ePIC Collaboration Technical Coordinator Report

Silvia Dalla Torre

INFN TRIESTE

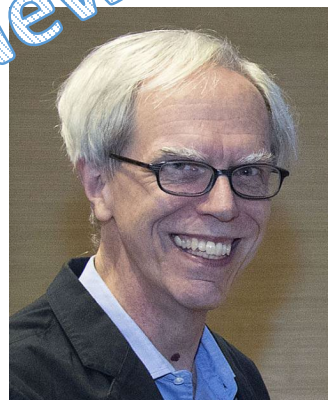
Electron-Ion Collider (EIC) Resource Review Board (RRB) Meeting
5th EIC RRB meeting, Prague, June 5-6, 2025

TC supported by the TC-office

TC-office members

Prakhar Garg
(Yale)

New



John Haggerty
(BNL)

Oskar Hartbrich
(ORNL)

Matt Posik
(Temple U.)

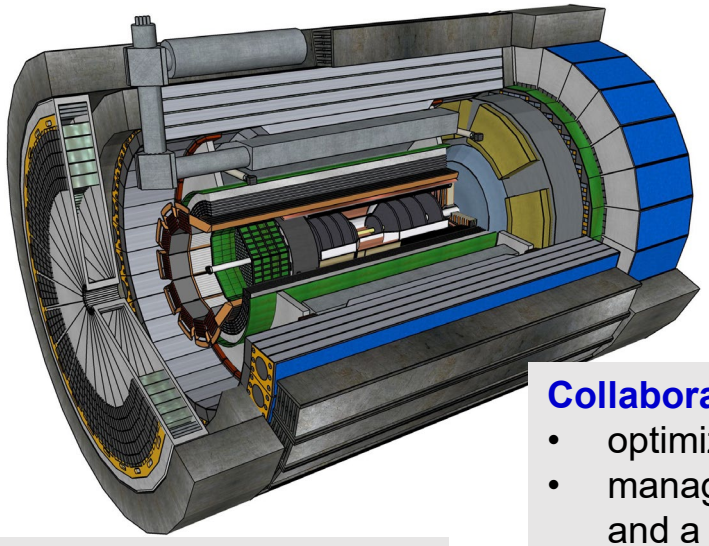
OUTLOOK

- The organizational model of the ePIC detector
- Intense ePIC detector activity towards engineering the subsystems
- Summarizing

The ePIC DETECTOR:

the combined EIC PROJECT and ePIC COLLABORATION efforts

ePIC (designed for IP6 at EIC) is the **Project Detector**



ePIC is the detector to which the **ePIC Collaboration** is dedicated

Project mission for the ePIC detector

- ensure that all aspects related to the EIC project realization and completion are satisfied

Project support to the ePIC detector

- Administrative structure
- Engineer team
- Financial support
  - Past : mainly via R&D program
  - Present: mainly via PED (Project Engineering & Design)
  - After CD3: construction

Collaboration mission for the ePIC detector

- optimize the physics reach of the detector
- manage the Collaboration to make it functional, effectively operative and a professionally sound environment

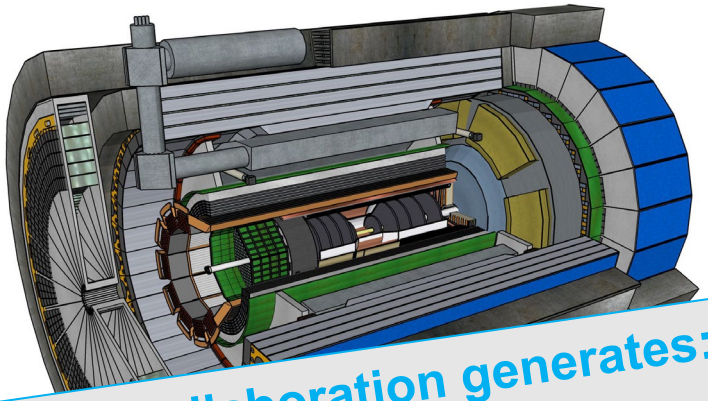
Collaboration support to the ePIC detector

- Scientific workforce
  - For hardware, software and dedicated physics studies
- Support
  - Staff members
  - Past and present: international cofinancing R&D, PED
  - International in-kind contribution to constructions

Beyond these specificities, **Project and Collaboration are synergistically cooperating** across the two missions towards the common goal:
a detector matching the overall EIC physics scope.

The ePIC DETECTOR:

the combined EIC PROJECT and ePIC COLLABORATION efforts



ePIC (designed for IP6 at EIC) is the **Project Detector**

ePIC is the detect… which the …dicated

Project missi…
- ensure that … completion

Project suppor…
- Administrativ…
- Engineer tea…
- Financial sup…
  - Past : m…
  - Present:…
  - After CD…

…effectively operative

…cs studies

…&D, PED …ions

Membership in the ePIC Collaboration generates:

- The large majority of **detector-dedicated scientific workforce;**
- The whole **complementary scientific workforce for simulation and physics studies** (these two ingredients are key for the optimization of the detector physics reach and for the detector R&D and engineering details);
- The motivation for the **in-kind** (they are agreed upon by Institutions and Agencies; they typically arise from the bottom-up pressure by scientists in the collaboration).

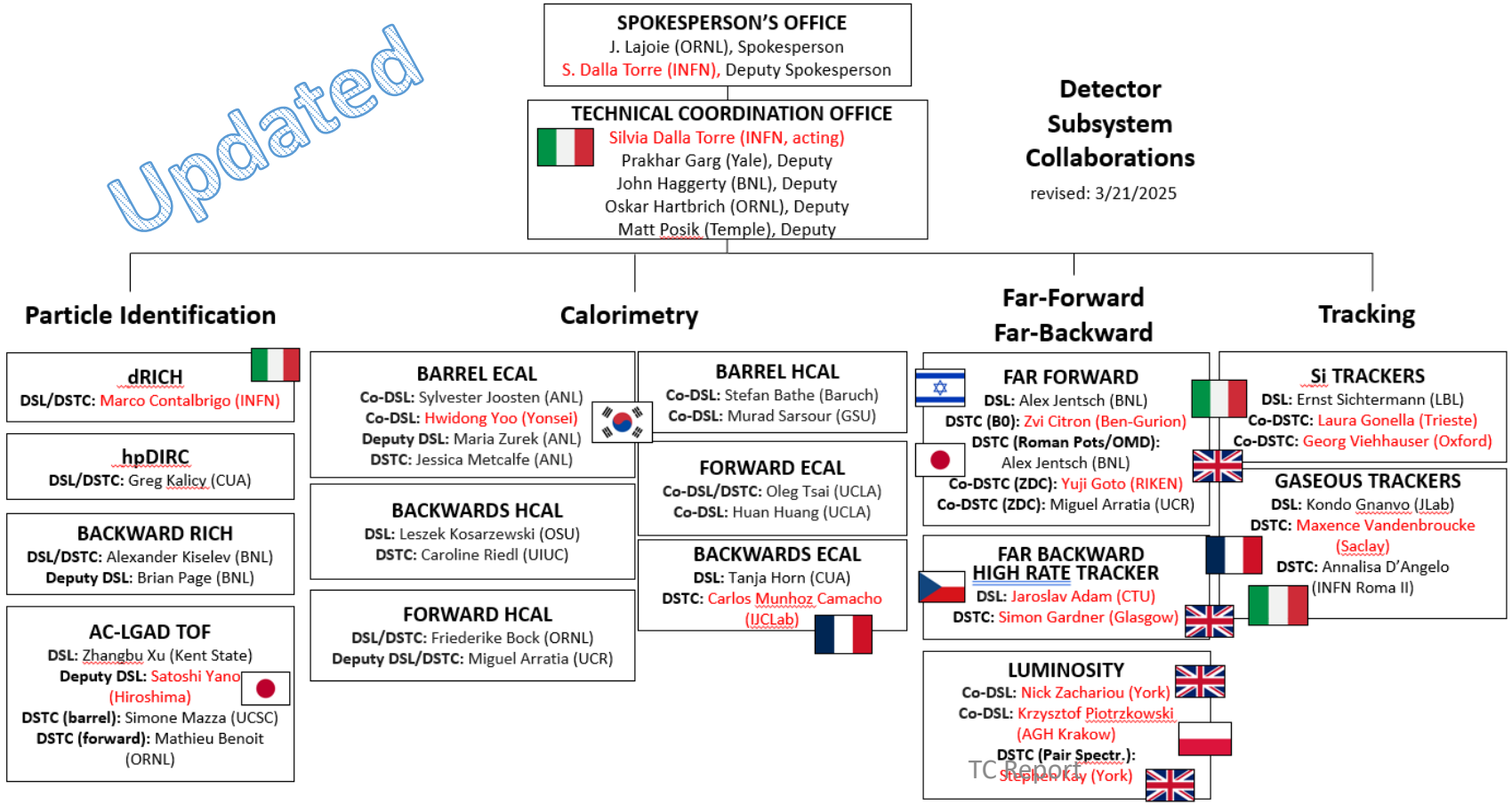
…specificities, **Project and Collaboration are synergistically cooperating** across the two missions towards the common goal:
a detector matching the overall EIC physics scope.

Engagement in hardware efforts (detector subsystems) within ePIC

Within ePIC, each subsystem is realized by a Detector Subsystem Collaboration, DSC (15 DSCs, in total) guided by a Leader (DSL) or two co-Leaders assisted by Technical Contacts (DSTC)

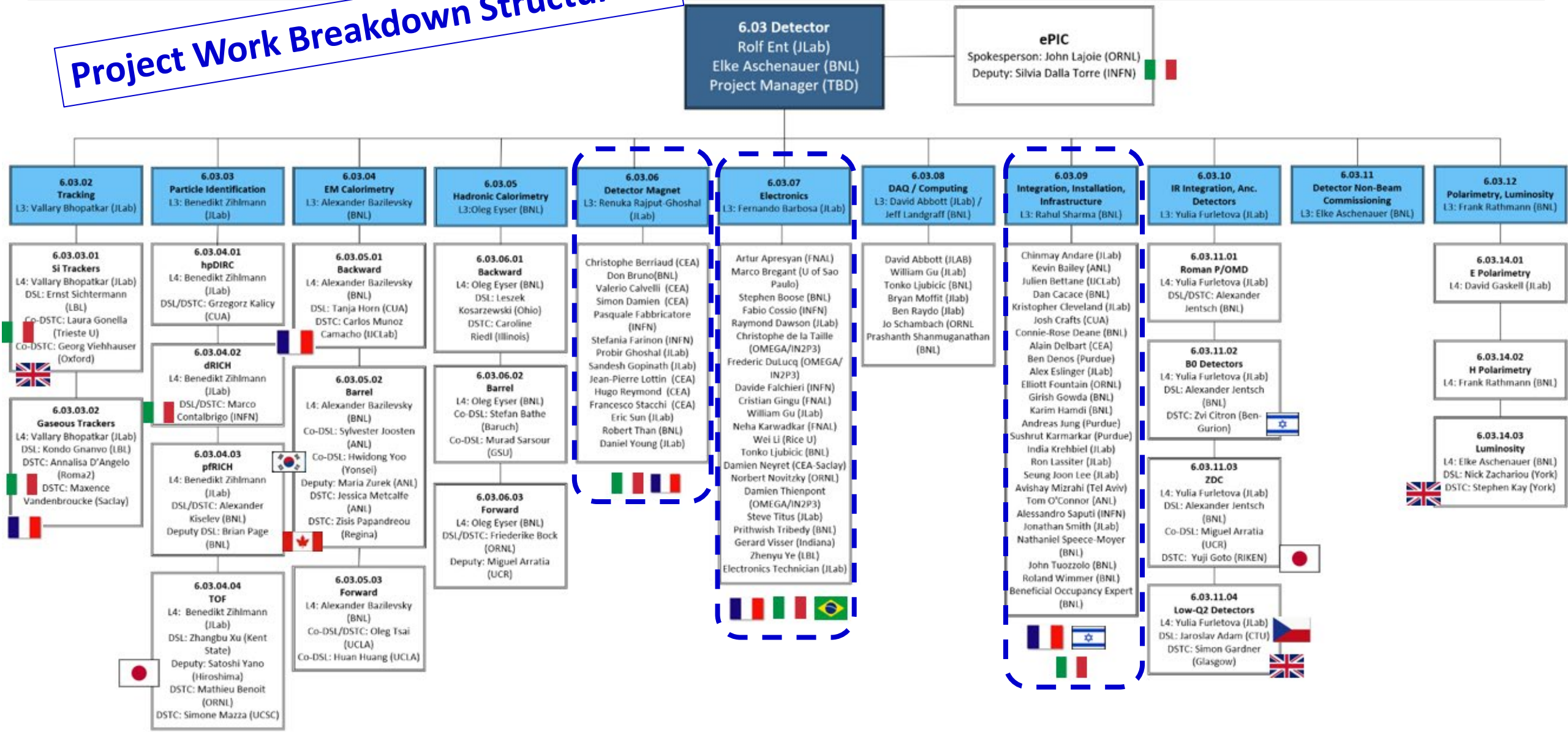
- The internal organization of the various DSCs is different because it is designed by each DSC autonomously
- The DSCs select their DSLs and DSTCs
- The autonomy of the DSCs guarantees flexibility as needed and ensures motivation and enthusiasm

Detector consistency is ensured by
- ePIC Technical Coordination
- **Role of DSLs/DSTCs in the Project**



The combined EIC PROJECT and ePIC COLLABORATION efforts: HOW?

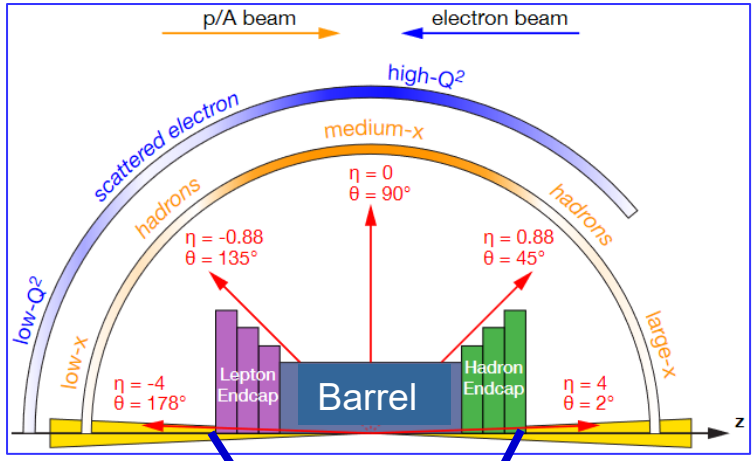
Project Work Breakdown Structure

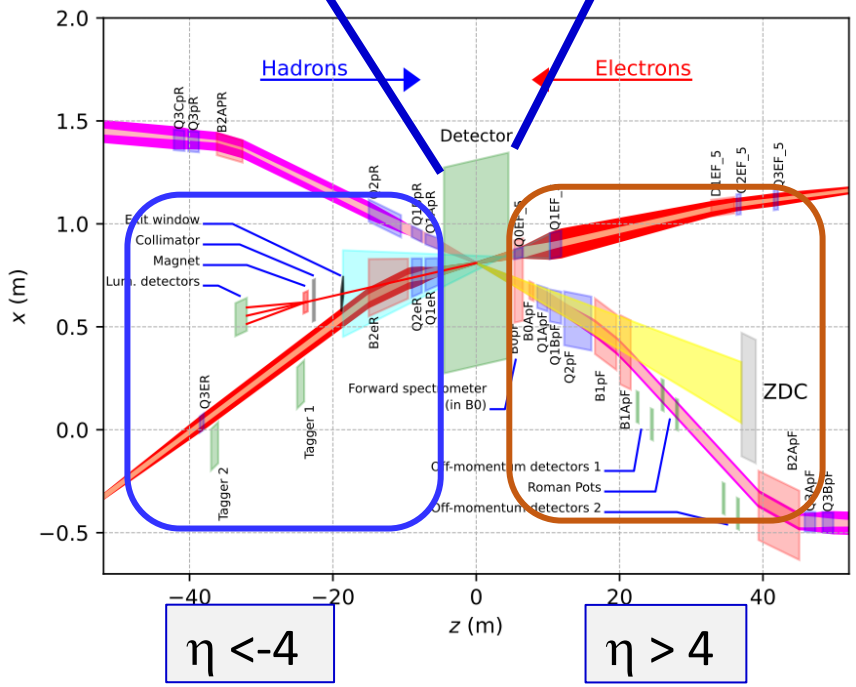


OUTLOOK

- The organizational model of the ePIC detector
- Intense ePIC detector activity towards engineering the subsystems
- Summarizing

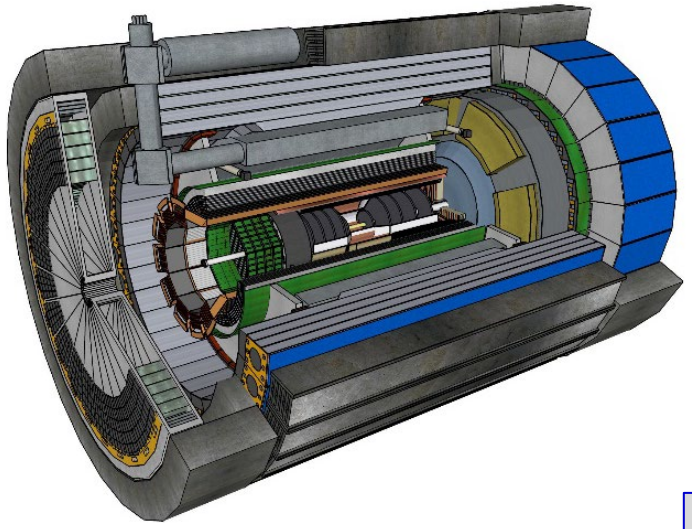
The ePIC Detector





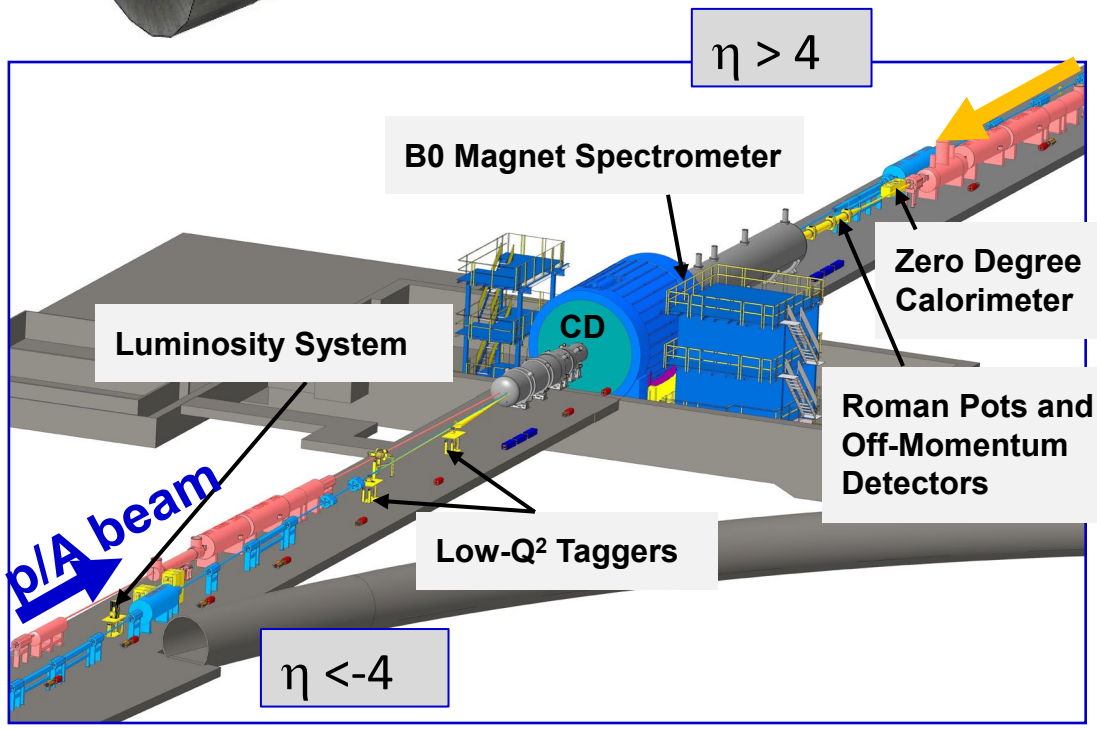
η <-4

η > 4

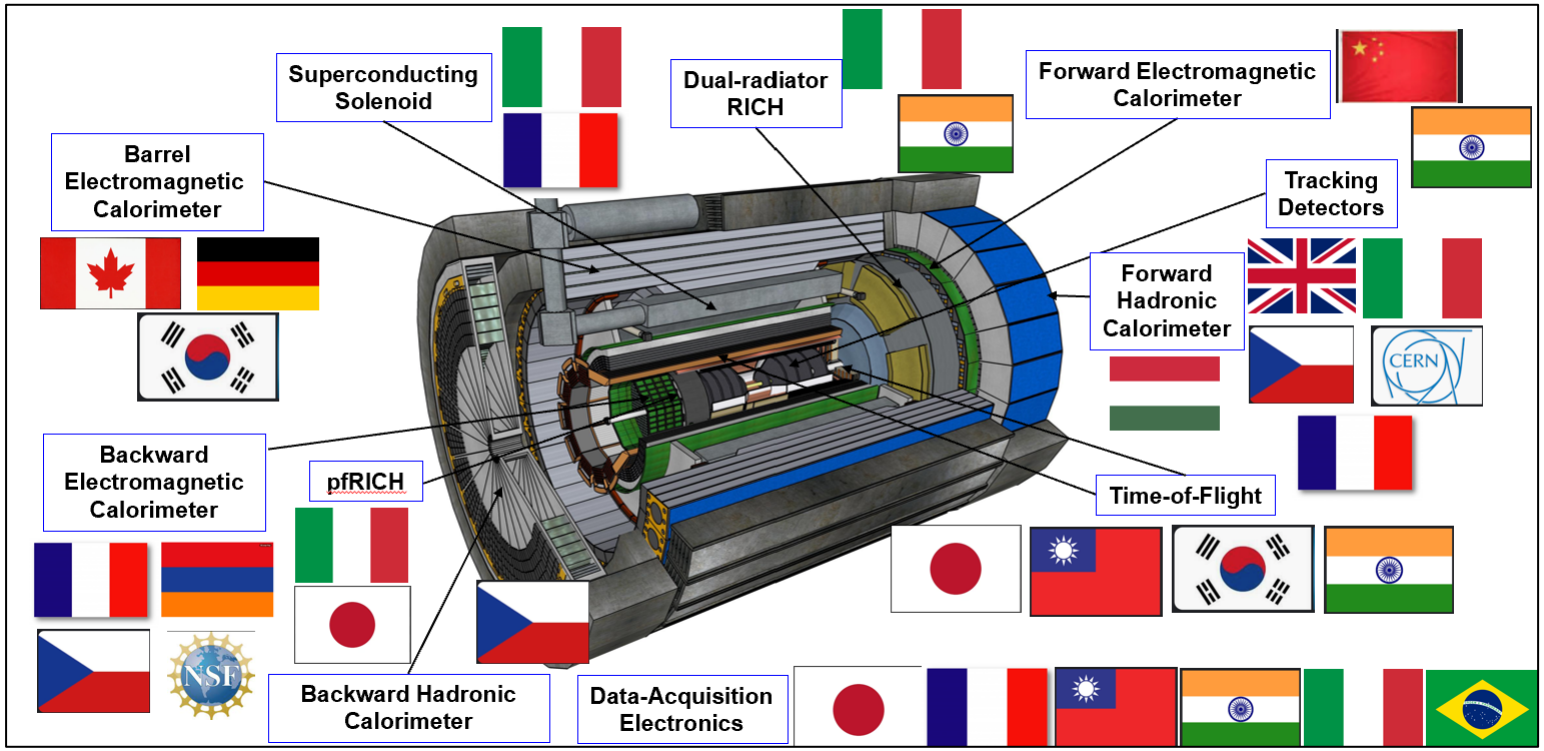


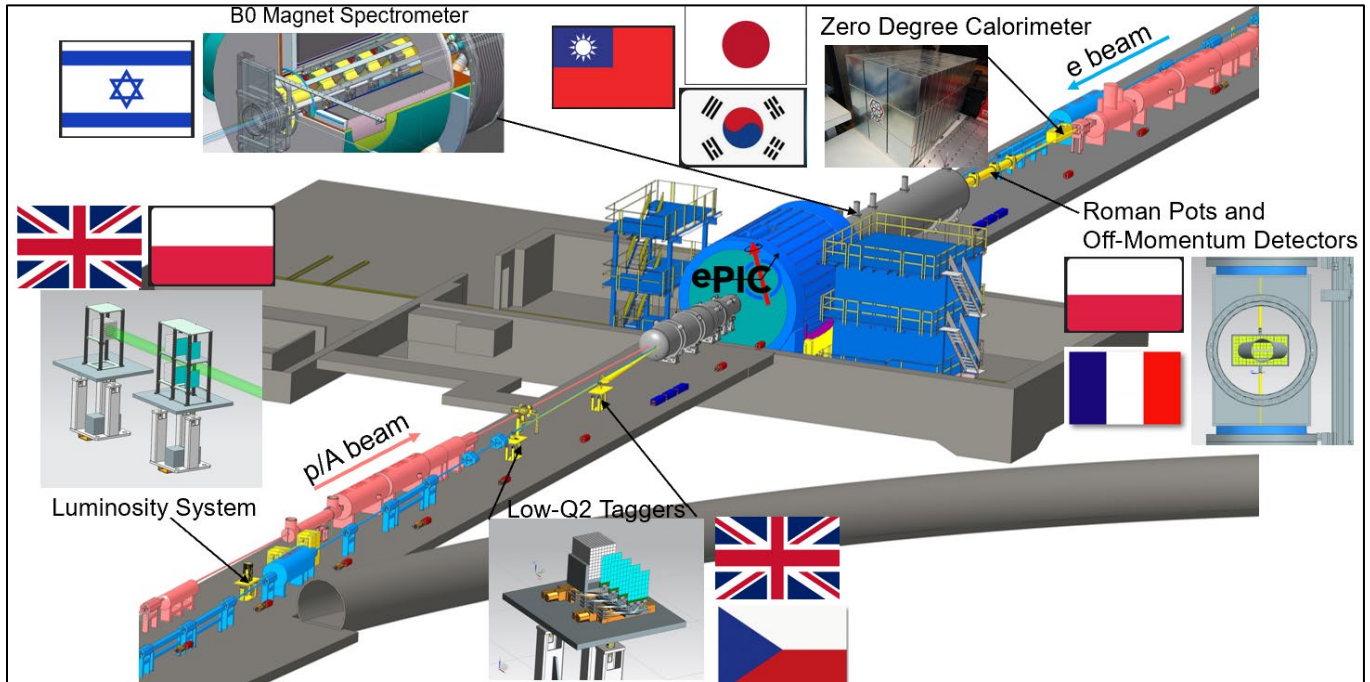
Central Detector (CD)

$-4 < \eta < +4$



ePIC Detector and International Collaborators





2025 Beam Tests, Irradiation Campaigns and Lab Studies

As from planning in November 2024

Far Backward + Luminosity Systems

- Shared beam — Mainz A2

Far Backward:

- 2 layer timepix4 + readout at Mainz
- Planning for ~week at JLAB for integration of timepix4 with DAQ prototypes

Luminosity:

- Few calorimeter prototypes (out of 60 total needed) at Mainz
- Comparing response custom SiPM boards to classical PMT readout
- JLAB test next year with EEEMC (to be scheduled) for DAQ prototype test

Far Forward (Calo)

- Calorimeters: single crystal irradiation test in LHC tunnel

AC-LGAD: TOF, Far Forward

- Time requested at JLab and KEK

hpDIRC

Running with cosmic ray telescope at Stony Brook and incrementally updating setup

dRICH

- Submitted request for two beam times at CERN in 2025:
- Real-scale dRICH prototype: two weeks
  - Single sector, composite material, realistic optics
- dRICH readout with dedicated ePIC RDO: one week in Fall

Silicon Vertex Tracking

- irradiation test of babyMOSS at UC Davis in January 2025
- Requested several weeks of FNAL beam time (December, February), but unclear.

2025 Beam Tests, Irradiation Campaigns and Lab Studies 2/2

As from planning in November 2024

Gaseous Trackers

	µRWELL-BOT & synergetic effort	µRWELL-ECT & synergetic effort	CyMBAL & synergetic effort
PED Engineering Test Article	- CERN (requested): EIC ePIC MPGD Fall 2025 - SPS/PS - CERN (to be requested): DRD1 beam test - Fall 2025 ➔ include B-field test	- CERN (requested): EIC ePIC MPGD Fall 2025 - SPS/PS	- CERN (requested): EIC ePIC MPGD Fall 2025 - SPS/PS
eRD108 Cylindrical µRWELL	- JLab (requested & funded): Hall D EIC Test beam		

Backward ECAL (EEEMCAL)

- Requested DESY February or May 2025
- JLAB spring/summer 2025, to be defined

Barrel ECAL (BIC)

Korean groups:

- Submitted request for CERN 2025: One week at PS in August
- Bigger module with Astropix + Pb/SciFi layers to validate integrated operation

ANL:

- Plan for two 2 week beam times at FNAL

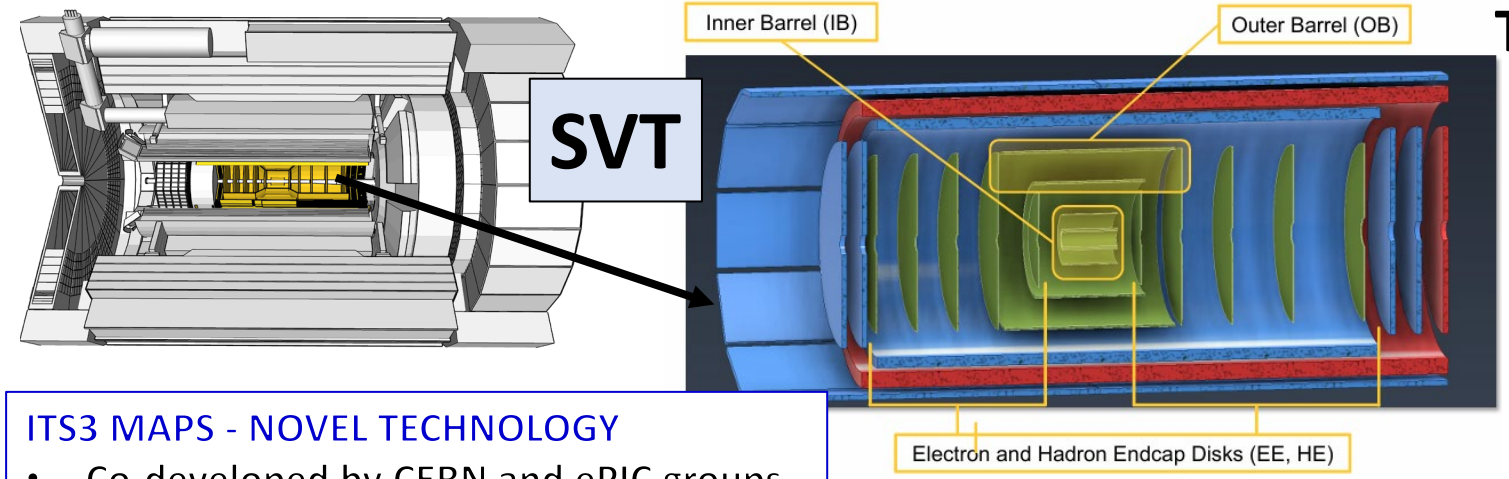
Forward HCAL

- Requested one week of CERN PS + one week of CERN SPS in Fall '25.
  - 8 fully instrumented LFHCAL modules with HGCROC readout
  - Open to accommodate parasitic beam use, especially trackers.
- Planning for tile + SiPM irradiation campaigns in LHC tunnel (in ATLAS ZDC area)

HGCROC Beam Times

- HGCROC ASIC planned/evaluated for various ePIC systems and other HEP experiments
  - ePIC: calorimeters, pfRICH, …
  - CMS HGCAL, ALICE FOCAL, …

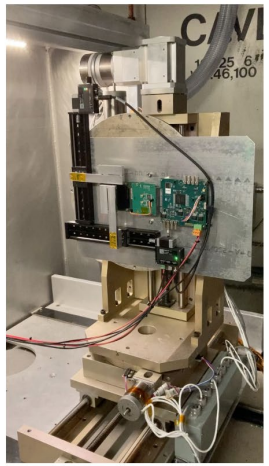
Progress towards detector engineering by TestBeams and Lab Studies



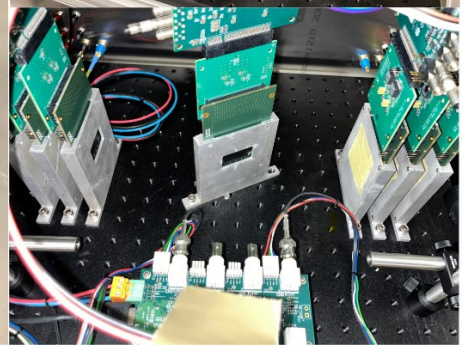
ITS3 MAPS - NOVEL TECHNOLOGY

- Co-developed by CERN and ePIC groups

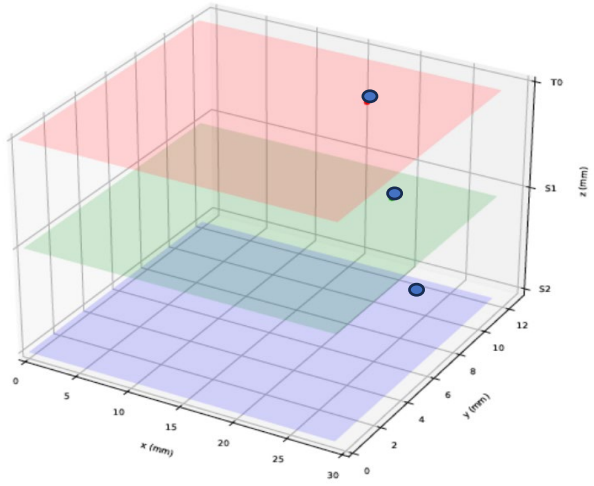
Testbeam at BASE (Berkley), May 2024



BabyMoss testbeam

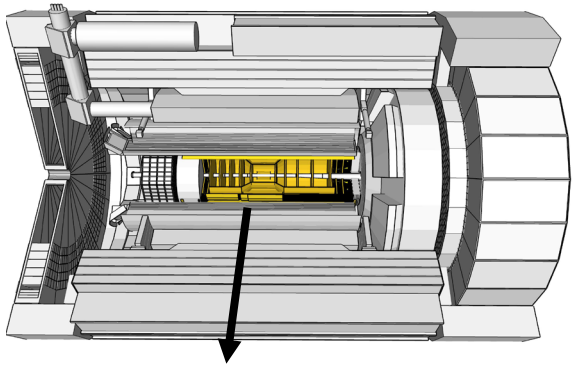


Recorded Cosmic Events



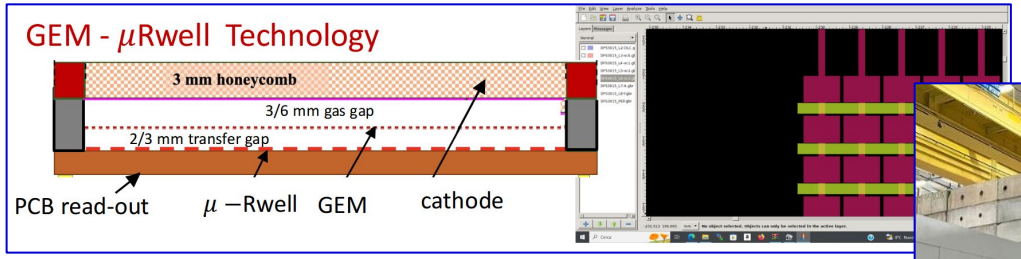
Test beam at FNAL, June-July 2024

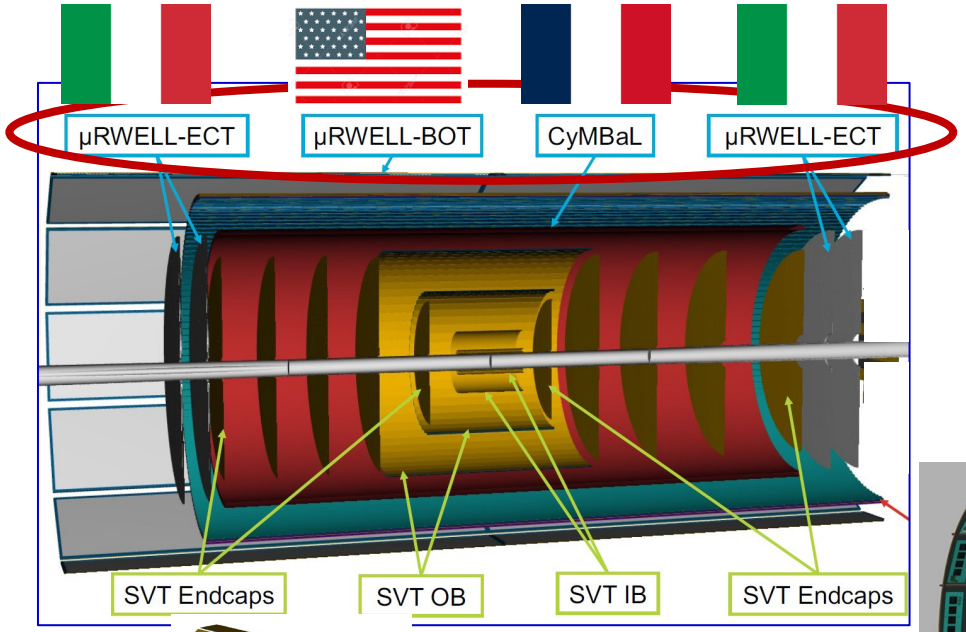
Progress towards detector engineering by **TestBeams** and **Lab Studies**

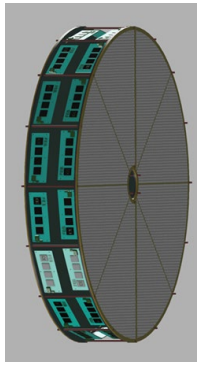


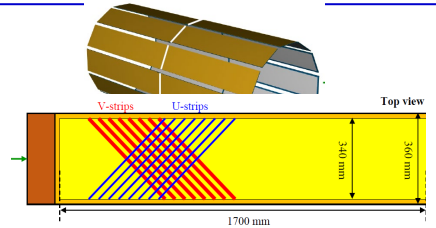
MPGDs

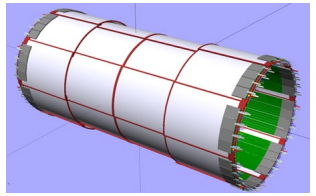
November 11 – 28 Test beam @ PS-T10 - CERN

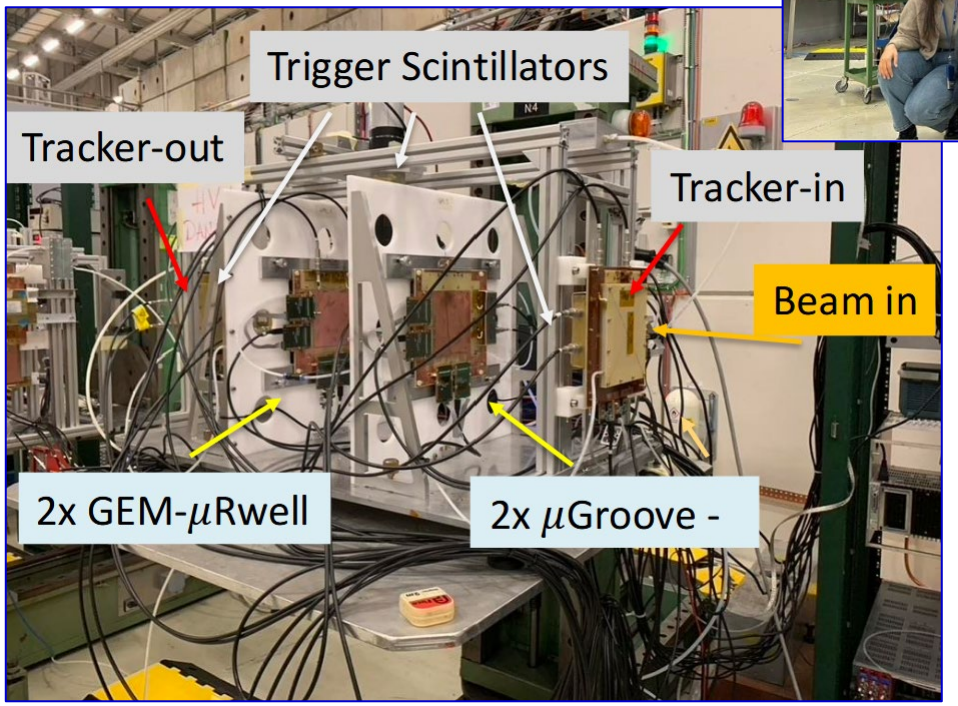












Further effort in 2025 in cross-cutting mode:
all ePIC MPGD technologies

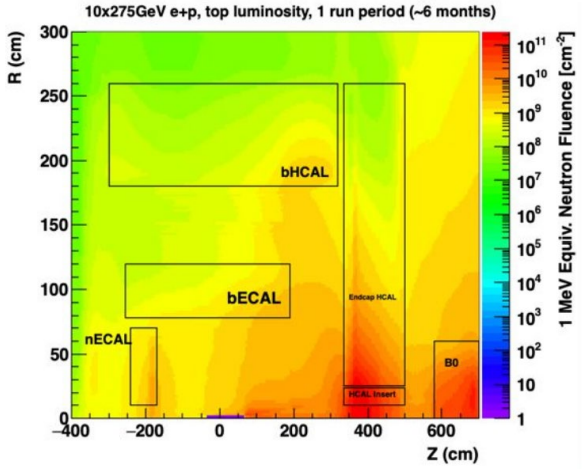
SENSORS for ePIC CALORIMETRY

SiPM sensors for all Calorimeters

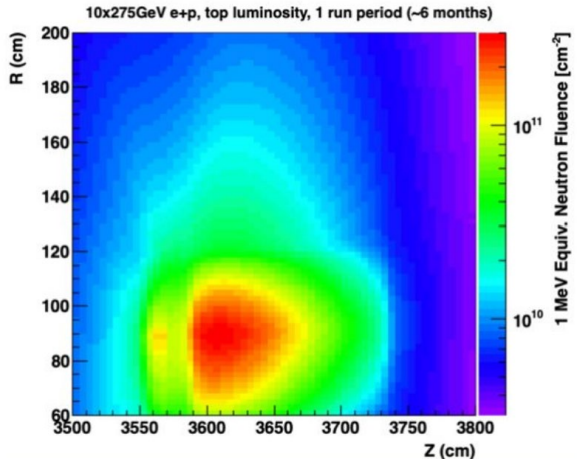
→ Irradiation campaigns for all SiPMs type foreseen in ePIC Colorimetry

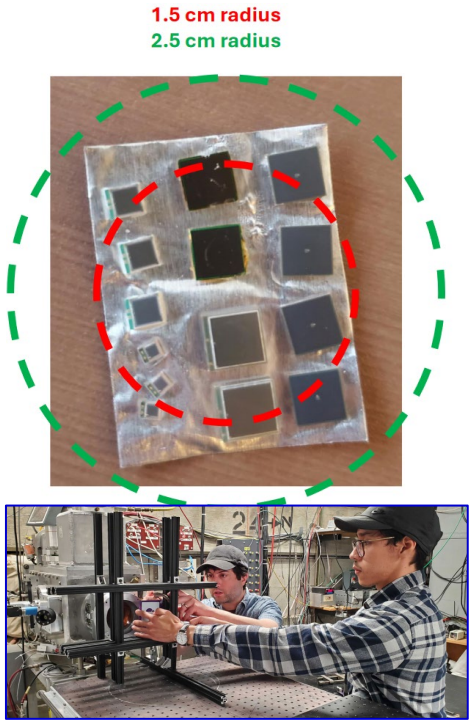
Rad Dose

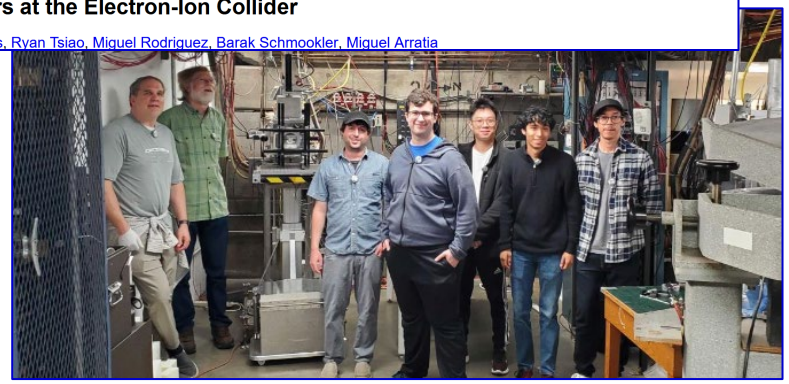
Central detector

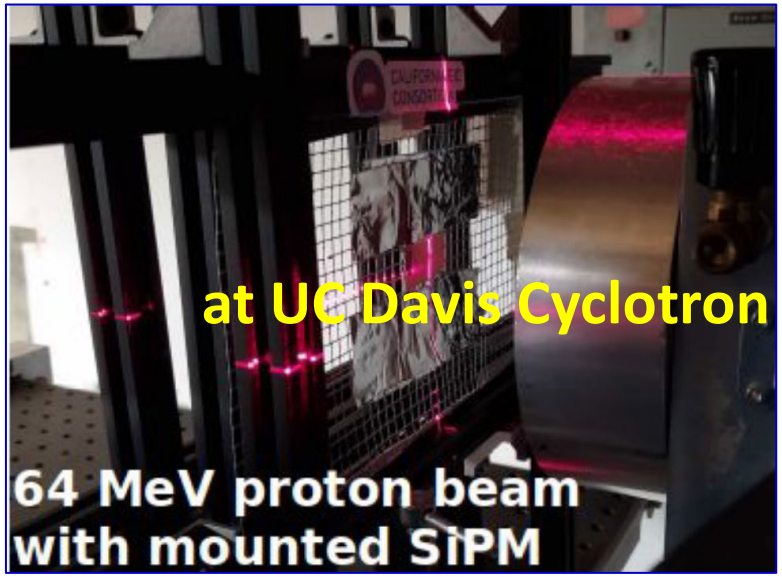


Far detectors









arXiv > physics > arXiv:2503.14622 Search... Help

Physics > Instrumentation and Detectors

[Submitted on 18 Mar 2025]

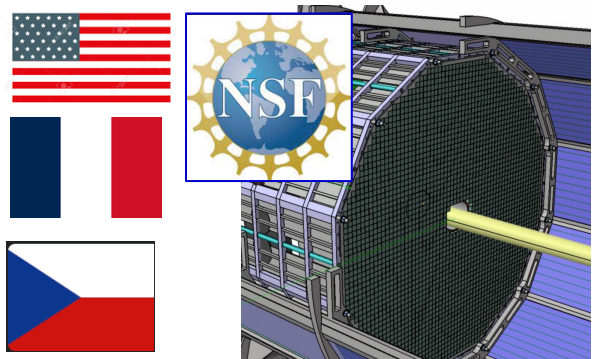
Measurement of SiPM Dark Currents and Annealing Recovery for Fluences Expected in ePIC Calorimeters at the Electron-Ion Collider

Jiajun Huang, Sean Preins, Ryan Tsiao, Miguel Rodriguez, Barak Schmookler, Miguel Arratia

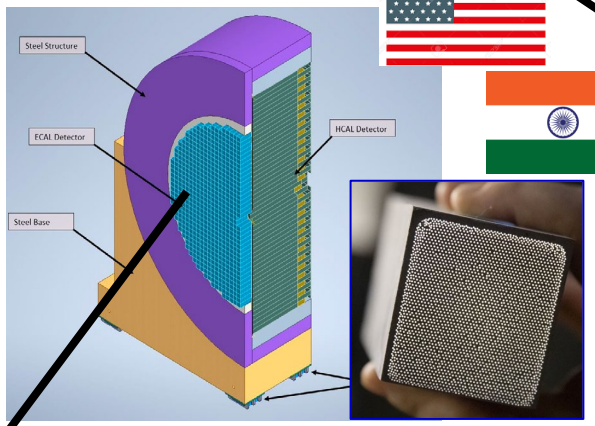
Models of SiPMs	10^8 N_{p^+}	10^9 N_{p^+}	10^{10} N_{p^+}	10^{11} N_{p^+}	10^{12} N_{p^+}	10^{13} N_{p^+}	ePIC Detector Usage
S14160 1315PS	1	3	3	3	3	2	nHCAL, pHCal
S14160 3015PS	1	2	2	3	3	1	nEMCAL , bHCAL, pHCal(Insert), ZDC
S14160 6015PS	1	1	1	2	2	1	nEMCAL, bEMCAL, pEMCAL
S14160 6050HS	2	4	4	4	4	2	bEMCAL , pEMCAL, pHCAL (Insert), ZDC
S13360 6050VE	2	2	2	2	2	0	bEMCAL

ELECTROMAGNETIC CALORIMETRY

Backwards EMCal
PbW04 crystals, fine granularity



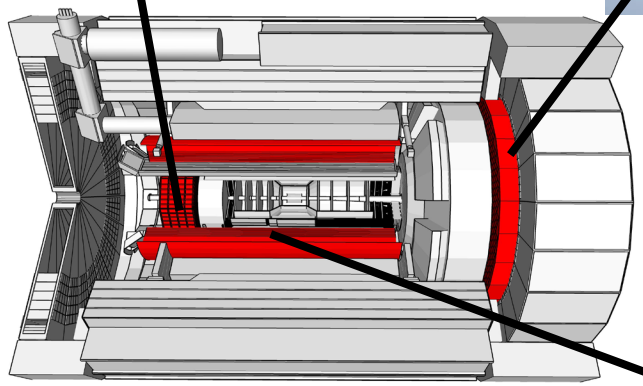
W/SciFi with W
powder in epoxy



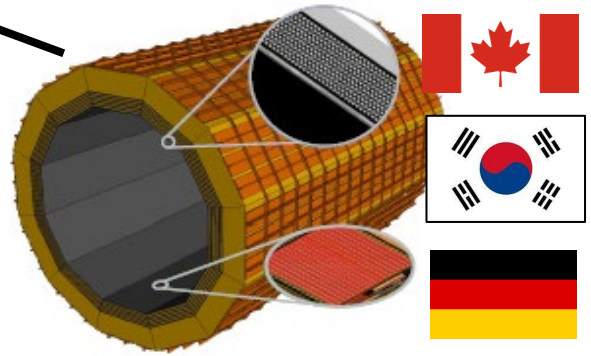
Same technology in far detectors

- in B0 far forward detector
- in luminosity pair spectrometer:
  first prototype realized!

- In low Q^2 taggers (far Backward)



Hybrid imaging
calorimeter,
Astropix MAPS and
Pb/Scifi

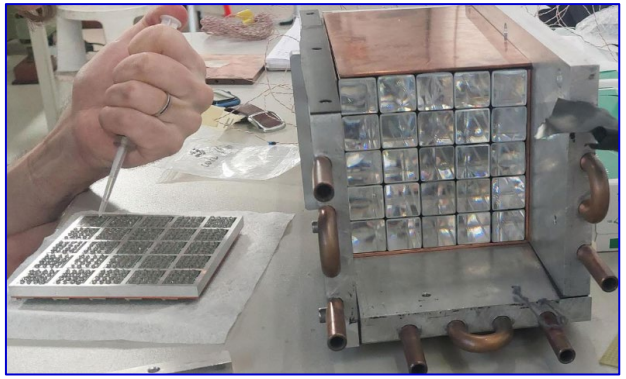


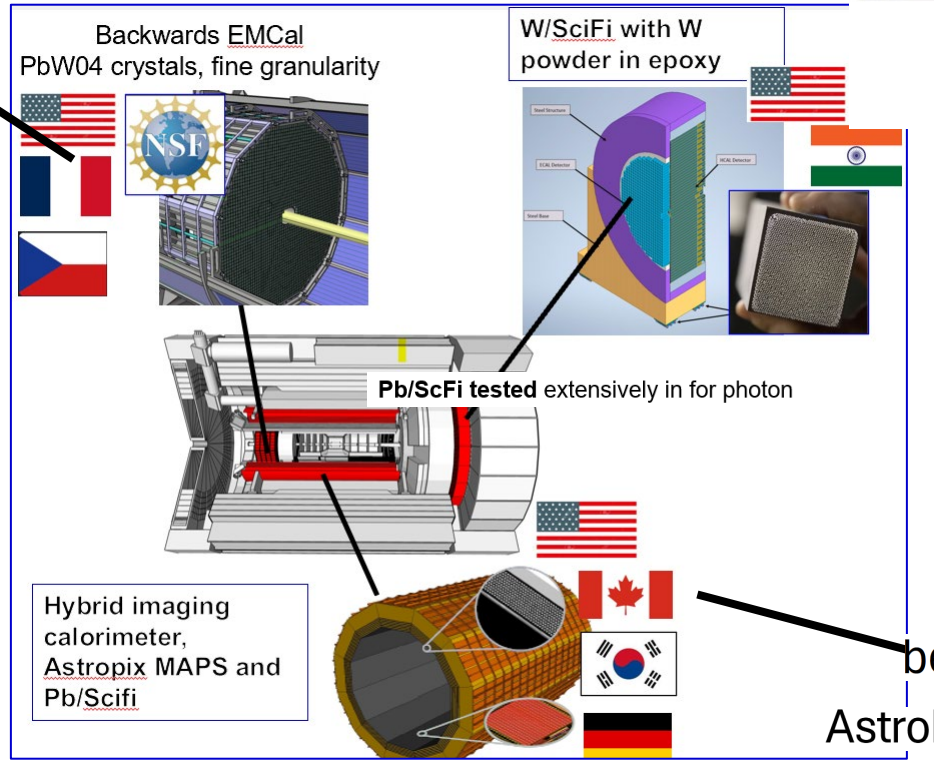
ELECTROMAGNETIC CALORIMETRY

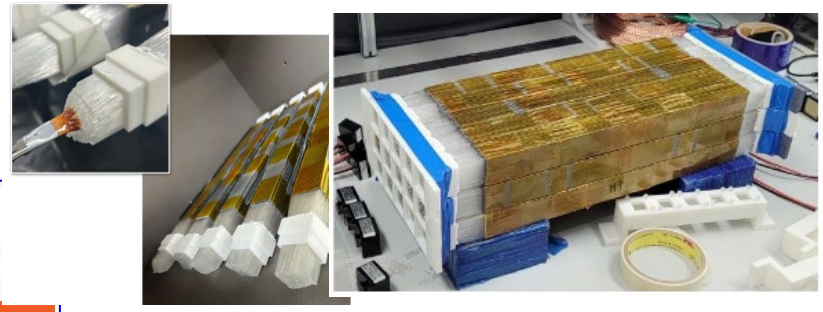
Backward ECal, test beams at DESY:

- Feb 17- Mar 2
- Mar 28 – April 7

Among the goals comparison of R-O with FEE ASICs vs COTs



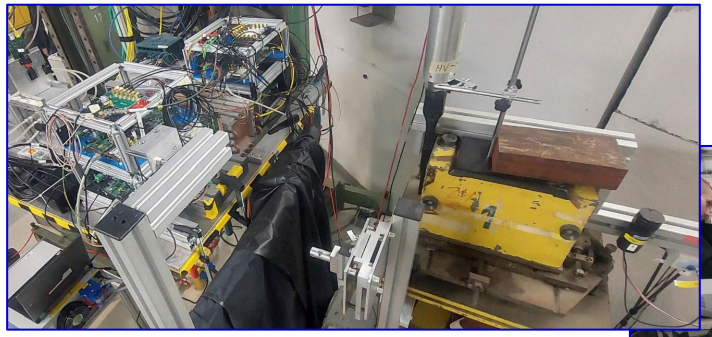


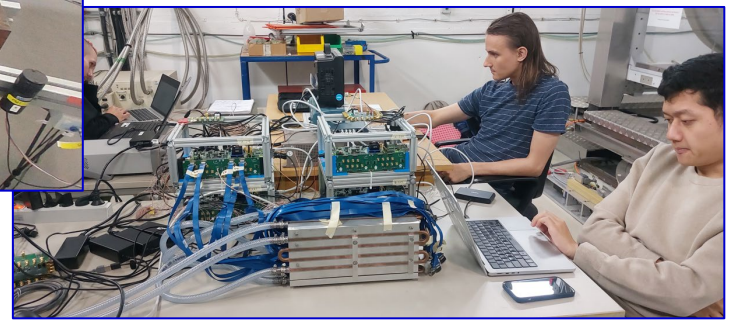


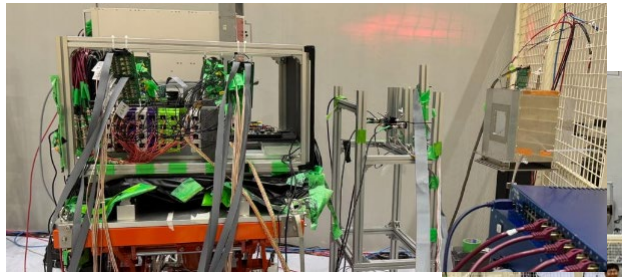
beam test in Aug 2024 at CERN PS T10

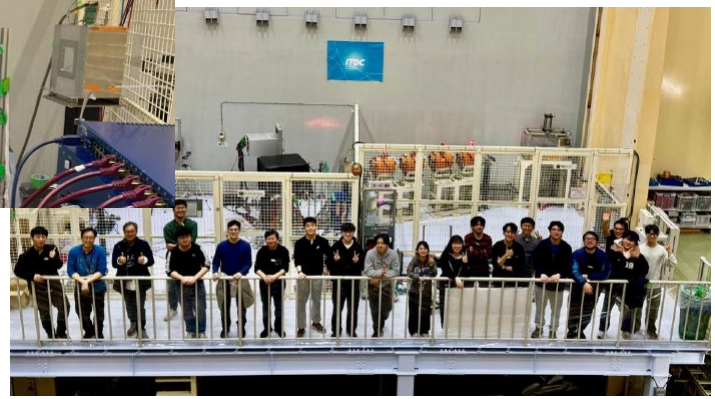
beam test in Mar 2025 at KEK PF-AR

AstroPix data taking between Pb/SciFi layers





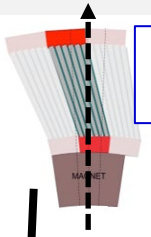




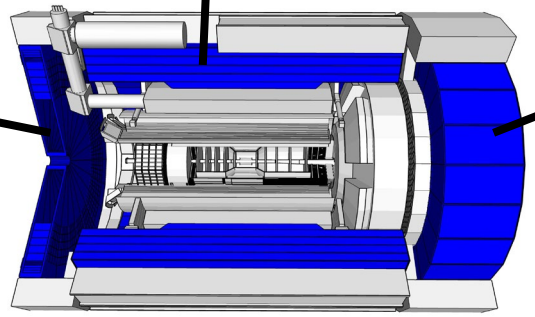
HADRONIC CALORIMETRY

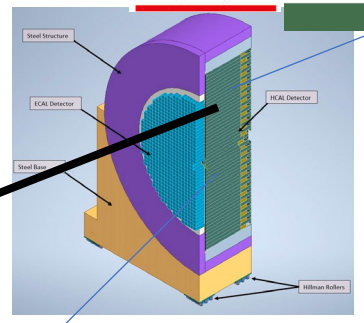
H Calorimetry in ePIC:
Steel/scintillator sampling calorimetry

Backward Hcal

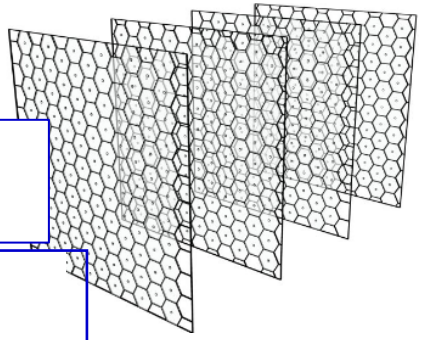


Barrel Hcal
(re-use from sPHENIX)

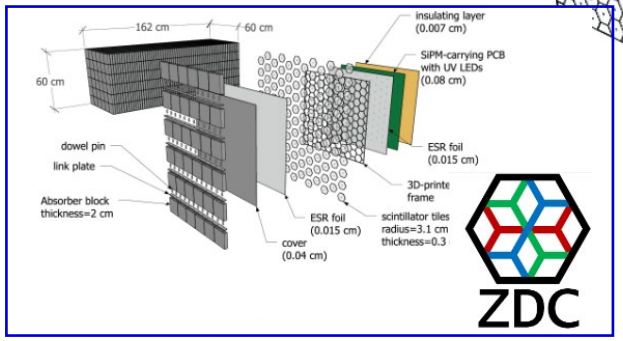


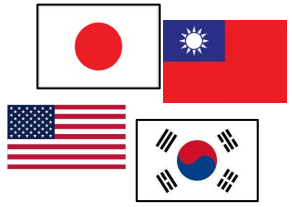


INSERT by the same technology
with finer granularity at high η

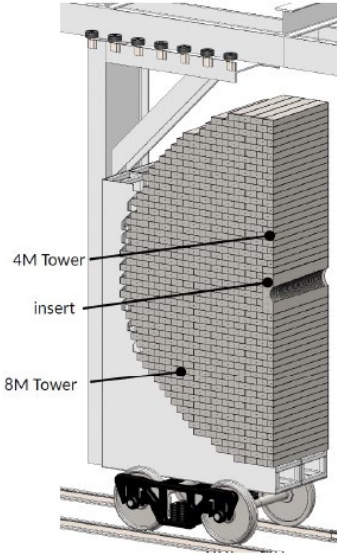


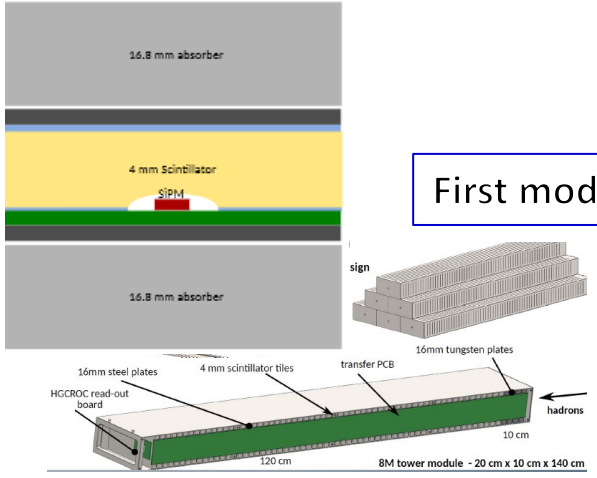
Same technology :
- Zero Degree Calorimeter





Forward Hcal: INNOVATIVE ORIGINAL DESIGN : "SiPM on tile"
- inspired by CALICE developments adopted by ePIC

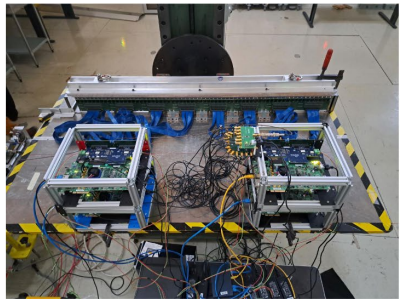




Same technology :
- Backward Hcal

ZDC module tested at STAR in 2024

First module at test beam (Sept/Oct 2024)

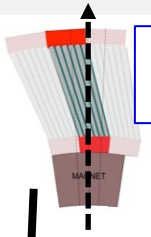


HADRONIC CALORIMETRY

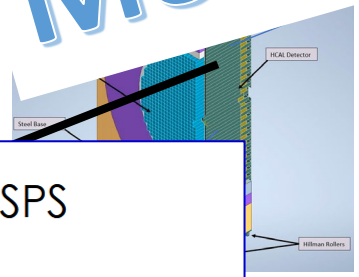
etry in ePIC:
illator sampling calorimetry

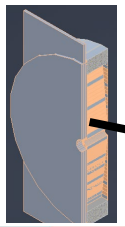
Moving to 2025

Backward Hcal



Barrel Hcal
(re-use from sPHE



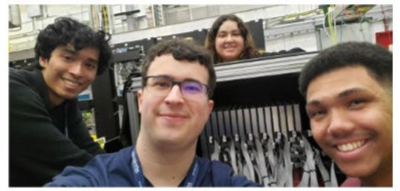


- 2023: mini-LFHCAL @ CERN SPS
  - 10 layers
- 2024: LFHCAL @ CERN PS
  - 65 layers, single full module
  - Single channel CAEN + HGCROC readout
- 2025: LFHCAL @ CERN
  - 8*65 layers, 8 full modules
  - Summed HGCROC readout

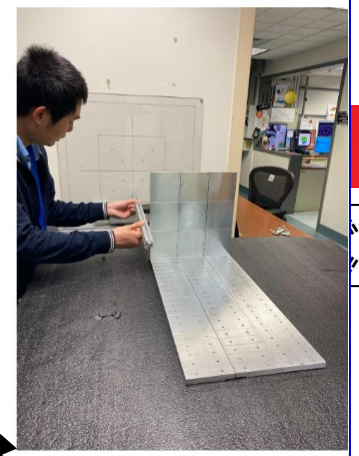
by the same technology

2024-2025 Brookhaven National Laboratory

2025 Jefferson Lab
Modular:
Toward an engineered design



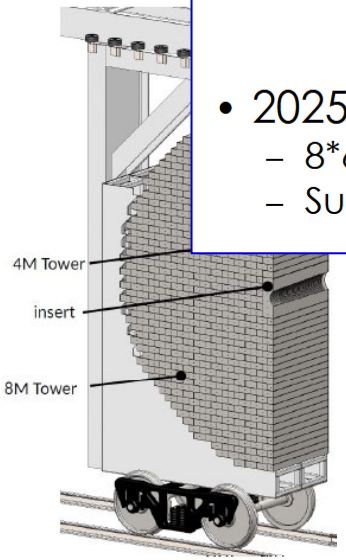
2025 Brookhaven National Laboratory NASA

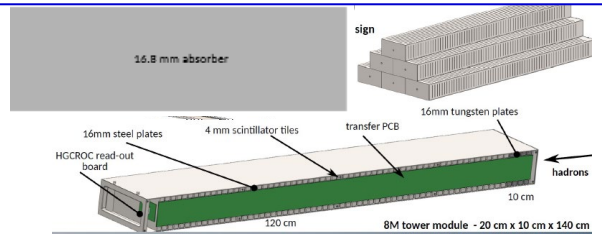


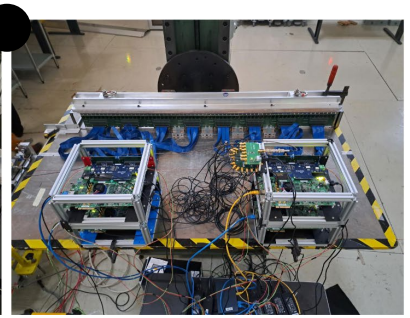
SIGN : "SiPM on
opted by ePIC

Same techno
- Backwar

est beam (Sept/Oct 2024)







PARTICLE IDENTIFICATION

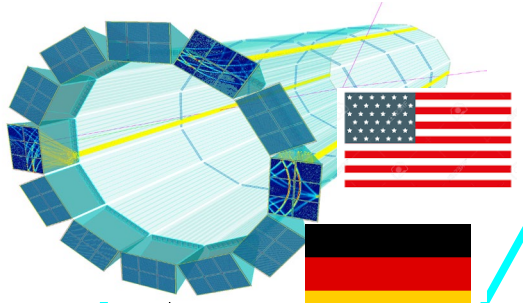
Cherenkov imaging PID in backward endcap:

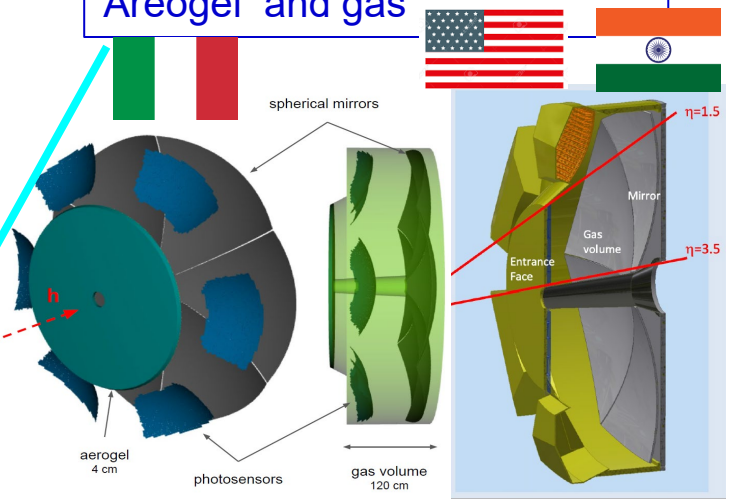
proximity focusing RICH (pfRICH)

High performance DIRC (hpDIRC)

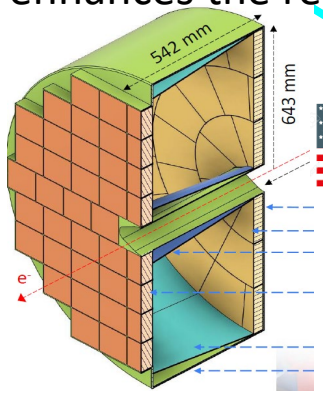
High performance thanks to **focalization** and **fine photosensor pizelization**

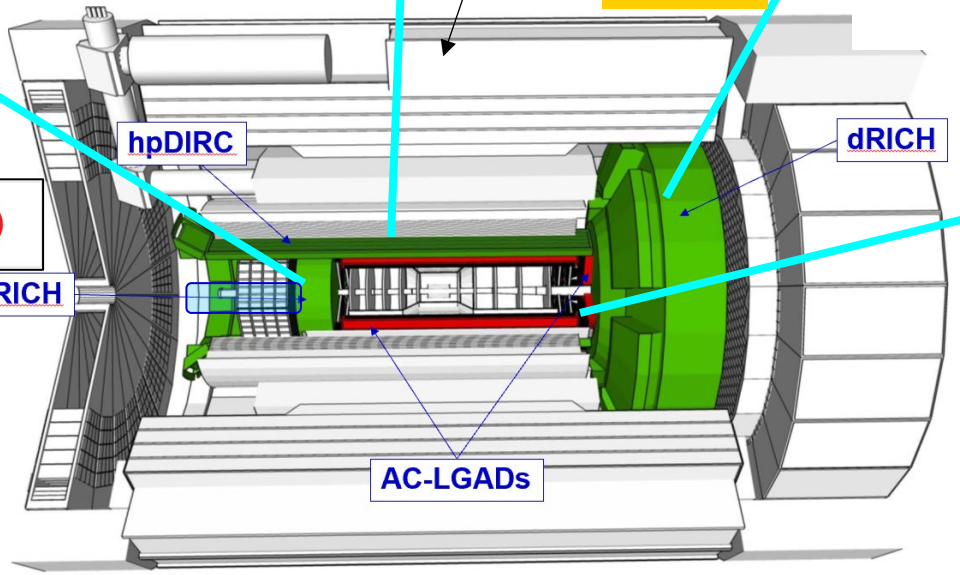
Dual radiator RICH (dRICH);
Areogel and gas

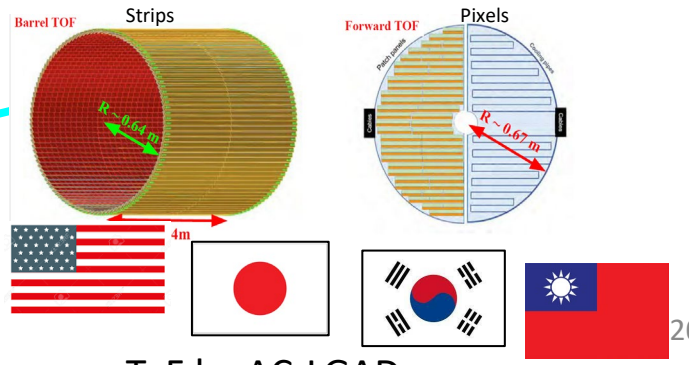




The long proximity gap (~ 35 cm) enhances the resolution







ToF by AC-LGADs

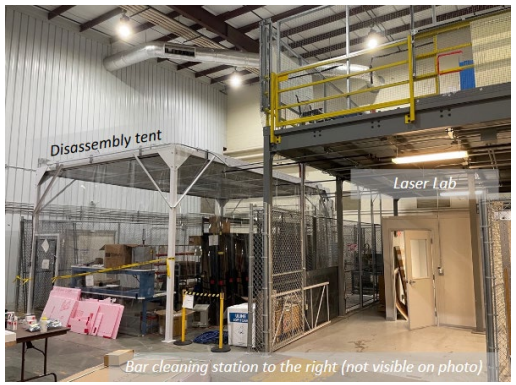
Goals for the application in ePIC:

- 30 μm space resolution
- 25-35 ps time resolution

20

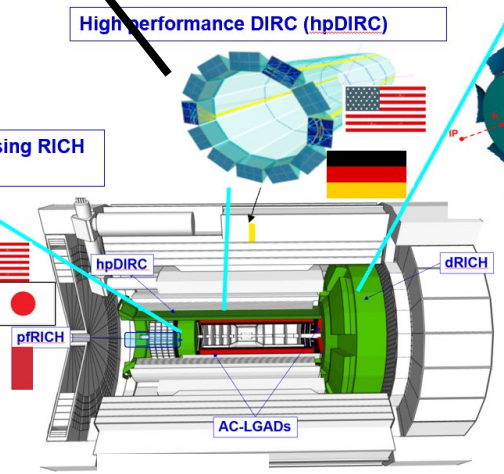
PARTICLE IDENTIFICATION – Cherenkov devices

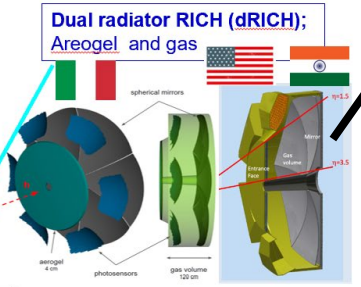
BaBar fused silica bars infrastructure for bar disassembling and testing

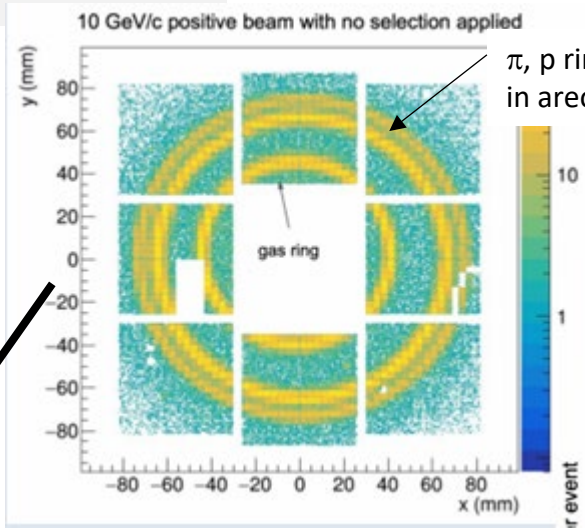


First bars successfully disassembled !

- Reused BaBar bars are an CD3-B item

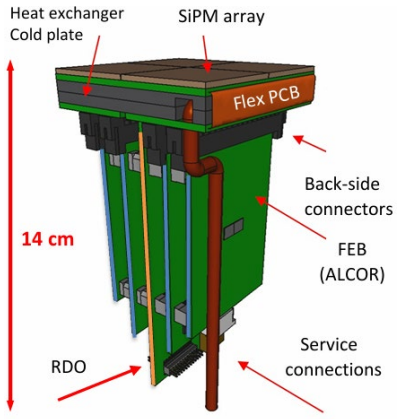


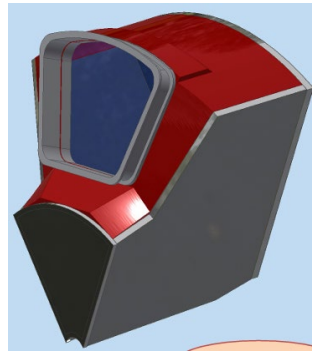




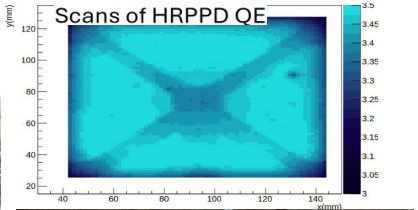
Building a full-scale prototype in 2025 to be validated in a testbeam in 2025

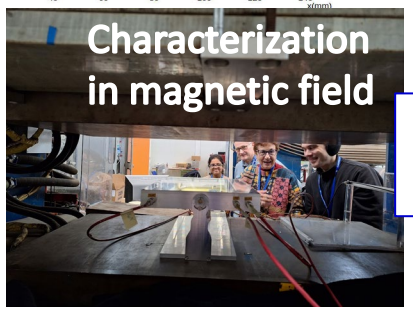
Engineered photon detector unit already used in 2024 testbeam





HRPPD characterization





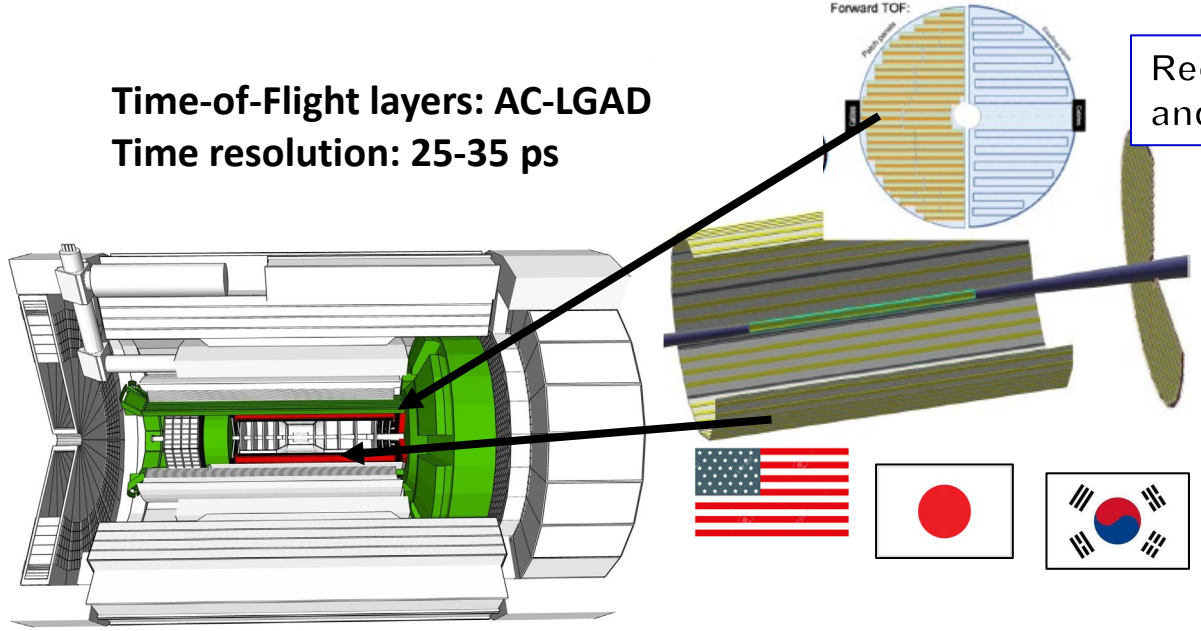
ageing studies ongoing in 2025

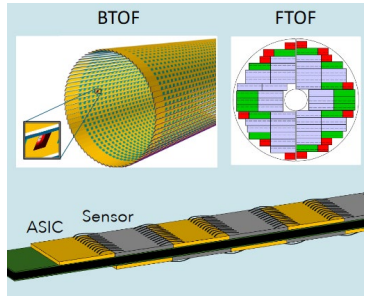
21

And MORE …

Time-of-Flight layers: AC-LGAD
Time resolution: 25-35 ps

Recent progress in sensor and detector design

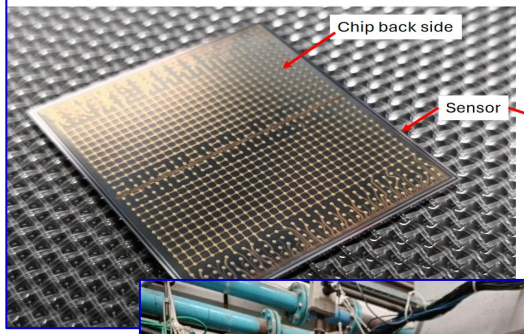


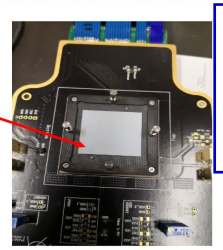


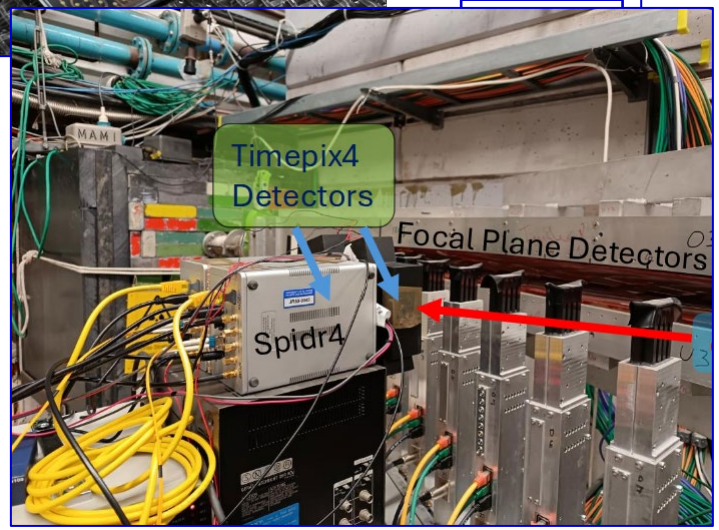
Low Q2 taggers (far forward detectors)
Tracking – Timepix4 Hybrid (ASIC+Si)
FRONTIER APPLICATION

Testbeam at MAMI A2 (Mainz) in January 2025

First Timepix4.1 TSV with Silicon Sensor

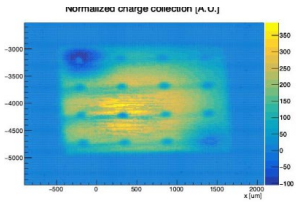


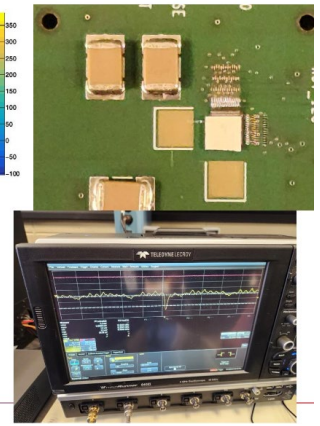




Same AC-LGAD technology :

- in Roman Pots and Off-Momentum detectors (far forward)
- recent results:
  - AC-LAD sensor coupled to the FE ASIC EICROC successfully tested!
  - Further step (May 2025) a sample with etched backplane now wire-bonded for noise studies
- in luminosity pair spectrometer (far backward)





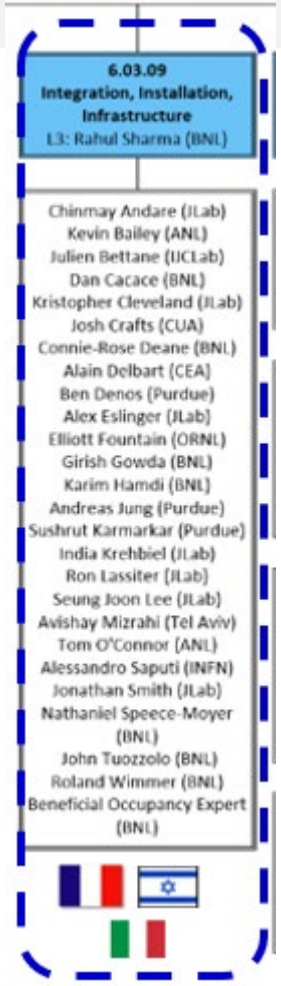
Progressing in Mechanics and Integration

Increasing integration of the Project engineers' team and the Collaboration DSCs

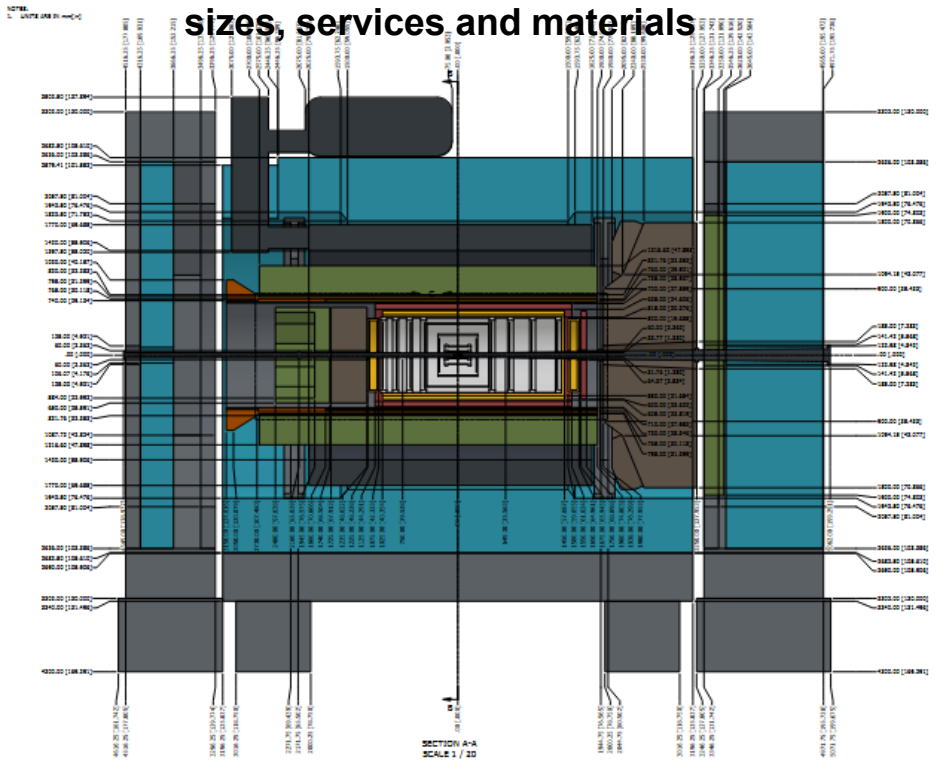
- Monthly update by the engineers to the ePIC Technical Integration Council

- Dedicated events:
  - Mechanics and integration sessions at the Collaboration meeting (July 2024 in Lehigh, January 2025 in Frascati)
  - Global Support Tube Workshop Meeting, BNL March 24th, 2025
    - Integration of SVT, ToF, MPGDs, pfRICH, EEEMCAL

- Weekly meetings of the Project engineers with the engineers from ePIC Institutions, now integrated in the EIC WBS



More and more detailed definition of sizes, services and materials



ePIC and the worldwide detector panorama:
ePIC detector technology document for **EPPSU2026** submitted (ID=17)

Enabling future detector technology within ePIC at the EIC

Contact persons: S. Dalla Torre*, D. Elia†, P.G. Jones‡, J. Lajoie§ and C. Munoz Camacho¶

On behalf of **the ePIC Collaboration**

Input to the European Strategy for Particle Physics - 2026 update

March 22, 2025

Abstract

The ePIC experiment at the EIC incorporates a wide variety of detector technologies. The different technological approaches are imposed by the broad EIC physics scope and by the nature of the collider, which is asymmetric in energy and beam particles, and by the wide variety of ion species that will collide with electrons. Major parts of the experiment use novel technologies, developed for application in ePIC and with applications at major coming experiments and facilities, worldwide. The ePIC detector is, therefore, both a stimulus toward innovative detector approaches and a testbench for the implementation of novel technologies in collider experiments.

This document is to underline the value of the ePIC detector in terms of technological developments and the options for collaborative efforts that can be beneficial to fundamental studies at high energies.

Novel detector technologies and implementations, techniques and methods in ePIC:

- ePIC solenoid
- A lightweight, MAPS based, Silicon Vertex Tracker
- Hybrid MPGD: µRWELL with GEM preamplification
- Innovative applications of SiPMs in calorimetry
  - SiPMs as sensors for a crystal electromagnetic calorimeter
  - W/SciFi electromagnetic calorimeter
  - SiPM-on-tile hadronic calorimeter
- Hybrid Si/PbSciFi electromagnetic calorimeter
- AC-LGADs
- Photosensors for Cherenkov imaging counters
  - High Rate Picosecond Photodetectors (HRPPD)
  - SiPMs
- New frontend ASICs with triggerless architecture
  - EICROC, CALOROC, FCFD, SALSA, ALCOR
- Innovative Compute-Detector Integration Using Streaming Readout
- Novel approaches to synchrotron radiation simulation

Context

- *One of the several submitted documents related to ePIC*
  - *EIC-LHC synergies (EICUG & ePIC effort), ID # 114*
  - *EIC accelerator (EIC accelerator collaboration)*
  - *DIS Physics*
  - *ePIC endorsing a document related to the relevance of computing in strategic terms*

OUTLOOK

- The organizational model of the ePIC detector
- Intense ePIC detector activity towards engineering the subsystems
- Summarizing

Take-away messages

- The **ePIC detector** is fully profiting of the opportunity offered by being, at the same time,
  - The EIC Project Detector
  - The ePIC Collaboration Detector

- The **ePIC Collaboration**
  - Brings in scientific workforce
    - 2025: ~200 FTE committed, >175 to the detector activities
  - Allows for a holistic approach (hardware complemented by simulation and physics studies)
  - Opens the way to in-kind contributions

- The **subsystems are progressing** thanks to the dedication and expertise of the ePIC Collaborators via an extremely intense activity:
  - Prototyping and engineered articles, laboratory studies, testbeam validations, subsystem simulations

  - Adequate qualified expertise is available for all the selected technologies thanks to the ePIC Collaborators

Thank you