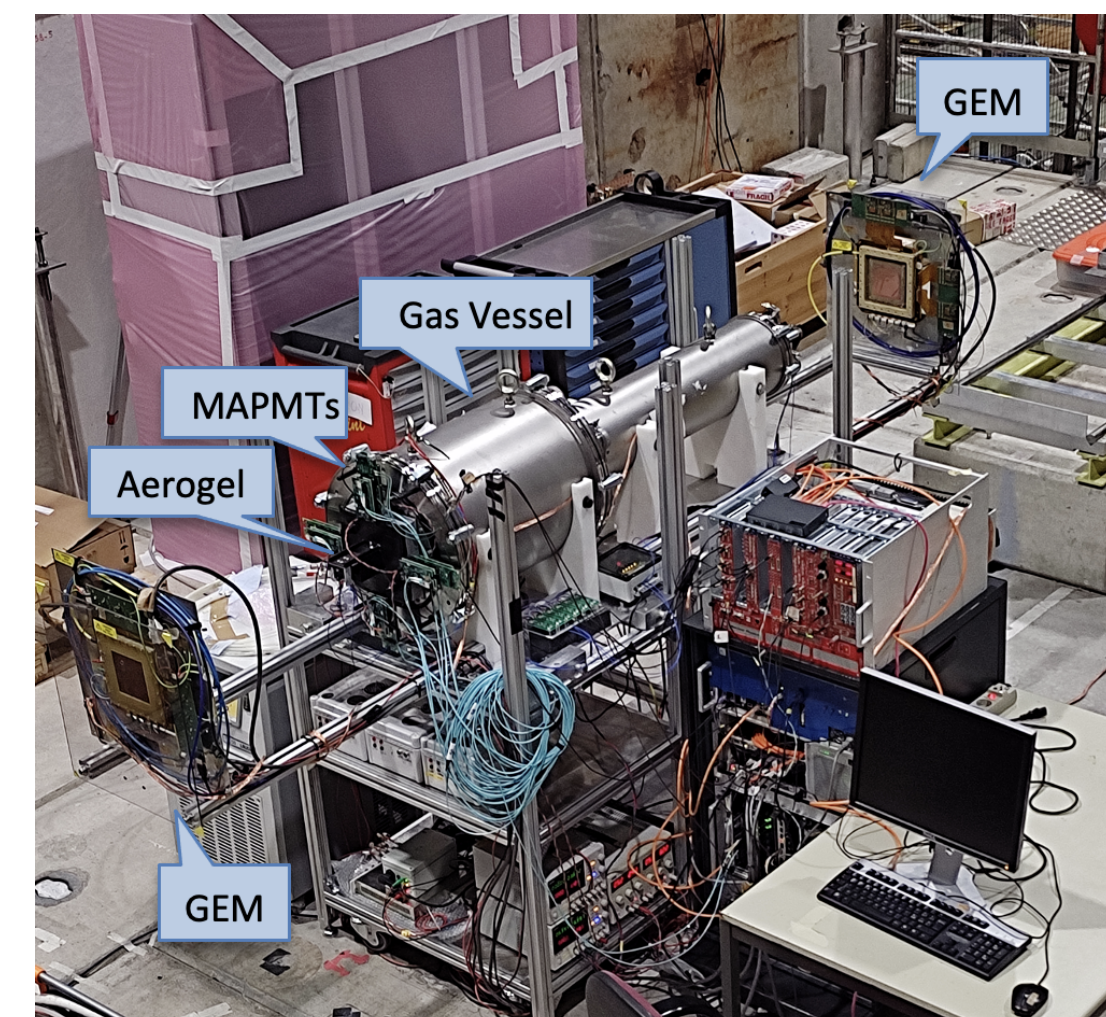
# Example: eRD102 - dRICH

- Milestones:
  - ▶ FY23: Characterization of realistic mirror and aerogel components and assessment of dRICH prototype performance in beam tests.
- Status
  - ▶ Characterization of realistic mirror and aerogel components, achieved (*April 23*)
  - ▶ Projected performance of the baseline detector as integrated into ePIC achieved with the general revision of the dRICH simulation framework (*June 23*)
  - ▶ Assessment of the dRICH prototype performance with the EIC-driven detection plane, for which a new test-beam campaign has been organized (*October 23*) with the primary scope to operate the new EIC-driven readout plane (SiPM sensors and ALCOR digitalization).

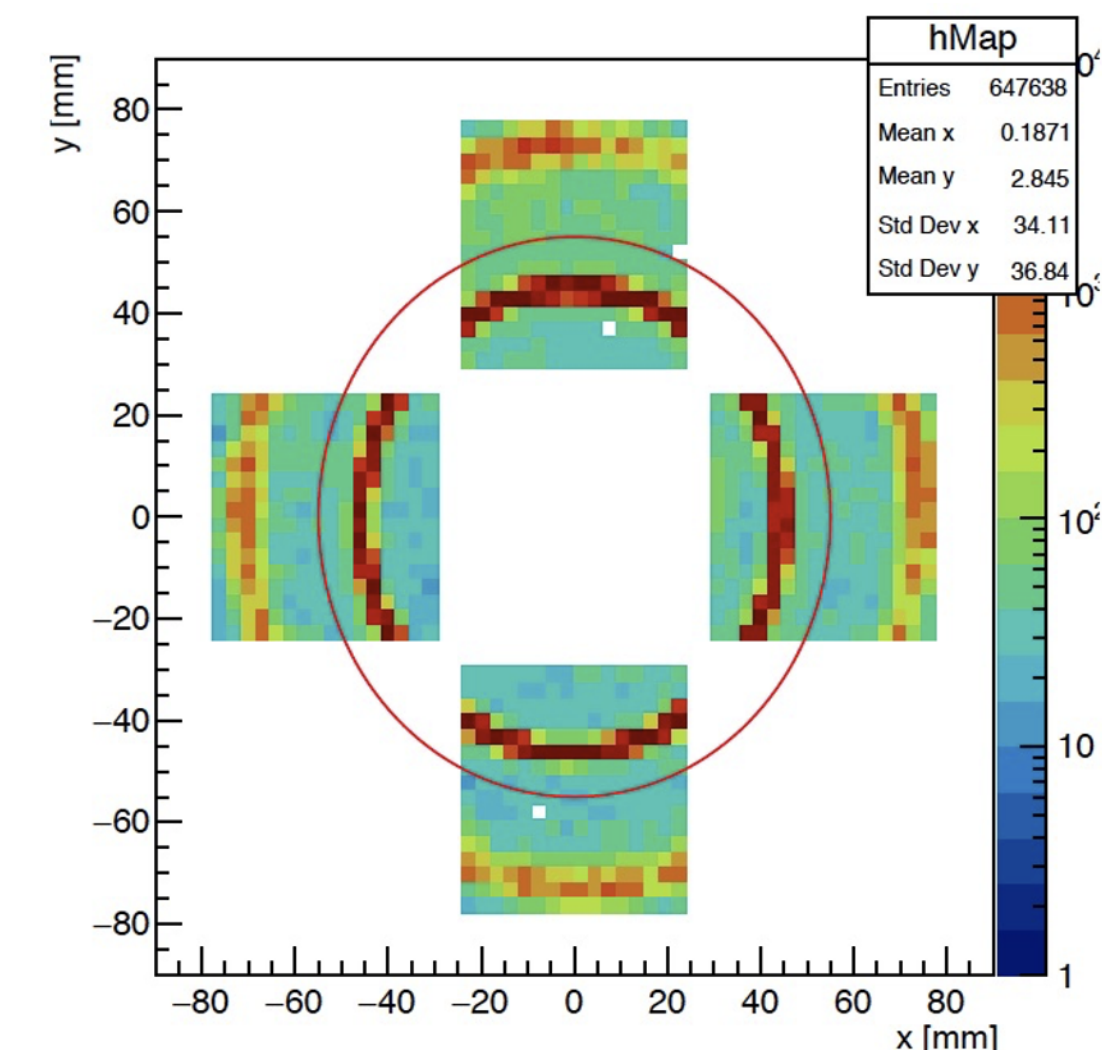


## Dual RICH

- Cherenkov radiator
  - aerogel
  - C2F6
- mirrors
  - large outward reflecting
  - 6 open sectors
- sensors
  - SiPM ( $\sim 1$  T field)



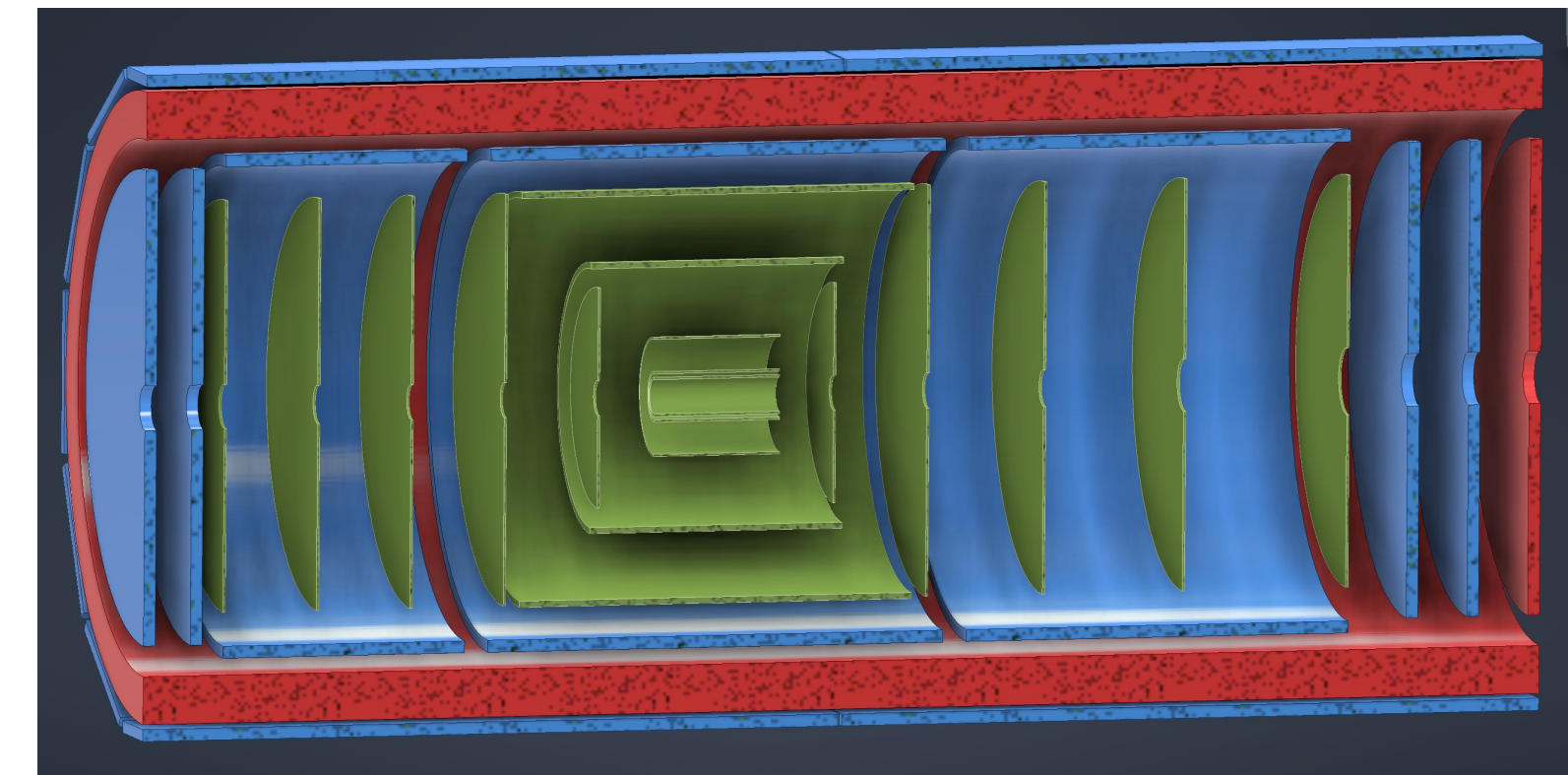
dRICH baseline prototype at the SPS beam





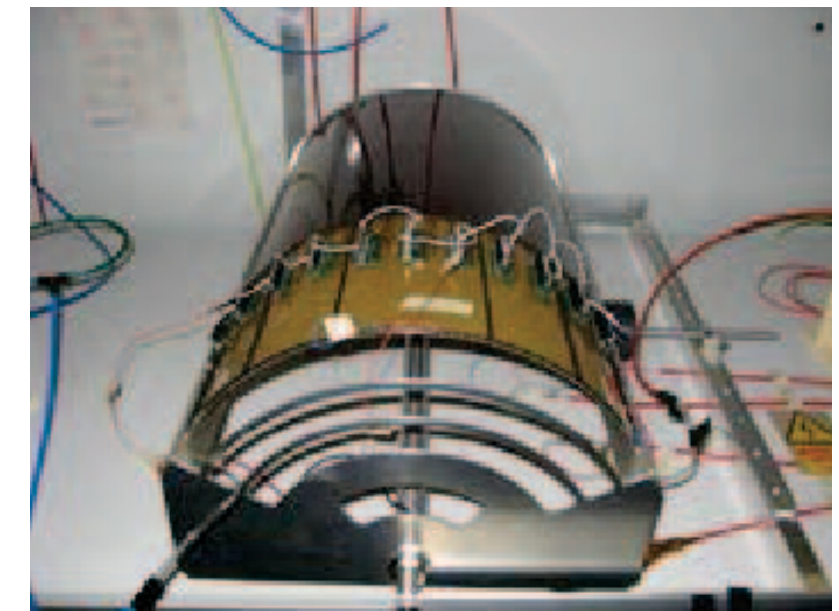
# Example: eRD108 - MPGDs

- Milestones:
  - ▶ FY23: Assembly of cylindrical  $\mu$ RWELL prototypes incl. new PCB design, front-end electronics, and DAQ interface. Bench tests in (05/2023) and Beam Test at FNAL (6/2023) followed by data analysis (12/2023).
- Status - MMG Barrel Tracker
  - ▶ Several prototypes with an active area of about 12x12cm<sup>2</sup> had been prepared in Saclay and tested in beam at MAMI (June 5th–11th 2023)
  - ▶ Different resistive layer patterns and different readout patterns have been tested
- Status - Cylindrical  $\mu$ RWell
  - ▶ R&D largely progressed according to plan in FY23
  - ▶ Final designs of two composite  $\mu$ RWELL/2D-readout foils with capacitive-sharing readout strips
  - ▶ The two detector halves were installed on a rotational mount and placed in a 120 GeV proton beam at the Fermilab test beam facility in June 2023
    - ◉ During test beam FNAL director had issued an order to stop all beam activities due to various safety and security issues encountered in other sections of the lab. Not able to collect data with the detector.
- eRD108 affected by recent re-design of min tracker

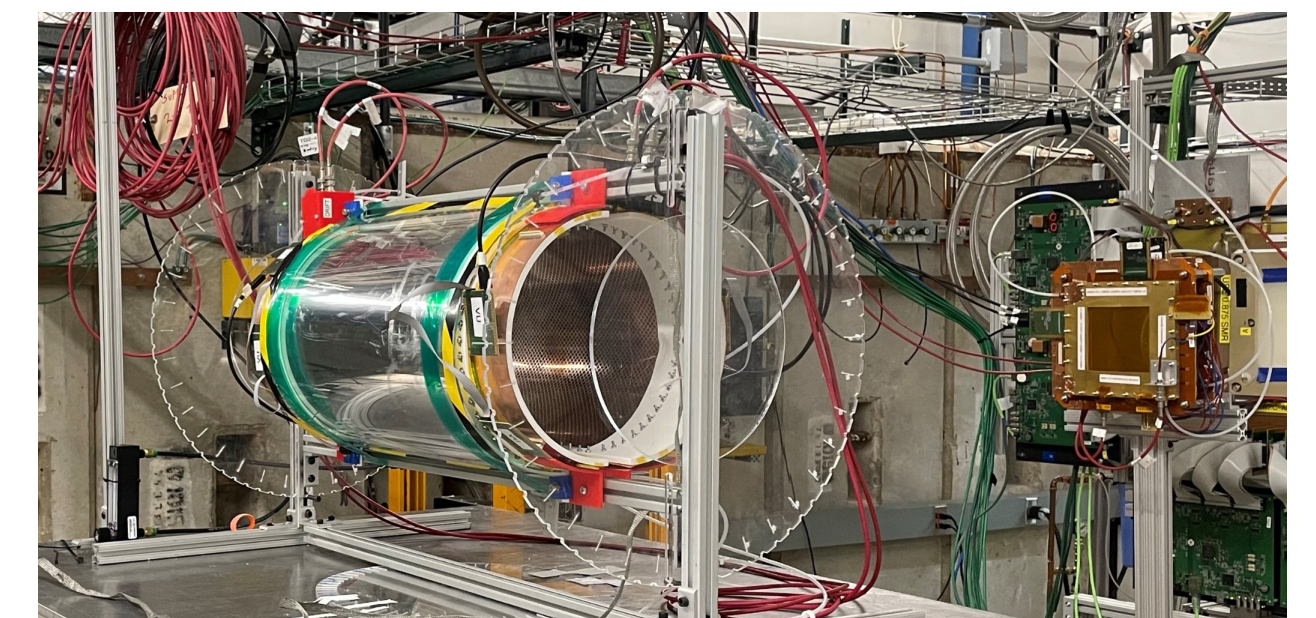


SVT      MPGDs      ToF (fiducial volume)

Cylindrical MMG



Cylindrical  $\mu$ RWell





# Completion of R&D Dates as Listed in P6

Layout: EIC - Full Detail Schedule (w)		Filter All: L4 Milestone, WBS: 6.10.XX																			
Activity ID	Activity Name	Original Duration	Start	Finish	Budgeted Labor Units	Budgeted Nonlabor Units	Budgeted Total Cost	Total Float	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
									FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35
6 EIC		1060	30-Sep-2022	04-Jan-2027	0	0	\$0.00	375	04-Jan-2027, 6 EIC												
6.10 EIC Detector		1060	30-Sep-2022	04-Jan-2027	0	0	\$0.00	375	04-Jan-2027, 6.10 EIC Detector												
6.10.02 Detector R&D and Physics Design		1060	30-Sep-2022	04-Jan-2027	0	0	\$0.00	375	04-Jan-2027, 6.10.02 Detector R&D and Physics Design												
E1002_10350	Detector R&D - Particle ID - eRD110 (Photosensors, SiPM) Milestone Complete	0		30-Sep-2022*	0	0	\$0.00	1435	Detector R&D - Particle ID - eRD110 (Photosensors, SiPM) Milestone Complete												
E1002_10610	Detector R&D - Calorimetry - eRD105 (Sciglass) Milestone Complete	0		18-Jul-2023	0	0	\$0.00	670	Detector R&D - Calorimetry - eRD105 (Sciglass) Milestone Complete												
E1002_10660	Detector R&D - Tracking - eRD108 (mRWELL) Milestone Complete	0		29-Sep-2023*	0	0	\$0.00	1063	Detector R&D - Tracking - eRD108 (mRWELL) Milestone Complete												
E1002_10690	Detector R&D - Tracking - eRD104 (Service Reduction, Develop Powering Scheme) complete	0		02-Jan-2024*	0	0	\$0.00	1006	Detector R&D - Tracking - eRD104 (Service Reduction, Develop Powering Scheme) complete												
E1002_10700	Detector R&D - Tracking - eRD111 (Si Tracker, Report completed on barrel and disc cooling opti	0		02-Jan-2024*	0	0	\$0.00	1006	Detector R&D - Tracking - eRD111 (Si Tracker, Report completed on barrel and disc cooling options) complete												
E1002_10810	Detector R&D - Particle ID - eRD110 (Photosensors, LAPPD/HRPPD) complete	0		30-Sep-2024*	0	0	\$0.00	924	Detector R&D - Particle ID - eRD110 (Photosensors, LAPPD/HRPPD) complete												
E1002_10820	Detector R&D - Calorimetry - eRD105 (Sciglass Beam Test Results) complete	0		30-Sep-2024*	0	0	\$0.00	369	Detector R&D - Calorimetry - eRD105 (Sciglass Beam Test Results) complete												
E1002_10830	Detector R&D - Tracking - eRD111 (Si Tracker, stitching of sensors) complete	0		30-Sep-2024*	0	0	\$0.00	816	Detector R&D - Tracking - eRD111 (Si Tracker, stitching of sensors) complete												
E1002_10900	Detector R&D - Tracking - eRD108 (Micromegas) complete	0		02-Jan-2025*	0	0	\$0.00	759	Detector R&D - Tracking - eRD108 (Micromegas) complete												
E1002_10910	Detector R&D - Tracking - eRD104 (Service Reduction, FPGAs) complete	0		02-Jan-2025*	0	0	\$0.00	759	Detector R&D - Tracking - eRD104 (Service Reduction, FPGAs) complete												
E1002_10920	Detector R&D - Particle ID - eRD101 (mRICH) complete	0		31-Mar-2025*	0	0	\$0.00	697	Detector R&D - Particle ID - eRD101 (mRICH) complete												
E1002_10930	Detector R&D - Particle ID - eRD102 (dRICH) complete	0		31-Mar-2025*	0	0	\$0.00	704	Detector R&D - Particle ID - eRD102 (dRICH) complete												
E1002_10970	Detector R&D - Particle ID - eRD103 (hpDIRC) complete	0		30-Jun-2025*	0	0	\$0.00	502	Detector R&D - Particle ID - eRD103 (hpDIRC) complete												
E1002_10980	Detector R&D - Calorimetry - eRD106 (fwd EMCal optimizing uniformity and efficiency) complete	0		30-Jun-2025*	0	0	\$0.00	508	Detector R&D - Calorimetry - eRD106 (fwd EMCal optimizing uniformity and efficiency) complete												
E1002_10990	Detector R&D - Calorimetry - eRD107 (fwd HCal Prototyping) complete	0		30-Jun-2025*	0	0	\$0.00	747	Detector R&D - Calorimetry - eRD107 (fwd HCal Prototyping) complete												
E1002_11030	Detector R&D - Electronics - eRD109 (ASICs/FEEs, Calorimeters) complete	0		30-Sep-2025*	0	0	\$0.00	562	Detector R&D - Electronics - eRD109 (ASICs/FEEs, Calorimeters) complete												
E1002_11040	Detector R&D - Electronics - eRD109 (ASICs/FEEs, AC-LGAD) complete	0		30-Sep-2025*	0	0	\$0.00	562	Detector R&D - Electronics - eRD109 (ASICs/FEEs, AC-LGAD) complete												
E1002_11100	Detector R&D - Electronics - eRD109 (ASICs/FEEs, RICH) complete	0		02-Jan-2026*	0	0	\$0.00	504	Detector R&D - Electronics - eRD109 (ASICs/FEEs, RICH) complete												
E1002_11110	Detector R&D - Electronics - eRD109 (ASICs/FEEs, MPGD) complete	0		31-Mar-2026*	0	0	\$0.00	442	Detector R&D - Electronics - eRD109 (ASICs/FEEs, MPGD) complete												
E1002_11120	Detector R&D - Particle ID - eRD112 (AC-LGAD/ToF) complete	0		30-Sep-2026*	0	0	\$0.00	315	Detector R&D - Particle ID - eRD112 (AC-LGAD/ToF) complete												
E1002_11130	Detector R&D - Tracking - eRD113 (Si Sensors/ITS3) complete	0		30-Sep-2026*	0	0	\$0.00	431	Detector R&D - Tracking - eRD113 (Si Sensors/ITS3) complete												
E1002_11180	Detector R&D - Electronics - eRD109 (ASICs/FEEs, PID LAPPDs and or MCPMTs) complete	0		04-Jan-2027*	0	0	\$0.00	373	Detector R&D - Electronics - eRD109 (ASICs/FEEs, PID LAPPDs and or MCPMTs) complete												
E1002_11190	Detector R&D and Physics Design - Complete	0		04-Jan-2027	0	0	\$0.00	373	Detector R&D and Physics Design - Complete												

Recall: CD-2/3 April 2025

# Take Away Message

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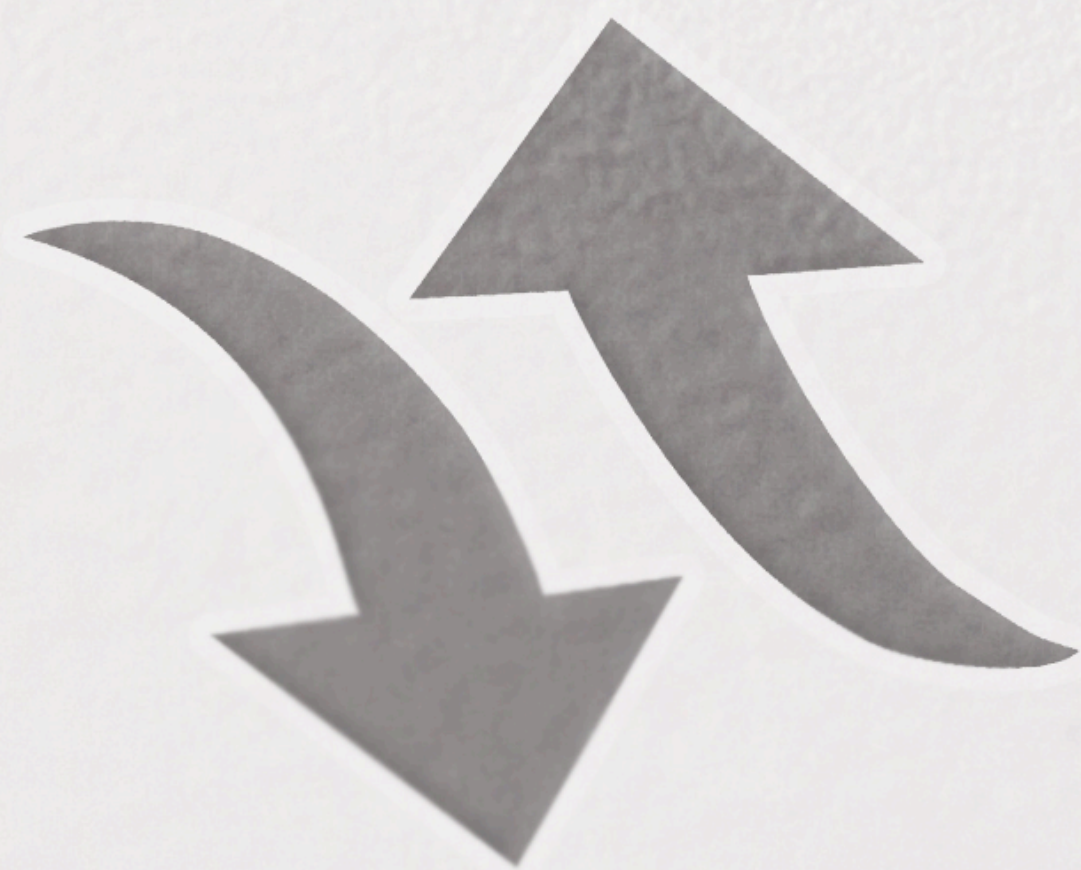
- Total of 13 R&D projects supported in FY23
- Overall in-line with current project schedule
- R&D program is adapting to changes in baseline
- Delays caused by
  - ▶ finalizing of contracts
  - ▶ availability of test beams
  - ▶ vendor delays, supply challenges (pandemic aftermath)
- Delicate line between R&D and PED
- Project detector R&D expected to dwindle down at CD-2

Note: Status of each project w.r.t. milestones attached as backup slides

On the web: [https://wiki.bnl.gov/conferences/index.php?title=General\\_Info](https://wiki.bnl.gov/conferences/index.php?title=General_Info)



backup





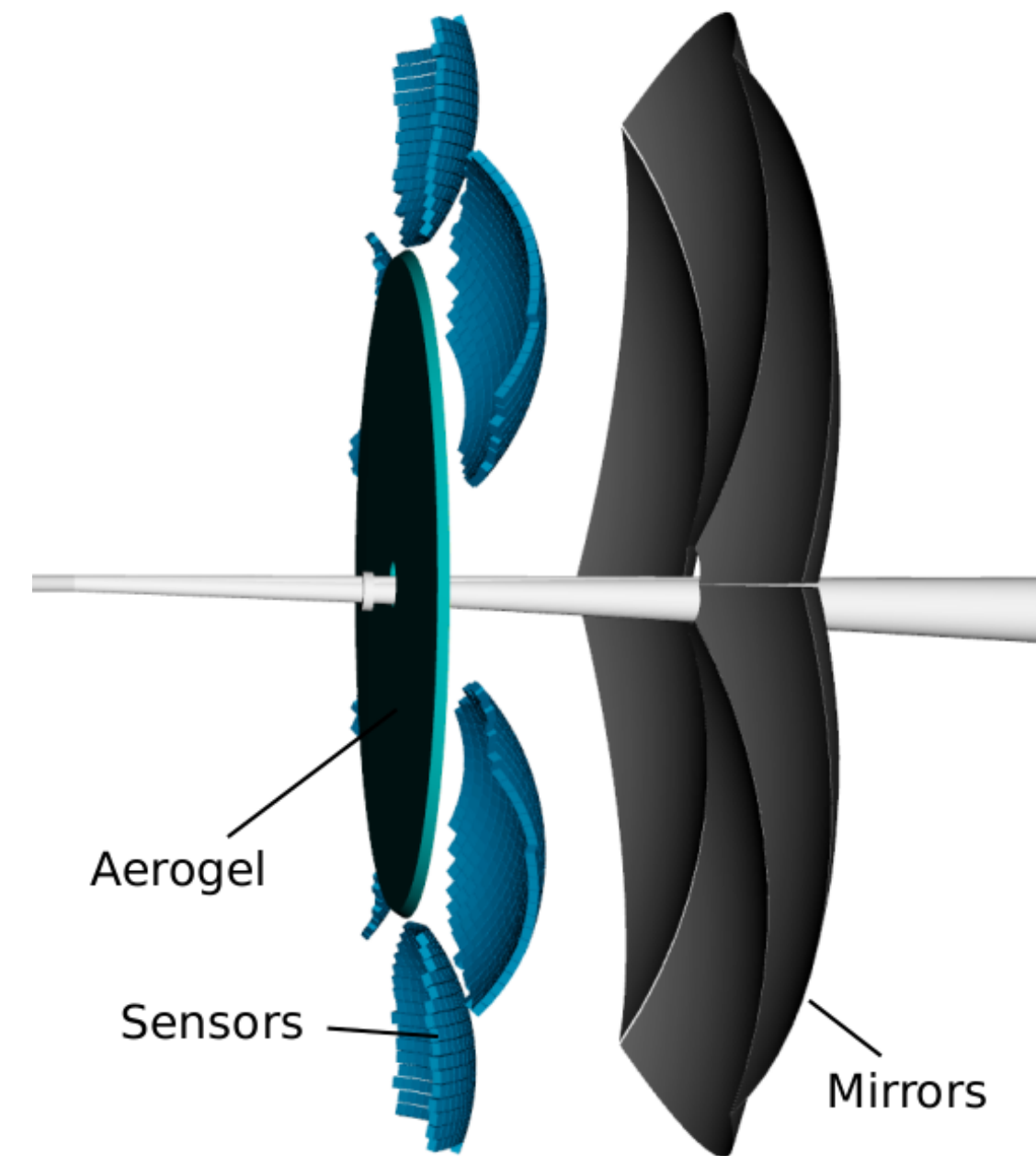
# eRD102 - dRICH

- Milestones:

- ▶ FY23: Characterization of realistic mirror and aerogel components and assessment of dRICH prototype performance in beam tests.

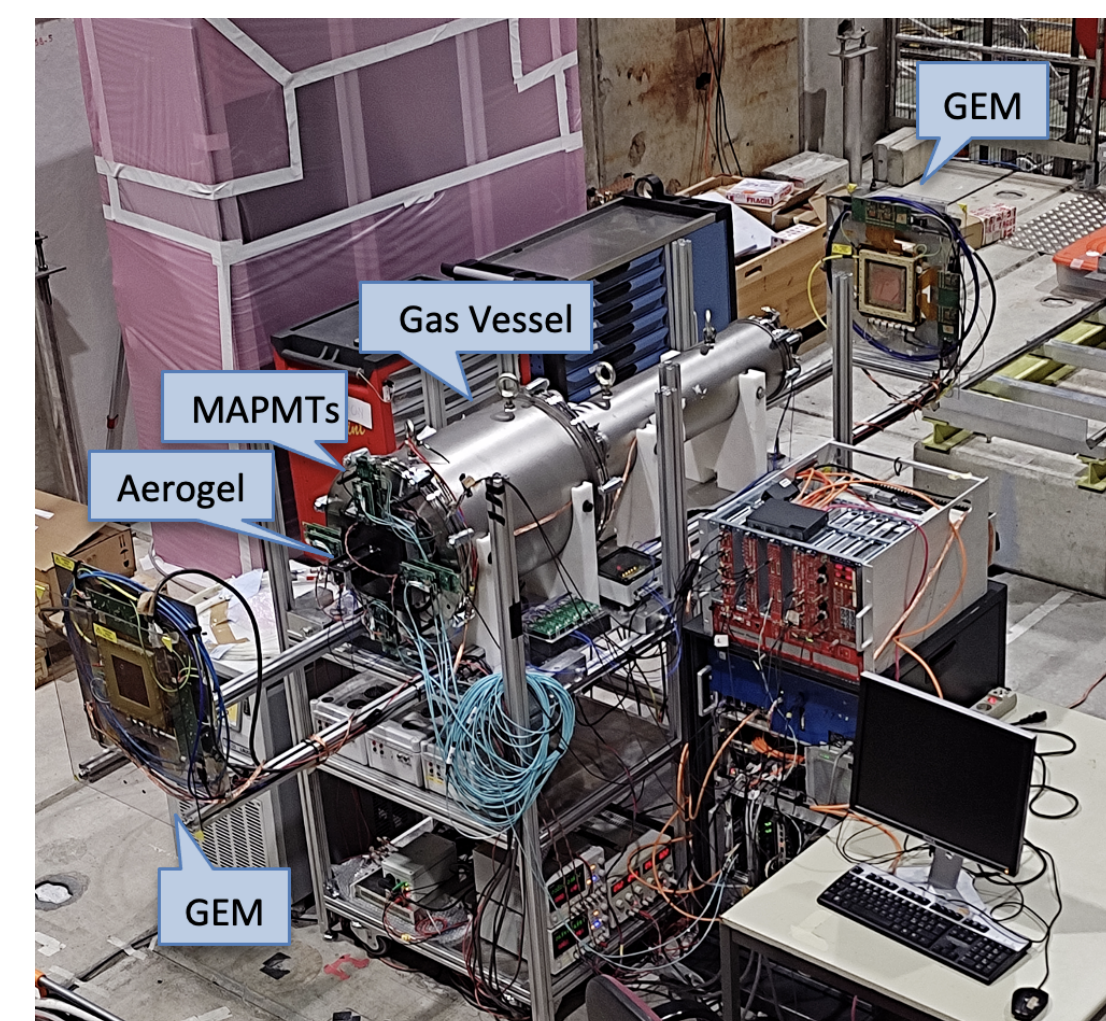
- Status

- ▶ Characterization of realistic mirror and aerogel components, achieved (*April 23*)
- ▶ Projected performance of the baseline detector as integrated into ePIC achieved with the general revision of the dRICH simulation framework (*June 23*)
- ▶ Assessment of the dRICH prototype performance with the EIC-driven detection plane, for which a new test-beam campaign has been organized (*October 23*) with the primary scope to operate the new EIC-driven readout plane (SiPM sensors and ALCOR digitalization).

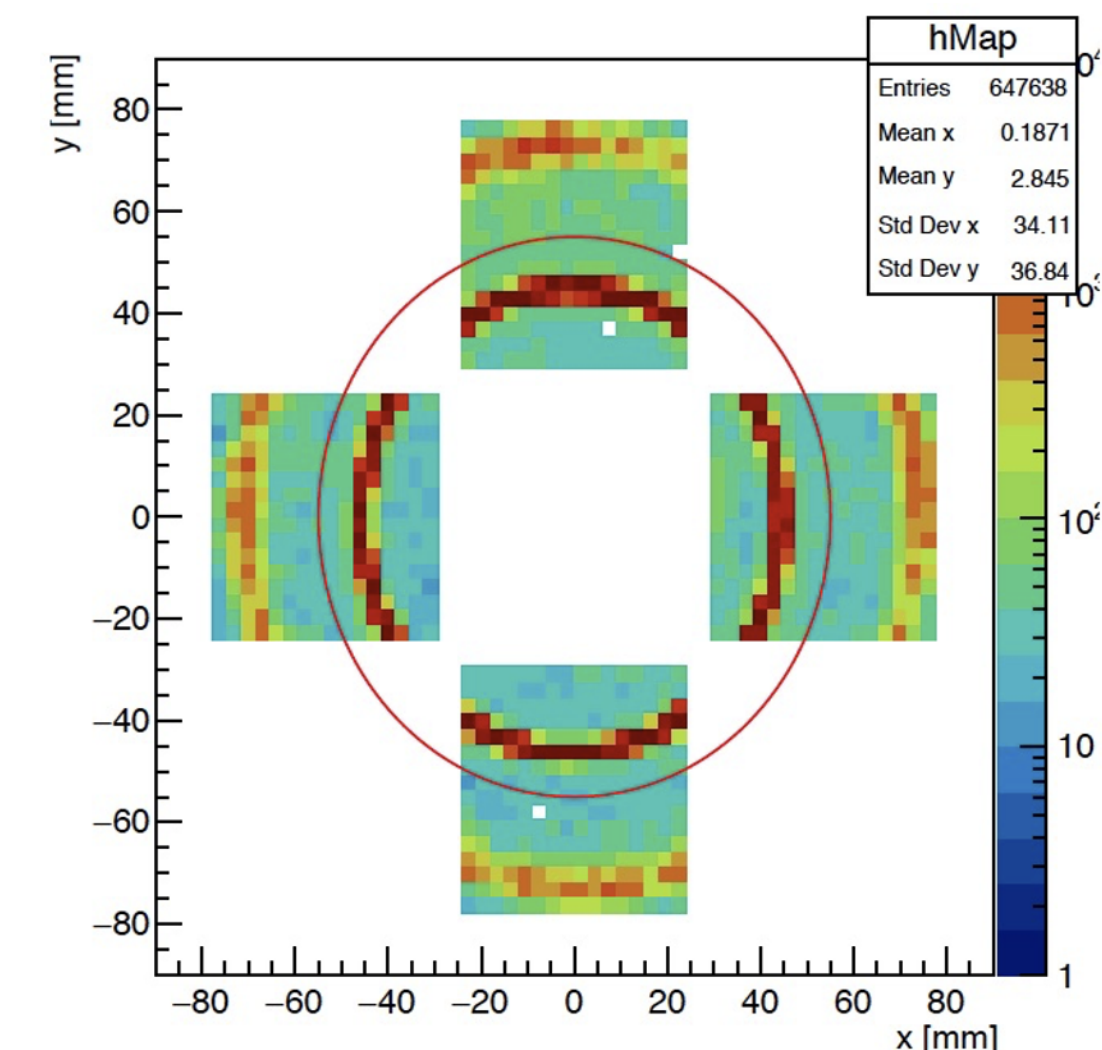


## Dual RICH

- Cherenkov radiator
  - aerogel
  - C2F6
- mirrors
  - large outward reflecting
  - 6 open sectors
- sensors
  - SiPM ( $\sim 1$  T field)



dRICH baseline prototype at the SPS beam





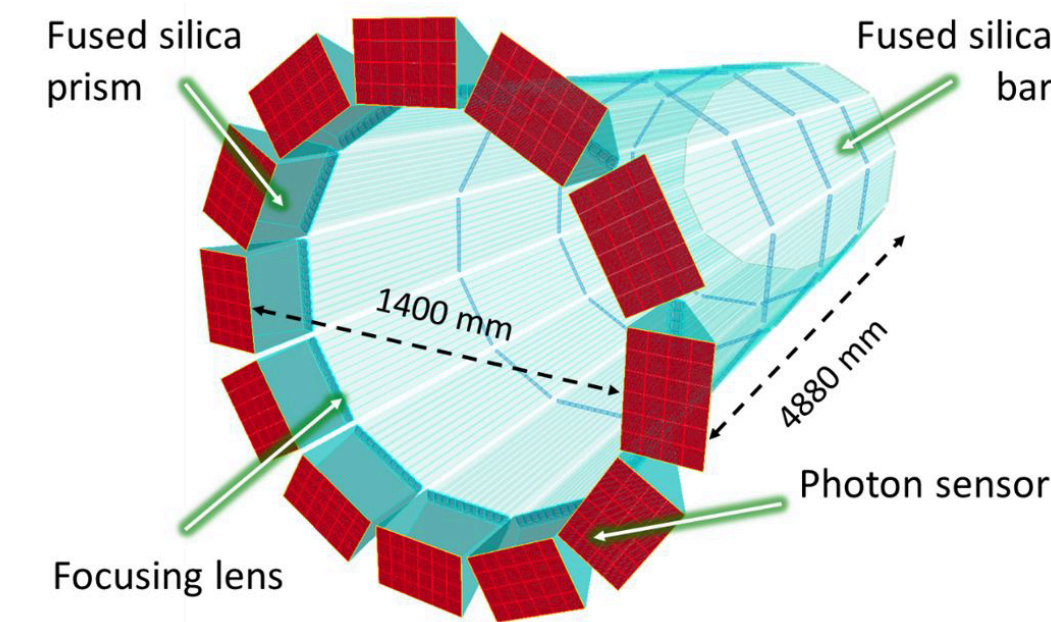
# eRD103 - hpDIRC

- Milestones

- ▶ FY23: Integration of hpDIRC prototype into Cosmic Ray Telescope (CRT) and commissioning of telescope setup. Complete QA of bars from first disassembled BaBar DIRC bar box, decision about further disassembly strategy.

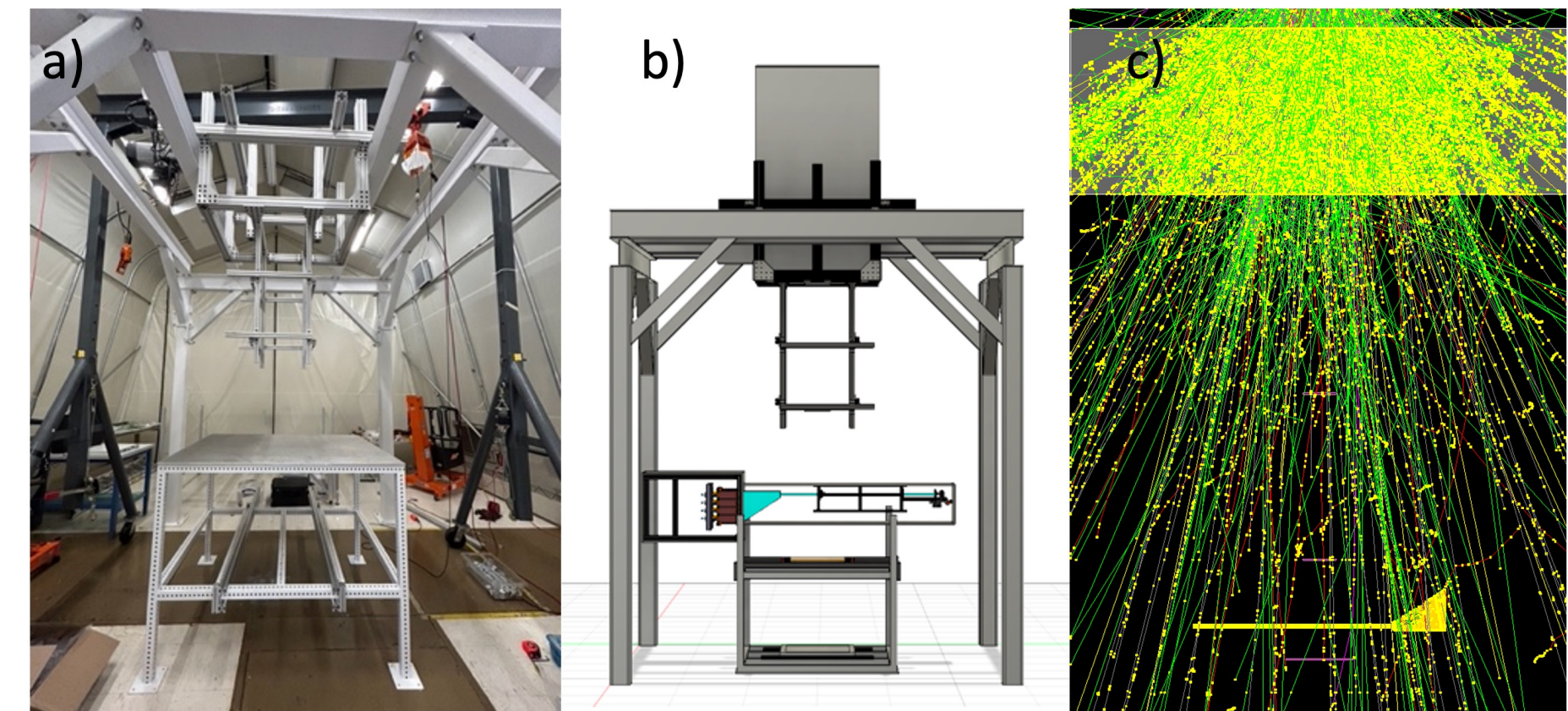
- Status

- ▶ CRTs mechanical framework has been constructed at SBU and mechanical design completed. hpDIRC prototype components, (GSI) were received in **March 2023**. Pre-assembly of the prototype has started and construction of a light-tight dark box and support platform for the prototype is underway. A motion-controlled 3D stage (Stewart platform) has been purchased to control the position of the prototype. The installation of the hpDIRC prototype will take place in the **late Summer/early Fall 2023**.
- ▶ JLab assumed responsibility for funding transportation, disassembly, and initial QA of the BaBar bars. Initial plan assumed disassembly of the 8 remaining DIRC bar boxes at SLAC in early 2023. Due limited availability of the workforce at SLAC, the decision was made to transport the complete bar boxes to JLab and perform the disassembly there. Transport from SLAC to JLab is expected to take place in the **fall of 2023**.



## High Performance DIRC

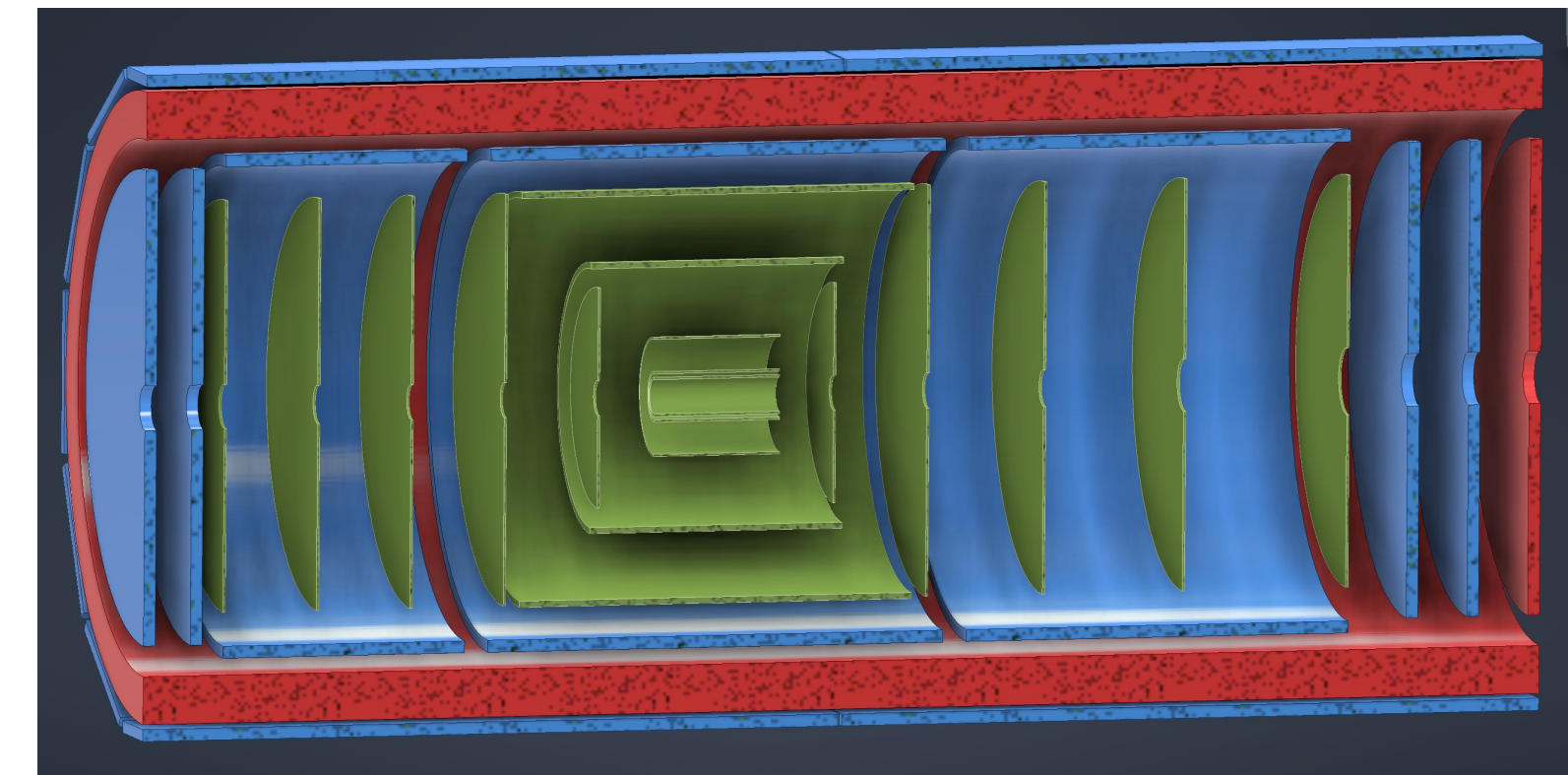
- crucial components
  - novel 3-layer spherical lenses
  - compact fused silica expansion volumes
  - fast photodetection, small pixel MCP-PMT
- hpDIRC creates focused images
  - significantly improved resolution





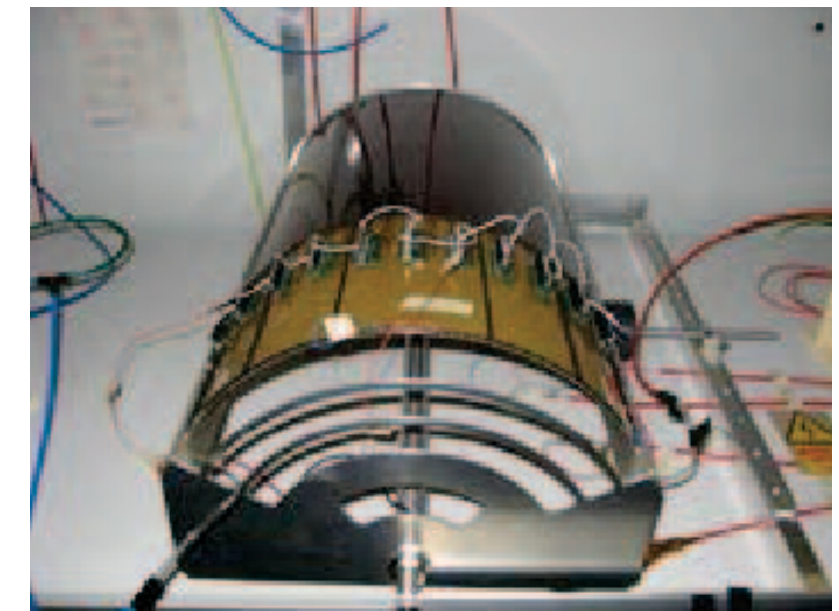
# eRD108 - MPGDs

- Milestones:
  - ▶ FY23: Assembly of cylindrical  $\mu$ RWELL prototypes incl. new PCB design, front-end electronics, and DAQ interface. Bench tests in (05/2023) and Beam Test at FNAL (6/2023) followed by data analysis (12/2023).
- Status - MMG Barrel Tracker
  - ▶ Several prototypes with an active area of about 12x12cm<sup>2</sup> had been prepared in Saclay and tested in beam at MAMI (June 5th–11th 2023)
  - ▶ Different resistive layer patterns and different readout patterns have been tested
- Status - Cylindrical  $\mu$ RWell
  - ▶ R&D largely progressed according to plan in FY23
  - ▶ Final designs of two composite  $\mu$ RWELL/2D-readout foils with capacitive-sharing readout strips
  - ▶ The two detector halves were installed on a rotational mount and placed in a 120 GeV proton beam at the Fermilab test beam facility in June 2023
    - ◉ During test beam FNAL director had issued an order to stop all beam activities due to various safety and security issues encountered in other sections of the lab. Not able to collect data with the detector.
- eRD108 affected by recent re-design of min tracker

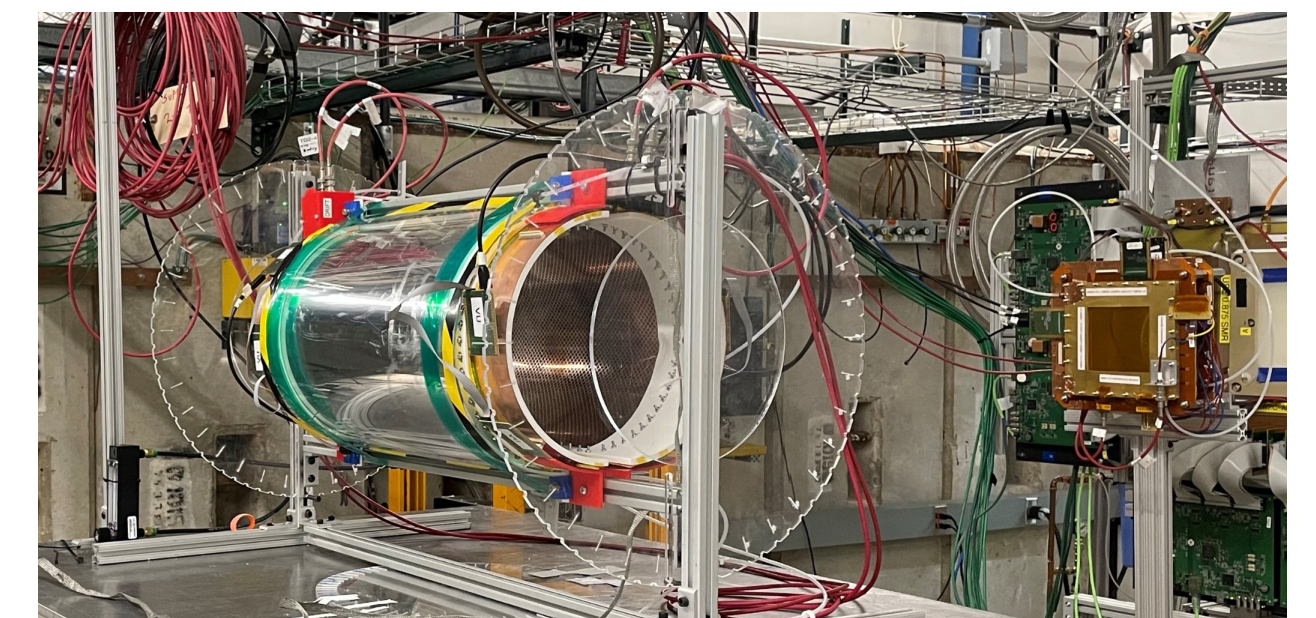


SVT      MPGDs      ToF (fiducial volume)

Cylindrical MMG



Cylindrical  $\mu$ RWell





# eRD104 - Service Reduction (Si Tracker)

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- Milestones

- ▶ FY23: Detailed concept and analysis of powering distribution schemes based on DC-DC and serial powering (SP). Evaluation of existing regulators and of MLR1 structures performance powered through those. For readout, exploration and evaluation of radiation tolerant FPGAs and high-speed fiber optic transmission options. Develop prototype multiplexing firmware.

- Status (Powering - UK)

- ▶ Significant expertise in DC-DC based powering scheme adopted by the ATLAS ITk strip detector and the SP scheme adopted by the ATLAS ITk pixel detector. SP would be the most promising option for EIC.
- ▶ Started design of an integrated Shunt-LDO regulator prototype. Also work on error amplifier, and start-up circuits are all in progress

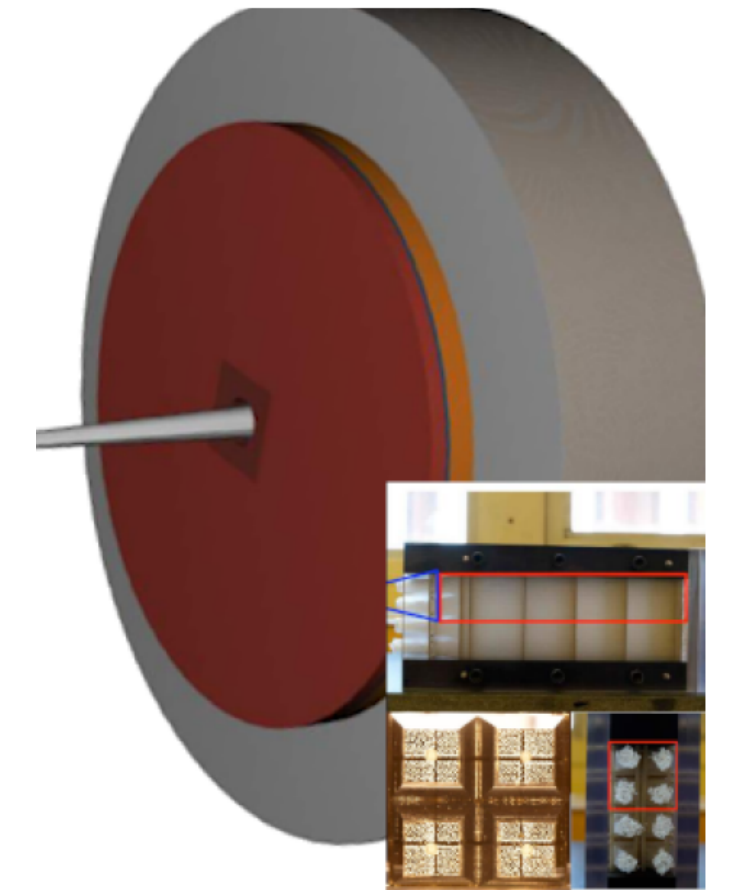
- Status (Readout - ORNL)

- ▶ Focus on Development & market survey of available components for a possible MUX board that uses data aggregation on or close to the detector using radiation tolerant FPGAs.
- ▶ FPGAs receive multiple data streams from sensor blocks directly from the detector FPC boards, and multiplexes and transmits the data out via high-speed fibers to intermediate data collection boards or directly to the Data Aggregation Modules (DAM) boards.
- ▶ Possible candidates for most components identified.
- ▶ Very long lead times for various boards, so that work on these evaluations will not be starting until **later this calendar year**.

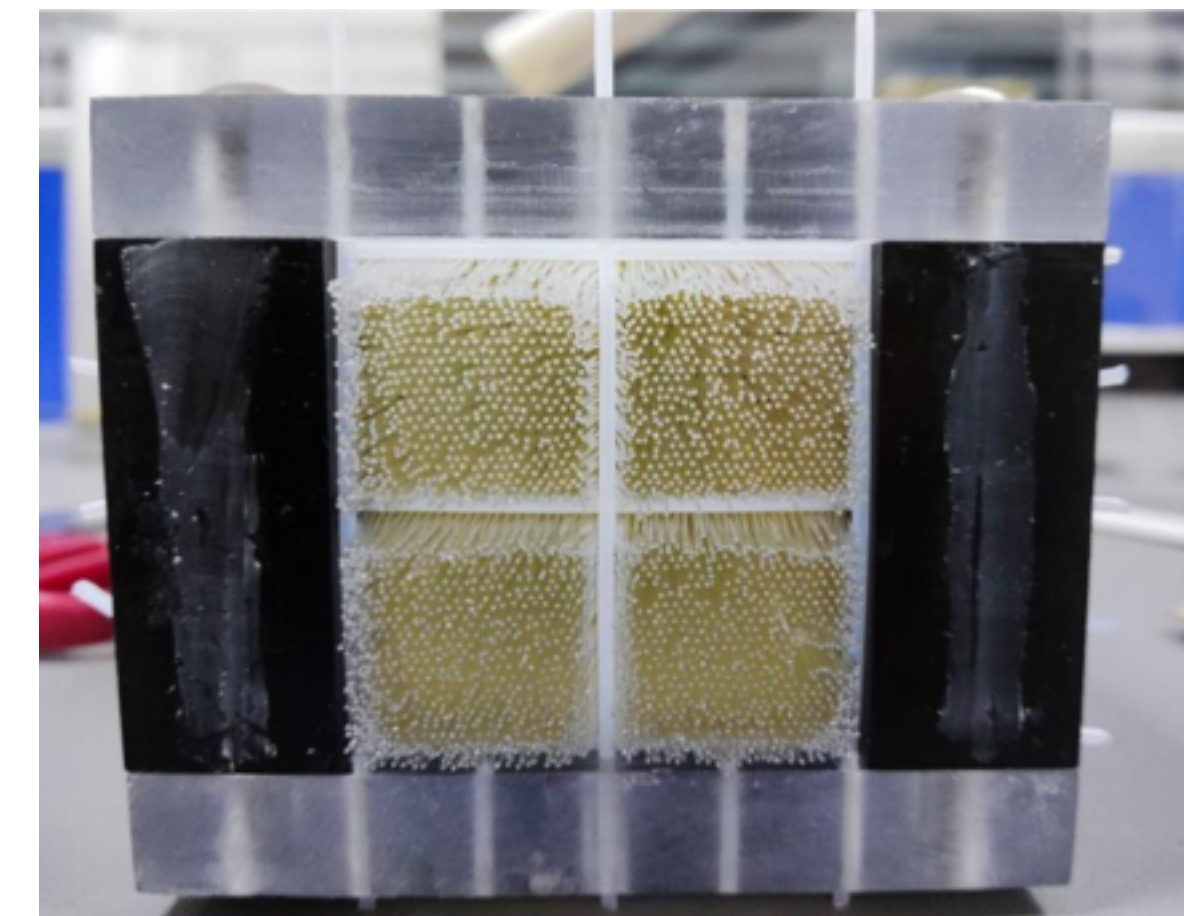


# eRD106 - Forward EM Calorimeter

- Milestones:
  - ▶ FY23: Optimize uniformity and efficiency of light collection with SiPM readout
- Status:
  - ▶ The major delay at UCLA site where university grant/contract office was negotiating the terms of agreement with BNL contract office (3-4 month delay)
  - ▶ Comparison of new Bicron with Kuraray fibers 1/15/23
  - ▶ Shear tests complete 3/30/23
  - ▶ Acquire Sc. Fibers, W Powder, meshes and tooling 02/27/23
  - ▶ Start production of blocks for test beam prototype 04/01/23
  - ▶ Perform UV scan to check uniformity LY 05/30/23
  - ▶ QA Production all blocks done 07/15/23
  - ▶ Compression tests complete 7/30/23
  - ▶ Mechanical/optical/electrical integration with readout complete 8/15/23
  - ▶ Light guides for prototype produced 8/30/23



High granularity  
W/SciFi  
**forward EMCal**





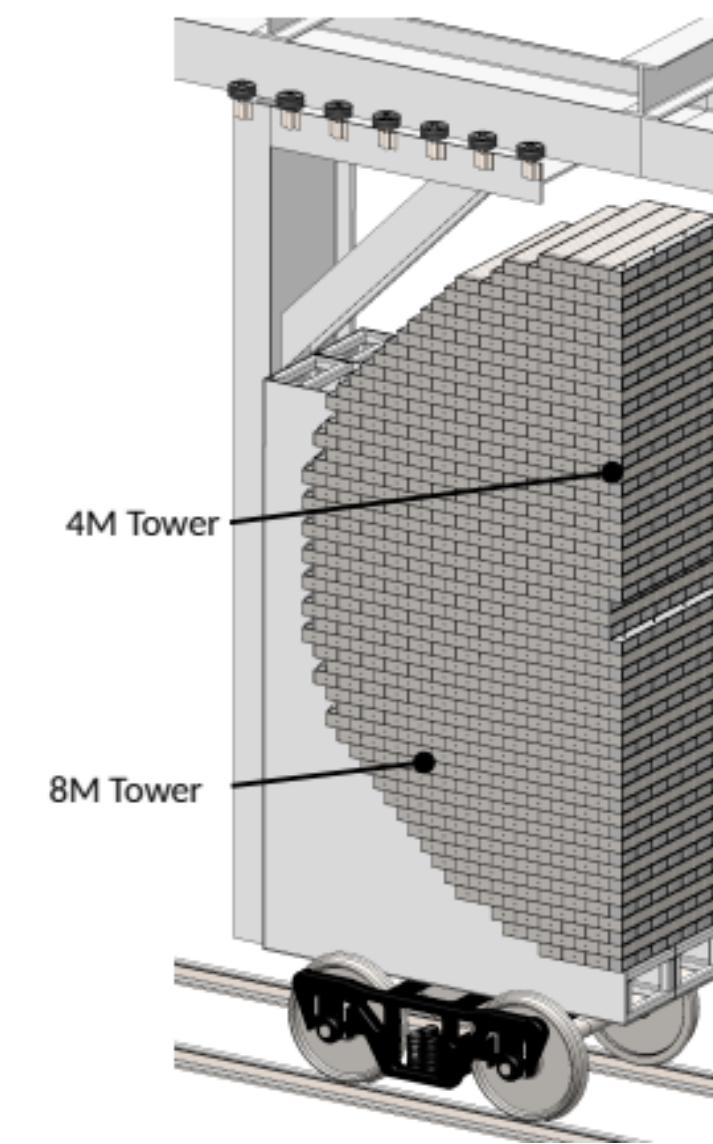
# eRD107 - Forward Hadronic Calorimeter

- Milestones

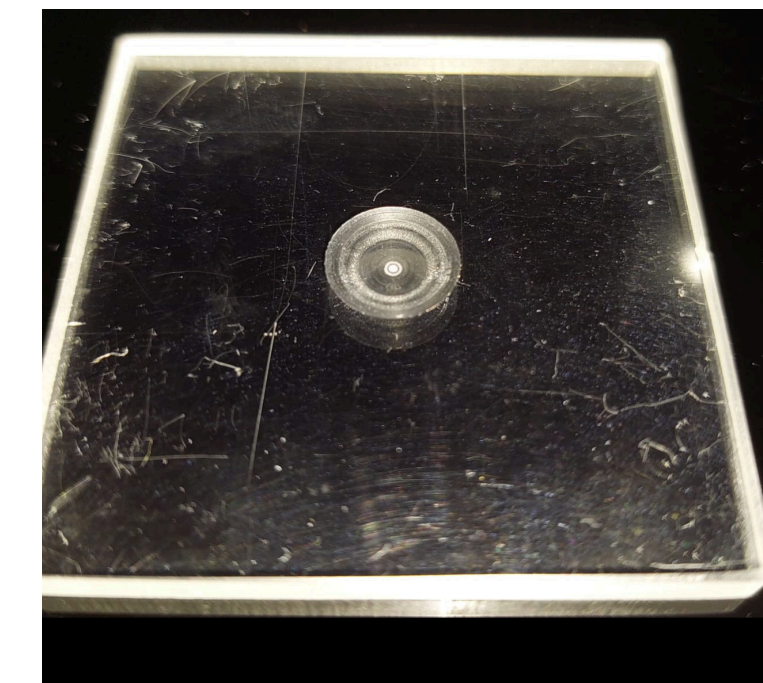
- ▶ FY23: Prototype tile production using machining & injection molding (April 2023). First prototype of single segment of 8M module (July 2023) and characterization of tiles from test bench & test beam measurement (August 2023).

- Status

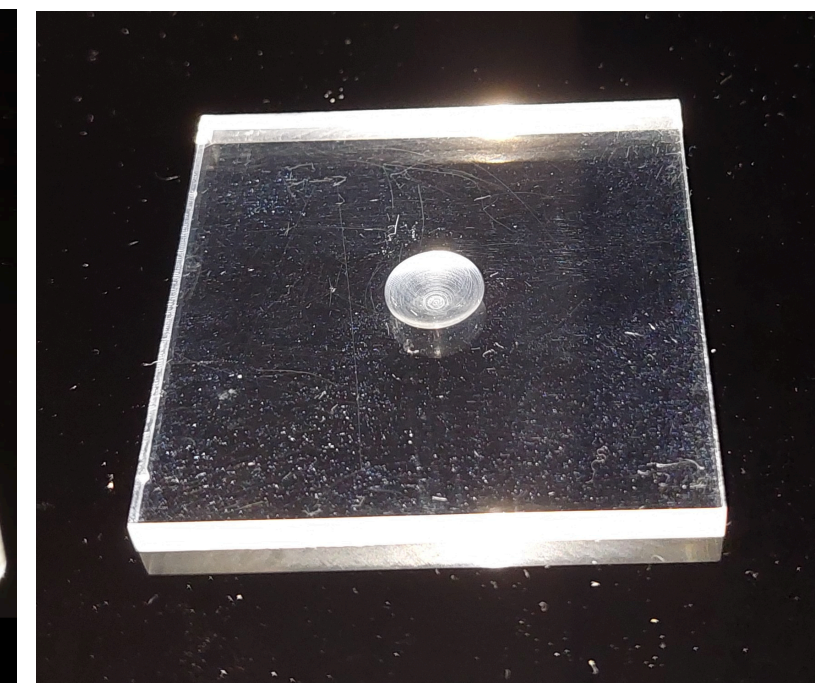
- ▶ Conducted market survey for obtaining cast and machined scintillator materials. Machining capabilities and prices are challenging. Studies at ORNL on how the machining of these delicate materials could be done for large quantities.
- ▶ Dark Box and Test Setup: Two different light-tight dark boxes were designed and assembled at Yale and ORNL. The functionality of the SiPM's were tested using LED pulser
- ▶ Verified the functionality of the SiPMs (spread of the break-down voltage, IV-curves etc) at ORNL and Yale using a Source-Measurement unit or PicoAmmeter and Voltage Source, respectively.
- ▶ Studies to optimize LFHCal & Insert



Longitudinally separated  
**forward HCal**  
with high- $\eta$  insert



Tiles cut with water jet



Tiles cut with modified  
wet tile saw



# eRD109 - ASICs

- Overall Milestones

- ▶ Develop a streaming readout solution specific to all ePIC subsystems through the development, design, and testing of ASICs. This included the realization of new ASICs, the modification of existing ASIC designs and the testing of COTS

- ▶ FY23:

	Subdetector	Sensor Type	Readout Solution
A	Calorimeter	SiPM	Discrete, COTS
B	Calorimeter	SiPM	ASIC (HGCROCv3)
C	dRICH	SiPM	ASIC (ALCOR)
D	Central, Far-Forward	AC-LGAD	ASIC (EICROC1, FCFD1)
E	Micromegas, GEM, $\mu$ RWell	MPGD	ASIC (SALSA)

- Status

- ▶ Overall on track (see talk by F. Barbosa)
- ▶ Various changes during FY23 due to improving definitions of requirements and specifications (more complete insights for FY24)



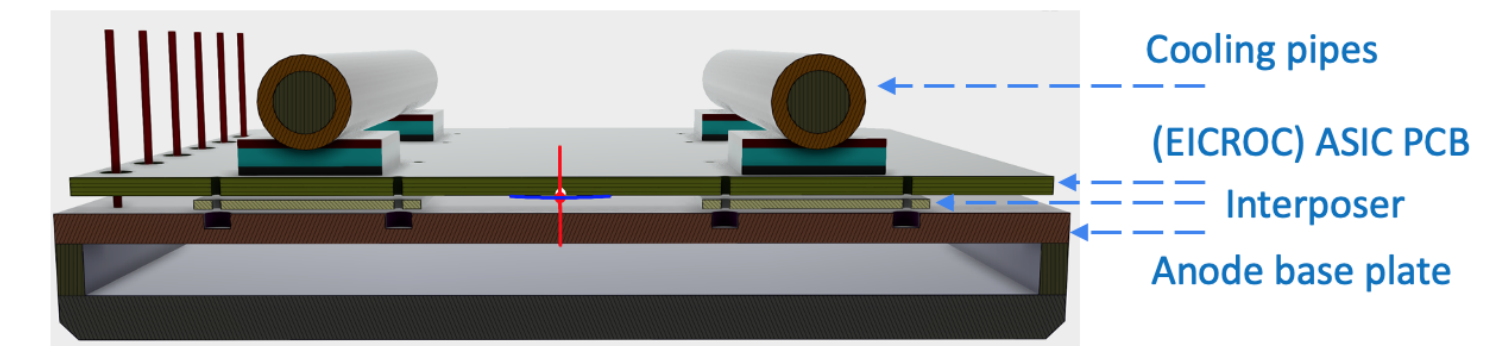
# eRD110 - Photosensors

- Milestones

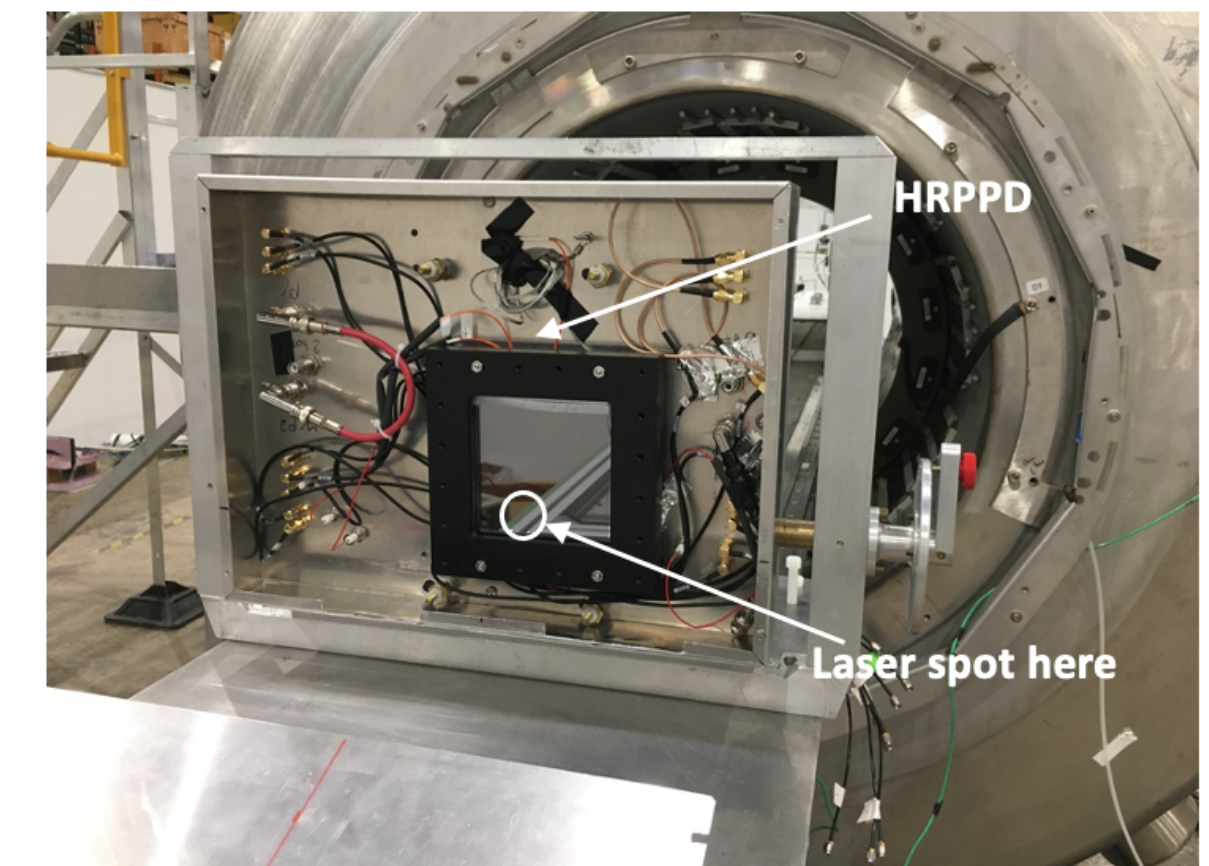
- ▶ FY23: Improvements of mechanical and electrical interface to HRPPD with a direct pixel readout. Gain and timing resolution characterization in magnetic field of two different advanced LAPPD/HRPPD prototypes (Sep 2023).

- Status

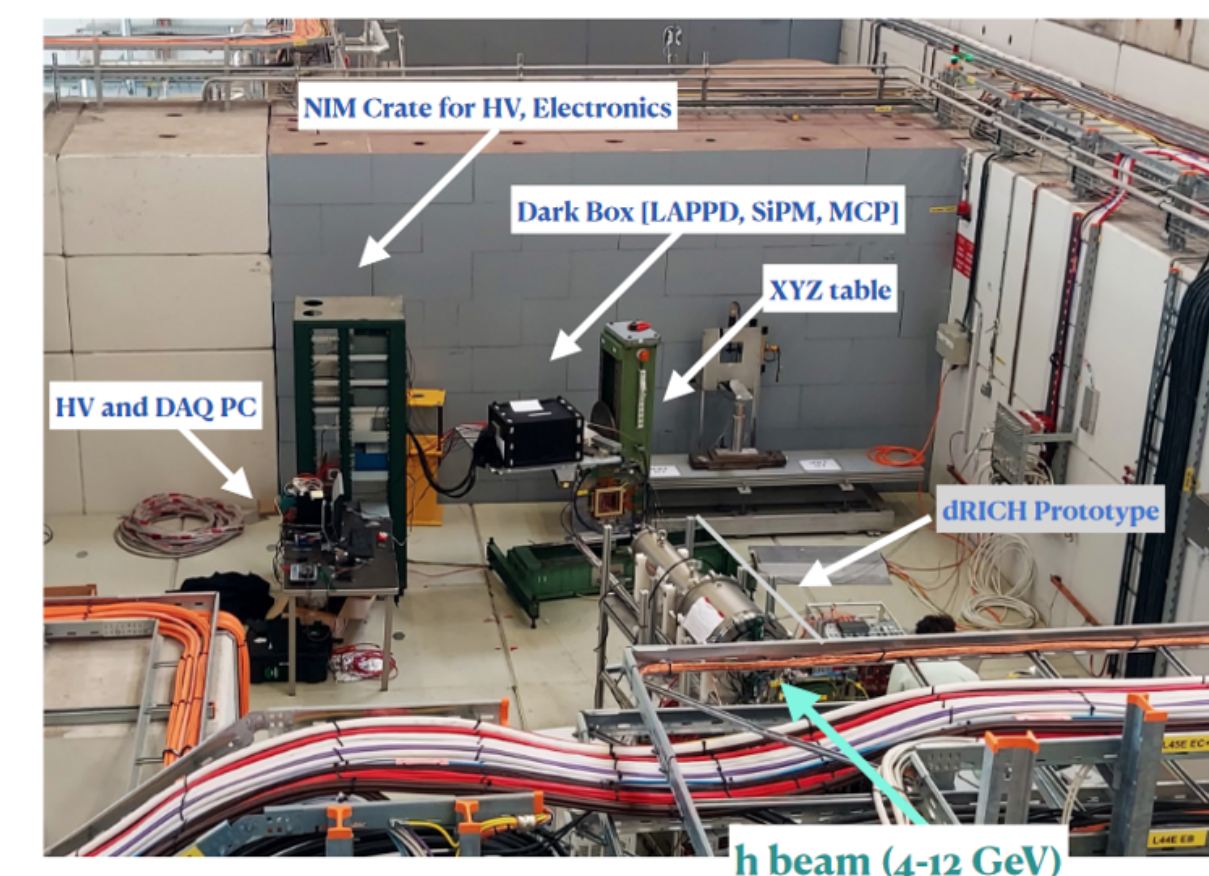
- ▶ Pogo pin based interface was implemented (late 2022) and used for HRPPD characterization at ANL and BNL. More advanced option based on Samtec compression interposers was developed (early 2023) and is now under test at Incom.
- ▶ Characterization of 3 different state-of-the-art LAPPD/HRPPD prototypes, in particular gain and QE uniformity in progress. Only one LAPPD and one HRPPD being studied due to limited availability from Incom.
- ▶ Gain and timing resolution characterization in magnetic fields of 2 different advanced LAPPD / HRPPD prototypes (April 2023)
  - LAPPD with 20  $\mu\text{m}$  pore size MCPs, exhibits a magnetic field tolerance up to  $\sim 0.9$  T. Whereas the HRPPD with 10  $\mu\text{m}$  pore size MCPs, exhibits a magnetic field tolerance up to  $\sim 1.8$  T



HRPPD with Samtec interposers and an ASIC PCB



Argonne g-2 test solenoid





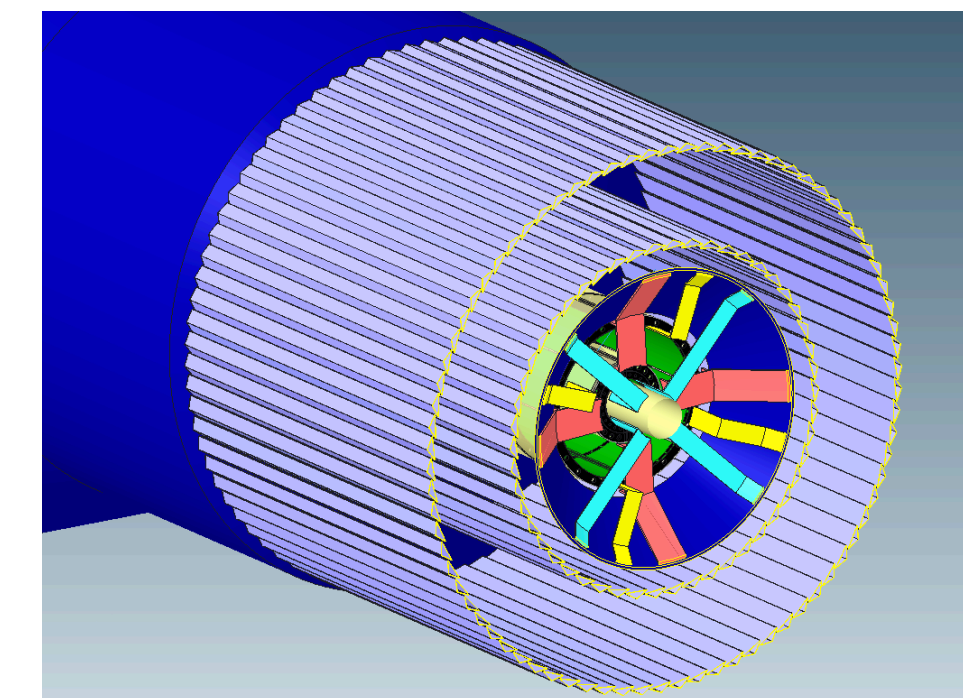
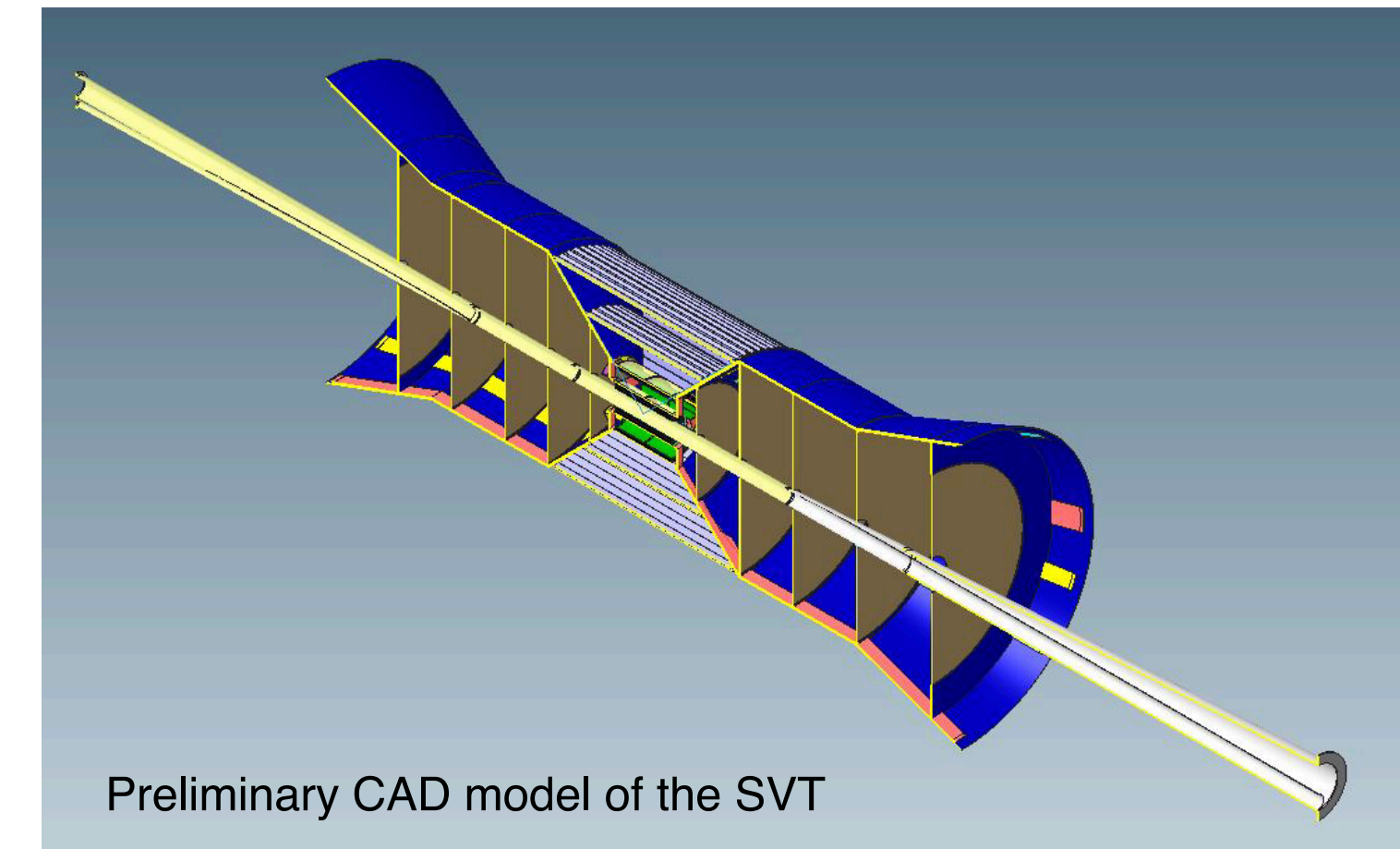
# eRD111 - Si Tracker

- Milestones:

- ▶ FY23: Concluding report on the optimized sensor dimensions for EPIC based on the measured yield, also in relation to the outcome of the bending and interconnection studies (September 2023). Concluding report on the barrel and disc cooling options (August 2023).

- Status

- ▶ A prototype layer based on a thinned and bent sensors assembled in a semi-cylindrical shape. Procedures and tools developed.
- ▶ Cooling R&D towards the understanding of air cooling for staves and discs continued. Mock-up pieces are made showing that air cooling is sufficient in this configuration to keep  $\Delta T$  below 10 C.
- ▶ Continued simulations related to beam pipe bake out.
- ▶ Developed a sensor layout that achieves coverage for all parts of the SVT, with particular challenges in the endcaps (mod. needed due to sensor changes).
- ▶ Started to implement a CAD representation of the SVT



View of  
SVT end with  
services



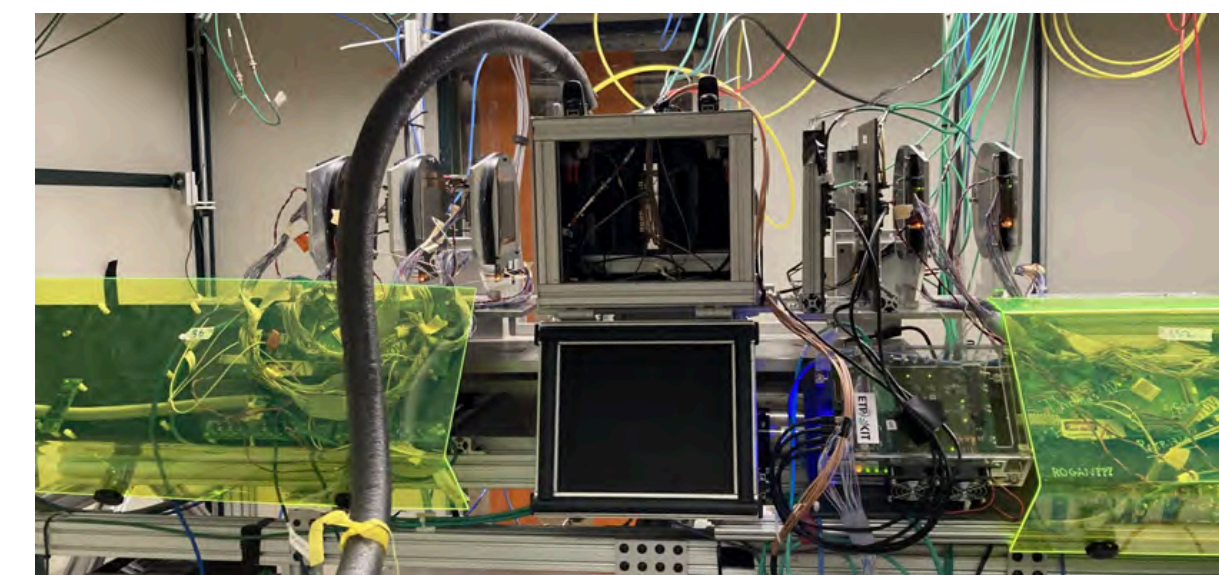
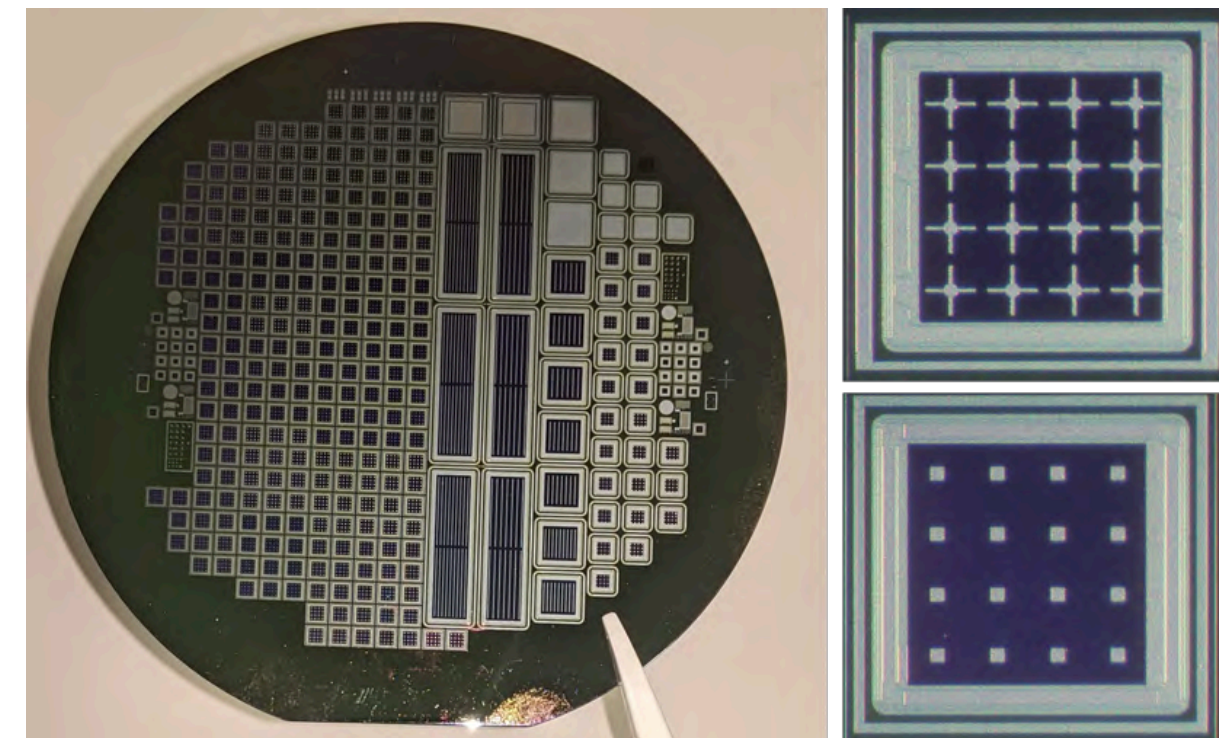
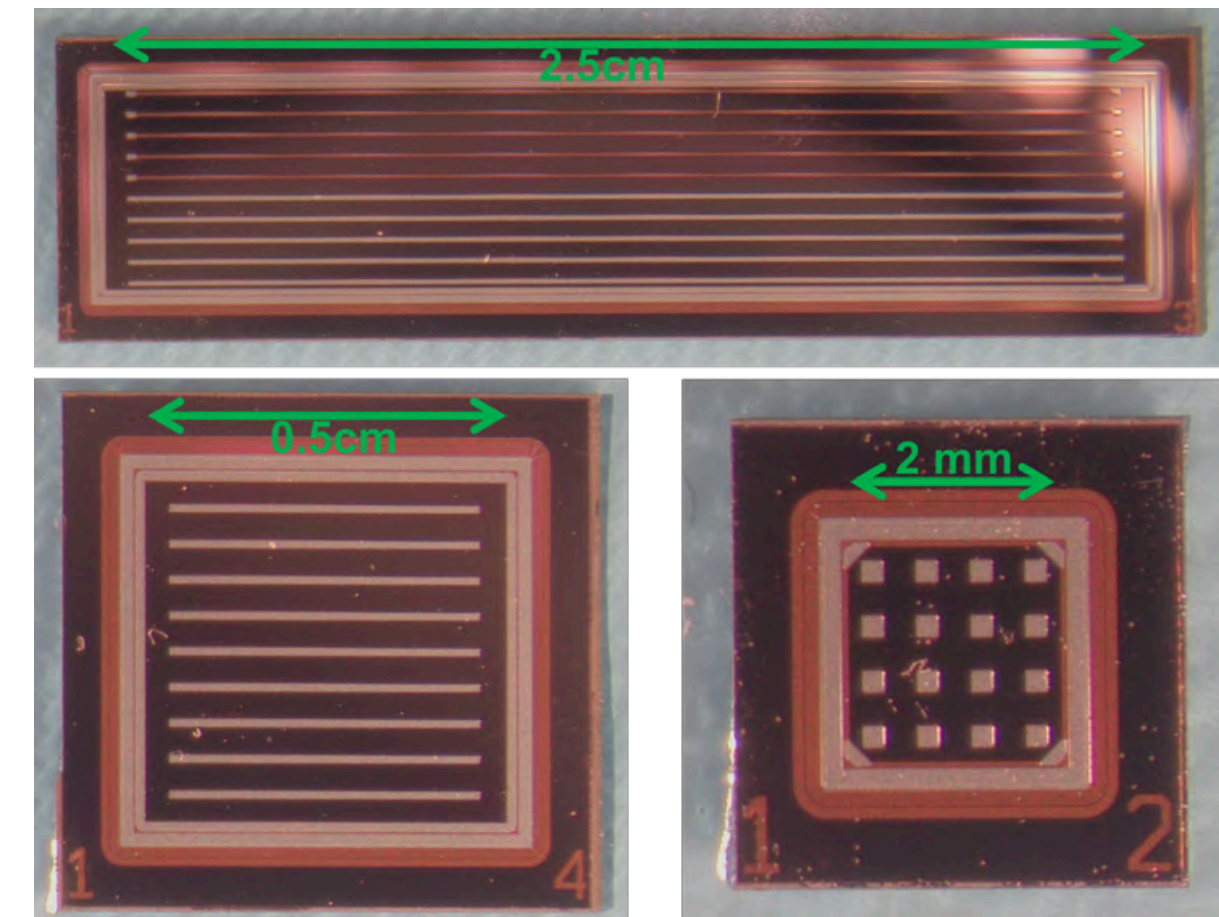
# eRD112 - AC-LGAD/ToF

- Milestones FY23

- ▶ Sensor prototypes and ASIC demonstrator that match tracking and Roman Pots requirements completed and evaluated in test beams
- ▶ Irradiation campaign for sensor and ASIC prototypes.
- ▶ Development of cooling strategy and mechanical design, design of flexes, interconnects and off-detector electronics

- Status

- ▶ Wafers with AC-LGAD strips & pixel completed at BNL.
- ▶ BNL fabricated a batch of EICROC-compatible AC-LGADs, such that the sensors can be bump-bonded to the ASIC
- ▶ Conducted a series of test beam campaigns to characterize sensors produced by BNL-IO and HPK at FTBF
- ▶ Excellent hit efficiency, timing resolution down to 20 ps and spatial resolution below  $20\ \mu\text{m}$  across the whole sensor have been observed with HPK E-type pixel sensors with  $500\ \mu\text{m}$  pitch
- ▶ Study the mechanical design of the barrel TOF started





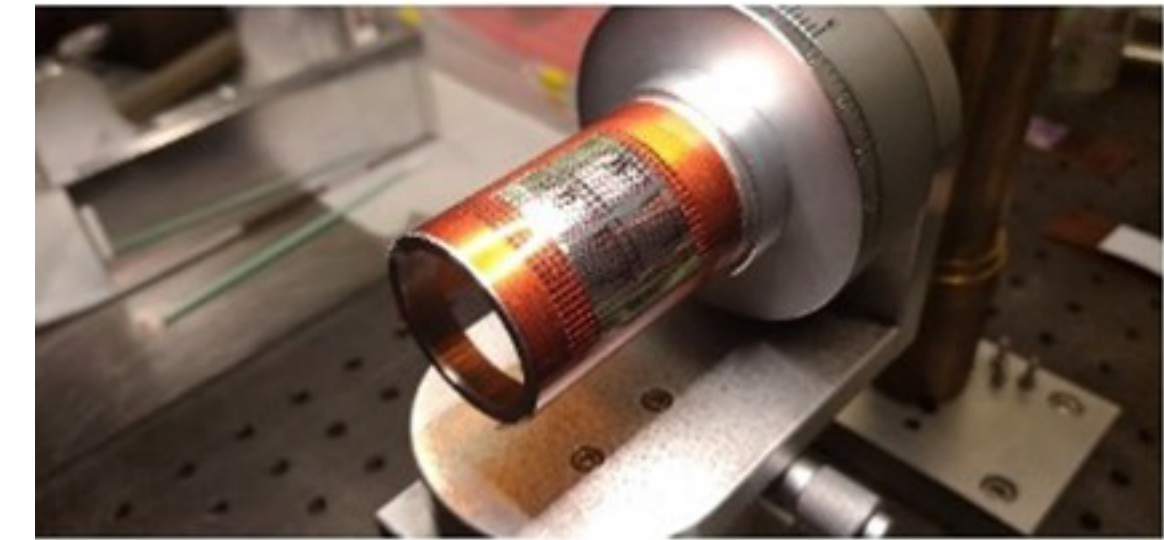
# eRD113 - MAPS/ITS3

- Milestones

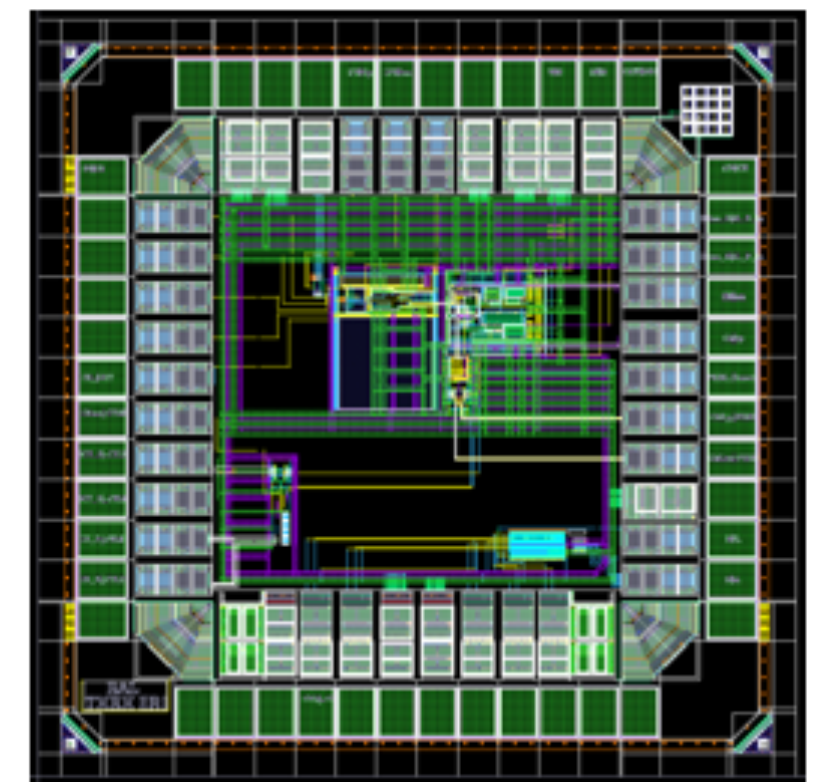
- ▶ Complete work on Serializer, DC-DC Schematic Design, and Shunt Regulator.
- ▶ Design of small-footprint, 10-b medium resolution ADC for on-a-chip monitoring
- ▶ Analysis based on the ALICE ITS3 experience of stitching methodologies for sensor layout
- ▶ Initiate conceptual design of EIC LAS adapted for serial powering
- ▶ Results of test and characterization of test structures fabricated on MLR1 and ER1.
- ▶ Results of test and characterization of test structures fabricated on MLR1 and ER1.
- ▶ Results of tests and characterization of structures, such as DPTS, from the ALICE ITS3 efforts and development of dedicated test setups.

- Status

- ▶ Much progress thus far on silicon sensor development and characterization (see extended report by eRD113)
- ▶ As a result of the work carried out over the past year, including in particular interactions with the ALICE-ITS3 team, some of the assumptions made when planning the work on FY23 have evolved



APTS structure in curved geometry



ER1 layout

