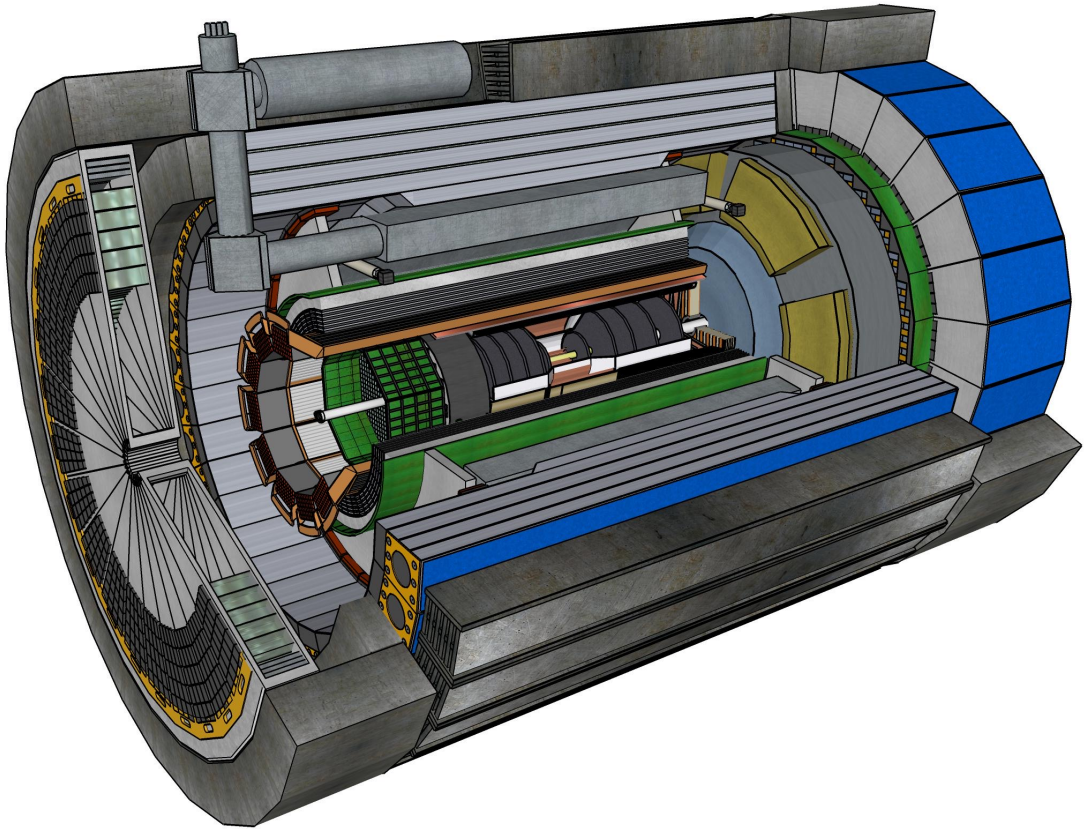
Status of the ePIC Collaboration



Rosi Reed

ePIC Analysis Coordinator

Lehigh University

LEHIGH UNIVERSITY

U.S. DEPARTMENT OF ENERGY

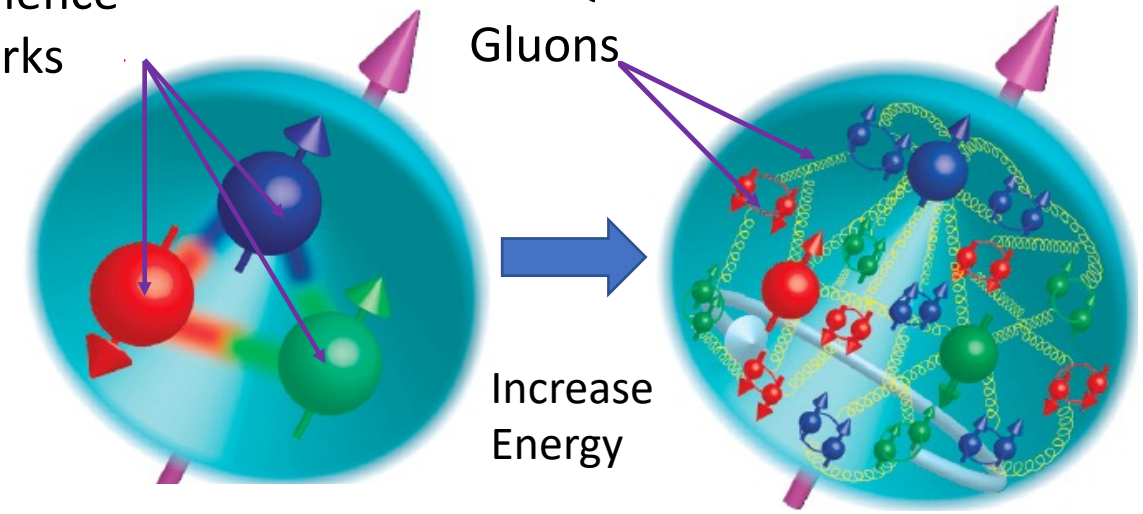
Office of Science

The ePIC/EIC Science Program

The Structure of the Proton

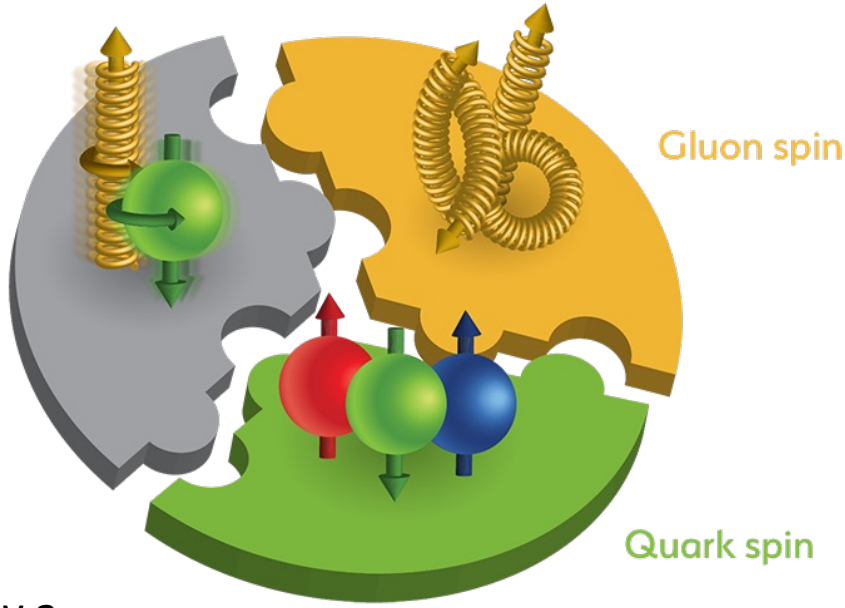
3 Valence Quarks

Sea Quarks and Gluons

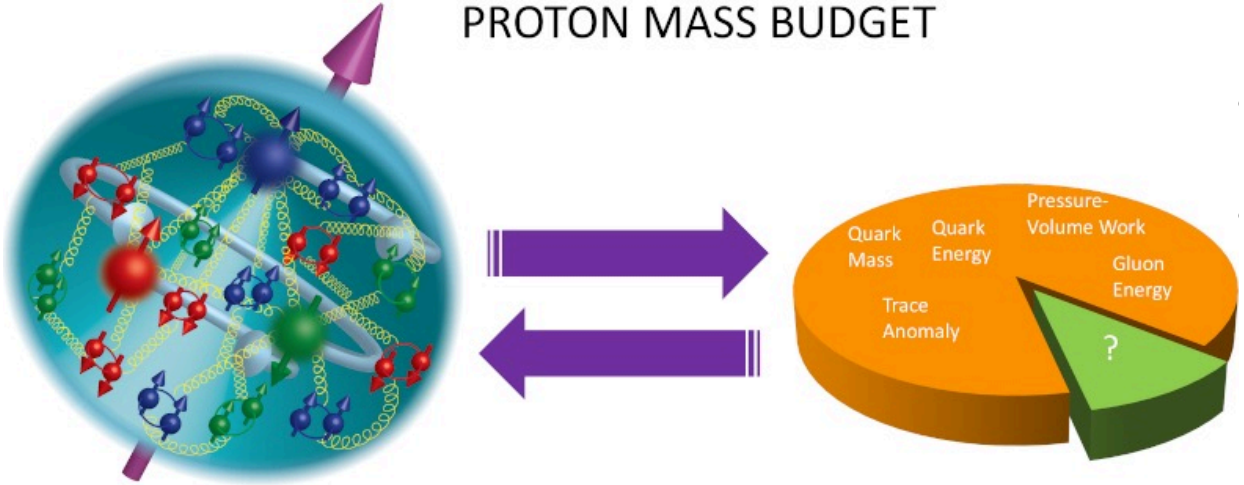


Increase Energy

Only 20-30% of the proton spin comes from the valence quarks!



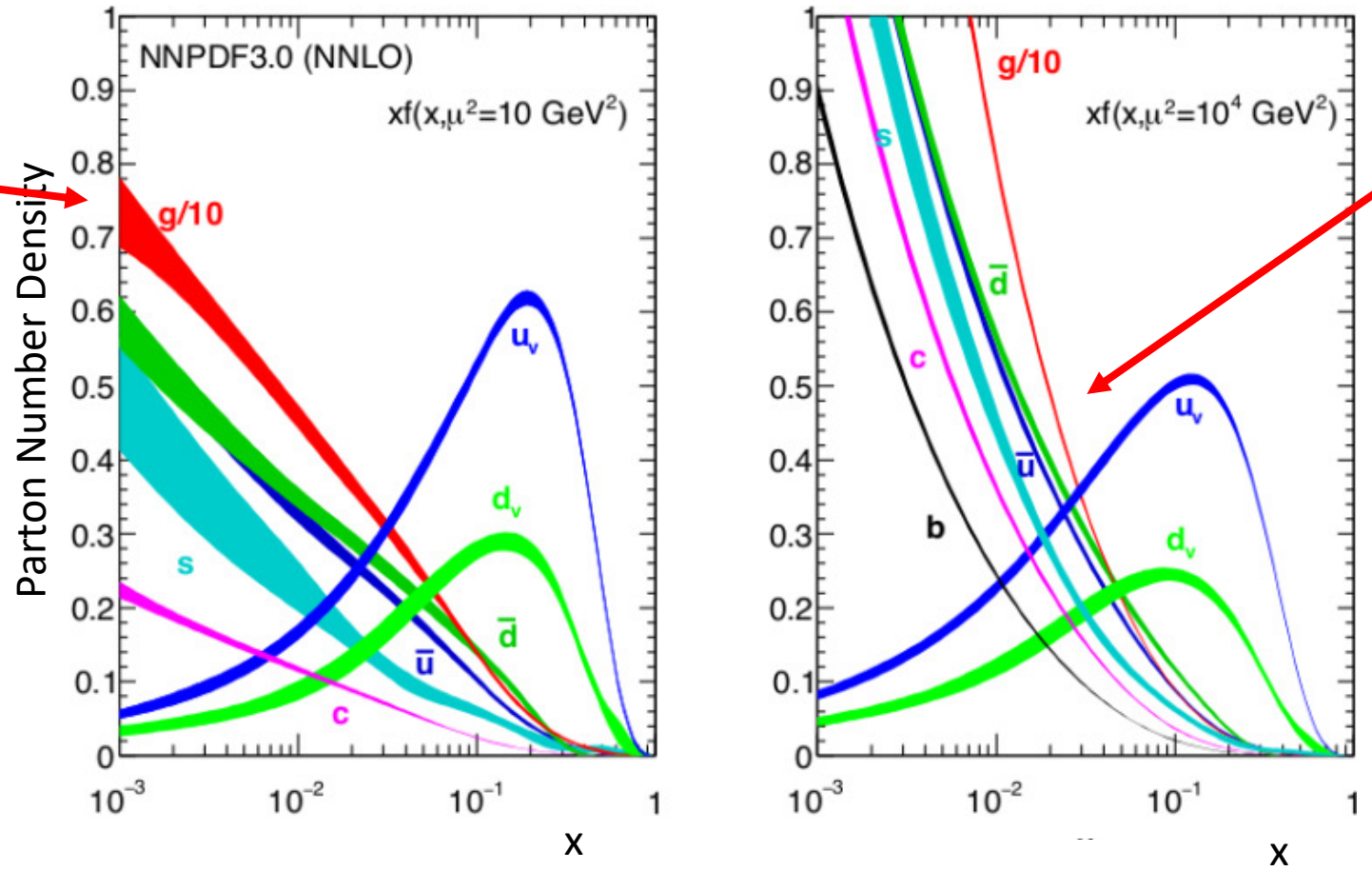
PROTON MASS BUDGET



Mass is driven by a complicated sum of various QCD interactions!

Longitudinal Momentum Structure

Where does this saturate?

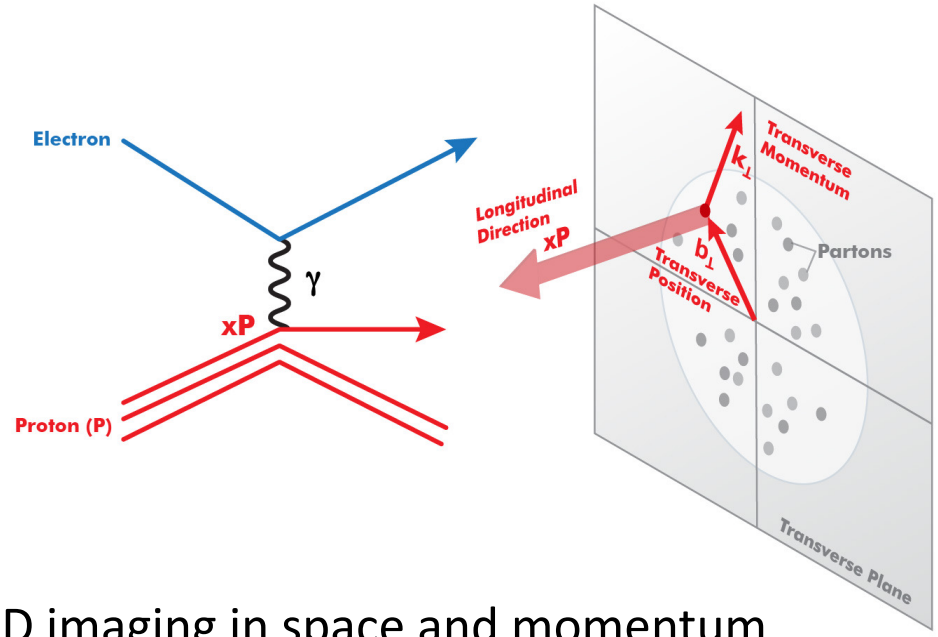


What do these distributions look like for protons in a nucleus?

Fraction of Proton Momentum Carried by Parton

3D Imaging in Space and Momentum

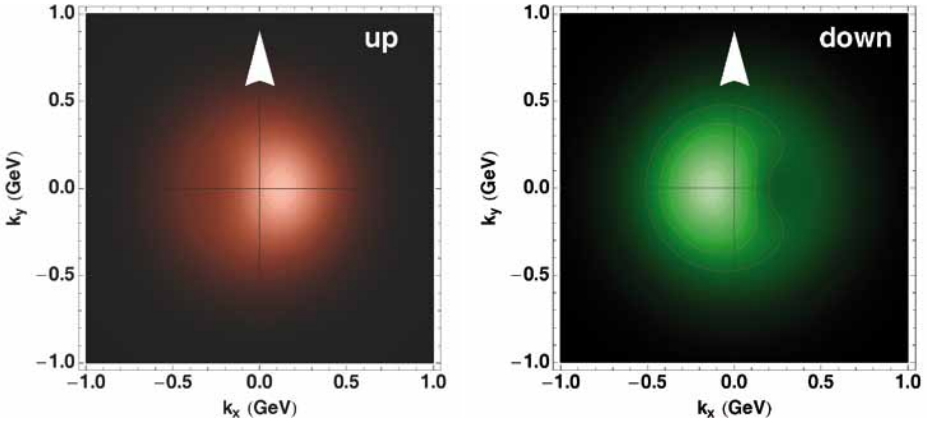
RHIC is the only polarized hadron collider in the world → EIC polarization capabilities



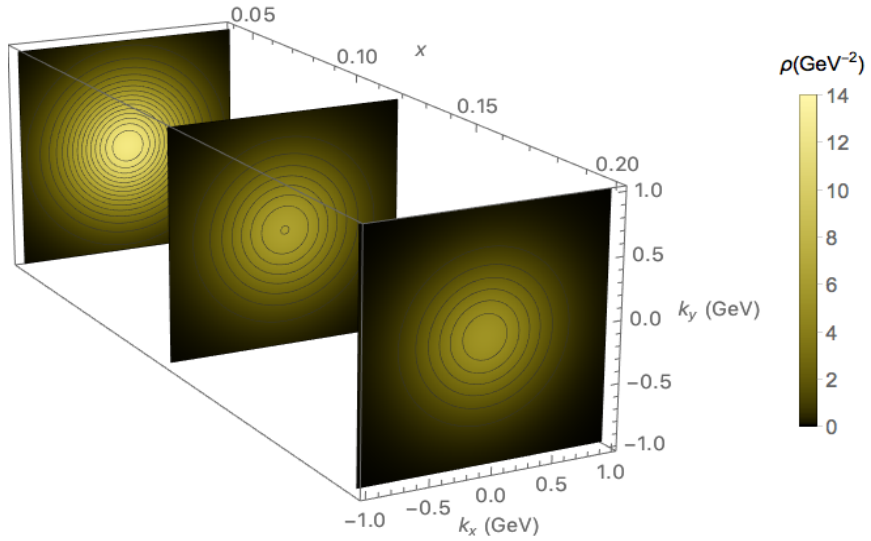
3D imaging in space and momentum

longitudinal structure (PDF)
+ transverse position Information (GPDs)
+ transverse momentum information (TMDs)

Transversely polarized nucleon

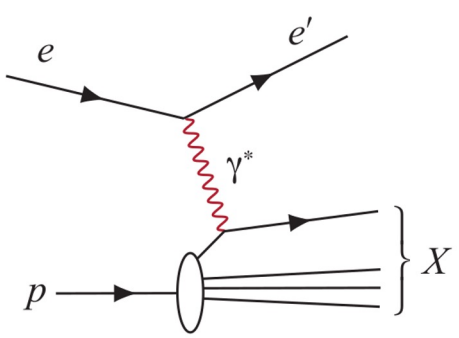


Unpolarized nucleon



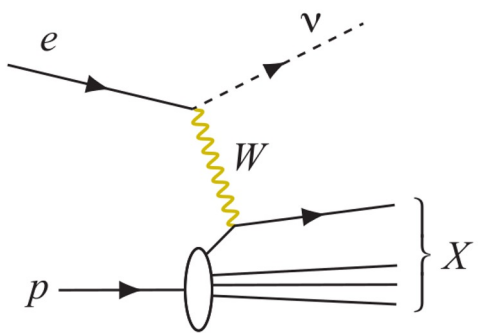
Experimental Processes to Access EIC Physics

DIS event kinematics - scattered electron or final state particles (CC DIS, low y)



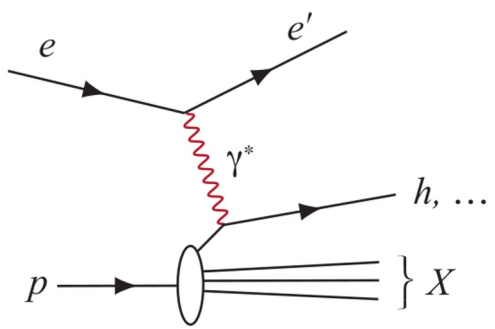
Neutral Current DIS

- Detection of scattered electron with high precision - event kinematics



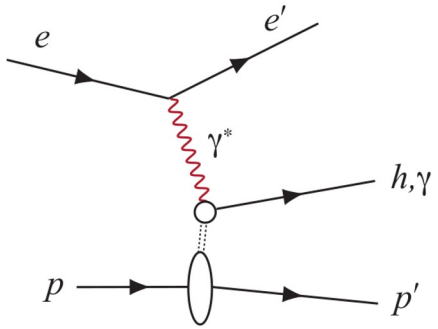
Charged Current DIS

- Event kinematics from the final state particles (Jacquet-Blondel method)



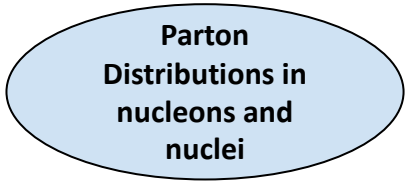
Semi-Inclusive DIS

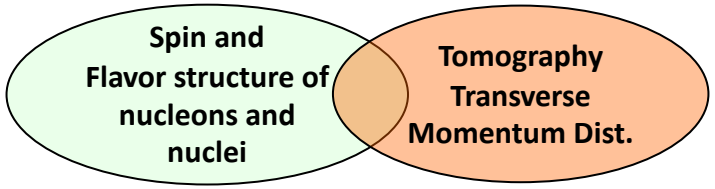
- Precise detection of scattered electron in coincidence with at least 1 hadron

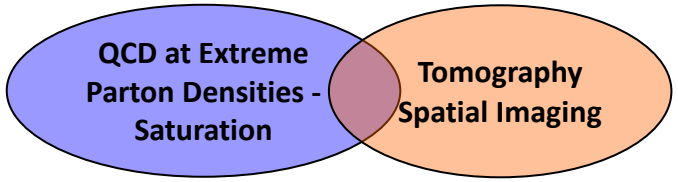


Deep Exclusive Processes

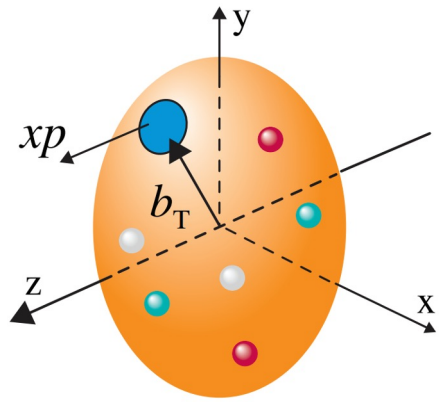
- Detection of all particles in event





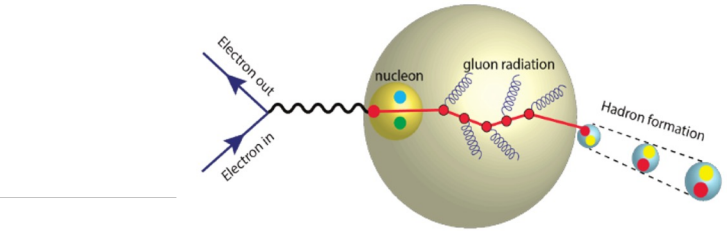


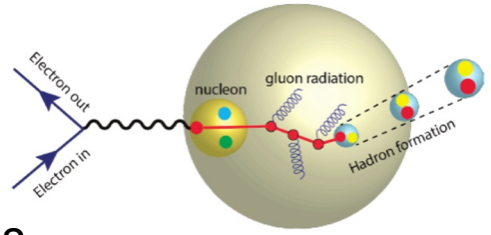
The Collaboration Pursues the Science



- How do the nucleon properties like mass and spin emerge from quarks and their interactions?

- How are the sea quarks and gluons distributed in space and momentum inside the nucleon? How is spin dynamically generated?



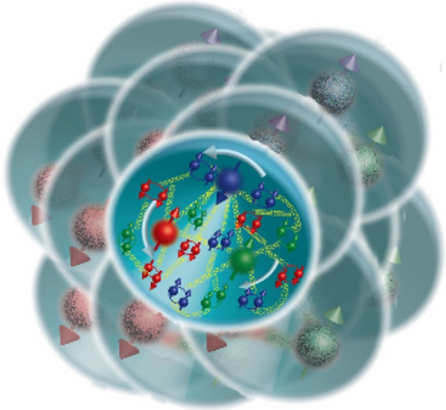


- In what manner do color-charged quarks and gluons, along with colorless jets, interact with the nuclear medium? And how do the confined hadronic states emerge from these quarks and gluons?

- What impact does a high-density nuclear environment have on the interactions, correlations, and behaviors of quarks and gluons?

s

- What is the mechanism through which quark-gluon interactions give rise to nuclear binding?



- Is there a saturation point for the density of gluons in nuclei at high energies, and does this lead to the formation of gluonic matter with universal properties across all nuclei, including the proton?

The ePIC Collaboration

What is ePIC

JLab, Jan. 2023

Warsaw, July 2023

ANL,
Jan. 2024

ePIC is a community of scientists dedicated to realizing the EIC science mission.

The ePIC Collaboration is as unique as the ePIC detector.

New Institutions Joining ePIC in 2024:

- Univ. of Texas at Austin
- Univ. Mohammed V in Rabat
- Univ. Ibn Tofail in Kénitra
- Univ. Mohammed Premier in Oujda
- Univ. Mohammed VI in Bengurir
- Kent State Univ.
- Laboratoire Leprince-Ringuet (LLR)
- American University in Cairo
- Central University of Haryana
- Indian Institute of Technology Mandi

UK
Ukraine

ePIC Collaboration Structure

Collaboration Council
Institutional Representatives

Spokesperson's Office
Spokesperson (SP)
Deputies

EIC Project

Executive Board

Standing Committees
DE&I
Conferences and Talks
Membership
Elections
Publications

Ad-Hoc Committees

Te  **rdinator**

Softwa Co  **nputing SCC)**

s Coo (AC)  **r**

Technical Coordinator (Acting)
- Silvia Dalla Torre (INFN)

Deputy TC's:
Prakhar Garg (Yale)
Oskar Hartbrich (ORNL)
Matt Posik (Temple)

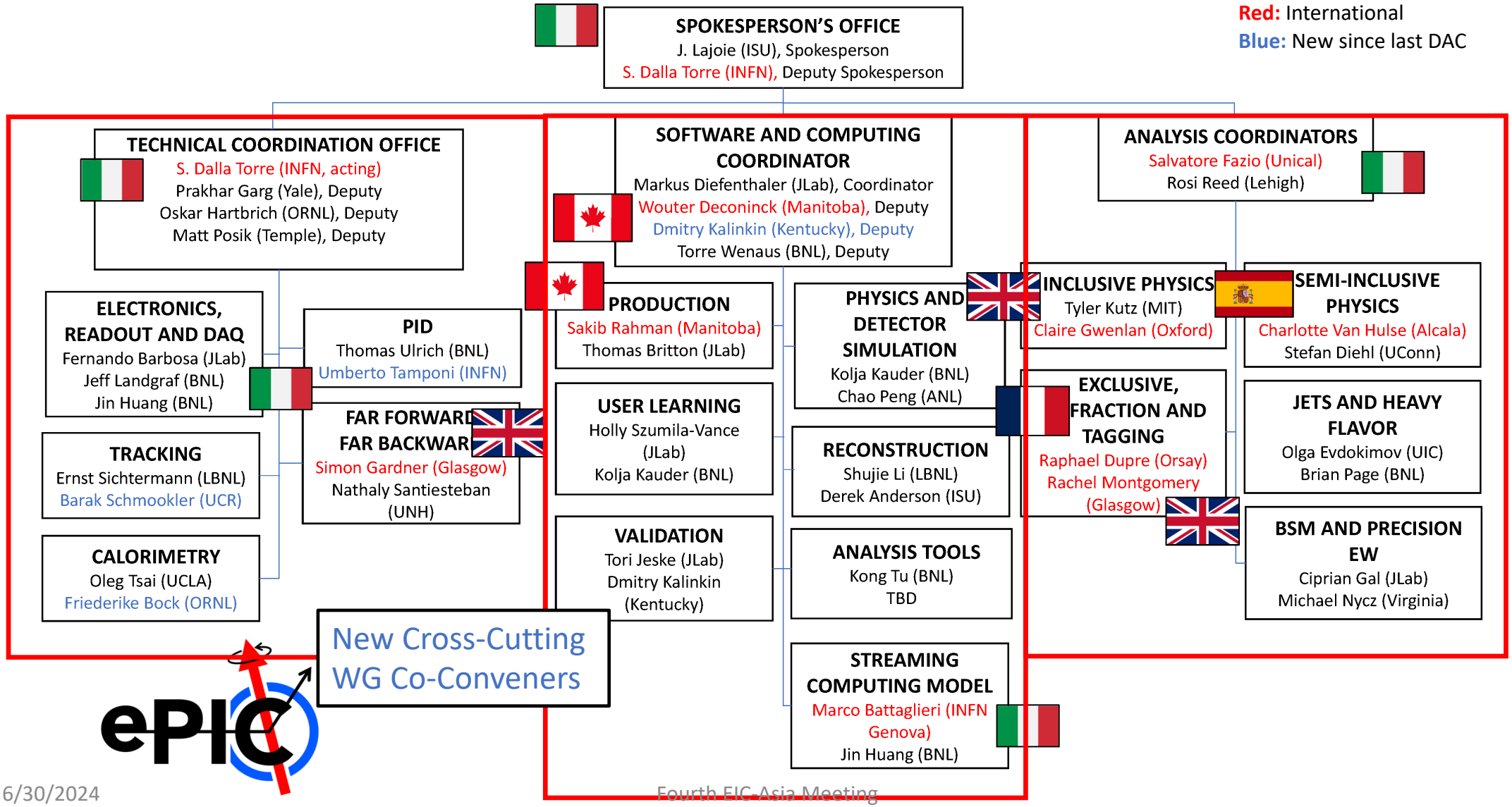
SCC Coordinator
- Markus Diefenthaler (JLab)

Dmitry Kalinkin
(Kentucky, Deputy SCC for Development)
Torre Wenaus
(BNL, Deputy SCC for Infrastructure)
Wouter Deconinck
(U. Manitoba, Deputy SCC for Operations)

Analysis Co-Coordinators
- Rosi Reed (Lehigh Univ.)
- Salvatore Fazio (Univ. Calabria)

ePIC Working Group Structure

Red: International
Blue: New since last DAC



ePIC DSC Structure

Red: International
Blue: New since last DAC

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

Detector Subsystem Collaborations

Particle Identification

dRICH
DSL/DSTC: Marco Contalbrigo (INFN)

hpDIRC
DSL/DSTC: Greg Kalicy (CUA)

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

AC-LGAD TOF
DSL: Zhangbu Xu (Kent State)
Deputy DSL: Satoshi Yano (Hiroshima)

Calorimetry

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

BACKWARDS HCAL
DSL/DSTC: Leszek Kosarzewski (OSU)

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

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

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)

Far-Forward Far-Backward

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)

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

LUMINOSITY
Co-DSL: Nick Zachariou (York)
Co-DSL: Krzysztof Piotrzkowski (AGH Krakow)
DSTC (Pair Spectr.): Dhevan Gangadharan (Houston)

Tracking

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

GASEOUS TRACKERS
DSL: Kondo Gnanvo (JLab)
DSTC: Maxence Vendenbroucke (Saclay)

ePIC Committees

Collaboration Council
Institutional Representatives

Standing Committees
DE&I
Conferences and Talks
Membership
Elections
Publications

Ad-Hoc Committees

DE&I Committee:
Chair: Megan Connors (GSU)
Vice-Chair: Christine Nattrass (UTK)
Francesco Bossù (CEA-Saclay), Wouter Deconinck (University of Manitoba), Narbe Kalantarians (Virginia Union

Conferences and Talks:
Chair: Maria Zurek (ANL)
Vice-Chair: Brian Page (BNL)

Membership Committee:
Chair: Peter Steinberg (BNL)
Vice-Chair: Pietro Anontioli (INFN-Bologna)
Friederike Bock (ORNL), Helen Caines (Yale), Doug

Elections Committee:
Chair: Helen Caines (Yale)

Publications Committee:
Chair: Rene Bellwied (U. Houston)
Vice –Chair: Annalisa Mastroserio (INFN Bari)
Lokesh Kumar (Panjab U.), Michela Chiosso (Torino), Prithwish Tribedy (BNL), Markus Diefenthaler (JLab), Sevil Salur (Rutgers),
ex-officio w. Conferences and Talks Committee:
Daniel Brandenburg (OSU)

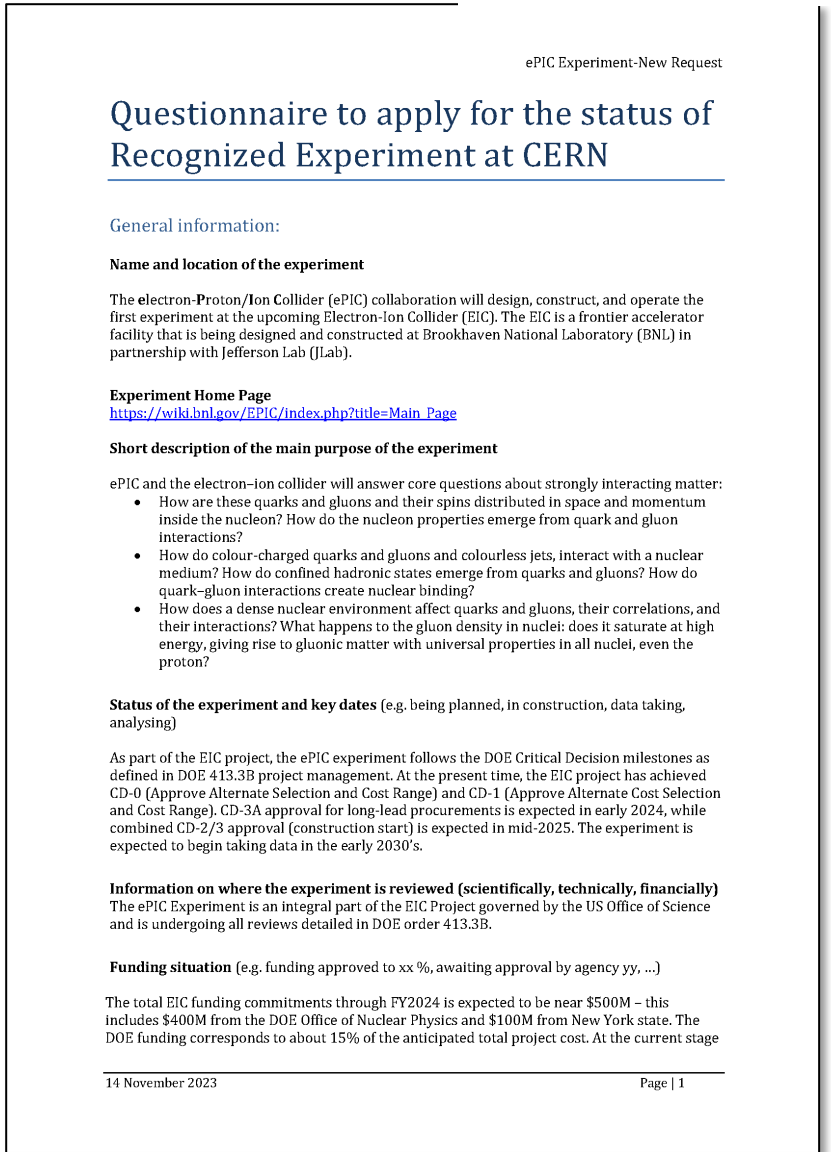
All ePIC Standing Committees now formed and at work.

Regular Cadence of the Collaboration

- New CC WG co-convenors submitted for Collaboration Council for endorsement
- New DSC Leaders and Technical Coordinators
- Collaboration Council Vice-Chair Election:
  - Thomas Ullrich (BNL) elected new CC Vice Chair
- Physics Working Group Convener Rotations
  - PWG Co-conveners serve staggered two-year terms
  - SP Office will submit new PWG conveners for CC endorsement at July collaboration meeting
- Spokesperson election in February 2025

CERN Recognized Experiment

- ePIC Application for CERN Recognized Experiment:
  - ePIC leadership has submitted an application to become a CERN Recognized Experiment
  - Strong synergies between CERN and EIC
  - Important for access to CERN resources (test beams, …)
  - Increase visibility in the European community
- ePIC presentation to CERN Recognized Experiments Committee (REC) Feb 8th
- Research Board confirmed the positive REC recommendation at CERN Council Meeting March 21-22nd
- Working with Helge Meinhard on next steps



ePIC Experiment-New Request

Questionnaire to apply for the status of Recognized Experiment at CERN

General information:

Name and location of the experiment

The **e**lectron-**P**roton/**I**on Collider (ePIC) collaboration will design, construct, and operate the first experiment at the upcoming Electron-Ion Collider (EIC). The EIC is a frontier accelerator facility that is being designed and constructed at Brookhaven National Laboratory (BNL) in partnership with Jefferson Lab (JLab).

Experiment Home Page
https://wiki.bnl.gov/EPIC/index.php?title=Main_Page

Short description of the main purpose of the experiment

ePIC and the electron–ion collider will answer core questions about strongly interacting matter:

- How are these quarks and gluons and their spins distributed in space and momentum inside the nucleon? How do the nucleon properties emerge from quark and gluon interactions?
- How do colour-charged quarks and gluons and colourless jets, interact with a nuclear medium? How do confined hadronic states emerge from quarks and gluons? How do quark–gluon interactions create nuclear binding?
- How does a dense nuclear environment affect quarks and gluons, their correlations, and their interactions? What happens to the gluon density in nuclei: does it saturate at high energy, giving rise to gluonic matter with universal properties in all nuclei, even the proton?

Status of the experiment and key dates (e.g. being planned, in construction, data taking, analysing)

As part of the EIC project, the ePIC experiment follows the DOE Critical Decision milestones as defined in DOE 413.3B project management. At the present time, the EIC project has achieved CD-0 (Approve Alternate Selection and Cost Range) and CD-1 (Approve Alternate Cost Selection and Cost Range). CD-3A approval for long-lead procurements is expected in early 2024, while combined CD-2/3 approval (construction start) is expected in mid-2025. The experiment is expected to begin taking data in the early 2030's.

Information on where the experiment is reviewed (scientifically, technically, financially)
The ePIC Experiment is an integral part of the EIC Project governed by the US Office of Science and is undergoing all reviews detailed in DOE order 413.3B.

Funding situation (e.g. funding approved to xx %, awaiting approval by agency yy, …)

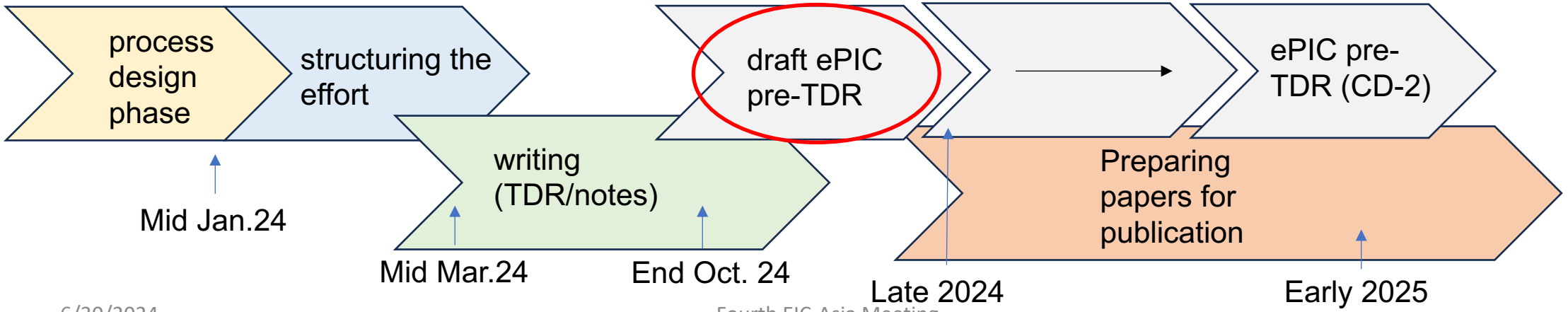
The total EIC funding commitments through FY2024 is expected to be near $500M – this includes $400M from the DOE Office of Nuclear Physics and $100M from New York state. The DOE funding corresponds to about 15% of the anticipated total project cost. At the current stage

14 November 2023 Page | 1

TDR Strategy and Publications

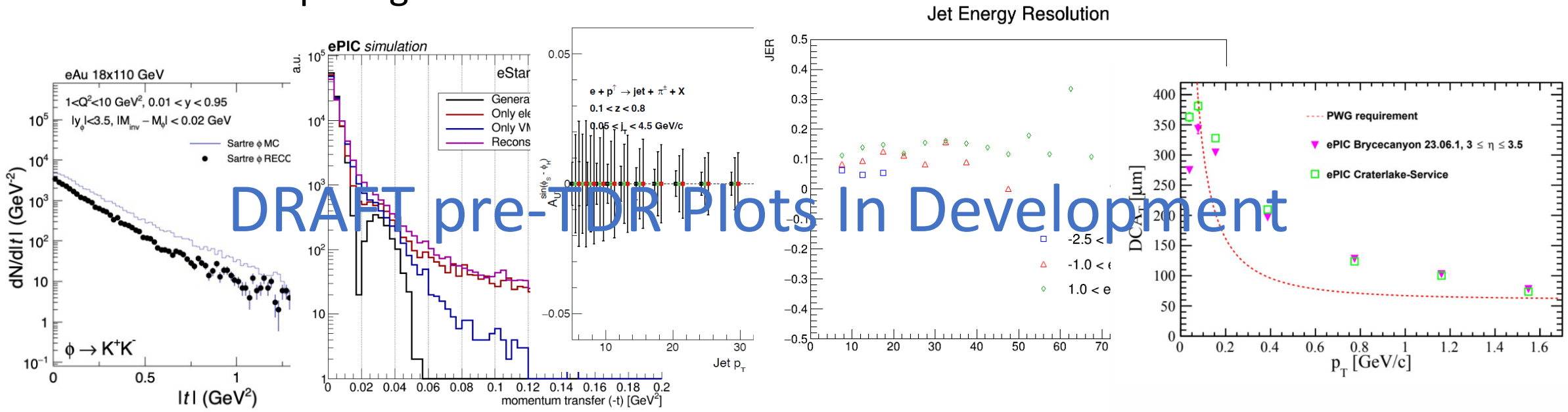
- In 2024 the ePIC collaboration will produce:
  - A draft of the ePIC contributions to the EIC TDR
    - The EIC TDR is the top priority
      - Chapters on *Physics Goals and Requirements* and *Experimental Systems*
      - Not just the document, but the simulations and detector R&D that form the basis
      - Requires close cooperation between the collaboration and the project!
- An ePIC Detector Design paper:
    - Derived and expanded from the *Experimental Systems* TDR chapter
- An ePIC Physics Performance paper:
    - Derived and expanded from the *Physics Goals and Requirements* TDR chapter
- Both to be published in a scientific journal (such as NIMA, JINST, or PRC)
- These publications will serve as a focus in developing the ePIC Membership and Publication policies.

Focused activity in the **Technical and Integration Council**



Analysis Coordination in ePIC

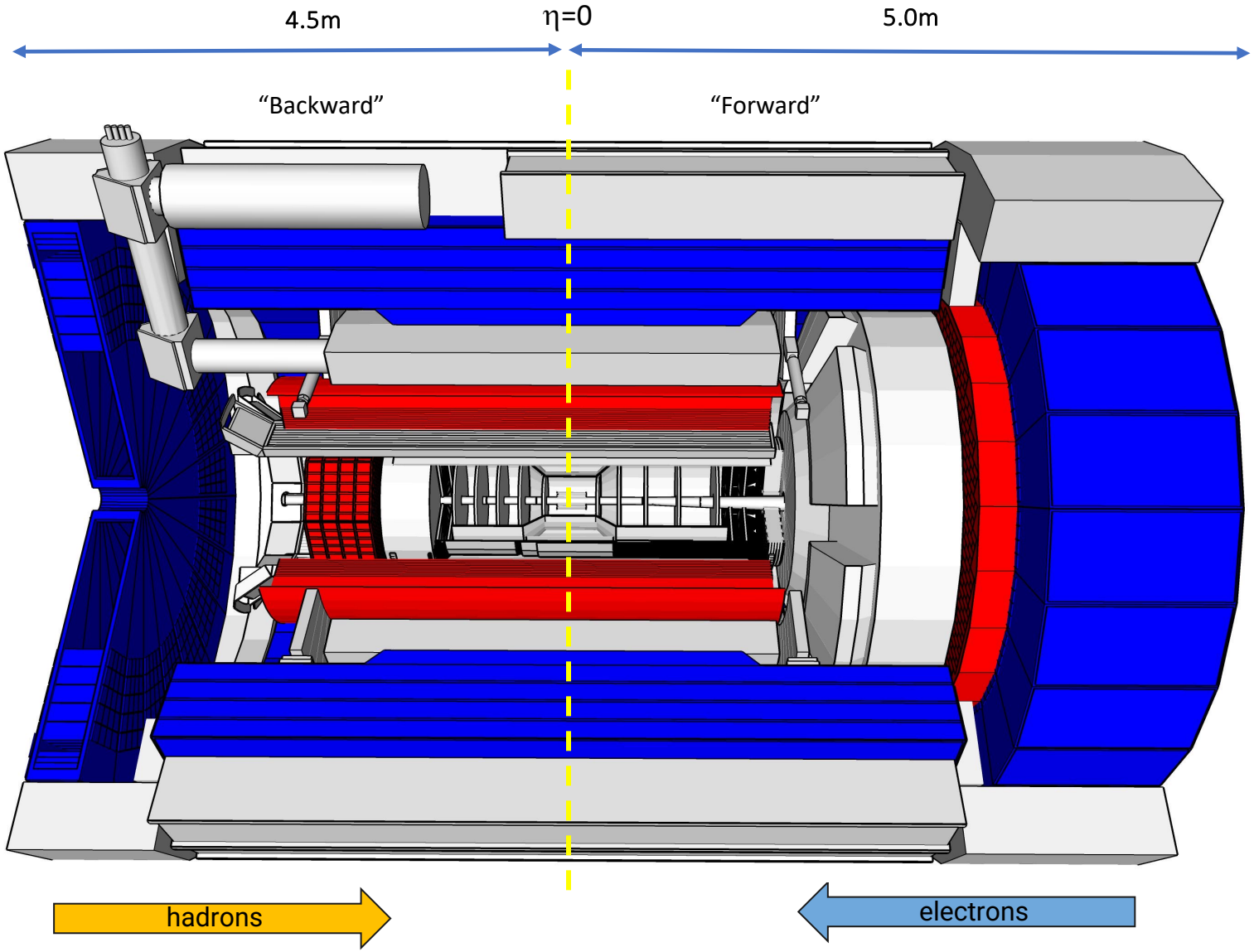
- Analysis Coordination is responsible for the simulations that demonstrate the ability of ePIC to do EIC science
  - A critical part of the TDR development process
  - Organizing physics “benchmark” plots for the TDR
  - Sets priorities for reconstruction development in conjunction with Software and Computing



DRAFT pre-TDR Plots In Development

The ePIC Detector

ePIC Detector Design



Tracking:

- New 1.7T (2.0T) solenoid
- Si MAPS Tracker
- MPGDs (μRWELL/μMegas)

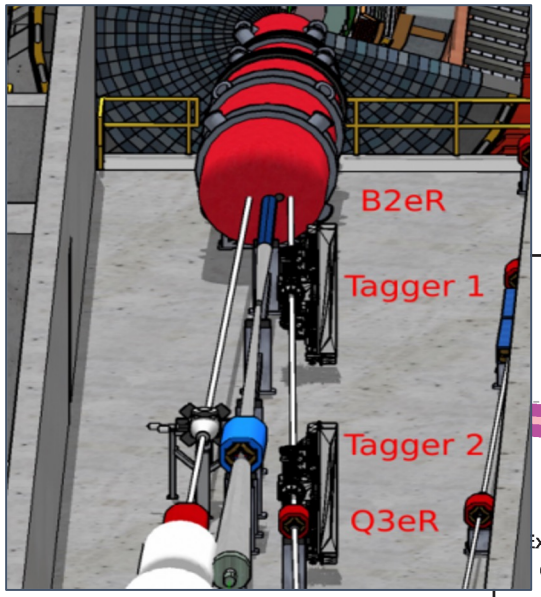
PID:

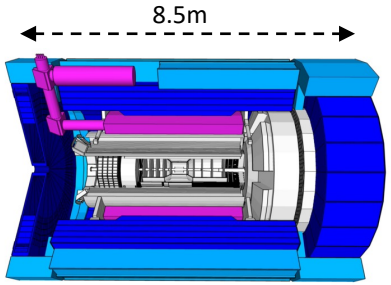
- high-performance DIRC
- proximity-focused RICH
- dual-radiator RICH
- AC-LGAD (~30ps TOF)

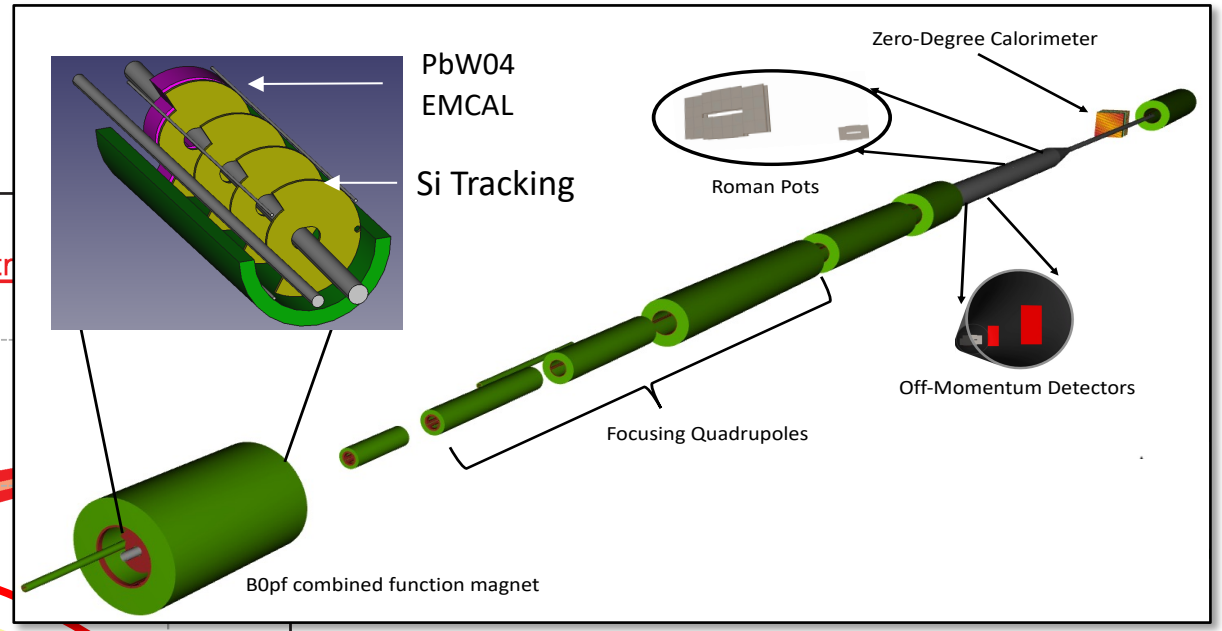
Calorimetry:

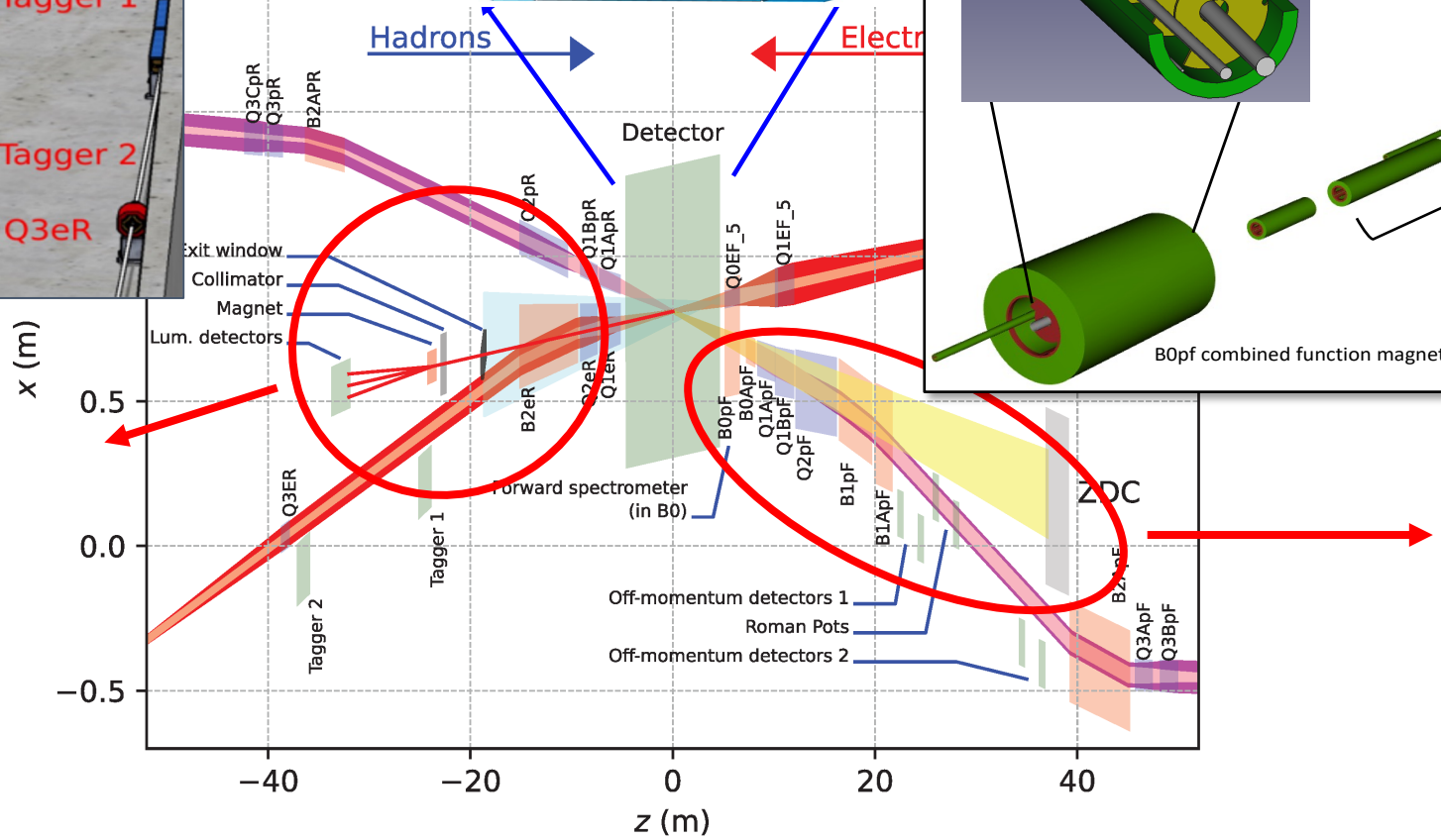
- Imaging Barrel EMCal
- PbWO4 EMCal (backwards)
- Finely segmented EMCal +HCal in forward direction
- Outer HCal (sPHENIX re-use)
- Backwards HCal (tail-catcher)

Far-Forward and Far-Backward Detectors









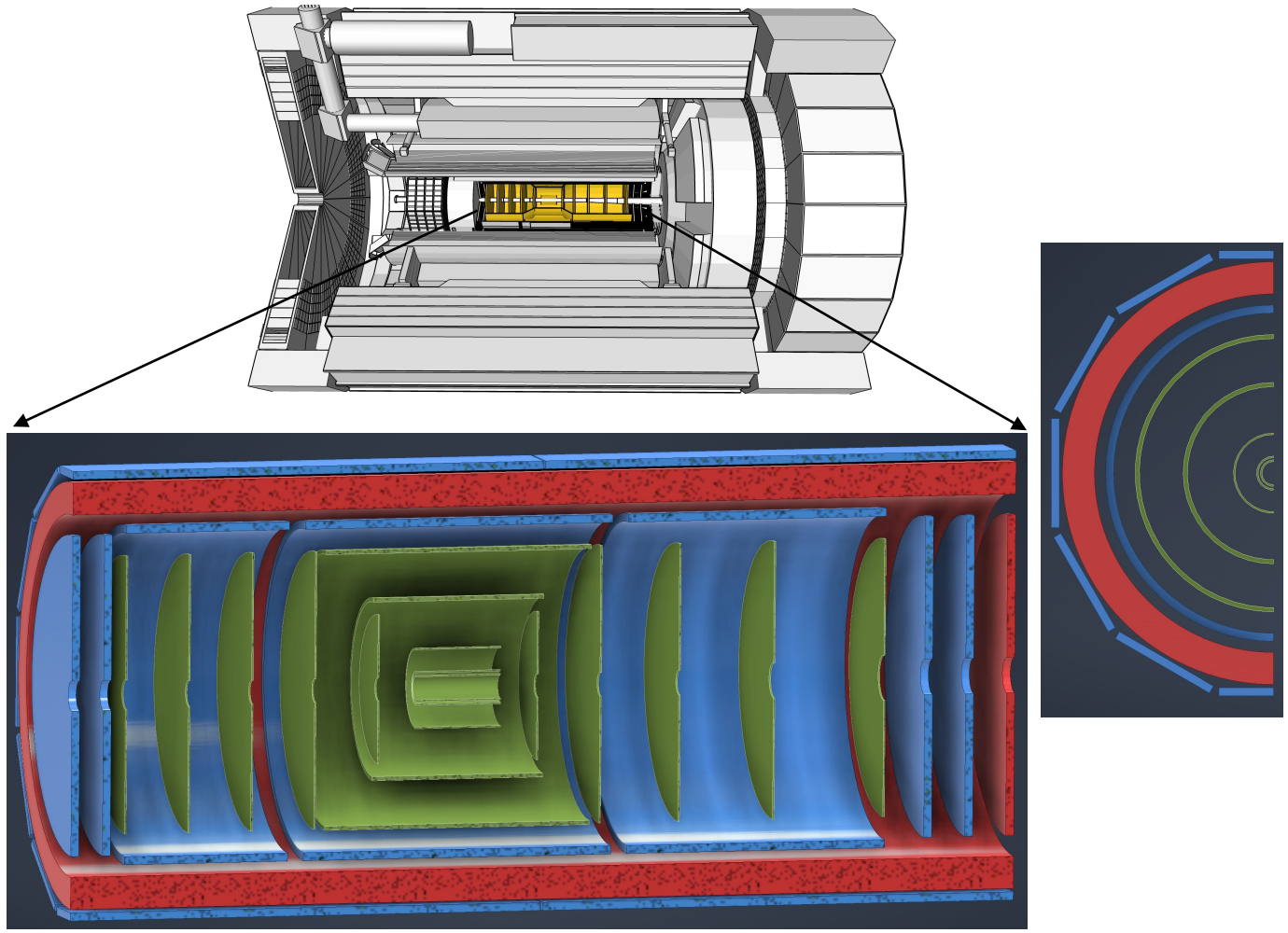
Far-Backward Detectors

- Luminosity monitor
- Low-Q^2 Tagging Detectors

Far-Forward Detectors

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

ePIC Tracking Detectors



MAPS Barrel + Disks

MPGD Barrels + Disks

AC-LGAD based ToF

- **MAPS Tracker:**
  - Small pixels (20 μm), low power consumption (<20 mW/cm^2) and material budget (0.05% to 0.55% X/X$_0$) per layer
  - Based on ALICE ITS3 development
  - Vertex layers optimized for beam pipe bakeout and ITS-3 sensor size
  - Barrel layers based on EIC LAS development
  - Forward and backwards disks

world's first at ePIC

- **MPGD Layers:**
  - Provide timing and pattern recognition redundancy
  - Cylindrical μMEGAs
  - Planar μRWell's before hpDIRC
    - Impact point and direction for ring seeding

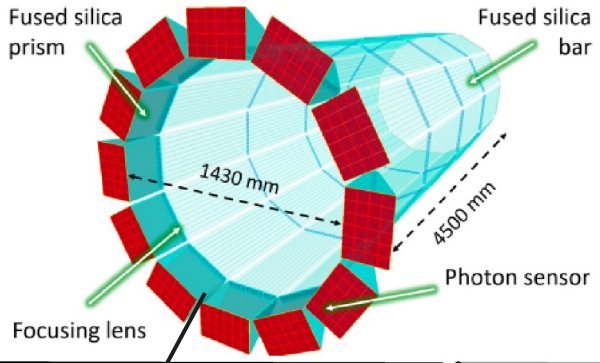
world's first at ePIC

- **AC-LGAD TOF and AstroPix (BECAL)**
  - Additional space point for pattern recognition / redundancy

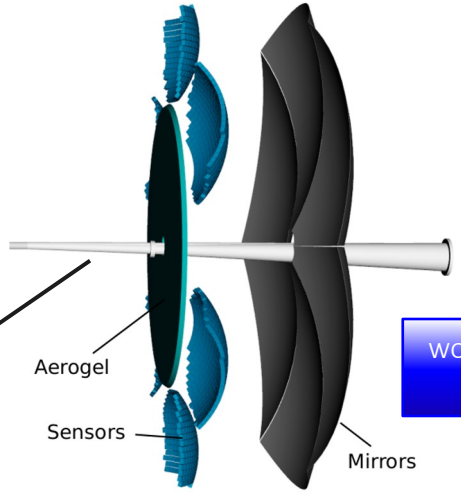
Particle ID

High-Performance DIRC

- Quartz bar radiator (BaBAR bars)
- light detection with MCP-PMTs
- Fully focused
- π/K 3σ separation at 6 GeV/c



Dual-Radiator RICH(dRICH)

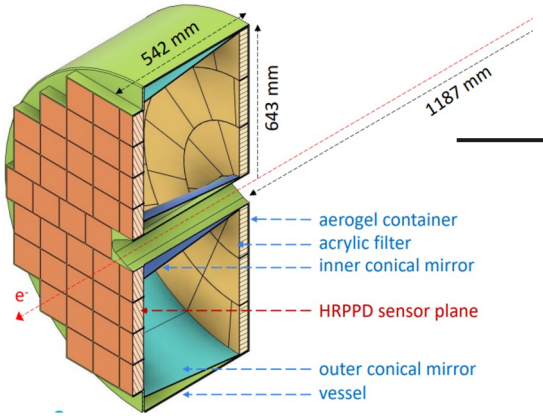


world's first at ePIC

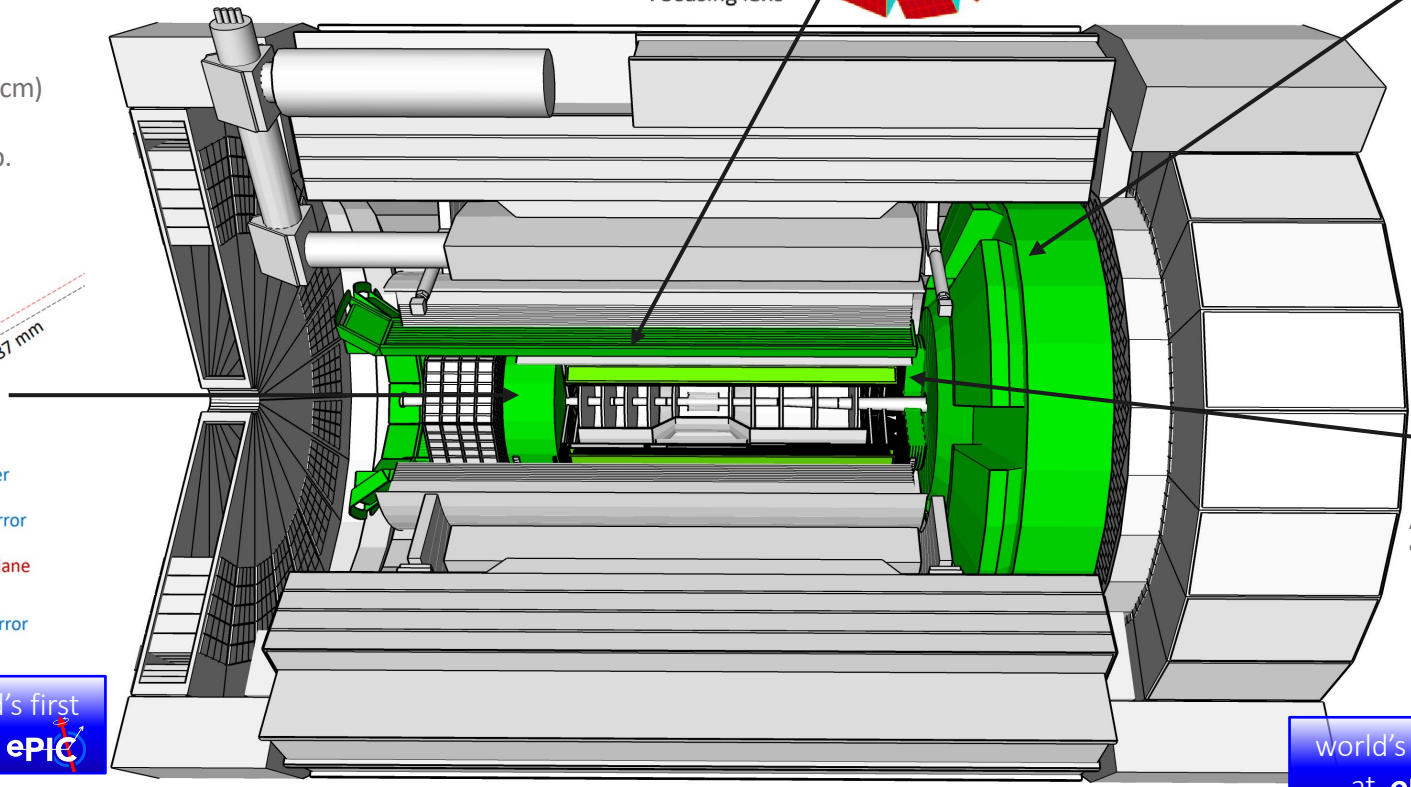
- C_2F_6 Gas Volume and Aerogel
- Sensors tiled on spheres (SiPMs)
- π/K 3σ sep. at 50 GeV/c

Proximity Focused (pfRICH)

- Long proximity gap (~40 cm)
- Sensor: HRPPDs
- up to 9 GeV/c 3σ π/K sep.

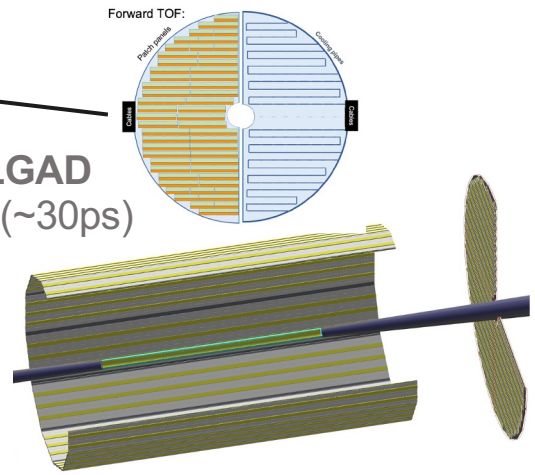


world's first at ePIC



world's first at ePIC

AC-LGAD TOF (~30ps)



- Accurate space point for tracking
- forward disk and central barrel

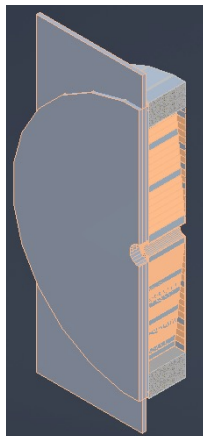
hadrons

electrons

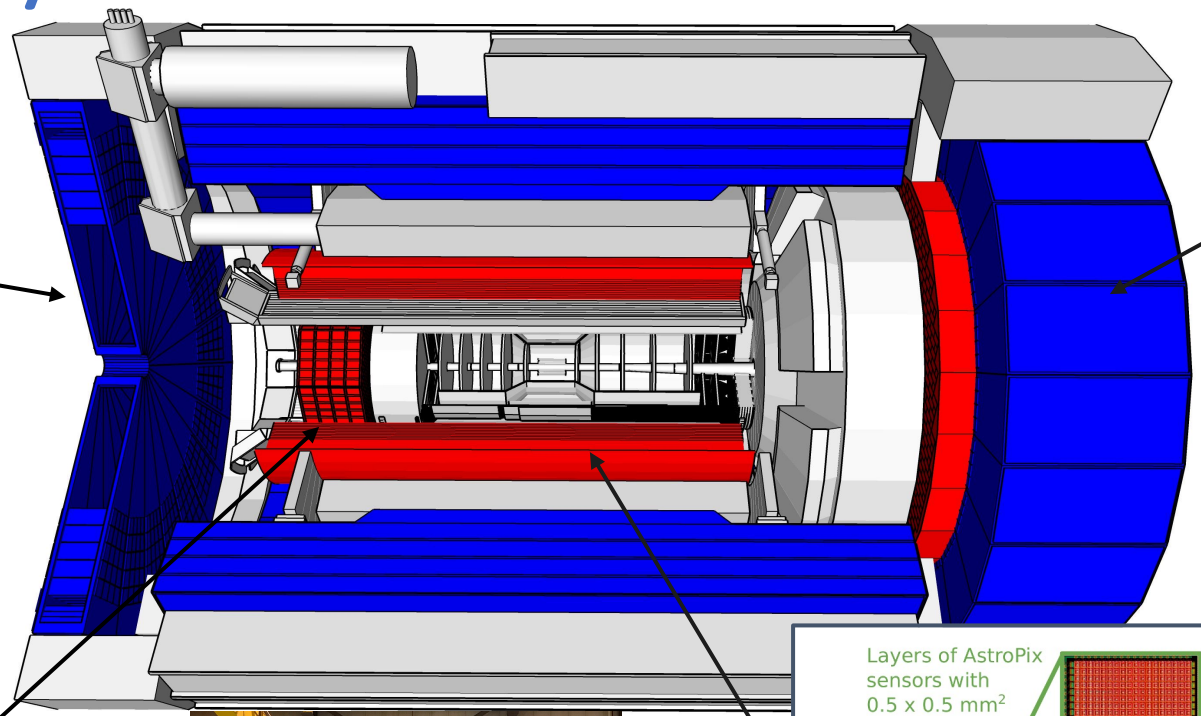
Calorimetry

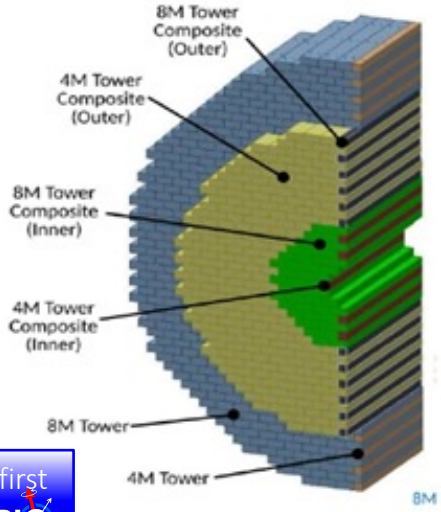
hadrons

electrons



Backwards HCal Steel/Sc Sandwich tail catcher

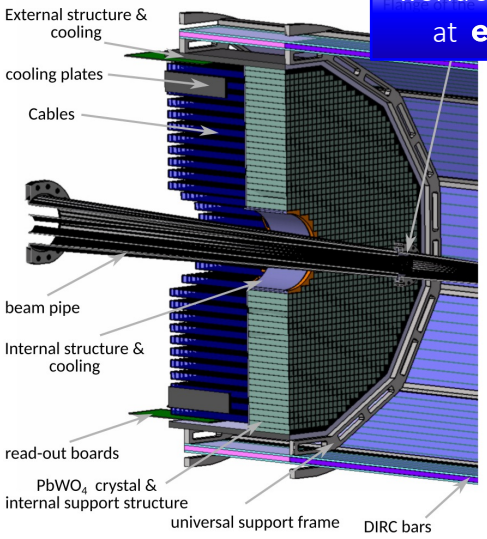




world's first at ePIC

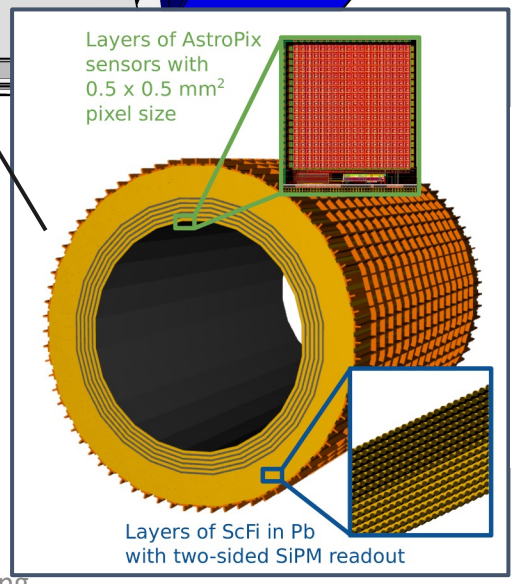
High granularity W/SciFi EMCal Longitudinally separated HCAL with high-η insert

world's first at ePIC



Backwards EMCal PbW04 crystals, SiPM photosensor

Barrel HCAL (sPHENIX re-use)

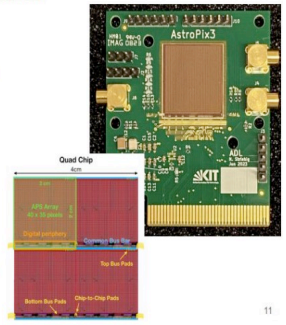


AstroPix v3: Design and Fabrication

Pixel Matrix:

- 500um² Pixel Pitch, 300um² Pixel Size
- 35 x 35 pixels
- first 3 cols PMOS amplifier others NMOS
- Pixel Comparator Outputs Row/ Column OR wired
- Goal:
  - Pixel Dynamic Range 20keV - 700keV
  - Noise Floor 5 keV (2%@662keV)

ASTROPIX



world's first at ePIC

Take-Away Messages

- The ePIC/EIC Science program will offer fundamental, new insights into QCD and the dynamical generation of hadron structure

- The ePIC Collaboration is strong, active and growing!
  - New member institutions bring new strengths
  - International participation is key to the success of ePIC!
    - International collaborators play key roles in collaboration leadership

- The ePIC Detector Design is progressing
  - Collaboration DSC's are leading the detector efforts
  - Detector R&D efforts transitioning to PED and integration


BACK UP

Formation of ePIC Policies

Latest drafts of Membership and Conference and Talks Policies presentated to Collaboration Council on April 26th.

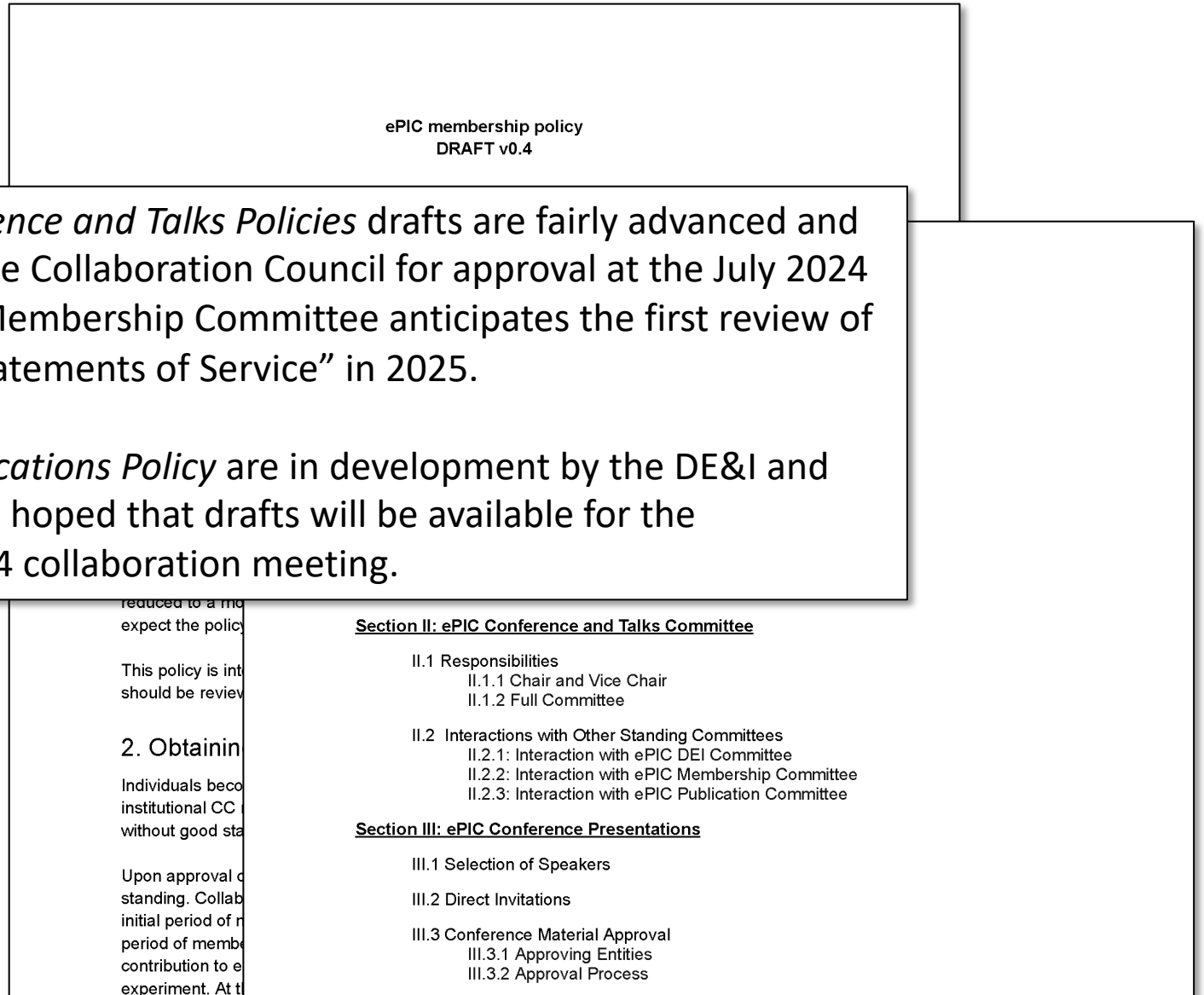
The Membership Policy defines the process by which individuals and
"good standing" – fro

- Individual "good st
  time identifiable c
- Institutional "good
  annual "Statemen
  - Threshold for

The Conference and Talks Policy defines the processes governing the speaker selection, quality assurance, approval, and archiving of conference abstracts and oral and poster presentations delivered at scientific conferences, workshops, etc.

The *Membership* and *Conference and Talks Policies* drafts are fairly advanced and potentially could be put to the Collaboration Council for approval at the July 2024 collaboration meeting. The Membership Committee anticipates the first review of collaboration institutions "Statements of Service" in 2025.

A *Code of Conduct* and *Publications Policy* are in development by the DE&I and Publications committees. It is hoped that drafts will be available for the collaboration by the July 2024 collaboration meeting.



ePIC membership policy
DRAFT v0.4

reduced to a mo
expect the policy

This policy is int
should be reviev

2. Obtainin

Individuals beco
institutional CC
without good sta

Upon approval c
standing. Collab
initial period of n
period of membe
contribution to e
experiment. At t

Section II: ePIC Conference and Talks Committee

II.1 Responsibilities
II.1.1 Chair and Vice Chair
II.1.2 Full Committee

II.2 Interactions with Other Standing Committees
II.2.1: Interaction with ePIC DEI Committee
II.2.2: Interaction with ePIC Membership Committee
II.2.3: Interaction with ePIC Publication Committee

Section III: ePIC Conference Presentations

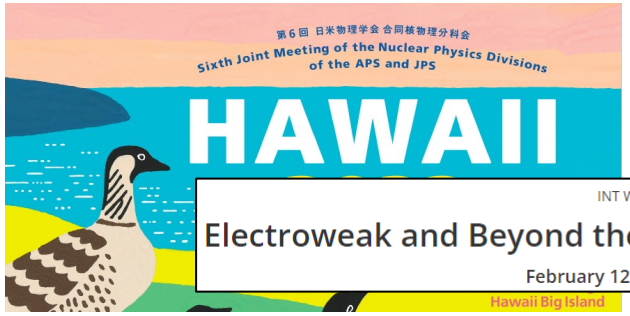
III.1 Selection of Speakers

III.2 Direct Invitations

III.3 Conference Material Approval
III.3.1 Approving Entities
III.3.2 Approval Process

ePIC Conference Presentations

A selection of ePIC presentations at conferences in the past year:



Six contributed talks

EINN2023

Two invited, two contributed

AI4EIC: four talks

6/30/2024

Multiple contributed, posters

Quark Matter 2023

apctp asia pacific center for theoretical physics

2nd APCTP Workshop on the Physics of Electron Ion Collider: ePIC Physics and Detectors

Invited talk

Two invited talks

INT WORKSHOP INT-24-87W

Electroweak and Beyond the Standard Model Physics at the EIC

February 12, 2024 - February 16, 2024

Hawaii Big Island

Forward Physics and QCD at the LHC and the EIC - 798 WE-Heraeus Seminar

invited talk

EPIPHANY 2024: invited talk

HADRON 2023

Invited talk

23rd Zimanyi School Winter Workshop

invited talk

Fourth EIC-A

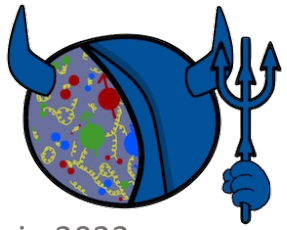
SESAPS 2023: invited talk

Three invited talks

2nd workshop on advancing the understanding of non-perturbative QCD using energy flow

Joint ECFA-NuPECC-APPEC Activity Workshop "Synergies between the EIC and the LHC"

Two invited talks



Spin 2023: two invited talks

MENU 2023

Invited talk

Six contributed talks

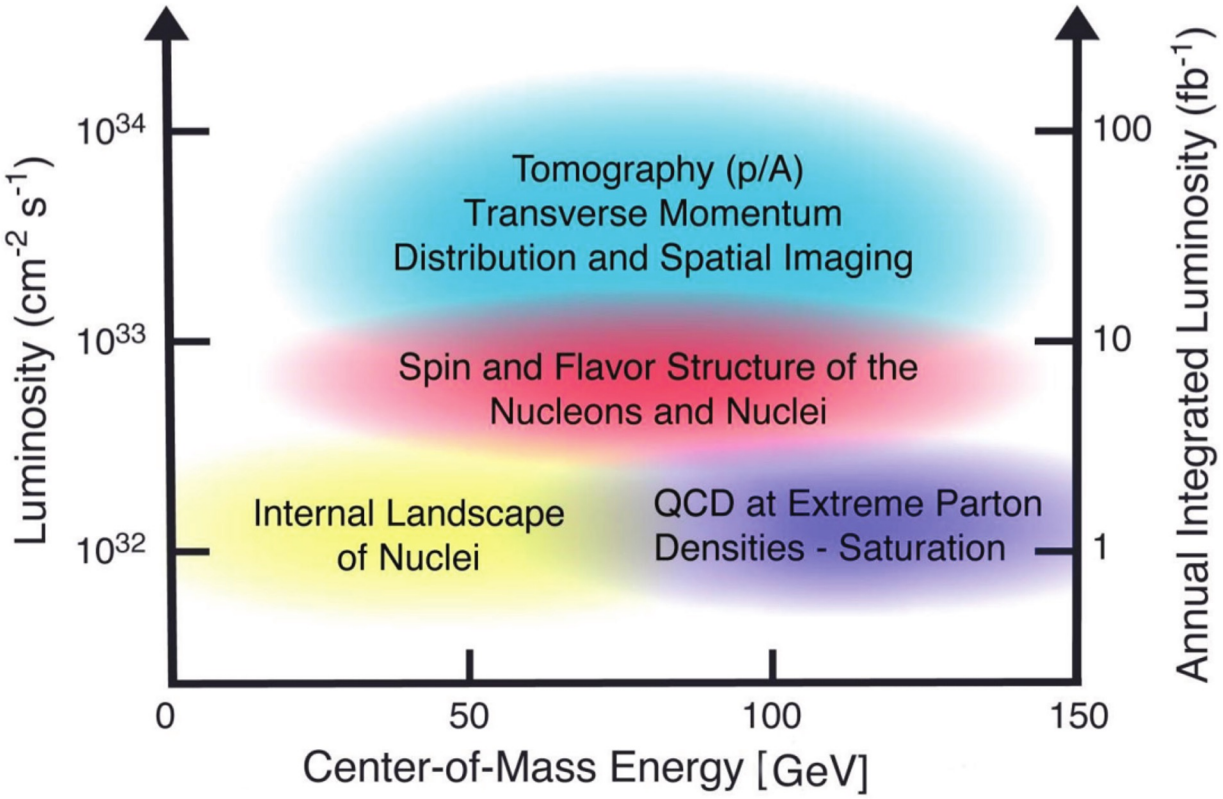
APS The 2023 Fall Meeting of the Division of Nuclear Physics of the American Physical Society and the Physical Society of Japan

Invited talk

Invited talk

UPC 2023: International workshop on the physics of Ultra Peripheral Collisions

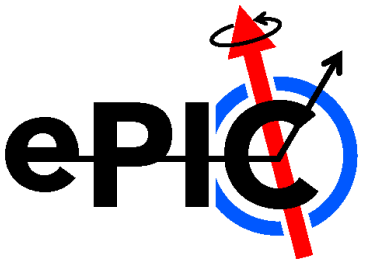
Experimental Access to EIC Physics



Access to EIC Physics through

- Large kinematic coverage
- Polarized electron and hadron beams and unpolarized nuclear beams with high luminosities
- Detector setup fulfilling specific requirements of the polarized e-p/A collider

ePIC Resources



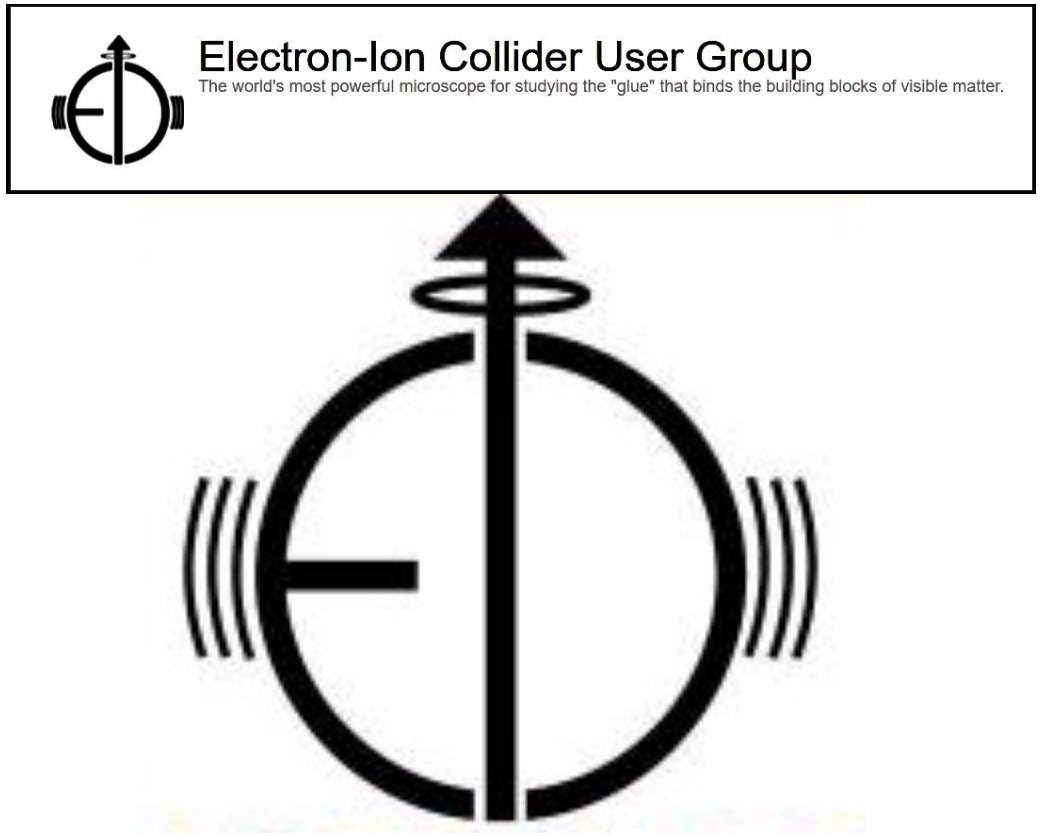
- Public Website - https://www.bnl.gov/eic/epic.php
- Mailing Lists – https://lists.bnl.gov/mailman/listinfo
- Indico Agenda - https://indico.bnl.gov/category/402/
  - ePIC Software and Computing: https://indico.bnl.gov/category/435/
- Wiki - https://wiki.bnl.gov/EPIC
- ePIC Software Training:
  - Landing Page: https://eic.github.io/documentation/landingpage.html
  - Tutorials: https://eic.github.io/documentation/tutorials.html
- Mattermost: https://chat.epic-eic.org
- ePIC Zenodo Community: https://zenodo.org/communities/epic

EICUG Membership

- The EICUG is a vital organization to promote the interests of the EIC community!
  - Without the EICUG we would never have gotten far enough to form ePIC!

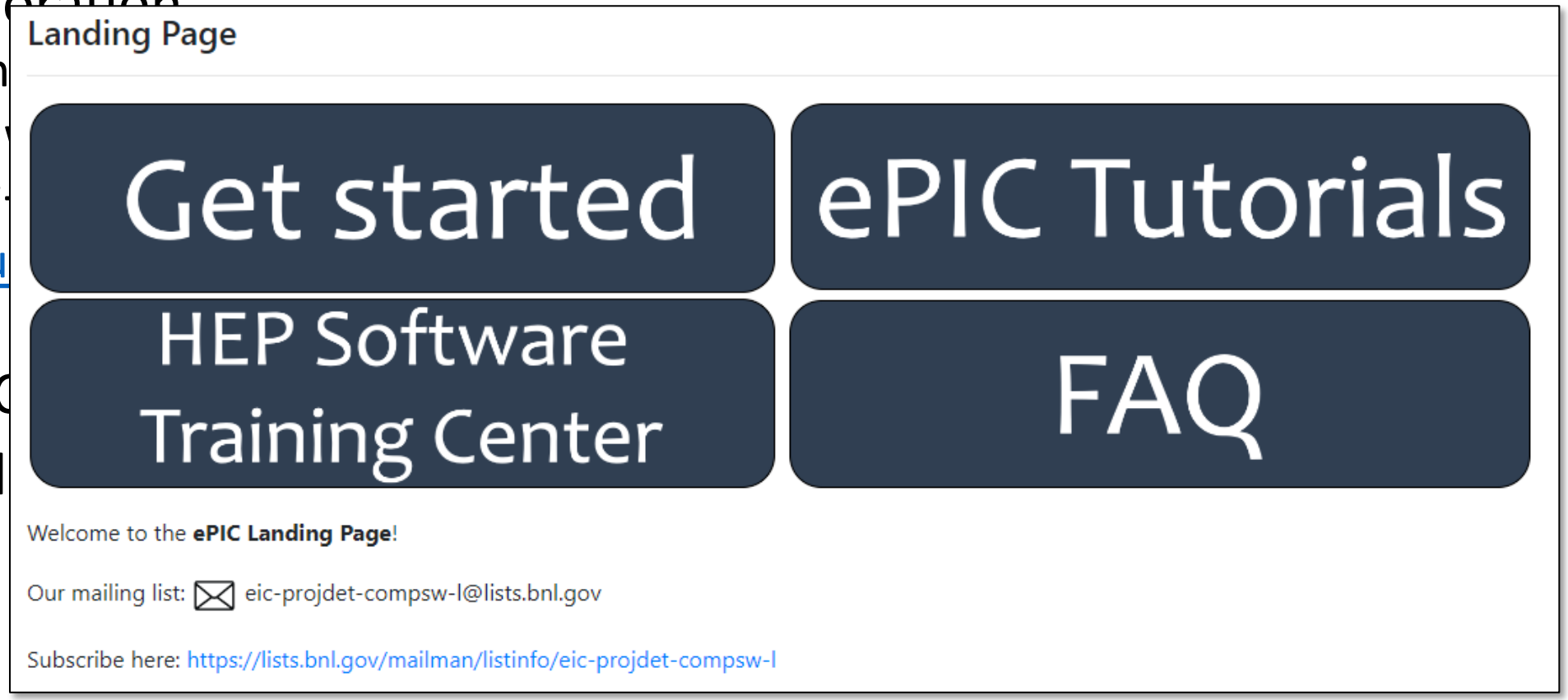
- Please register your institution!
- Check with your EICUG IB representative to get registered as a member

- https://www.eicug.org/content/join.html

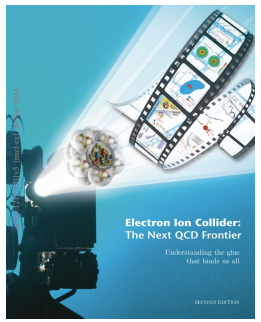


Broadening Engagement in ePIC

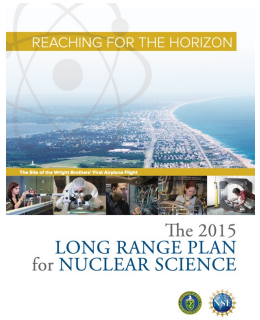
- The ePIC collaboration must be a welcoming environment for people to pursue their science
- Established procedures to welcome new institutions and integrate them into the collaboration
  - Meeting with
- User Learning
  onboarding wi
  (https://eic.githu
- Well-attended
  Software and C
- AC's organized
- …



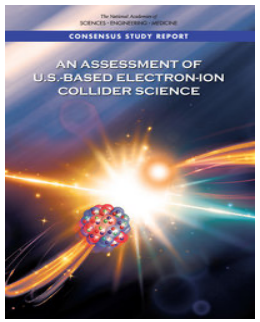
Detector Design Process Timeline



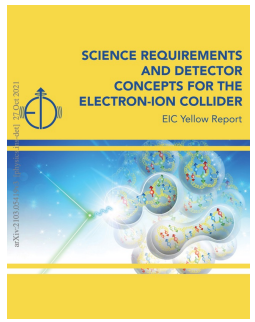
2012



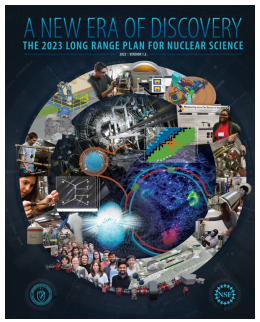
2015



2018



2020



2023

Detector and machine design parameters driven by physics objectives

- Call for proposals issued jointly by BNL and JLab in **March 2021** (Due Dec 2021)
  - ATHENA, CORE and ECCE proposals submitted
- DPAP review **Dec 2021 – Jan 2022**, closeout **March 2022**
  - ECCE proposal chosen as basis for first EIC detector reference design
- **Spring/Summer 2022** – ATHENA and ECCE form joint leadership team
  - Joint WG's formed and consolidation process undertaken
  - Coordination with EIC project on development of technical design
- Collaboration formation process started **July 2022**
- Charter ratified & elected ePIC Leadership Team **February 2023**
- **EIC/ePIC endorsed as highest priority for new facility construction in 2023 LRP.**
- **Working towards TDR and CD-3A (review Nov. 2023) and CD-2/3 (2025)**