ePIC Collaboration
Technical Coordinator Report

Silvia Dalla Torre

INFN TRIESTE

Electron-Ion Collider (EIC) Resource Review Board (RRB) Meeting

4th EIC RRB meeting, BNL, November 12-13, 2024

TC supported by the TC-office

TC-office members

Prakhar Garg
(Yale)

Oskar Hartbrich
(ORNL)

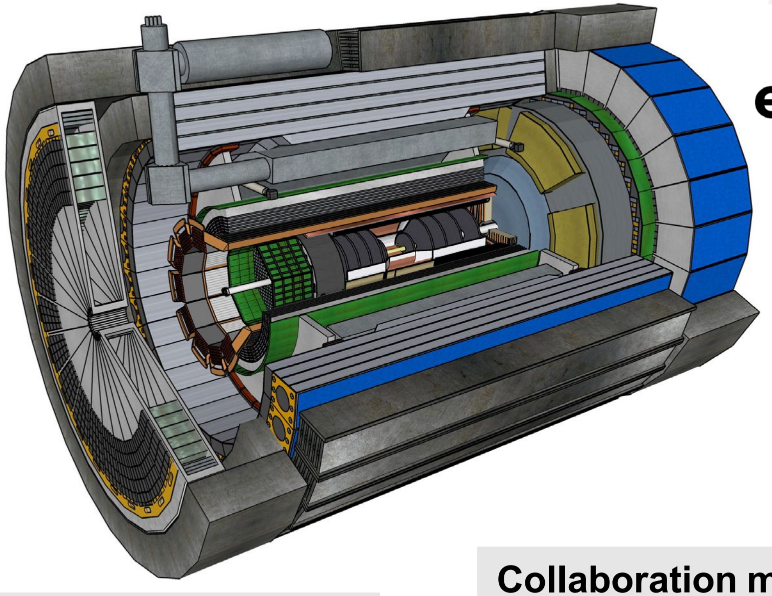
Matt Posik
(Temple U.)

OUTLOOK

- The organizational model of the ePIC detector
- ePIC detector aspects deserving emphasis: examples of recent progress
- 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

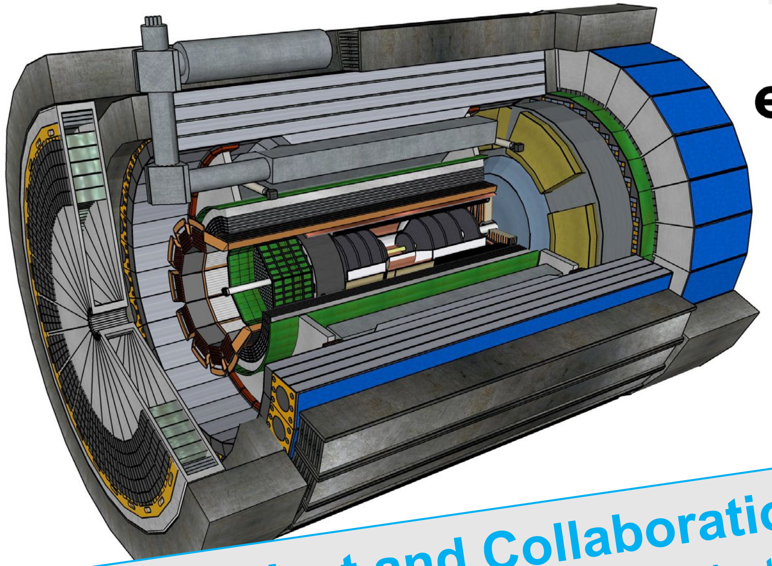
- optimize the physics reach of the detector
- manage the Collaboration, goals: making it functional, effectively operative and a professionally sound environment

Collaboration support to the ePIC detector

- Scientific workforce
  - For hardware, software and dedicated physics studies
- Financial support
  - Staff members from academic Institutions and international Institutions
  - Past and present: international cofinancing R&D, engineering studies
  - international in-kind contributions to constructions

The ePIC DETECTOR:

the combined EIC PROJECT and ePIC COLLABORATION efforts



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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.**

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  completion a

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The ePIC DETECTOR:

the combined EIC PROJ ... orts

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 <u>optimization of the detector physics reach</u> and for the <u>detector R&D and engineering details</u>);
- 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).

ePIC (des ... o which the EIC) is the ... s dedicated

Project mission f...

- ensure that all a ... project realization and completion are s...

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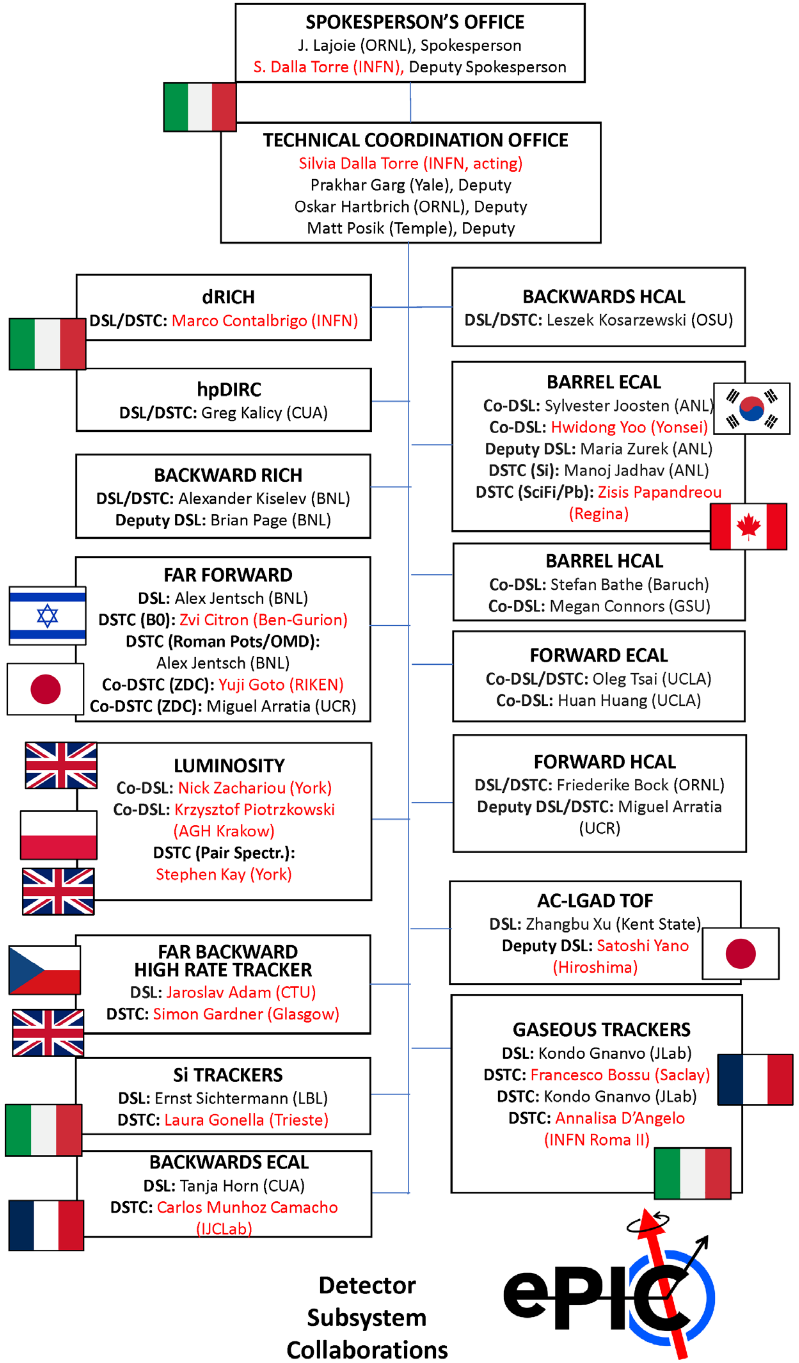
Engagement in hardware efforts (detector subsystems) within ePIC

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?

ePIC Collaboration

SPOKESPERSON'S OFFICE
J. Lajoie (ORNL), Spokesperson
S. Dalla Torre (INFN), Deputy Spokesperson

TECHNICAL COORDINATION OFFICE
Silvia Dalla Torre (INFN, acting)
Prakhar Garg (Yale), Deputy
Oskar Hartbrich (ORNL), Deputy
Matt Posik (Temple), Deputy

dRICH
DSL/DSTC: Marco Contalbrigo (INFN)

hpDIRC
DSL/DSTC: Greg Kalicy (CUA)

BACKWARD RICH
DSL/DSTC: Alexander Kiselev (BNL)
Deputy DSL: Brian Page (BNL)

FAR FORWARD
DSL: Alex Jentsch (BNL)
DSTC (B0): Zvi Citron (Ben-Gurion)
DSTC (Roman Pots/OMD): Alex Jentsch (BNL)
Co-DSTC (ZDC): Yuji Goto (RIKEN)
Co-DSTC (ZDC): Miguel Arratia (UCR)

LUMINOSITY
Co-DSL: Nick Zachariou (York)
Co-DSL: Krzysztof Piotrzkowski (AGH Krakow)
DSTC (Pair Spectr.): Stephen Kay (York)

FAR BACKWARD HIGH RATE TRACKER
DSL: Jaroslav Adam (CTU)
DSTC: Simon Gardner (Glasgow)

Si TRACKERS
DSL: Ernst Sichtermann (LBL)
DSTC: Laura Gonella (Trieste)

BACKWARDS ECAL
DSL: Tanja Horn (CUA)
DSTC: Carlos Munhoz Camacho (IJCLab)

BACKWARDS HCAL
DSL/DSTC: Leszek Kosarzewski (OSU)

BARREL ECAL
Co-DSL: Sylvester Joosten (ANL)
Co-DSL: Hwidong Yoo (Yonsei)
Deputy DSL: Maria Zurek (ANL)
DSTC (Si): Manoj Jadhav (ANL)
DSTC (SciFi/Pb): Zisis Papandreou (Regina)

BARREL HCAL
Co-DSL: Stefan Bathe (Baruch)
Co-DSL: Megan Connors (GSU)

FORWARD ECAL
Co-DSL/DSTC: Oleg Tsai (UCLA)
Co-DSL: Huan Huang (UCLA)

FORWARD HCAL
DSL/DSTC: Friederike Bock (ORNL)
Deputy DSL/DSTC: Miguel Arratia (UCR)

AC-LGAD TOF
DSL: Zhangbu Xu (Kent State)
Dep. DSL: Satoshi Yano (Hiroshima)
DSTC's: Mathieu Benoit (ORNL), Matthew Gignac (Santa Cruz)

GASEOUS TRACKERS
DSL: Kondo Gnanvo (JLab)
DSTC: Francesco Bossu (Saclay)
DSTC: Kondo Gnanvo (JLab)
DSTC: Annalisa D'Angelo (INFN Roma II)

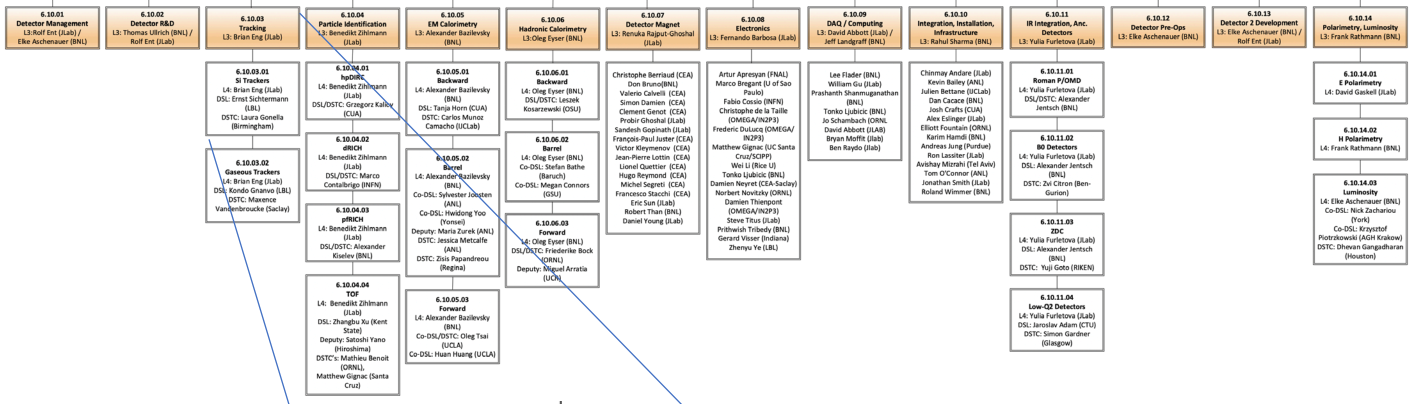
Detector Subsystem Collaborations

Project

In the Project organization, subsystems are under the responsibilty of CAMs and L4 managers – DSCs are co-responsible at L4 level

6.10 Detector
Rolf Ent (JLab)
Elke Aschenauer (BNL)

ePIC
Spokesperson: John Lajoie (ORNL)
Deputy: Silvia Dalla Torre (INFN)



6.10.03
Tracking
L3: Brian Eng (JLab)

6.10.03.01
Si Trackers
L4: Brian Eng (JLab)
DSL: Ernst Sichtermann (LBL)
DSTC: Laura Gonella (Trieste)

Si TRACKERS
DSL: Ernst Sichtermann (LBL)
DSTC: Laura Gonella (Trieste)

A TC-office initiative: at the ePIC Collaboration Meeting, the parallel session dedicated to "Integration & Installation"

An opportunity for a deeper and deeper collaboration between Project Engineers and Detector Scientists

At the July 2024 ePIC meeting in Lehigh

Integration and Installation
Prakhar Garg, Silvia Dalla Torre

Time	Contribution	Speaker	Location	Slot
13:00	Introduction/ Current status of ePIC Detector & discussion	Rahul Sharma	Rm 151, Rauch Business Center	13:00 - 13:35
	Central Detectors Installation and supports & discussion	Dan Cacace et al.	Rm 151, Rauch Business Center	13:35 - 14:10
14:00	Mechanics and simulation information exchanges	Dr Wouter Deconinck	Rm 151, Rauch Business Center	14:10 - 14:30
	Far detectors installation and support & discussion	Jonathan Smith	Rm 151, Rauch Business Center	14:30 - 15:05
15:00	Routing Plans for Cooling and Services & discussion	Roland Wimmer	Rm 151, Rauch Business Center	15:05 - 15:40
	dRICH Removal Considerations	Alex Eslinger	Rm 151, Rauch Business Center	15:40 - 15:55
16:00	BOT and ECT (uRwell detectors) design and integration for the MPGD	Seung Joon Lee	Rm 151, Rauch Business Center	15:55 - 16:10
	Barrel EMCAL Engineering Update	Kevin Bailey et al.	Rm 151, Rauch Business Center	16:10 - 16:25
	nEMCal Engineering Design Update	Carlos Munoz Camacho	Rm 151, Rauch Business Center	16:25 - 16:40

Global

Subsystems

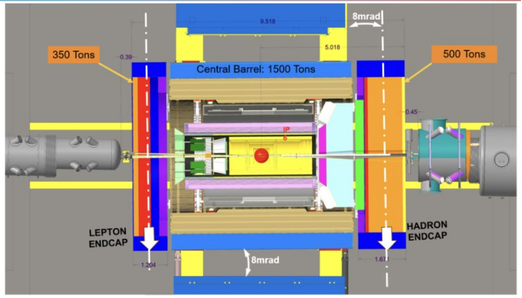
~50 in-person

~10 online

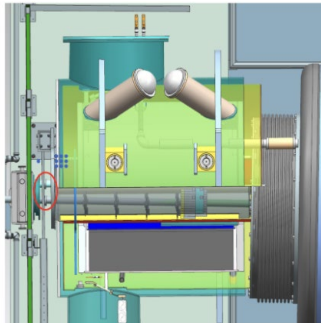
~10 Engineers

An I&I session planned at the coming ePIC meeting in January 2025, Frascati

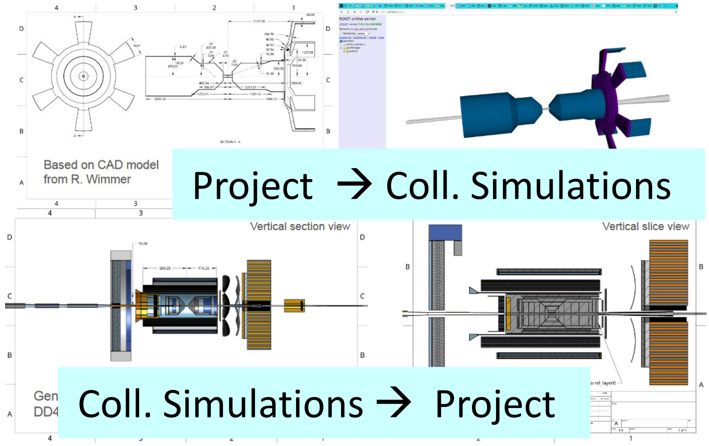
8mrad Rotation



B0 Challenges



CAD
EIC Project ↔ ePIC Collaboration
Full Geometry Exchange, Both Ways



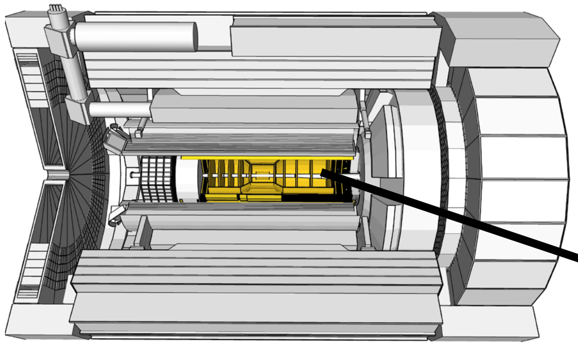
OUTLOOK

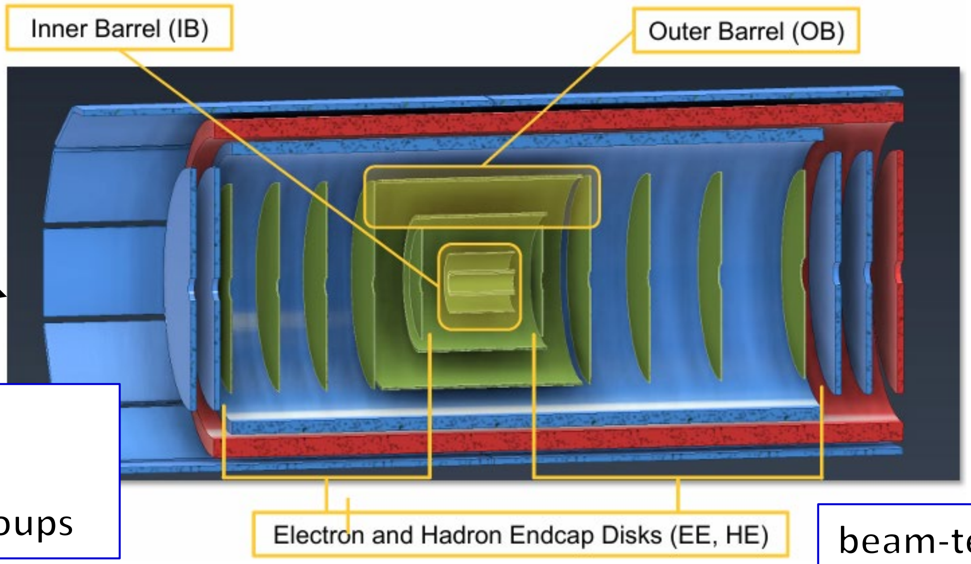
- The organizational model of the ePIC detector

- ePIC detector aspects deserving emphasis:
  examples of recent progress

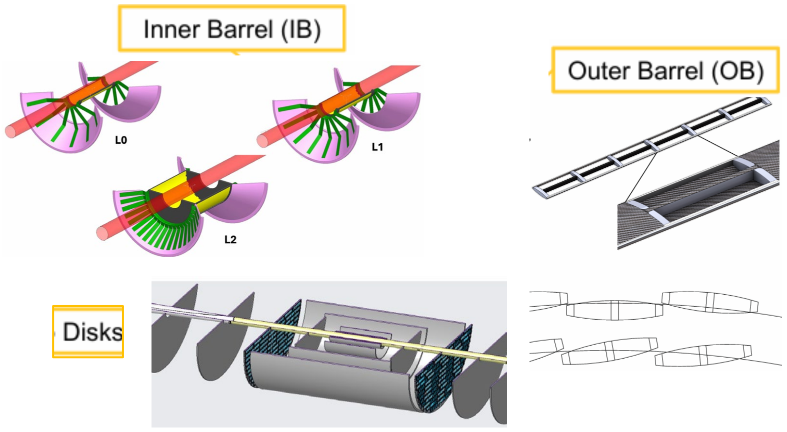
- Summarizing

Si TRACKING : the SVT





- Local mechanics



ITS3 MAPS - NOVEL TECHNOLOGY

- Co-developed by CERN and ePIC groups

Participating Institutions

CERN

UNIVERSITY OF BIRMINGHAM

INFN

BERKELEY LAB

Jefferson Lab

Berkeley UNIVERSITY OF CALIFORNIA

Brookhaven National Laboratory

Brunel University London

University of Oxford

UNIVERSITY OF LIVERPOOL

UKRI Science and Technology Facilities Council

Los Alamos NATIONAL LABORATORY

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

UIC

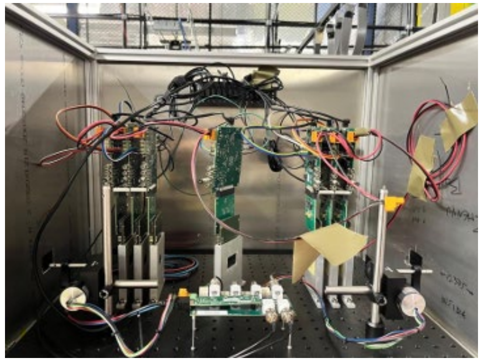
MIT

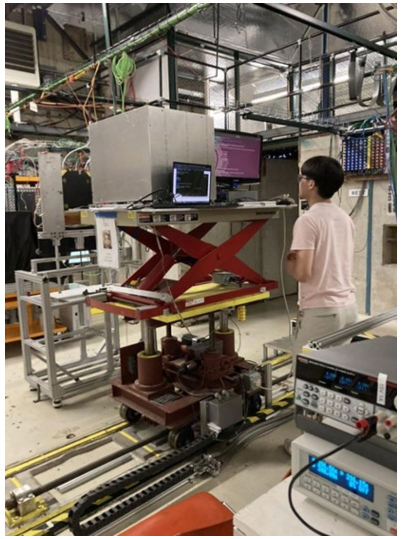
PURDUE UNIVERSITY

OAK RIDGE National Laboratory

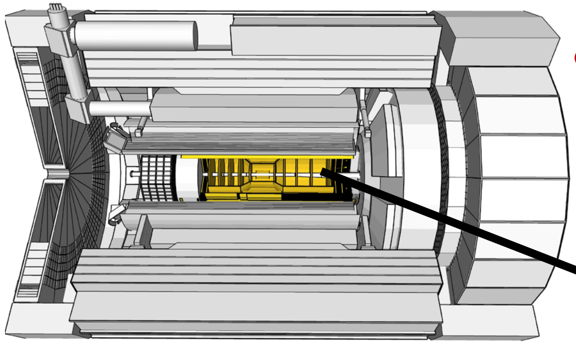
Extensive Si-detector experience in the ALICE, ATLAS, CMS, sPHENIX, STAR collider experiments

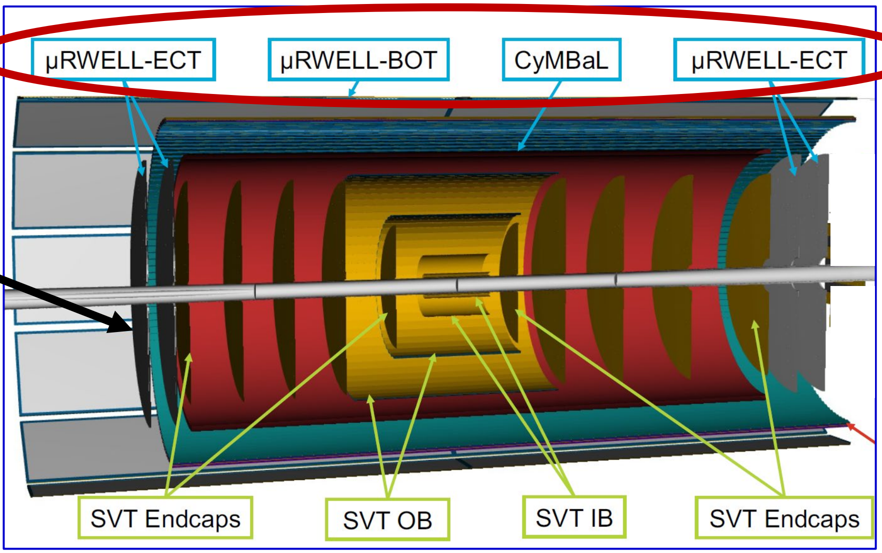
beam-test at FNAL with a telescope of ITS3 ER1 “baby-MOSS” sensors



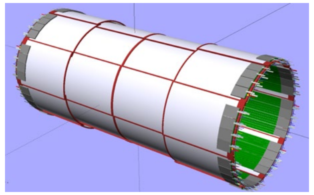


TRACKING by MPGDs

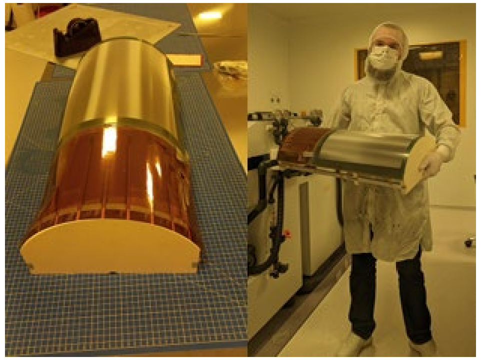




CyMBaL – cylindrical MicroMegas

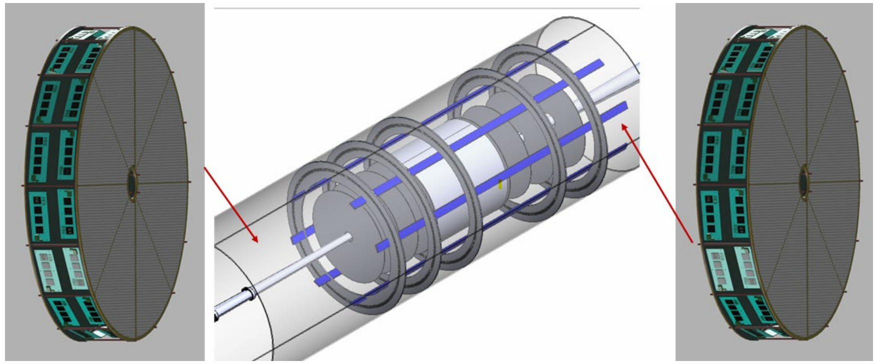


- Moving to prototyping phase



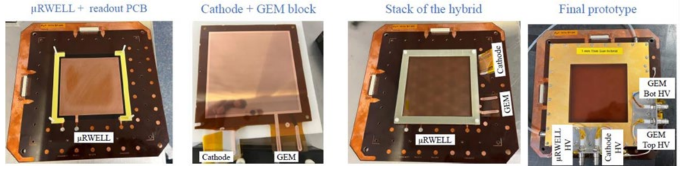
µRWELL-ECT

- Defining configuration and integration



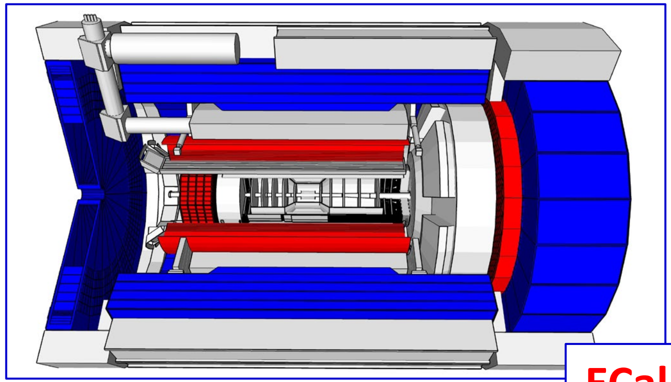
µRWELL-BOT

- Technology validated by prototyping and testbeam



- Preparing the assembly site

SENSORS for ePIC CALORIMETRY

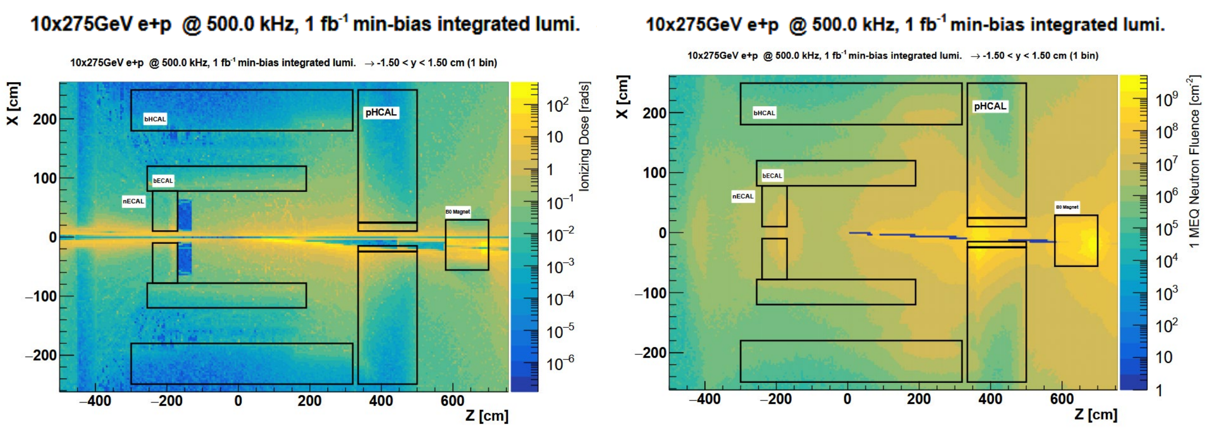


ECal in red
HCal in blue

SiPM sensors for all Calorimeters
- SENSORS RECENTLY INTRODUCED IN CALORIMETRY

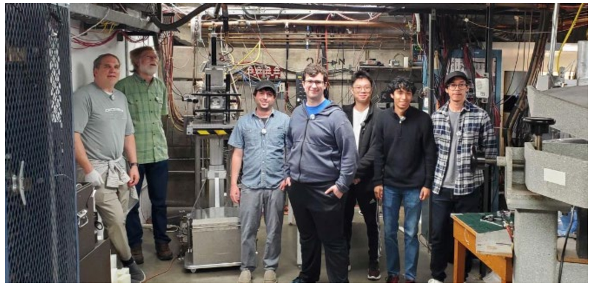
- direct experience is coming from the applications in GlueX, STAR and sPHENIX (these colleagues now at work for ePIC calorimetry)
- **For the first time so extended calorimetric usage in an experiment !**

Rad Dose and Neutron Flux



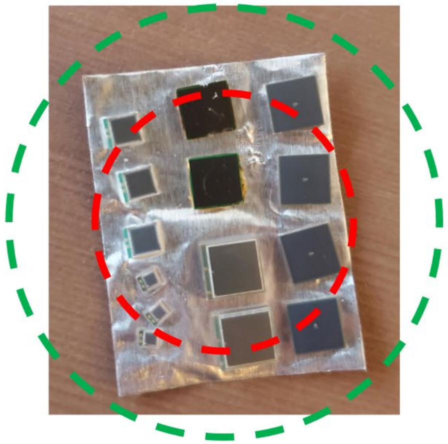
Doses and fluxes ~ 10^{-3} compared to HL-LHC

Irradiation campaigns



Accumulated fluence

1.5 cm radius
2.5 cm radius



Run info for 10^{12} fluence setting

Beam Type: Proton Target: Si File Name:
Beam E (MeV): 64.0 dE/dx (MeV·cm²/g): 8.334 c:\ref_user\UC Riverside\UC-Riverside_5-14-24.html
Date: 5/14/2024

5/14/2024 FC Lkg (A): -4.800E-13 ± 1.056E-13
8:46:03 SEM Lkg (A): 1.299E-11 ± 1.328E-12
8:47:05 FC/SEM Ratio: 1.8896E+00 ± 4.0255E-03

		Run Time (s)	Mean Current (A)	Std Dev <I> (A)	Incr Dose (rad)	Acc Dose (rad)	Incr Fluence (p/cm²)	Acc Fluence (p/cm²)	Avg Dose Rate (rad/s)	Beam Profile
Run #1										
	9:00:35	789.401	1.016E-08	1.751E-09	1.336E+05	1.336E+05	1.001E+12	1.001E+12	1.693E+02	0 - 0.5 cm
	L12				1.329E+05	1.329E+05	9.957E+11	9.957E+11	1.684E+02	0.5 - 1.5 cm
					1.303E+05	1.303E+05	9.757E+11	9.757E+11	1.650E+02	1.5 - 2.5 cm

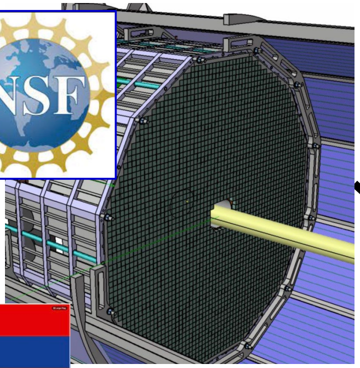
Between 1.5 and 2.5 cm radius, the total fluence relative decreases by ~2.5% compared to r = 0.

The absolute beam fluence is measured to about 2% precision.

7/8/2024 7

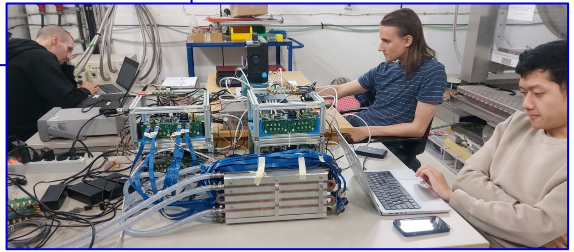
ELECTROMAGNETIC CALORIMETRY

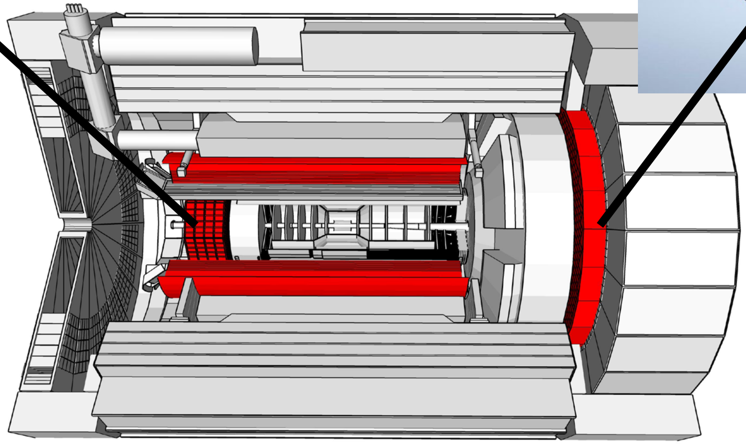
Backwards EMCal
PbW04 crystals, fine granularity

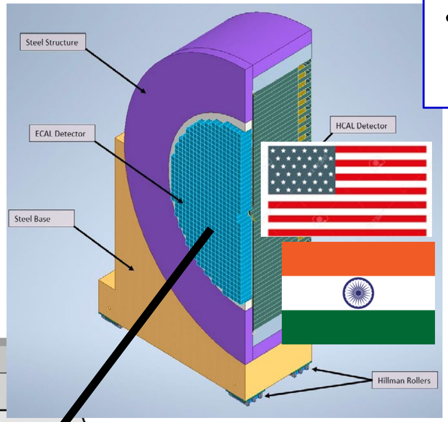


PbW0$_4$ crystals - WIDELY CONSOLIDATED TECHNOLOGY

- Novel challenge: preserving the exceptional resolution adopting SiPM sensors
- Prototyping advanced and ready for testbeam validation → unfortunately, no beam delivered

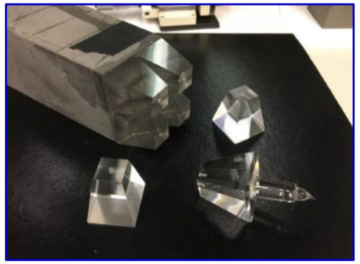


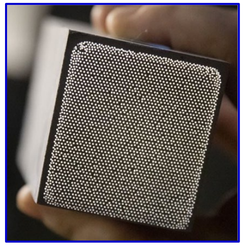




SciFi/W - NOVEL TECHNOLOGY MOVING TOWARDS COINSOLIDATION

- Pioneered for EIC and already used for sPHENIX

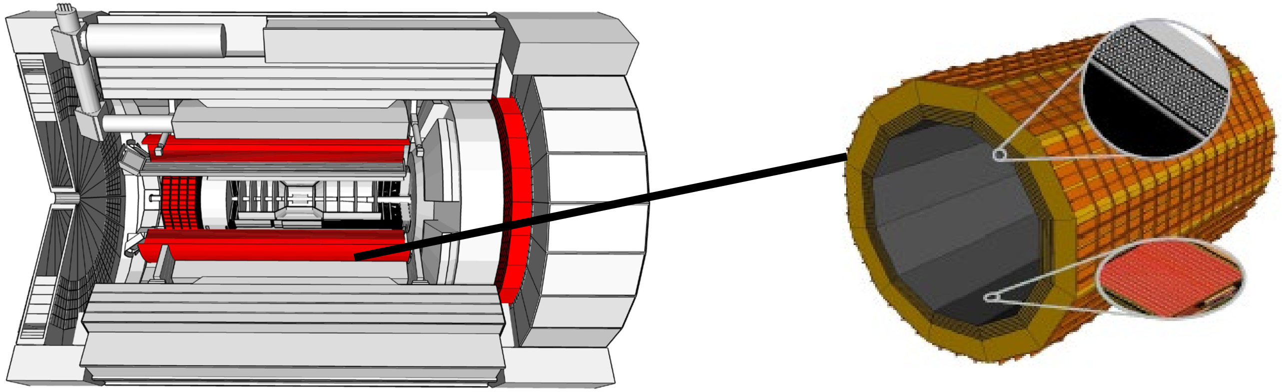




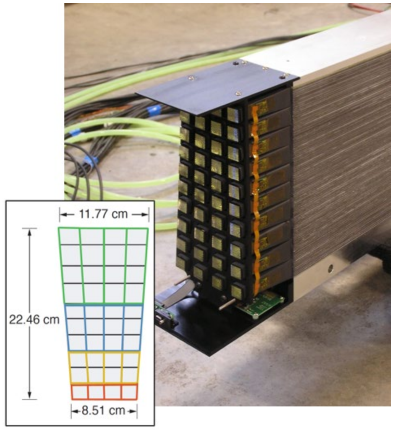
Same technology :

- in B0 far forward detector
- in luminosity pair spectrometer: first prototype realized!
- In low Q^2 taggers (far backward)

ELECTROMAGNETIC CALORIMETRY



Pb/ScFi tested extensively in for photon

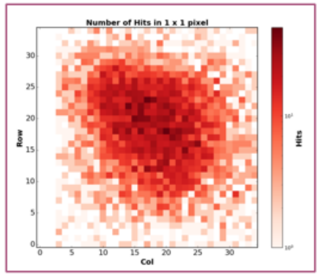


- 60-cm long prototype
- 40 light guides on either side
- 40 SiPMs per side

Baby BCal commissioned with proton, pion, and electron beams during a June 2024 FBTF test

Beam hit map **FNAL, May 2023** AstroPix v3 Test with 120 GeV protons

Performs well in much harsher conditions than EIC



Hybrid imaging calorimetry - INNOVATIVE ARCHITECTURE BY CONSOLIDATED INGREDIENTS

- imaging calorimetry developed at CERN
- Imaging by ASTROPIX MAPS (for NASA AMEGO-X mission, NASA collaborators), following ATLASPIX
- Pb/SciFi sampling calorimetry established at GlueX

USA: Argonne National Laboratory; NASA Goddard Space Flight Center; Oklahome State University; University of Connecticut; University of California Santa Cruz

Canada: University of Manitoba; University of Regina; Mount Allison University

Korea: Kyungpook National University; Yonsei University; University of Seoul; Pusan National University; Korea University; Sungkyunkwan University; Hanyang University; Gangneung-Wonju National University

Germany: Karlsruhe Institute of Technology; University of Giessen

BIC Collaborating Institutions

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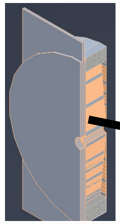
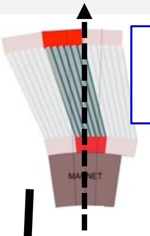
HADRONIC CALORIMETRY

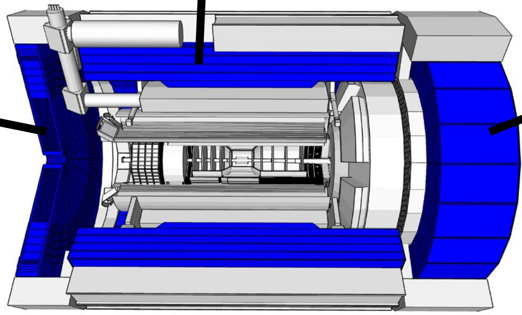
H Calorimetry in ePIC:
Steel/scintillator sampling calorimetry

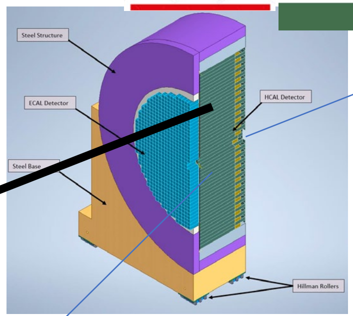
Backward Hcal



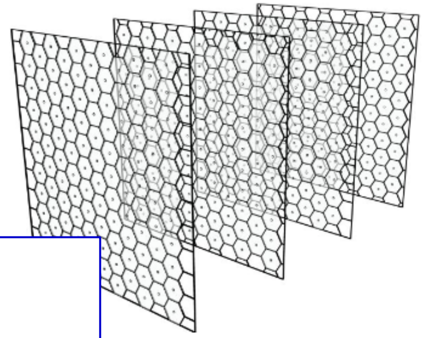


Barrel Hcal
(re-use from sPHENIX)



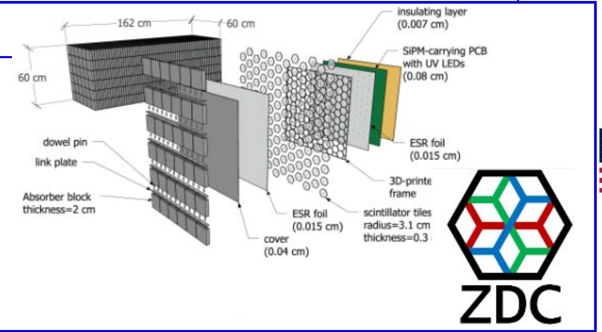


INSERT by the same technology with finer granularity at high η



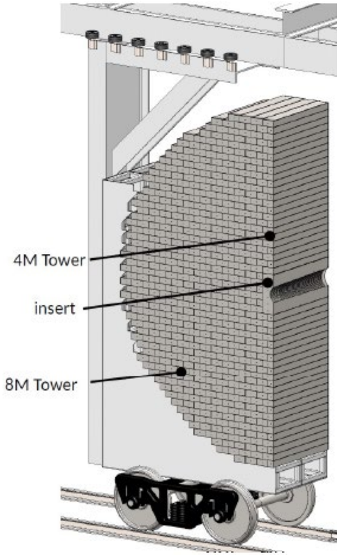
Same technology :

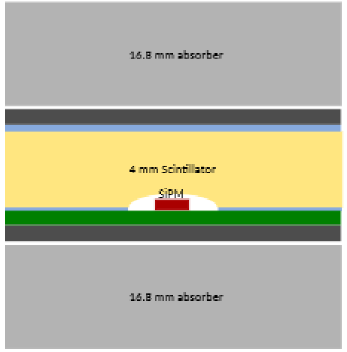
- Zero Degree Calorimeter

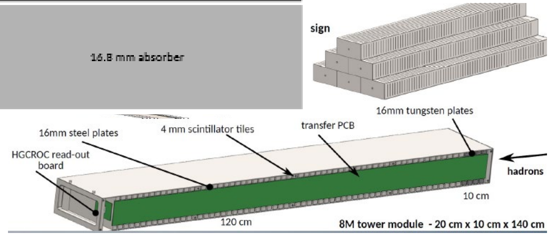


Forward Hcal: INNOVATIVE ORIGINAL DESIGN : "SiPM on tile"

- inspired by CALICE developments adopted by ePIC



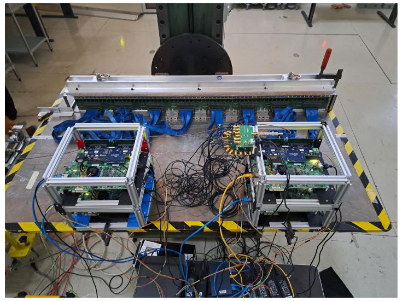




Same technology :

- Backward Hcal

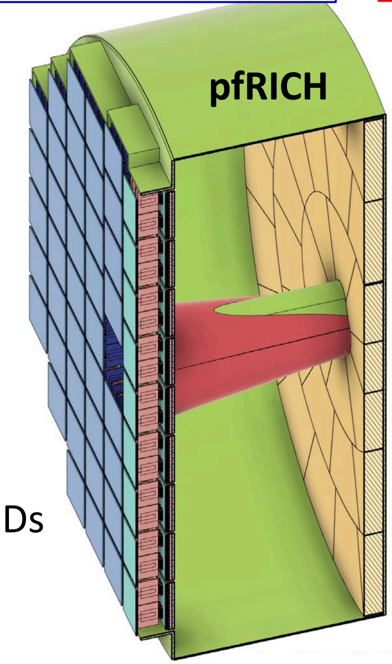
First module at test beam (Sept/Oct 2024)



ZDC module under test at STAR

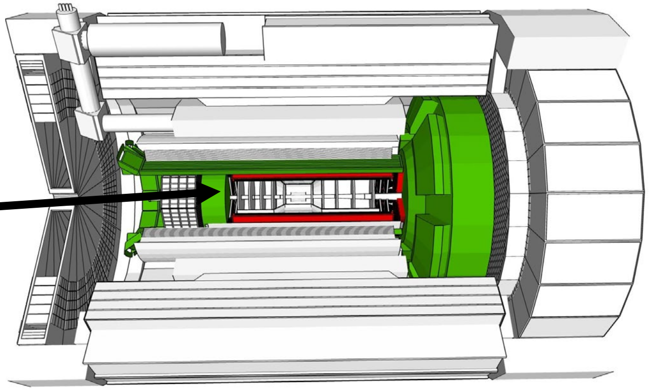
PARTICLE IDENTIFICATION - Cherenkov Imaging

Proximity focusing RICH

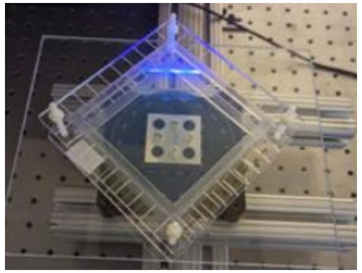


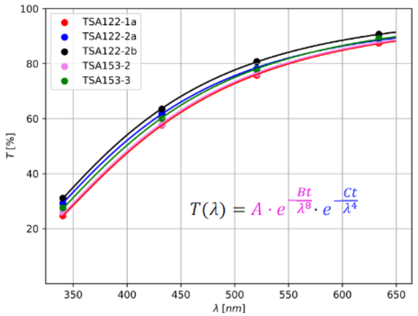
aerogel

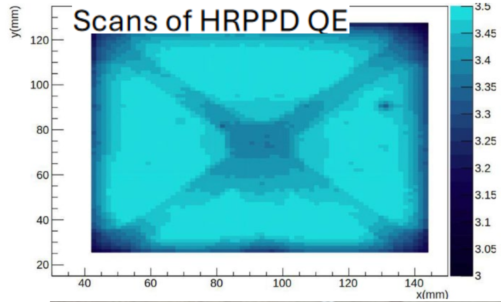
HRPPDs



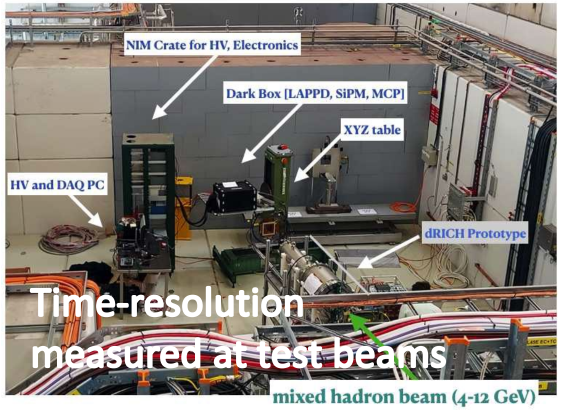
Aerogel characterization
- Together with dual RICH



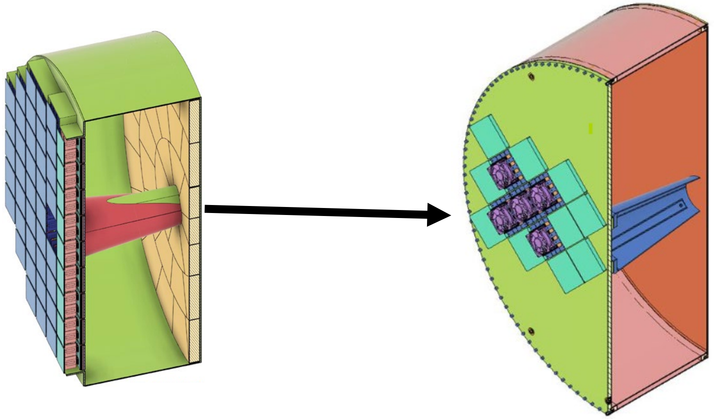


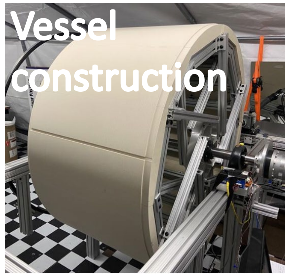


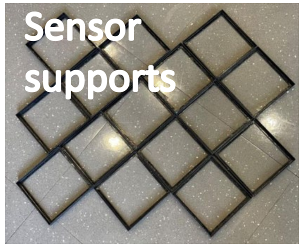
HRPPD characterization

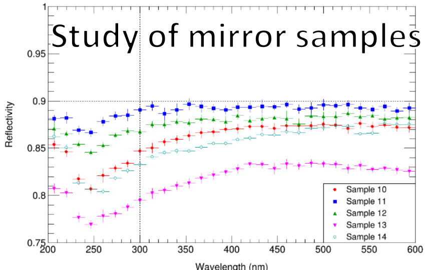


Progressing towards prototype

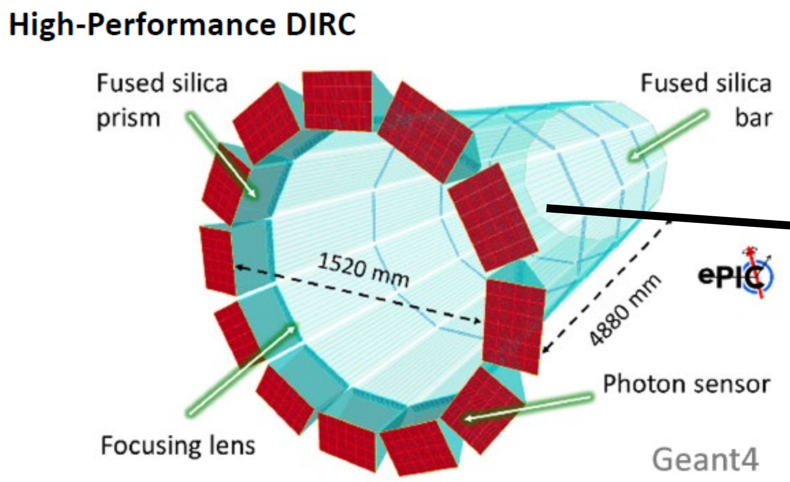


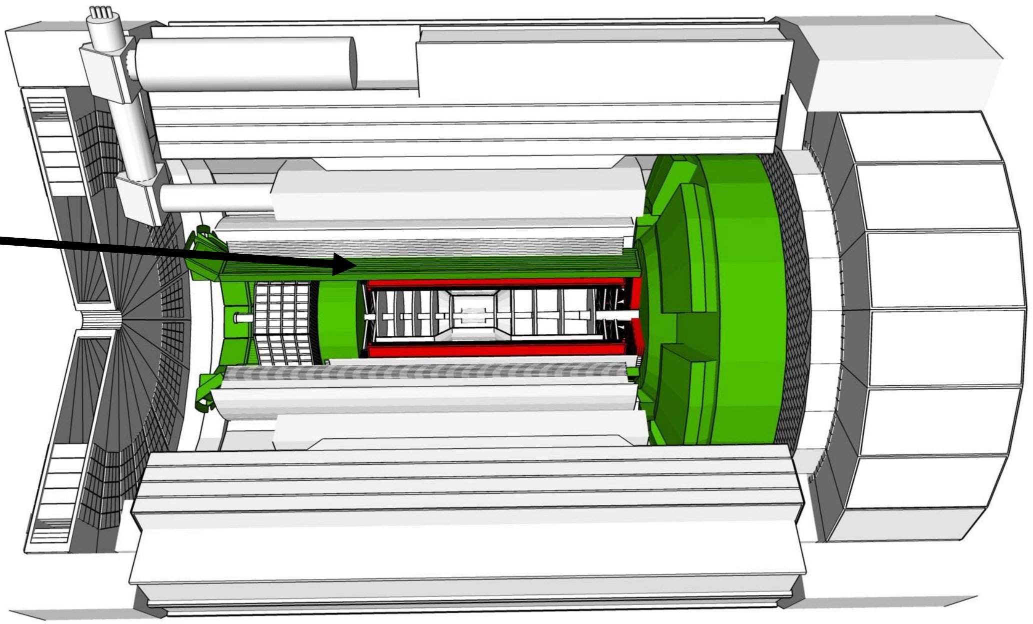




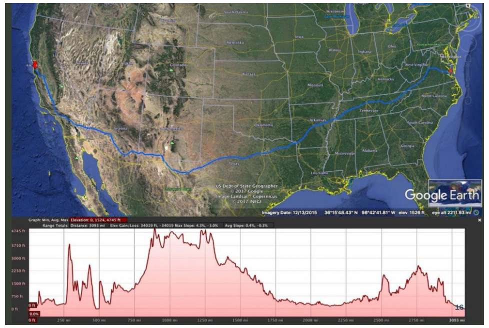


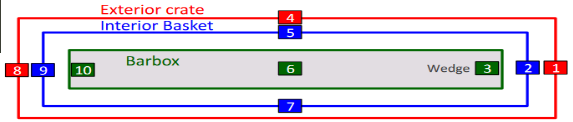
PARTICLE IDENTIFICATION - Cherenkov Imaging

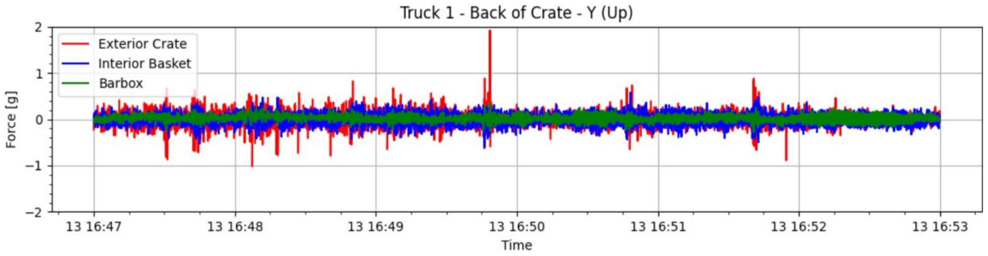




BaBar DIRC bars moved to Jlab

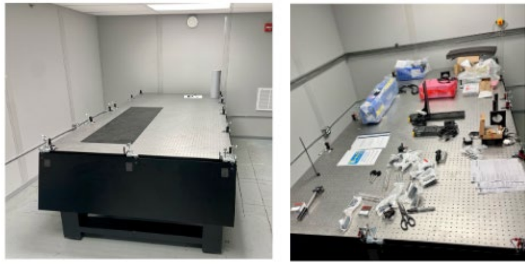






infrastructure for bar disassembling

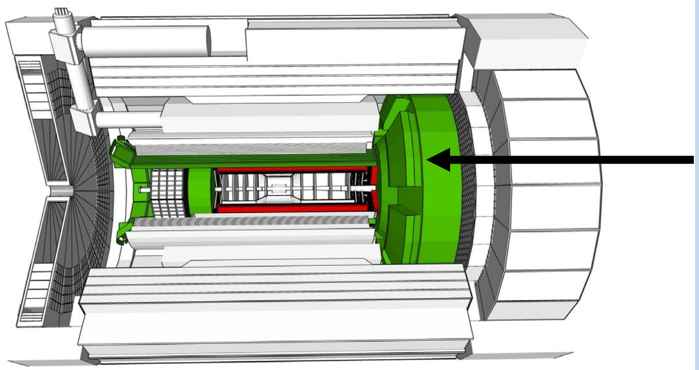
infrastructure for testing the disassembled bars

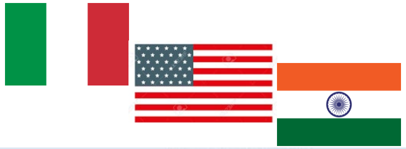


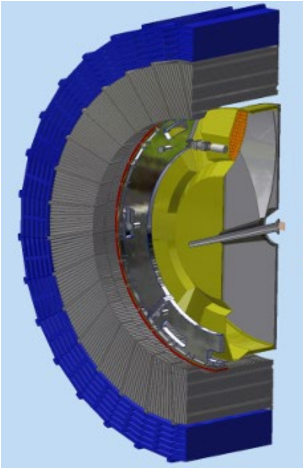
DIRC labs under construction at Jlab EEL108

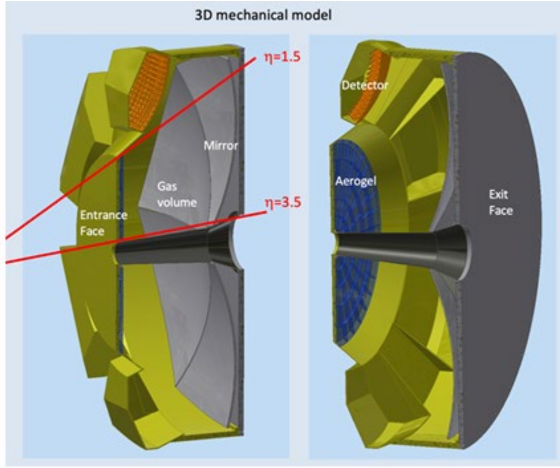
PARTICLE IDENTIFICATION - Cherenkov Imaging

Dual radiator RICH - dRICH

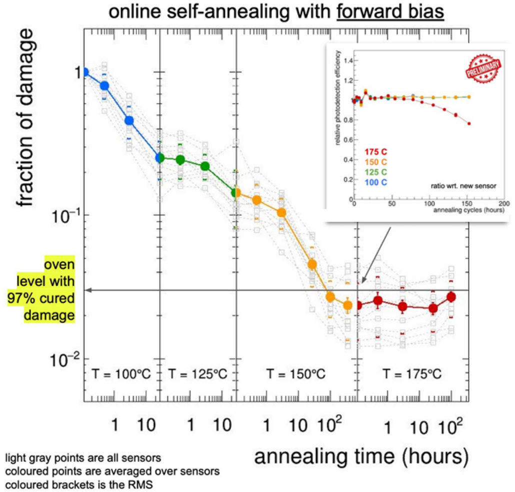




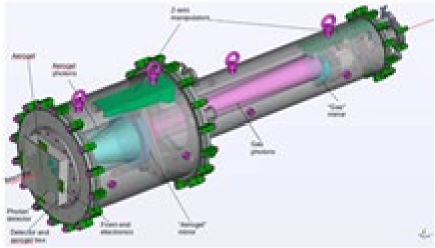




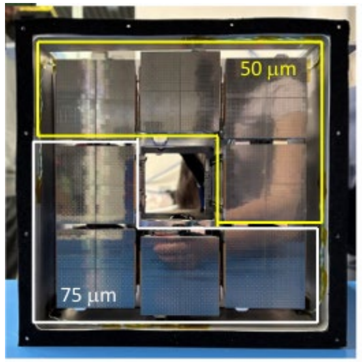
Further SiPM studies to confirm the feasibility of in-situ annealing with thermal cycle



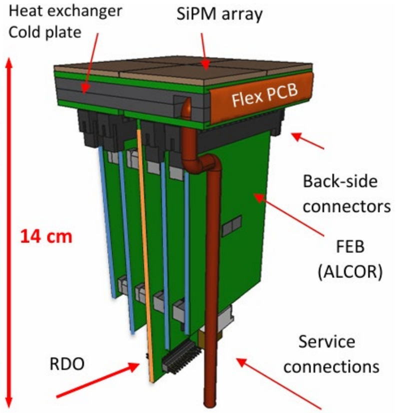
Prototype for principle demonstration at test beams

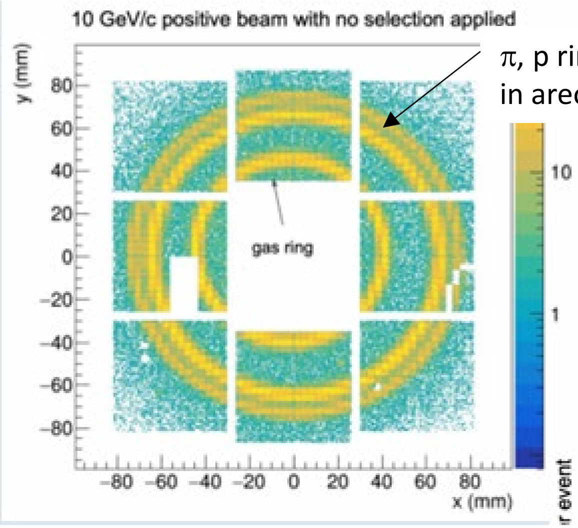


2024 sensor system



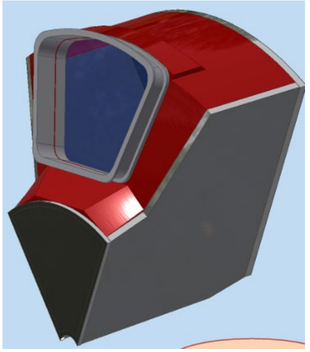
Photon Detector Unit (PDU) already in use





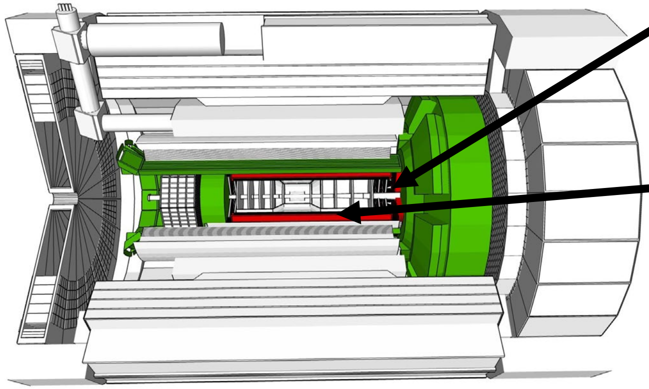
π, p rings in areogel

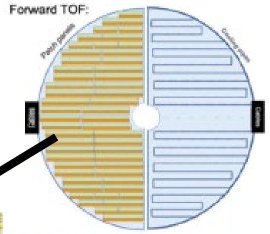
Progressing towards a full-scale prototype

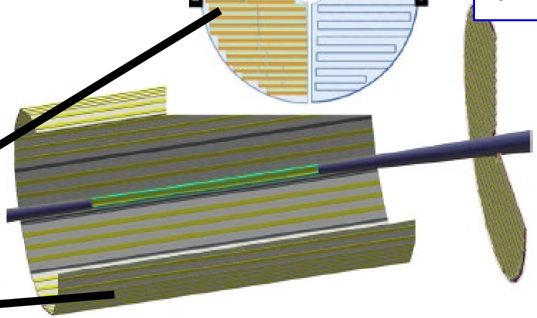


And MORE …

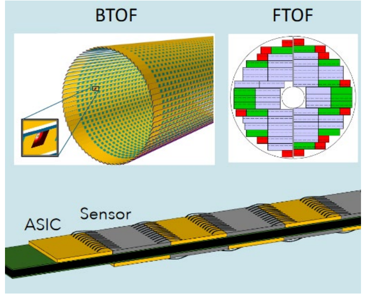
Time-of-Flight layers: AC-LGAD
Time resolution: 25-35 ps





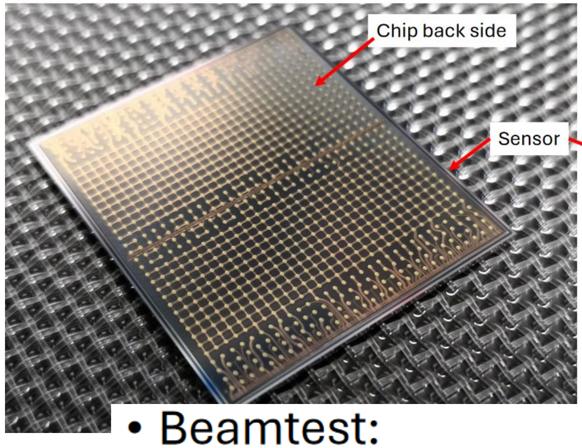


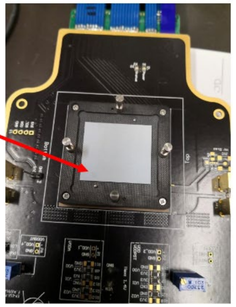
Recent progress in sensor and detector design



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

First Timepix4.1 TSV with Silicon Sensor

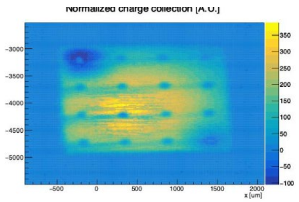


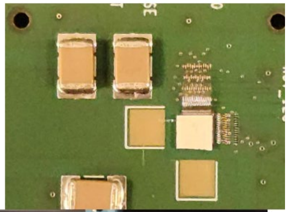


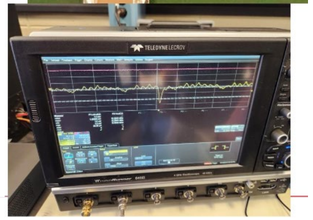
- Beamtest:
  - Mainz 3-6th December

Same AC-LGAD technology :

- in Roman Pots and Off-Momentum detectors (far forward)
- recent result:
  - AC-LAD sensor coupled to the FE AIC EICROC successfully tested!
- in luminosity pair spectrometer (far backward)







OUTLOOK

- The organizational model of the ePIC detector
- ePIC detector aspects deserving emphasis: examples of recent progress
- 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 <u>scientific workforce</u>
    - Allows for a <u>holistic approach</u> (hardware complemented by simulation and physics studies)
    - Opens the way to <u>in-kind contributions</u>

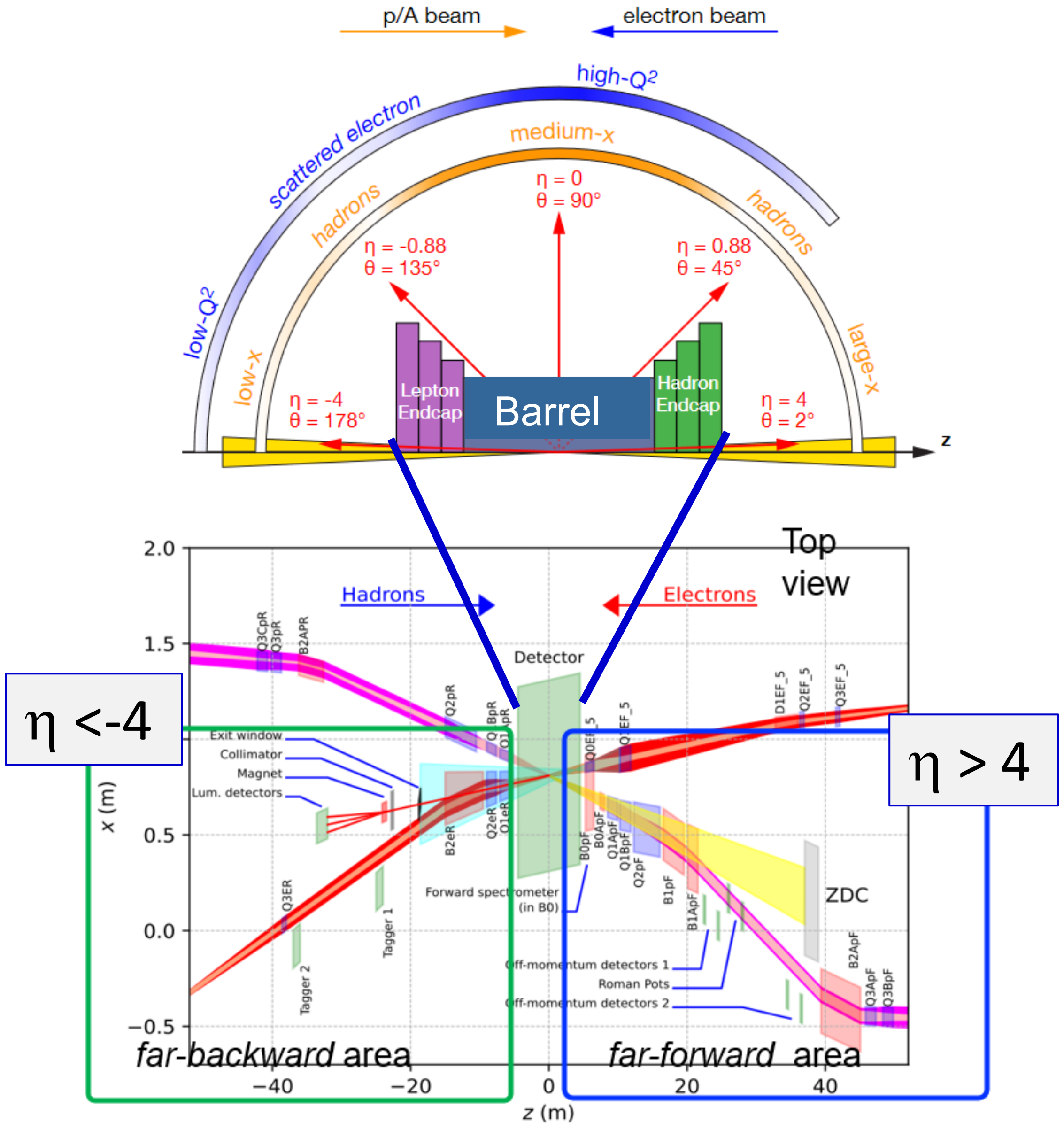
- The **subsystems are progressing** thanks to the dedication and expertise of the ePIC Collaborators

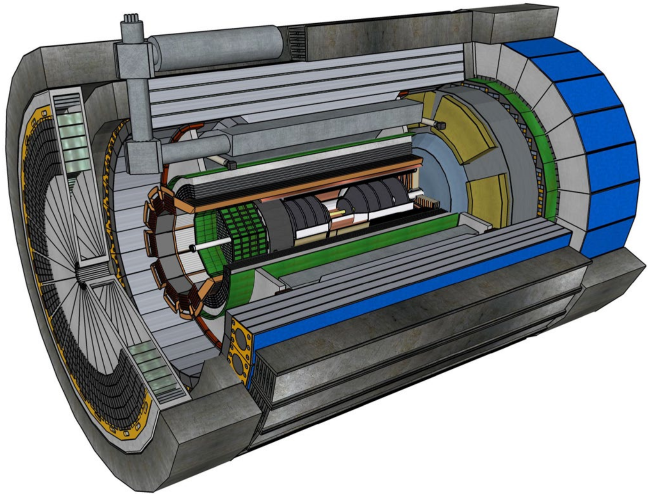
    - <u>Adequate qualified expertise</u> is available for all the selected technologies thanks to the ePIC Collaborators

Thank you

THE COMPLETE ePIC DETECTOR

A reminder



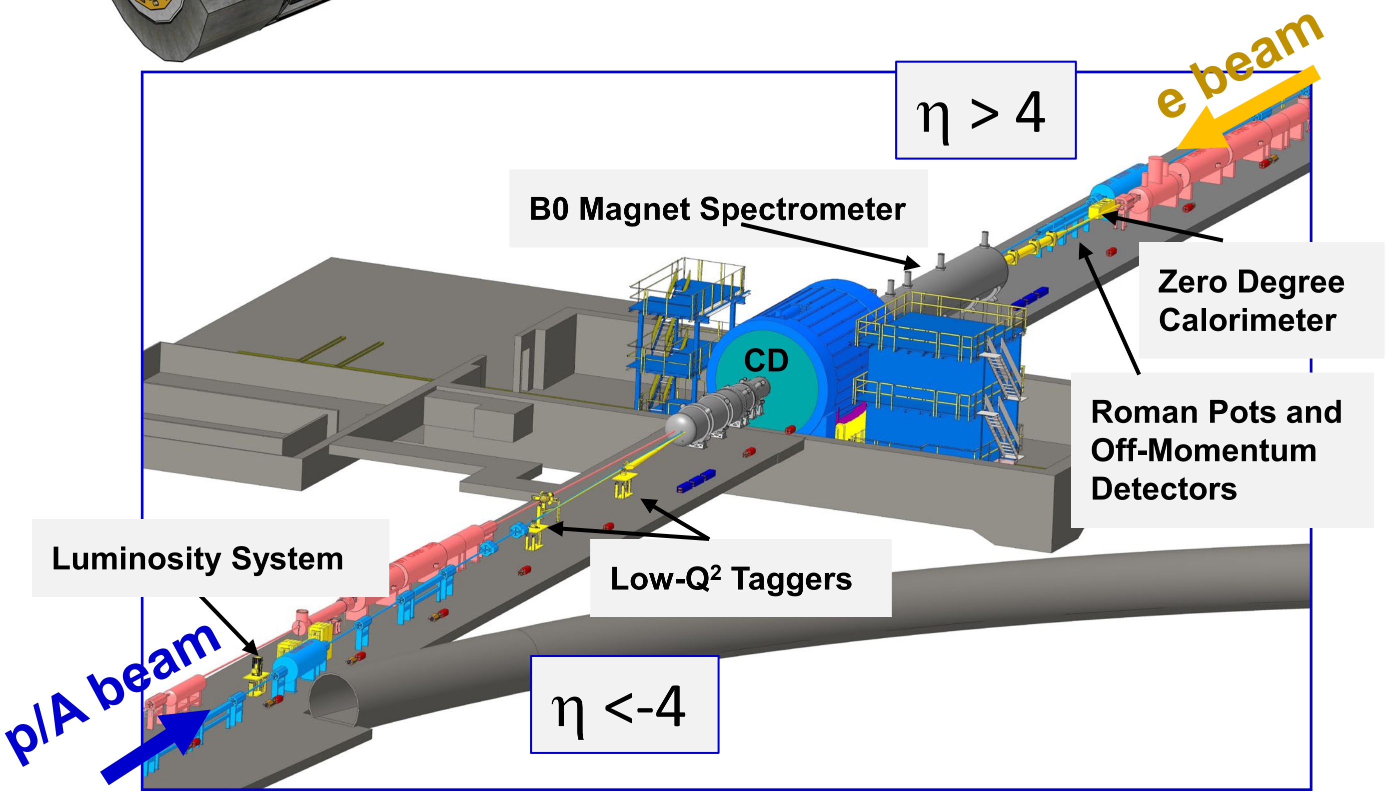


Central Detector (CD)

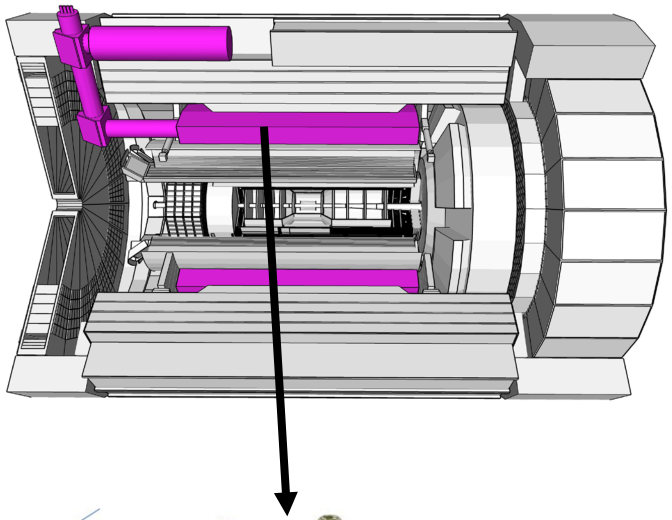
-4 < η < +4

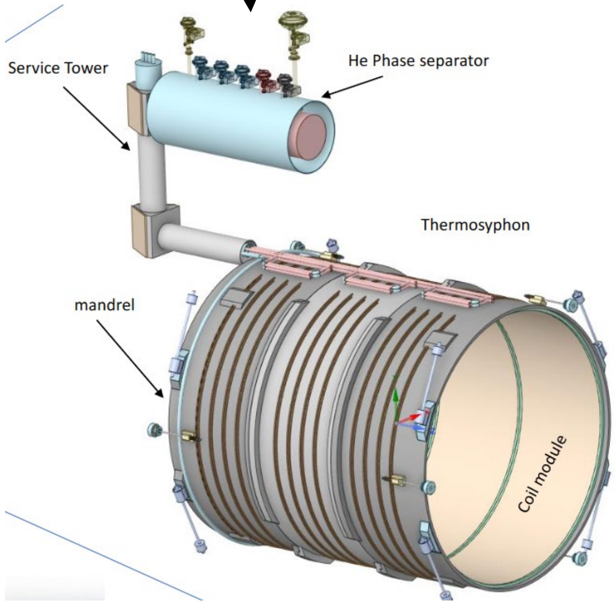
Formed by:

- Backward endcap
- Barrel
- Forward endcap



THE SOLENOID

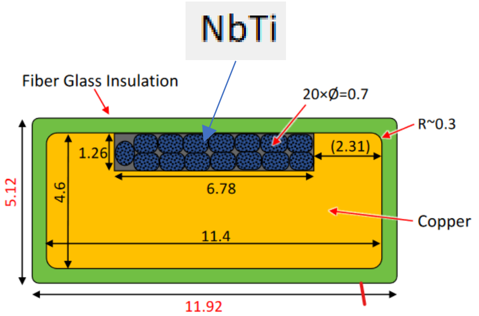




Parameter	Value	Comment
Central Field B_0	2.0 T	
Lowest operating field	0.5 T	
Field Uniformity in FFA	12.5 % ± 100 cm around center 80 cm radius	Magnetic Field Properties
Projectivity in RICH Area	< 0.1 (mrad@30GeV/c) < 10 T/A/mm² From Z = 180 cm to 280 cm	

Reference field value: 1.7 T

Conductor Design



90% readiness review successfully passed in Fall 2023

Solenoid design :

- **A combined effort Saclay – JLab – BNL**
- **groups with wide expertise in magnet design (magnets for accelerator/projects at CERN, Orsay, Jlab, BNL, …)**

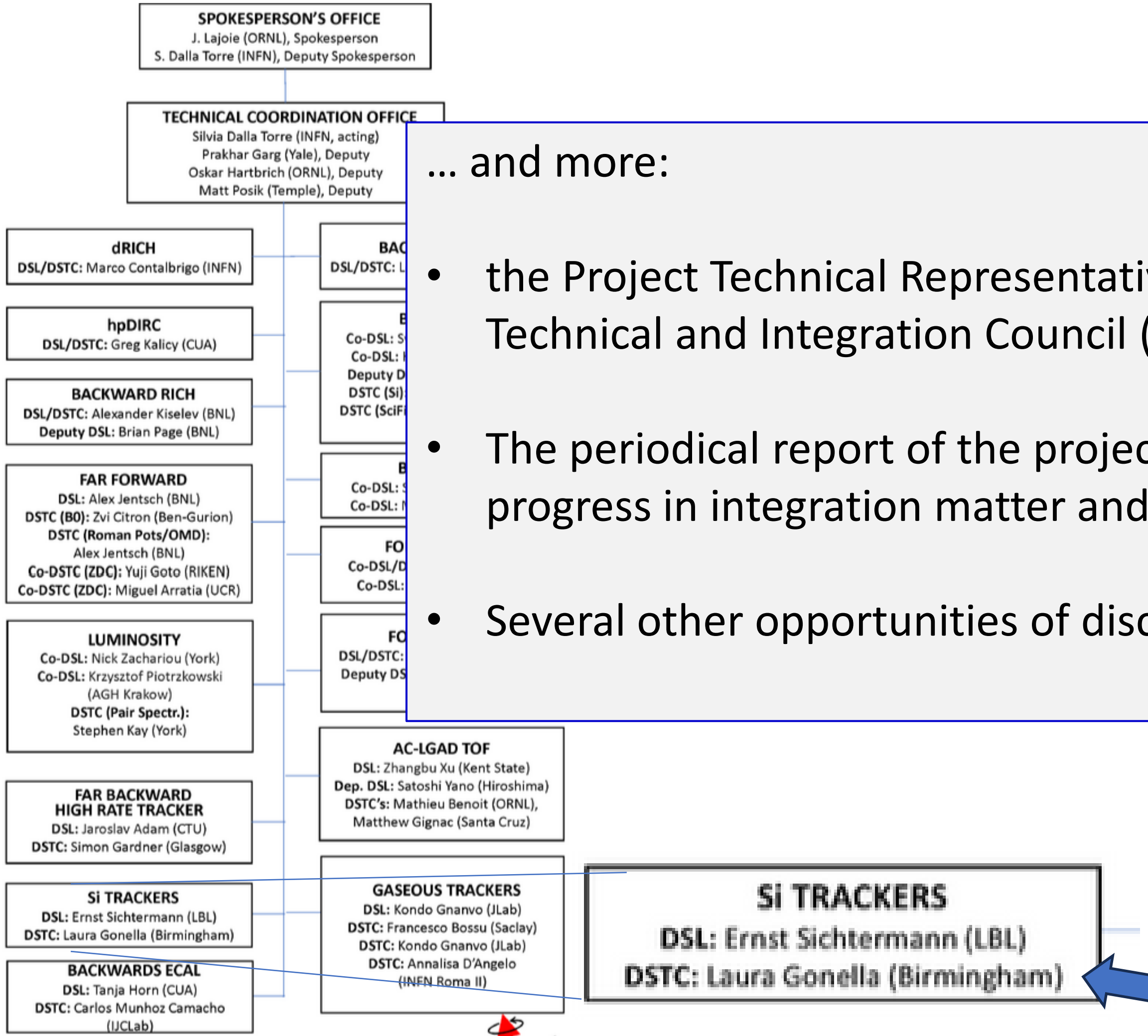
Realization :

- **interest from Italy under investigation**
- **the considered Italian company realized the CMS solenoid and ~1/3 of the LHC dipoles**

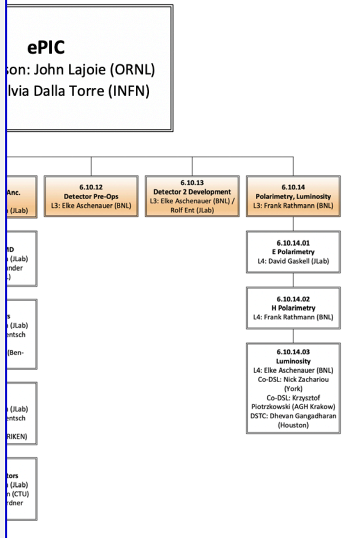
The combined EIC PROJECT and ePIC COLLABORATION efforts:

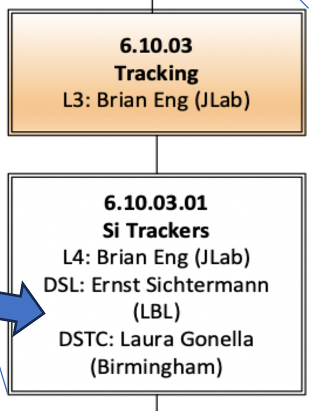
HOW?

In the Project organization, subsystems are under the responsibilty of CAMs and L4 managers – DSCs are co-responsible at L4 level



Detector Subsystem Collaborations



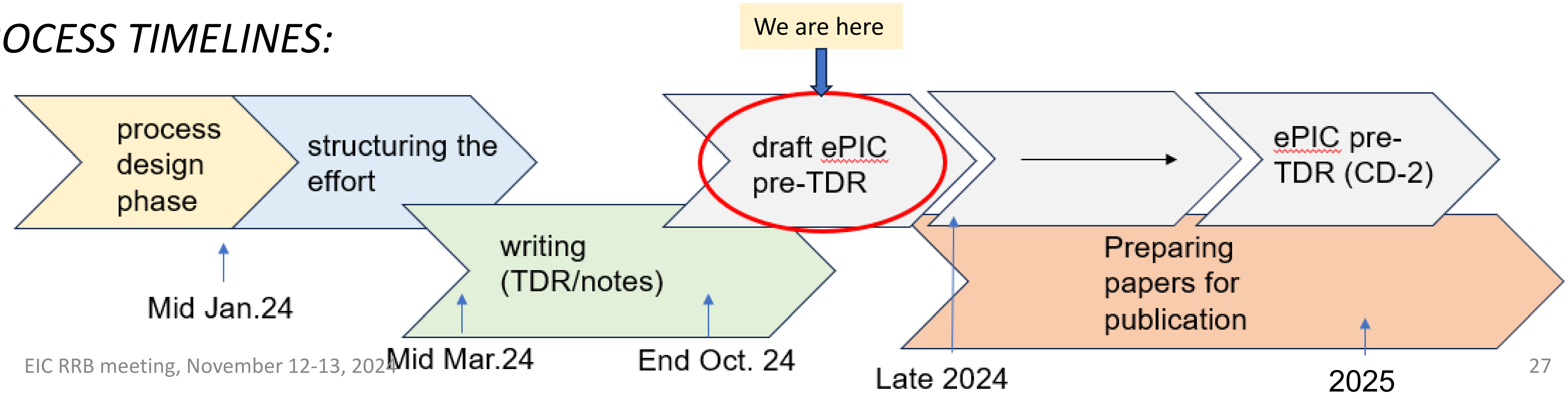


… and more:

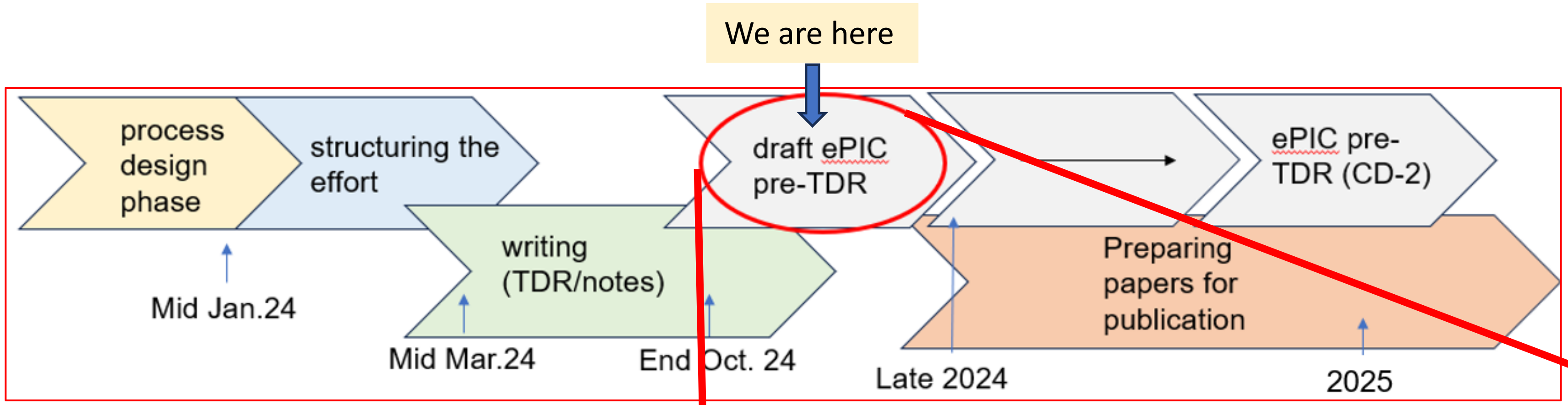
- the Project Technical Representative attending the weekly meetings of the Technical and Integration Council (TIC)
- The periodical report of the project engineers at the TIC meetings presenting the progress in integration matter and mechanical arrangements
- Several other opportunities of discussions and coworking

ePIC engagement in EIC pre-TDR

- Enthusiastic contribution by the collaboration
- Domain of ePIC contributions:
  - *Chapter 2 "Physics Goals and Requirements"*
  - *Chapter 8 "Experimental Systems"*
- ePIC planning: with priority to preTDR, prepare in parallel 3 publications on high-rank scientific journals, reshaping the preTDR material and focusing on
  - The ePIC Detector *(from chapter 8)*
  - The ePIC detector performance for EIC physics scope *(from chapter 2)*
  - The ePIC software and computing model *(from dedicated subsection in chapter 8)*
- *PROCESS TIMELINES:*



ePIC engagement in EIC pre-TDR - STATUS



ZOOMING

<u>2 preTDR draft versions in 2024</u>

- **Version0** by **September 29**
  - ✓ **ACHIEVED** (all subsystem texts inserted in the overleaf support tool)
- During October 2024, <u>internal review process</u>!
  - ✓ **ACHIEVED**
- **Version1 by December 1**
  - material for the <u>Jan. 2025 DOE OPA review</u>

a flavor of the ePIC contribution to the pre-TDR draft

Electron Ion Collider

Preliminary Design Report

DRAFT
EIC PDR
October 7, 2024

266 pages,
198 figures