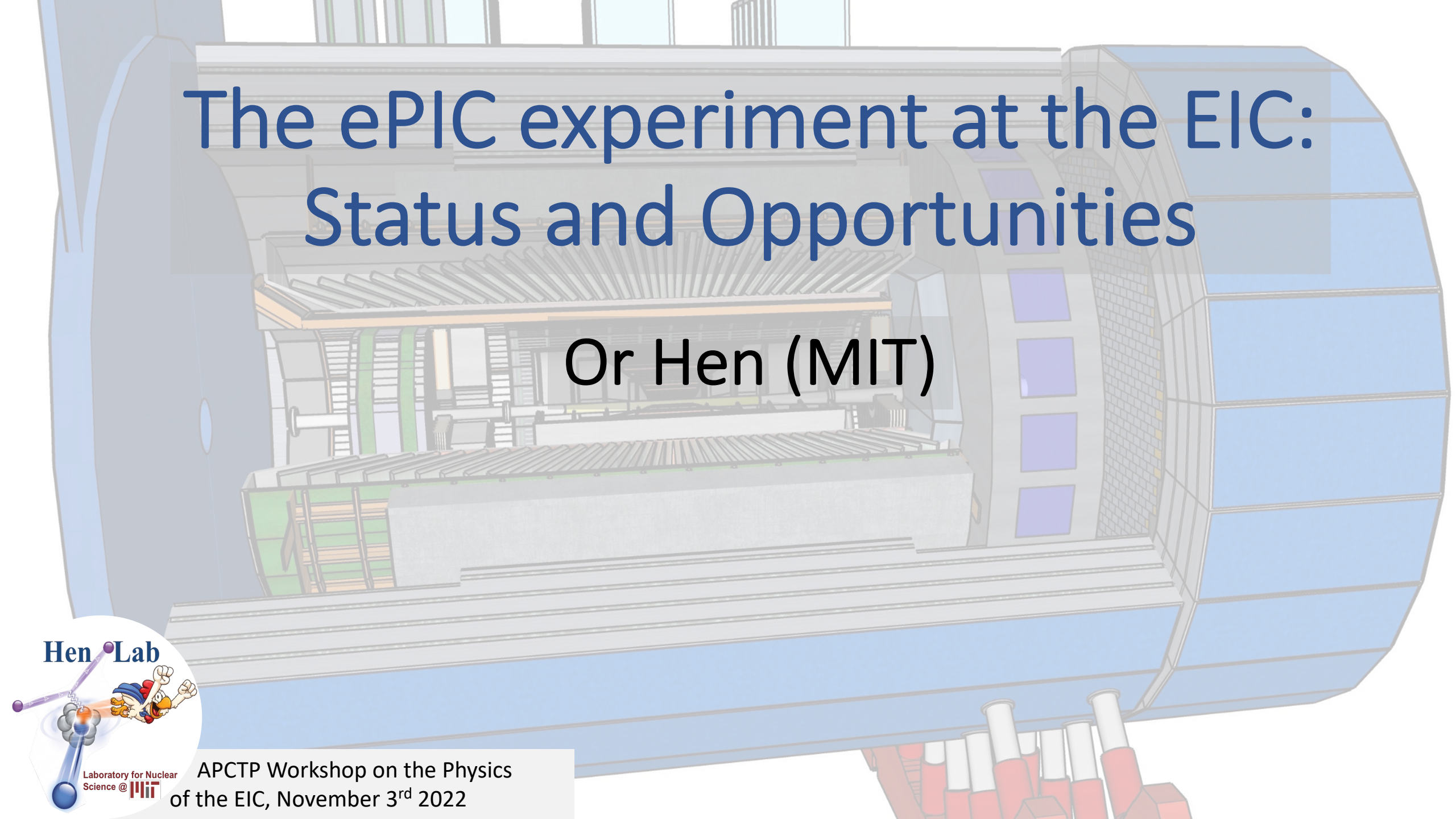
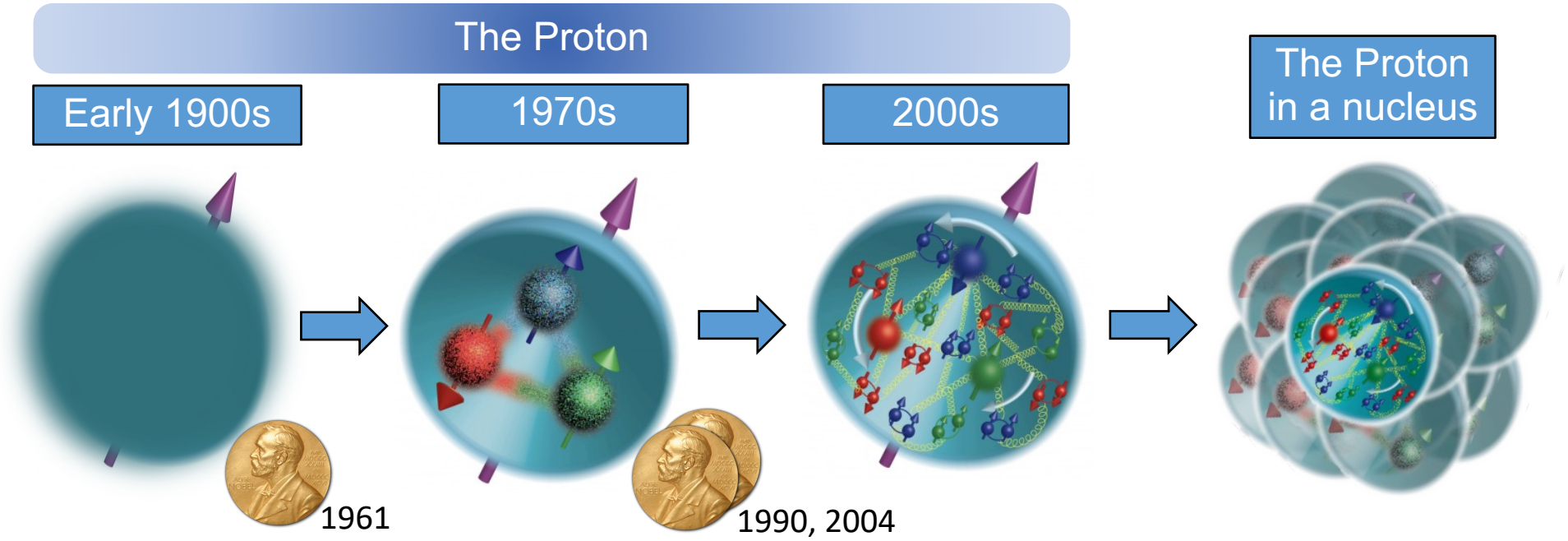
The ePIC experiment at the EIC: Status and Opportunities

Or Hen (MIT)



APCTP Workshop on the Physics of the EIC, November 3rd 2022

The EIC Physics Program

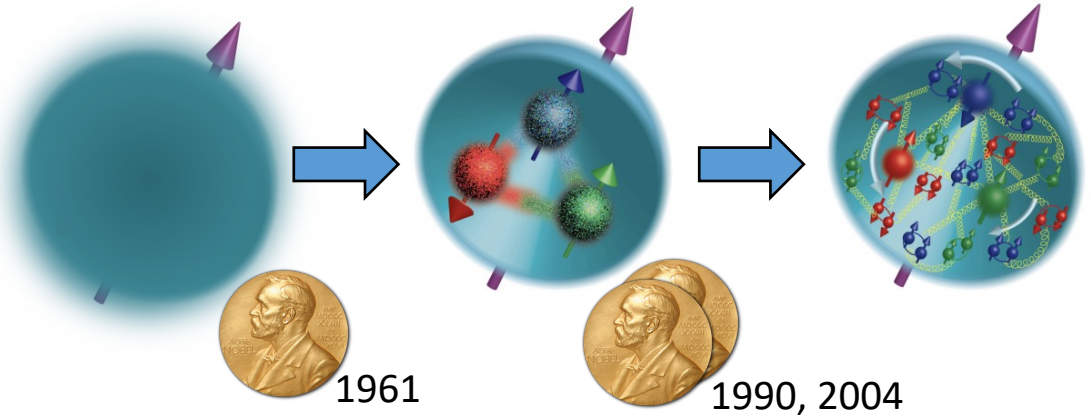


The EIC Physics Program

Multidimensional imaging of the structure of the proton; Origin of Mass, Spin, …

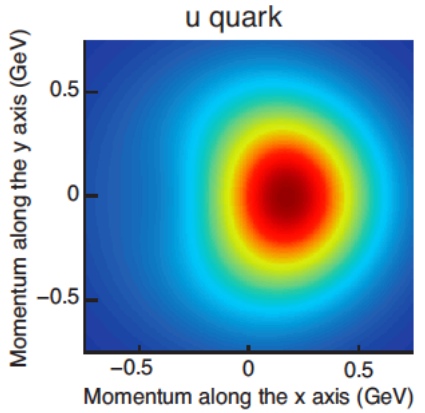
The Proton

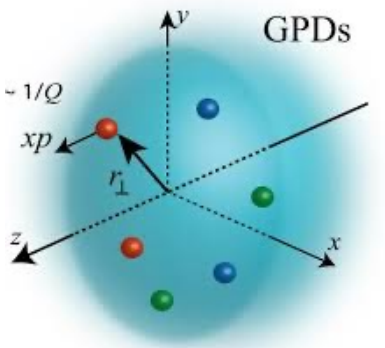
Early 1900s | 1970s | 2000s



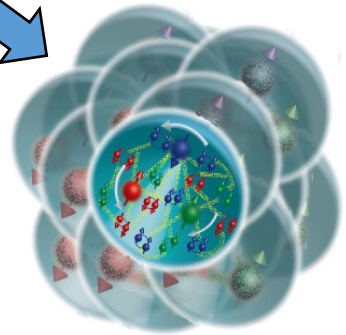
1961

1990, 2004

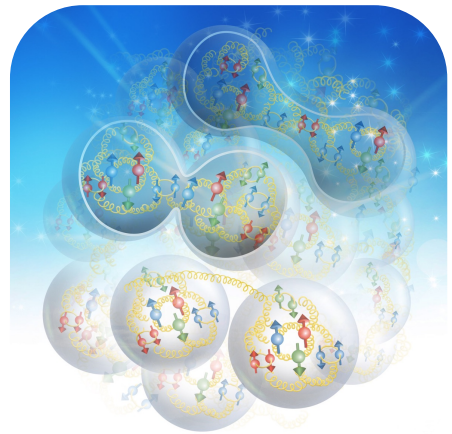




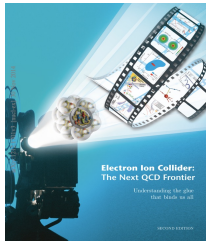
The Proton in a nucleus



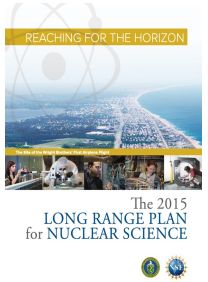
QCD dynamics that can affect the identity of nucleons in a nucleus



EIC Physics & Technology is Developing For a Long Time



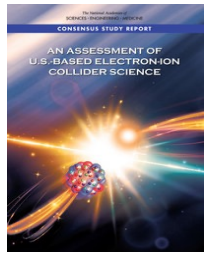
2012-14: EIC White Paper



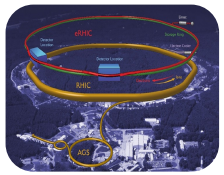
2015: NSAC Long-Range Plan

We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB.

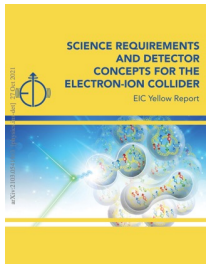
2016: EICUG Formation



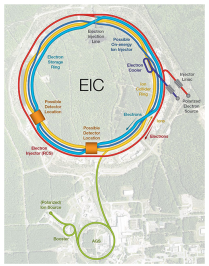
2018: NAS Study & Report



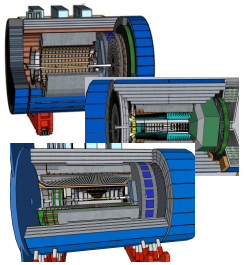
2020: Site Selection



2021: Yellow Report



2021: CDR & CD-0



2022: DPAP Reference Design

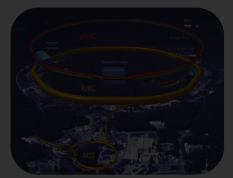
2022: ePIC Collaboration!

EIC Physics & Technology is Developing For a Long Time

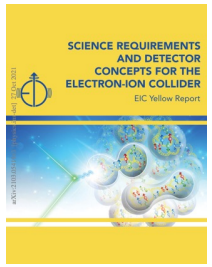
This talk is about technology and collaboration

Focus on developments from 2020

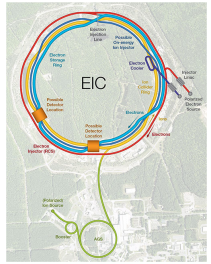
2018: NAS Study & Report



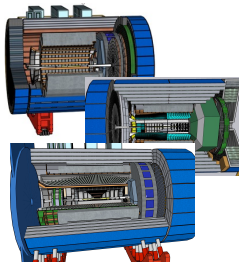
2020: Site Selection



2021: Yellow Report



2021: CDR & CD-0



2022: DPAP Reference Design

2022: ePIC Collaboration!

(1) Community effort to assess technology solutions that enable the EIC science program

ECCE

EIC Comprehensive Chromodynamics Experiment

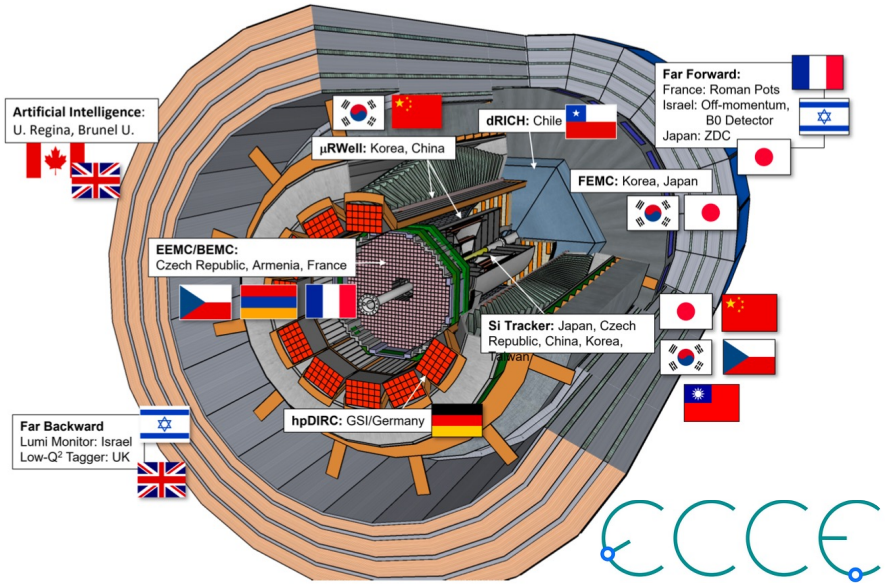
ATHENA

A Totally Hermetic Electron-Nucleus Apparatus

(2) Specific detector proposals, based on different magnets and detector technologies. Assessed by blue ribbon expert panel.

(3) ECCE chosen as reference design. Full community needed for success. Continue develop and optimize towards technical design.

ECCE and ATHENA Consolidation



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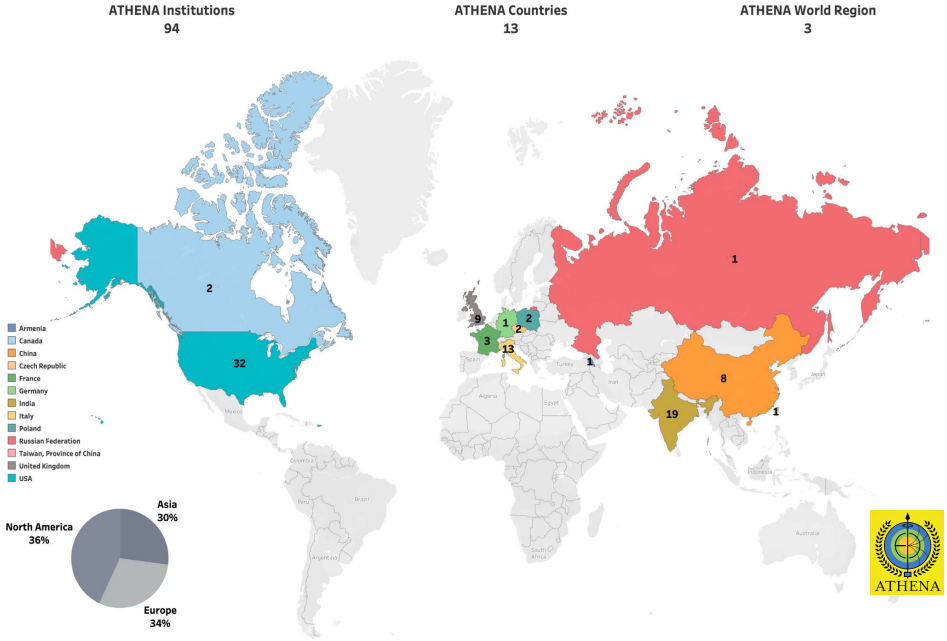


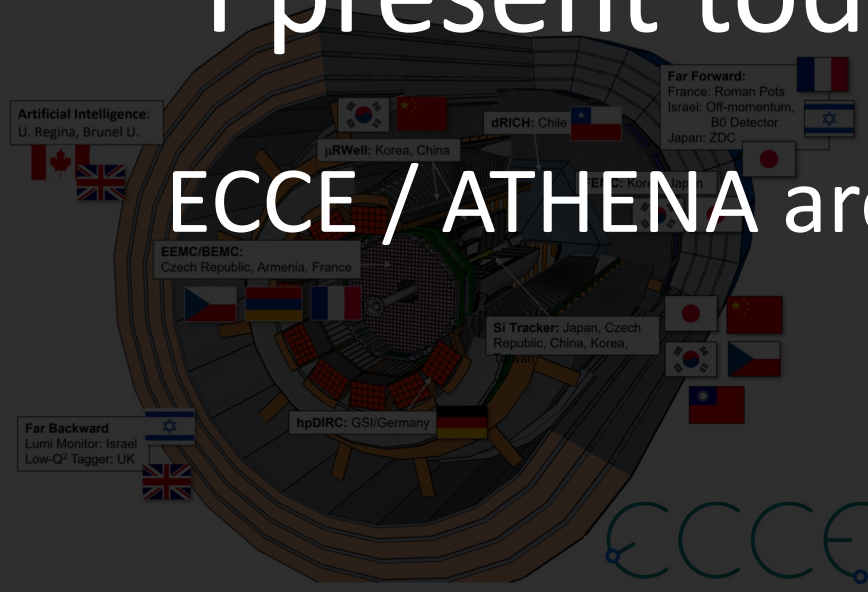
= ePIC

Key conceptual differences – bore size and magnetic field!

ECCE and ATHENA Consolidation

I present today the status & plans of ePIC

ECCE / ATHENA are fully merged and don't exist anymore



+

= ePIC

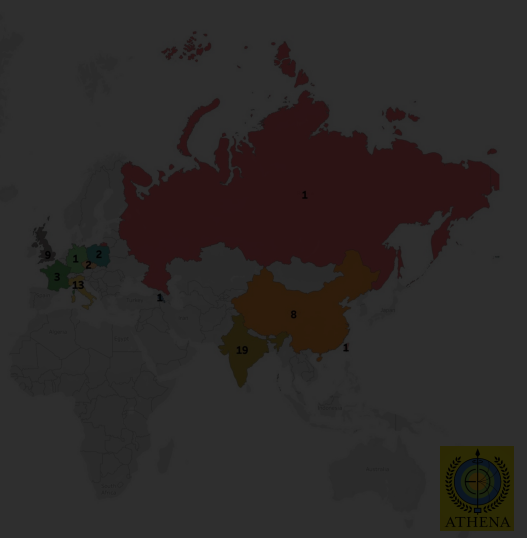
Key conceptual differences – bore size and magnetic field!

ECCE and ATHENA Consolidation

I present today the status & plans of ePIC

1. The ePIC Detector
2. The ePIC Collaboration

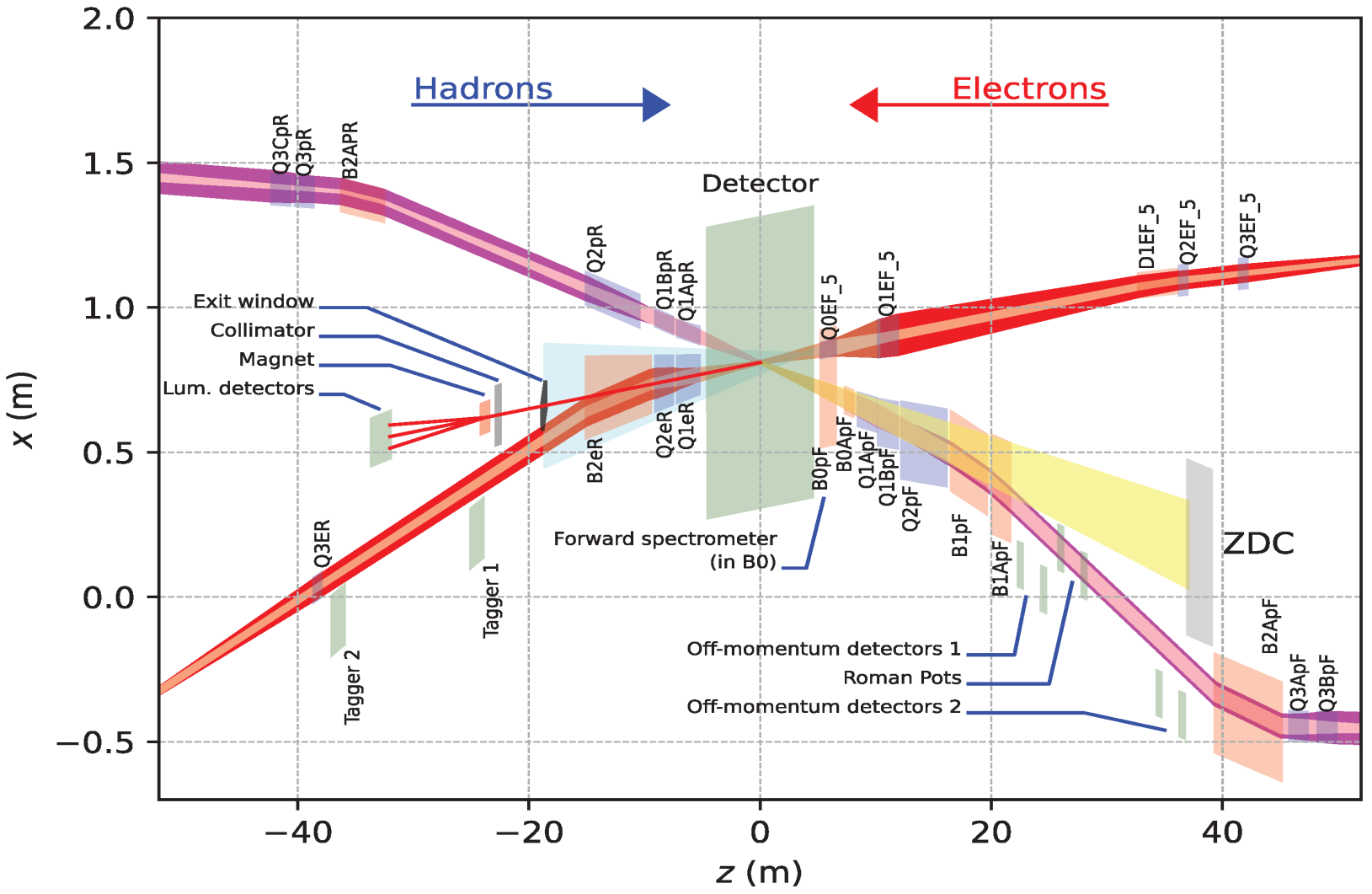
+

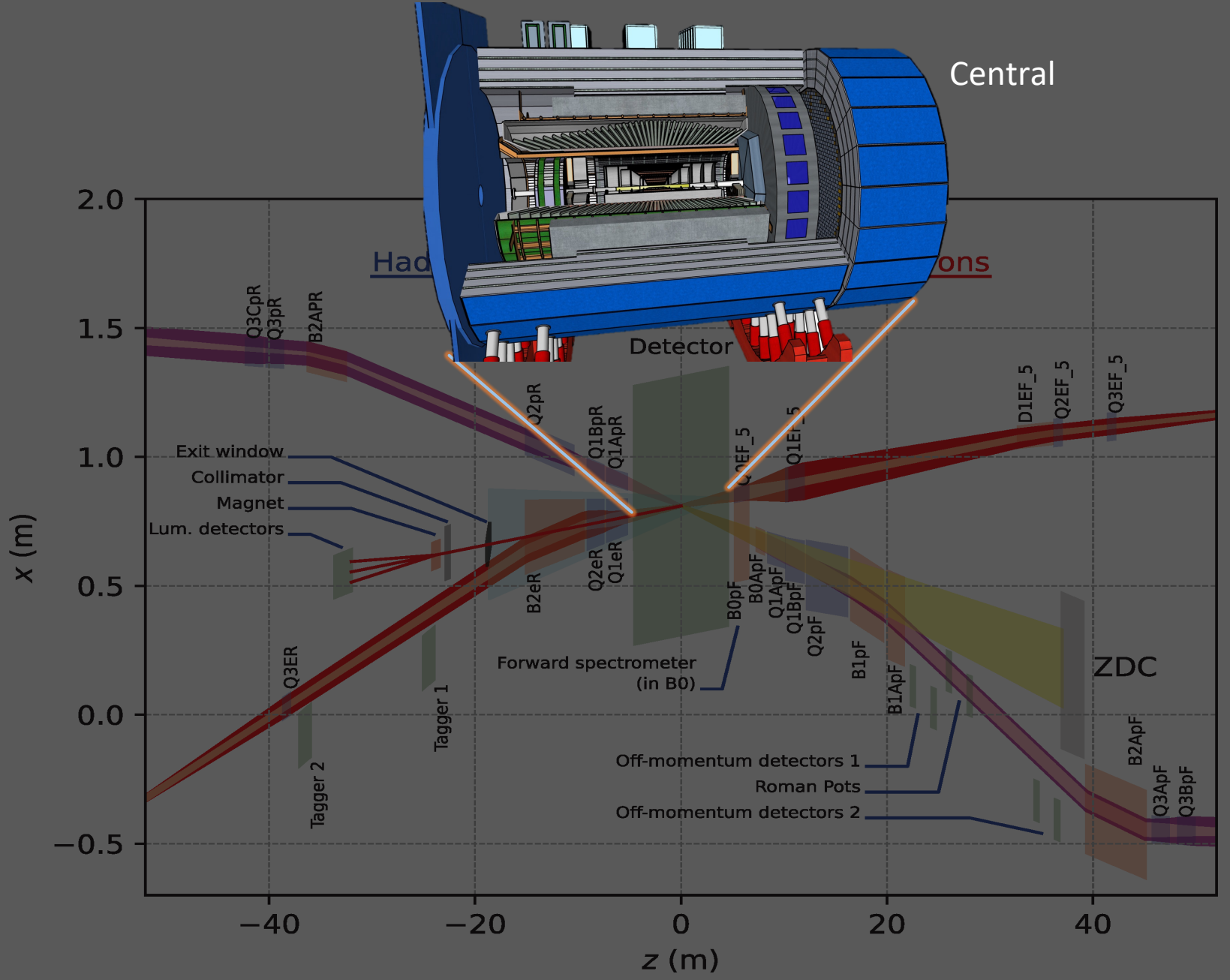


= ePIC

Key conceptual differences – bore size and magnetic field!

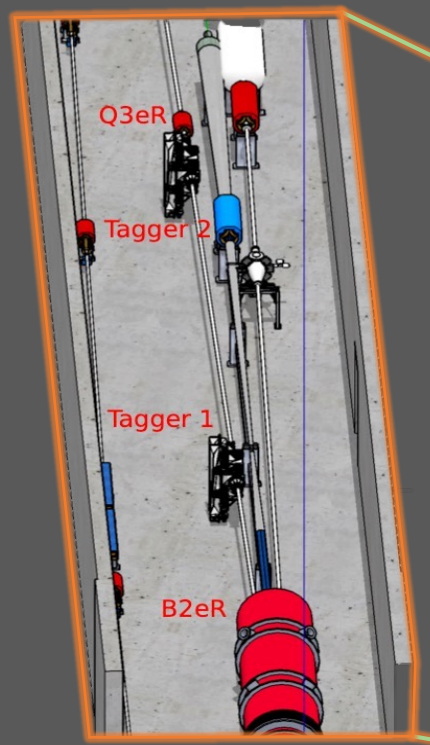
EIC Interaction Region 6 (IR-6)

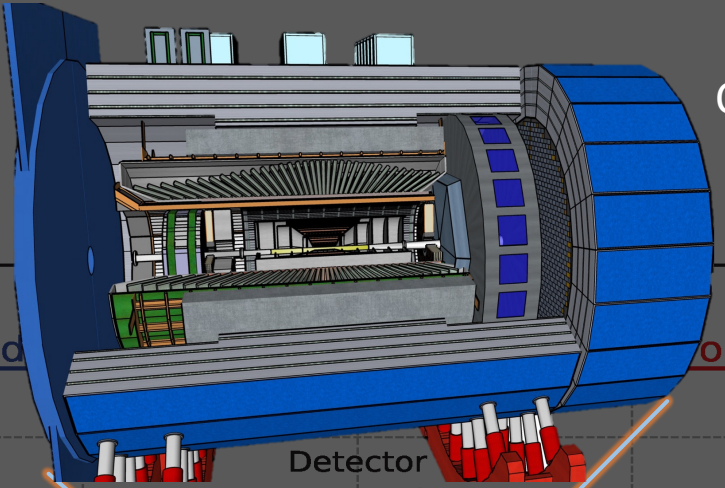


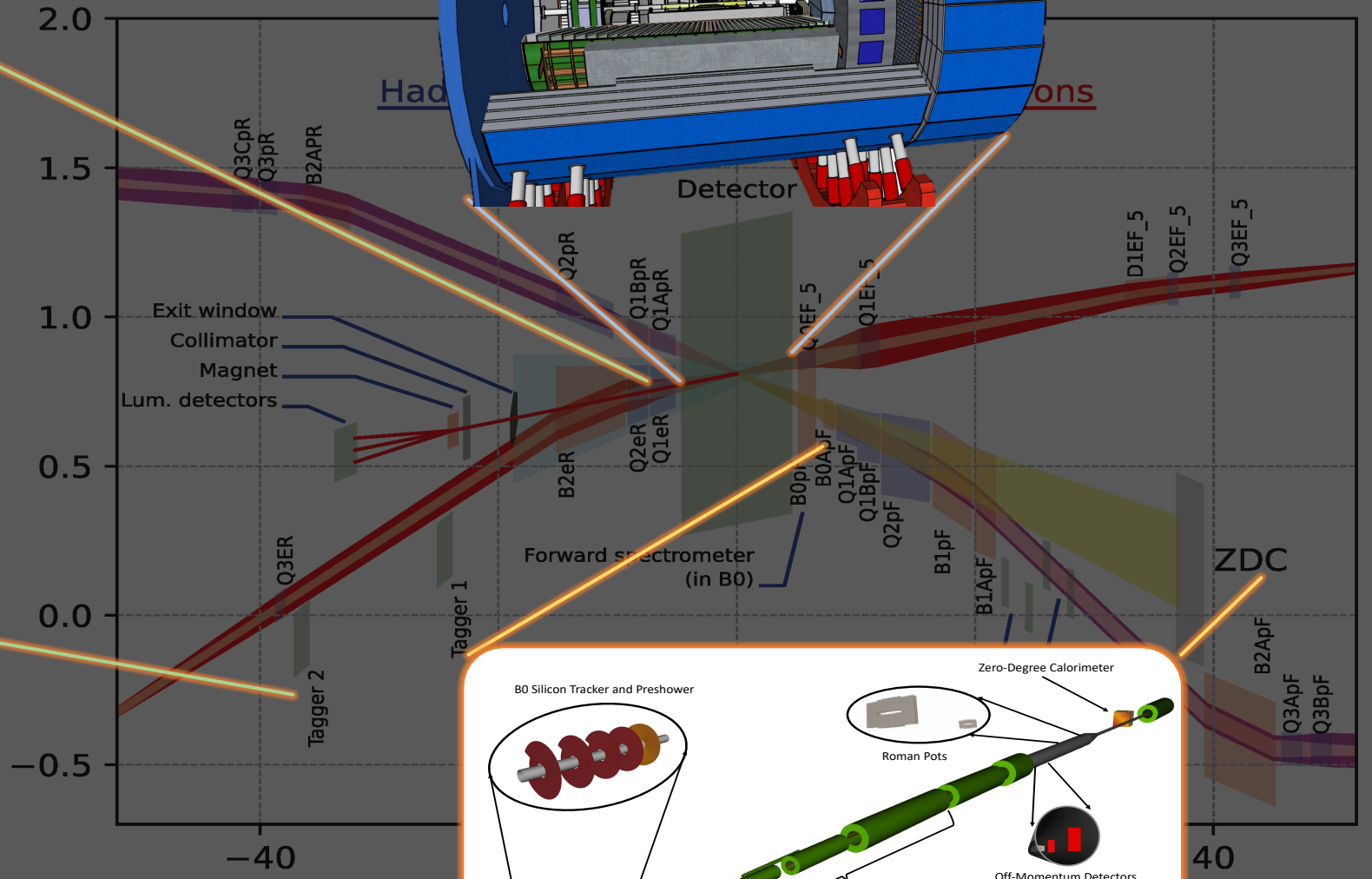

Central
Detector
Had
ons
Q3CpR
Q3pR
B2APR
Q2pR
Q1BpR
Q1ApR
D1EF_5
Q2EF_5
Q3EF_5
Exit window
Collimator
Magnet
Lum. detectors
B2eR
Q2eR
Q1eR
B0pF
B0ApF
Q1ApF
Q1BpF
Q2pF
B1pF
B1ApF
Forward spectrometer
(in B0)
ZDC
Q3ER
Tagger 1
Tagger 2
Off-momentum detectors 1
Roman Pots
Off-momentum detectors 2
B2ApF
Q3ApF
Q3BpF
2.0
1.5
1.0
0.5
0.0
−0.5
x (m)
−40
−20
0
20
40
z (m)

Far-Backward

Central

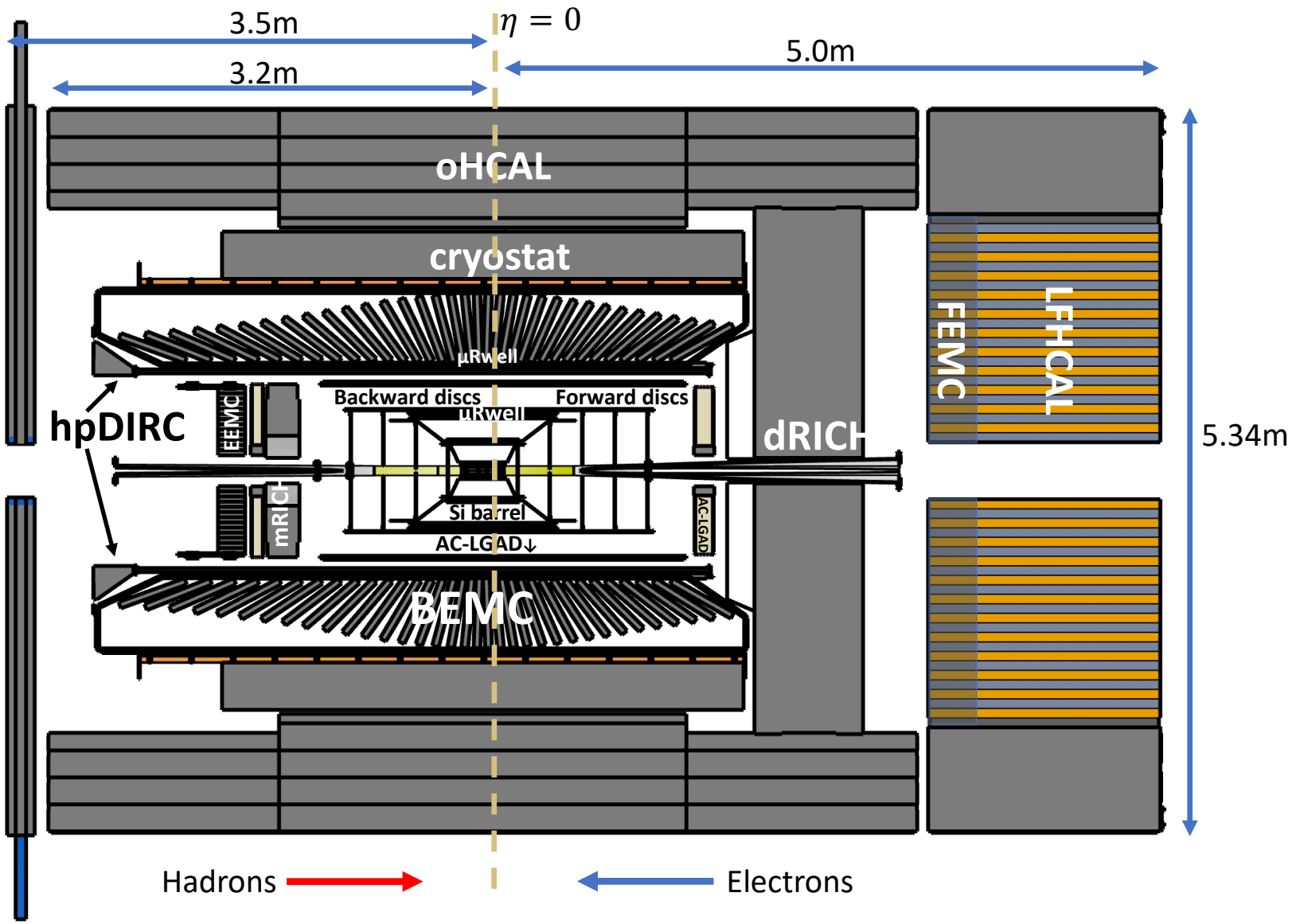




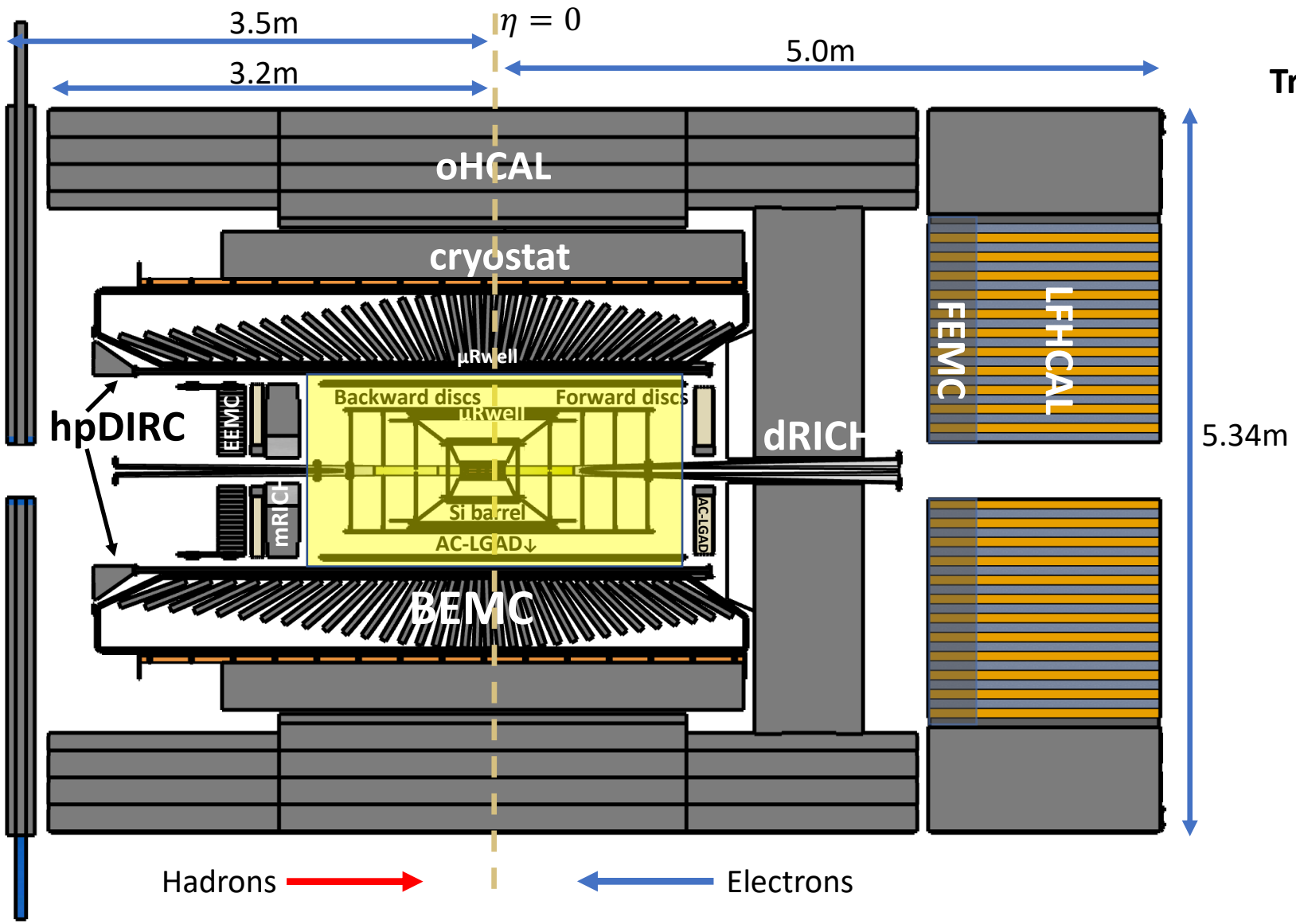


Far-
Forward

ePIC Detector Design (Current)



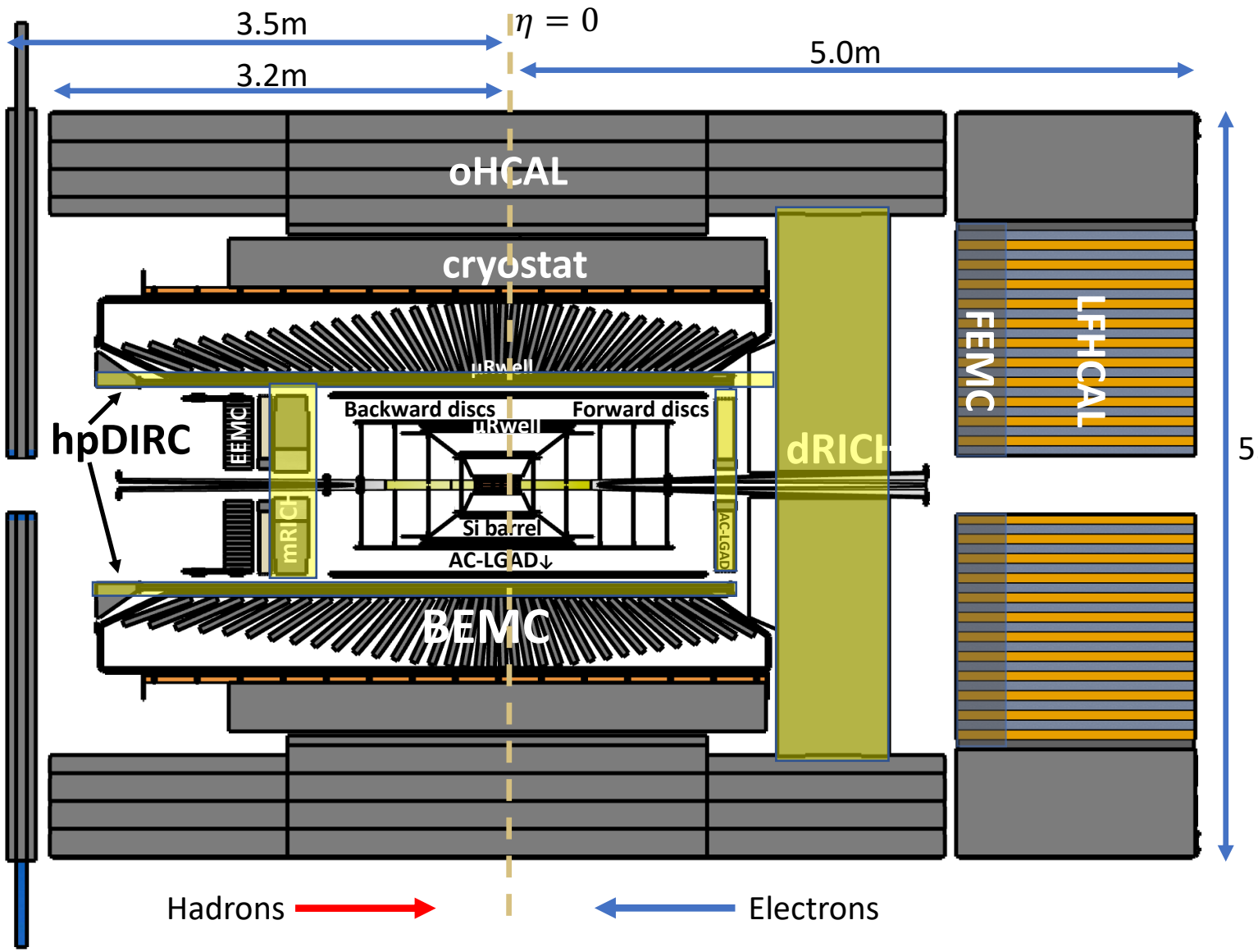
ePIC Detector Design (Current)



Tracking:

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

ePIC Detector Design (Current)



Tracking:

- New 1.7T solenoid
- Si MAPS Tracker
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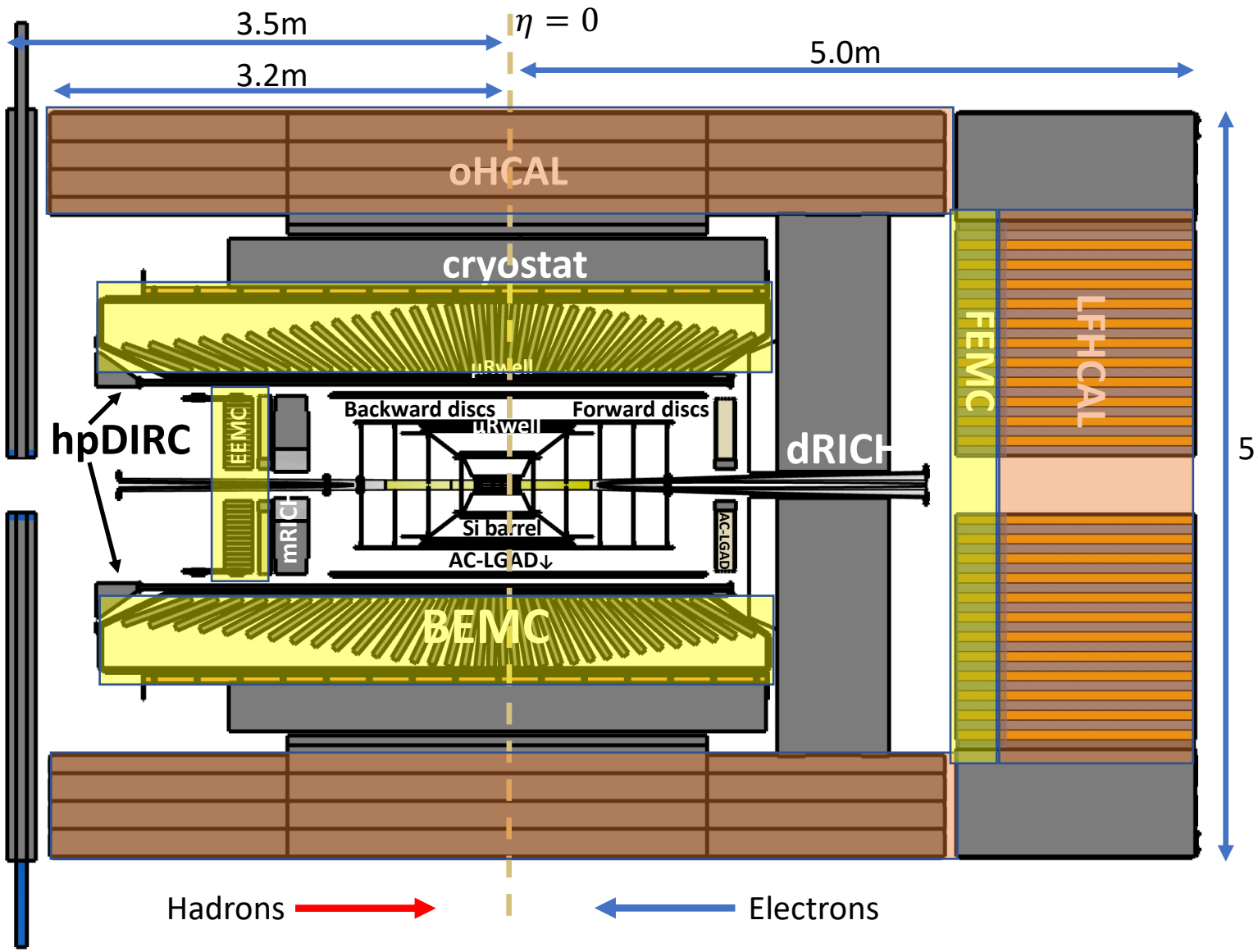
PID:

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

ePIC Detector Design (Current)



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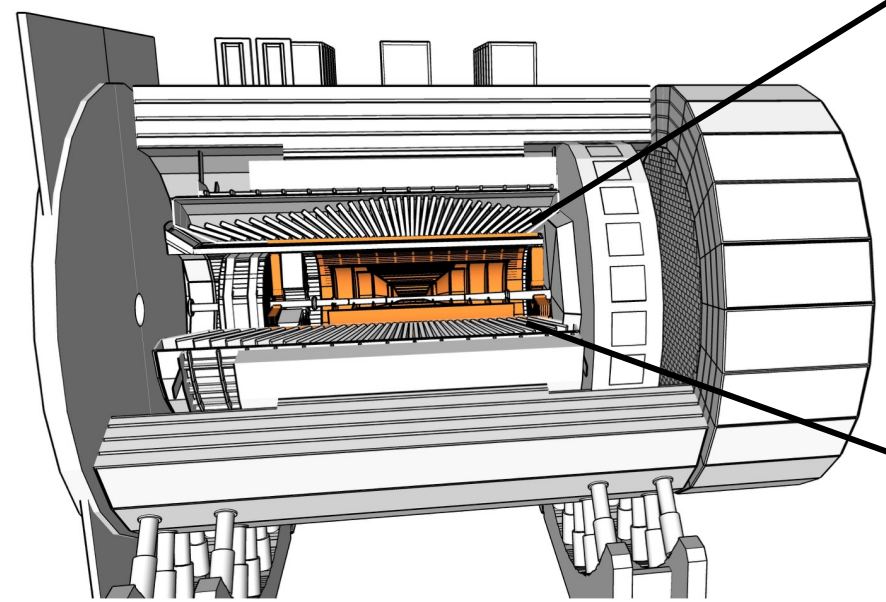
PID:

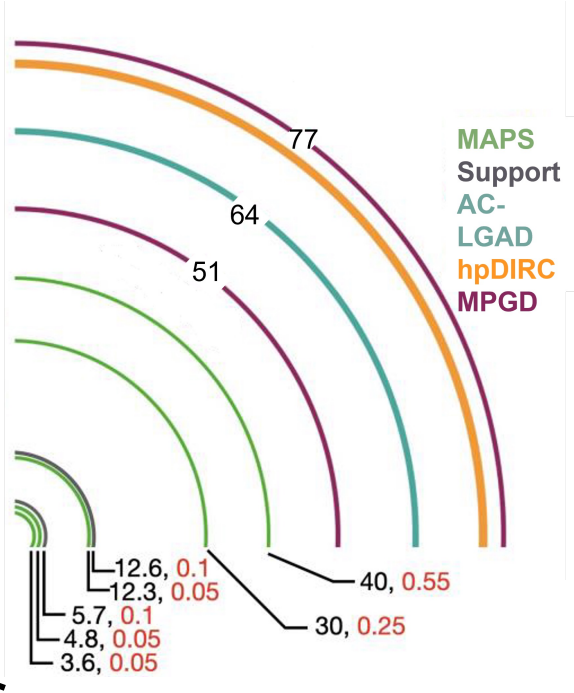
- hpDIRC
- mRICH / pfRICH
- dRICH
- AC-LGAD (~30ps TOF)

Calorimetry:

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

Tracking





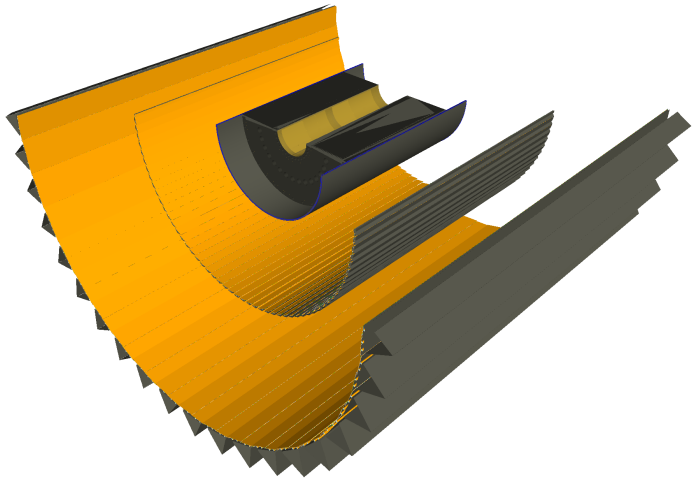
Black numbers are radii in cm

Red numbers are material in % X0

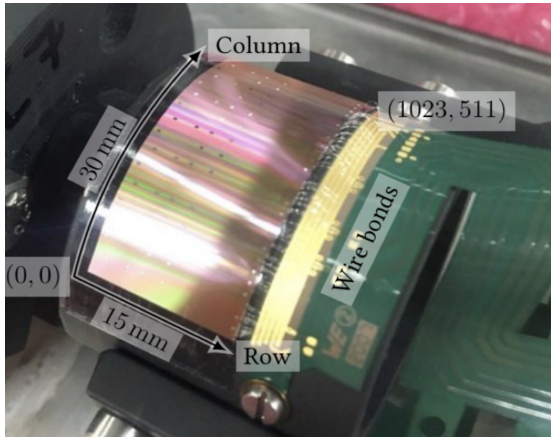
Si Tracker using ALICE ITS3 65nm MAPS sensors

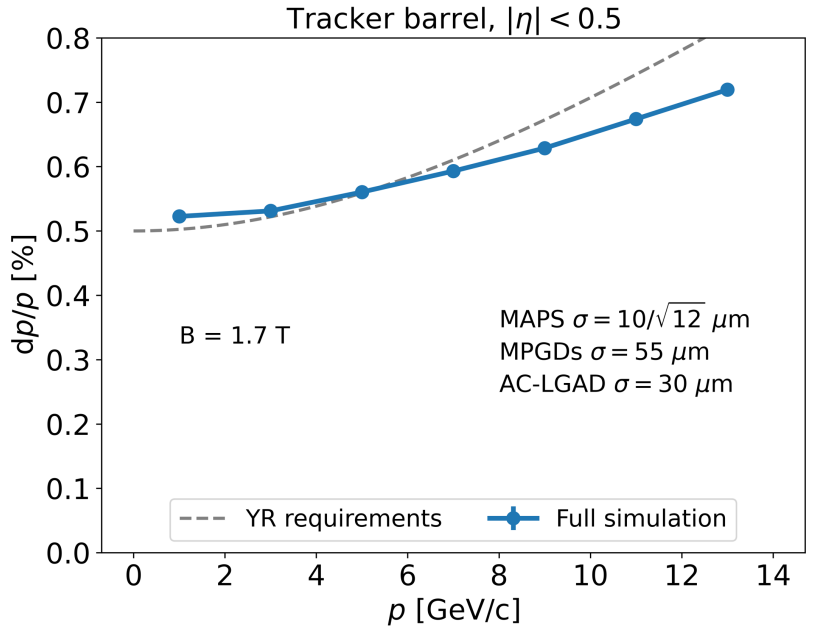
Five barrel layers + MPGDs.

Five discs in forward/backward directions (+MPGD in forward)

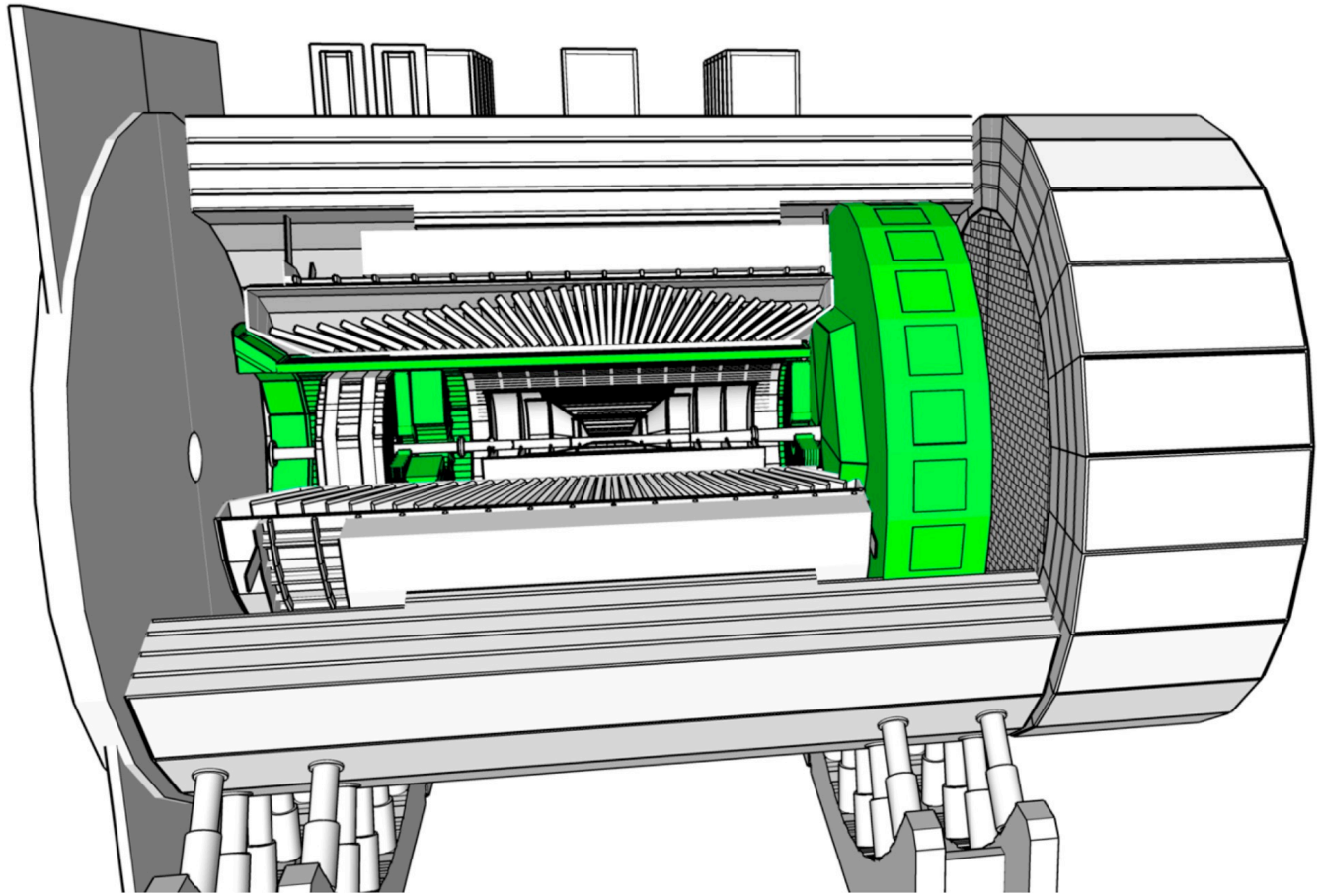


First "µITS3" assembly at CERN

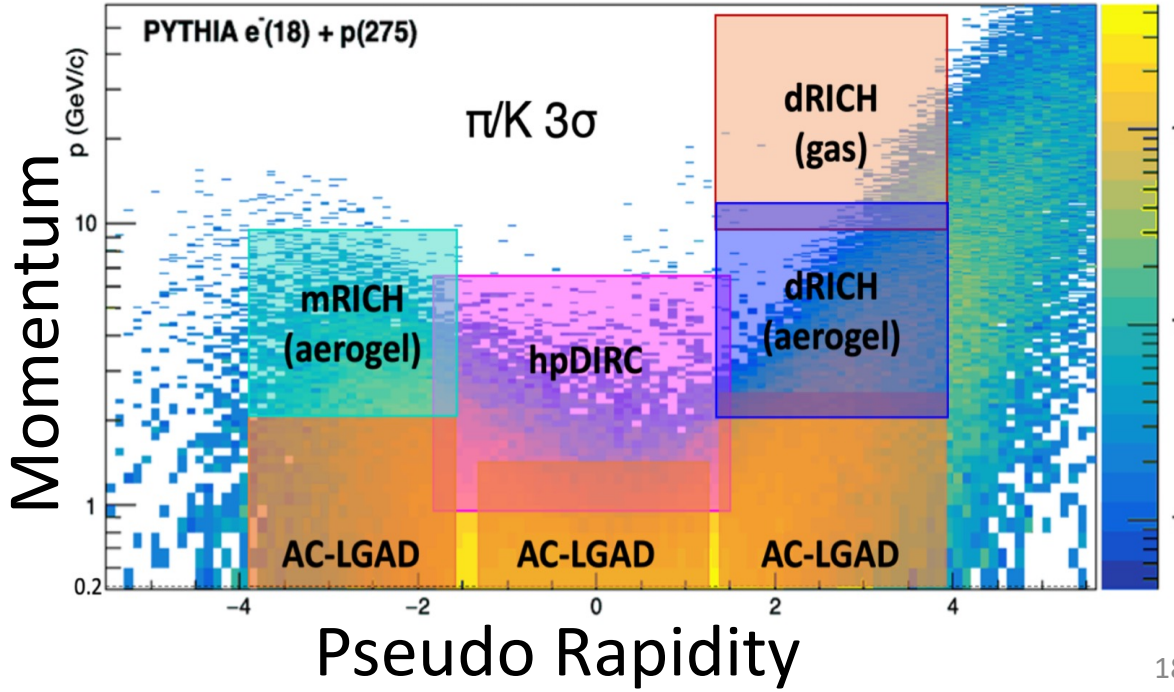




Particle ID



Goal: Complete Coverage!



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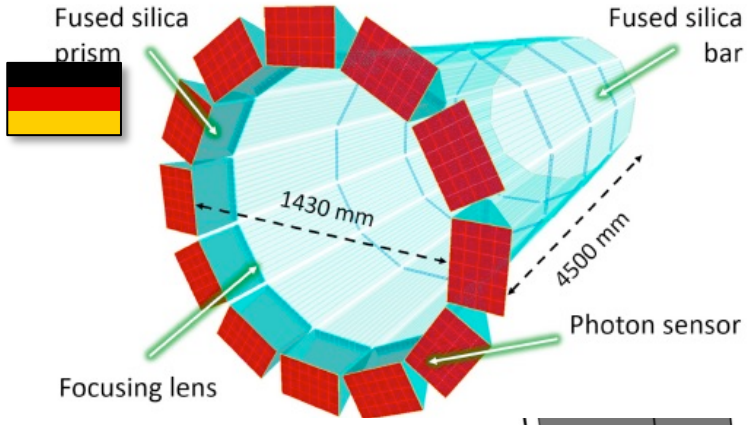
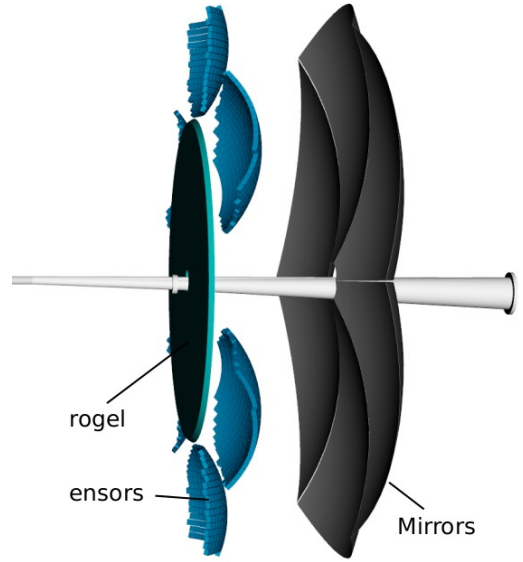
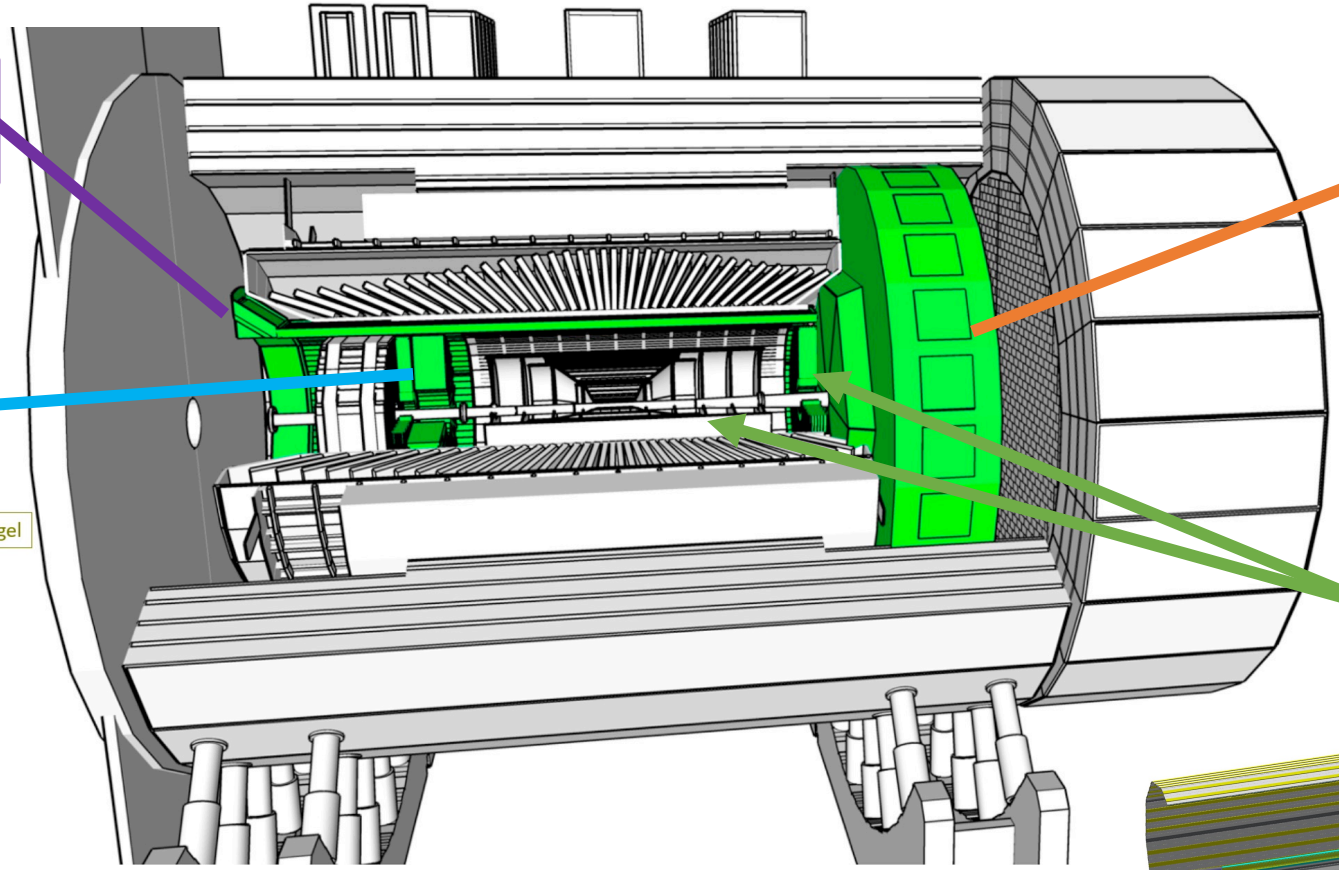


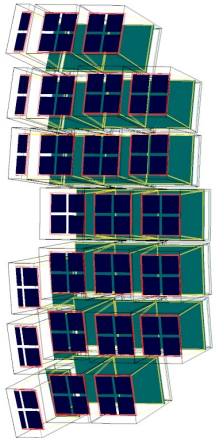


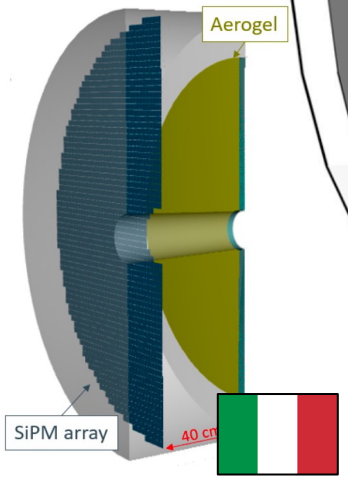
High-Performance DIRC



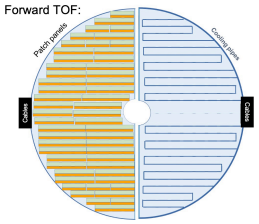
Dual-Radiator RICH (dRICH)

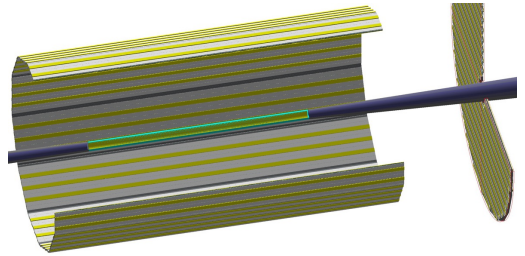
Modular (mRICH) / Proximity Focused (pfRICH)



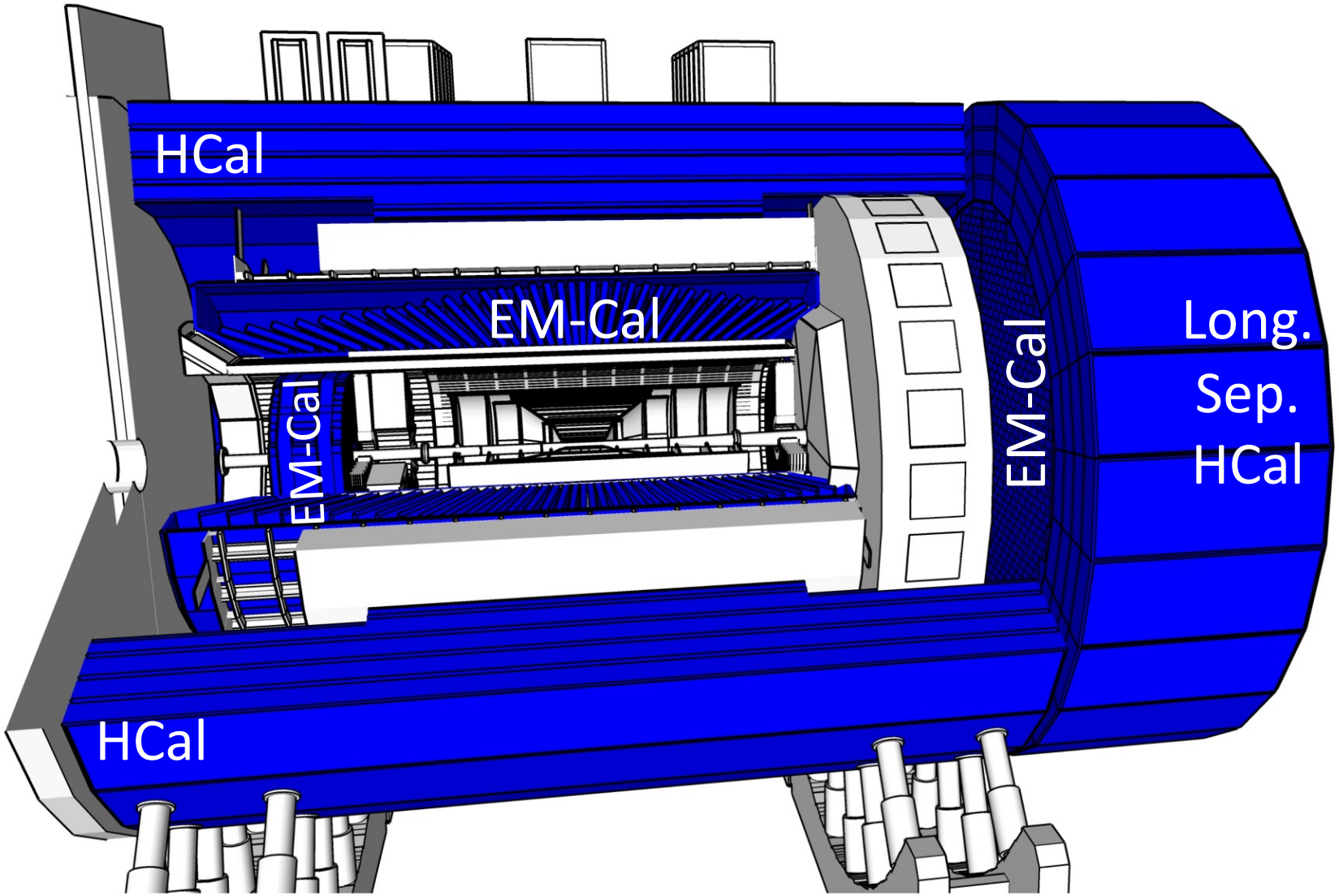


AC-LGAD TOF (~30ps)

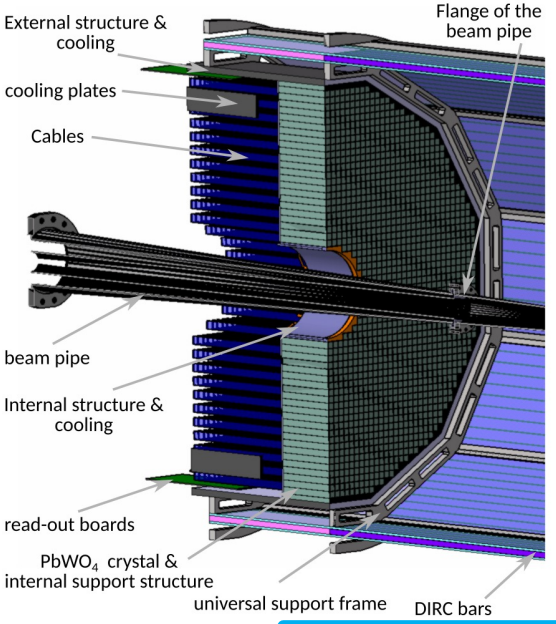


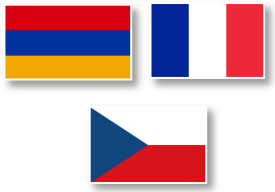


Calorimetry

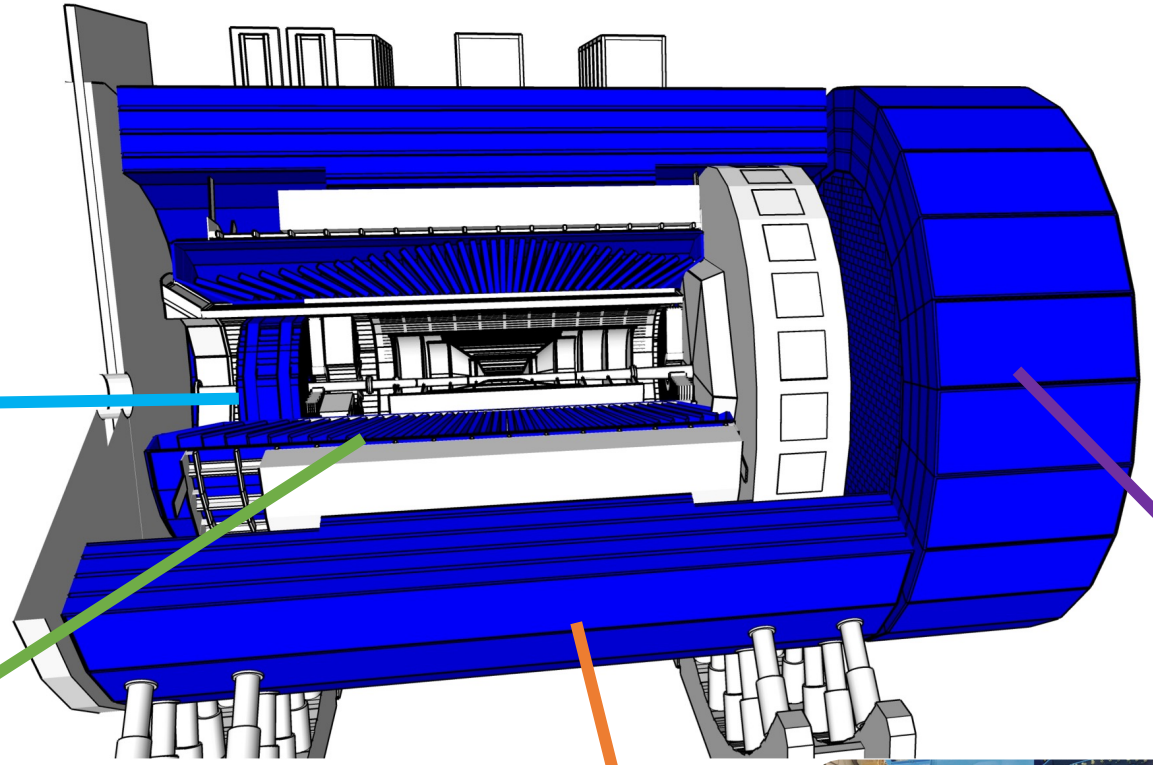


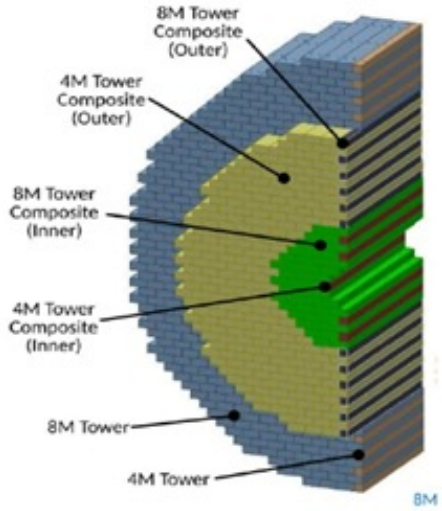
Calorimetry



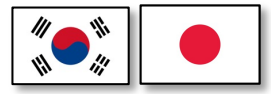


Backwards EMCal PbW04 crystals

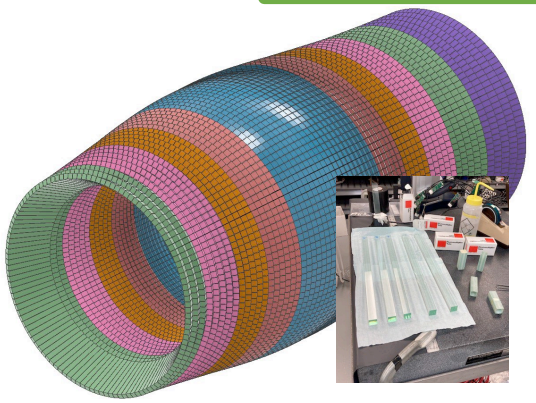


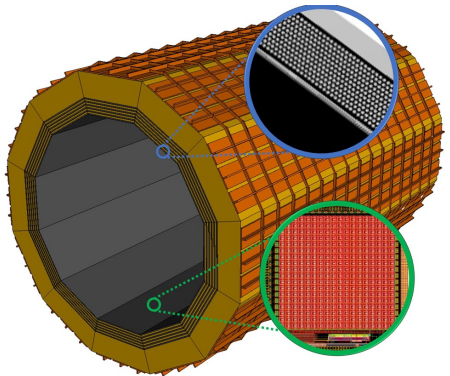


High granularity W/SciFi EMCal Longitudinally separated HCAL with high-η insert

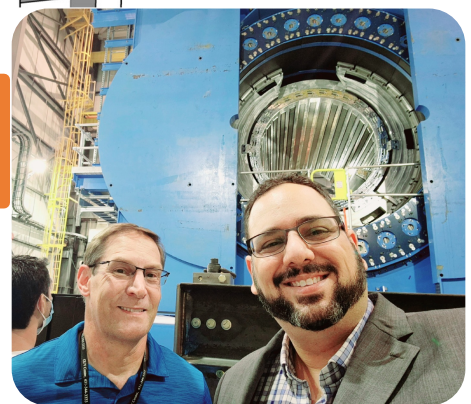


BECAL: SciGlass or Imaging Calorimeter



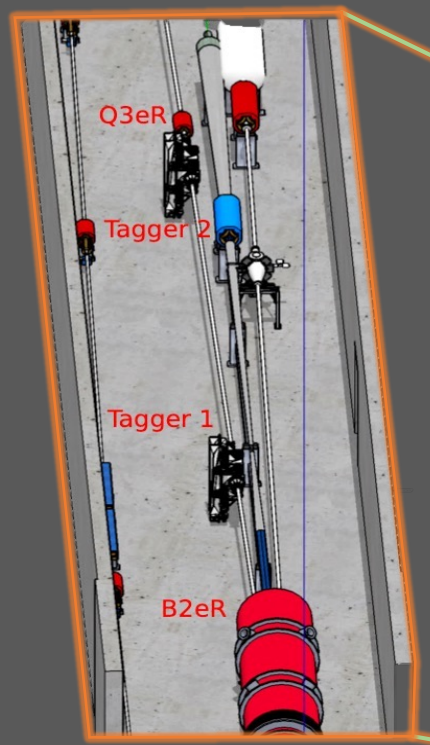


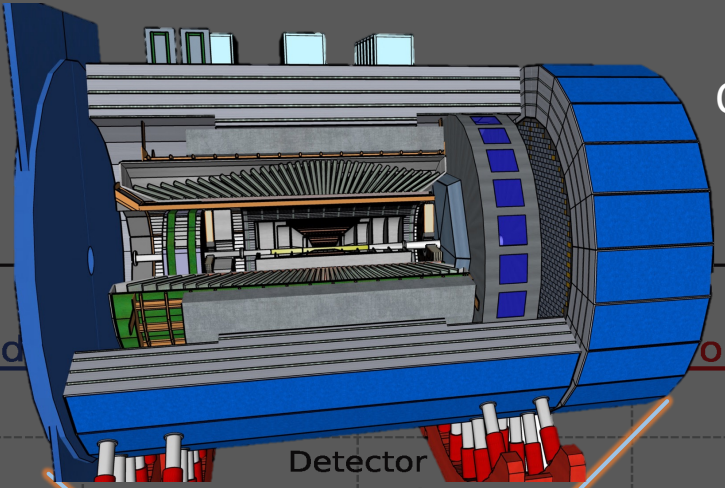
Barrel HCAL (sPHENIX re-use)

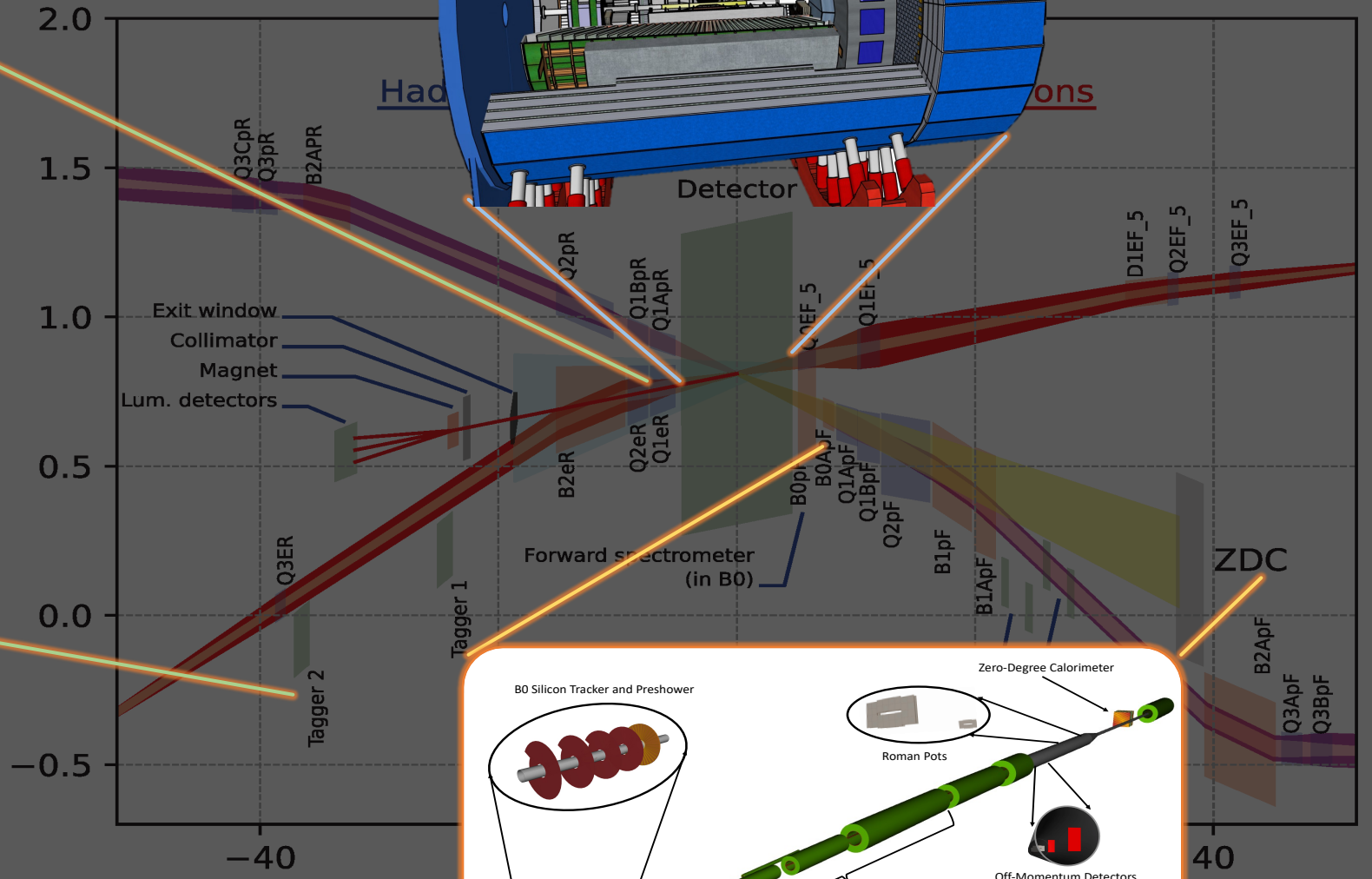


Far-Backward

Central

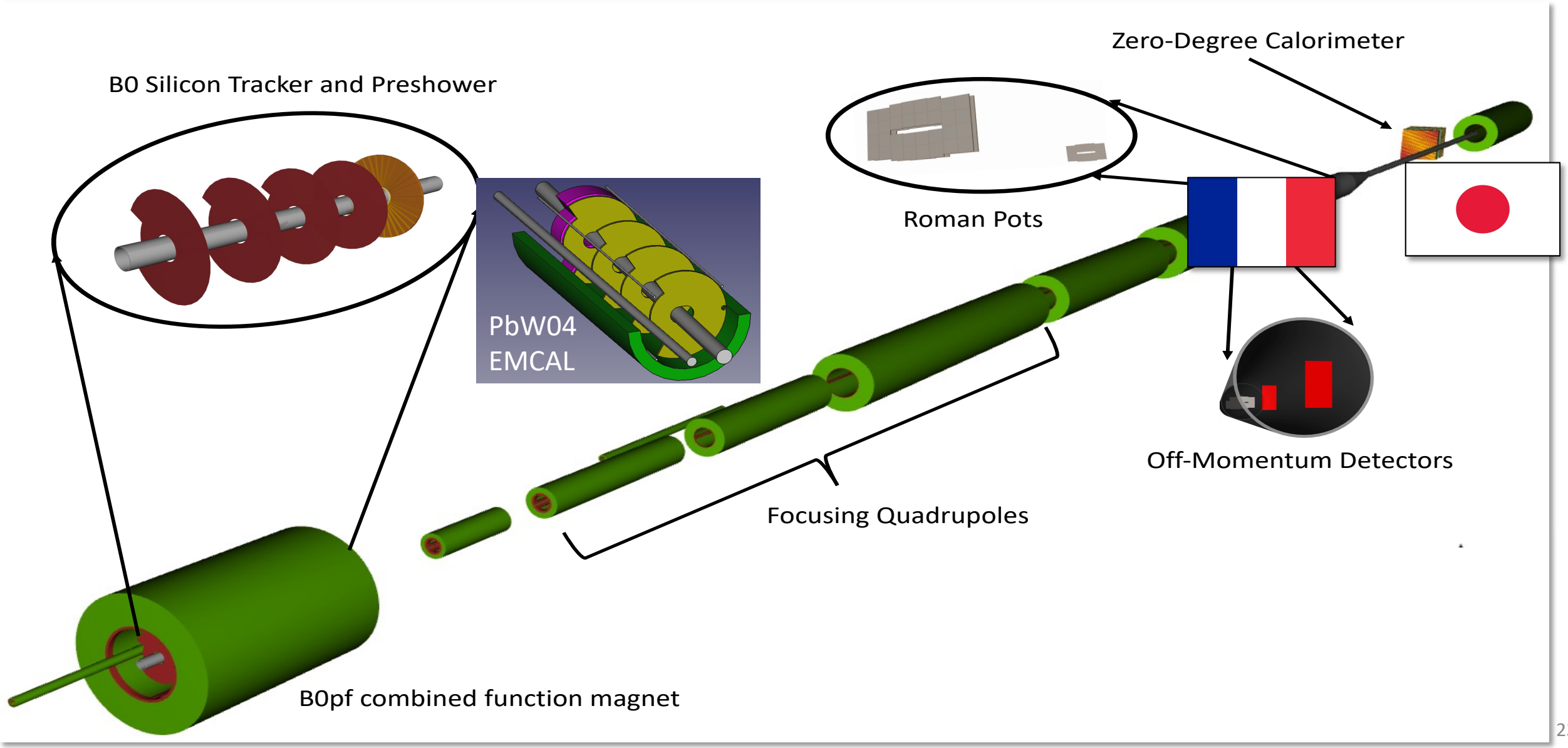


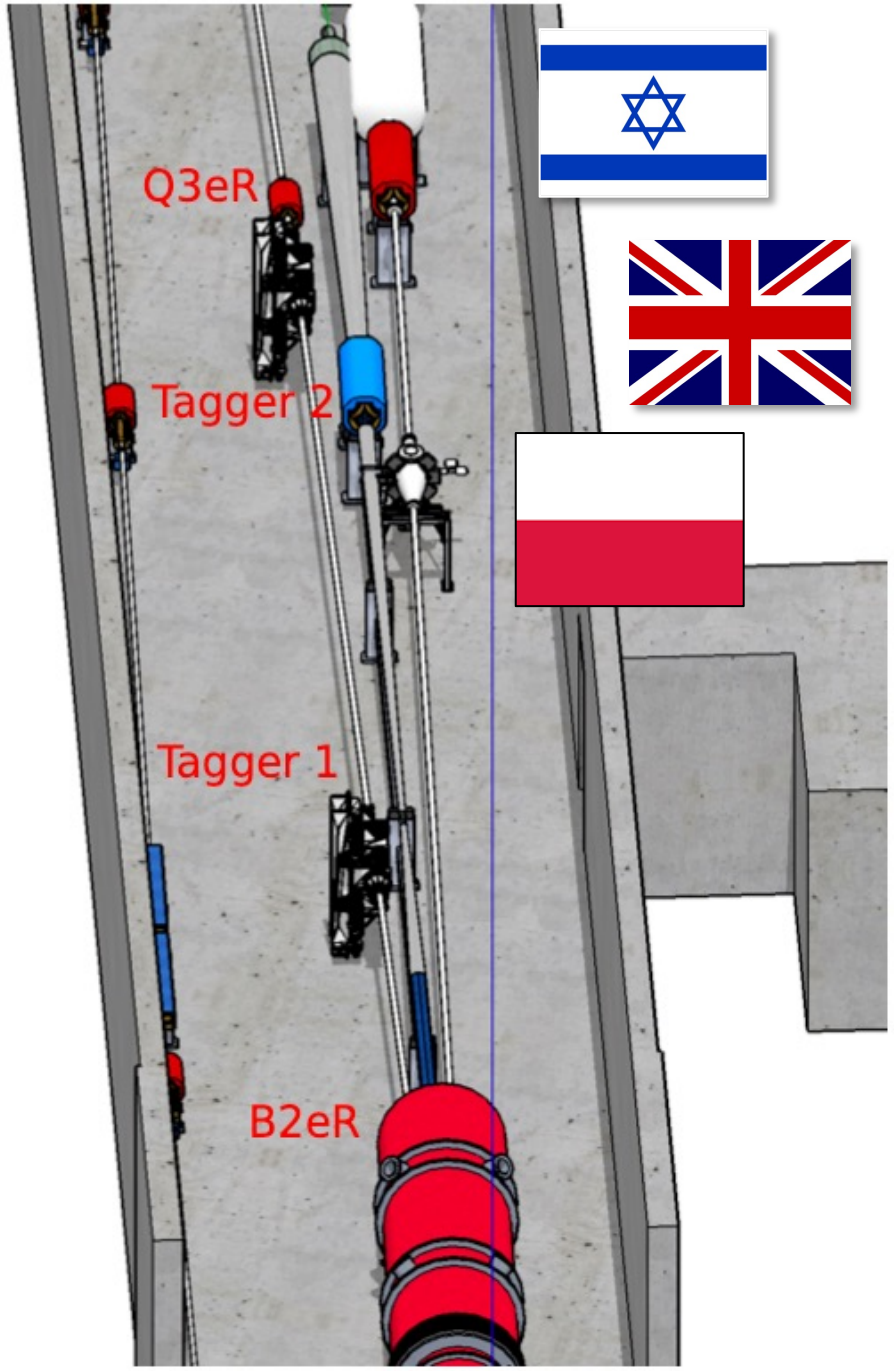




Far-
Forward

Far-Forward Detectors

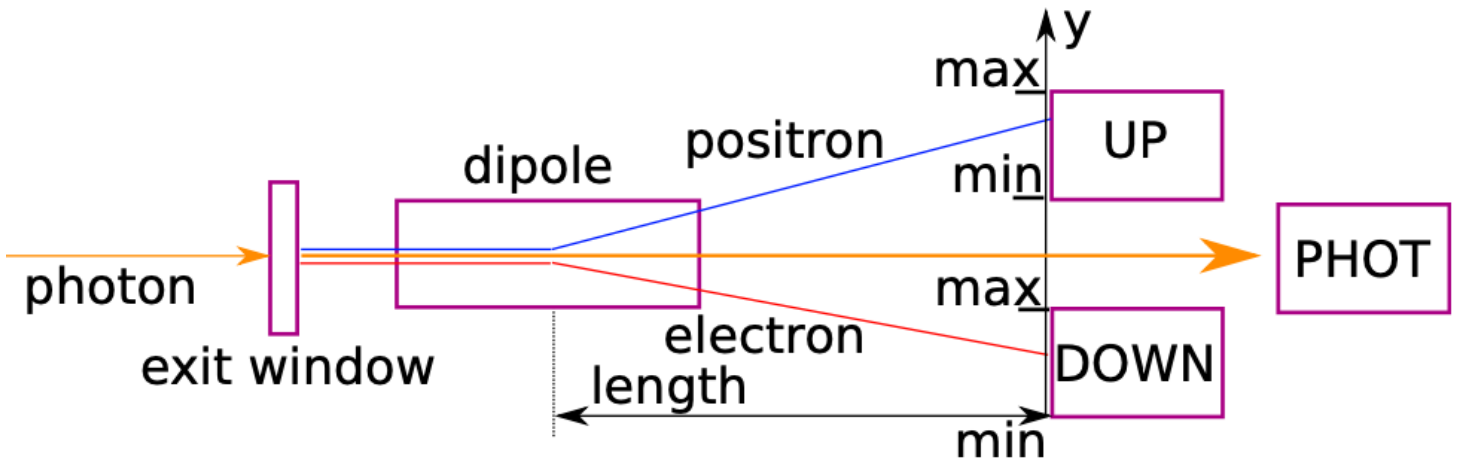




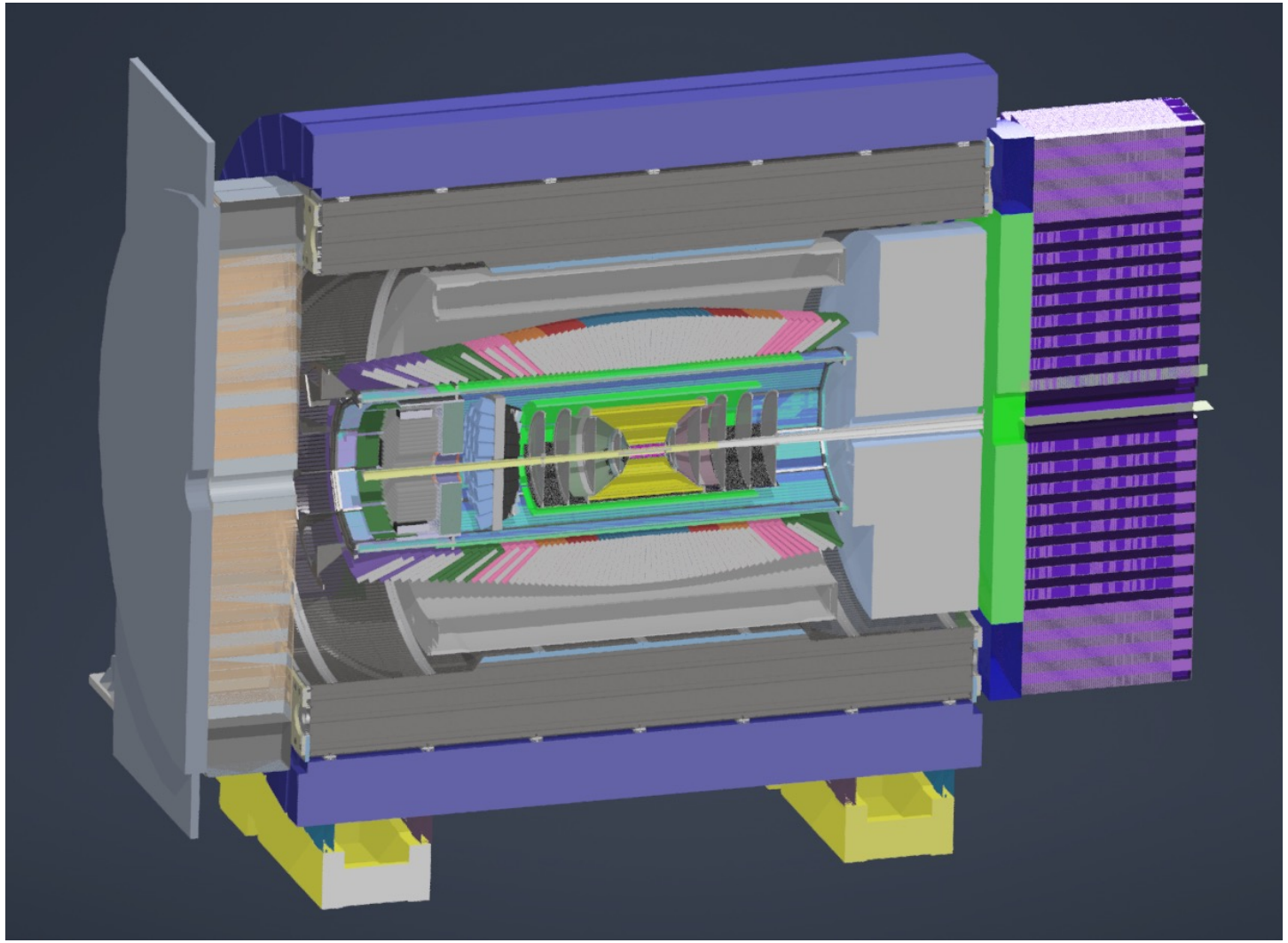
Far-Backward Detectors

Far-Backward Detectors

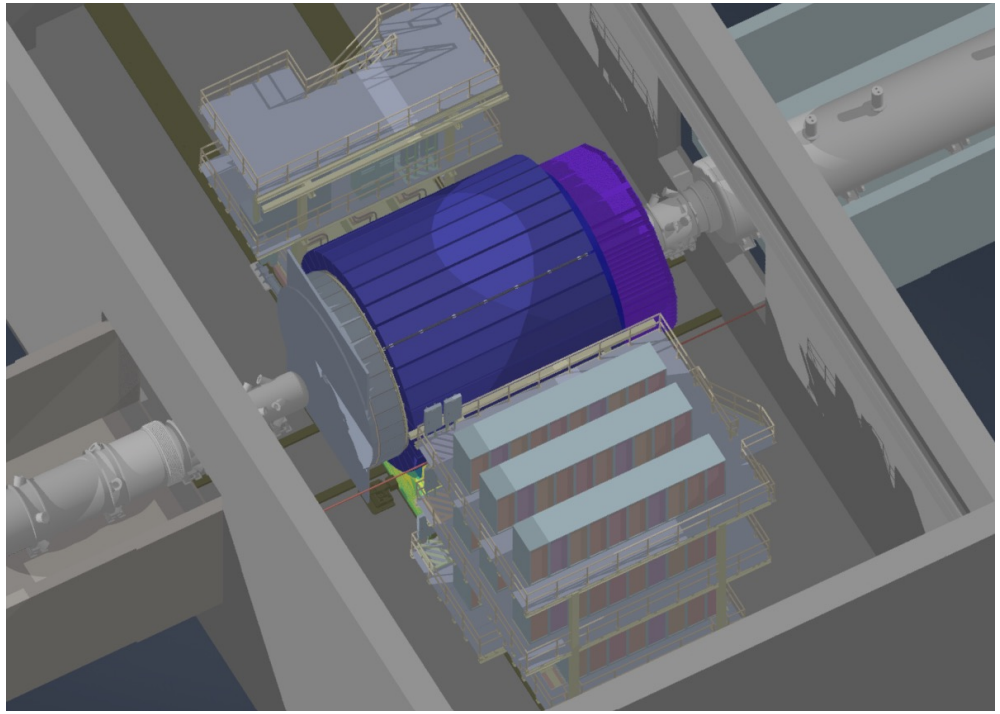
- **Luminosity monitors**
- **Low-Q^2 Taggers**



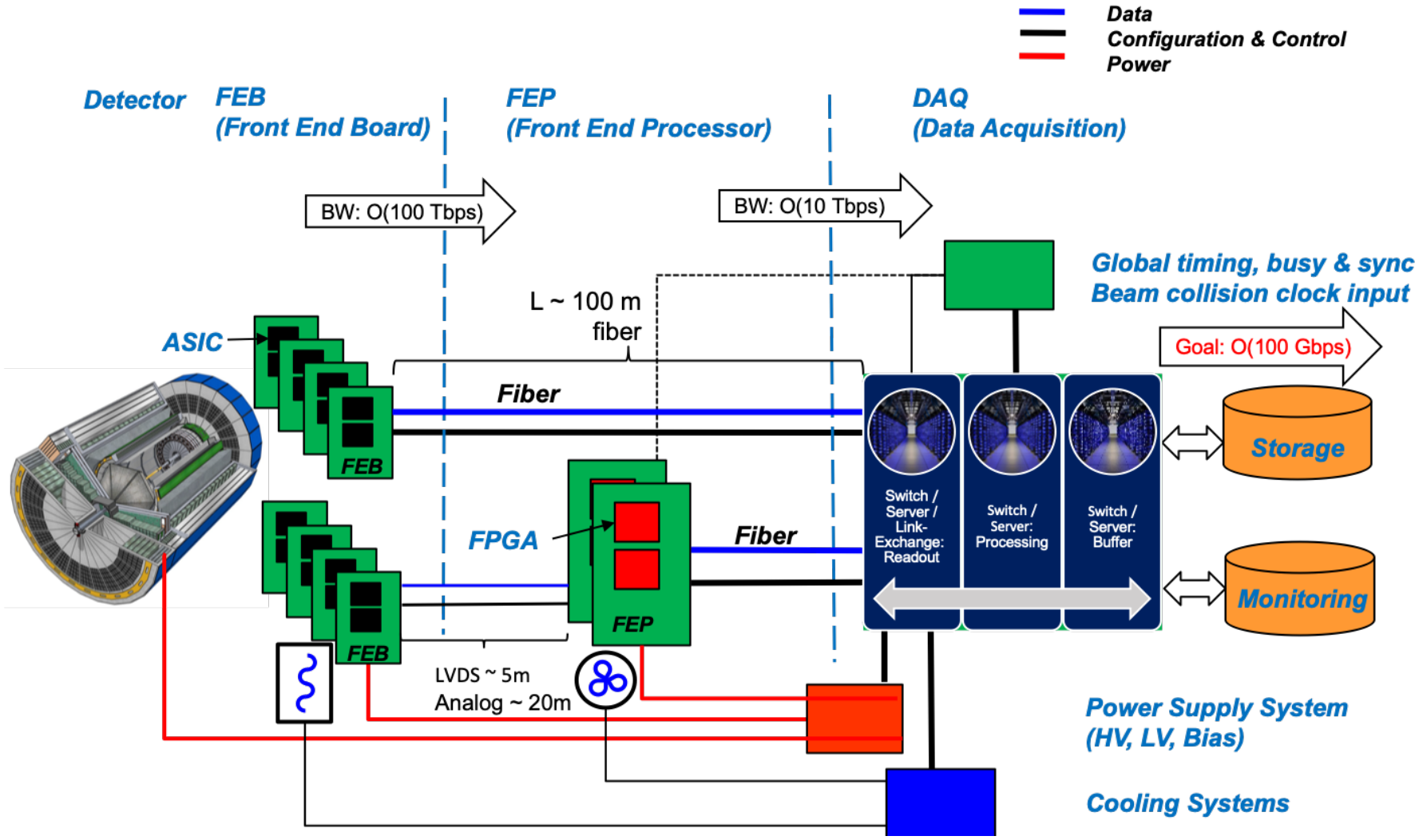
Engineering Design



Full CAD design of ePIC ongoing to facilitate *realistic* detector integration.



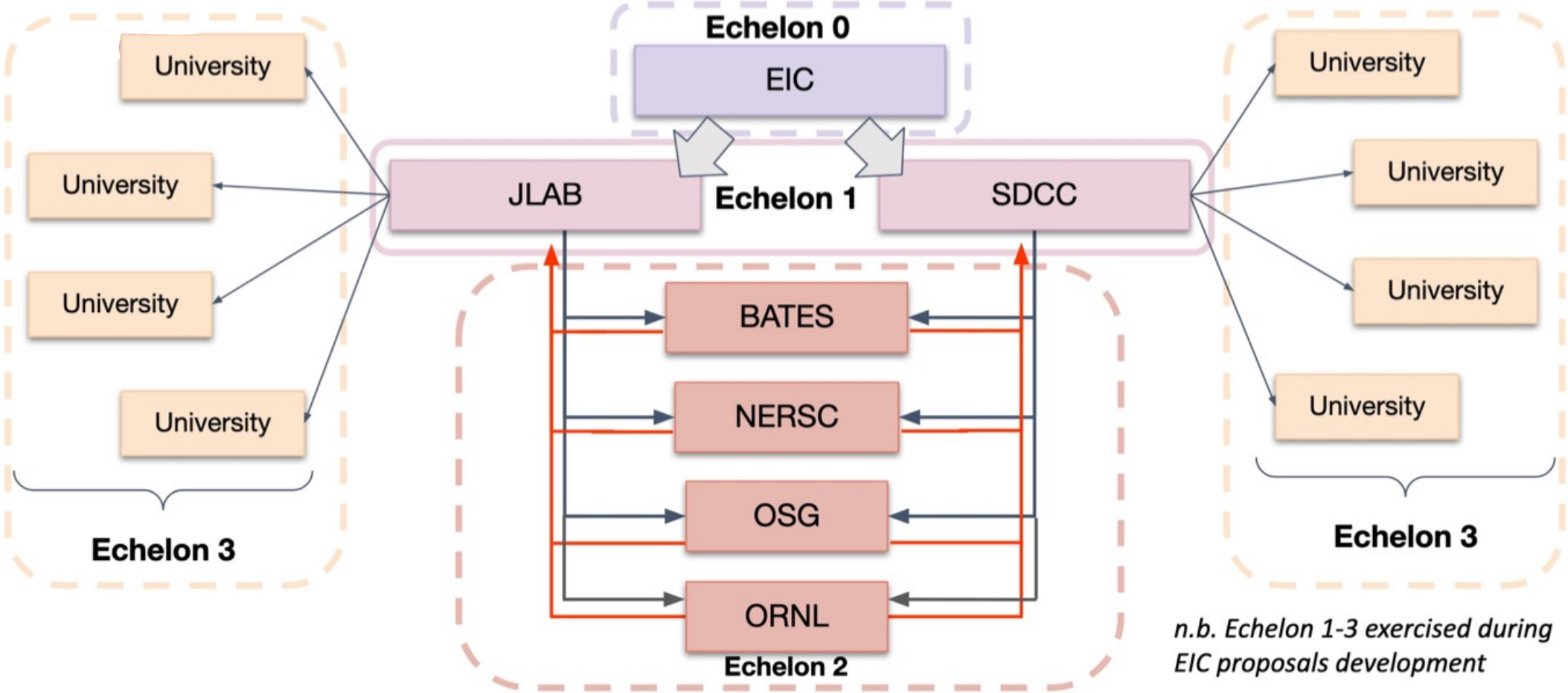
ePIC Streaming DAQ



No trigger → much more flexibility to do physics not planned from the start

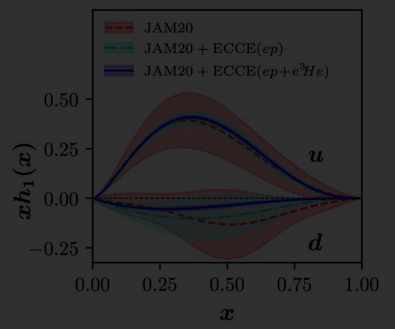
Stored data volumes and manageable, ~O(100Pb) per run

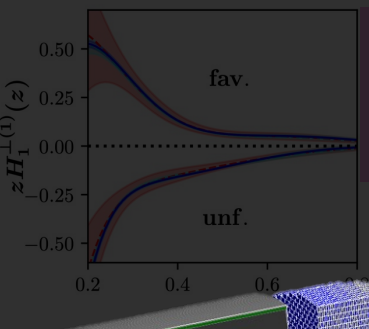
Computing butterfly model



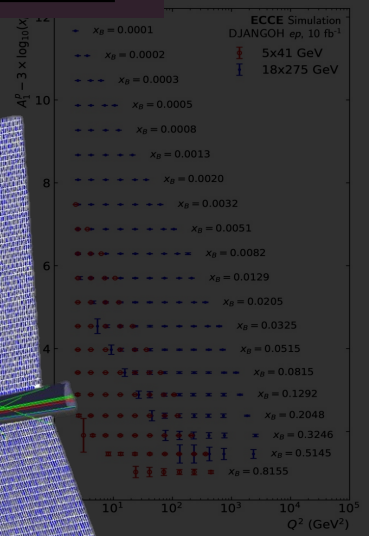
*Nearly all storage (raw data, reconstructed data, simulated data) is stored across **Echelon 1** sites*

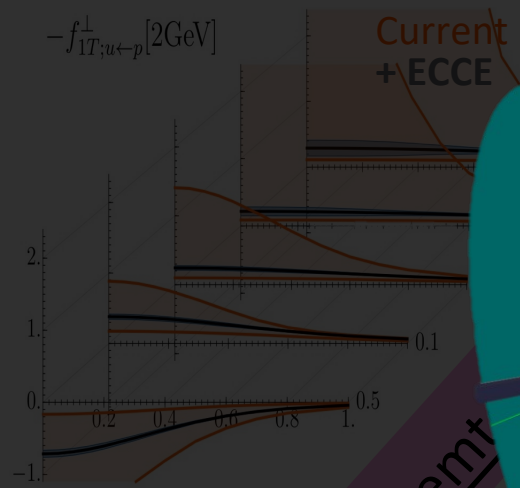
Geant4 Implementation for performance and physics studies



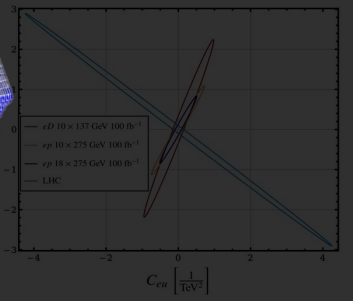


Origin of Spin

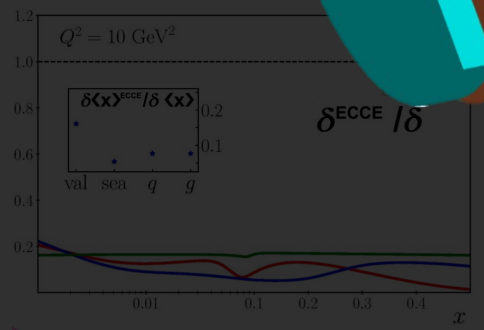




Femt

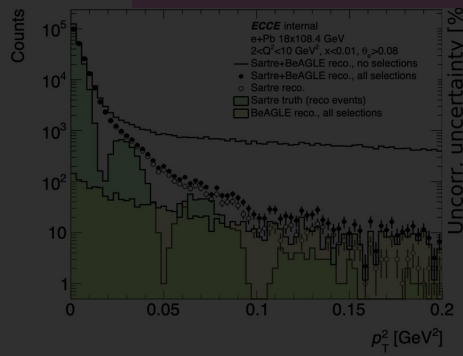


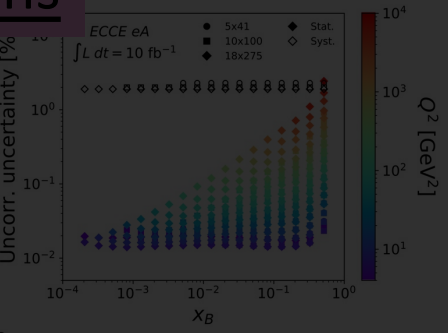
Standard Model

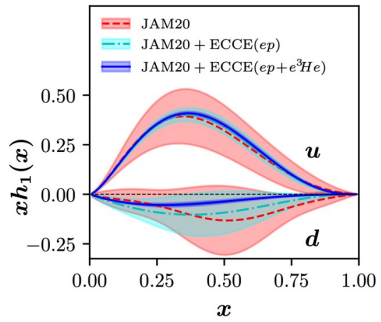


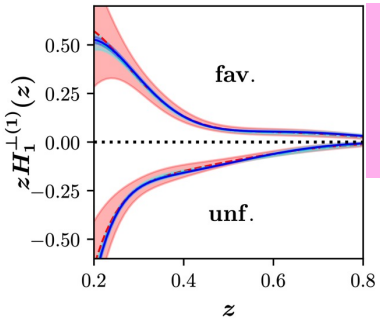
Origin of Mass

Dense Gluons

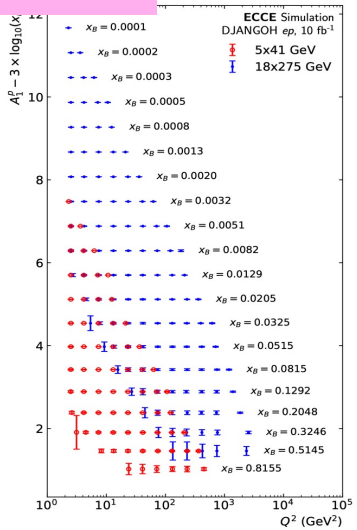


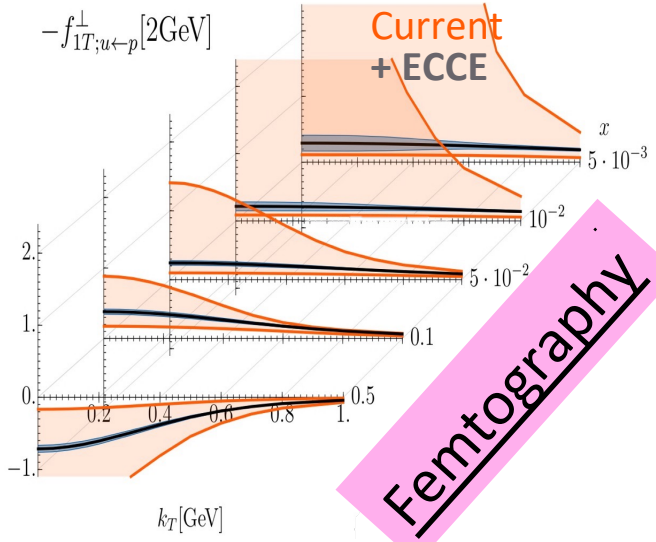




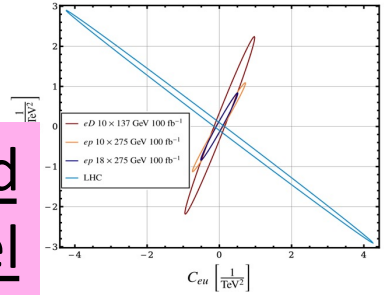


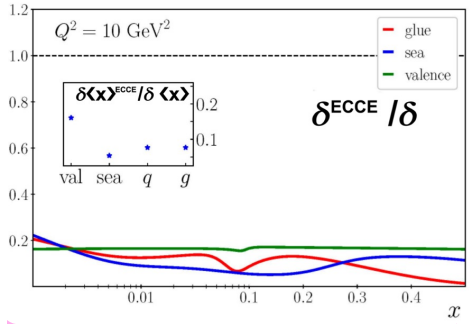
Origin of Spin

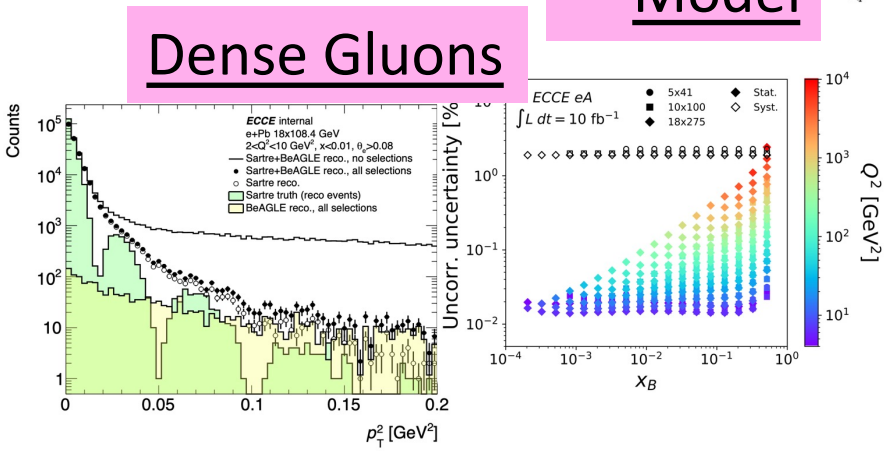




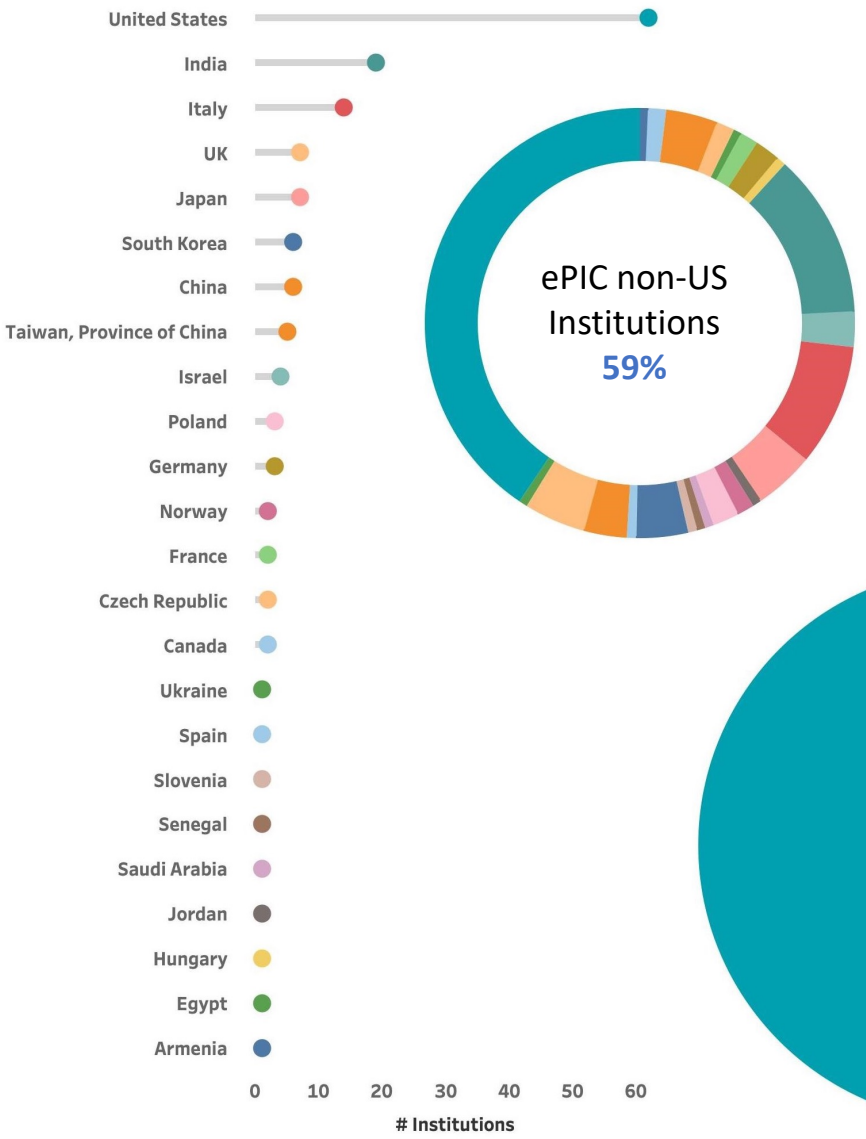
✓ Ensuring Science Program Feasibility

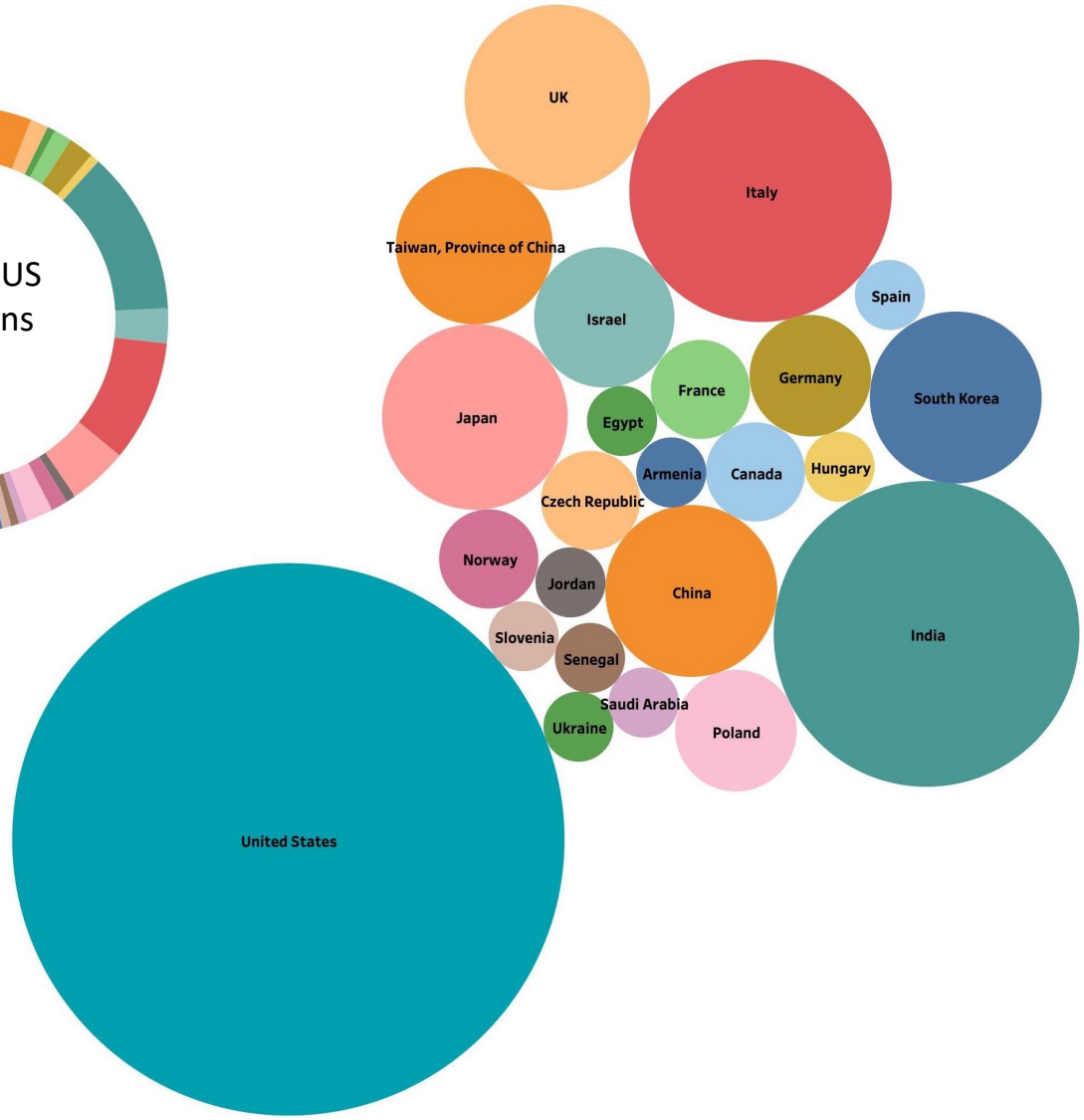






The ePIC Collaboration



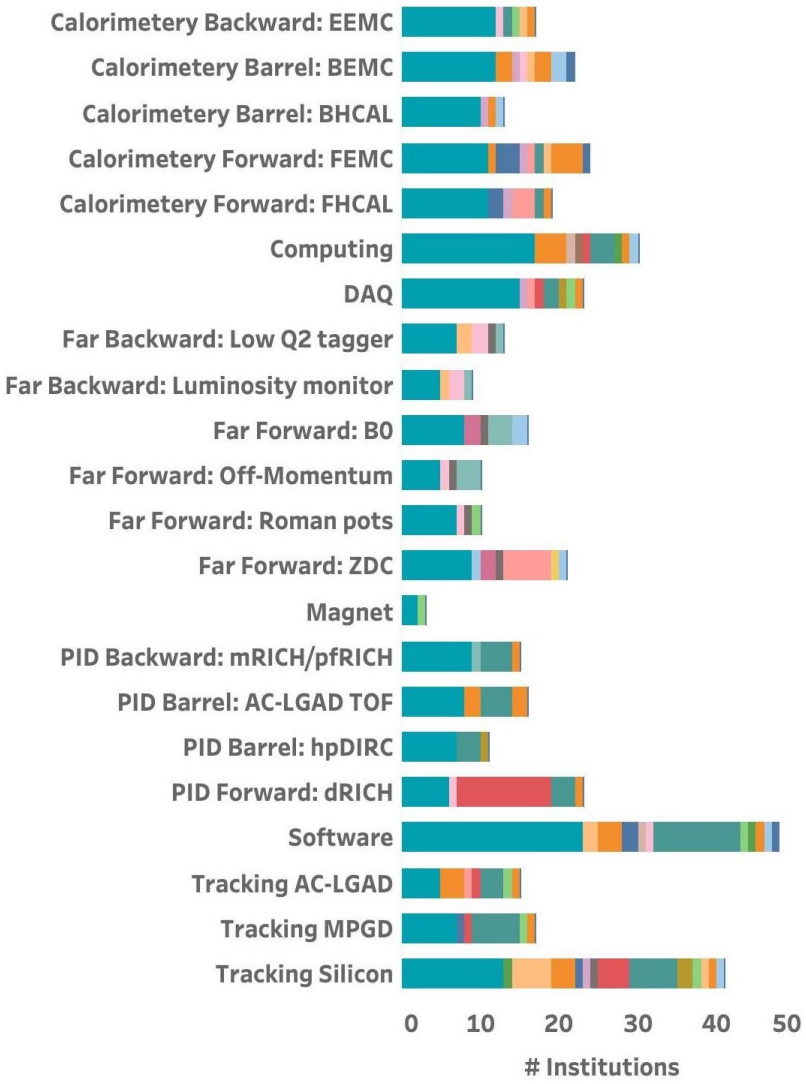


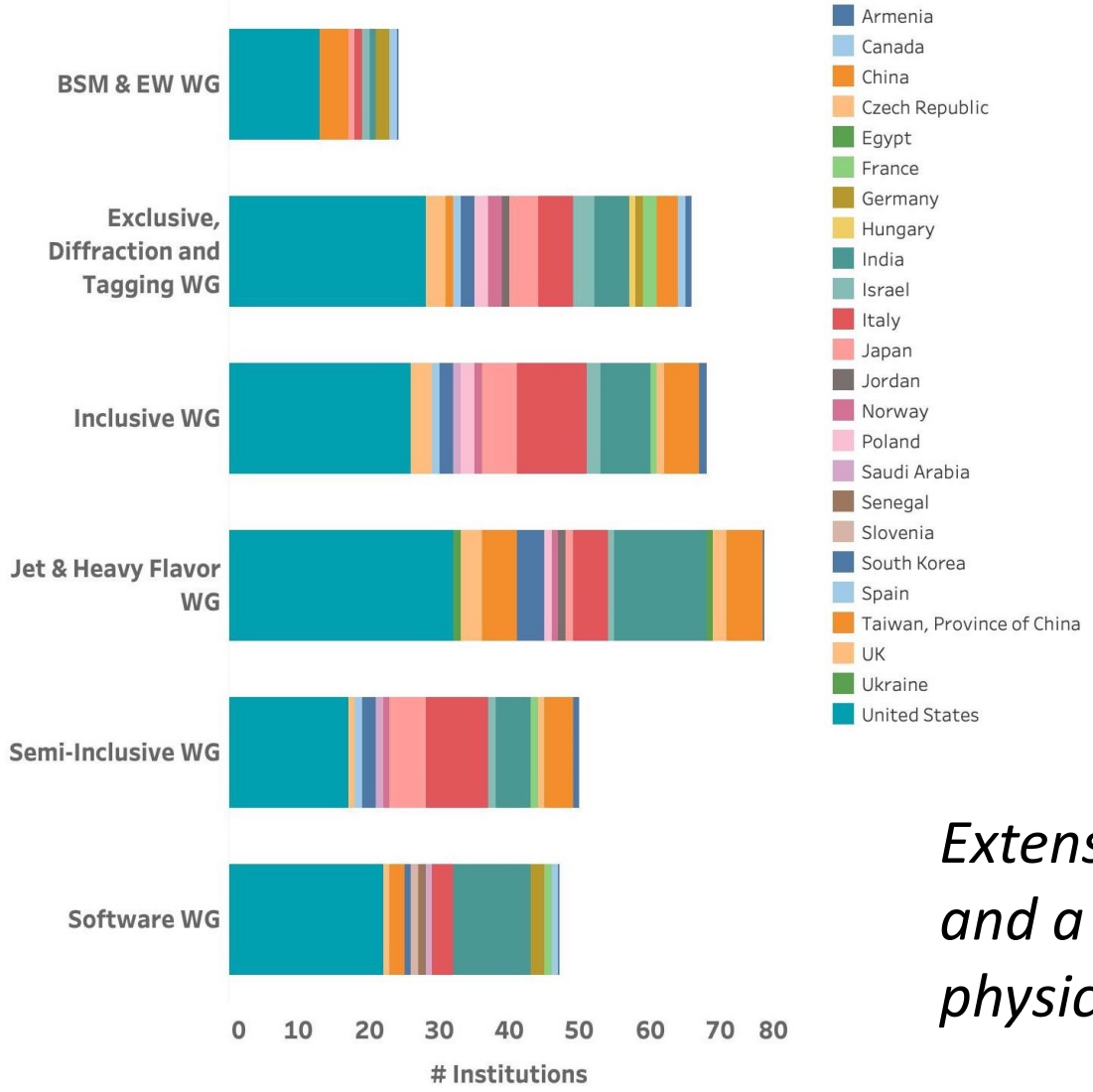
160+ institutions
24 countries

500+ participants

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

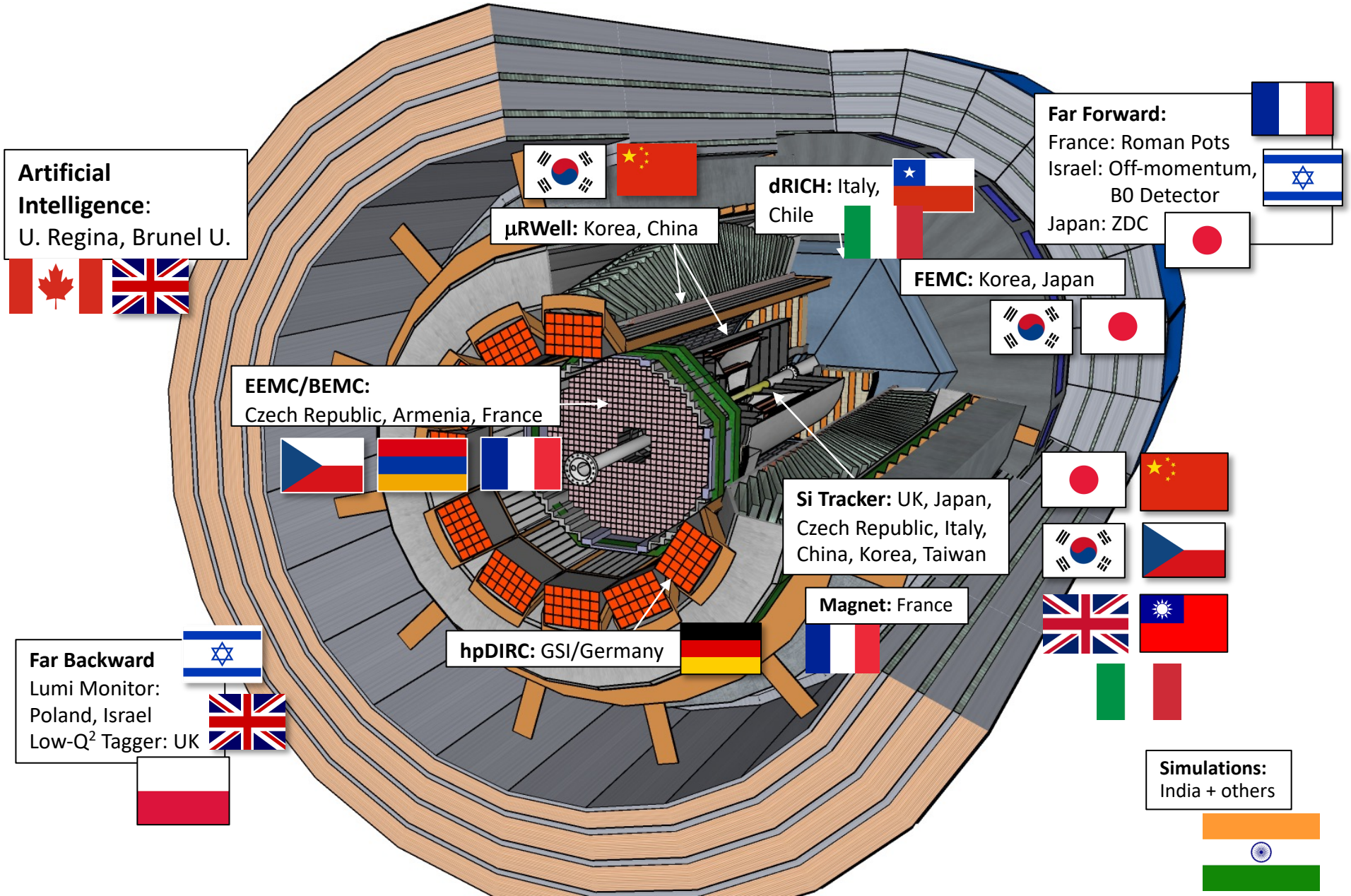
The ePIC Collaboration





Extensive expertise and a wide array of physics interests.

Large International Involvement



Collaboration Formation Timeline

- April: Formation of joint working groups and start of technological consolidation process
- June: Collaboration roster established via institutional survey
- July:
  - Name selection via members vote,
  - Collaboration council establishment and interim chairs appointment,
  - Collaboration formation meeting @ Stony Brook University (July 26th-28th).
- August: Formation of charter committee
- October:
  - 6th: Draft bylaws sent to collaboration,
  - 14th: Collaboration council meeting to discuss draft bylaws,
- Late October – Early November:
  - Comments and feedback collection of draft bylaws,
  - Final bylaws circulated to collaboration members,
  - Vote and adoption of collaboration bylaws.
- Late November: Collaboration leadership election and appointment of formal roles as defined by bylaws.

Joining ePIC

ePIC is forming into a full collaboration, with bylaws, etc. A collaboration council (institutional board equivalent) is formed and governance documents are being drafted.

Once formal bylways are adopted (in the coming ~month) there will likely be a formal requirement for approval of new institution by the collaboration council. Until that time, oining ePIC is simply done by formally expressing interest in being involved in ePIC:

(0) Email the ePIC Steering committee (Silvia Dalla Torre, Or Hen, Tanja Horn, John Lajoie, and Bernd Surrow)

(1) Fill out the institutional survey at:

https://forms.gle/FMMgEcaux9MY9noC8

Don’t need to fill all FTE information right now. What is important is the institutional interest and contact details. This will get your institution into the institutional roster, and we will add your contact information so they can get the emails from the current Collaboration Council co-chairs: Vicki Greene and Franck Sabatie.

(2) Fill individual institute members contact information:

https://forms.gle/cdec9ffq6hrDV1ET6

(3) Go to lists.bnl.gov and sign up to eic-projdet-collab-l, and all other relevant working group mailing lists. You will want to distribute this internally at your institution so other interested people can sign up as well.

Conclusions

- The ePIC Collaboration has kicked-off following a detailed development process (Yellow-report and Detector proposals):
  - Working groups focused on consolidation and developing the ePIC technical design for CD-2/3A (Forum to focus community and R&D consortium expertise),
  - Collaboration formed, draft charter circulated, elections expected soon,
  - Next collaboration meeting at JLab, Jan. 9-11th.
- The ePIC Detector is maturing into a detailed technical design
  - EIC detectors are an enormous undertaking that will require participation and expertise from both the RHIC and JLab communities, as well as key international contributions!
- Key requirements for ePIC to be successful:
  - EIC construction, HP computing, Theory, Experienced Workforce, international engagement
- ePIC continues engaging with the community via U.S. and European long-range plans
  - First step in U.S. process: QCD Town Hall Meeting on Sep. '22. Strong commitment to EIC,
  - EIC positively mentioned in European Particle Physics Strategy document (2020),
  - Working on contributions to NuPECC process with EIC Users Group.


BACK UP

U.S. QCD Community Remains Committed!

We recommend the expeditious completion of the EIC as the highest priority for facility construction

The Electron-Ion Collider (EIC) is a powerful and versatile new accelerator facility, capable of colliding high-energy beams ranging from heavy ions to polarized light ions and protons with high-energy polarized electron beams. In the 2015 Long Range Plan the EIC was put forward as the highest priority for new facility construction and the expeditious completion remains a top priority for the nuclear physics community. The EIC, accompanied by the general-purpose large-acceptance detector, ePIC, will be a discovery machine that addresses fundamental questions such as the origin of mass and spin of the proton as well as probing dense gluon systems in nuclei. It will allow for the exploration of new landscapes in QCD, permitting the “tomography”, or high-resolution multidimensional mapping of the quark and gluon components inside of nucleons and nuclei. Realizing the EIC will keep the U.S. on the frontiers of nuclear physics and accelerator science and technology.

Building on the recent EIC project CD-1 approval, the community-led Yellow-Report, and detector proposals, the QCD research community is committed to continue the development and timely realization of the EIC and its first detector, ePIC. We recommend supporting the growth of a diverse and active research workforce for the ePIC collaboration, in support of the expeditious realization of the first EIC detector.