EIC - Detector Advisory Committee

Report to EIC Resource Review Board

Andy White, DAC Chair
(University of Texas at Arlington)

Detector Advisory Committee

Brief history: Formed in 2020 to advise Laboratory and Project Management on EIC Detector R&D and Design

DAC members have expertise in Tracking, Calorimetry, Particle Identification, Electronics, Infrastructure and Mechanics, Data Acquisition and Computing and EIC Science

DAC has general meetings to review detector progress and more focused meetings on R&D on specific topics

Detector Advisory Committee 2024 Members

Edward Kinney	Boulder CO
Ken Wyllie	CERN
Petra Merkel	FNAL
Antonis Papanestis	Rutherford Appleton Laboratory
Peter Krizan	U Ljubljana
Ana Amelia Machado	University of Campinas, Brazil
Cecillia Gerber	UIC
Brigitte Vachon	McGill
Stefano Miscetti	INFN Frascati
Roman Poeschl	IJCLab
Andrew White (Chair)	U. Texas Arlington
Eraldo Oliveri	CERN

Detector Advisory Committee Meetings in 2024

- June 21 EIC Detector – 8th DAC Meeting

- August 28, 29 EIC Detector R&D DAC Meeting

In addition incremental Subsystem Design Reviews:

- Incremental Design and Safety Review of the EIC Tracking Detectors

- Electronics/DAQ Review

Supplemental DAC Reviews 2024

(no detailed reports at this meeting)

Incremental Design and Safety Review of the EIC Tracking Detectors
March 2024

Michael Begel BNL, Piotr Gasik GSI, David Lynn BNL, Maxim Titov CEA, Andy White UTA

Electronics/DAQ Review
June 2024

Ken Wyllie CERN, Mitch Newcomer Upenn, Prashansa Mukim BNL, Filippo Costa CERN

EIC Detector – 8th DAC Meeting
June 2024

Charge for the Review

- The progress and status of the ePIC detector.
- Is the ePIC detector scope appropriate for achieving the key physics goals?
- Will the detector be ready for CD-2 baselining in the Fall of 2025?
- Are the detector technologies appropriate and are their risks and opportunities adequately understood?
- Are the resources planned, including people and infrastructure for production and testing, adequate?
- Are there critical areas where further collaboration engagement and international outreach should be pursued?

EIC Detector - 8th DAC Meeting

Friday, June 21, 2024

Agenda

(Eastern Daylight Savings Time)

09:00 – 09:30	DAC Executive Session
09:30 – 10:00	EIC Status and Plans – Jim Yeck
10:00 – 10:30	ePIC Collaboration, Detector, and EIC Science – John/Silvia
10:30 – 10:45	*Break*
10:45 – 11:30	ePIC Technical Baseline and Collaboration Contributions – Elke/Rolf
11:30 – 12:00	EIC Detector Organization and Management in Next Phases – Elke/Rolf
12:00 – 12:30	ePIC Detector Integration Planning Status – Rahul Sharma
12:30 – 13:00	ePIC Electronics/DAQ Planning Status – Dave/Jeff for Fernando Barbosa
13:00 – 13:30	*Lunch Break*
13:30 – 14:00	Planning for Production Phases – Elke/Rolf
14:00 – 14:15	Planning for Early Physics Phases – Elke/Rolf
14:15 – 14:45	Discussion on Strengths/Weaknesses
14:45 – 15:00	*Break*
15:00 – 16:15	DAC Executive Session
16:15 – 16:45	Closeout

EIC Detector – 8th DAC Meeting

Summary from the Review

Charge 1: The progress and status of the ePIC detector.

The design of tracking system is mature but its realization is critically dependent on external development (Si/ITS3) and success of new technology (uRWELL).

The calorimeter system design looks well advanced for the CD-2 level of preparation and most of the chosen detector technologies take advantage of good prototyping development.

In general, the PID detector system seems to be on track.

DAQ/Readout needs continuing close attention to integration and testing, especially integration of many readout lines. Proper resources for firmware development need to be available and started early.

Infrastructure and integration need focused effort, there are still incomplete views of services status, especially cooling and gas for tracking chambers and the dRICH. These may affect overall detector performance as well as affect component access.

Charge 2: Is the ePIC detector scope appropriate for achieving the key physics goals?

Since a 2nd EIC detector appears unlikely to be installed on day 1, we urge the ePIC collaboration to investigate means of cross-checking the results of the critical key physics measurements, especially eA.

Tracking scope is appropriate if ITS3 will be ready in time and large scale uRWELLs are successfully demonstrated.

ePIC has concluded that detector performance with ITS2 does not meet requirements. Performance with micromegas & micro-RWELL disks replacing silicon detectors has not been established.

Charge 3: Will the detector be ready for CD-2 baselining in the Fall of 2025?

Tracking: ER-2 for ITS3 - planned for Fall 2024. Will this result in a device that is sufficient for baseline/CD-2? If not what is the implied delay? An ER-3 might be very close to CD-2. MPGDs need to demonstrate large area working prototypes prior to CD-2. The schedule for this looks tight. There are several significant studies yet to be carried out (vibration analysis, impacts of services routings, magnetic forces analysis, etc.) that could potentially affect baseline and physics performance expectations.

Calorimetry and PID seem on track, however, hpDIRC work has just begun, so this might be tight if new bars are required. Newly manufactured bars may have a long lead time/high cost.

We understand that it is still a possibility that CD2 and 3 reviews would occur at the same time. Having all components ready for CD3 by fall of 2025 seems very challenging

Charge 4: Are the detector technologies appropriate and are their risks and opportunities adequately understood?

The proposed tracking system technologies appear appropriate to address the needs of the physics program. However, significant risks still exist that can only be lowered following successful testing of full-scale prototypes.

There is a premium on reliability of the tracking systems since fixing a major problem requires removal of the central detector to the assembly hall and unstacking for access.

Calorimetry design/plan seems appropriate, however the use of the AstroPix requires close monitoring.

The R&D phase is coming to a close, but some engineering 1st articles will not be available until early 2025.

We encourage that the testing plans include testing of components in magnetic fields (static and ramping).

Charge 5: Are the resources planned, including people and infrastructure for production and testing, adequate?

Agreements for in-kind contributions are expected from Italy, UK, Korea, France, Czech Republic and CERN. Timely execution of these agreements will allow testing of full-scale prototypes of tracking elements prior to CD-2.

Difficult to evaluate whether sufficiently strong and experienced manpower is applied to the different systems; FTEs by “project” would be useful.

Details of how new groups are integrated into the collaboration/project would be useful.

Project management/ePIC Collaboration coordination appears to work, but seems complex enough that overall organization/communication may suffer, and will require strong oversight effort to maintain.

Are expected in-kind contributions of adequate size and required items for both detector side and accelerator side?

Charge 6: Are there critical areas where further collaboration engagement and international outreach should be pursued?

Now that technologies are chosen, it is important to learn about component reliability and lifetime. This has strong implications for maintenance access needs as well as cost. A comprehensive review of all components would be prudent. We welcome efforts to try to limit the need to roll out for maintenance, and encourage management moving forward to gather all maintenance requirements for all detectors.

Background rates may be significantly higher in the early commissioning phase of the accelerator, which could lead to early radiation damage of some components. This should be considered in installation/commissioning planning.

We encourage ePIC and management to start thinking about the commissioning needs of the different detector subsystems and their timescales.

Summary DAC Comments

- The committee congratulated the collaboration on the enormous progress on developing realistic designs and starting active design review cycles on different systems.

- The committee was happy to see planning for the physics programs in the first few years that would allow flexibility in component installation. We encourage the collaboration to begin early public discussion of the physics run planning, possibly engaging with some sort of Physics Advisory Committee.

- We welcome the ePIC collaboration recognition of the importance of support and development of Early Career Researchers. We suggest that this be kept in the forefront, and also consider ways to further strengthen, e.g. through formalization of appointment of ECR within all committees. The current work on EIC detector design, R&D, prototyping and engineering is an invaluable opportunity for training young physicists.

- We encourage the project management to continue to look for opportunities to increase its diverse representation, especially as it affects young career physicist involvement and inspiration.

EIC Detector – 9th DAC Meeting
August 2024

Review of Progress towards Completion of Detector R&D

R&D Areas and DAC members' expertise

eRD102 – dRICH – Krizan, Machado
eRD103 – hpDIRC – Machado, Papanestis

eRD104 – Si Service Reduction – Merkel
eRD111 – Silicon Vertex – Gerber, White
eRD113 – Si Sensor Dev/Char – Wyllie

eRD106 – Forward ECal – Miscetti, Poeschl
eRD107 – Forward HCal – Miscetti, Poeschl
eRD115 – Imaging Cal – Miscetti, Poeschl

eRD108 – MPGD – White, Oliveri
eRD112 – AC-LGAD – Gerber, Oliveri

eRD109 – ASIC/Electronics – Vachon, Wyllie
eRD110 – Photosensors – Machado, Wyllie

EIC Project R&D DAC Review

Contribution: Welcome of DAC and Discussion (Closed Session)
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Edward Kinney

Contribution: eRD106 - Forward EM Calorimeter
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Oleg Tsai

Contribution: eRD107 Forward Hadron Calorimeter
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Friederike Bock

Contribution: eRD115 - Barrel EM Calorimeter
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Sylvester Joosten

Break: Coffee Break
Time and Place: (Aug 28, 2024 - Aug 28, 2024)

Contribution: eRD102 - dual RICH
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Marco Contalbrigo

Contribution: eRD112 - Time-of-Flight & AC-LGAD
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Alexander Jentsch

Contribution: eRD103 - high performance DIRC
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Grzegorz Kalicy

Contribution: DAC Meeting (Closed Session)
Time and Place: (Aug 28, 2024 - Aug 28, 2024)
Presenter: : Edward Kinney

Contribution: eRD104/eRD111/eRD113 - Silicon Tracker
Time and Place: (Aug 29, 2024 - Aug 29, 2024)
Presenter: : Ernst Sichtermann

Contribution: eRD108 - MPGD Tracker
Time and Place: (Aug 29, 2024 - Aug 29, 2024)
Presenter: : Francesco Bossu

Break: Coffee Break
Time and Place: (Aug 29, 2024 - Aug 29, 2024)

Contribution: eRD110 - Photosensors
Time and Place: (Aug 29, 2024 - Aug 29, 2024)
Presenter: : Alexander Kiselev

Contribution: eRD109 - ASICs/FEE
Time and Place: (Aug 29, 2024 - Aug 29, 2024)
Presenter: : Fernando Barbosa

Contribution: DAC Meeting (Closed Session)
Time and Place: (Aug 29, 2024 - Aug 29, 2024)

EIC Project R&D DAC Review – Summary/Highlights

Calorimetry

Forward Electromagnetic Calorimeter

Much good progress with production of final design blocks and improvement in uniformity seen in June test beam. Need prototype test with final frontend electronics. Completion of eRD106 planned in the next few months. Moving towards CD2/3A – mechanical integration of ECal into ePIC , integration of readout (with eRD109).

Forward Hadron Calorimeter

Based on CALICE design/shares work with CMS HGCAL. Good progress on scintillator tile production and QA/QC and third iteration of flexible printed circuit. Test beam results from 2023 – e, π shower profiles.
Test beam late August 2024. Attention needed to the development of the long readout PCBs – key detector component.

Barrel Imaging Electromagnetic Calorimeter

Combines Pb/SciFi technology with high precision Astropix position detector. Successful integration of Astropix and BabyCal – first results from June test beam (despite many difficulties). Need extension of R&D to 2025 – further beam tests with more Astropix layers at FTBF (PED?).

EIC Project R&D DAC Review – Summary/Highlights

Particle ID

Dual RICH

Project progressing well, aligning with ‘24, ’25 goals.
Optimization of aerogel radiator; progress in development of lightweight mirrors; compact photon detection units with advanced SiPM arrays; integration of key components like the ALCOR digitizing chip; multiple TBs conducted.
Main challenge for 2025: validation of real-scale prototype with component demonstrators. Timeline needed.

High Performance DIRC

R&D objective is to ensure that the required performance for ePIC can be achieved using a Cosmic Ray Telescope, which can also be used to test the completed hpDIRC bar boxes. Significant progress with all components of the CRT, but not yet at commissioning stage.

Timeline needed for hpDIRC construction and possible bar procurement schedule (if needed).

Time of flight and AC-LGAD

AC-LGADs - chosen technology for the timing layer in the barrel and forward TOF detector, the B0 tracker, the Roman Pots, and the Off-Momentum Detectors.
Positive results with basic sensors, but some cases small margin v. requirements.
Still need information on how the sensor will be integrated into the various sub-detectors (modules, support, services), including the impact on the material budget.

EIC Project R&D DAC Review – Summary/Highlights

Tracking

Silicon - Sensor

Connections with the ALICE ITS3 community have been strengthened by embedding two designers from EIC institutes into the MOSAIX design team at CERN.
EIC institutes have carried out a wide range of tests on prototype chip structures.
Concerned that a collaboration agreement with ALICE is not yet in place and that access to the design technology is not yet possible.

Silicon – Modules, Mechanics, Cooling, Integration

R&D is progressing according to plan – DAC congratulates groups on past year advances (despite funding delays).
General concern that delays in establishing funding can lead to accumulating delays.

Silicon – Services reduction

Work on serial powering to reduce power infrastructure; reduction of signal readout cabling.
Steady progress since August 2023 review, but much fabrication/testing remains to be done
Radiation hardness – concern in August 2023 review – lpGBT and VTRx+ now used for which radiation hardness is known.
Actual component fabrication and testing should proceed with high priority.

EIC Project R&D DAC Review – Summary/Highlights

Tracking

MPGD Tracker - CymBal

Results of the 2023 MAMI test beam, the upgrade of the cosmic stand in Saclay, and the steps toward re-establishing the production of curved micromegas in Saclay were presented. Production in Saclay strongly supported by DAC.
Test beams campaigns needed in FY24, FY25 – to finalize technical choices for r/o layout, large angle tracks, gas.
Previous review raised concern about close interaction of services between SVT and MM – need conceptual design.
Continue the studies toward full-scale prototyping, focusing on critical issues to prepare for CD2/3.

MPGD Tracker - µRWELL Barrel

Modifications required in the prototype constructed in FY23 successfully made - detector ready for beam testing.

Recommend testing in beam ASAP - confirm gas tightness, viability of 1mm gap.

Tests based on expected working conditions should be defined by end of 2025 to conclude R&D phase.

EIC Project R&D DAC Review – Summary/Highlights

Photosensors

DAC commends the preparation of the testing infrastructure for timing and ageing studies and clear definition of the testing program.
Positive news on the status of the EIC-HRPPD - launch programme of detailed characterisation in the institutes.
Recommend careful planning towards testing photosensors coupled to the EICROC/FCFD ASICs.
Strongly recommend approval of funding though modest to conclude studies in 2025.

ASICs, Frontend Electronics

DAC commends progress on all sub-proposals of eRD109 – clear development paths.
Concern over delays in submission milestones, resulting delays in integration with detector technologies (EICROC1/FCFD for the AC-LGAD; HRPPD, MCP-PMT; SALSA for MPGDs; CALOROC for SiPMs).
DAC recommends that the proponents carefully plan the EICROC/FCFD ASIC testing with HRPPD/MCP-PMT to be ready as soon as ASIC availability permits it - steps are critical to ensure the specifications and performance of the ASICs are adequate for these sensors.

EIC Project R&D DAC Review – Summary/Highlights

R&D Summary Comments

Good progress in many R&D areas.

Many test beam runs completed, but more needed.

Many good lessons learned from prototypes, but large prototypes of final technologies needed.

R&D in many areas needs to continue into 2025 and conclude for CD2/3 late 2025.

Some R&D may need to continue as PED.