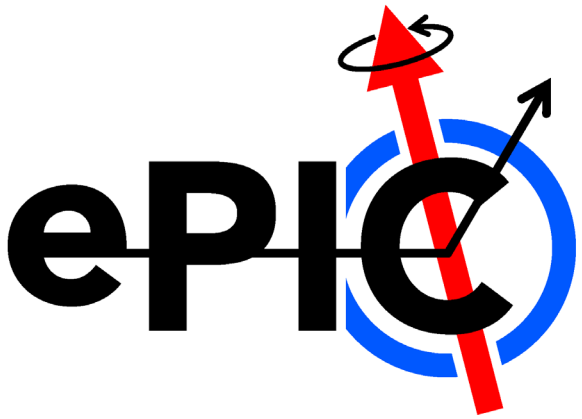
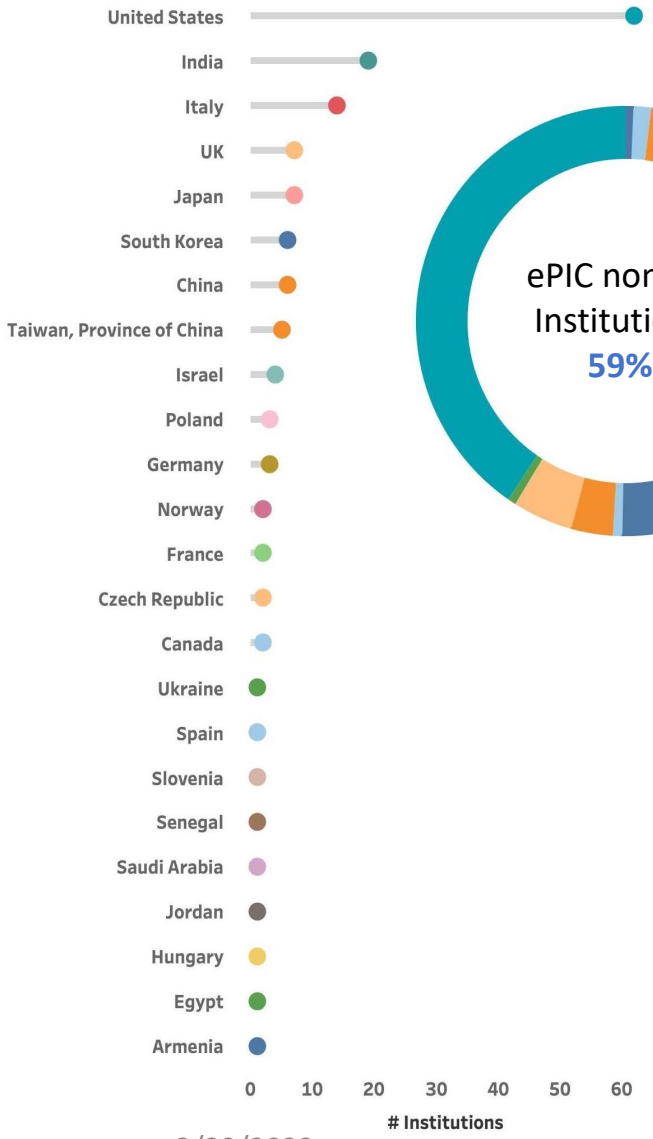
Welcome and Introduction: ePIC Backwards PID Review

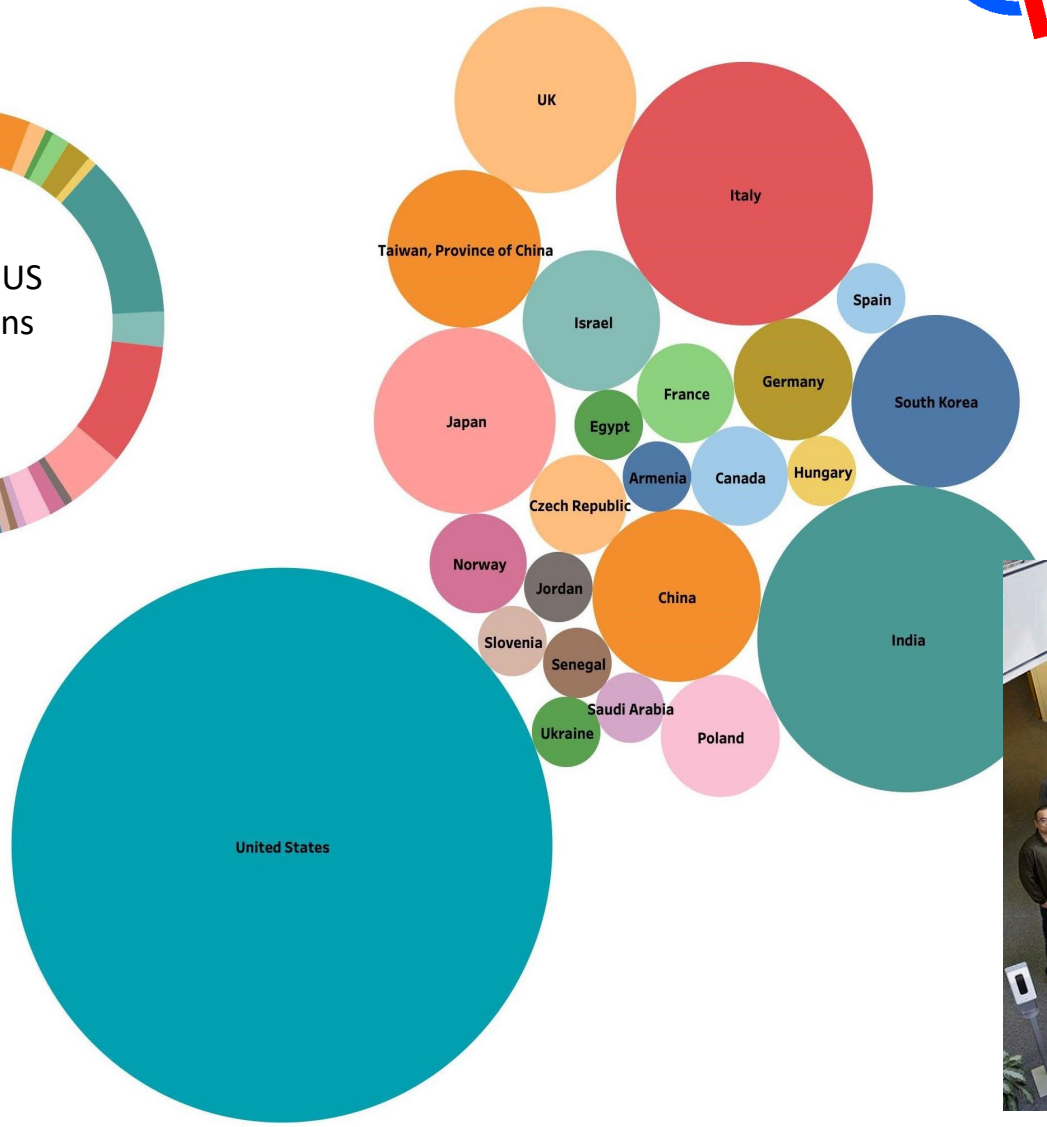
John Lajoie

Iowa State University



The ePIC Collaboration





160+ institutions
24 countries

500+ participants

A truly global pursuit for a new experiment at the EIC!

Requirements for an a EIC Detector

Radius/Distance from IP

Vertex detector → Identify primary and secondary vertices,
Low material budget: 0.05% X/X_0 per layer;
High spatial resolution: 10 mm pitch CMOS Monolithic Active Pixel Sensor

Central tracker → Measure charged track momenta
MAPS – tracking layers in combination with micro pattern gas detectors
MPGD: μRWell or MicroMegas

electron and hadron endcap tracker → Measure charged track momenta
MAPS – disks in combination with micro pattern gas detectors

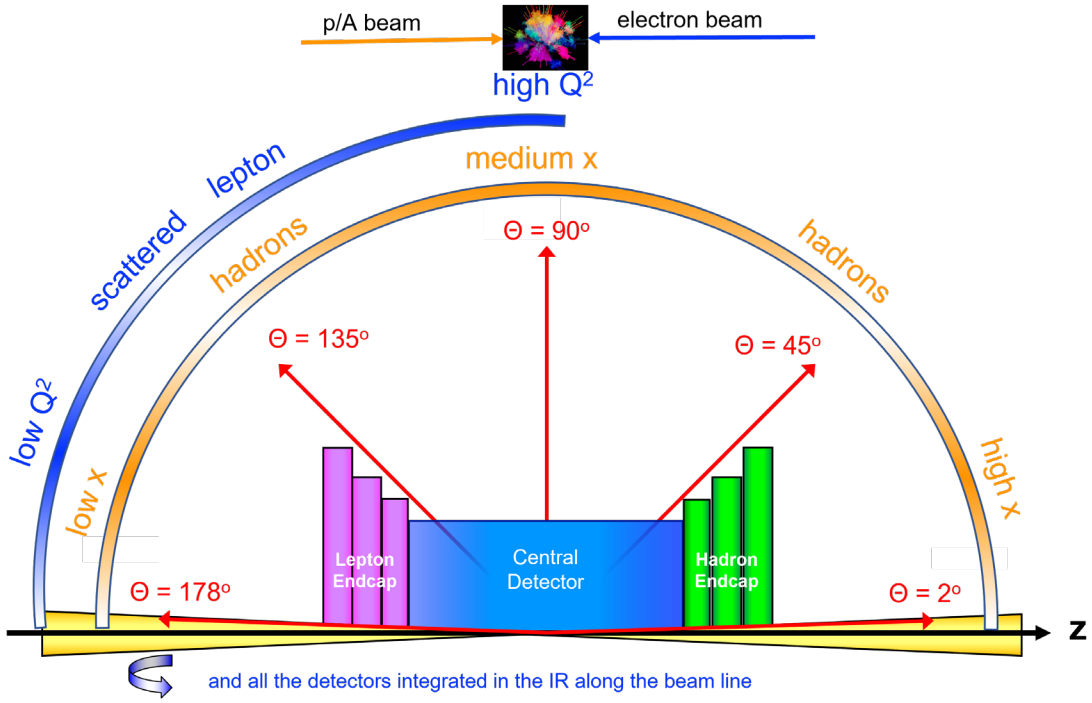
Particle Identification → pion, kaon, proton separation on track level
RICH detectors (modular and dual radiator RICH, DIRC) & Time-of-Flight
high resolution timing detectors (LAPPDs, LGAD) 10 – 30 ps
novel photon sensors: MCP-PMT / LAPPD

Electromagnetic calorimeter → Measure photons (E, angle), identify electrons
$PbWO_4$ Crystals (backward), W/SciFi Spacal (forward)
Barrel: Pb/SciFi+imaging part or new Scintillating glass

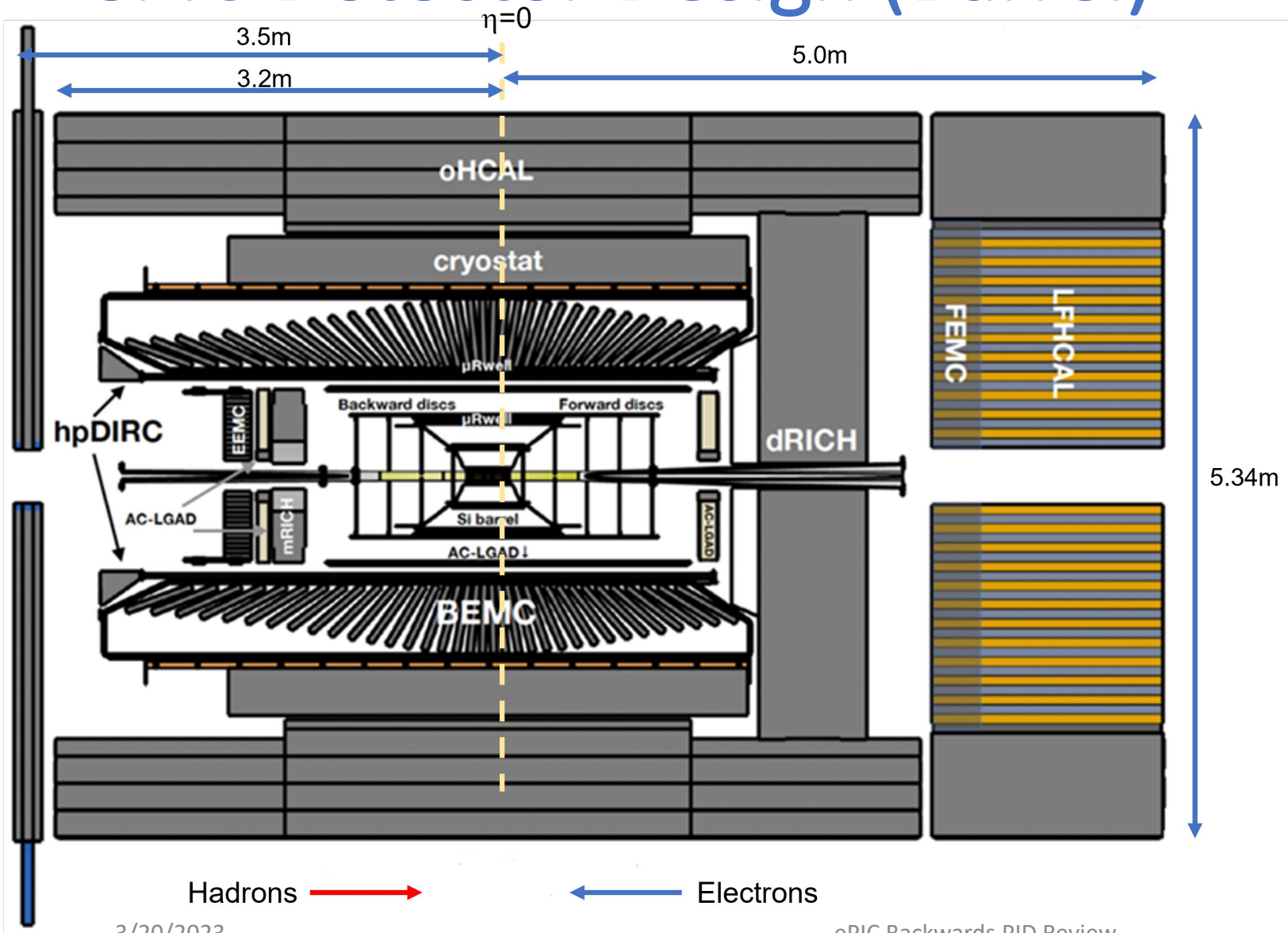
Hadron calorimeter → Measure charged hadrons, neutrons and K_L^0
challenge achieve ~50%/√E + 10% for low E hadrons (<E> ~ 20 GeV)
Fe/Sc sandwich with longitudinal segmentation

DAQ & Readout Electronics: trigger-less / streaming DAQ
Integrate AI into DAQ → cognizant Detector

Very forward and backward detectors → scattered particles under very small angles
Silicon tracking layers in lepton and hadron beam vacuum
Zero – degree high resolution electromagnetic and hadronic calorimeter



ePIC Detector Design (Barrel)



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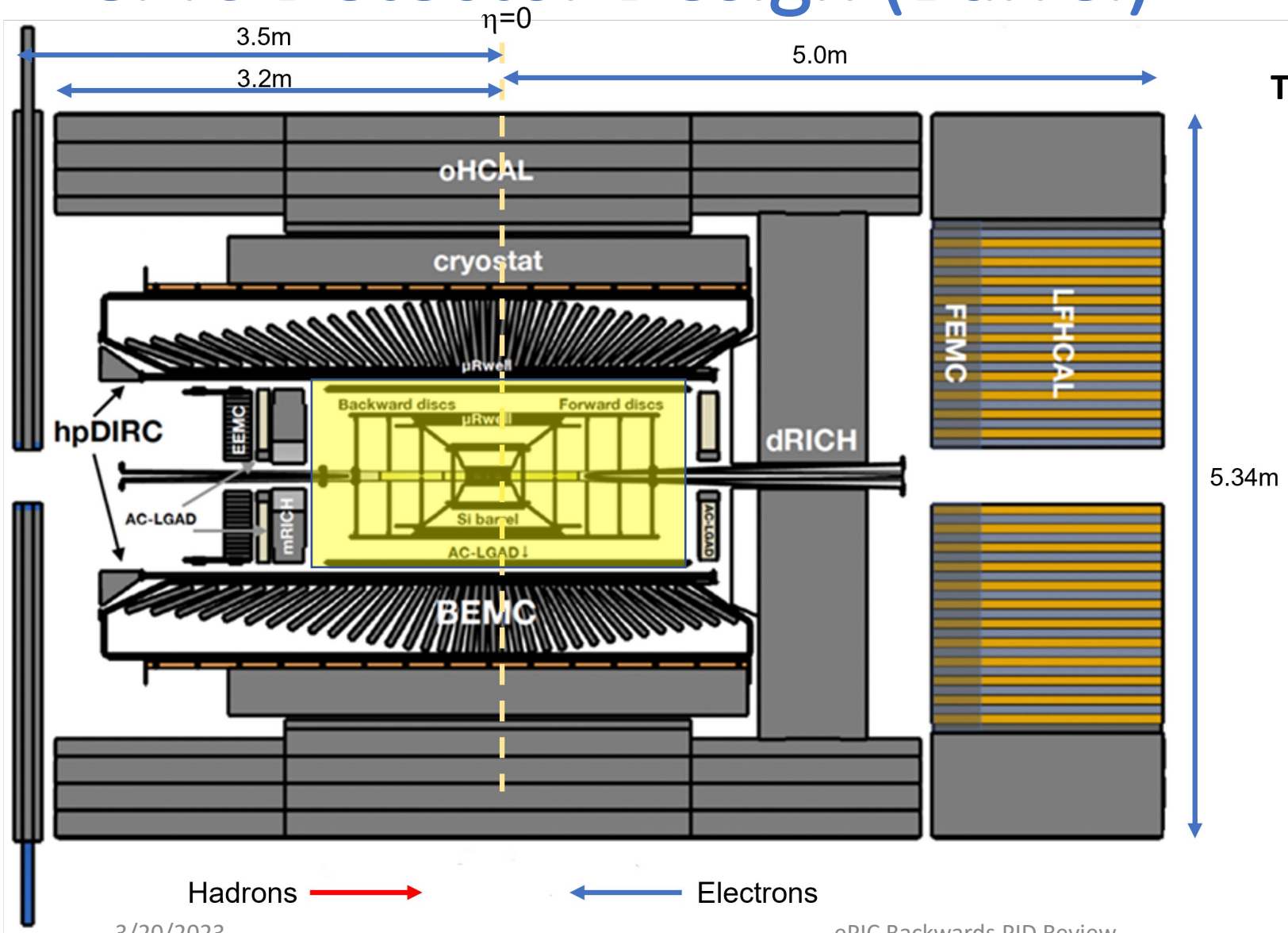
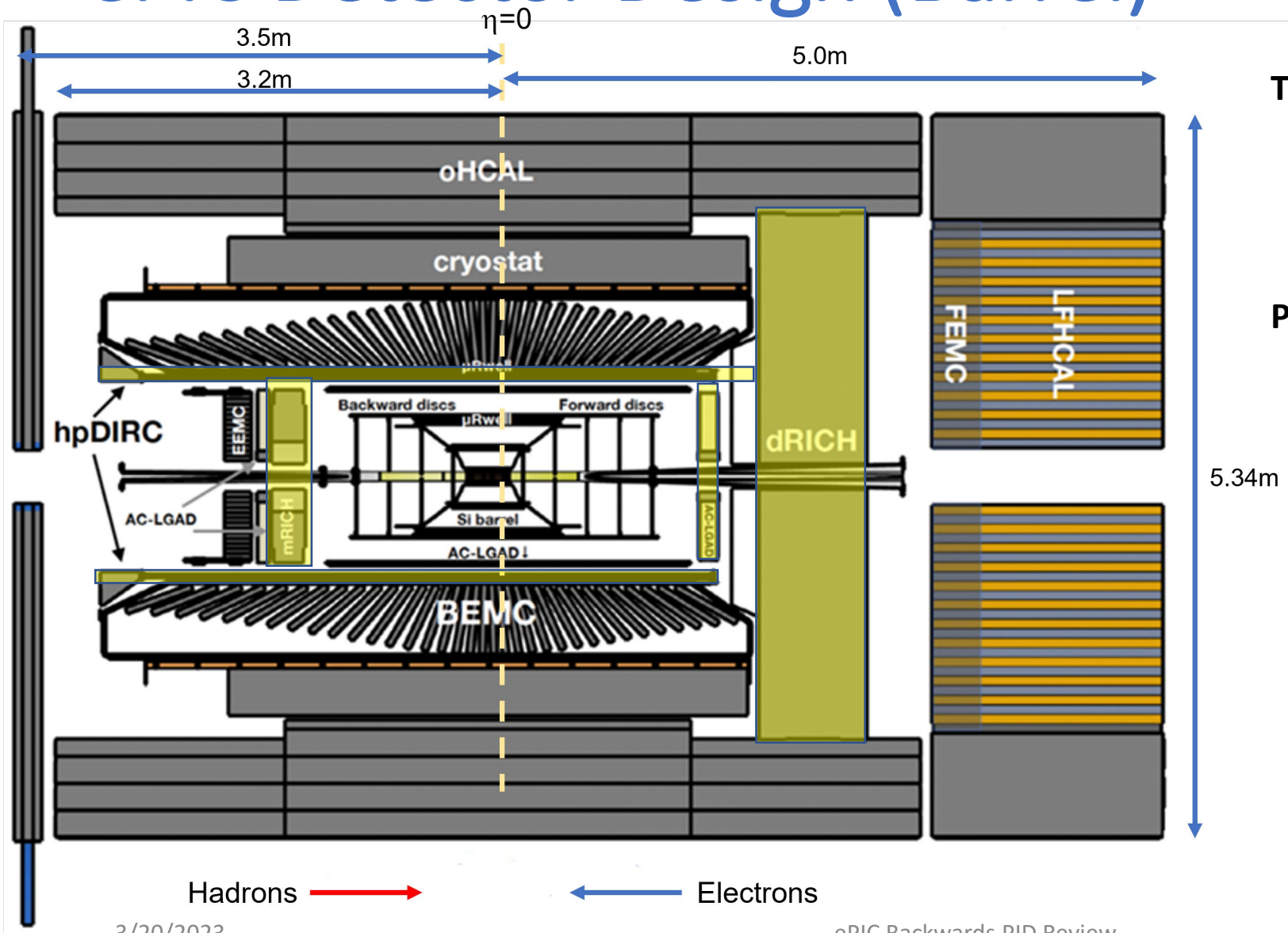


Tracking:

- New 1.7T solenoid
- Si MAPS Tracker
- MPGDs (µRWELL/µMegas)

ePIC Detector Design (Barrel)



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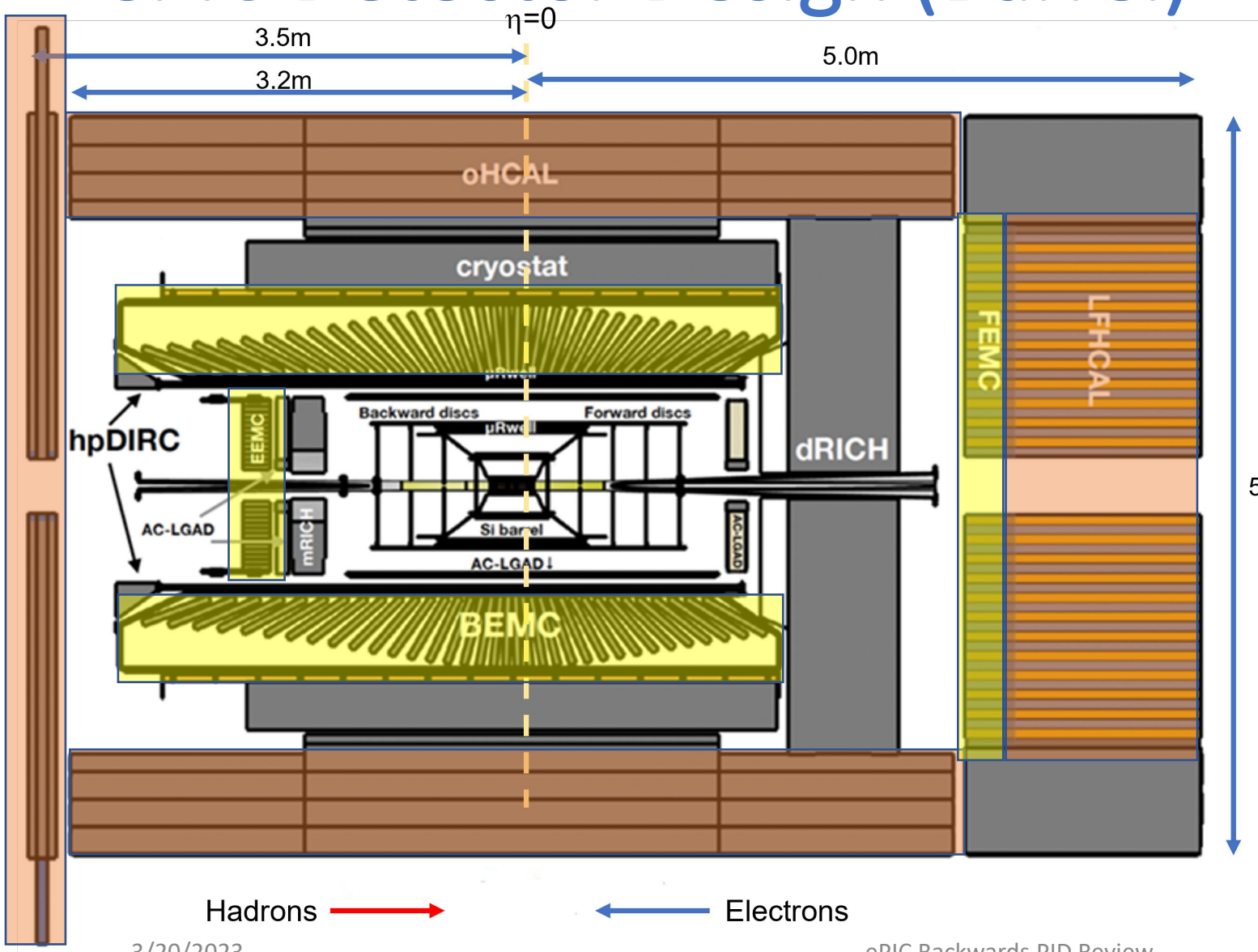
PID:

- hpDIRC
- mRICH/pfRICH
- dRICH
- AC-LGAD (~30ps TOF)

ePIC Detector Design (Barrel)



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Calorimetry:

- SciGlass/Imaging Barrel EMCal
- PbWO4 EMCal in backward direction
- Finely segmented EMCal +HCal in forward direction
- Outer HCal (sPHENIX re-use)
- Backwards HCal (tail-catcher)

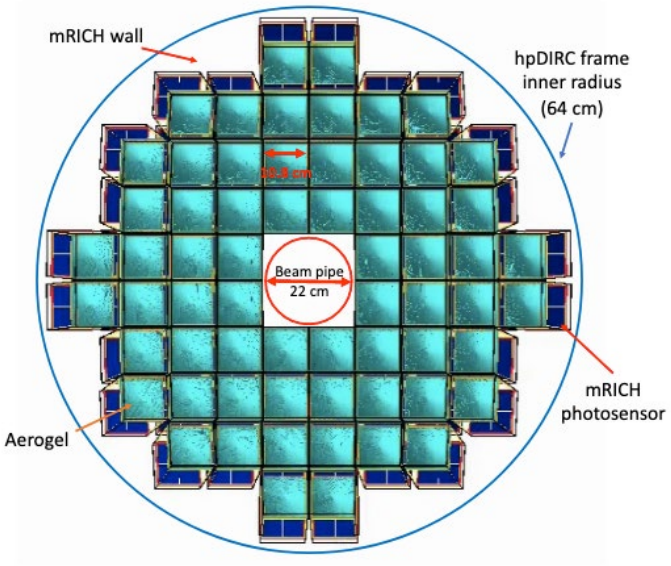
Backwards PID Requirements

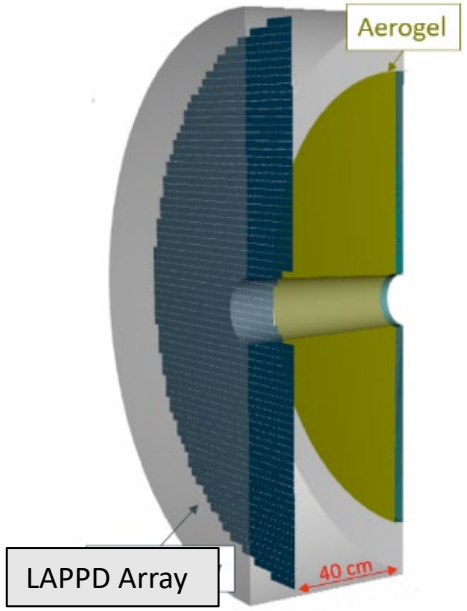
η	Nomenclature			π/K/p PID	
				p-Range (GeV/c)	Separation
-6.9 — -5.8	↓ p/A	Auxiliary Detectors	low-Q^2 tagger		
…					
-4.5 — -4.0			Instrumentation to separate charged particles from γ		
-4.0 — -3.5					
-3.5 — -3.0		Central Detector	Backwards Detectors	≤ 7 GeV/c	≥ 3σ
-3.0 — -2.5					
-2.5 — -2.0					
-2.0 — -1.5					
-1.5 — -1.0					
-1.0 — -0.5					
-0.5 — 0.0			Barrel	≤ 10 GeV/c	
0.0 — 0.5					
0.5 — 1.0				≤ 15 GeV/c	
1.0 — 1.5			Forward Detectors	≤ 30 GeV/c	
1.5 — 2.0				≤ 50 GeV/c	
2.0 — 2.5					
2.5 — 3.0				≤ 30 GeV/c	
3.0 — 3.5				≤ 45 GeV/c	
3.5 — 4.0	↑e	Auxiliary Detectors	Instrumentation to separate charged particles from γ		
4.0 — 4.5					
…					
> 6.2			Proton Spectrometer		

Extracted from EICUG Yellow Report Table 8.20 (PWG Requirements)

Backwards PID Technology Selection

ePIC Review
March 20-21, 2023





Modular RICH (mRICH)

- Aerogel radiator
- Longitudinally compact due to Fresnel lens focusing

Proximity Focusing RICH (pfRICH)

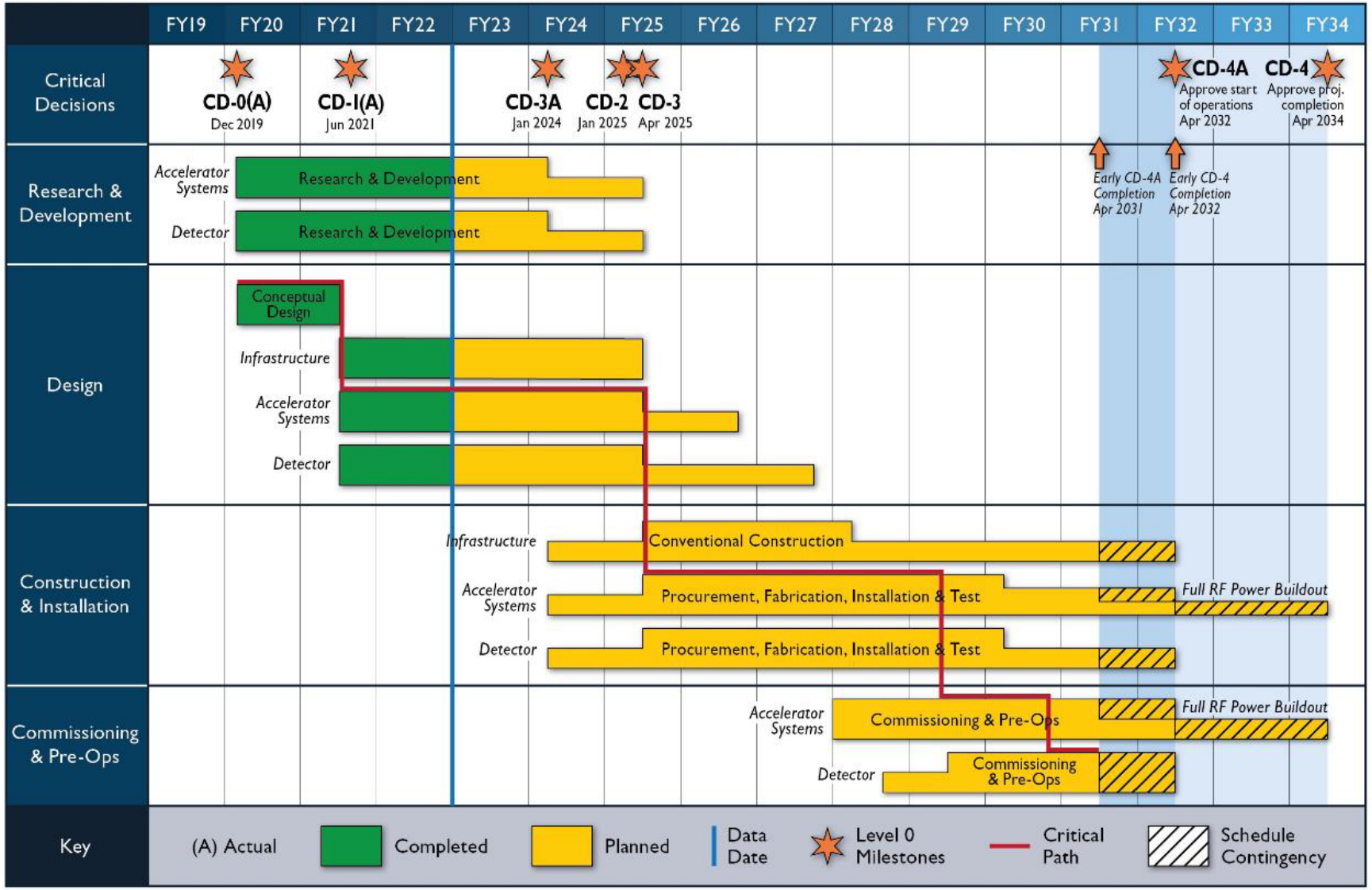
- Aerogel radiator
- Gas threshold-based electron ID
- Requires expansion volume

Both with use LAPPD (HRPPD) readout to provide additional timing information.

Project Schedule

Construction Phase

Science Phase



Committee Charge

Many thanks to our external reviewers:

Ichiro Adachi (KEK)
Roberta Cardinale (U. Genova)
Carmelo D'Ambrosio (CERN)
Antonello Di Mauro (CERN)

ePIC Backwards PID Technology Review

Charge to the Committee

The scope of this review is to gather information and feedback on the anticipated performance, cost and risk of two proposed technology choices (the modular RICH and proximity-focused RICH) for the ePIC backwards particle identification system. This review should focus primarily on the detector performance and integration issues.

It is understood that both technology choices are currently evolving from advanced conceptual designs to full technical designs and should be evaluated with this level of development in mind. For the ePIC Backwards PID Technology Review, you are asked to address the following questions for each of the two technology options:

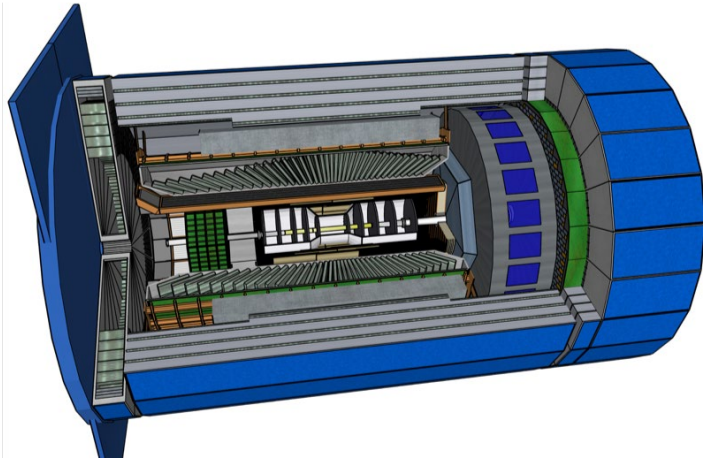
1. Is the anticipated performance, as demonstrated by simulations, test beam, R&D, etc. realistic given existing experience? Is the anticipated performance adequate to address the full EIC science program, as outlined in the National Academy (link) report and the EICUG Yellow Report (link)?
2. Does the mechanical integration of the detector present any unique challenges?
3. Is there an adequate workforce to build, commission and maintain the detector, or are there adequate plans to evolve the workforce towards these goals?
4. Is the cost and schedule presented realistic? Are the production capabilities of vendors fully understood and consistent with the schedule?
5. Have the proponents adequately identified technical, cost and schedule risks? Are appropriate risk mitigations identified? Please comment on production and performance uncertainties for both the aerogel and the LAPPD's.

Please address the above questions point-by-point.


BACK UP

A Brief Timeline

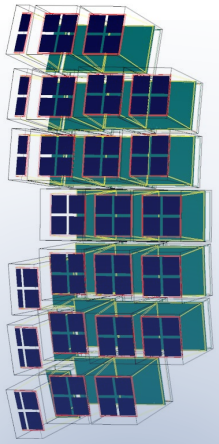
- EICUG Yellow Report (2020-21)
- Call for proposals issued jointly by BNL and JLab in March 2021
  - Proposals due Dec. 1, 2021
  - ATHENA, CORE and ECCE proposals submitted
- Public DPAP meetings Dec. 13-15, 2021
  - Presentations from proto-collaborations
  - Panel-assigned homework questions
- Second DPAP session Jan. 19-21, 2022
- DPAP closeout March 8th, 2022
  - Final report available March 21st, 2022
  - ECCE proposal chosen as basis for Detector-1 reference design
- Spring/Summer/Fall 2022:
  Detector-1 joint leadership team, WG's
  - Coordination with EIC project on development of technical design
  - Joint WG's formed and consolidation process undertaken with Global Detector and Integration WG
  - Identified two options for barrel ECal, Backwards PID



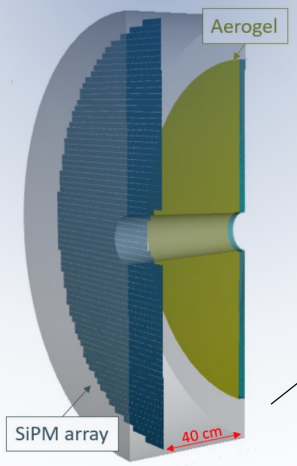
ePIC Detector

- To be sited at IP6 (25mr crossing angle)
- Addresses EIC science program as outlined in the EIC white paper and NAS report
- Must be ready for Day-1 EIC operations
- Working towards pre-TDR and CD-2/3A

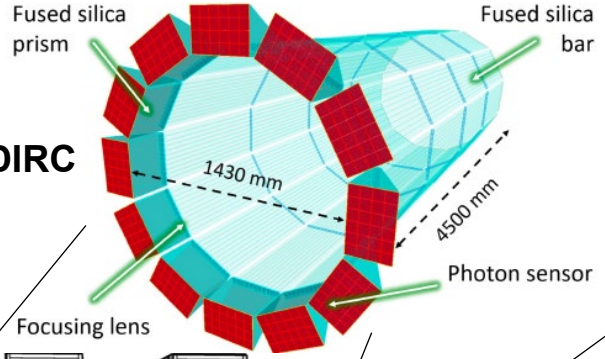
Particle ID

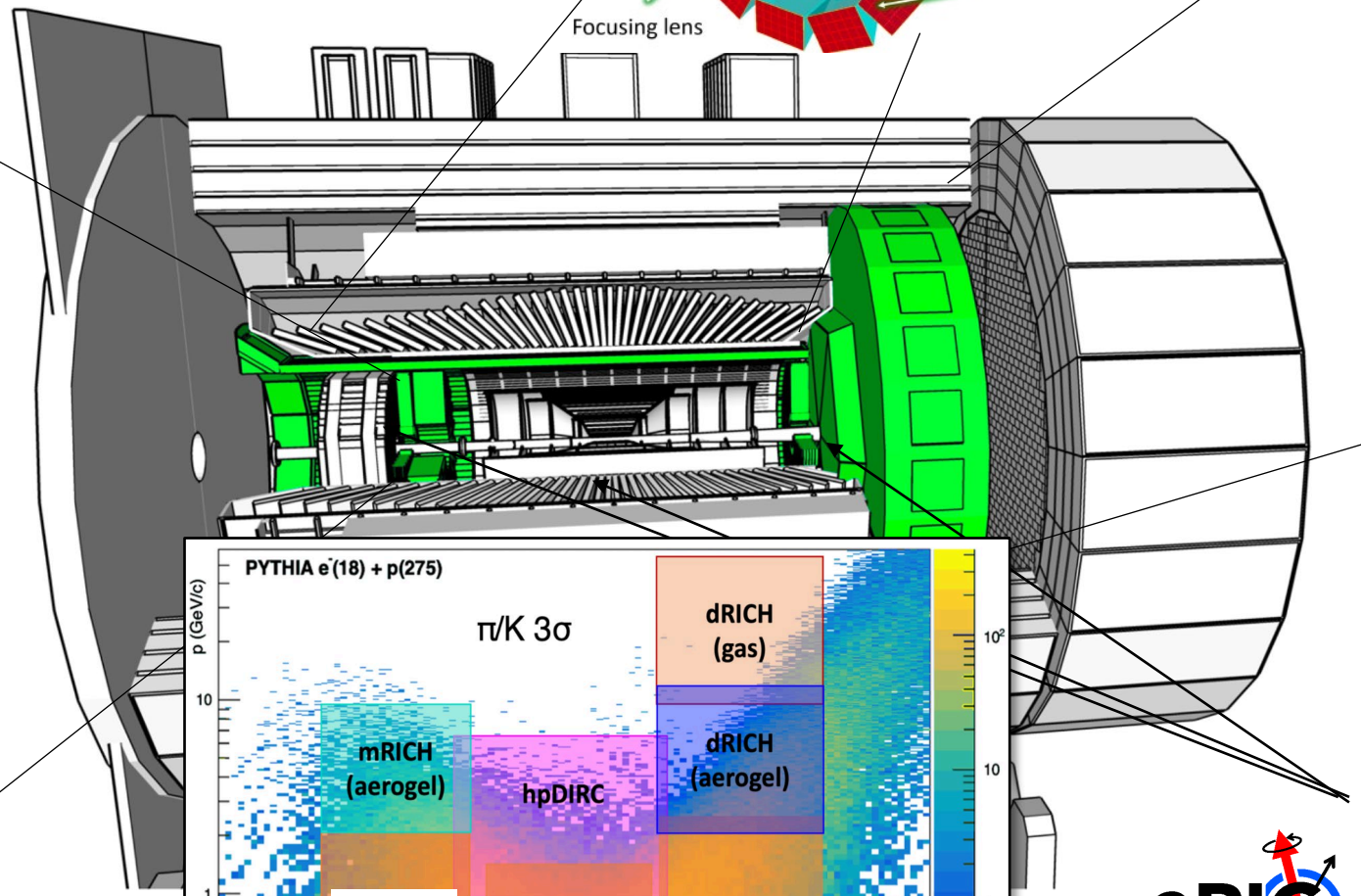


Modular (mRICH) or Proximity Focused (pfRICH)

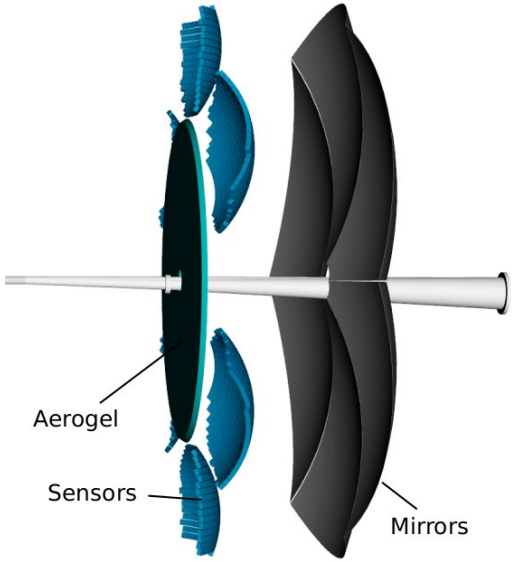


High-Performance DIRC

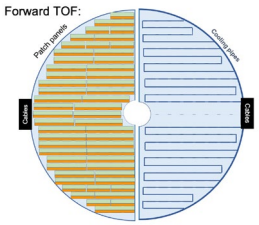


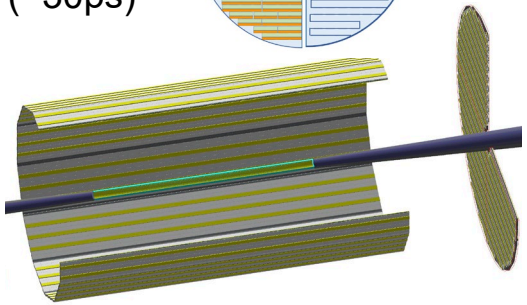


Dual-Radiator RICH (dRICH)



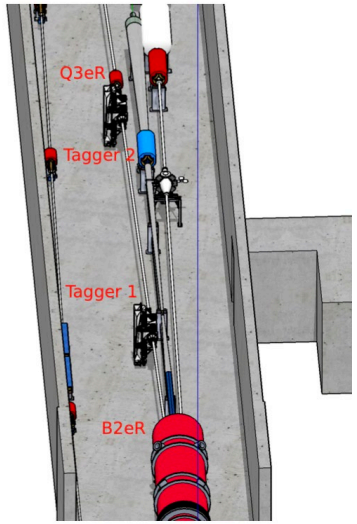
AC-LGAD TOF (~30ps)

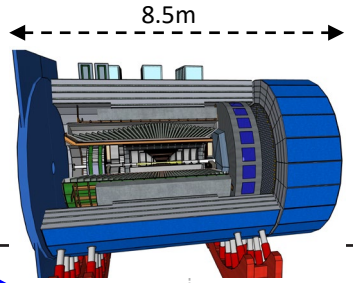


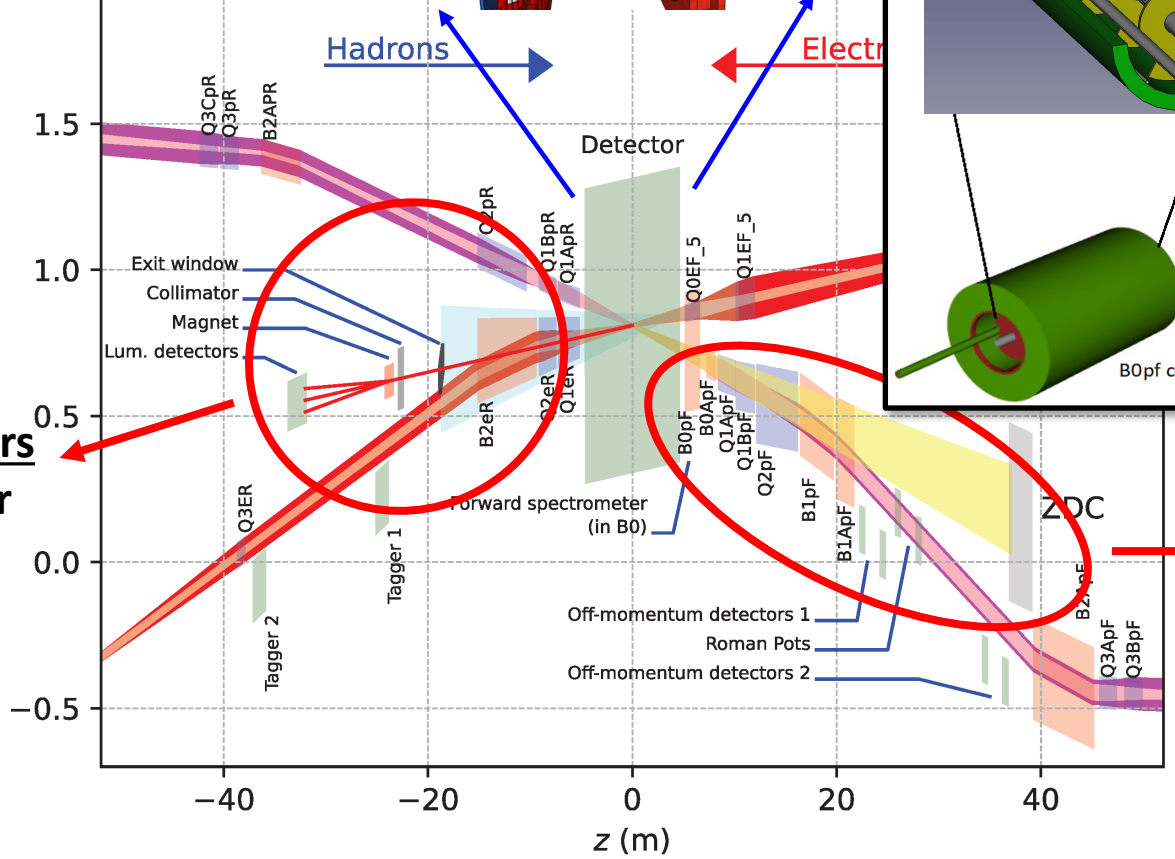


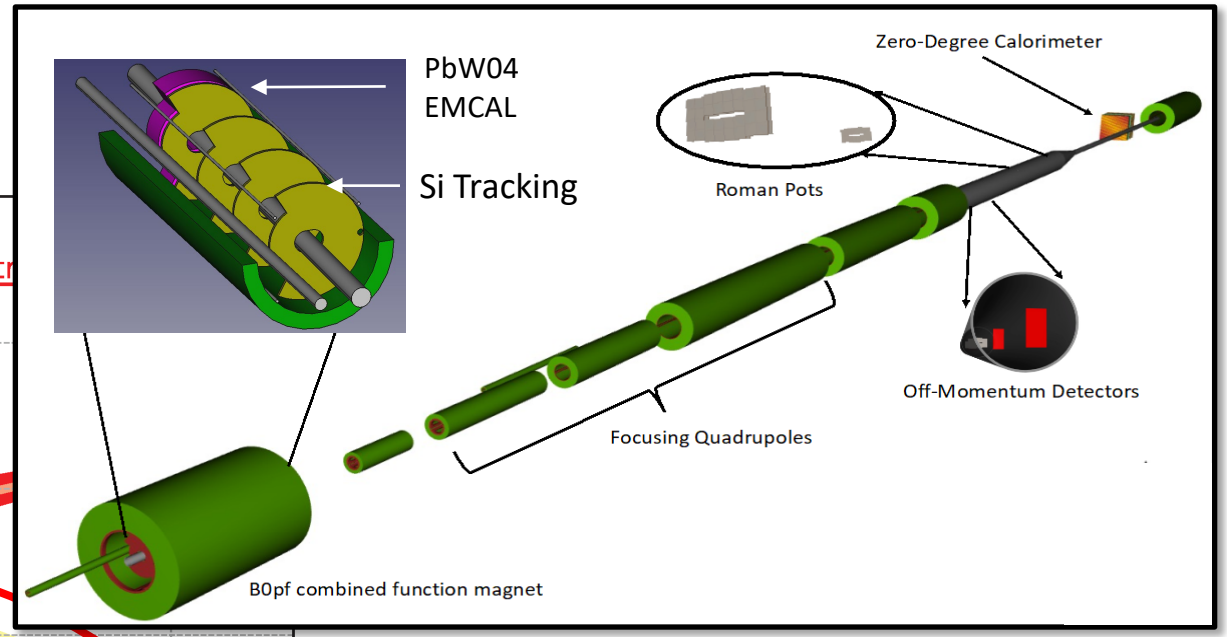
ePIC

Far-Forward and Far-Backward Detectors









Far-Backward Detectors

- **Luminosity monitor**
- **Low-Q^2 Tagging Detectors**

Far-Forward Detectors

- **B0 Tracking and Photon Detection**
- **Roman Pots and Off-Momentum Detectors**
- **Zero-Degree Calorimeter**