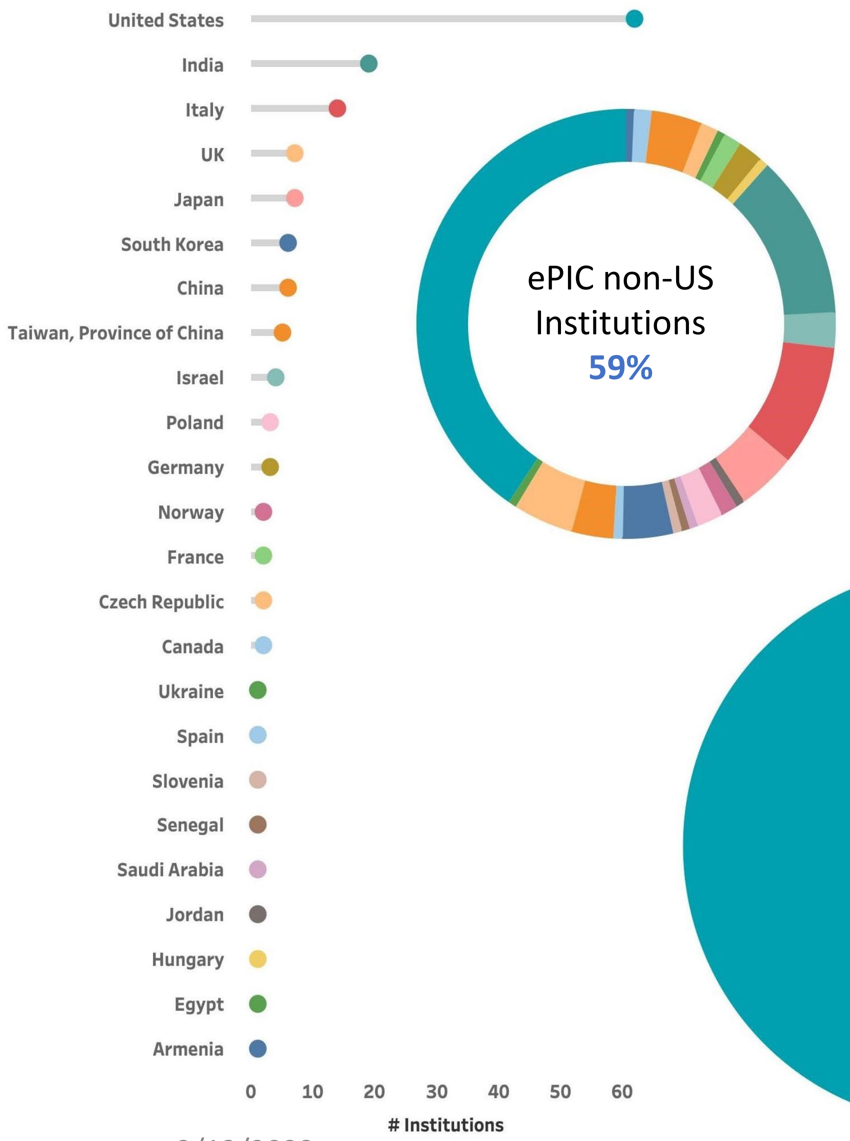
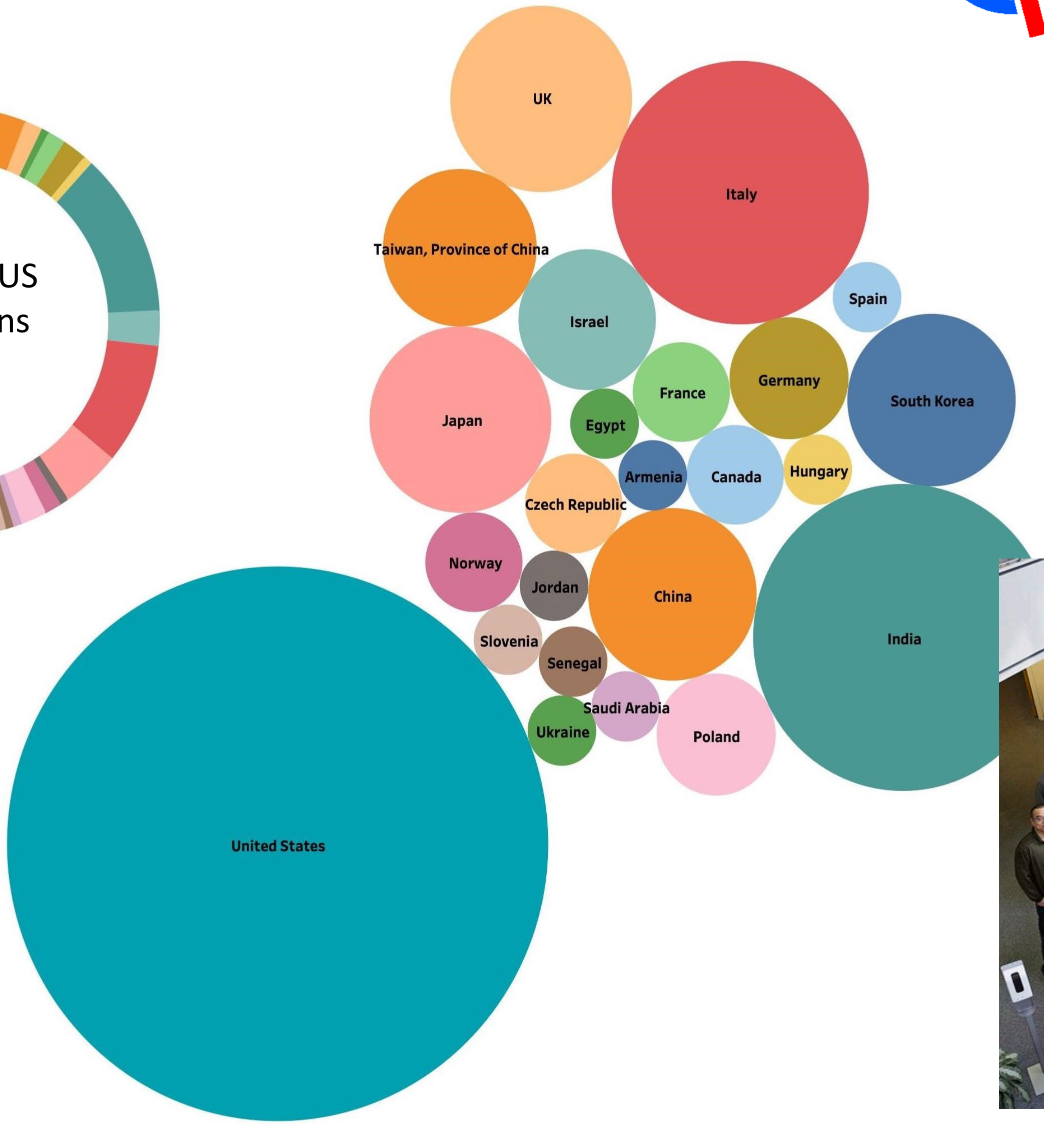
Welcome and Introduction: ePIC Barrel ECal Review

John Lajoie

Iowa State University

The ePIC Collaboration



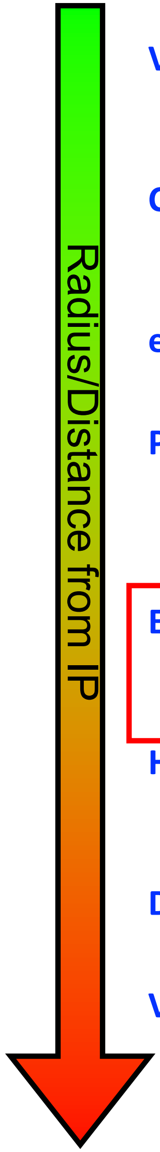


160+ institutions
24 countries

500+ participants

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

Requirements for an a EIC Detector



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

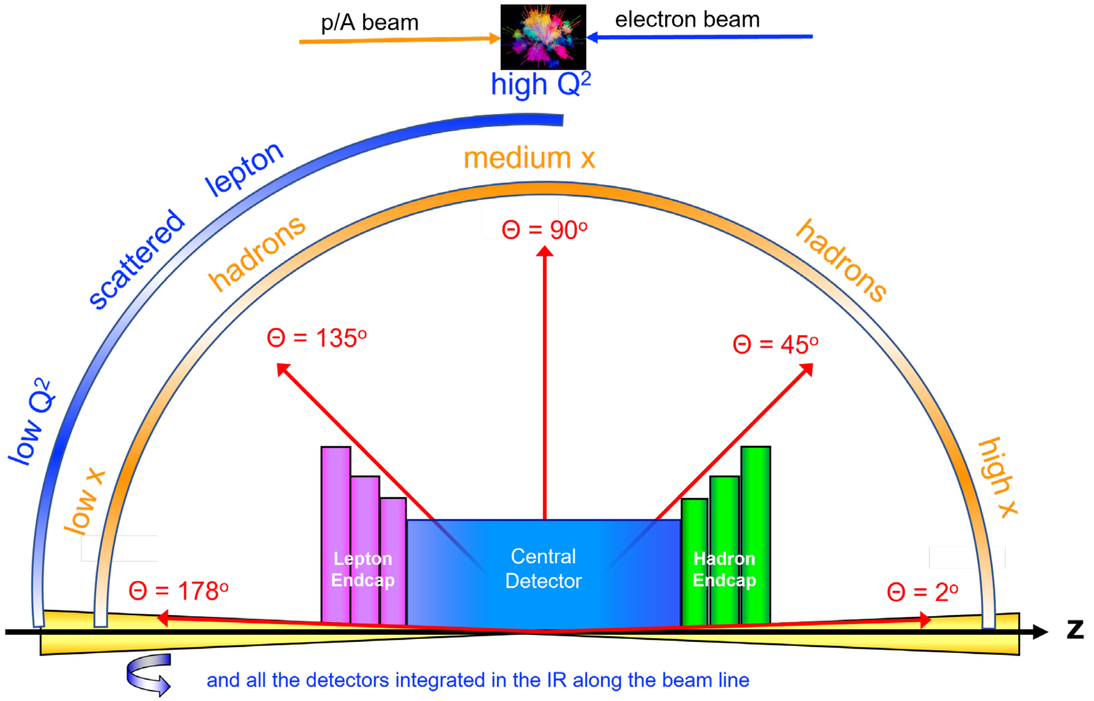
Particle Identification → pion, kaon, proton separation on track level
RICH detectors (modular and dual radiator RICH, DIRC) & Time-of-Flight
high resolution timing detectors (LAPPDs, LGAD) 10 – 30 ps
novel photon sensors: MCP-PMT / LAPPD

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

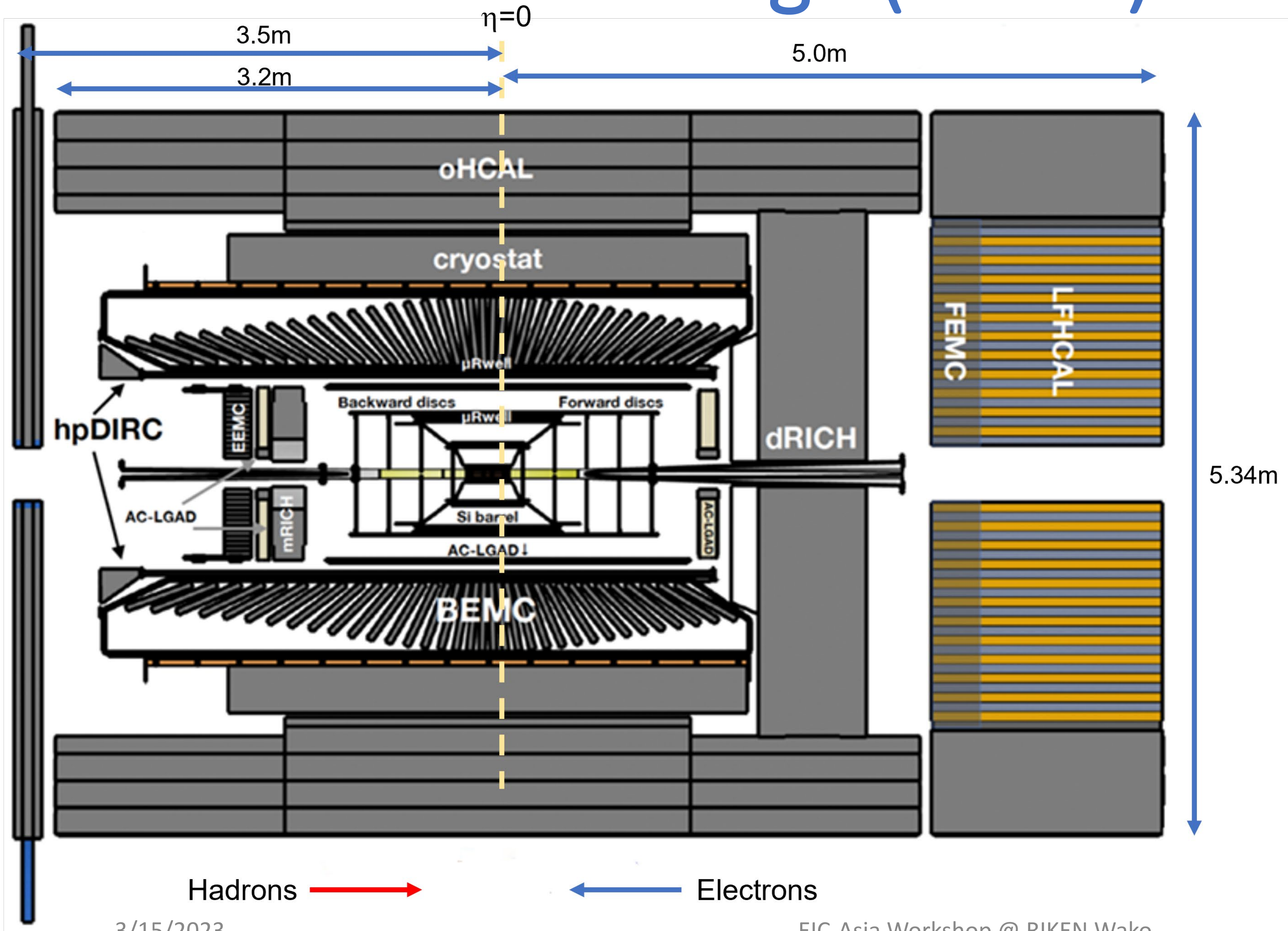
Hadron calorimeter → Measure charged hadrons, neutrons and K_L^0
challenge achieve ~50%/√E + 10% for low E hadrons (<E> ~ 20 GeV)
Fe/Sc sandwich with longitudinal segmentation

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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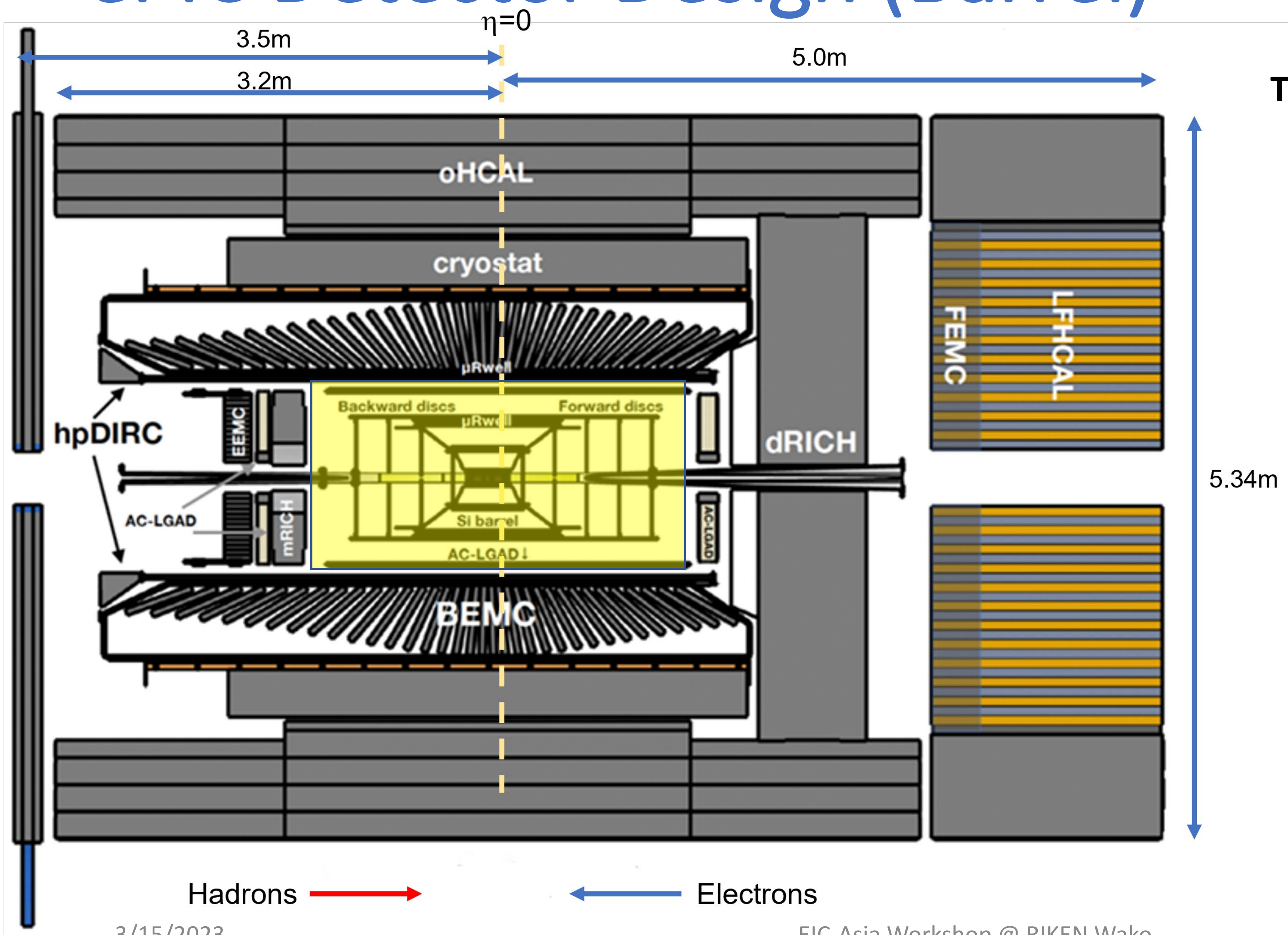
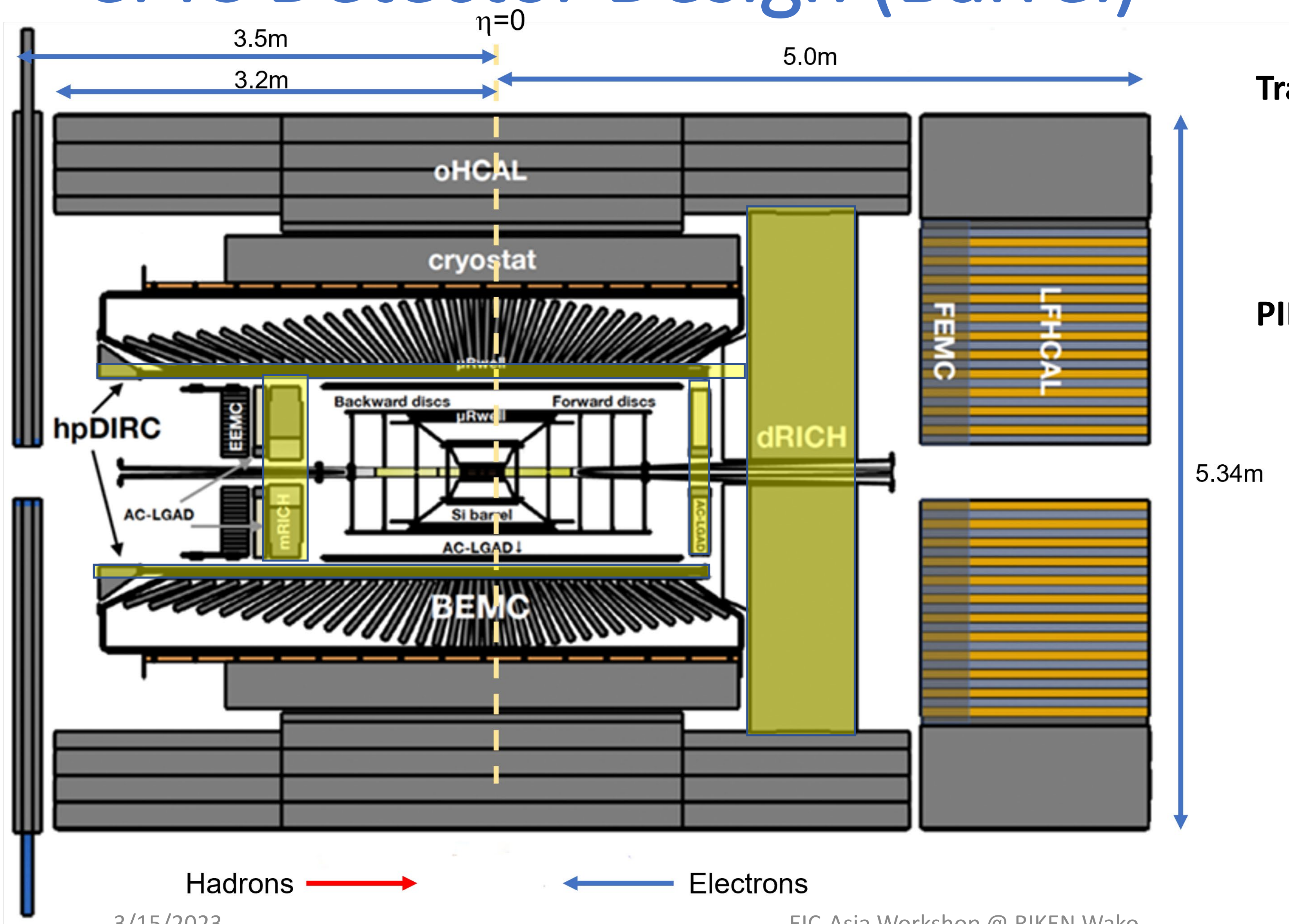


Tracking:

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

ePIC Detector Design (Barrel)



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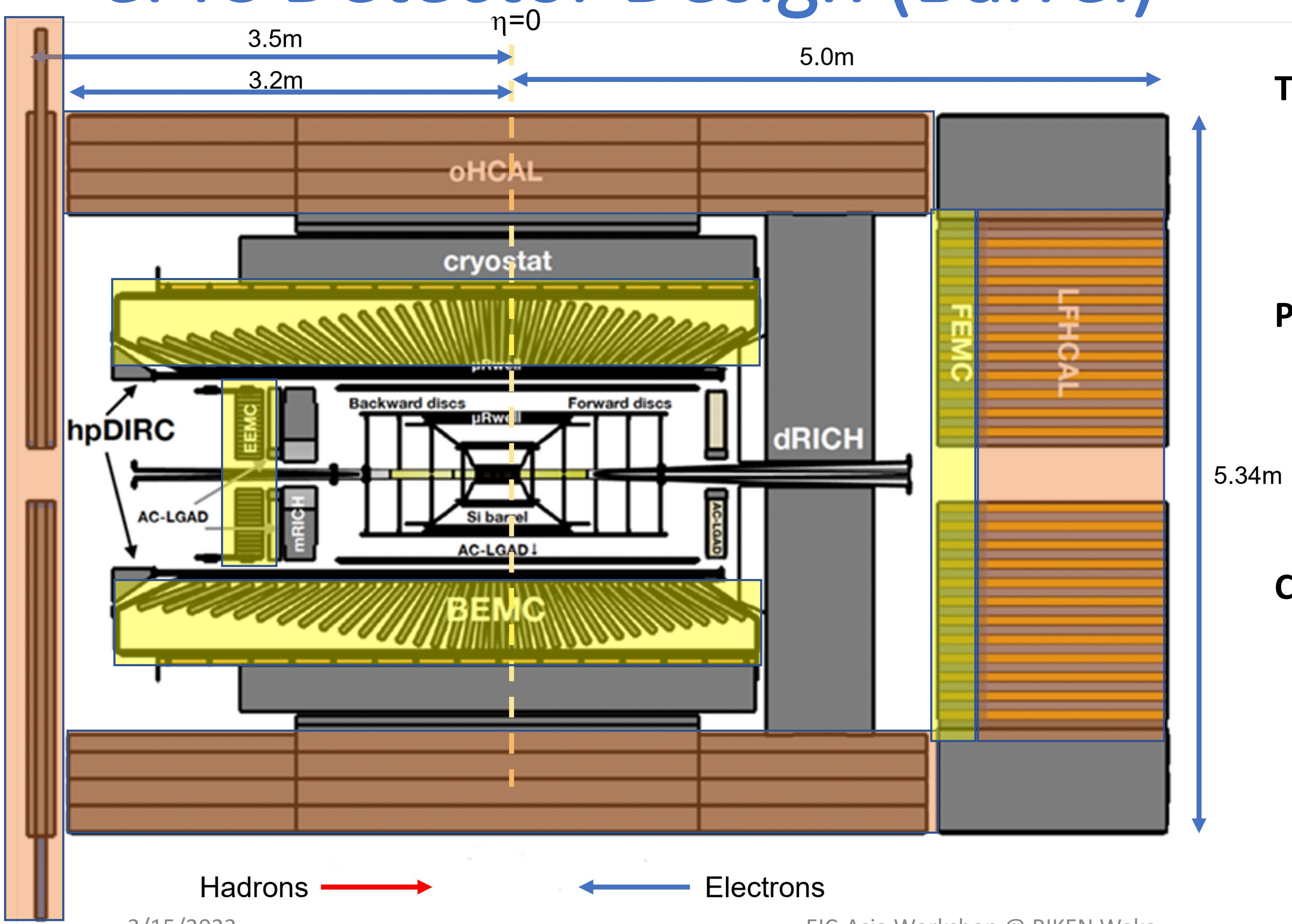
PID:

- 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)

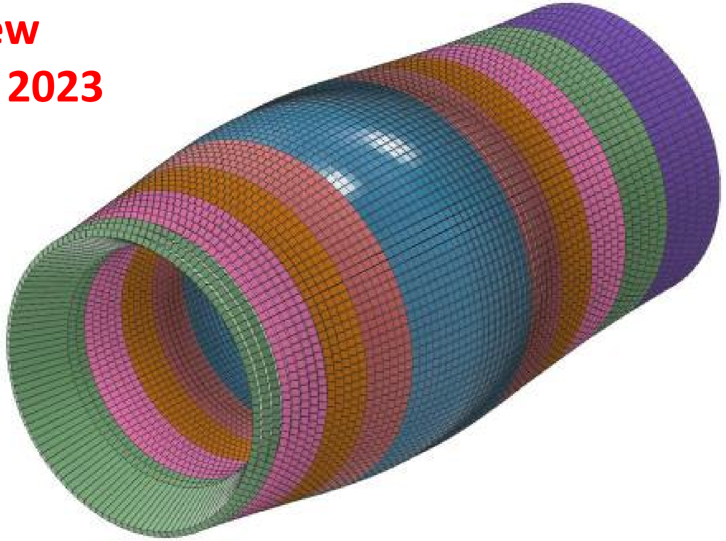
Barrel Ecal Requirements

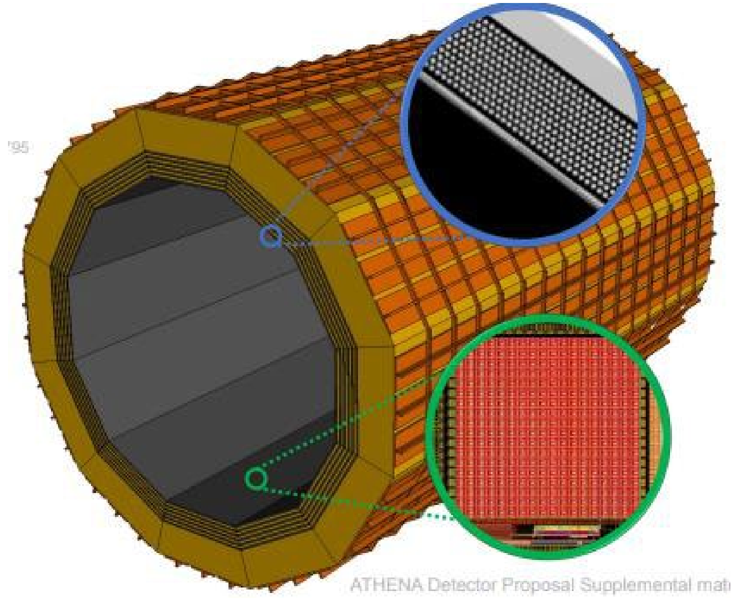
η	Nomenclature			Electrons and Photons		
				Min E	Resolution σ_E/E	PID
-6.9 — -5.8	↓ p/A	Auxiliary Detectors	low-Q^2 tagger			
…						
-4.5 — -4.0			Instrumentation to separate charged particles from γ		2%/√E+ (1-3)%	
-4.0 — -3.5				50 MeV		
-3.5 — -3.0		Central Detector	Backwards Detectors			π suppression up to 1:10^4
-3.0 — -2.5						
-2.5 — -2.0						
-2.0 — -1.5					7%/√E+ (1-3)%	
-1.5 — -1.0						
-1.0 — -0.5			Barrel		(10-12)%/ √E+(1-3)%	
-0.5 — 0.0						
0.0 — 0.5						
0.5 — 1.0						
1.0 — 1.5			Forward Detectors			3σ e/π
1.5 — 2.0						
2.0 — 2.5						
2.5 — 3.0						
3.0 — 3.5						
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)

Barrel ECal Technology Selection

ePIC Review
March 13-14, 2023





Homogeneous Calorimeter:

- SciGlass: cost-effective radiator
- Geometry and mechanical design based on PANDA
- Anticipated readout with SiPM matrices

Hybrid Design:

- Imaging calorimetry based on monolithic silicon sensors (AstroPix)
- 6 layers of imaging Si sensors interleaved with 5 SciFi/Pb layers
- Followed by a large section of SciFi/Pb (can serve as inner HCAL)

Committee Charge

Many thanks to our external reviewers:

Etiennette Auffray (CERN)
Tom LeCompte (SLAC)
Rainer Novotny (Univ. Giessen)

ePIC Barrel ECAL 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 (scintillating glass and imaging calorimeter) for the ePIC barrel electromagnetic calorimetry system. This review should include both the detector itself and the required readout and digitization electronics.

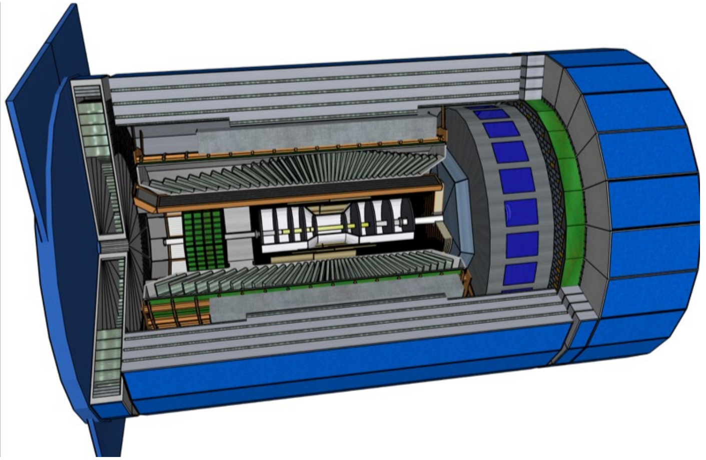
It is understood that both technology choices are currently evolving from advanced conceptual designs to full technical designs and should be evaluated with this level of development in mind. For the ePIC Barrel ECAL Technology Review, you are asked to address the following questions for each of the 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. Are the plans for the detector front-end electronics realistic and well-matched to the sensor properties? Is the detector readout compatible with a streaming readout DAQ, as planned for ePIC?
3. Does the mechanical integration of the detector present any unique challenges?
4. Is there an adequate workforce to build, commission and maintain the detector, or are there adequate plans to evolve the workforce towards these goals?
5. Is the cost and schedule presented realistic? Are the production capabilities of vendors fully understood and consistent with the schedule?
6. Have the proponents adequately identified technical, cost and schedule risks? Are appropriate risk mitigations identified?

Please address the above questions point-by-point.


BACK UP

A Brief Timeline



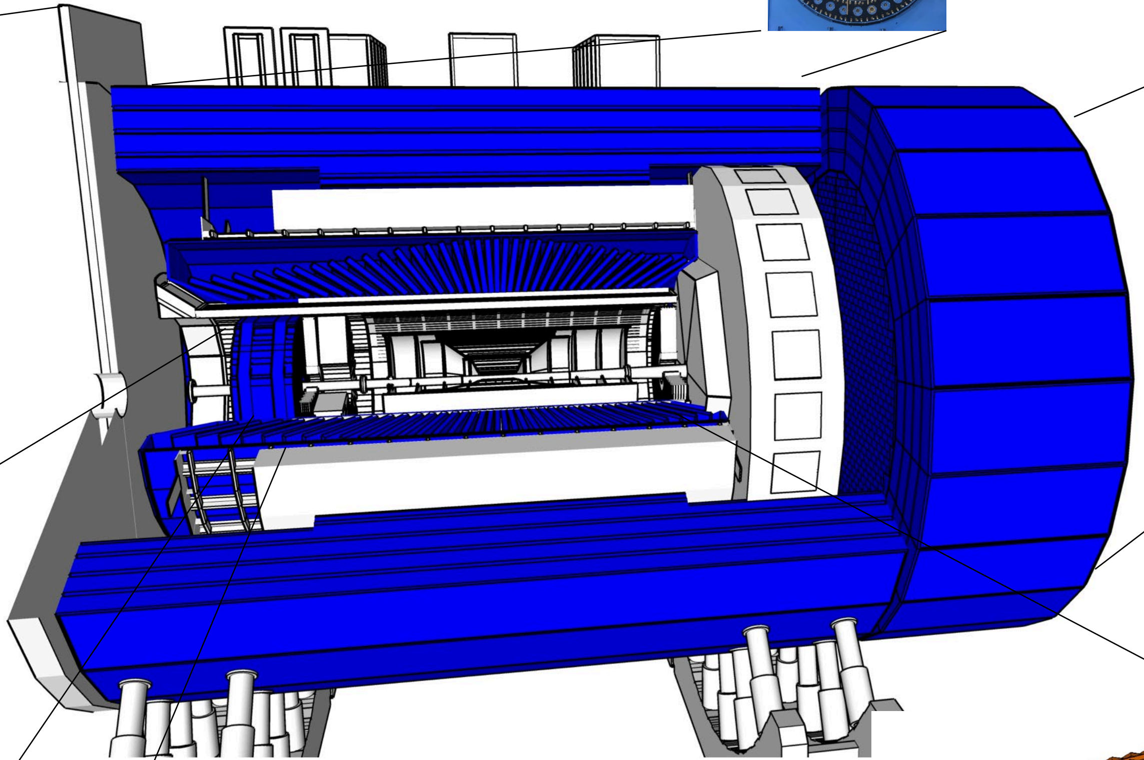
- EICUG Yellow Report (2020-21)
- Call for proposals issued jointly by BNL and JLab in March 2021
  - Proposals due Dec. 1, 2021
  - ATHENA, CORE and ECCE proposals submitted
- Public DPAP meetings Dec. 13-15, 2021
  - Presentations from proto-collaborations
  - Panel-assigned homework questions
- Second 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

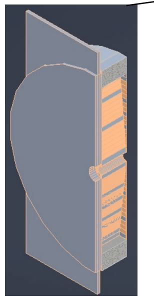
ePIC Detector

- 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

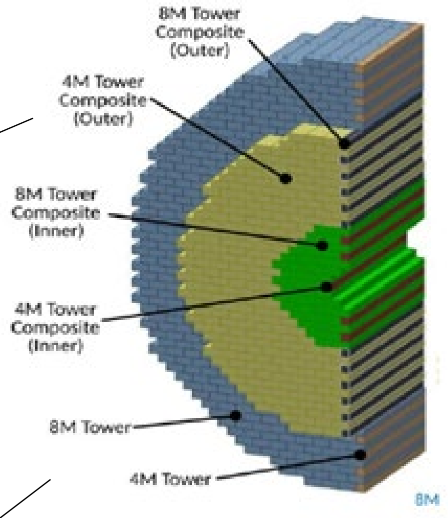
Calorimetry

Barrel HCAL (sPHENIX re-use)

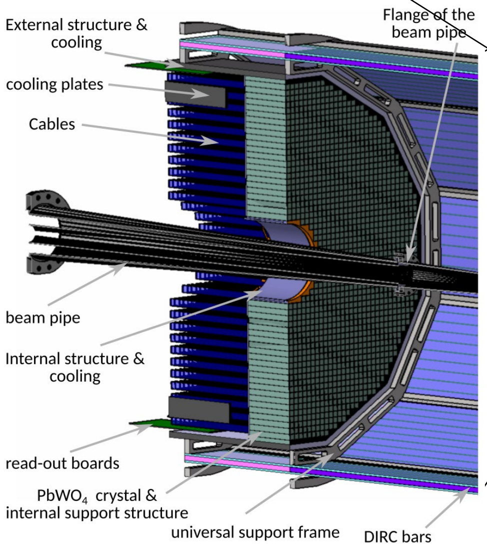




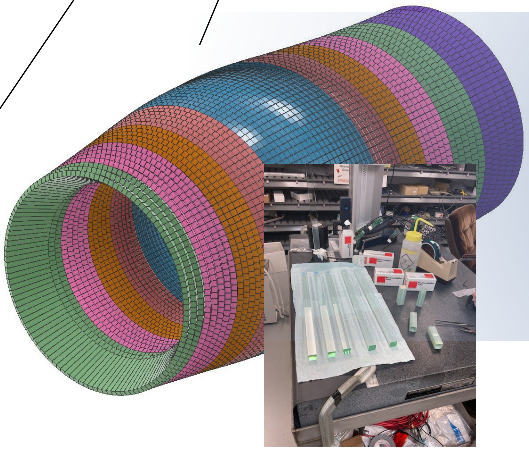
Backwards HCal Steel/Sc Sandwich tail catcher



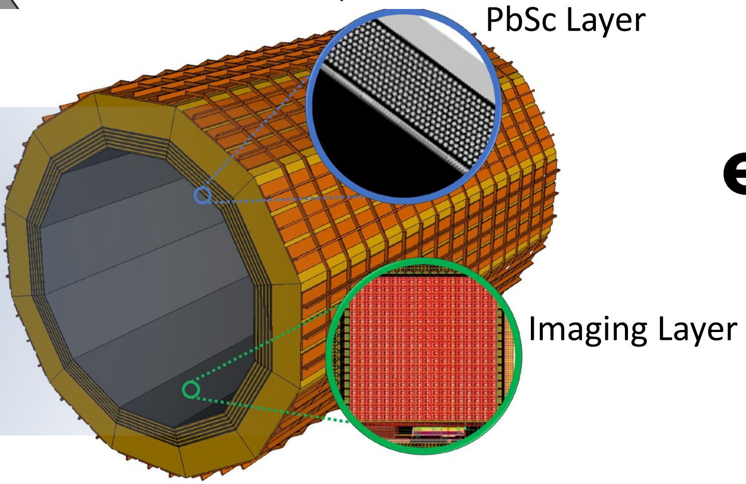
High granularity W/SciFi EMCal Longitudinally separated HCAL with high-η insert



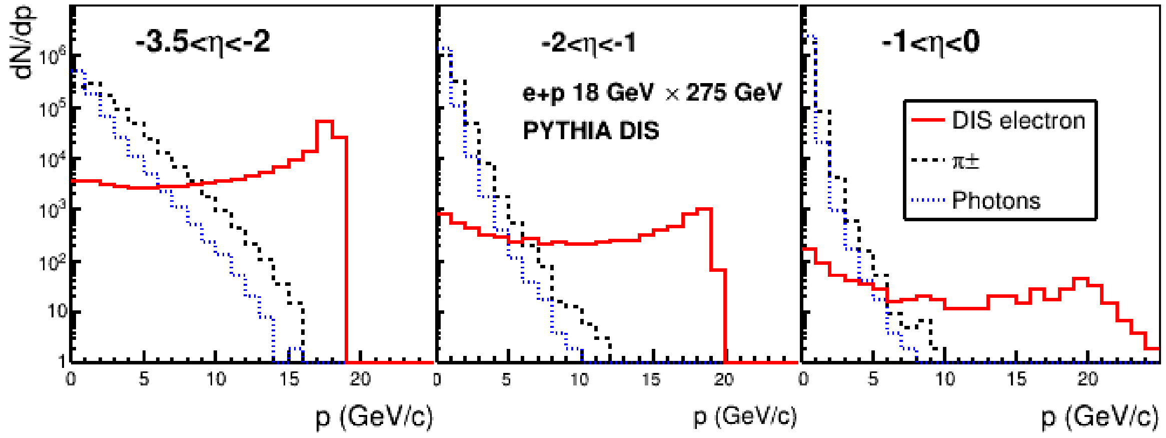
Backwards EMCal PbW04 crystals



Complementary options for BECAL: SciGlass or Imaging Calorimeter

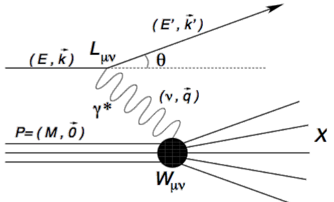


Example: EM Calorimetry Requirements



Electron/photon PID, energy, angle/position:

Coverage (in rapidity and energy), resolution, e/π, granularity, projectivity



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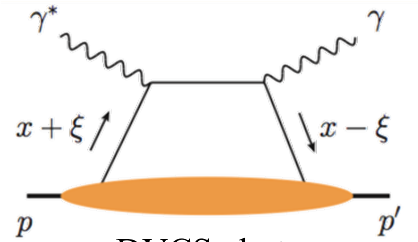
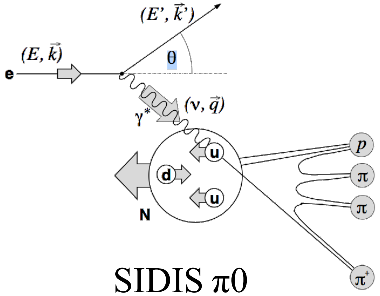
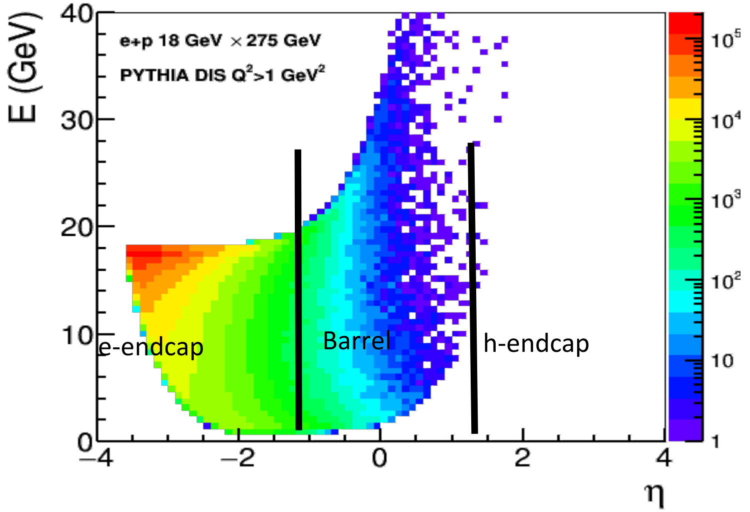
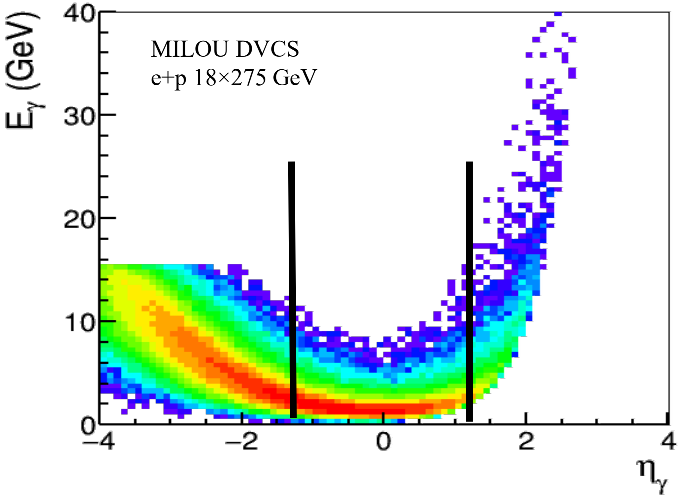


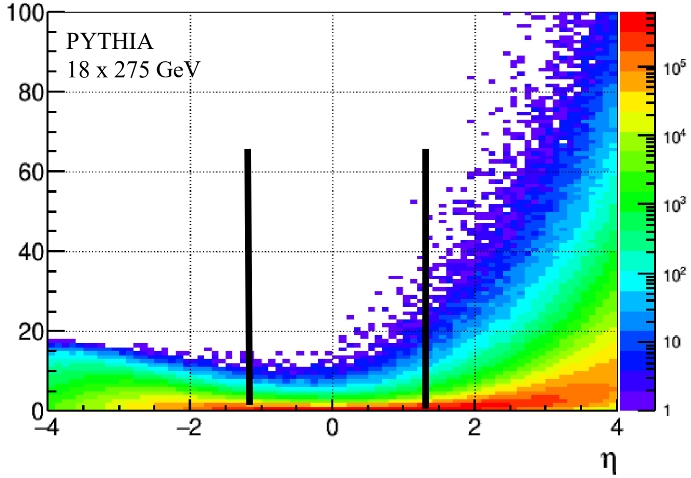
DVCS photons



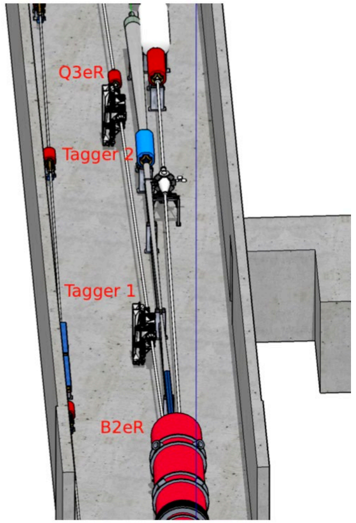
SIDIS π0

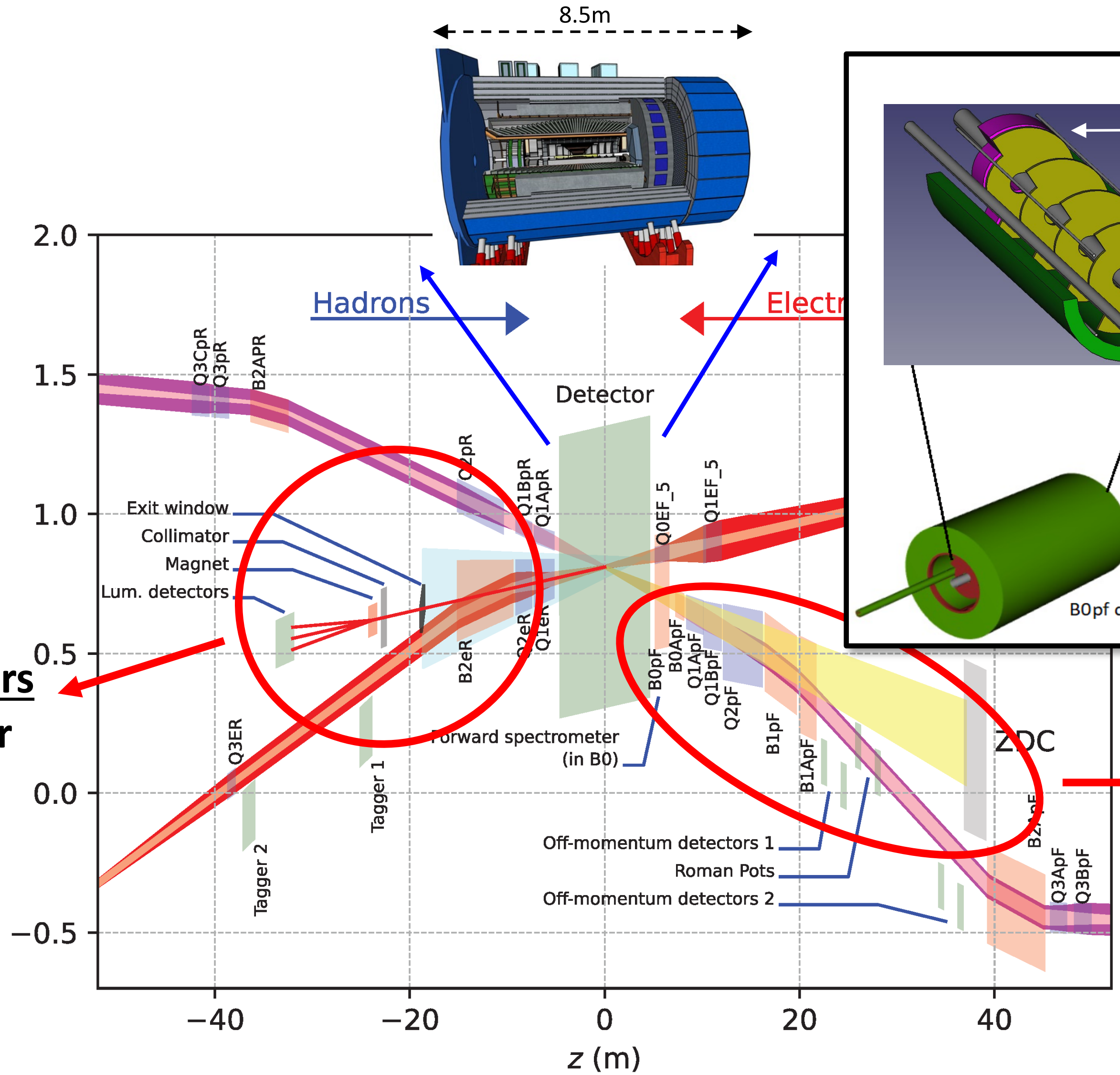


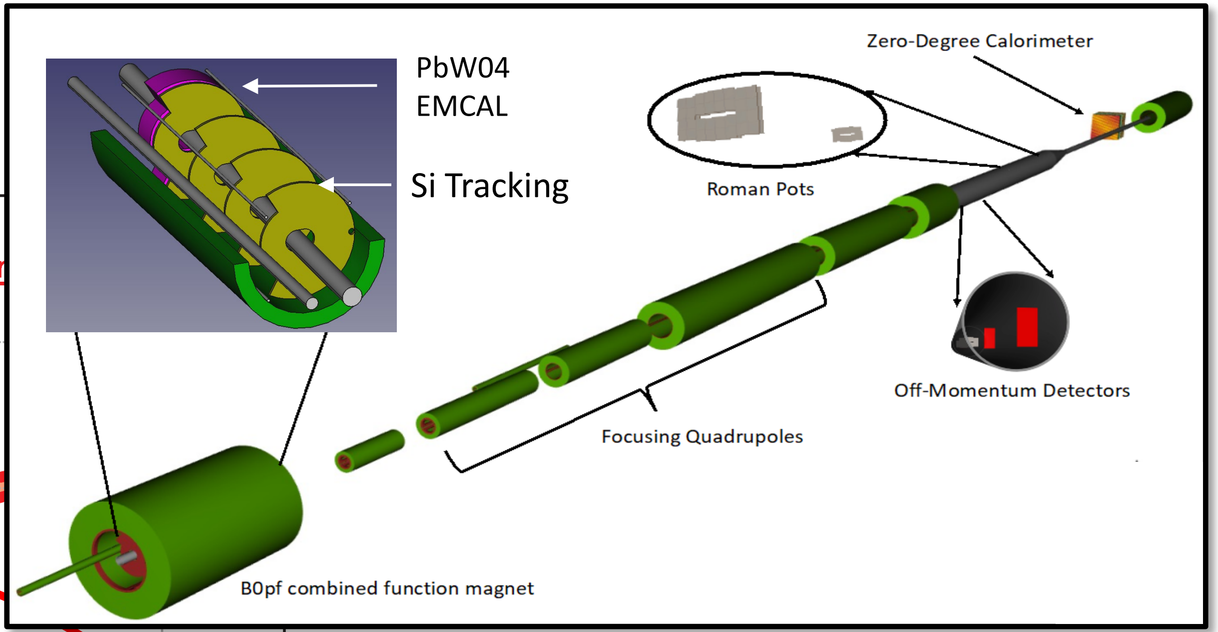




Far-Forward and Far-Backward Detectors







Far-Backward Detectors

- **Luminosity monitor**
- **Low-Q² Tagging Detectors**

Far-Forward Detectors

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