

EIC Detectors

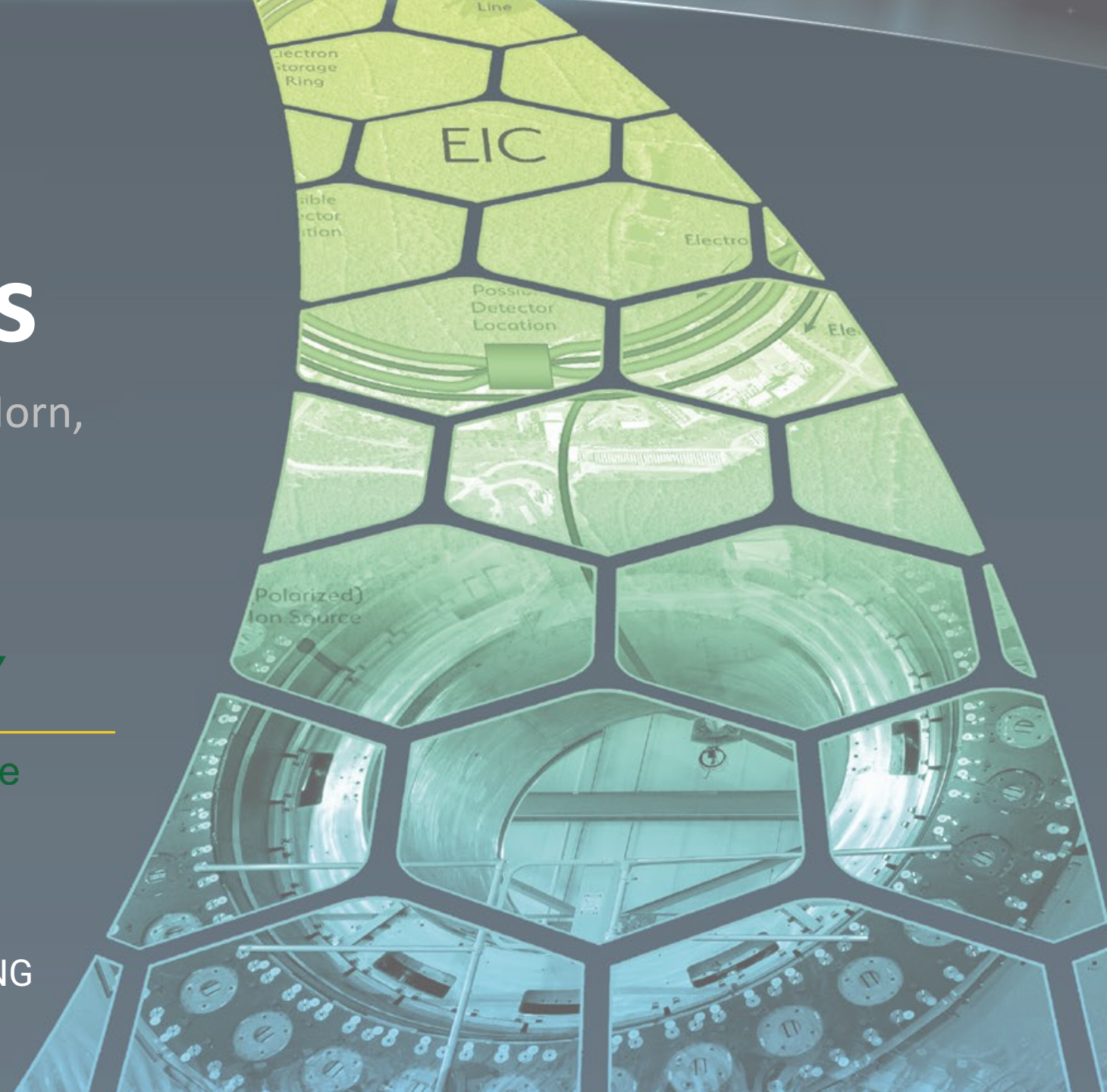
Silvia Dalla Torre, Or Hen, Tanja Horn,
John Lajoie, Bernd Surov



U.S. DEPARTMENT OF
ENERGY

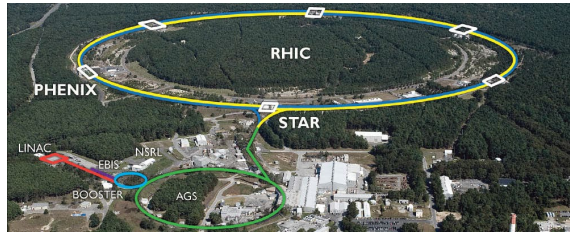
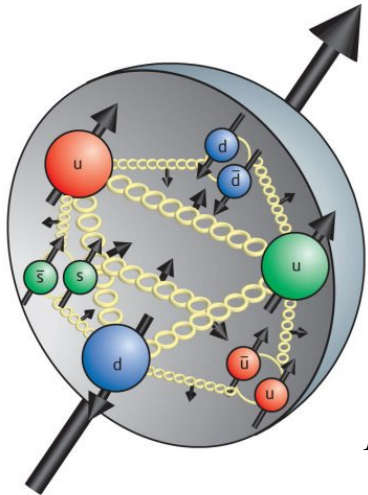
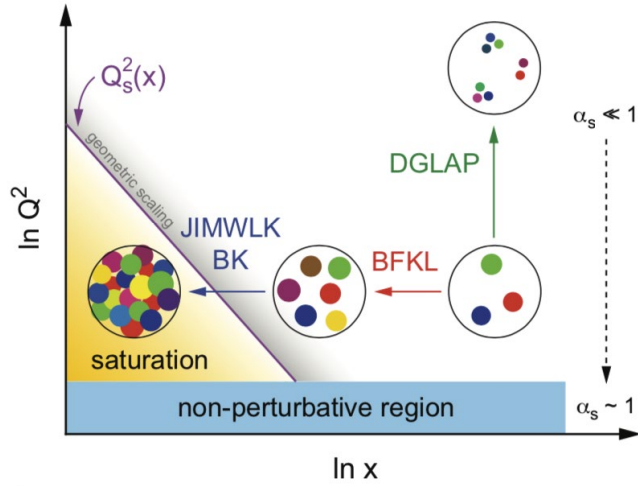
Office of Science

2022 RHIC/AGS ANNUAL USERS' MEETING



The Big Picture *from* RHIC to the EIC...

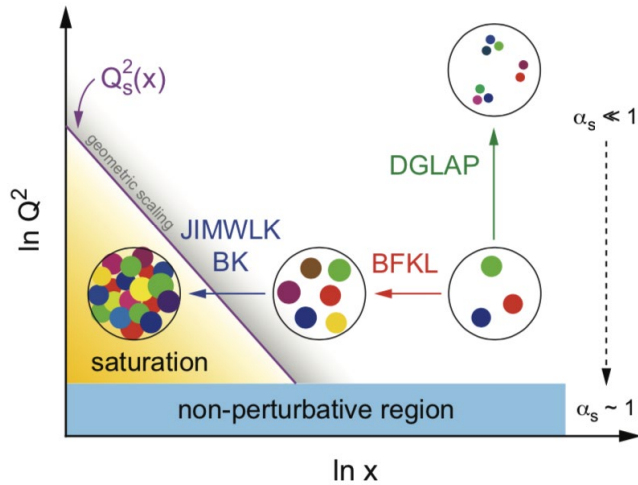
$p(A)+A$ Collisions



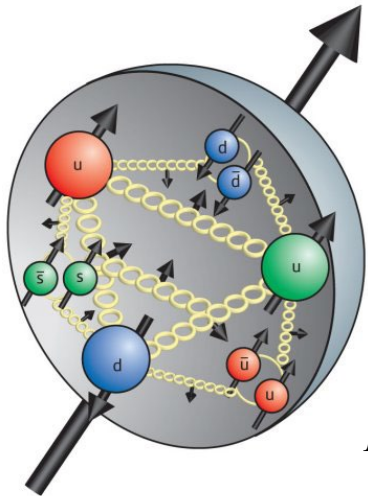
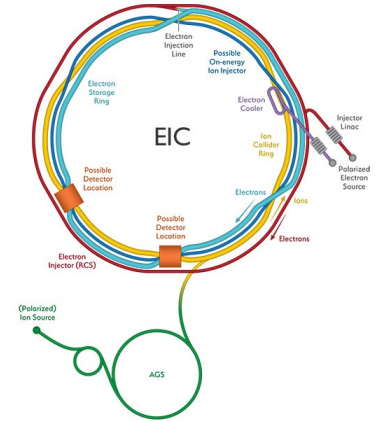
$p \uparrow + p \uparrow$ Collisions

The Big Picture *from* RHIC to the EIC...

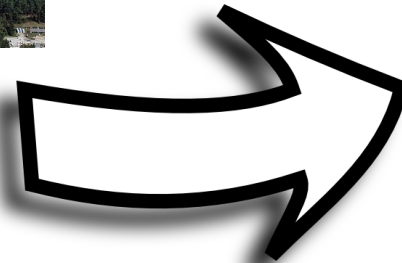
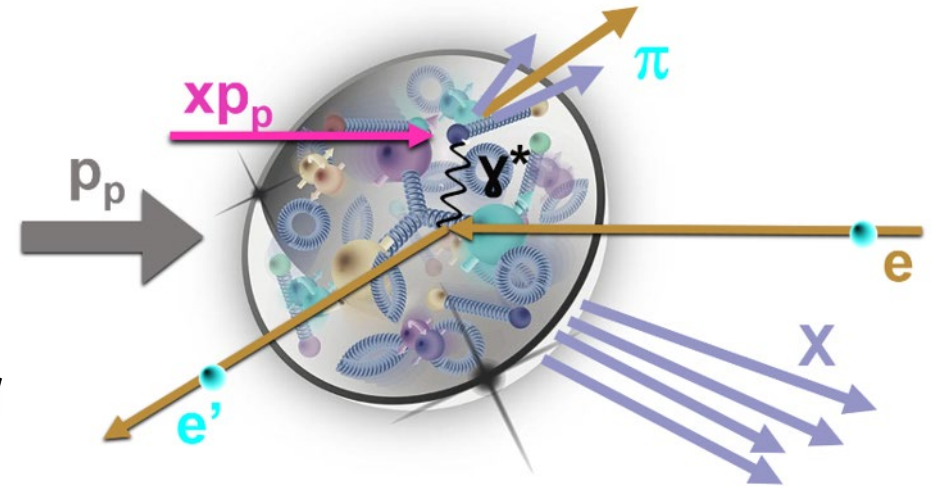
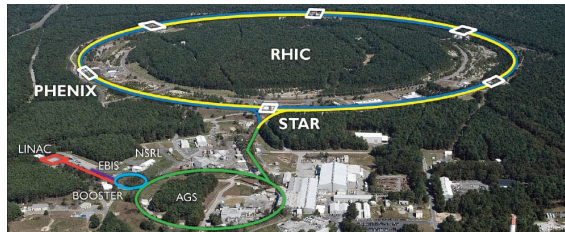
$p(A)+A$ Collisions



How do collective, many-body phenomena arise from first-principles QCD?

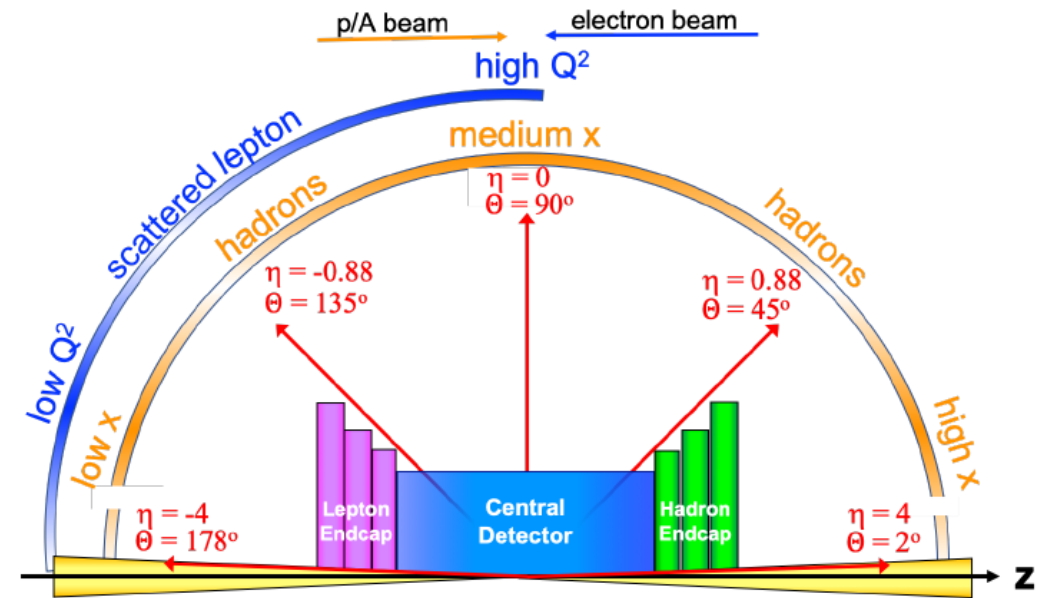


$p \uparrow + p \uparrow$ Collisions



EIC Detectors


- Detector-1 (EIC Project 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
 - DPAP proposal process
 - Working towards pre-TDR/CD-2
- Detector-2
 - To be sited at IP8 (35mr crossing angle, secondary focus)
 - Requires development of 2nd IR
 - Physics program complementary to Detector-1
 - Ready 2-5 years after Detector-1
 - Development activity at the WG level



Call for Proposals and DPAP

- Issued jointly by BNL and JLab in March 2021
- Proposals due Dec. 1, 2021
- 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



**Call for Collaboration Proposals
for Detectors at the Electron-Ion Collider**

Brookhaven National Laboratory (BNL) and the Thomas Jefferson National Accelerator Facility (JLab) are pleased to announce the Call for Collaboration Proposals for Detectors to be located at the Electron-Ion Collider (EIC). The EIC will have the capacity to host two interaction regions, each with a corresponding detector. It is expected that each of these two detectors would be represented by a Collaboration.

Detector 1 is within the scope of the EIC project and should be based on the "reference" detector described by the EIC User Group (EICUG) in the Yellow Report (YR) and included in the EIC Conceptual Design Report (CDR). This detector must satisfy the requirements of the EIC "mission need" statement based on the EIC community White Paper and the National Academies of Science (NAS) 2018 report. US Federal funds are expected to support most but not all of the acquisition of Detector 1. It is currently planned to be located at Interaction Point 6 (IP6) on the Relativistic Heavy-Ion Collider.

Detector 2 could be a complementary detector that may focus on optimizing particular science topics or address science topics beyond those described in the White Paper and the National Academies of Science (NAS) 2018 report. Detector 2 would reside at a different Interaction Point from Detector 1 and is currently not within the EIC project scope. Routes to make Detector 2 and a second interaction region possible are being explored.

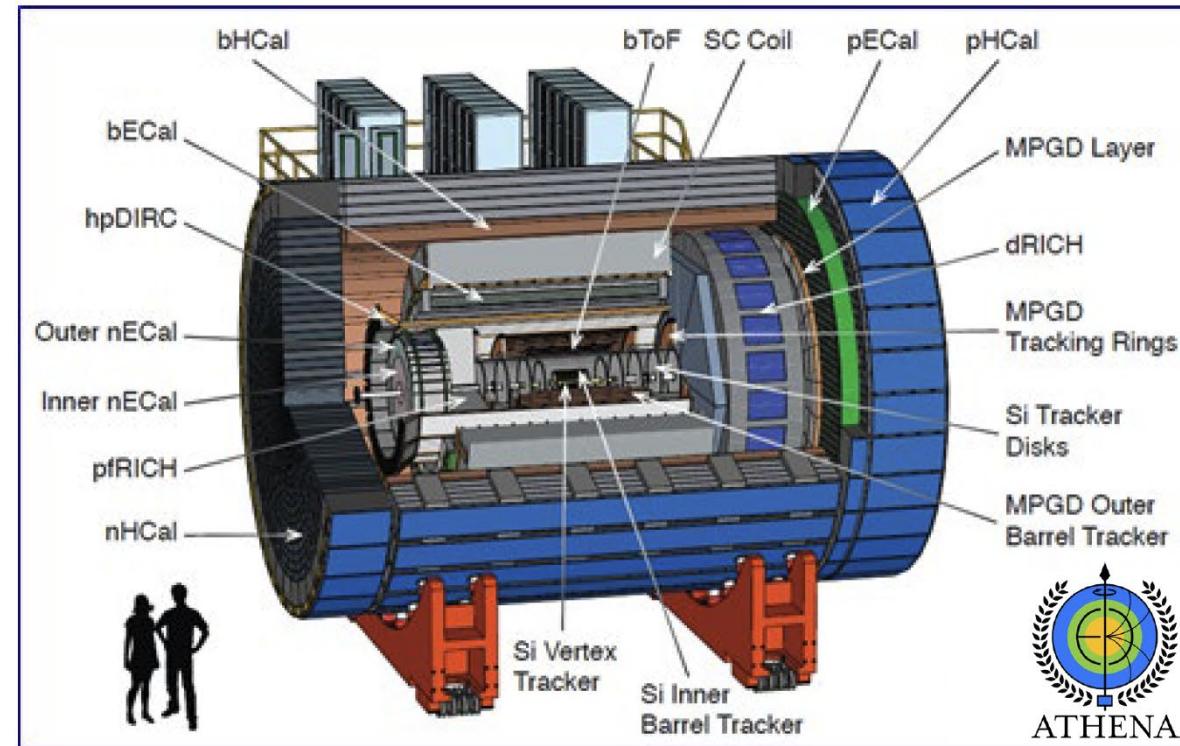
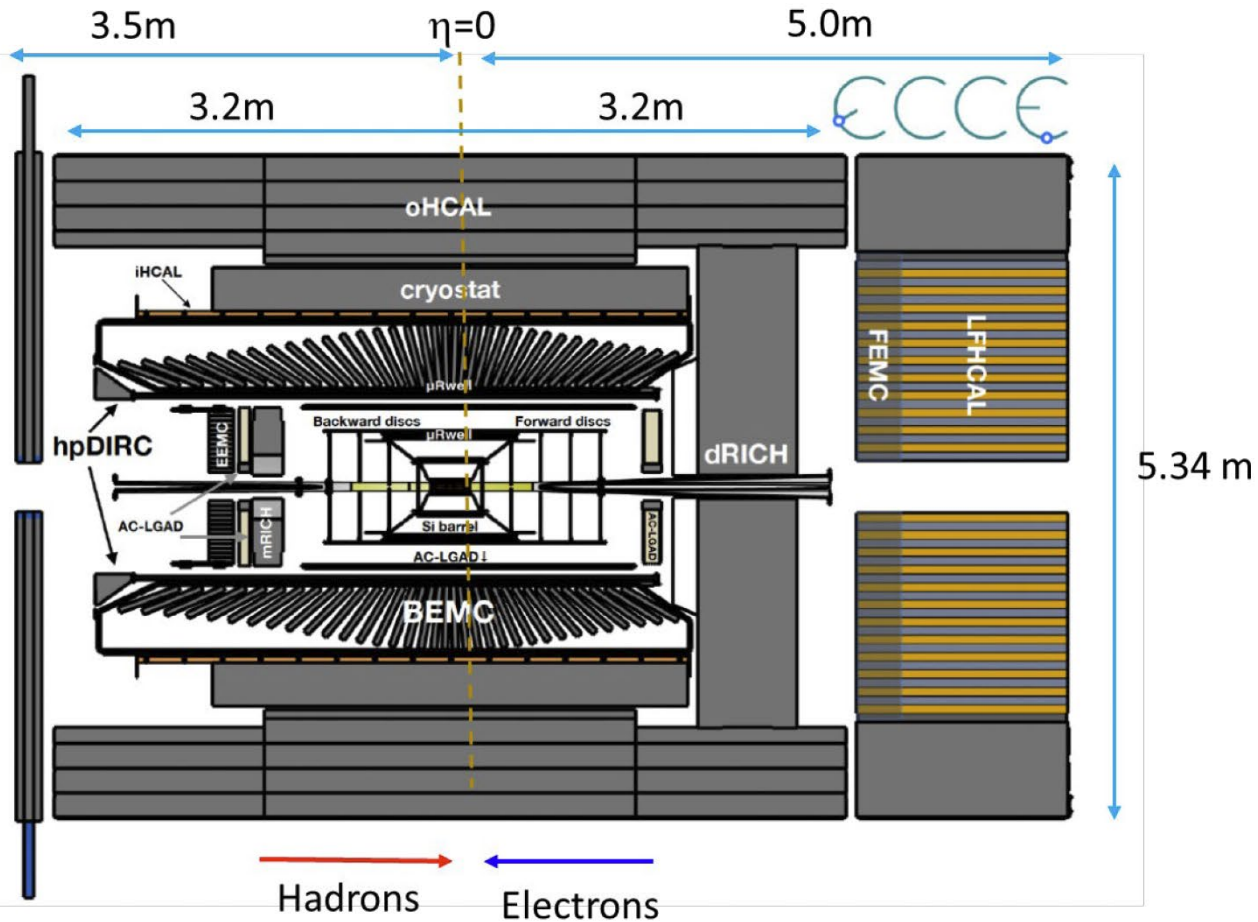
Collaboration proposals made in response to this call could relate to either Detector 1 or Detector 2. Proposals should consider the siting scenario for the detectors described in the CDR. Other options are welcome but proposals that deviate from the CDR will need to address the implications to the EIC project. For reference, proposals should utilize information in the CDR, EICUG YR, and the posted Expressions of Interest as background information. References are listed below.

The separate guidance for each detector is as follows:

- **Detector 1 Collaboration Proposals:** Experiments must address the EIC White Paper and NAS Report science case. The collaboration should propose a system that meets the performance requirements described in the EIC CDR and EICUG YR. The design should be compatible with that of the accelerator and interaction region layout of the CDR. Completion of detector construction must be achieved by Critical Decision (CD)-4A, the start of EIC accelerator operations.

ECCE and ATHENA

See talk by Rolf Ent (Tuesday)



Key conceptual differences – bore size and magnetic field!

DPAP Outcome

- The final DPAP [report](#) was released on March 21, 2022. Based on the DPAP recommendations, the EIC project has confirmed that the ECCE detector design will serve as the reference in developing a technical design for CD-2/3a:

*“The EIC Project recognizes that the panel recommended ECCE as the Project Detector. As described in the panel report, we will urge the proto-collaboration to: (1) **integrate new collaborators** in a manner that enables them to make contributions that impact the capabilities and success of the experiment in significant ways, including new collaborating individuals and groups into positions of responsibility and leadership; and (2) **integrate new experimental concepts** and technologies that improve physics capabilities without introducing inappropriate risk. **ECCE is the reference design for this optimization and consolidation so that the Project Detector can advance to CD2/3a in a timely way**”* – email communication from the EIC Project Team on 13 March 2022.

- From the DPAP report: “...none of the three proto-collaborations is yet large enough or strong enough for successful development of a detector for Day 1 of the EIC”.

DPAP Outcome

- The final recommendations will serve as a

“The ECCE and ATHENA proto-collaborations have come together to chart the path forward to a new scientific collaboration and a technical design of the EIC Project Detector:

- From the **or strong**

The ECCE and ATHENA proto-collaborations have come together to chart the path forward to a new scientific collaboration and a technical design of the EIC Project Detector:

- Interim SC formed from proto-collaboration leadership
- Formed joint working groups
- Organizing detector consolidation, evolution to an *advanced conceptual design* this summer
- Working towards collaboration formation meeting at end of July (coincident with EICUG summer meeting), preparatory work ongoing

design will

*described in
manner
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Joint Detector-1 Working Groups

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Miguel Arratia miguela@ucr.edu
Brian Page bpage@bnl.gov

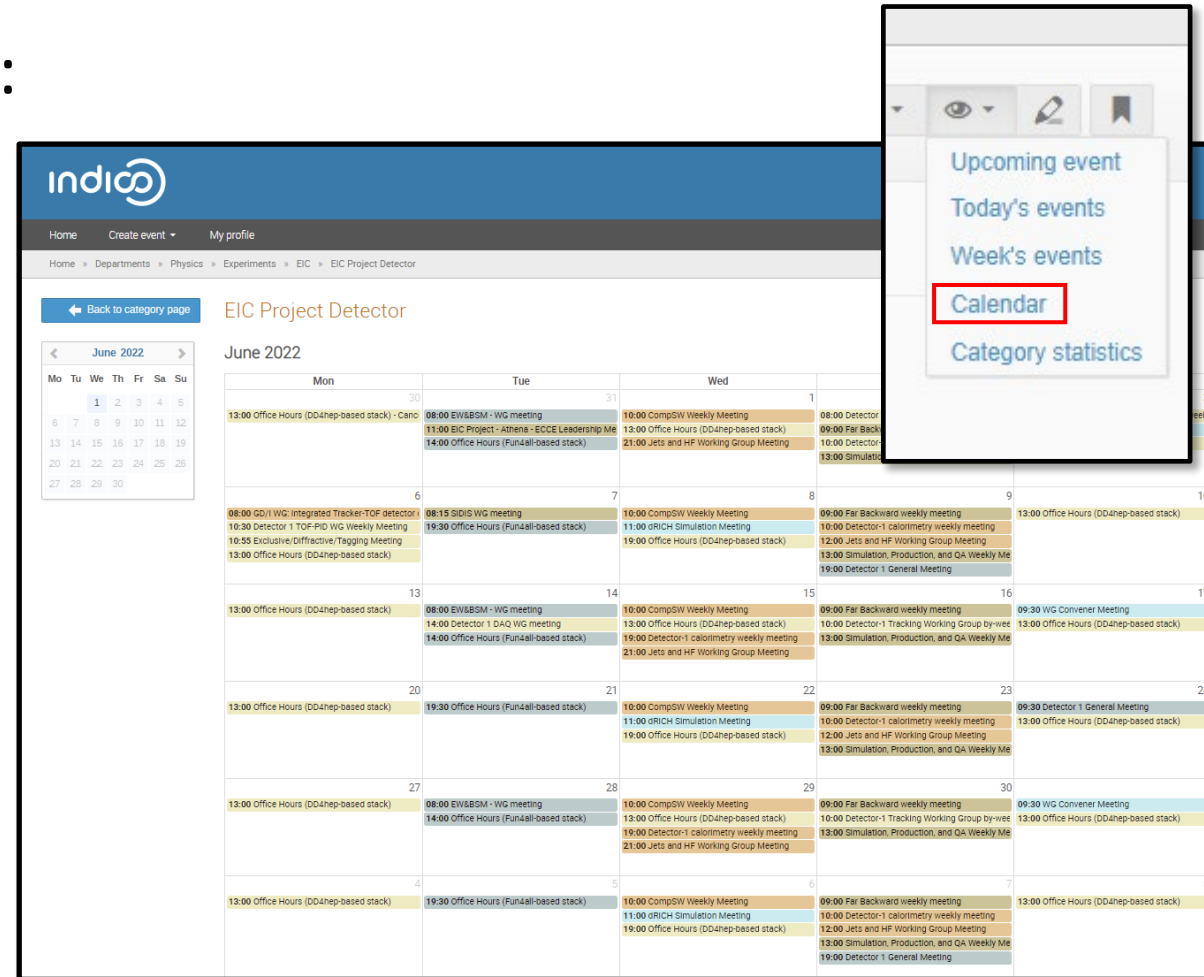
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Ciprian Gal ciprian@jlab.org

Detector-1 Resources

- New Indico section for Detector-1 WG's:
 - <https://indico.bnl.gov/category/402/>
- New mailing lists (lists.bnl.gov)

Indico calendar for all Detector-1 meetings can be connected to your calendar (View->Calendar)



eic-projdet-SimQA-l@lists.bnl.gov
eic-projdet-FarBack-l@lists.bnl.gov
eic-projdet-daq-l@lists.bnl.gov
eic-projdet-FarForw-l@lists.bnl.gov
eic-projdet-CompSW-l@lists.bnl.gov
eic-projdet-Inclusive-l@lists.bnl.gov
eic-projdet-JetHF-l@lists.bnl.gov
eic-projdet-GlobalInt-l@lists.bnl.gov

eic-projdet-TOFPID-l@lists.bnl.gov
eic-projdet-calo-l@lists.bnl.gov
eic-projdet-ExclDiff-l@lists.bnl.gov
eic-projdet-SemiIncl-l@lists.bnl.gov
eic-projdet-BSMEW-l@lists.bnl.gov
eic-projdet-CPID-l@lists.bnl.gov
eic-projdet-tracking-l@lists.bnl.gov

- Additional Collaboration resources available:
 - [Wiki](#), Mattermost, etc.

Detector-1 Institutional Survey

- This survey is geared towards collecting institutional information for planning purposes of the EIC Detector 1 effort. The form should be completed by each institution only once. The survey collects institutional information for both existing and new institutions. The survey is separated into several sections:
 - General Institutional Information (Institutional representative, Name, Address, Size of research group by category, Consortia Membership) - **this is all we need to start!**
 - Consortia Information (Size of the research group involved in consortia)
 - Physics and Sub-system Interest
 - Resources and Infrastructure (Lab/Computing/Machine shop)
 - Comment and Feedback
- Link to survey [here](#).

EIC Detector-1 Institutional Survey Form

This survey is geared towards collecting institutional information for planning purposes of the EIC Detector 1 effort. The form should be completed by each institution. Please consult with your institutional representative to collect the requested information. The survey will collect institutional information for both existing and new institutions. The survey is separated into several sections:

(A) General Institutional Information (Institutional representative, Name, Address, Size of research group by category, Consortia Membership)

(B) Consortia Information (Size of research group involved in consortia)

(C) Physics and Sub-system Interest

(D) Resources and Infrastructure (Lab/Computing/Machine shop)

(E) Comment and Feedback

Note: Labor estimates (Size of research group) should be estimated in units of Full-Time Employees (FTE) per year for the following labor categories, assuming the guidelines below for yearly fractional FTE efforts:

- # Annual FTE Faculty: Max. 0.25

- # Annual FTE Scientific Staff / Research Professor: Max. 0.5

- # Annual FTE Postdocs: 1.0

- # Annual FTE Graduate students: Max. 0.75

- # Annual FTE Undergraduate students: Max. 0.2

- # Annual FTE Mechanical Engineers: Max. 0.8

- # Annual FTE Electrical Engineers Max. 0.8

- # Annual FTE Mechanical Technicians/Designers: Max. 0.8

- # Annual FTE Electrical Technicians/Designers: Max. 0.8

Example: If your institution has two faculty members and you assume a yearly fractional FTE effort of 0.2 each, then 0.4 should be entered for # Annual FTE Faculty at the appropriate sections of this survey.

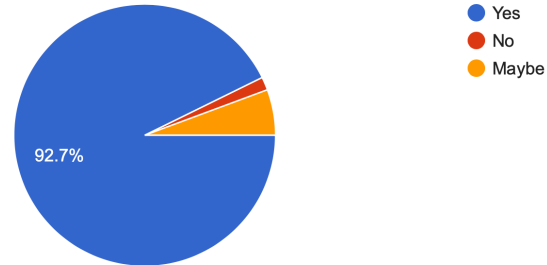
We suggest that you do your best in answering all FTE-related questions. If you cannot, please submit the urgently needed "General Institutional Information" questions first and complete the FTE-related questions at a later stage.

Detecto

Some early results....

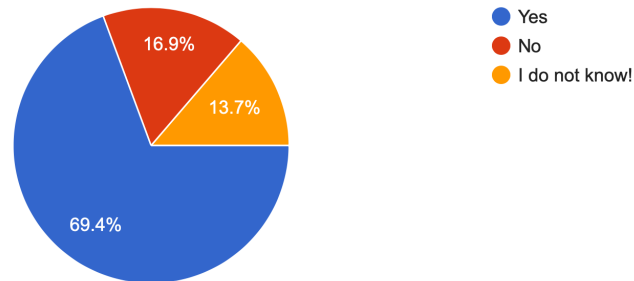
Please confirm that your institution is interested to join the EIC Detector 1 effort:

124 responses



Did your institution participate in the Expression-of-Interest survey in 2019 (<https://www.bnl.gov/eic/eoi-faq.php>)?

124 responses



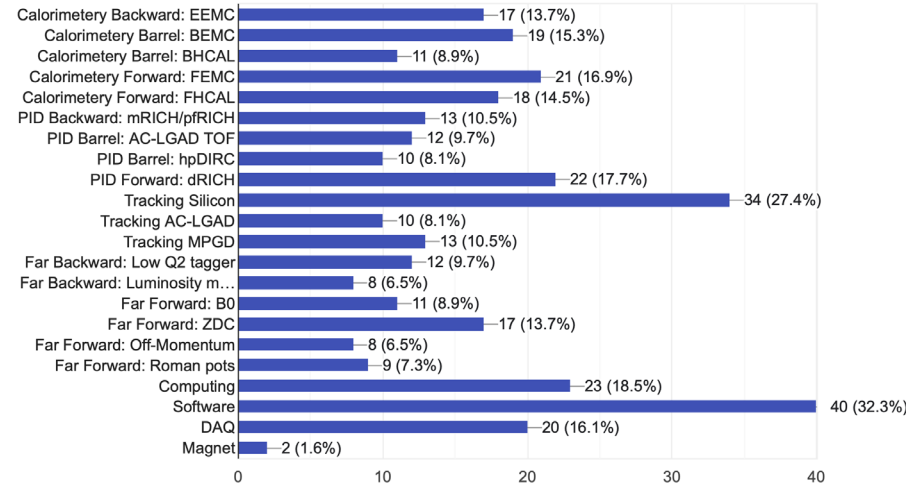
124 responses!

13 "new" institutions that were not a part of an EIC proposal!

Please provide your institutional sub-system interests to actively participate in a Detector 1

sub-system:

124 responses



Survey Form

for planning purposes of an institution. Please consult the survey form for more information. The survey will be available in several locations. The survey is

Name, Address, Size of

consortia)

p)

ated in units of Full-Time Faculty assuming the guidelines below

assume a yearly fractional FTE Faculty at the

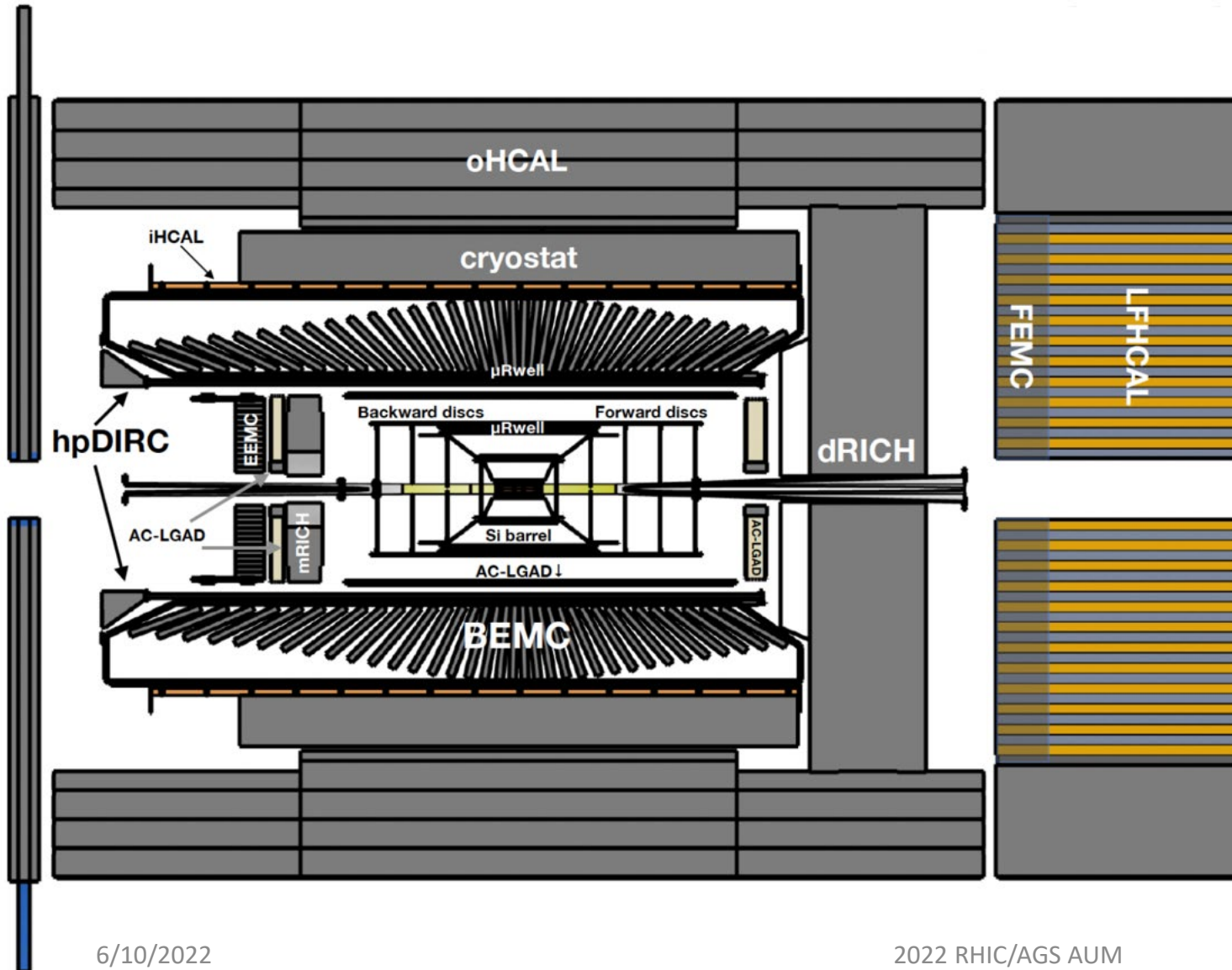
questions. If you cannot, please answer "preference" questions first and

- This survey is for information purposes only. The form will be used only once. The information will be separated into

- General Information (Name, Address, Membership)
- Consortia (Name, Address, Size of consortia)
- Physics and Detector Interests
- Resources
- Comments

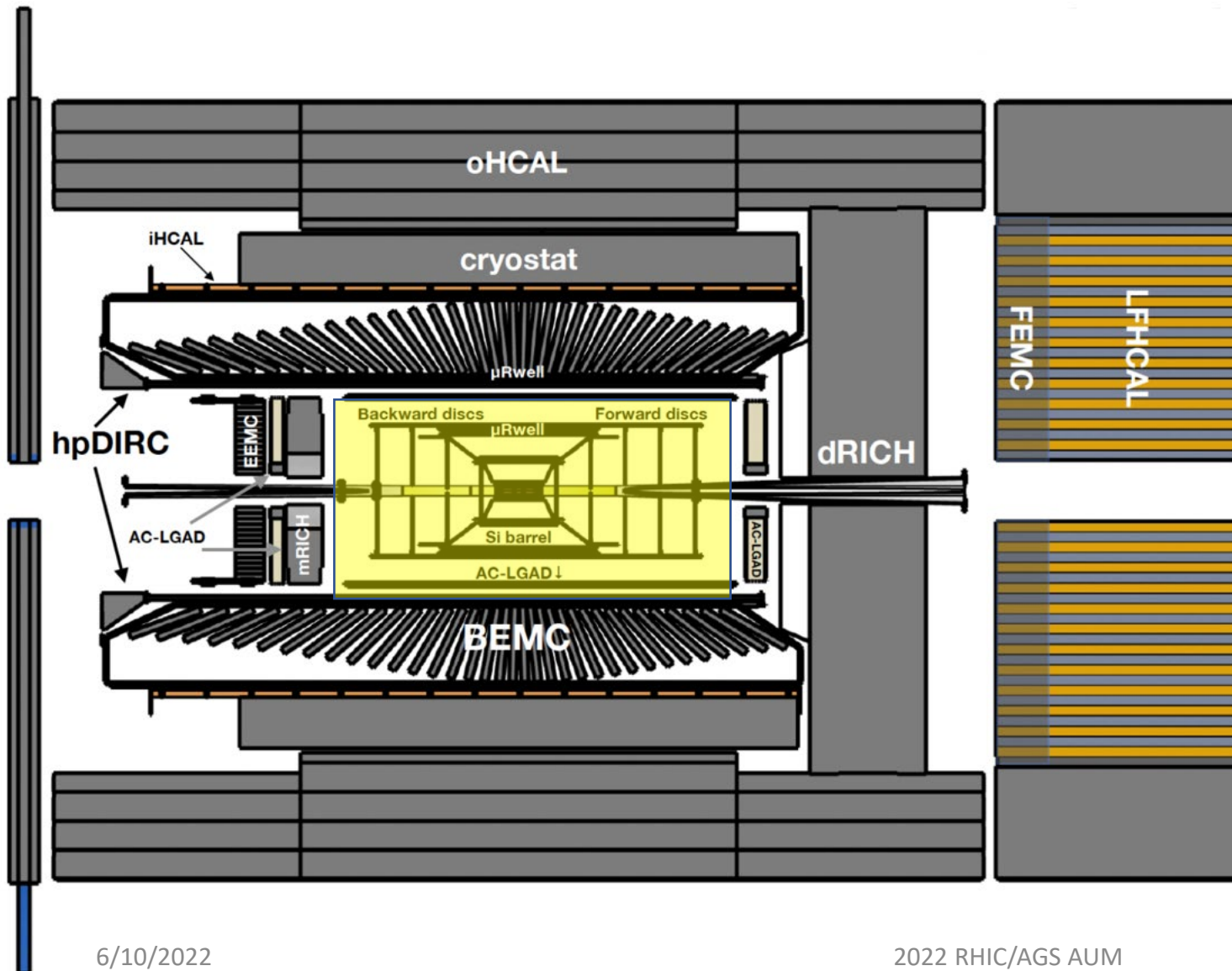
- Link to survey

Detector-1 Reference Design (Current)



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Wed. EIC Detector
Session:



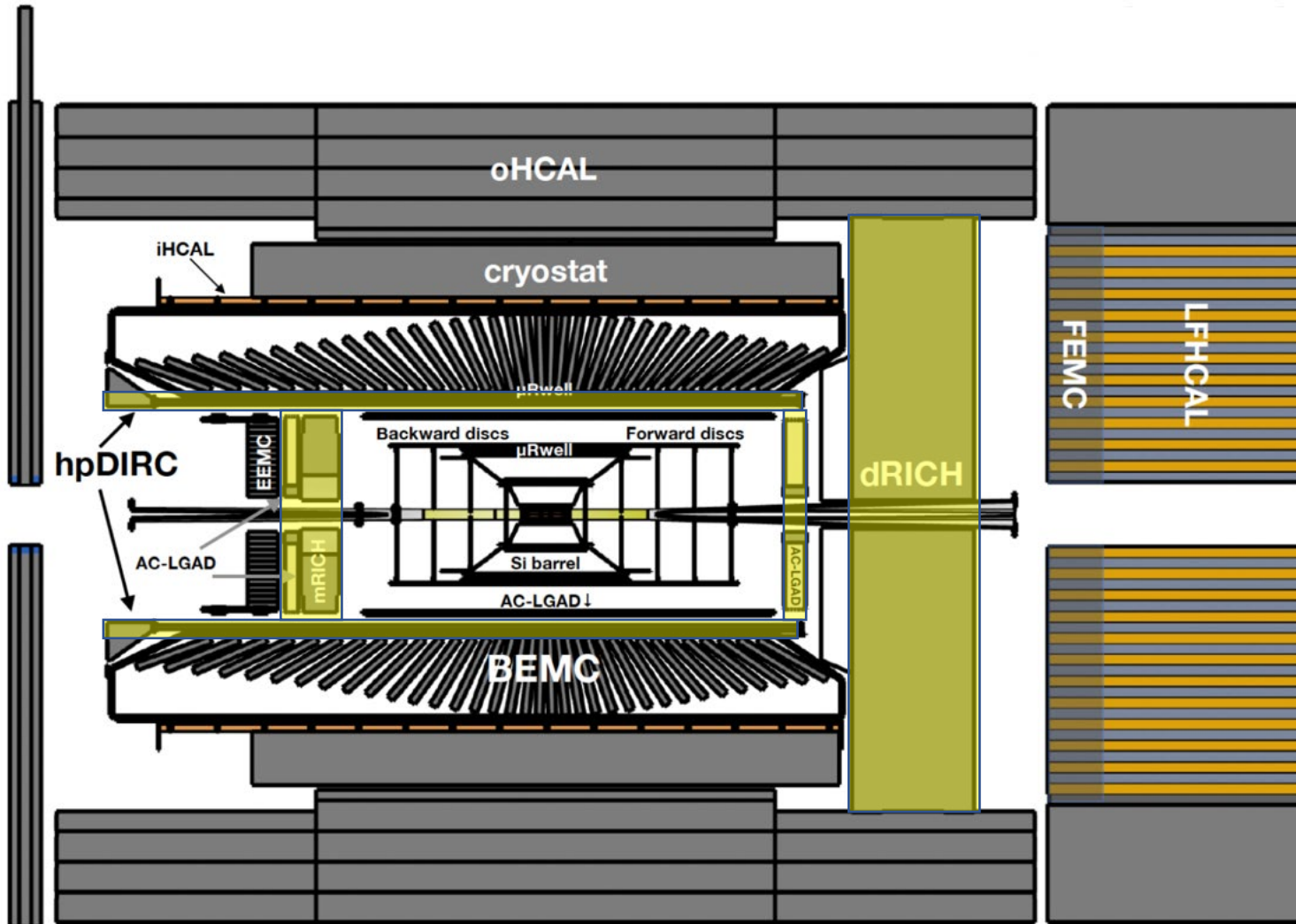
Tracking:

- Si MAPS (65nm)
- AC-LGAD
- μ RWELL

Xuan Li
Zhenyu Ye
Sourav Tarafdar
Nicola Apadula

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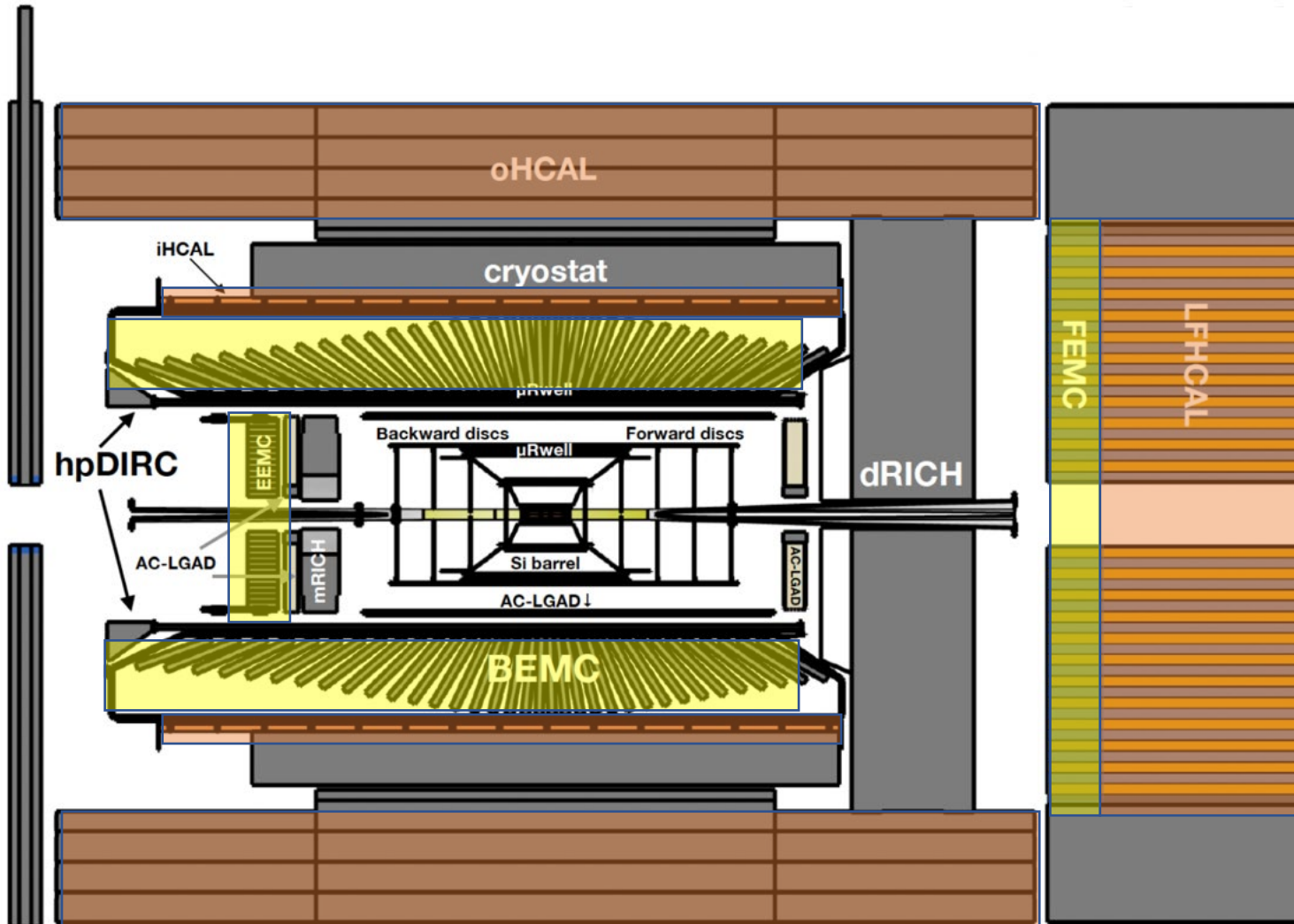
PID:

- hp-DIRC
- mRICH
- dRICH
- AC-LGAD (~30ps TOF)

Greg Kalicy
Deepali Sharma
Marco Contalbrigo

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Calorimetry:

- SciGlass Barrel EMCal
- PbWO EEEMCal
- Longitudinally separated EM+Hcal
- Inner HCal (instrumented frame)
- Outer HCal (sPHENIX re-use)

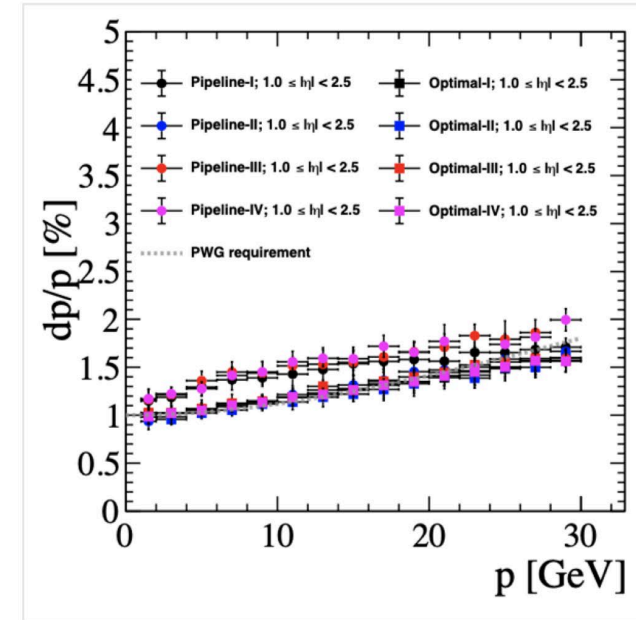
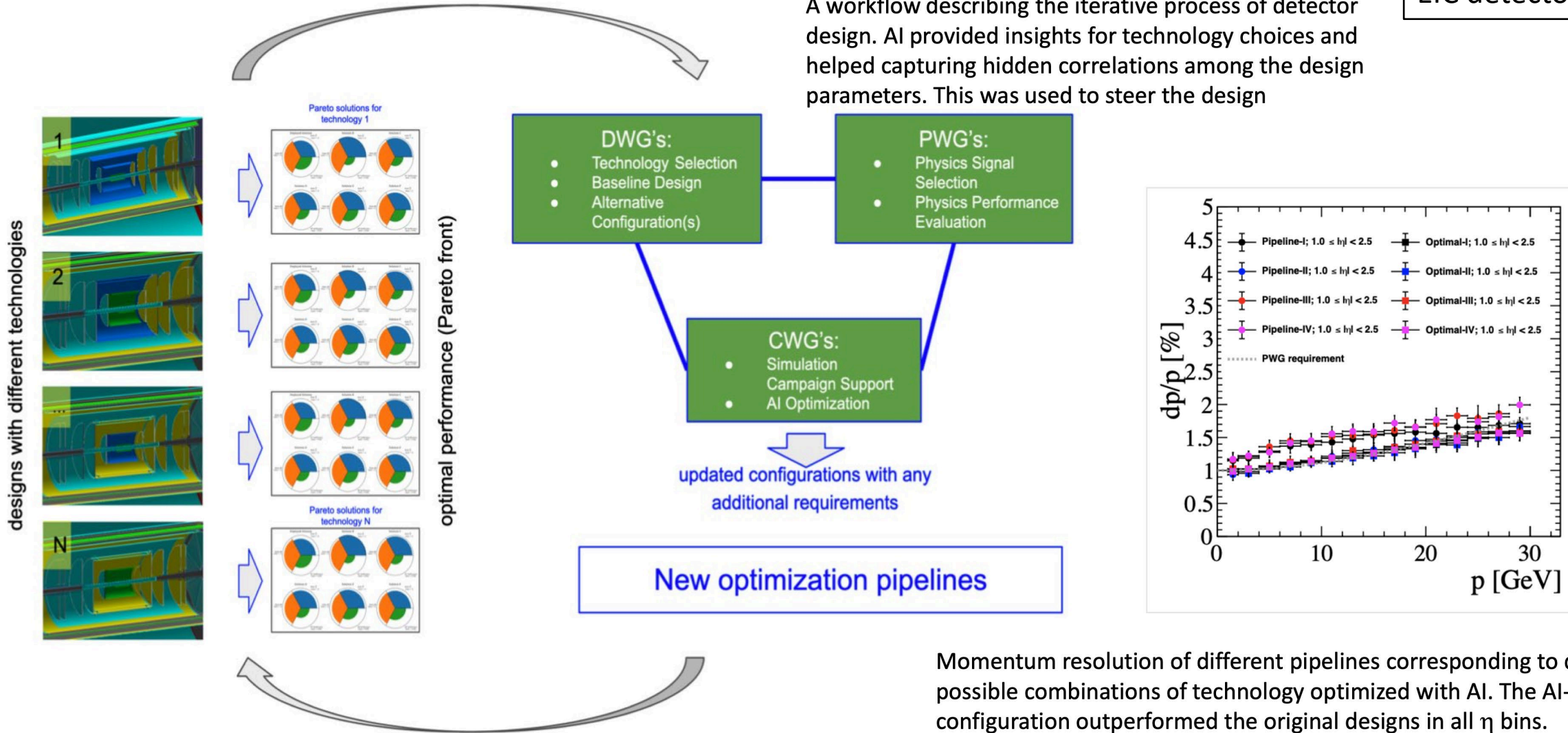
Maria Zurek
Tanja Horn

See “Accelerating RHIC Science with Machine Learning” (Tues)

AI Assisted Detector Design

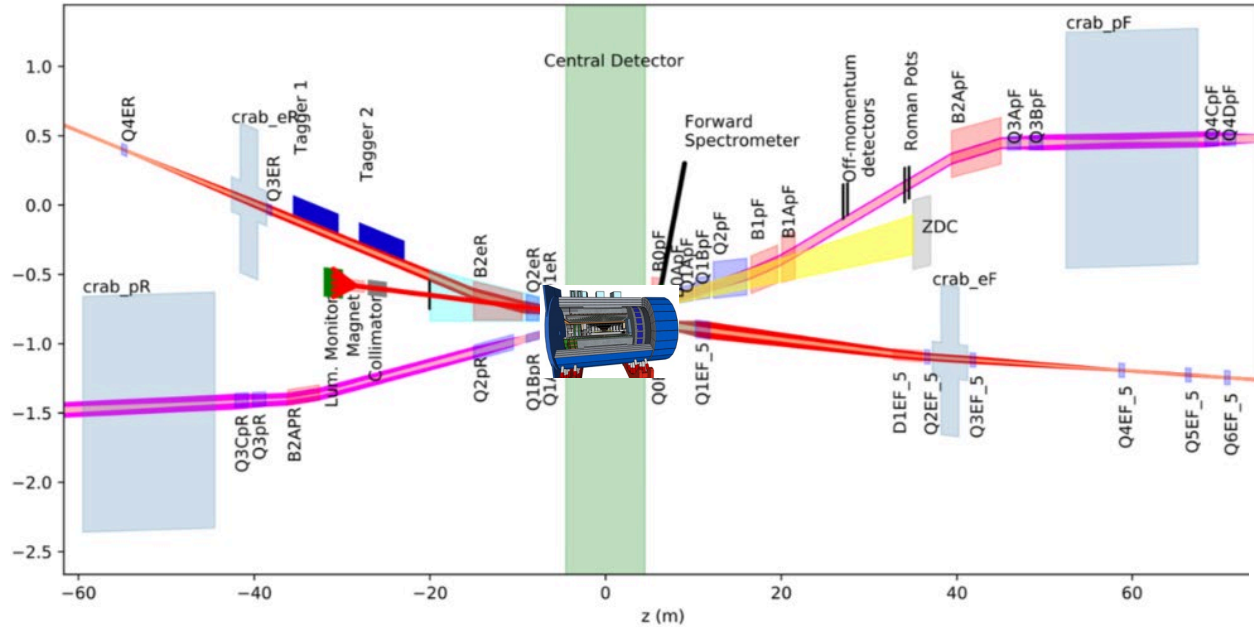
AI is a key part of EIC detector design!

A workflow describing the iterative process of detector design. AI provided insights for technology choices and helped capturing hidden correlations among the design parameters. This was used to steer the design



Momentum resolution of different pipelines corresponding to different possible combinations of technology optimized with AI. The AI-optimized configuration outperformed the original designs in all η bins.

Far-Forward / Backward Instrumentation



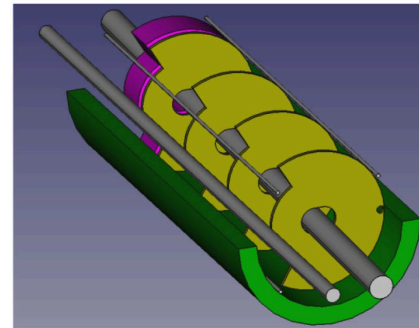
EIC detectors are highly integrated with the accelerator – extensive cooperation required to achieve science goals!

Far-Forward Instrumentation

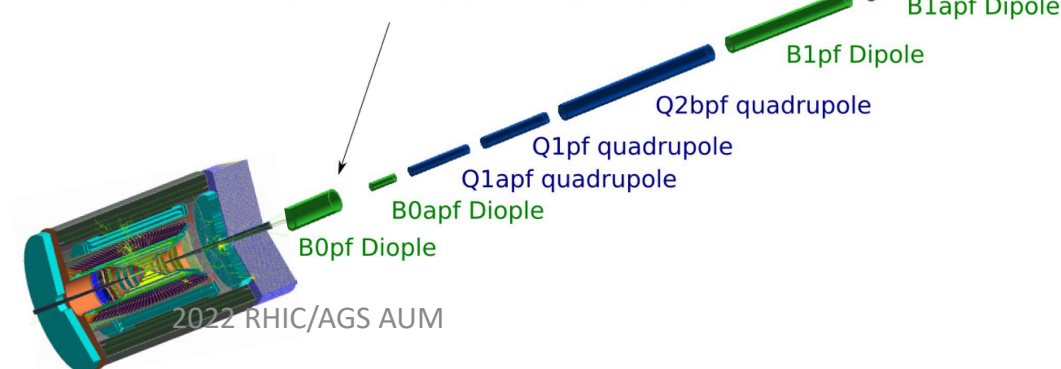
See talk by Alex Jentsch (Wed)

Far-Backwards

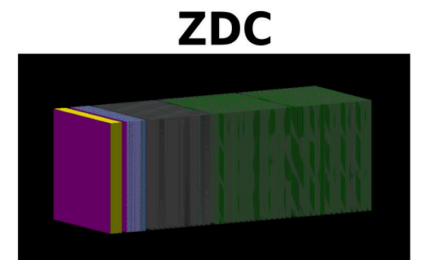
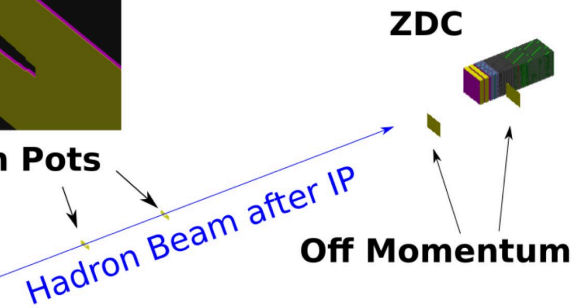
- Low- Q^2 tagger
- Luminosity monitor



B0 Trackers + Calorimeter



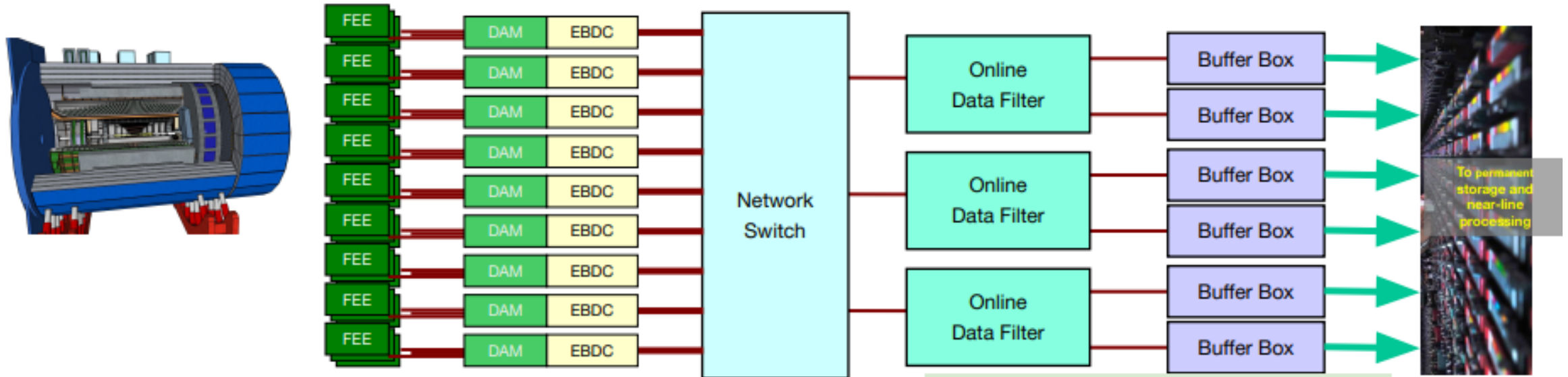
Roman Pots



ZDC

Streaming DAQ

See talk from Jeff Landgraf (Wednesday)



- No External trigger
- All collision data digitized but aggressively zero suppressed at FEE
- Low / zero deadtime
- Event selection can be based upon full data from all detectors (in real time, or later)
- Collision data flow is independent and unidirectional-> no global latency requirements
- Avoiding hardware trigger avoids complex custom hardware and firmware
- The “Front End Processing”, programmable hardware between the FEEs and the DAQ computers, is deemphasized relative to the yellow report, but should not be precluded.
- Data volume is reduced as much as possible at each stage

FEE = Front End Electronics
DAM = Data Aggregation Module
EBDC = Event Buffer / Data Compressor

Reference Detector Consolidation

- Return to the guidance from the EIC project:

*“The EIC Project recognizes that the panel recommended ECCE as the Project Detector. As described in the panel report, we will urge the proto-collaboration to: (1) **integrate new collaborators** in a manner that enables them to make contributions that impact the capabilities and success of the experiment in significant ways, including new collaborating individuals and groups into positions of responsibility and leadership; and (2) **integrate new experimental concepts** and technologies that improve physics capabilities without introducing inappropriate risk. **ECCE is the reference design for this optimization and consolidation so that the Project Detector can advance to CD2/3a in a timely way**”* – email communication from the EIC Project Team on 13 March 2022.

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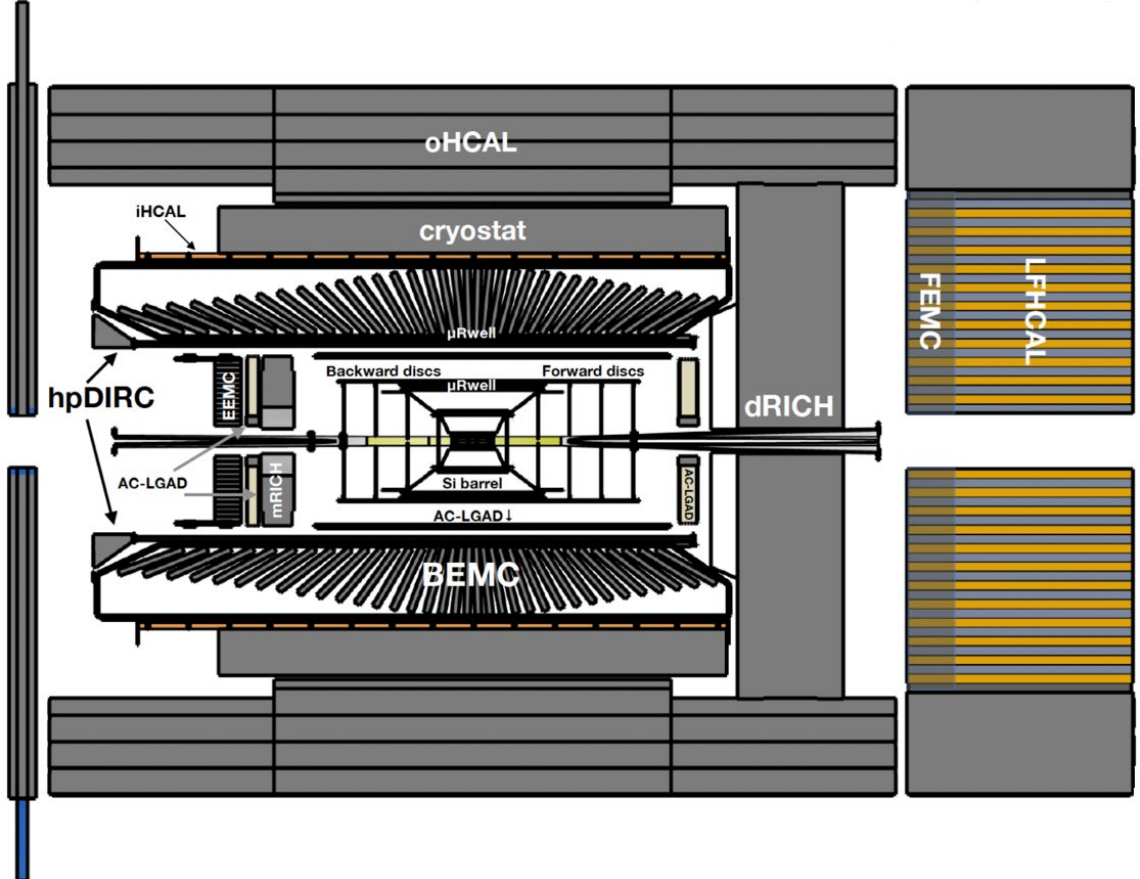
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*“The EIC Project recognizes that the panel recommended ECCE as the Project Detector. As described in the panel report, we will urge the proto-collaboration to: (1) **integrate new collaborators** in a manner that enables them to make contributions that impact the capabilities and success of the experiment in significant ways, including new collaborating individuals and groups into positions of responsibility and leadership; and (2) **integrate new experimental concepts** and technologies that improve physics capabilities without introducing inappropriate risk. **ECCE is the reference design for this optimization and consolidation so that the Project Detector can advance to CD2/3a in a timely way**” – email communication from the EIC Project Team on 13 March 2022.*

Make use the creativity and ingenuity of the entire community to make the EIC project detector the best it can be within cost and risk constraints!

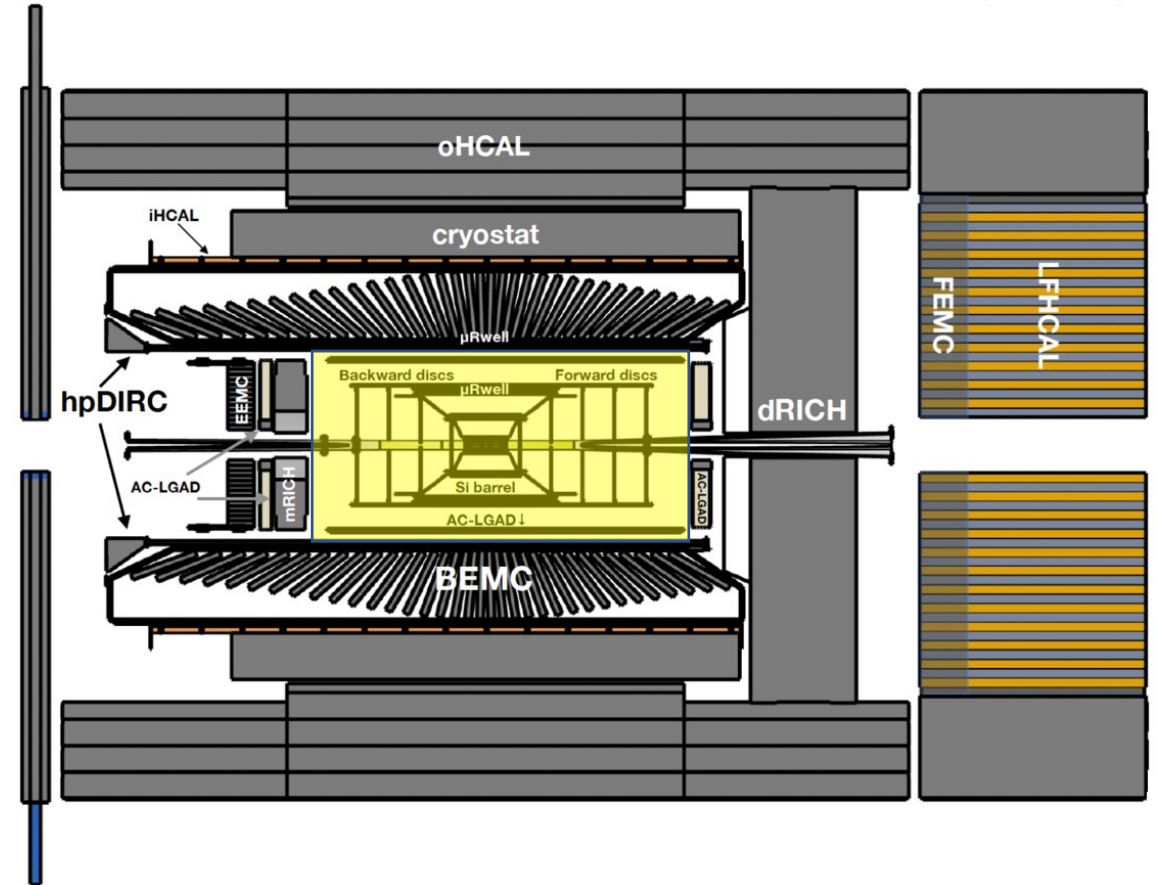
This process must be driven by physics performance!

Key items under consideration by Det1 WG's



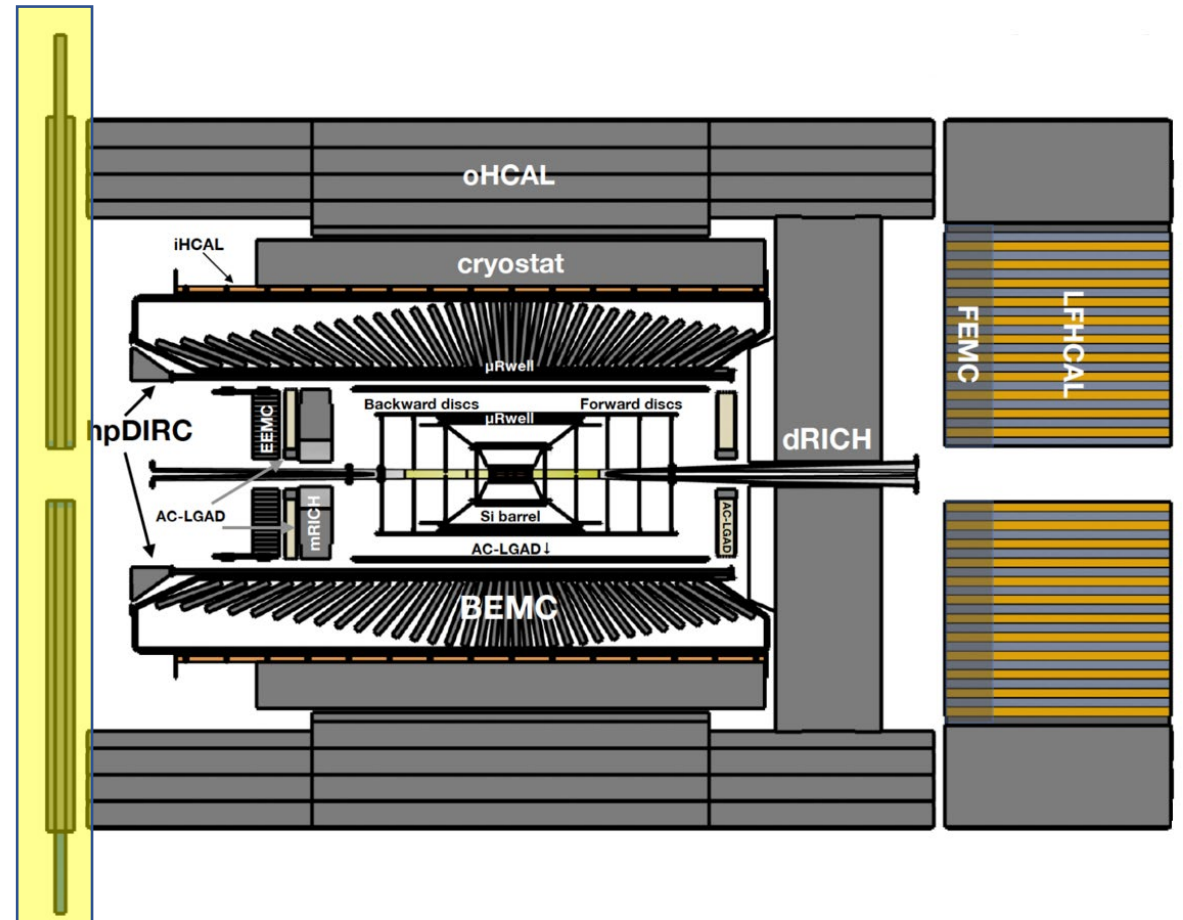
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 - Achieving a realistic, low-mass design with good performance
 - MPGD selection (μ RWell or μ Mega)



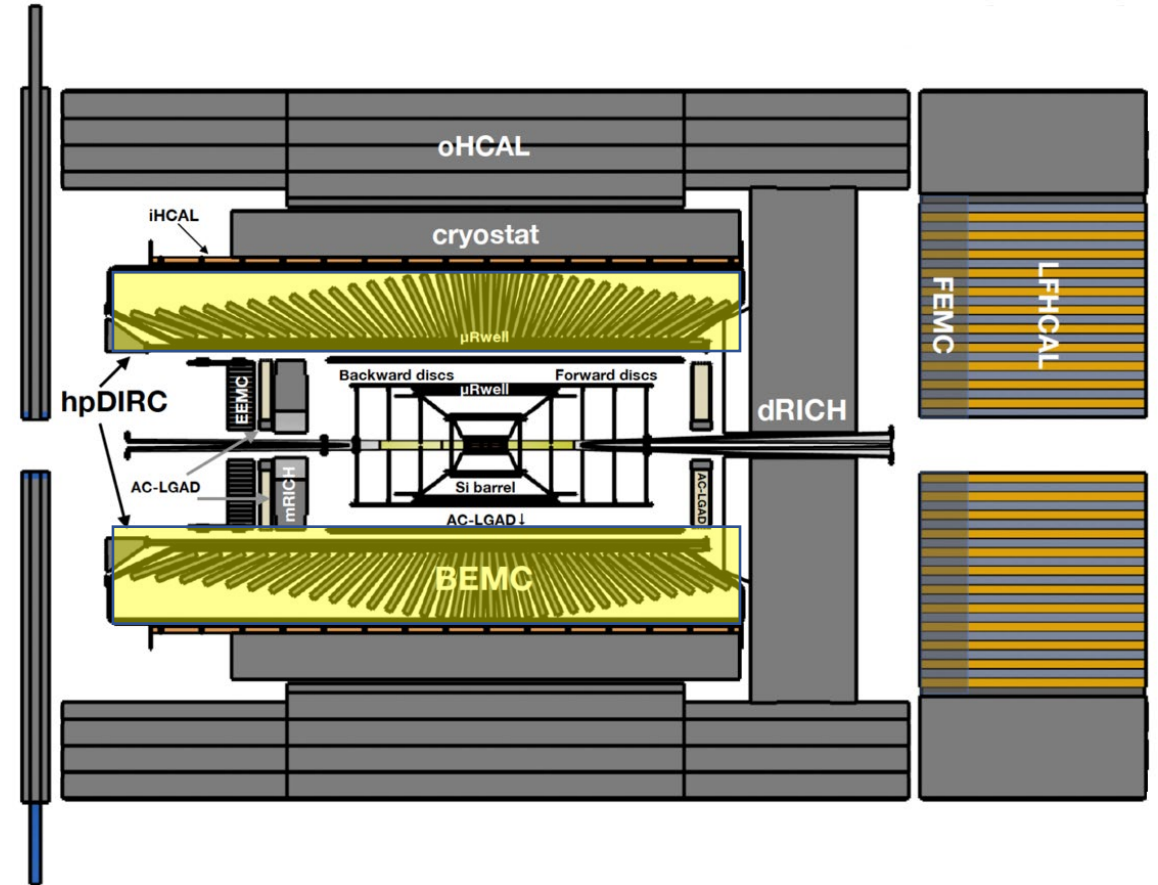
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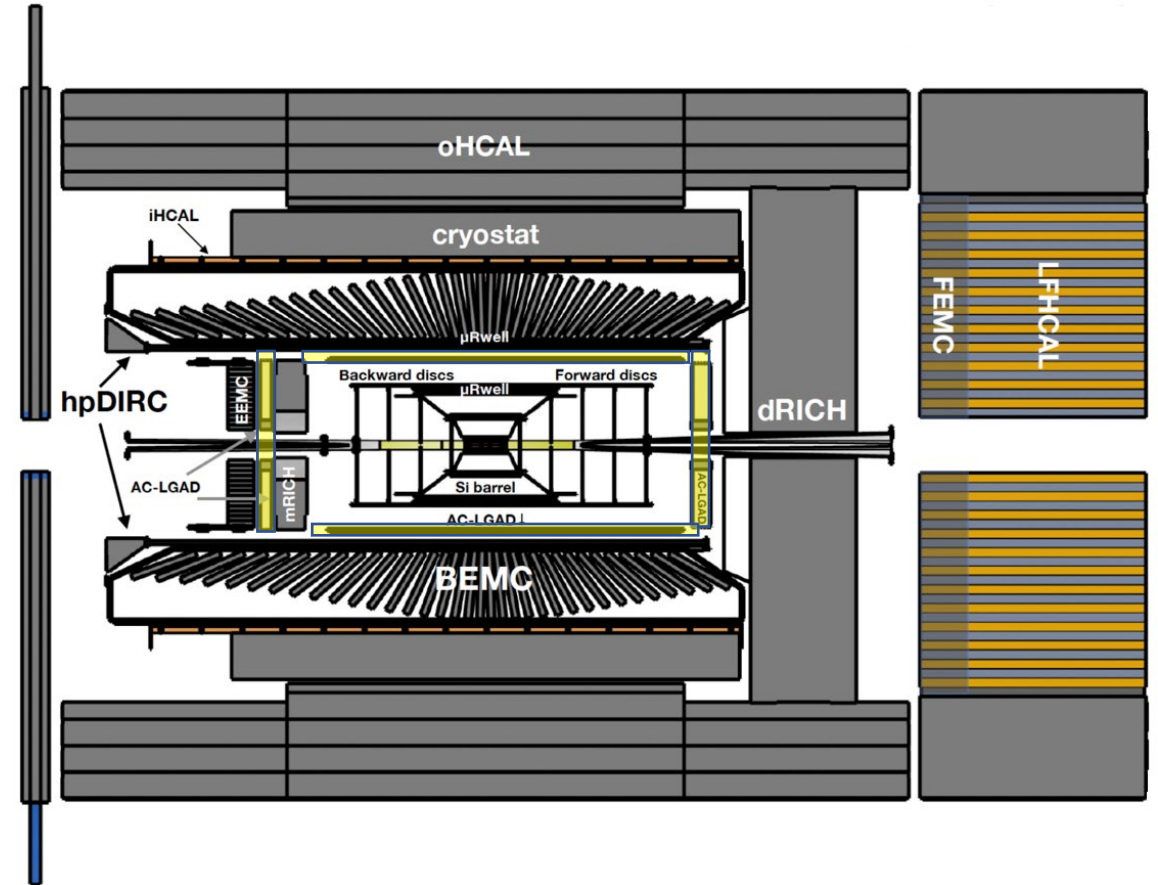
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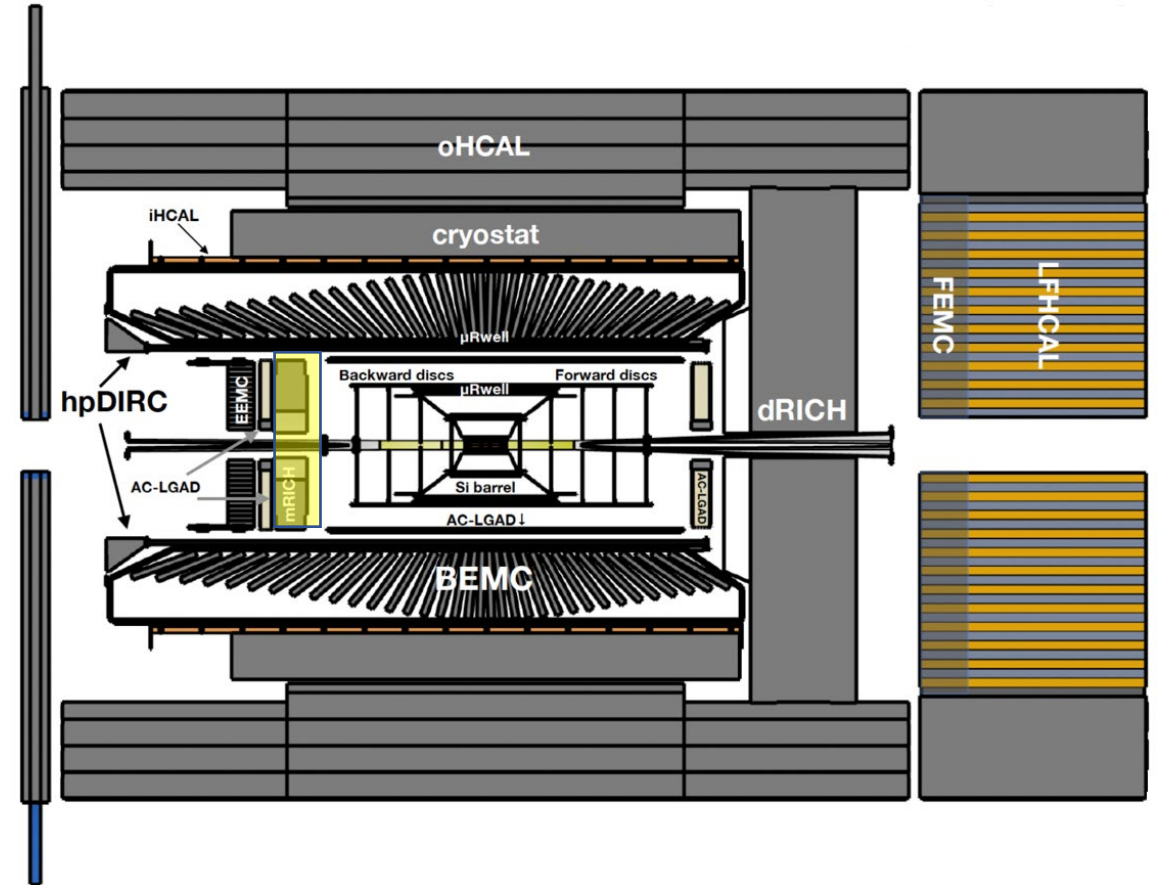
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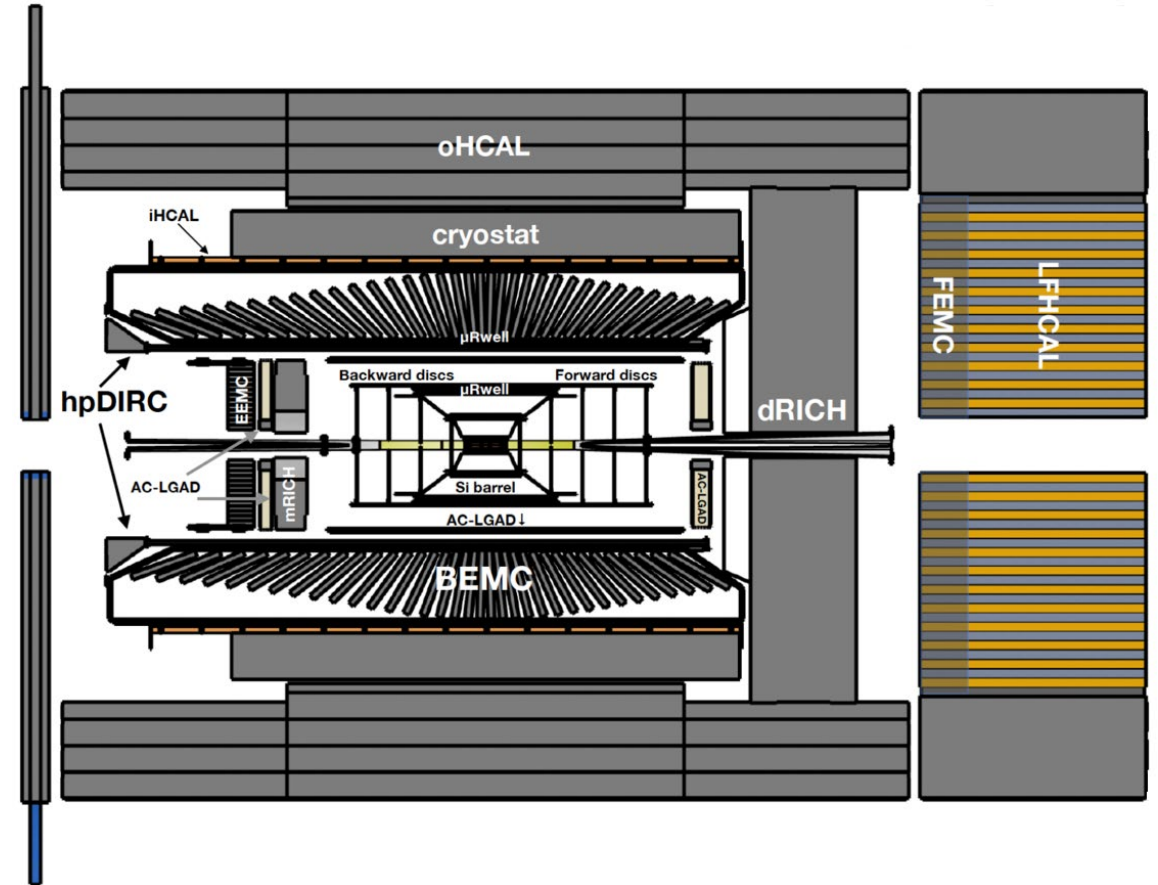
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***This process must be driven by the physics performance!
Iterative process between DWG's, PWG's and GD/I WG***

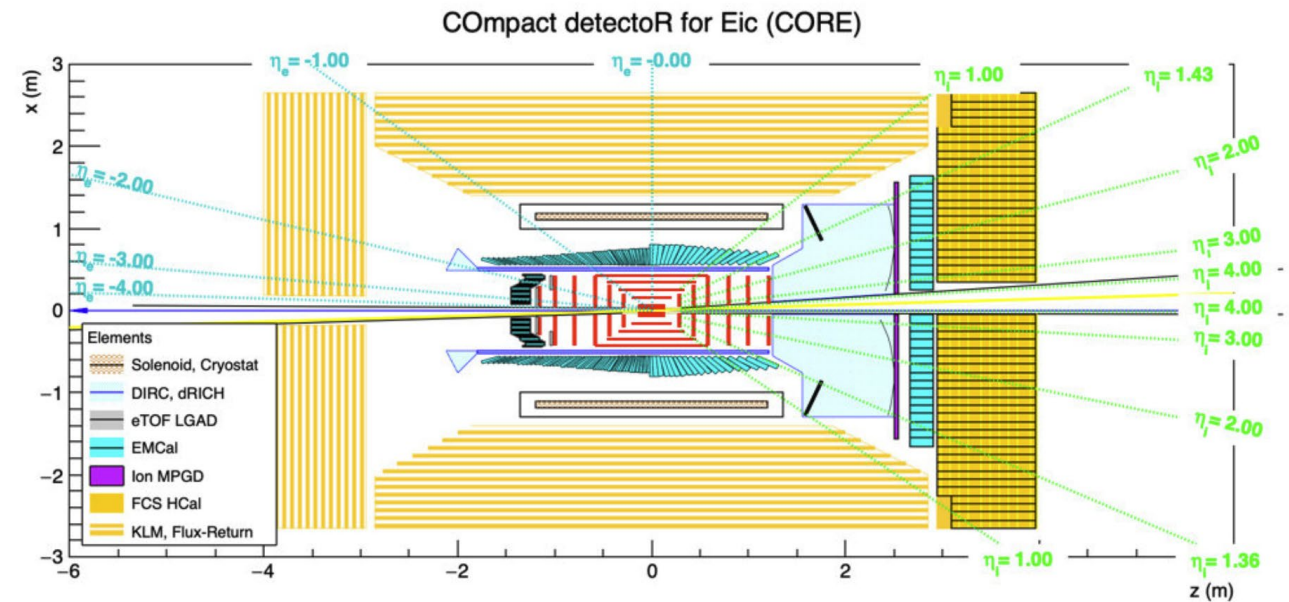
Detector-1 Collaboration Formation

- EICUG Annual Meeting
July 26-30, 2022
 - Early Career meeting July 24-25th
- Detector 1 Dedicated sessions:
 - July 27th (half day), 28th
 - Scientific program focused on Det1
 - Collaboration formation:
 - IB Meeting Session
 - Open discussion on bylaws/charter



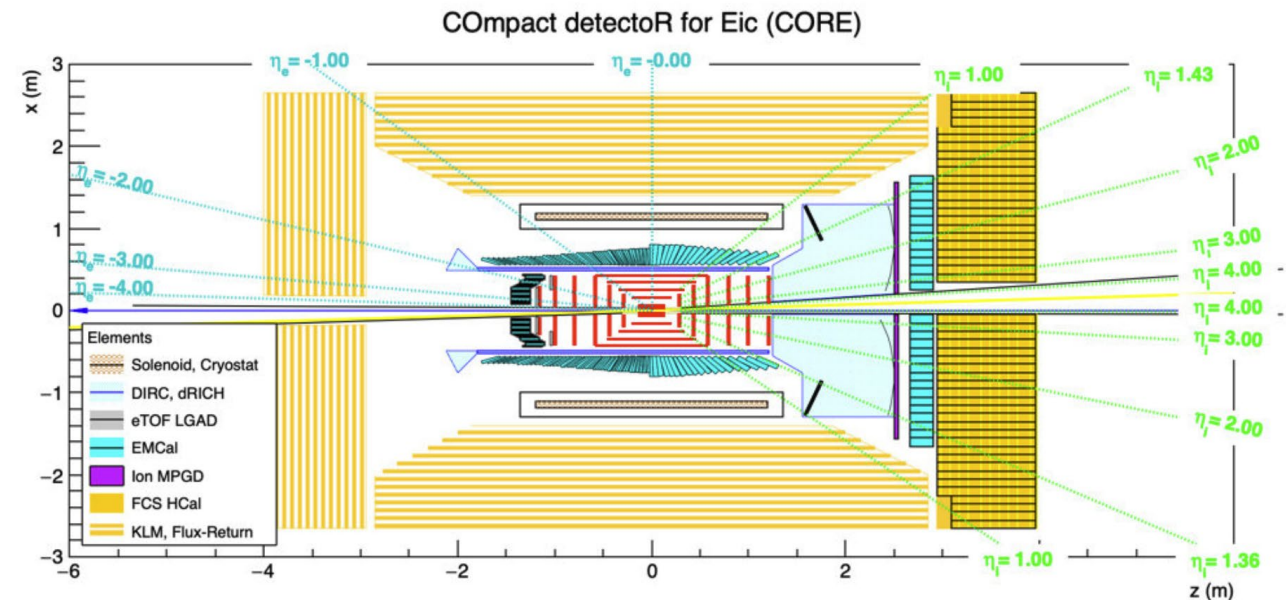
The July meeting will kick off the start of the official Detector-1 collaboration. Following this meeting the IB will form a bylaws/charter committee and the process will continue throughout the fall with the approval of the charter and elections for leadership positions.

Second EIC Detector – DPAP Recommendations



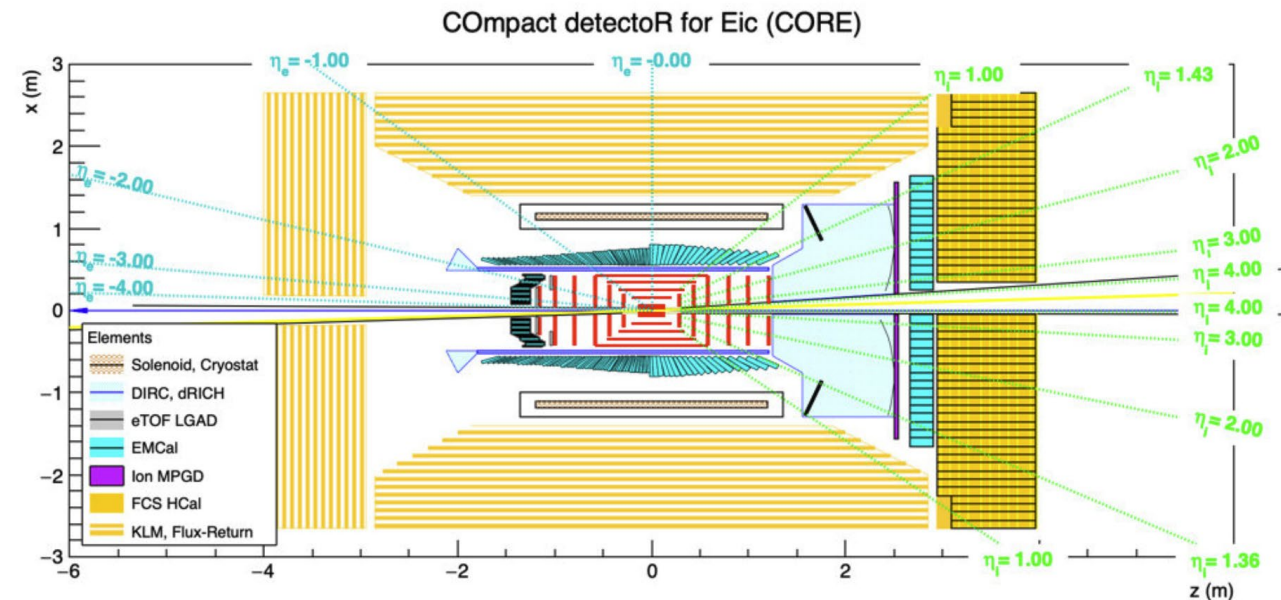
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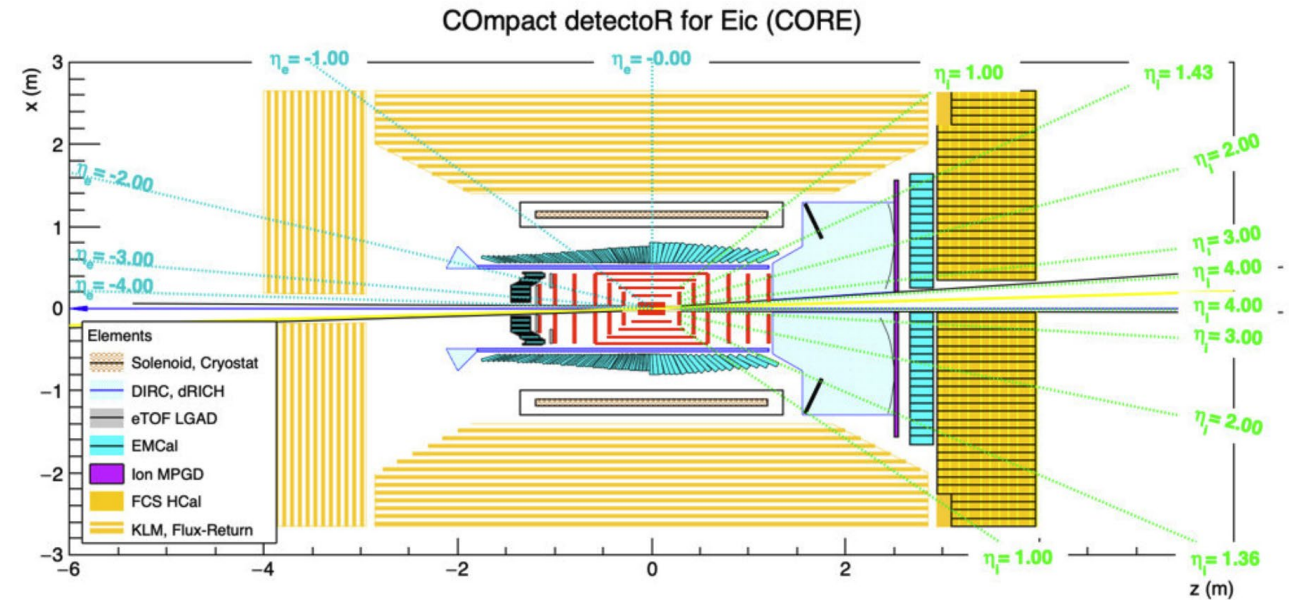
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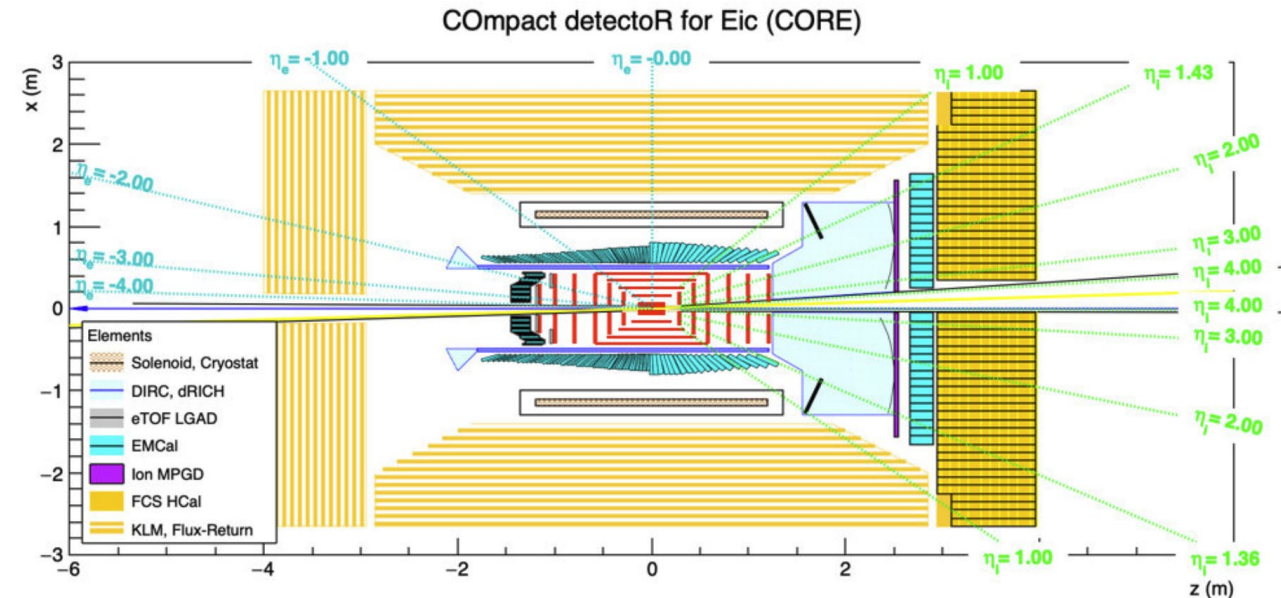
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Generic R&D - Patrizia Rossi (Wed)

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- “The time required for its design and construction may offer *opportunities for benefiting from technological progress*.”
- “The CORE proposal makes a convincing case for the *significant gain in physics reach* achievable with a secondary focus:
 - Increased acceptance in the invariant momentum transfer t of the scattered proton in ep collisions, which directly translates into an increased resolution power for imaging partons in the transverse plane,
 - Significantly improved abilities to detect nuclear breakup in exclusive and diffractive scattering on light and heavy nuclei. The distinction between coherent and incoherent scattering is essential for the physics interpretation of these processes.
 - Prospects for a program of low-background gamma spectroscopy with rare isotopes in the beam fragments.”



Generic R&D - Patrizia Rossi (Wed)

The Path to a Second Detector

- *“There is significant support in the community and from the panel for a second general-purpose detector system* to be installed in IR8 when resources are available. This detector should take advantage of the delayed start to explore opportunities for some complementarity in the physics reach and/or in the technologies used.”
- EICUG and Project Leadership have defined four areas of focus:
 - Complementarity to the Project Detector
 - Refine the physics case for the secondary focus
 - Define a generic R&D program
 - Build and engage the community
- EICUG-hosted workshops to help develop focus areas

Conclusions

- The “Detector-1” Collaboration effort has kicked-off:
 - Ongoing WG meetings focused on consolidation and developing technical design for CD-2/3A
 - Collaboration formation meeting July 27-28th , preparatory work ongoing
- Second detector effort organizing in order to capitalize on strong support in DPAP recommendations
- The process of developing the EIC detectors is really just maturing
 - 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!
 - There is still time to join the effort and get involved!
 - Fill out the [institutional survey](#) or contact the Det1 SC directly

