ATHENA

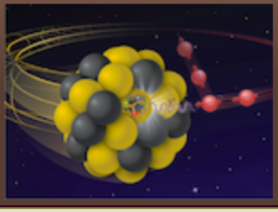
A Totally Hermetic Electron-Nucleus Apparatus

9 June 2021
RHIC/AGS Annual Users' meeting

Yulia Furletova (JLAB),
On behalf of ATHENA pre-collaboration

Kick-off meeting for EIC@IP6

https://indico.bnl.gov/event/10825/



Kick-off Meeting for an EIC Detector at IP6 (EIC@IP6)

12-13 March 2021

US/Eastern timezone

- Overview
- Timetable
- Remote Login Instructions
- Contribution List
- My Conference
  - My Contributions
- Registration
- Participant List
- Code of conduct

Following the site selection for construction of the U.S. Electron-Ion Collider research facility by the U.S. Department of Energy (DOE) in early 2020, the EIC Users Group led a year-long Yellow Report initiative to define the detector design criteria needed to realize the EIC physics described in the EIC White Paper, supported by the National Academy of Sciences. Using the Yellow Report as input, a Reference Detector concept was presented at the recently held DOE Critical Decision-1 review of the EIC.

A Call for EIC Detector Proposals has been issued by DOE & BNL/JLab on March 6, 2021, with an expected proposal submission deadline on December 1st, 2021. The EICUG community's strong preference for two detectors has led to multiple exciting detector initiatives. We invite all interested groups and consortia to come together to plan for a detector inspired by the Yellow Report detector concept based on a new central detector magnet up to 3T, which could evolve into a concrete proposal and collaboration formation for IP6.

This message is to invite you to a kick-off meeting on March 12-13, 2021. We will review the Yellow Report's work, consider all emerging ideas for EIC detectors, encourage the formation of subsystem consortia, and organize ourselves for the next steps. The meeting is meant to enable forming a collaboration, planning timelines, and developing strategies to engage EIC community members to meet the deadline for submitting a detector proposal.

Hosted by Collaborating Universities

with 292 register participants,

attendance peak at 197,

no session with less than 130 participants

Kick-off meeting for EIC@IP6

the warm and wide Expressions Of Interest presentation:

1:30 PM **DAQ/Readout subsystems presentations: 3**
DAQ_Readout.pptx

1:45 PM **Calorimetry subsystems presentations: 6**
Calorimetry.pptx

2:15 PM **Tracking subsystems presentations: 10**
Tracking.pptx

3:20 PM **Particle-ID subsystems presentations: 6**
PID.pptx

3:50 PM **Rear/Forward taggers subsystems presentations: 3**
Rear_Froward_Tagg...

4:05 PM **Polarimetry subsystems presentations: 3** ¶
Polarimetry.pptx

4:20 PM **EIC Software presentations: 4**
Software.pptx

EIC@IP6

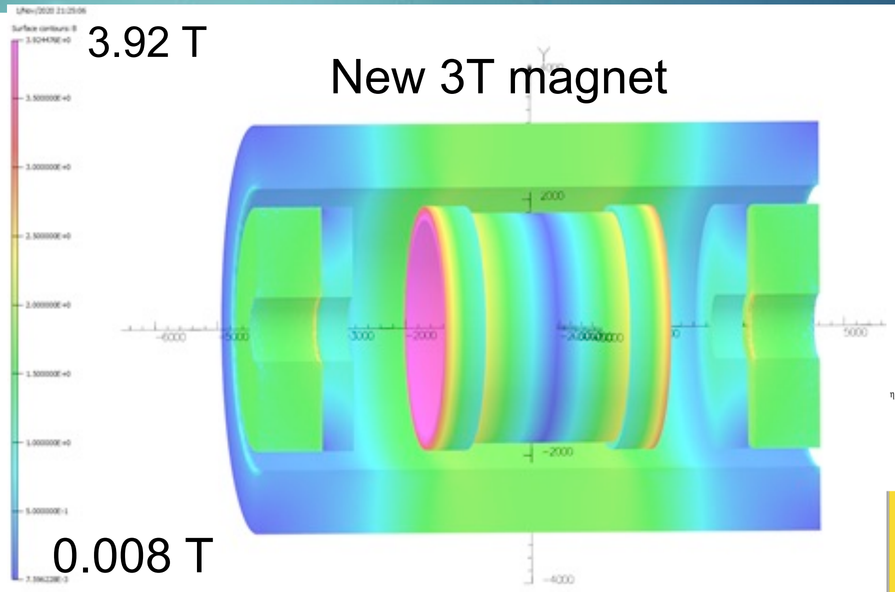
- ✓ Based on new up to 3T magnet and the YR reference detector

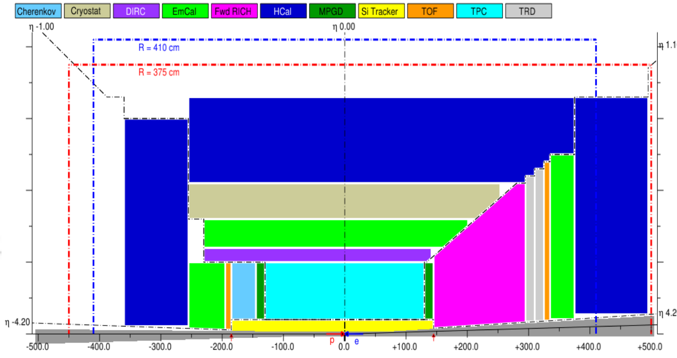
An initial Reference Detector concept was presented at the recently held DOE Critical Decision-1 review of the EIC and is included in the EIC-CDR 2021

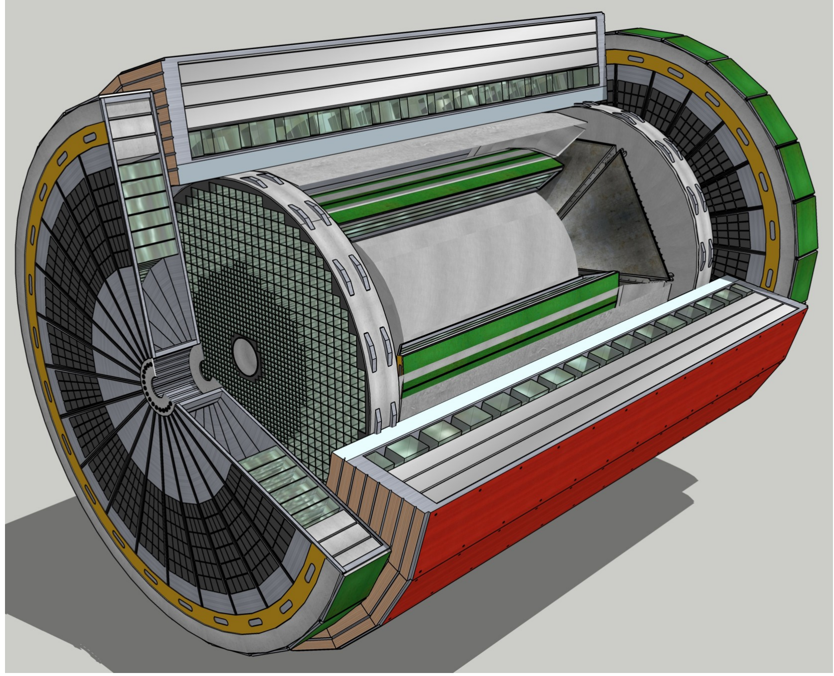
It should/will cover the physics of EIC White Paper, NAS report and Yellow Report.

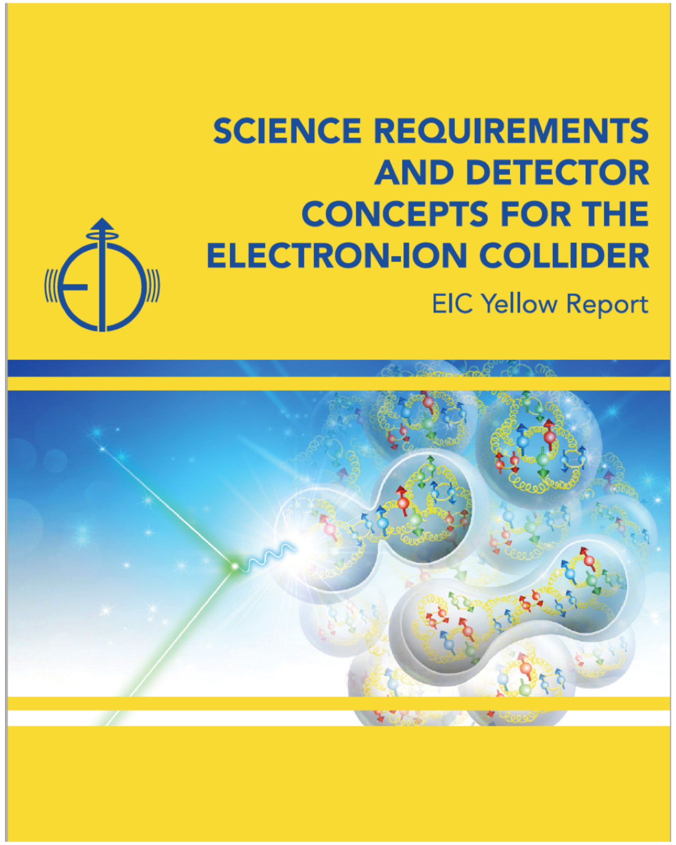
It will fulfill entirely the Call for Detector Proposal mandate for Detector1

- ✓ Contact to EIC Project Management: Elke Aschenauer









Structuring the collaboration

Temporary structure (still for a few weeks) needed to let the activity progress while preparing a consolidate structure. It includes :

- the coordination committee (eic-ip6-org-l@lists.bnl.gov) (namely the kick-off meeting organizers).
  Silvia Dalla Torre, Abhay Deshpande, Olga Evdokimov, Yulia Furletova , Barbara Jacak, Alexander Kiselev, Franck Sabatie, Bernd Surrow
- the preliminary IB (one representative per Institution for the time being)
  * the charter in preparation by a dedicated committee (illustrated in the following slides)
- presently 94 institutions are contributing

A new EIC experiment at IP6 at BNL | Home | Institutions | Community Links | Working Groups | News and Events | Contact

Welcome

Following the site selection for construction of the U.S. Electron-Ion Collider research facility by the U.S. Department of Energy (DOE) in early 2020, the EIC Users Group led a year-long Yellow Report initiative to define the detector design criteria needed to realize the EIC physics described in the EIC White Paper, supported by the National Academy of Sciences. Using the Yellow Report as input, a Reference Detector concept was presented at the recently held DOE Critical Decision-1 review of the EIC.

- ATHENA pre-collaboration is open to the whole EICUG community
- Web-page: https://sites.temple.edu/eicatip6
- Mailing lists: https://lists.bnl.gov/mailman/listinfo/
- Join EIC@IP6 on Slack: link

Image design by Joanna Griffin and Shannon West of Jefferson Lab

AGH University of Science and Technology, Krakow, Poland	CUA, USA	**Fudan University,China**	**INFN Ferrara, Italy**
Akal University, India	**A. Alikhanyan National Science Laboratory (Yerevan Physics Institute), Armenia**	**Goa University,India**	**INFN Genova, Italy**
ANL, USA	**Czech Technical University in Prague, Czechia**	**GSI, Germany**	**INFN Laboratori Nazionali di Frascati,Italy**
Banaras Hindu University , India	**DA V College, Chandigrah,India**	GSU, USA	**INFN Laboratori Nazionali del Sud,Italy**
BNL, USA	**Daresbury Laboratory, UK**	**IFJ PAN, Poland**	**INFN Padova, Italy**
Brunel University, UK	Duke University, USA	**IJCLab, Université Paris-Saclay, CNRS-IN2P3, Orsay, France**	**INFN Roma1, Italy**
CCNU Wuhan,China	FIT,USA	**INFN Bari, Italy**	**INFN Roma2,Italy**
Central University of Karnataka, India	Florida International University, USA	**INFN Bologna, Italy**	**INFN Torino, Italy**
Central University of Tamil Nadu	Florida State University , USA	**INFN Catania, Italy**	**INFN Trieste, Italy**
CIAE , China	**Forschungszentrum Jülich, Germany**	**INFN Cosenza, Italy**	

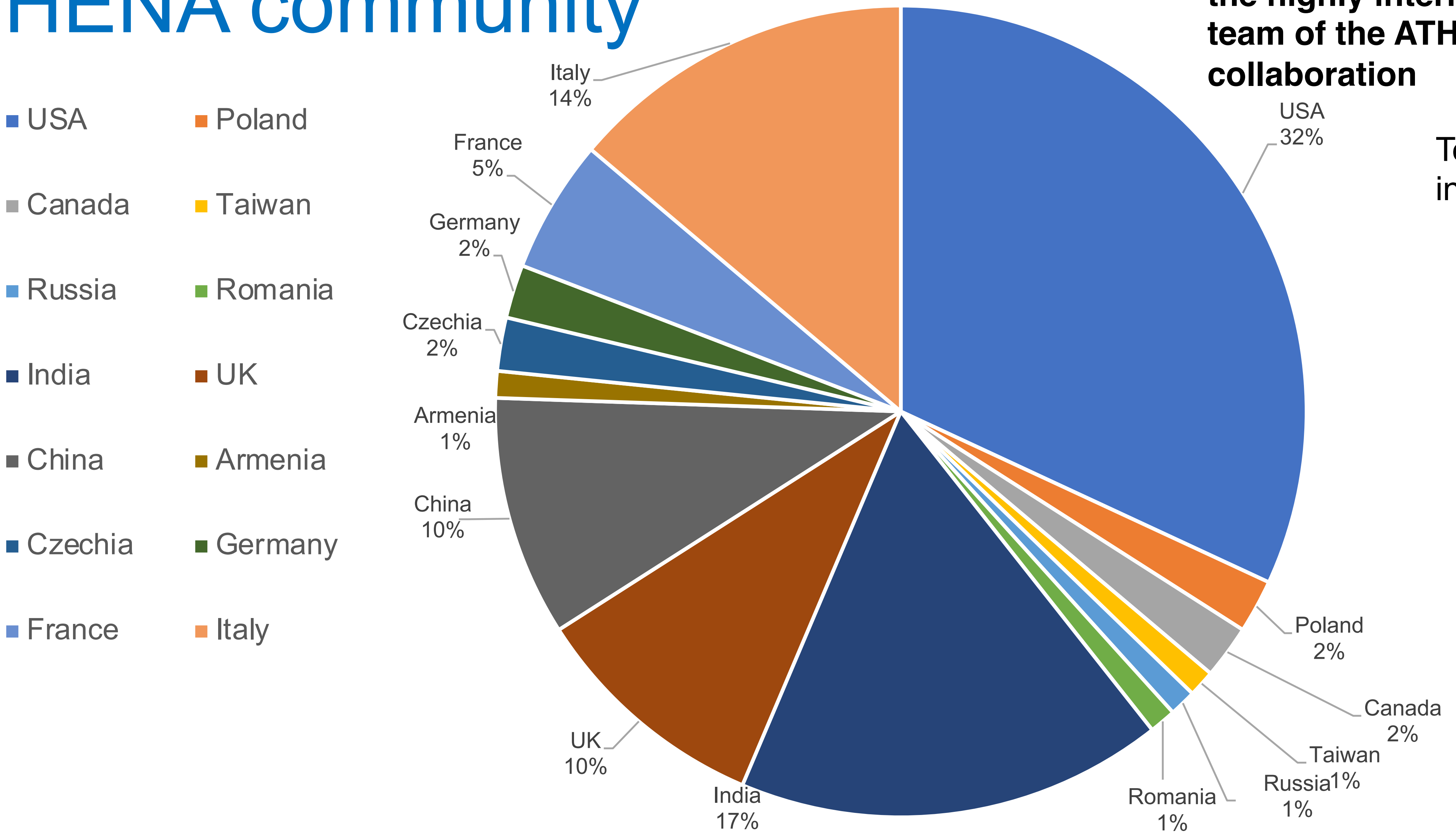
Indian Institute of Science Research and Education, Berhampur , India	**Indian Institute of Technology Patna , India**	Lehigh University, USA	**National Research Nuclear University MEPhI (NRNU MEPhI), Russia**
Indian Institute of Science Research and Education, Tirupati , India	**Institute of Modern Physics, Chinese Academy of Sciences, China**	LLNL, USA	**Nuclear Physics Institute of the Czech Academy of Sciences , Czechia**
Indian Institute of Technology Bombay , India	**Institute of Physics, IOP CAS , China**	**LLR, CNRS-IN2P3, Ecole Polytechnique, Institut Polytechnique de Paris, Paris, France**	ORNL, USA
Indian Institute of Technology Delhi , India	**IPHC, Université de Strasbourg, CNRS-IN2P3, Strasbourg, France**	**Malaviya National Institute of Technology Jaipur , India**	**Panjab University, India**
Indian Institute of Technology Indore, India	JLAB, USA	**Mount Allison University, Canada**	**RAL CMOS Sensor Design Group (CSDG) ,UK**
Indian Institute of Technology Madras ,India	LANL, USA	**National Cheng Kung University,Taiwan**	**RAL Particle Physics Division (PPD), UK**
	LBNL,USA	**National Institute of Science Education and Research,India**	**Ramakrishna Mission Residential College, Kolkata, India**

Rice University, USA	UC Davis, USA	University of Virginia, USA	
Irfu, CEA-Saclay, Université Paris-Saclay, Saclay, France	UCLA, USA	**University of Glasgow, UK**	
South China Normal University (SCNU), China	UC Riverside, USA	**University of Jammu, India**	
Shandong University,China	University of Illinois at Chicago, USA	University of Kansas, USA	
SMU, USA	**University of Birmingham, UK**	University of Kentucky, USA	
Stony Book University, USA	**University of Manitoba, Canada**	**University of Lancaster, UK**	
Subatech, IMT Atlantique, Université de Nantes, CNRS-IN2P3, Nantes, France	**University of Massachusetts Amherst**	**University of Liverpool, UK**	
Temple University, USA	University of North Georgia, USA	**University of York, UK**	
Tsinghua University, China	University of Michigan,USA	**University of Science and Technology of China, China**	
UC Berkeley, USA	University of Tennessee, USA	UT Austin, USA	

ATHENA community

the highly international team of the ATHENA pre-collaboration

Total 94 institutions

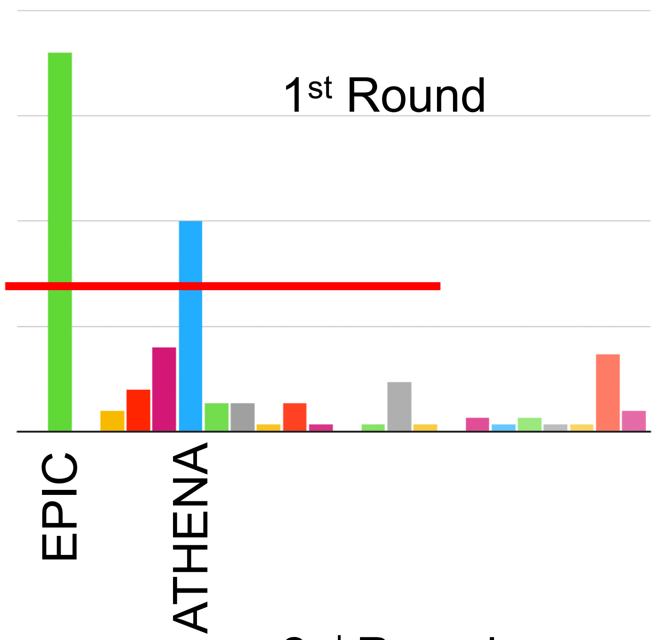


EIC@IP6 → ATHENA

https://sites.temple.edu/eicatip6/athena-logo-competition/

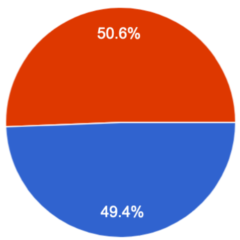
24 naming proposals, 23 LOGO proposals
open to the whole collaboration

- #1 ePIC
- #2 EPIC
- #3 EPIC
- #4 EPICA
- #5 ERICA
- #6 ARES
- #7 ATHENA
- #8 PERSEI
- #9 IONE
- #10 THEIA
- #11 NICE
- #12 SPICE
- #13 DICE
- #14 ICE
- #15 HELIX
- #16 SiMPLECS
- #17 PEIPE
- #18 ELEIDA
- #19 ENSUEX
- #20 POSEIDON
- #21 NEREID
- #22 ZeleX
- #23 EIC@IP6
- #24 IP6@EIC



2nd Round

164 responses



ATHENA →

9 June 2021

Charter Committee

in parallel an active ad hoc committee is preparing a charter:

- Our Charter Committee:
  - Ken Barish (UC Riverside)
  - Olga Evdokimov (UIC)
  - David Gaskell (JLAB)
  - Nicole d'Hose (CEA-Saclay)
  - Tom Hemmick (Stony Brook)

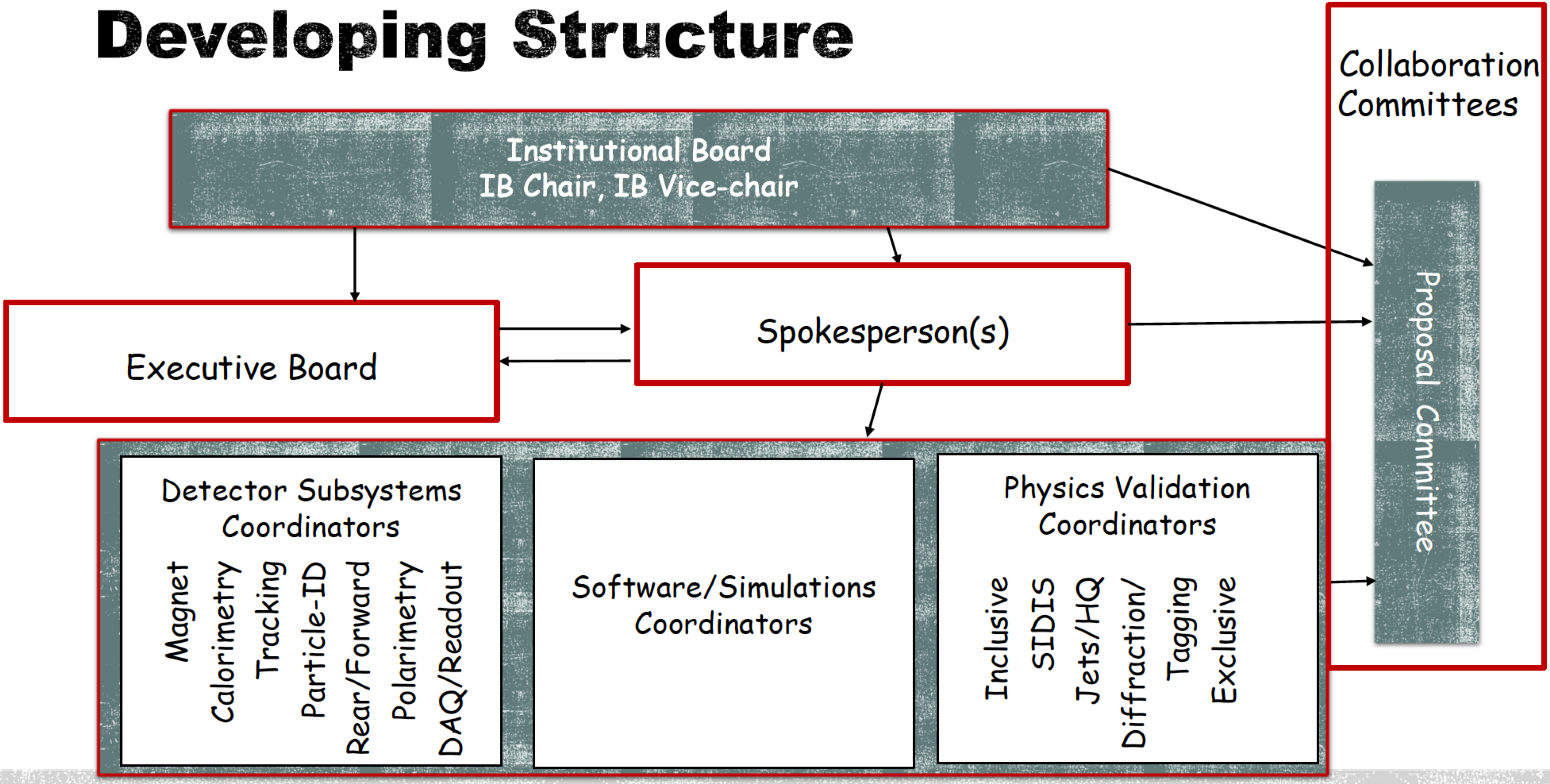
  Zein-Eddine Meziani (ANL)
  Bedanga Mohanty (NISER)
  Marta Ruspa (Torino)
  Murad Sarsour (GSU)
  Ernst Sichtermann (LBNL)

  Daria Sokhan (Glasgow)
  Thomas Ullrich (BNL)
  Anselm Vossen (Duke)
  Qinghua Xu (Shandong)

Meetings began on 4/23 and have made significant progress laying the foundations for the developing document

The goal is to have a full draft available by early June, for the subsequent iterations with the IB and the adoption vote.

Developing Structure



Proposal Committee

✓ Ex-officio / Official EIC project contact: Elke Aschenauer

- ❑ **Integration / Global design:** Bedanga Mohanty, Franck Sabatie, Alexander Kiselev, Thomas Ullrich , Silvia Dalla Torre
  - Engage in a dialog between physics WGs concerning requirements and subsystem WGs concerning performance and help realize a global detector model based on performance, cost, maturity, and institutional commitment while
  - Keeping the ATHENA community fully informed about design considerations, ensuring opportunities for feedback from collaborators.
- ❑ **Costing:** Bernd Surrow, Olga Evdokimov, Zhangbu Xu, Yulia Furletova
  - Use cost template from EIC project team and EIC reference detector costing evaluation presented to the ICR in January 2021 as a starting point for completing detector costing.
  - Communicate with subsystem WGs about costing: Subsystem template, expected cost bracket, holding regular costing meetings with a "costing" representative for each subsystem WGs.
  - Prepare full costing of detector proposal with advice/input from the EIC project team and ATHENA community.
- ❑ **Draft/ Editing:** Abhay Deshpande, Barbara Jacak, Zein-Eddine Meziani, Peter Jones
  - Prepare a draft outline for the detector proposal and present it to the ATHENA community using shared overleaf document.
  - Writing of introductory material.
  - Solicit input from WGs specifying details for each section, including costing from the costing focus group.
  - Compiling the entire document, soliciting comments, and finalizing the document.

WG conveners and charge highlights

Subsystem detector WG Conveners:
Technology choices / Estimate of services, support + active materials / Implementation into global experimental model / Simulation of subsystem performance in the global experiment / Costing of each subsystem

Tracking: Francesco Bossu, Domenico Elia, Laura Gonella, Matt Posik
PID: Frank Geurts, Tom Hemmick, Roberto Preghenella
Calorimetry: Vladimir Berdnikov, Paul Reimer, Oleg Tsai
Far Forward: John Arrington, Alexander Jentsch
Far-Backward: Jaroslaw Adam, Krzysztof Piotrzkowski
DAQ: Alexandre Camsonne , Jeffery Landgraf
Polarimetry*: Oleg Eyser*, Ciprian Gal (*we propose Polarimetry as a joint group across EIC detectors)

Physics Validation WG Conveners:
Identify key observables described in YR / 2-3 plots which will illustrate the ability of EIC@IP6 to address NAS report and YR / Additional physics performance plots that would give a competitive advantage for the proposal?

Inclusive: Paul Newman, Barak Schmookler, Qinghua Xu
Semi-inclusive: Marco Radici, Anselm Vossen
Jets/HF/EW-BSM: Miguel Arratia, Brian Page, Stephen Sekula, Ernst Sichtermann
Exclusive: Salvatore Fazio, Spencer Klein, Daria Sokhan

Software WG Conveners:
Full detector assembly / Assist detector and physics WG's to perform simulation and detector integration / Complete and improve reconstruction software

Whitney Armstrong, Andrea Bressan(*), Wouter Deconinck, Sylvester Joosten, Dmitry Romanov
(*)- liaison to EICUG software group

Highlights from the WGs

https://sites.temple.edu/eicatip6/calendar/collaboration-calendar/

https://sites.temple.edu/eicatip6/calendar/collaboration-calendar/ Search

Mon	Tue	Wed	Thu	Fri	Sat	Sun
	1 Steering Committee Meeting Tracking Working Group Jets/HF Working Group	2 SIDIS Working Group Far-Backward Working Group	3 Software & Computing Working Group ATHENA Monthly Meeting	4 Working Group Conveners Meeting	5	6
7 Inclusive Working Group PID Working Group Far-Forward Working Group Calorimetry Working Group	8 Steering Committee Meeting Tracking Working Group Jets/HF Working Group	9 SIDIS Working Group Far-Backward Working Group	10 DAQ Working Group Meeting ATHENA Bi-Weekly Meeting	11 Working Group Conveners Meeting Exclusive/Tagging Working Group	12	13
14 PID Working Group Far-Forward Working Group Calorimetry Working Group	15 Steering Committee Meeting Tracking Working Group Jets/HF Working Group	16 SIDIS Working Group Far-Backward Working Group	17 DAQ Working Group Meeting Software & Computing Working Group	18 Working Group Conveners Meeting Exclusive/Tagging Working Group	19	20
21 Inclusive Working Group PID Working Group Far-Forward Working Group	22 Steering Committee Meeting Tracking Working Group Jets/HF Working Group	23 SIDIS Working Group Far-Backward Working Group	24 DAQ Working Group Meeting ATHENA Bi-Weekly Meeting	25 Working Group Conveners Meeting Exclusive/Tagging Working Group	26	27

Bi-weekly ATHENA meetings on Thrs 11-2pm EDT

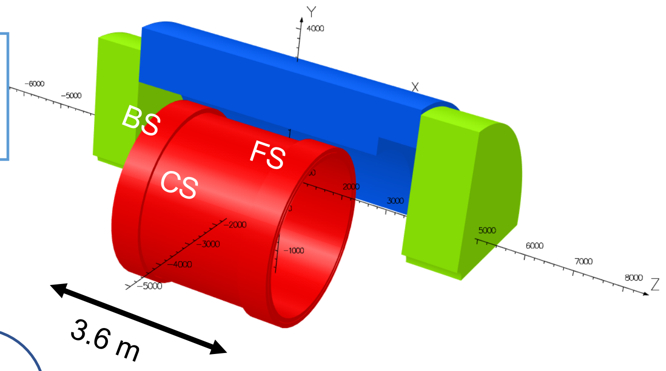
Monthly ATHENA meetings on Thr 8pm-11pm EDT (for ASIA)

New Solenoid (up to 3T)

By: V. Calvelli (CEA), R. Rajput-Ghoshal (JLAB)

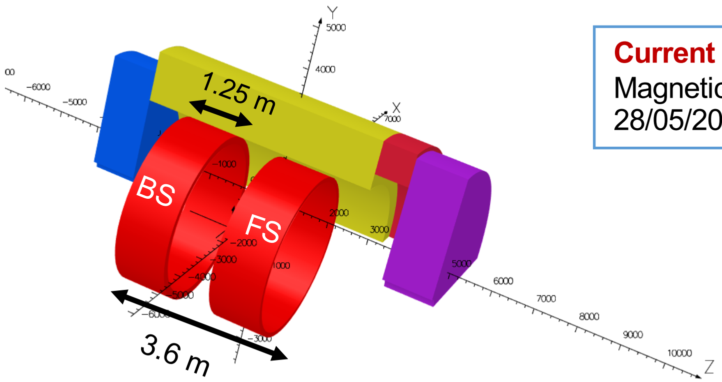
Solenoidal Configuration

Version for full analysis
Magnetic field map released
07/05/2021

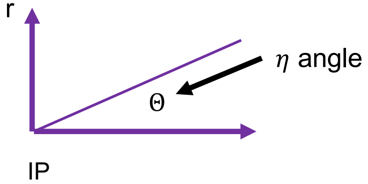


Helmholtz Configuration

Current version ONGOING
Magnetic field map released
28/05/2021



On the Interaction Point rz plane



$$Proj = \frac{B_z \tan\Theta - B_r}{J_E}$$

If $Proj = 0$ everywhere, particles are not deflected from the original trajectory (same as $\frac{dP}{dt} = 0$)

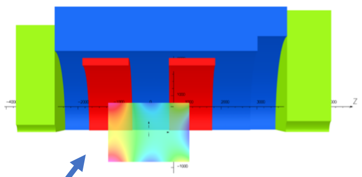
Parameter	Values
B_{IP} (T)	3.15
B_{peak} (T)	4.35
Coil thickness (mm)	200
Energy (MJ)	183.9
H TPC 2 (%)	6.61
H FLAT 1 (%)	**25.12**
Projectivity (T/Amm²)	**14.82**

Parameter	Goal
B_{IP} (T)	3.00
Bore diameter (mm)	1600
Coil length (mm)	3600
H TCP 2 (%)	5.0
H FLAT 1 (%)	10.0
Projectivity (T/Amm²)	min

Parameter	Values
B_{IP} (T)	2.97
B_{peak} (T)	4.84
Coil thickness (mm)	210
Energy (MJ)	235.7
H TPC 2 (%)	4.83
H FLAT 1 (%)	16.37
Projectivity (T/Amm²)	**17.51**

$$H^2_{TPC} = \left|\frac{B_r}{B_z}\right| < 5\%$$

$$H^1_{FLAT} = \frac{B_{max} - B_{min}}{B_{IP}} < 10\%$$



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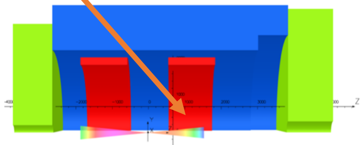


Mostly difficult to reach before the RICH
Due to the short length of the magnet

Silicon vertex and tracking detector

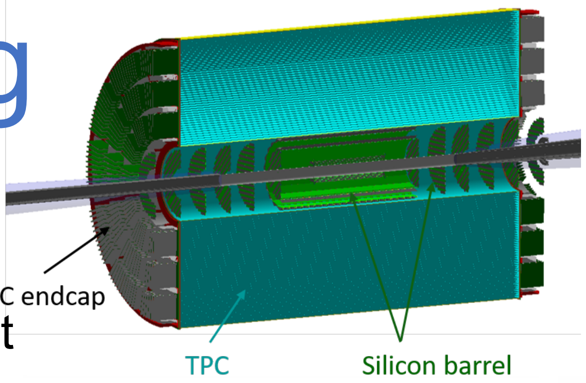
Primary and secondary vertex reconstruction + momentum measurement in combination with gas based tracking system at larger radii and Z (see next slides)

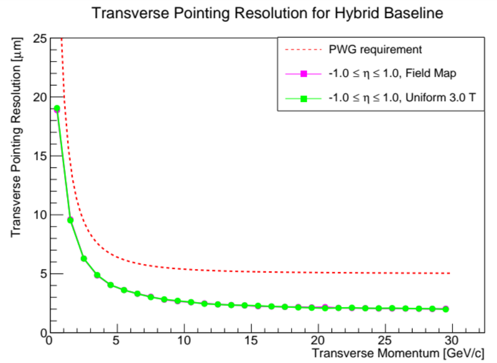
Currently two configurations studied:
 ”YR hybrid” and “YR all-silicon”
- Both based on ALICE ITS3 65 nm MAPS sensor
- Ongoing layout optimisation: # of vertex layers and disks, integration of barrel region with disks, overall integration with MPGD tracking detector, …

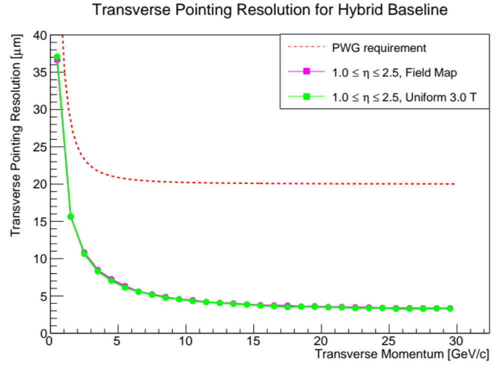
# layers/disks	Vertex	Barrel	Endcaps
YR Hybrid	3+2	2	7 fwd + 7 bwd
YR All-silicon	2	2+2	5 fwd + 5 bwd

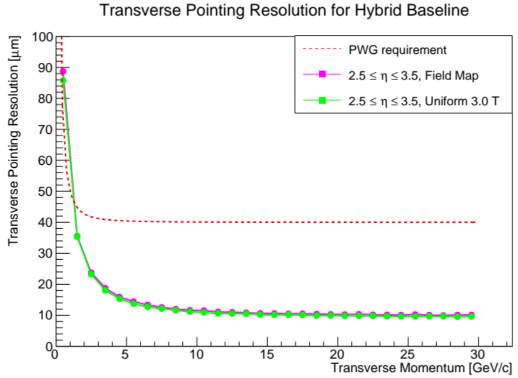
10μm pixel pitch

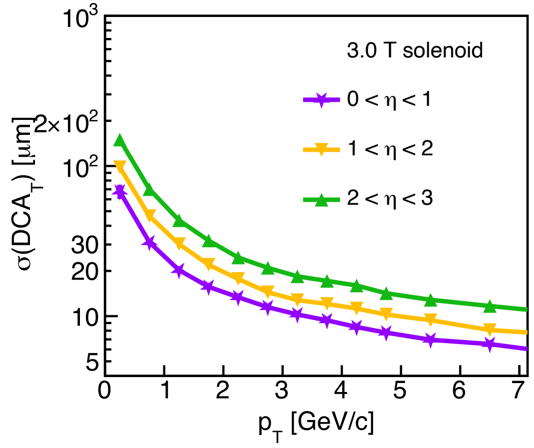
x/X_0 = 0.05% per vertexing layer
x/X_0 = 0.55% per tracking layer
x/X_0 = 0.24% per disk

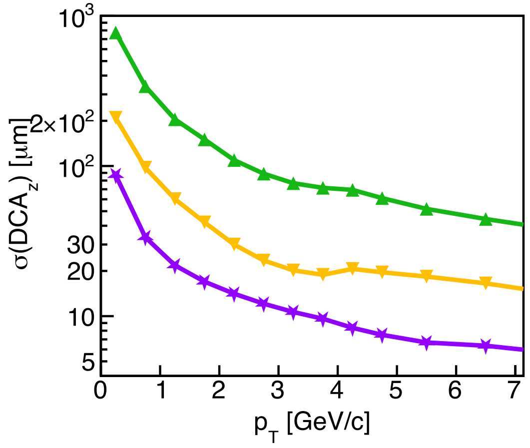


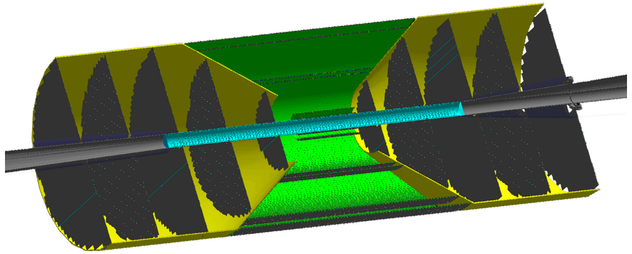








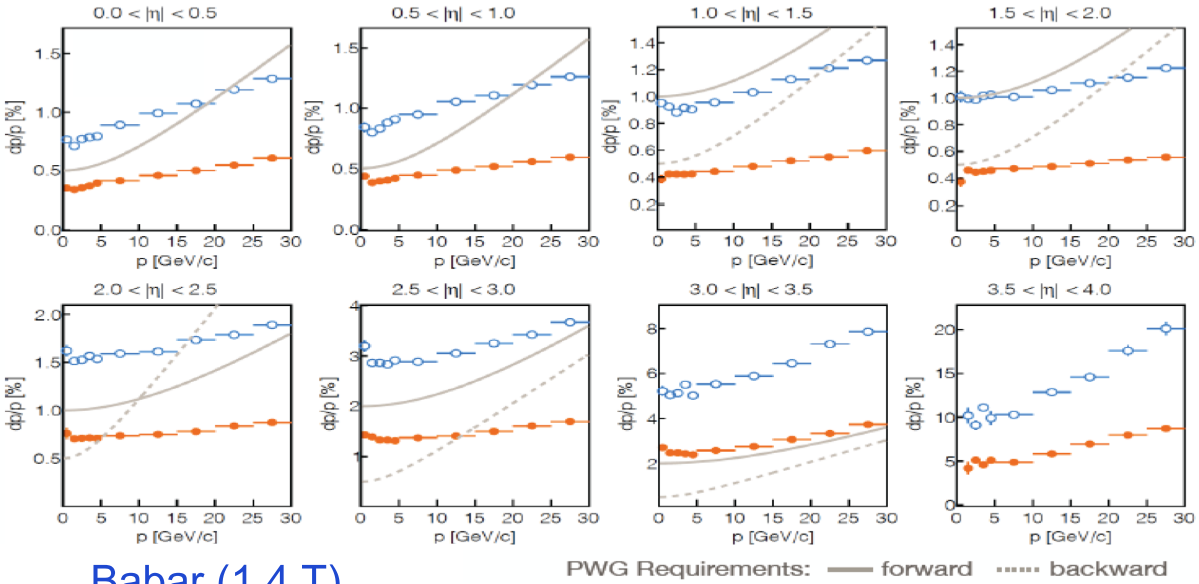




Momentum performance

Results from the YR studies compared with Physics WG (PWG) requirements:

All-Silicon

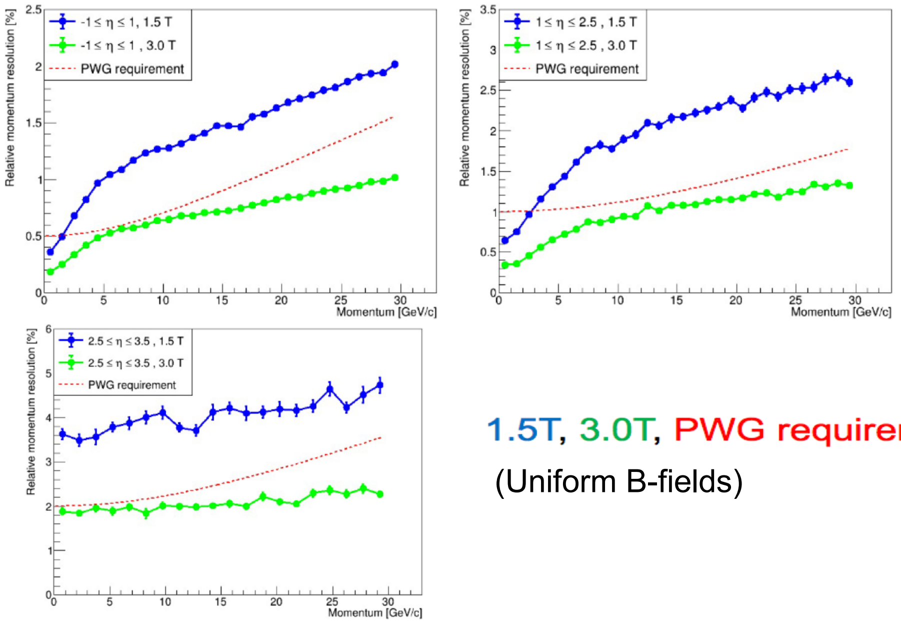


Babar (1.4 T)

Beast (3.0 T)

- PWG Requirements

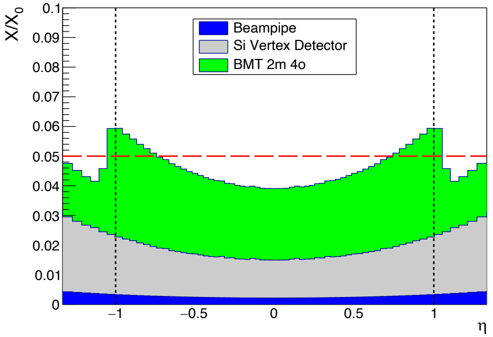
Hybrid (Si+TPC)

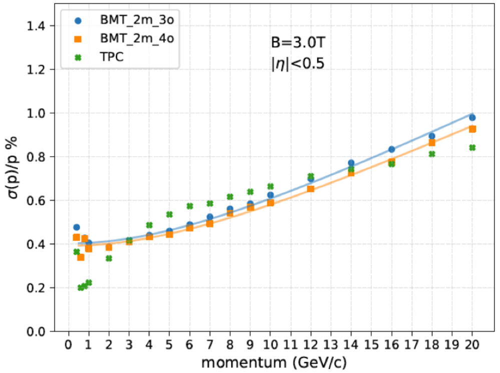


1.5T, 3.0T, PWG requirement

(Uniform B-fields)

Hybrid (Si Vertex + Micromegas)





End Cap Trackers

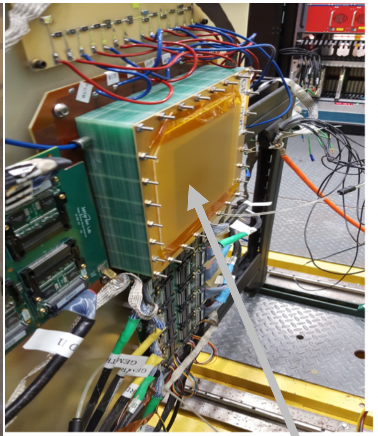
End cap trackers can be relatively large. MPGD based tracking detectors can cover large areas and provide tracking information at a reasonable cost.

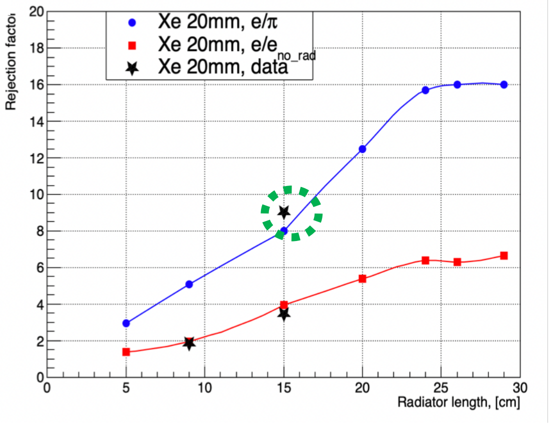
Hardware R&D work within eRD6 and eRD22

- Large area GEM for forward / backward trackers
  - Large area (1 m × 0.5m) & Low mass GEMs (~0.5% X/X0)
- High performance & low channels count anode readout for MPGD
  - Zigzag strips, Capacitive-sharing readout
- GEM-based transition radiation detector (GEM-TRD)
  - Prototyping and Gas system
  - Provide e/π discrimination and tracking
- Resistive Micro-Well (µRWELL) technology
  - Develop large area µRWELL with capacitive-sharing readout

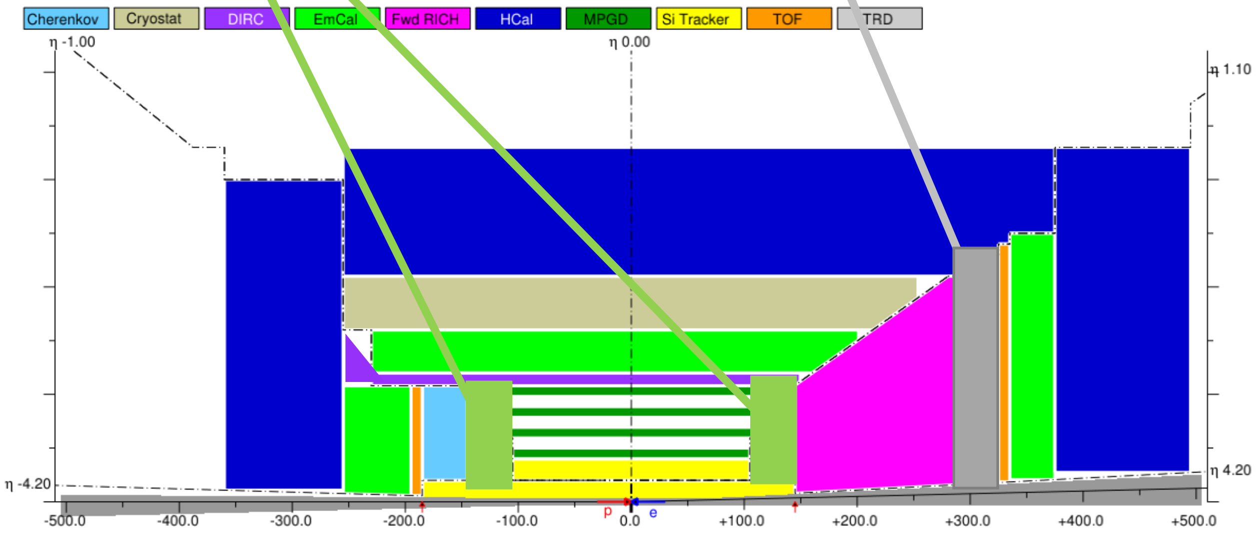
Large & Low mass GEM

GEM-TRD Prototype





GEM-TRD e/π rejection performance

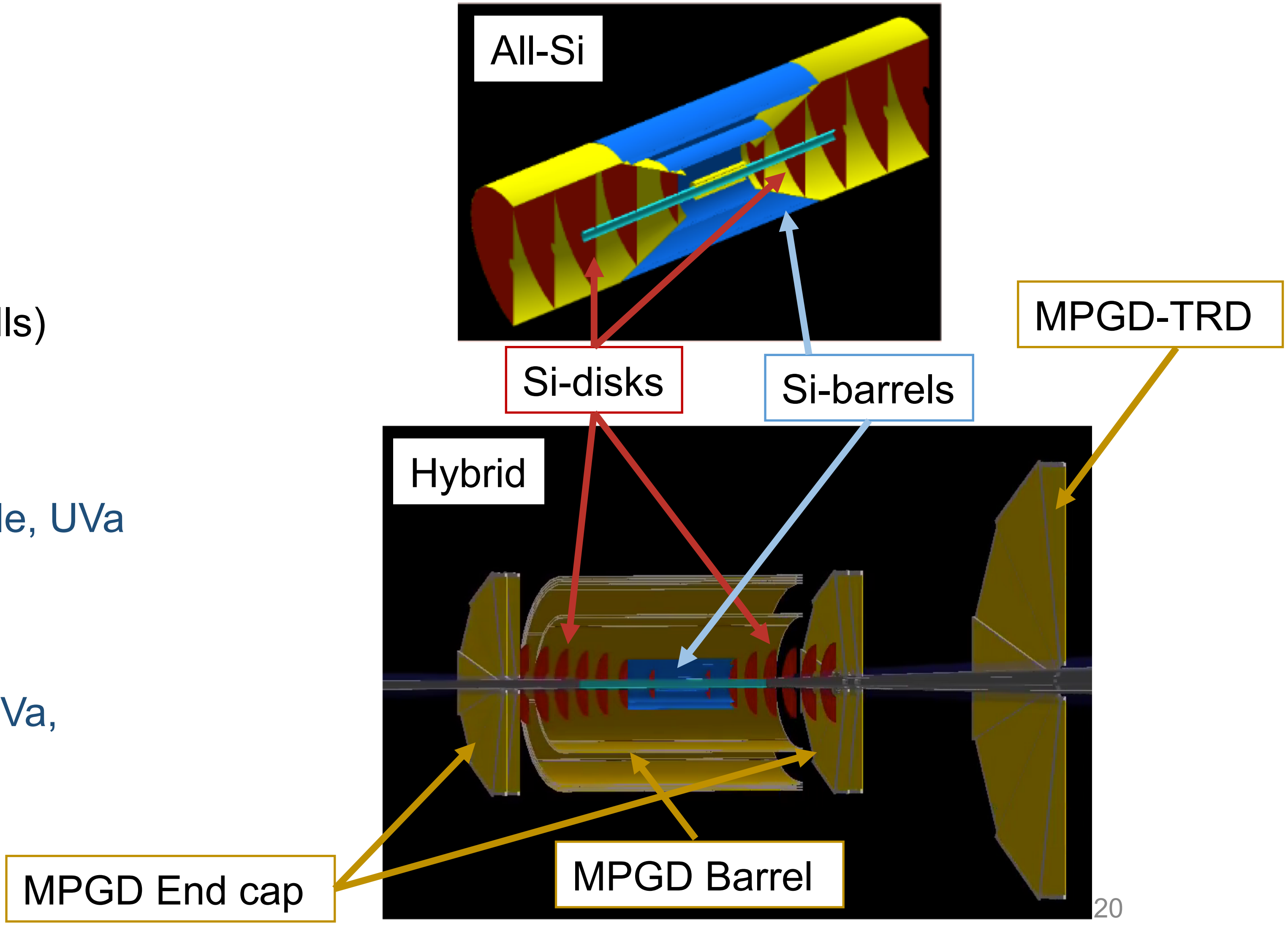


All-Silicon and Hybrid Concepts

Current detector concepts have general layouts and technologies. Discussions of specific choices now underway within tracking WG.

- **All-Silicon concept**
  - Vertex/Barrels and disks
    - EIC Silicon consortium

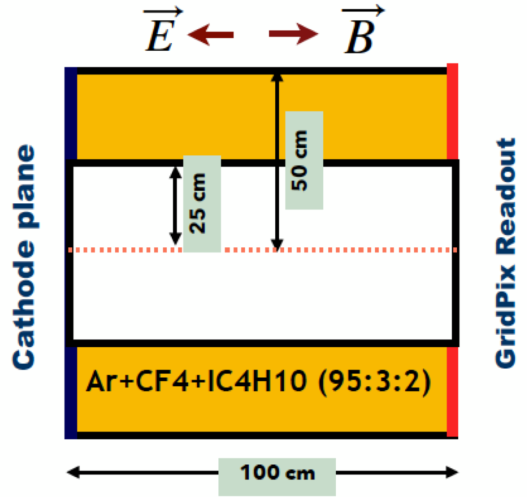
- **Hybrid concept**
  - MPGD end cap: (GEMs or micro R-Wells)
    - Florida Tech., Temple, UVa
  - MPGD barrel
    - Micromegas – Saclay
    - Micro R-Well – Florida Tech, Temple, UVa
  - Silicon vertex/barrels and disks
    - EIC Silicon consortium
  - Large z MPGD-TRD
    - BNL, Florida Tech. Jlab, Temple, UVa, Vanderbilt



Low momentum PID with GridPix

Known and Proven Technology for GridPix

- GridPix is a 55 μm × 55 μm pixel readout for a gaseous TPC
- First Timepix3 based GridPix test beam (2017)
- Quad module performance from test beam (2018)
- Investigations of the 8 quad detector (2020)



Schematic View of GridPix based PID Detector

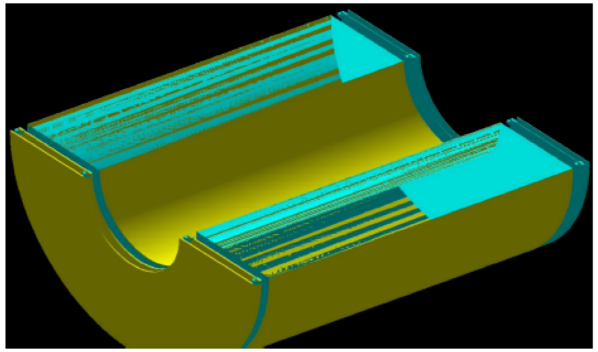
Ultimate dE/dx Device

- Avalanche grid in front of 55 x 55 μm2 pixels.
- Greater than 90% efficiency for single electrons.

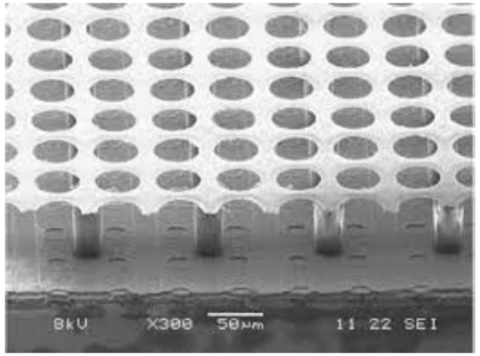
Goal:

- Enough diffusion to get every electron into a different hole
- Count electrons one-by-one.

- Three generations of development and continuing.
- Large area is VERY expensive, but this proposal is small area.



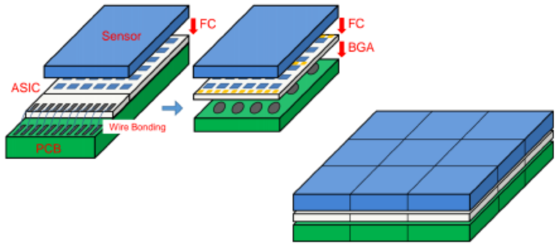
Preliminary Geometry in GEANT



SEM image of an InGrid

4-sided buttable pixel arrangement

- Model 4 replaces wires bond with bump bond (improves active area) (93.7% -> 99.5% active area)
- DAQ interface by Through-Silicon-Vias (TSV).



Current Group Members:

Tom Hemmick, Klaus Dehmelt, Sanghwa Park, Prakhar Garg (SBU)
Nikolai Smirnov (Yale)
Jochen Kaminski (Bonn)

HPDIRC FEATURES

Concept:

- Fast focusing DIRC, utilizing high-resolution 3D (x,y,t) reconstruction
- Innovative 3-layer spherical lenses, compact fused silica expansion volumes
- Fast photon detection using small-pixel MCP-PMTs *(eRD14)* and high-density readout electronics *(eRD14)*

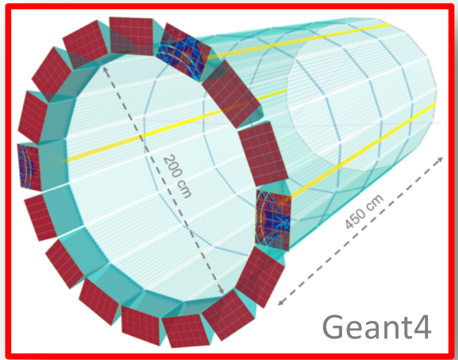
Excellent performance over wide angular range:

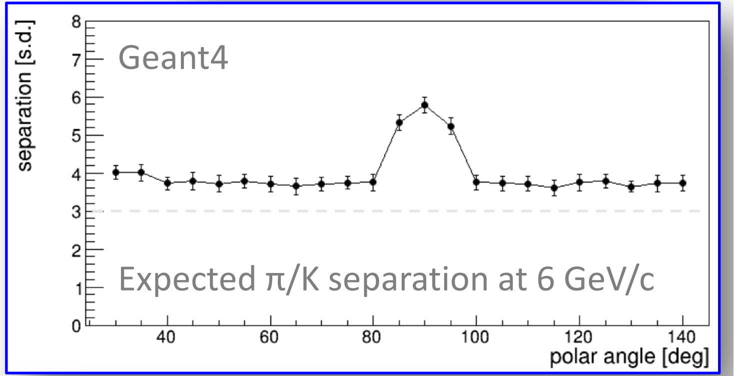
- ≥ 3 s.d. π/K up to 6 GeV/c, ≥ 3 s.d. e/π up to ~1.2 GeV/c
- Low momentum π/K identification in "veto mode" down to 0.2-0.3 GeV/c

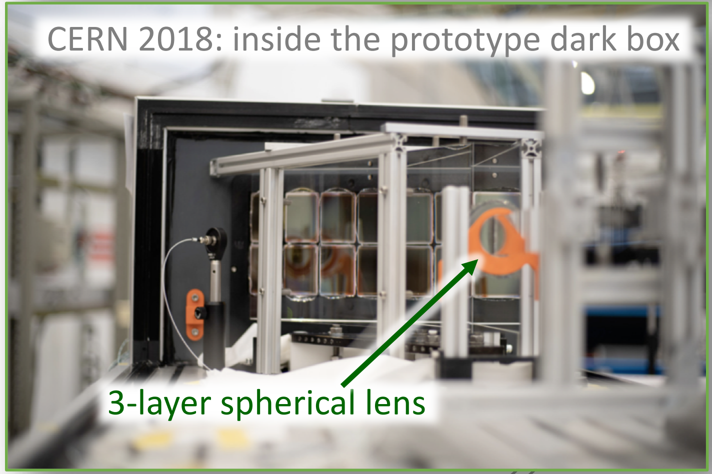
Features:

- **Radially compact** (8-10 cm; impact on cost of post-DIRC systems)
- **Flexible design** (to deal with sensor in B-field and detector integration)
- **Low demand on detector infrastructure** (no cryogenic cooling, no flammable gases)
- **R&D at advanced stage** (PID performance estimate based on test beam results, excellent agreement between detailed simulation and prototype data, fast simulation available)

Involved institutions: CUA, GSI, BNL, W&M, USC, SBU, UH, JLab, ODU







dRICh Overview

Radiators:

- Aerogel: 4 cm, $n_{(400nm)}$~1.02 + 3 mm acrylic filter
- Gas: 1.6m (1.1m ePHENIX), n_{C2F6}~1.0008

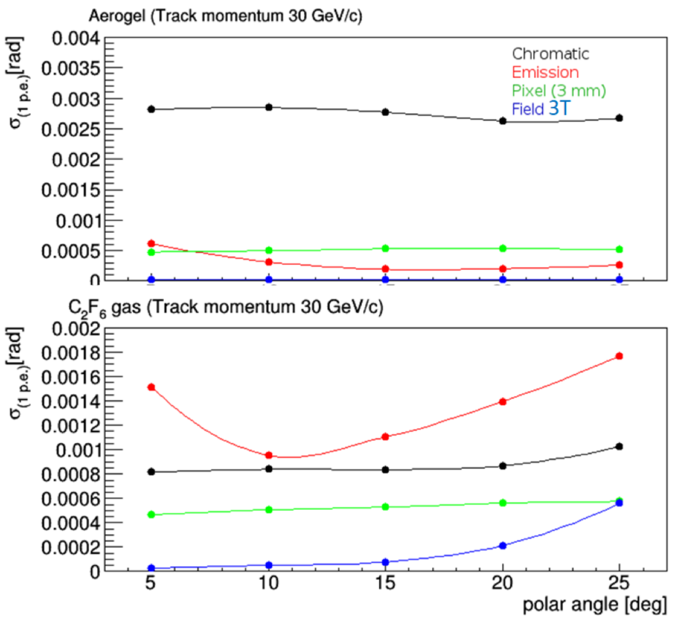
6 Identical Open Sectors (Petals):

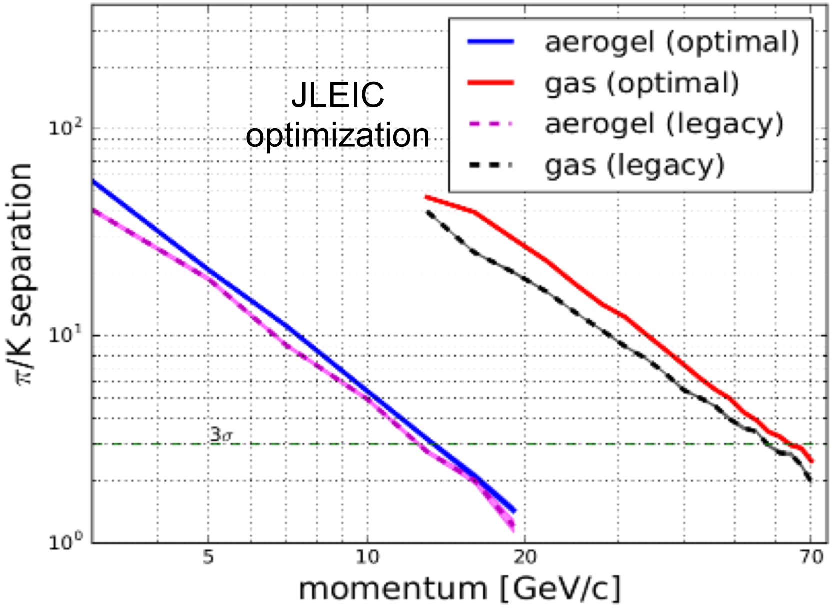
- Large Focusing Mirror with R ~2.9m (~2.0m ePHENIX)
- Optical sensor elements: ~4500 cm²/sector, 3 mm pixel size, UV sensitive, out of charged particles acceptance

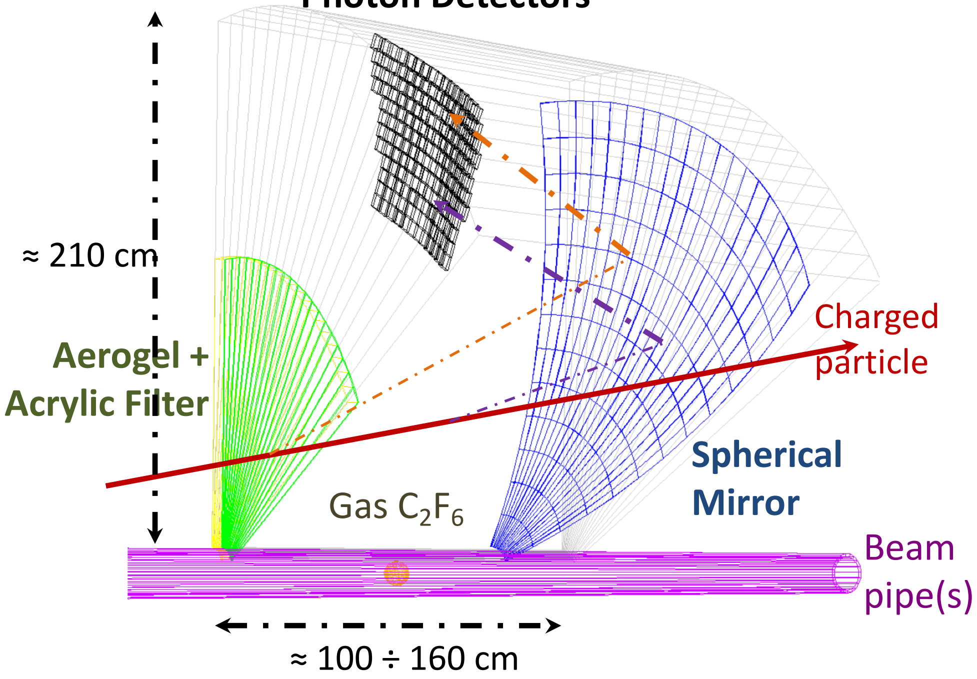
Optimized for JLEIC, preliminary implementation in ePHENIX

Phase Space:
- Polar angle: 5-25 deg
- Momentum: 3-50 GeV/c

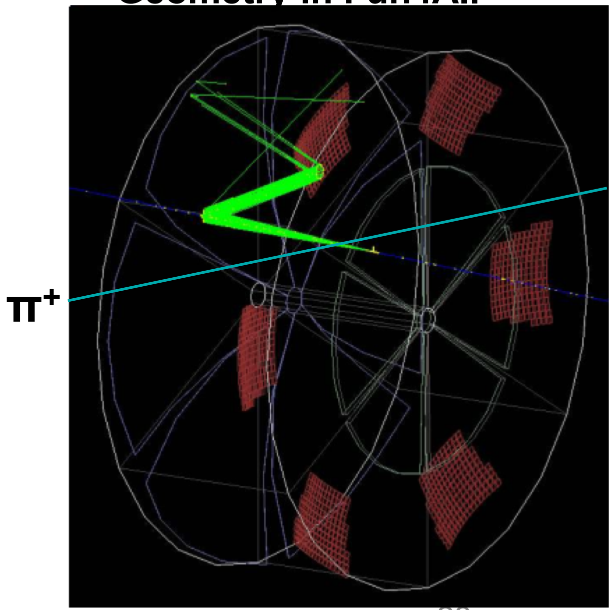
Typical contributions to angular errors





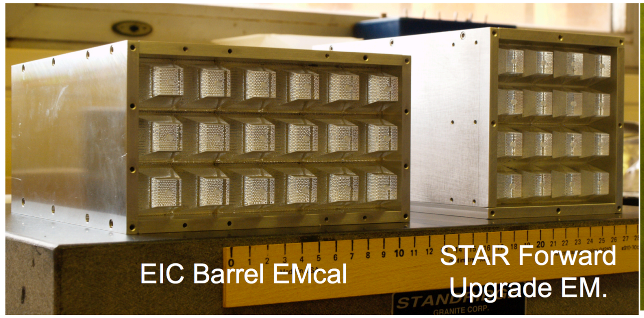


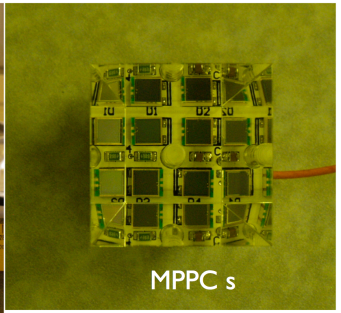
Geometry in Fun4All



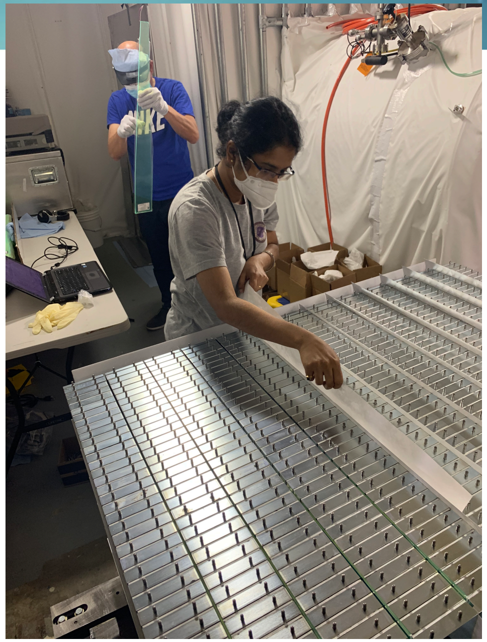
ATHENA Calorimetry at a glance.

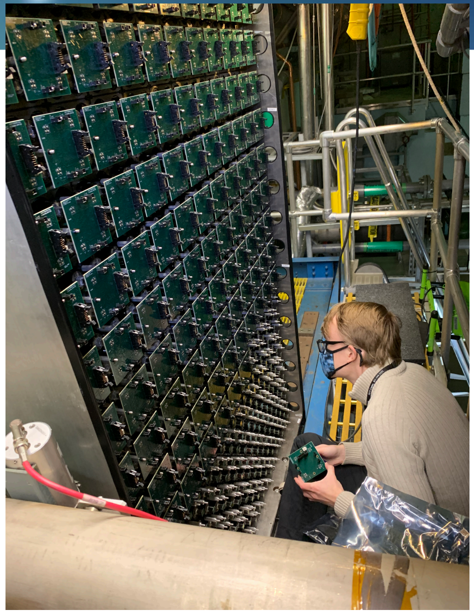
- High Resolution EndCaps.
- Technologies developed during EIC generic detector R&D. Well established and spread in the EIC users community.
- Barrel Calorimeters – being optimized, depends on design of the new SC magnet.





- WScFI EM section of Hadron EndCap.
- Technology pioneered at UCLA.
- Very Compact with good EM resolution.
- Similar technology now used in construction of sPHENIX emcal.

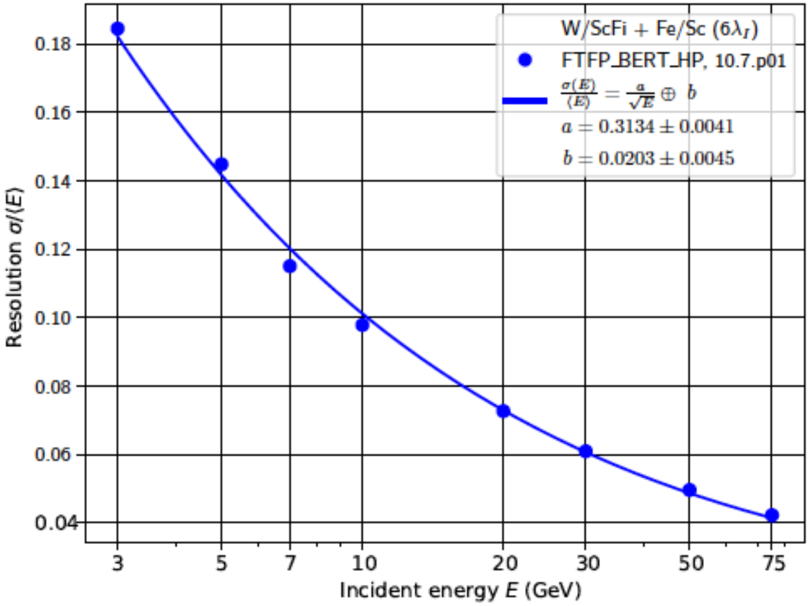




STAR Forward Calorimeter System.

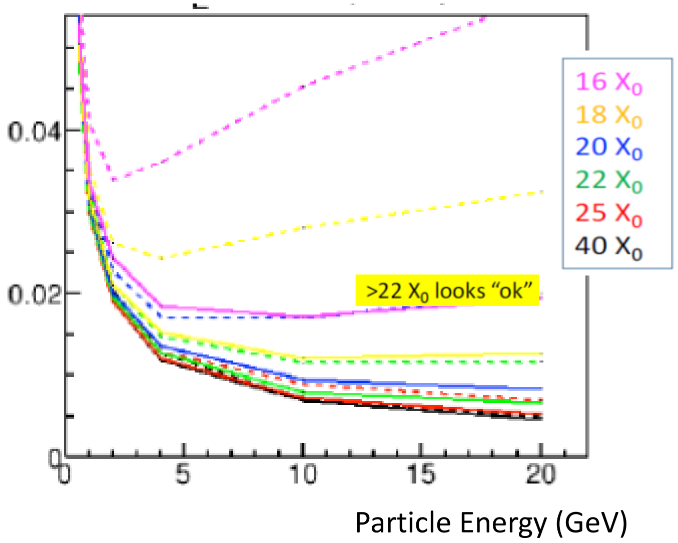
Constructed in 2020 with new, very efficient method.

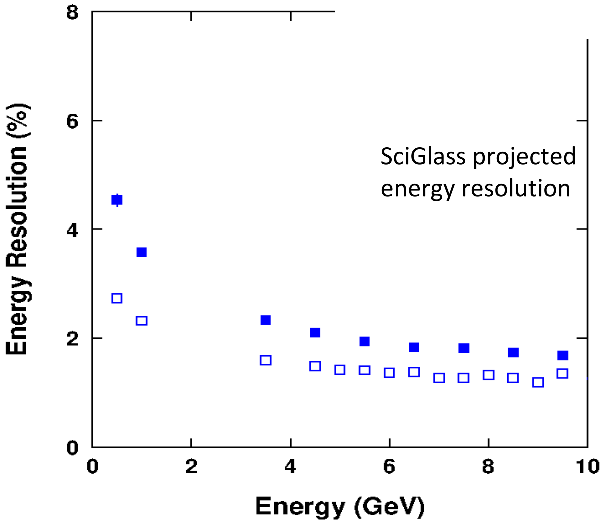
HCal Fe/Sc, similar technology for EIC reference detector.



Expected performance of ATHENA hadron endcap (improved version of STAR FCS)

High resolution electron arm ECAL. EEEmCal.



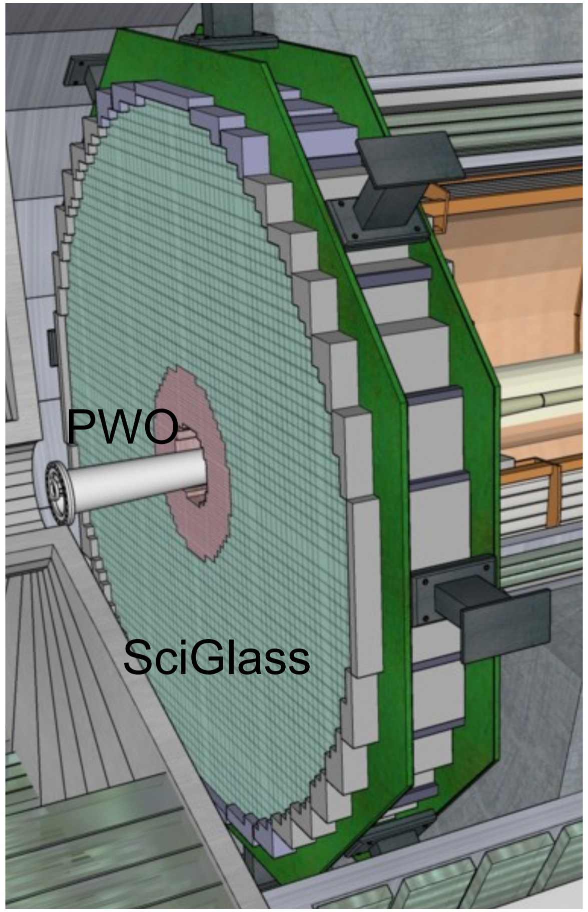


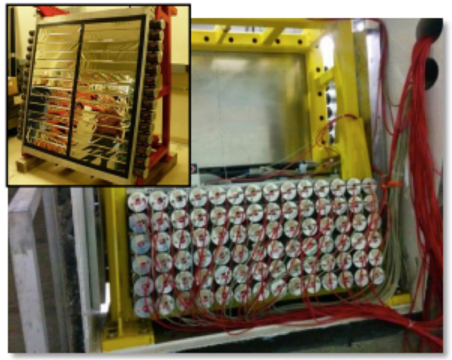
PbWO4 crystals (inner)

- compact, radiation hard, luminescence yield to achieve high energy resolution, including the lowest photon energies
- Sensor: SiPMs (TBC)

SciGlass (outer)

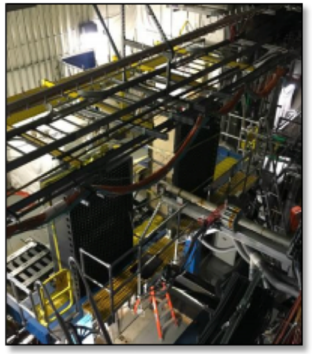
- EIC eRD1
- radiation hard, luminescence yield similar or better than crystals depending on longitudinal length
- Sensor: SiPMs (TBC)





SHMS EMCal: 28 TF-1 (preshower) and 224 F-101 (shower) blocks

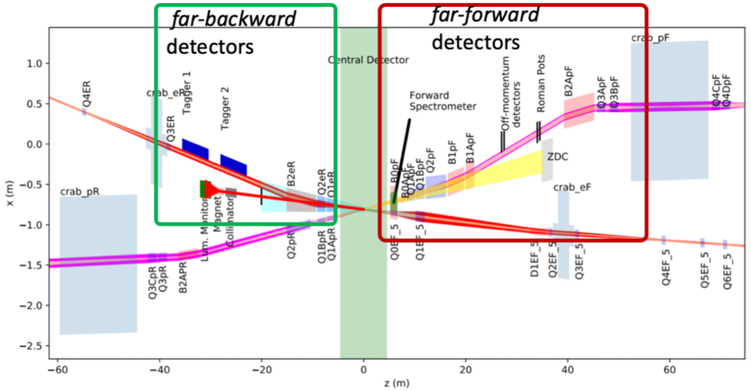
NPS: 1080 $PbWO_4$ (CRYTUR, SICCAS)



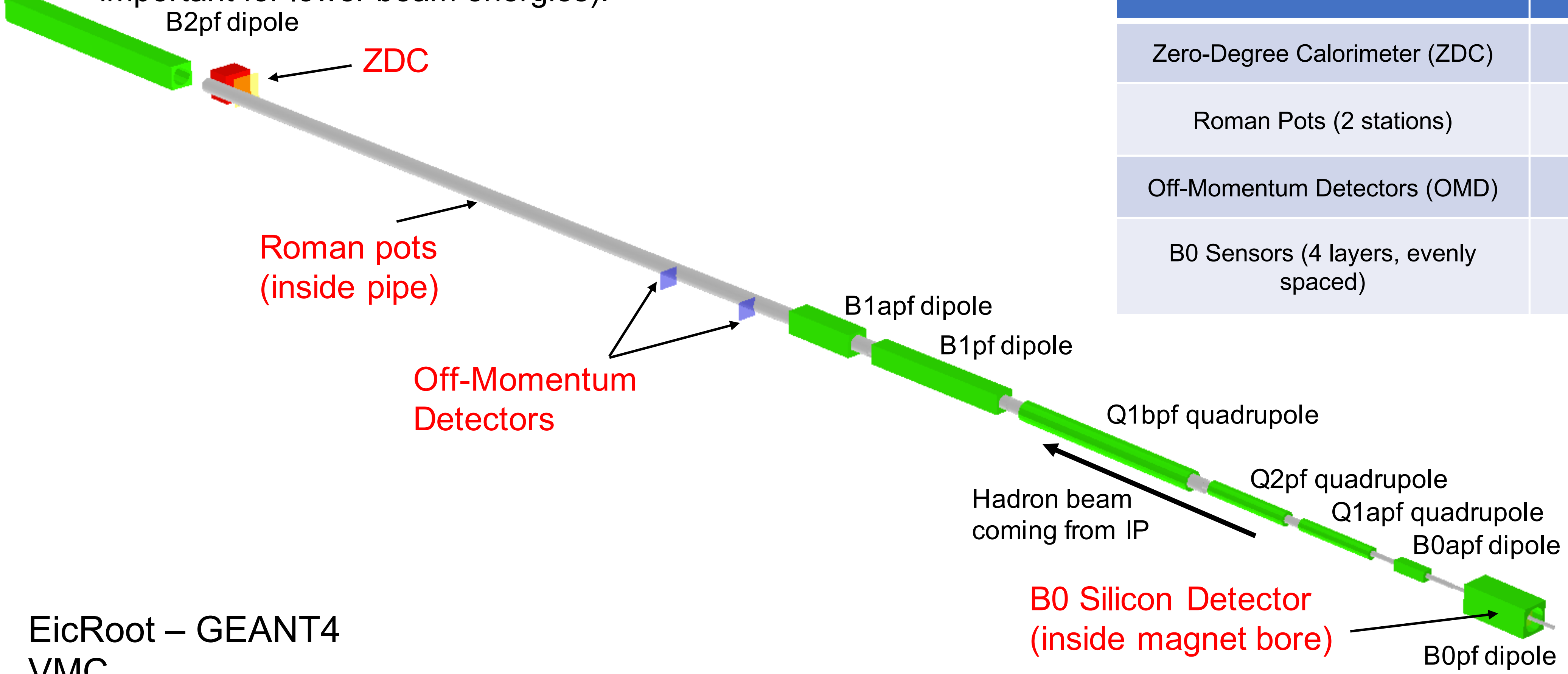
STAR: installed ECAL of the forward upgrade

ATHENA Far-Forward Detectors

- Roman pots and ZDC cover the normal diffractive proton tagging and neutron/photon tagging from nuclear breakup.
- OMD required for tagging protons and pions from nuclear breakup and lambda since they will have a different magnetic rigidity in the beamline than the beam itself.
- B0 required for tagging protons at higher angles (especially important for lower beam energies).



Detector	Acceptance
Zero-Degree Calorimeter (ZDC)	$\boldsymbol{\theta} < 5.5$ mrad ($\eta > 6$)
Roman Pots (2 stations)	0.0* $< \boldsymbol{\theta} < 5.0$ mrad ($\eta > 6$) (*depends on beam optics)
Off-Momentum Detectors (OMD)	$0.0 < \boldsymbol{\theta} < 5.0$ mrad ($\eta > 6$)
B0 Sensors (4 layers, evenly spaced)	$5.5 < \boldsymbol{\theta} < 20.0$ mrad ($4.6 < \eta < 5.9$)



EicRoot – GEANT4 VMC

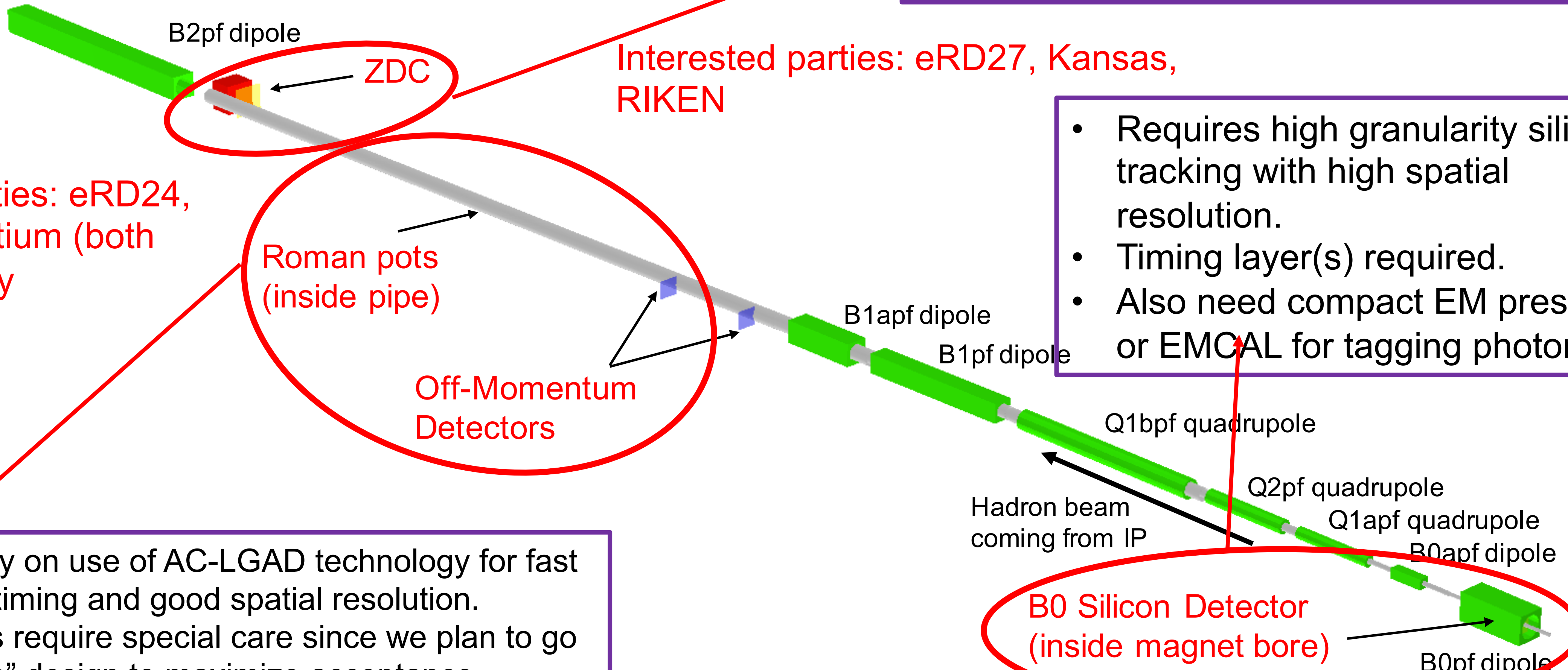
ATHENA Far-Forward Detectors

- Combination EMCAL and HCAL with high granularity and resolution.
- Design starting point is ALICE FoCal.

Interested parties: eRD27, Kansas, RIKEN

- Requires high granularity silicon tracking with high spatial resolution.
- Timing layer(s) required.
- Also need compact EM preshower or EMCAL for tagging photons.

Interested parties: eRD24, LGAD Consortium (both comprise many institutions)

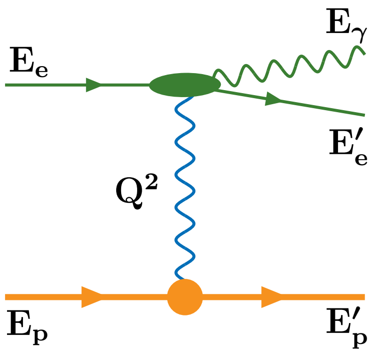


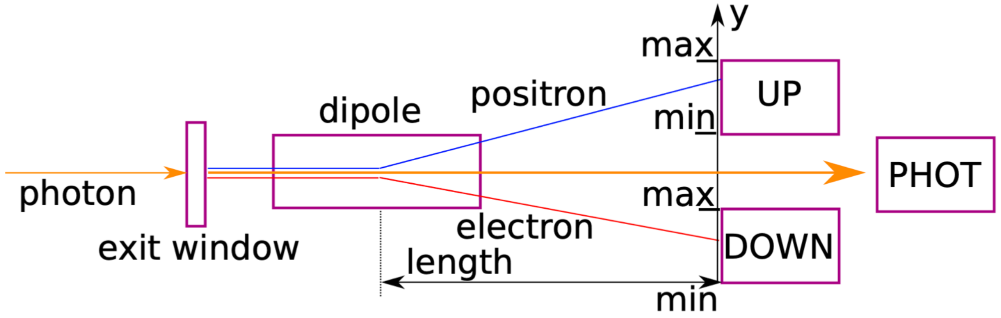
- Both can rely on use of AC-LGAD technology for fast (~20-30ps) timing and good spatial resolution.
- Roman Pots require special care since we plan to go with “potless” design to maximize acceptance.

Interested parties: LANL, and others

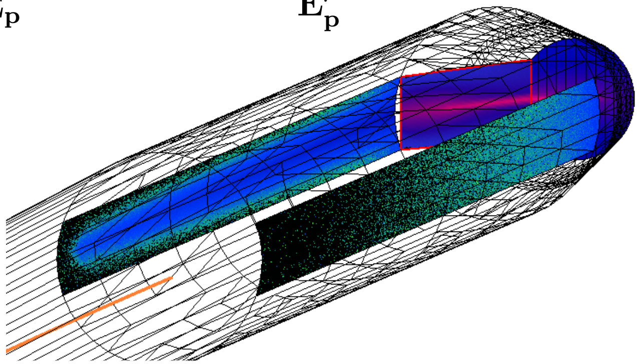
ATHENA Far-Backward Detectors

We aim to measure the EIC luminosity with a precision better than 1% using the electron-ion bremsstrahlung:



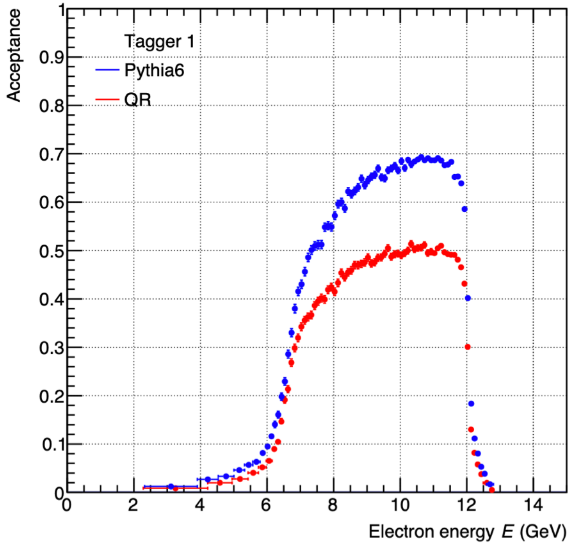


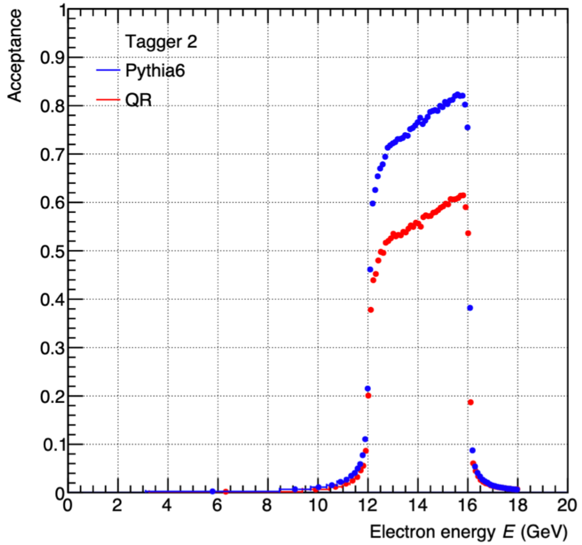
Dedicated detectors will measure "zero-degree" photons, and the design effort started from the challenging design of the photon exit window, hit by a SR fan.



See more about the EIC luminosity measurement later this morning: https://indico.bnl.gov/event/11322/#day-2021-06-09

A fraction of the scattered electrons in bremsstrahlung will be measured too, and the electron detectors will also be used to tag low-Q^2 Events (photoproduction) in ATHENA:



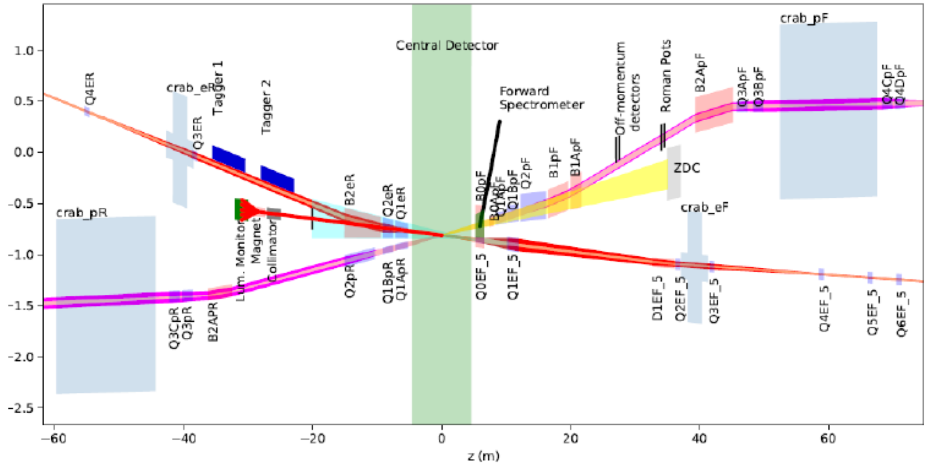


Interested groups in this ATHENA project:

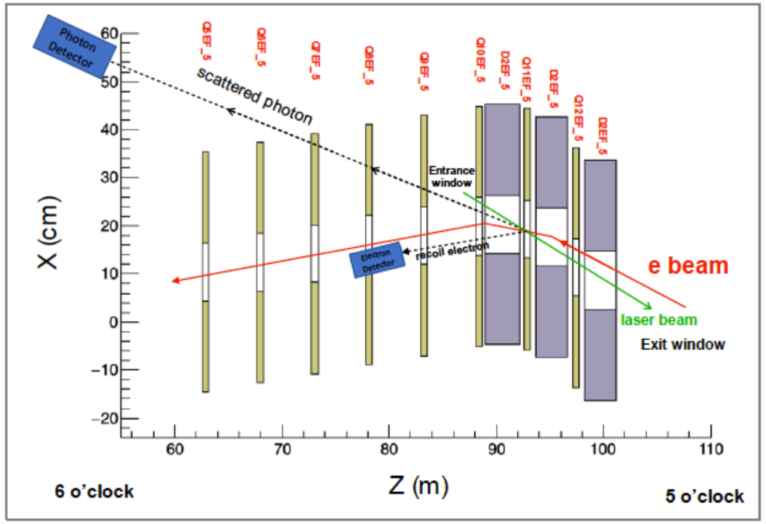
AGH UST (Kraków),
BNL, Glasgow Univ.,
IFJ PAN (Kraków),
Temple Univ.

Polarimetry (joint with EICUG WG)

- **Hadron Polarimeter at IP6 (elastic recoil)**
- pC for relative polarimetry
- Inside of spin rotators / crab cavities
- Confirmation of polarization vector (start of fill)
- Polarization bunch profile (after crab rotation)
- Ultra-thin Carbon fiber targets may not be suitable for high bunch repetition rate at EIC



- **Electron Polarimeter at IP6 (Compton scattering)**
- Backscattered photon needs feedthrough for some magnets
- Available acceptance, effect of beam pipe/exit window
- Cross talk between longitudinal/transverse asymmetries



EIC UG working group on polarimetry/luminosity

https://indico.bnl.gov/category/280/

Monthly meetings → higher frequency for proposal specific topics

Software & Computing WG

Bi-weekly software meeting: Thursday 12:00pm EDT

Software & Computing Conveners:

Whitney Armstrong, Andrea Bressan(*), Wouter Deconinck, Sylvester Joosten, Dmitry Romanov

(*)- liaison to EICUG software group

Day 0 WG support:

Kolja Kauder, Miguel Arratia, Stephen Sekula, Dmitry Romanov, Yulia Furletova, Andrea Bressan

Full simulation/reconstruction team

Whitney Armstrong, Miguel Arratia, Wouter Deconinck, Sylvester Joosten, Jihee Kim, Chao Peng, Tomas Polakovic, Dmitry Romanov, Marshall Scott, Zhenyu Ye, Ziyue Zhang, Maria Żurek

...and a rapidly growing amount ATHENA collaborators!

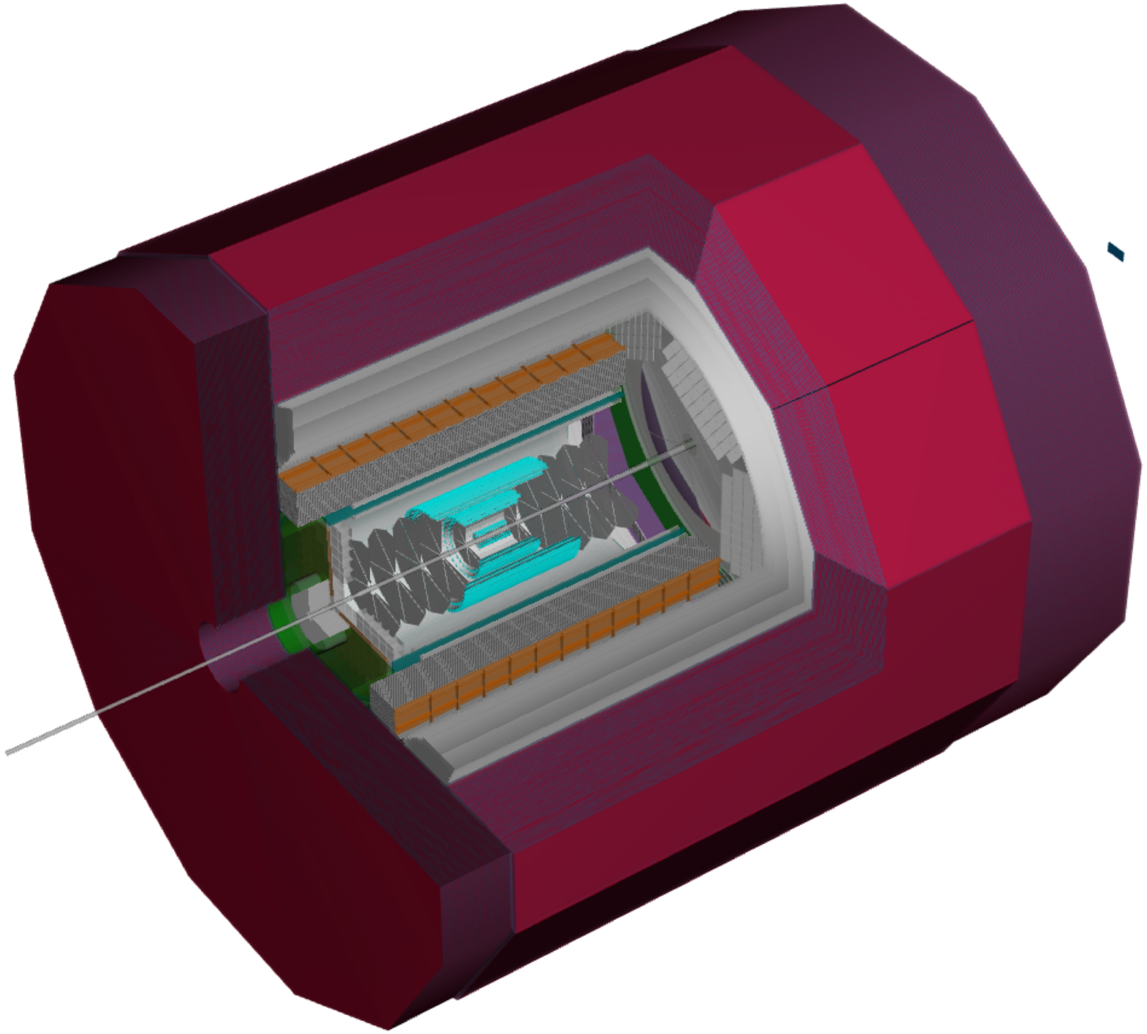
User support and documentation

Documentation portal:
doc.athena-eic.org

Full simulation tutorial

eic-ip6-software-l@lists.bnl.gov

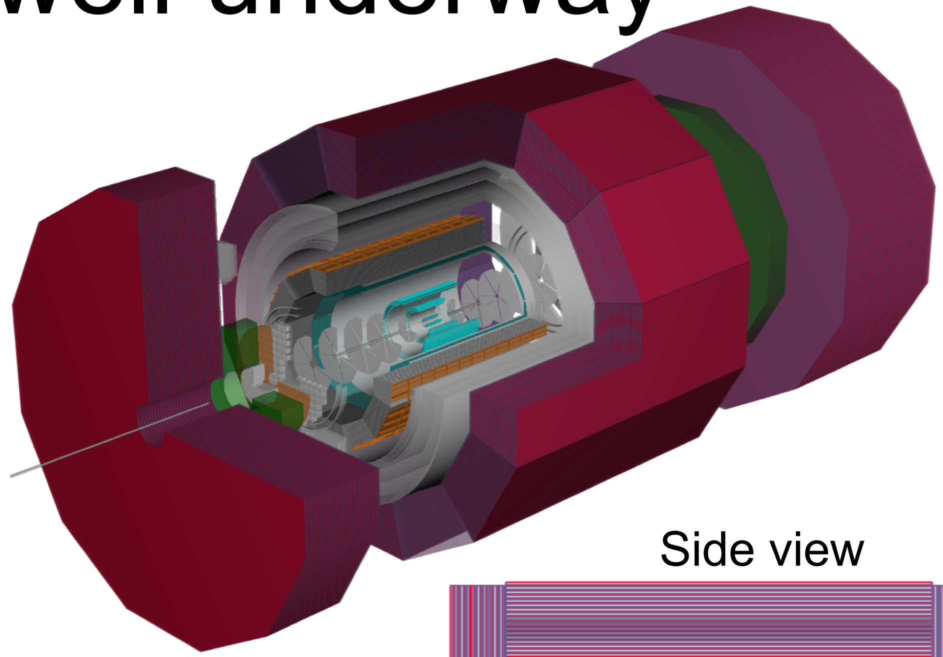
#software-helpdesk at Slack



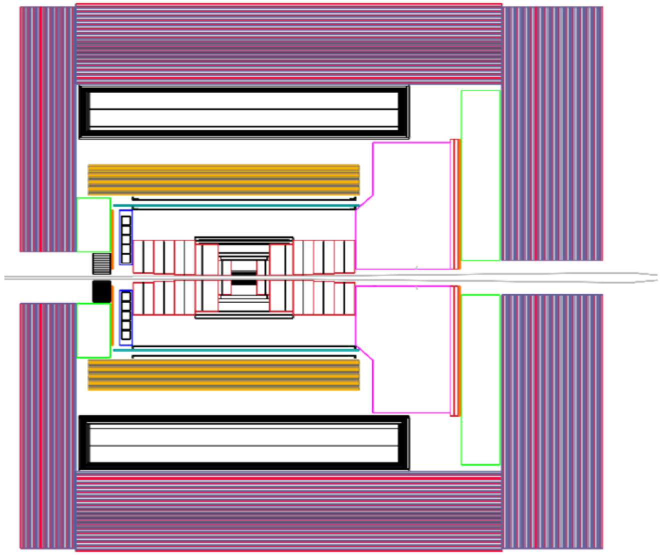
ATHENA central detector

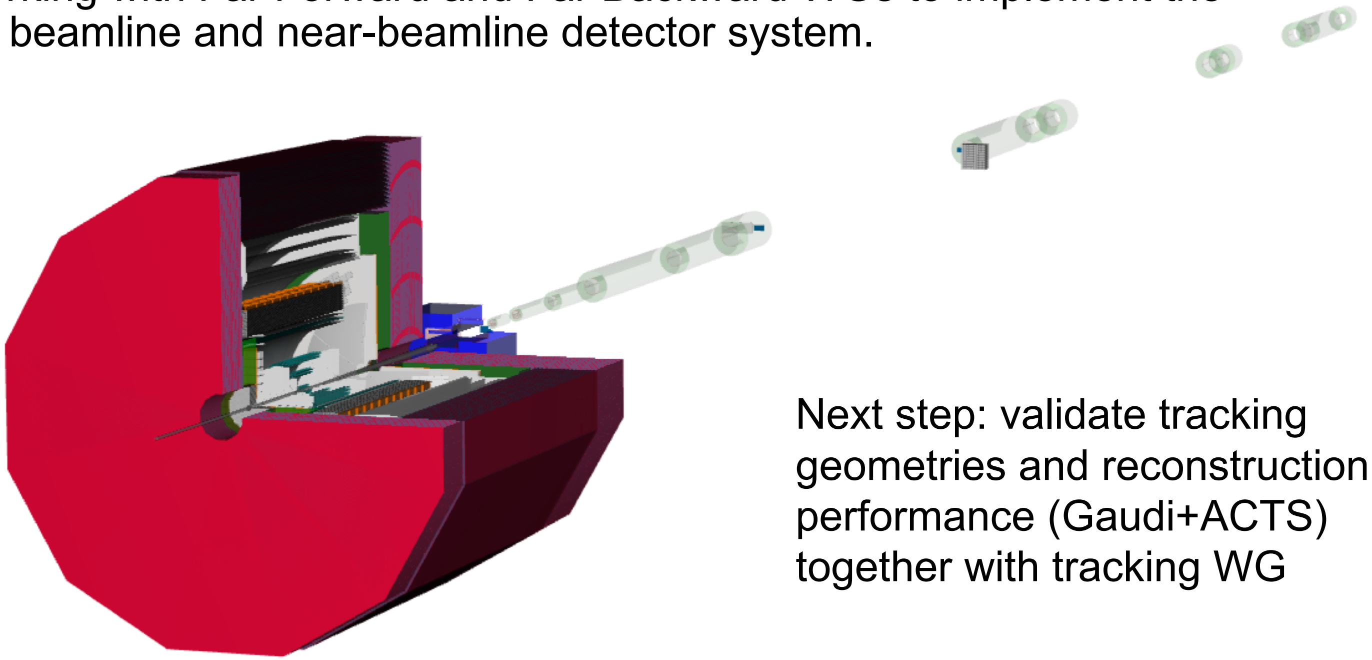
[ATHENA detector](#) implementation well underway

- Full geometry based on reference detector implemented in DD4hep
- Reasonable detail in central detector tracking
  - Detailed geometry and services for silicon tracker
  - µRWEL detectors around the DIRC
  - TRD in forward region
  - Various ECAL and HCAL options with support structures
  - Latest Solenoid geometry and beamline setup
- Working with PID working group to enhance implementations of dRICH, mRICH and DIRC systems.
- Working with Far Forward and Far Backward WGs to implement the full beamline and near-beamline detector system.



Side view





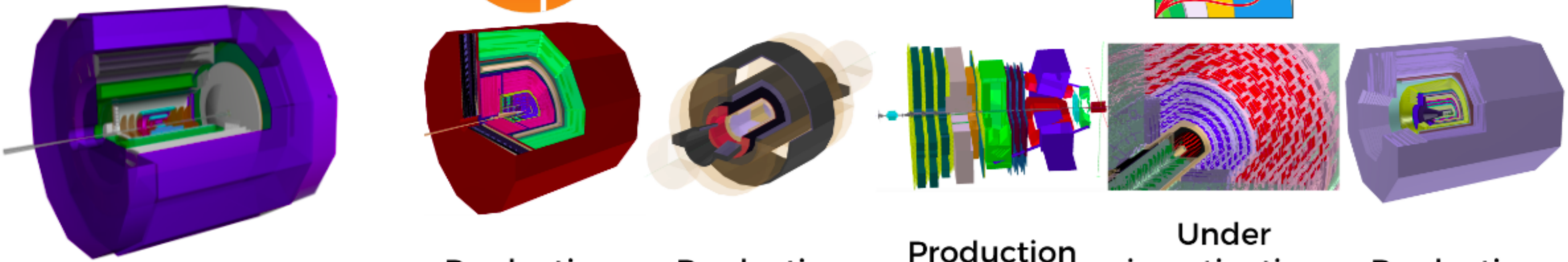
Detector and FF beamline

Next step: validate tracking geometries and reconstruction performance (Gaudi+ACTS) together with tracking WG

The DD4HEP community

ATHENA@EIC

Super Charm Tau Factories



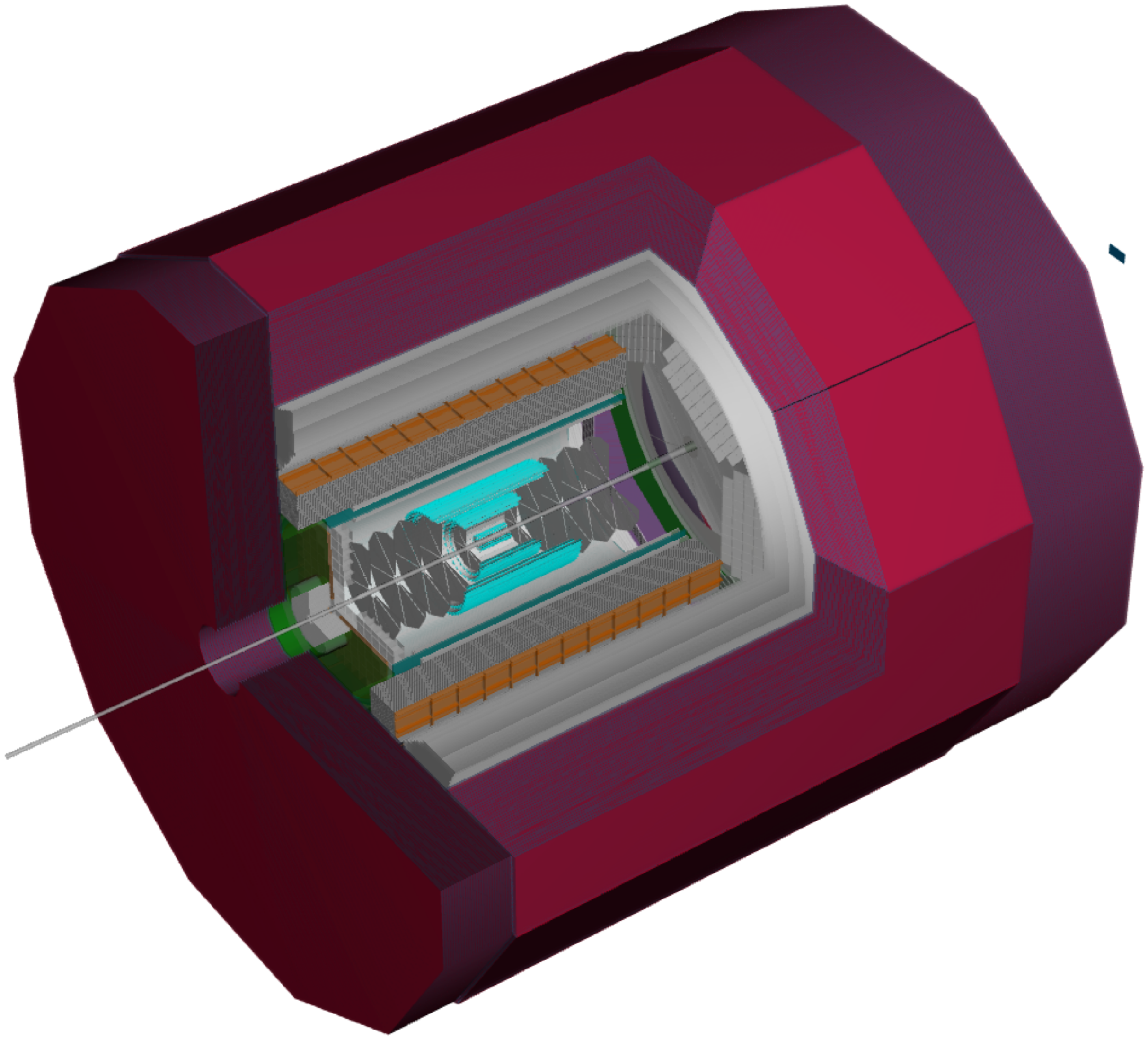
Production | Production | Production Run 3 | Under investigation Run 3 | Production

“framework for providing a complete solution for full detector description (geometry, materials, visualization, readout, alignment, calibration, etc.)”

Summary

- ATHENA is international pre-collaboration, currently includes 94 institutions
- To join: send email to eic-ip6-org-l@lists.bnl.gov
- Stay connected: subscribe to public mail eic-ip6-public-l@lists.bnl.gov or join Slack: link
  or webpage https://athena-eic.org/meetings-and-events/
- ATHENA detector
  - ✓ It is based on the EICUG reference detector
  - ✓ The Yellow Report physics studies show that it meets the requirements
  - ✓ A new 3 T magnet matching this configuration is being designed.
  - ✓ The detector includes a variety of different technologies for tracking, calorimetry, particle identification and ancillary detectors along the beam line
  - ✓ The technology choice is largely determined by the EIC Detector R&D Program
- A concrete configuration will be defined shortly in the detector proposal drafting process, based on the groups joining the effort, within the available cost range
- The detailed Geant4 simulations will be conducted for this coherent detector setup (DD4HEP implementation)

Thank you !



Backup

Vertex/tracking performance

Results from the YR studies compared with PWG performance summary:

all-silicon

Tracking performance (All-silicon concept, B = 3 T)						
			Momentum res.		Transverse pointing res.	
η			Performance	Requirements	Performance	Requirements
-3.5 to -3.0	Central Detector	Backward Detector	σp/p ~ 0.1%×p ⊕ 2%	σp/p ~ 0.1%×p ⊕ 0.5%	dca(xy) ~ 60/pT μm ⊕ 20 μm	
-3.0 to -2.5						dca(xy) ~ 30/pT μm ⊕ 40 μm
-2.5 to -2.0			σp/p ~ 0.02%×p ⊕ 1%	σp/p ~ 0.05%×p ⊕ 0.5%	dca(xy) ~ 40/pT μm ⊕ 10 μm	dca(xy) ~ 30/pT μm ⊕ 20 μm
-2.0 to -1.5						
-1.5 to -1.0						
-1.0 to -0.5		Barrel	σp/p ~ 0.02%×p ⊕ 0.5%	σp/p ~ 0.05%×p ⊕ 0.5%	dca(xy) ~ 30/pT μm ⊕ 5 μm	dca(xy) ~ 20/pT μm ⊕ 5 μm
-0.5 to 0						
0 to 0.5						
0.5 to 1.0						
1.0 to 1.5		Forward Detector	σp/p ~ 0.02%×p ⊕ 1%	σp/p ~ 0.05%×p ⊕ 1%	dca(xy) ~ 40/pT μm ⊕ 10 μm	dca(xy) ~ 30/pT μm ⊕ 20 μm
1.5 to 2.0						
2.0 to 2.5						
2.5 to 3.0			σp/p ~ 0.1%×p ⊕ 2%	σp/p ~ 0.1%×p ⊕ 2%	dca(xy) ~ 60/pT μm ⊕ 20 μm	dca(xy) ~ 30/pT μm ⊕ 40 μm
3.0 to 3.5						dca(xy) ~ 30/pT μm ⊕ 60 μm

Hybrid (Si+TPC)

Tracking performance (Hybrid concept, B = 3 T)								
			Momentum res.		Minimum pT		Transverse pointing res.	
η			Performance	Requirements	Performance	Requirements	Performance	Requirements
-3.5 to -3.0	Central Detector	Backward Detector	σp/p ~ 0.05%×p ⊕ 2%	σp/p ~ 0.1%×p ⊕ 0.5%		100-150 MeV/c	dca(xy) ~ 50/pT μm ⊕ 10 μm	
-3.0 to -2.5					160-220 MeV/c	100-150 MeV/c		dca(xy) ~ 30/pT μm ⊕ 40 μm
-2.5 to -2.0			σp/p ~ 0.11%×p ⊕ 0.4% (0-8 GeV/c) σp/p ~ 0.04%×p ⊕ 1% (8-30 GeV/c)	σp/p ~ 0.05%×p ⊕ 0.5%		100-150 MeV/c	dca(xy) ~ 25/pT μm ⊕ 3 μm	dca(xy) ~ 30/pT μm ⊕ 20 μm
-2.0 to -1.5						100-150 MeV/c		
-1.5 to -1.0					300 MeV/c	100-150 MeV/c		
-1.0 to -0.5		Barrel	σp/p ~ 0.11%×p ⊕ 0.2% (0-5 GeV/c) σp/p ~ 0.03%×p ⊕ 0.5% (5-30 GeV/c)	σp/p ~ 0.05%×p ⊕ 0.5%	400 MeV/c (90% acceptance)	100-150 MeV/c	dca(xy) ~ 15/pT μm ⊕ 2 μm	dca(xy) ~ 20/pT μm ⊕ 5 μm
-0.5 to 0								
0 to 0.5								
0.5 to 1.0								
1.0 to 1.5		Forward Detector	σp/p ~ 0.11%×p ⊕ 0.4% (0-8 GeV/c) σp/p ~ 0.04%×p ⊕ 1% (8-30 GeV/c)	σp/p ~ 0.05%×p ⊕ 1%	300 MeV/c	100-150 MeV/c	dca(xy) ~ 25/pT μm ⊕ 3 μm	dca(xy) ~ 30/pT μm ⊕ 20 μm
1.5 to 2.0					160-220 MeV/c	100-150 MeV/c		
2.0 to 2.5						100-150 MeV/c		
2.5 to 3.0			σp/p ~ 0.05%×p ⊕ 2%	σp/p ~ 0.1%×p ⊕ 2%		100-150 MeV/c	dca(xy) ~ 50/pT μm ⊕ 10 μm	dca(xy) ~ 30/pT μm ⊕ 40 μm
3.0 to 3.5						100-150 MeV/c		dca(xy) ~ 30/pT μm ⊕ 60 μm