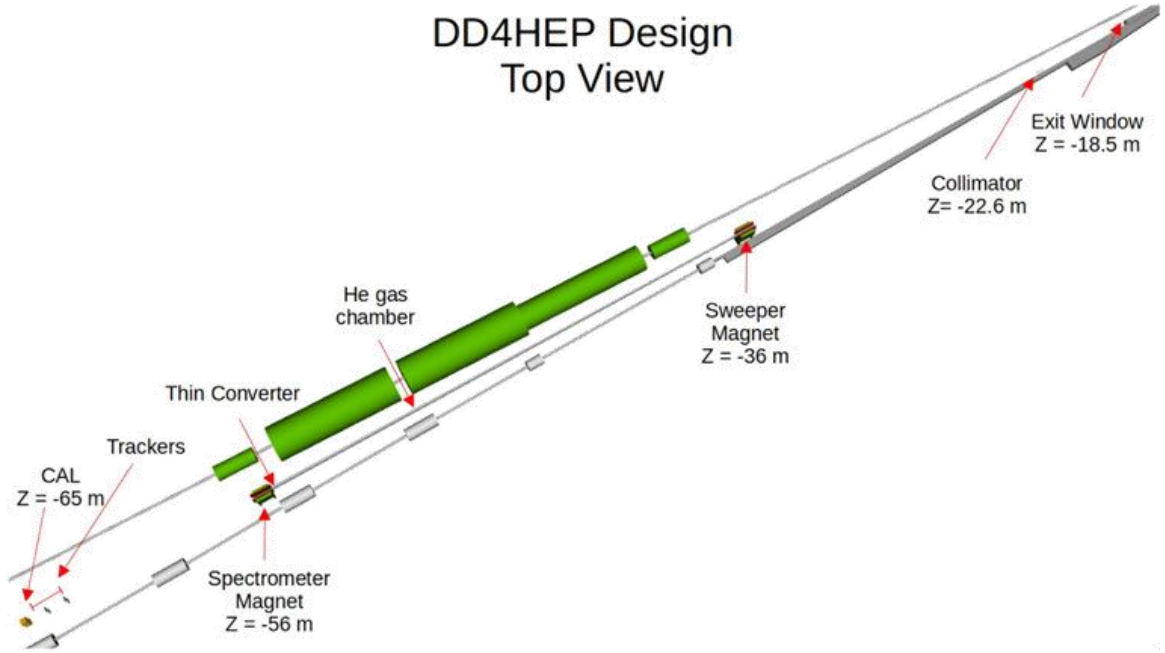
DETECTOR SUBSYSTEM COLLABORATIONS

- DSC representatives
- Technical Integration Council Meeting
- April 28, 2023

Far Backward Pair Spectrometer Detector Collaboration

Designed to measure the luminosity via Bremsstrahlung photon conversions (e+e-) on a thin conversion foil. System composed of:

- Sweeper and Analysing Magnet
- Conversion foil
- He/Vacuum Chamber
- Trackers
- Calorimeters



The detector will provide complementary information needed for the precise luminosity determination (1% on absolute and 10^{-4} for relative).

Far Backward Pair Spectrometer Detector Collaboration

Subsystem Structure:

- Leader: Nick Zachariou (UoY)
- Technical Leader: Dhevan Gangadharan (UoH)
- Advisors and Collaborators: Bill Schmidke (BNL), Stephen Kay (UoY), Igor Korover(MIT), Georgios Krintiras (KU), Dan Watts(UoY), Mikhail Bashkanov(UoY), Aranya Giri(UoH), Alex Smith(UoY), Jaroslav Adam, Krzysztof Piotrzkowski.

Weekly meetings: Tuesday at 10 am ET.

Wiki page: https://wiki.bnl.gov/EPIC/index.php?title=Luminosity_Pair_Spectrometer

Extensive task list and investigations underway. Priority in technology of choice of Calorimeter design, tracker optimisation and technology, and optimisation of detector placement and magnetic fields of analysing and sweeping magnets.

(FB) High Rate Calorimeter DSC

DSC composition: Y. Ali, A. Kowalewska, K. Piotrzkowski-DSL/DSTL, M. Przybycien (AGH); J. Chwastowski (IFJ); J. Nam (Temple), I. Korover (MIT); N. Zachariou (x-link to Pair Spectrometer DSC); J. Adam (x-link to High Rate Tracker DSC)

This DSC is part of *FarBackward consortium* and is dedicated to design of calorimeters for detection of brems-strahlung direct photons and low-Q^2 electrons, which will have to face event rates (well) in excess of 100 MHz.

The baseline **fiber/tungsten spaghetti calorimeters** are being studied in Monte Carlo simulations to assess the required radiation hardness of fibers (scintillator vs. fused silica) as well as to determine channel occupancies. In addition, fiber size and spacing will be selected to get optimal detector performances.

Impact of direct and secondary synchrotron radiation (SR) is also being investigated – that will allow to propose set of optimal SR filters (graphite vs. lead) as well as SR monitoring devices.

In Fall we will be ready to propose tentative calorimeter (conceptual) designs including associated photosensors, and this in turn will allow to tentatively propose readout electronics in concertation with two other FB DSCs.

ePIC, fECal DSC

- Chinese Universities Consortia (Fudan University, Shandong University, South China Normal University, Tsinghua University)
- University of California EIC Consortium (UCLA, UCR)
- IUCF
- BNL

DSL - Huan Z. Huang (UCLA), Oleg Tsai (UCLA/BNL)
DSTC – O. Tsai

Groups has extensive expertise and capabilities in executing large scale project in high energy and nuclear physics experiments around the world. (RHIC, JLab, CERN, Super KEKB).

Including recently built forward calorimetry systems for STAR and participating in sPHENIX WScFi barrel Ecal construction (same technology for fECal).

Participating Institution has extensive capabilities to curry large scale construction projects.

All are members of ongoing ePIC R&Ds. All groups are in eRD106 (fECal), and some are members of related R&D projects eRD109 and eRD110.

FAR-FORWARD SUBSYSTEM COLLABORATIONS

- One Detector Subsystem lead for all subsystems: Alex Jentsch
- Three technical contacts:
  - Yuji Goto – Zero-Degree Calorimeter (goto@bnl.gov)
  - Zvi Citron – B0 Tracker + EMCAL (zhcitron@bgu.ac.il)
  - Alex Jentsch – Roman pots and Off-momentum detectors (ajentsch@bnl.gov)
- Cross-cutting FF + FB working group (for common integration issues): Nathaly Santiesteban and Simon Gardner.

- **Status summary**
  - All detector's primary technologies chosen.
  - Heavy focus on engineering design and integration (for B0, RP, and OMD); optimization of setup for ZDC (# of imaging layers, more uniformity in design to for compensation).
  - Impedance studies and iteration of engineering design (RP + OMD).
  - Support infrastructure and integration with accelerator magnet (B0).
  - Understanding of background and doses (B0 + ZDC, primarily).

AC-LGAD TIME-OF-FLIGHT DETECTOR

- **ePIC AC-LGAD TOF Detector System**
  - Barrel: 1 cm*500 um strips, ~10 m^2, ~2M channels
  - Forward: 500*500 um^2 pixels, ~1.4 m^2, ~6M channels
- **TOF Detector Working Group**
  - Convener: Constantin Loizides (ORNL), Frank Geurts (Rice), Wei Li (Rice), Zhenyu Ye (UIC)
  - DAQ contact: Tonko Ljubicic (BNL)
  - Simulation contact: Nicholas Schmidt (ORNL)
  - LGAD consortium, eRD109 (ASIC & Electronics), eRD112 (Sensor & Mechanics)
- **TOF Detector Subsystem Collaboration**
  - **Nominated for DSL and Deputy DSL**: Zhenyu Ye (UIC), Satoshi Yano (Hiroshima)
  - In the process of defining working groups/packages, and collect institutional interests/responsibilities
  - **Institutions**:
    - **USA**: Brookhaven National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Ohio State University, Purdue University, Rice University, University of California Santa Cruz, University of Illinois at Chicago
    - **Japan**: Hiroshima University, RIKEN, University of Tokyo
    - **India**: IIT Mandi, National Institute of Science Education and Research
    - **Taiwan**: National Central University, National Cheng Kung University, National Taiwan University
    - **China**: South China Normal University, University of Science and Technology of China

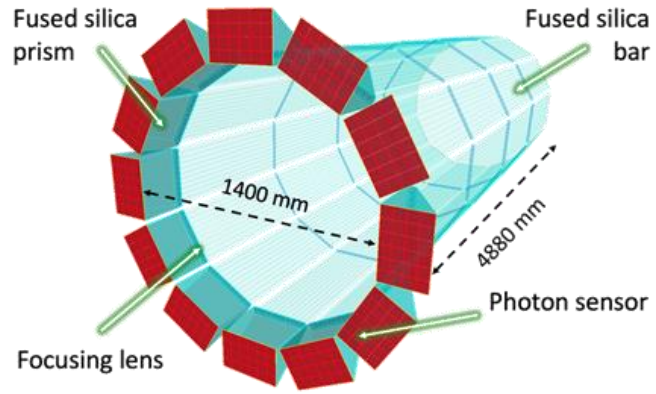
HPDIRC DSC

Kick-off meeting for hpDIRC DSC held last week

- Slides and recording available (next May 5th, 8:30 am EST*) (https://indico.bnl.gov/event/19338/)

What happened:

- Defined scope of hpDIRC DSC
  - Merging coordination of DIRC activities at EIC: hpDIRC DSC / eRD103 / EICGEN
- Discussed and started procedure for leadership nomination and voting (Finalized today)
- Scheduled bi-weekly DSC meetings
- Reviewed preliminary breakdown of projects
- Members introduced themself
- Defined priorities moving forward
- Announced hybrid DIRC@EIC Annual meeting in Jlab June 1-4th



Project Management

- Coordination hpDIRC efforts (DSL, deputy)
- ePIC liaisons (tracking, readout, software)
- TDR lead

Hardware

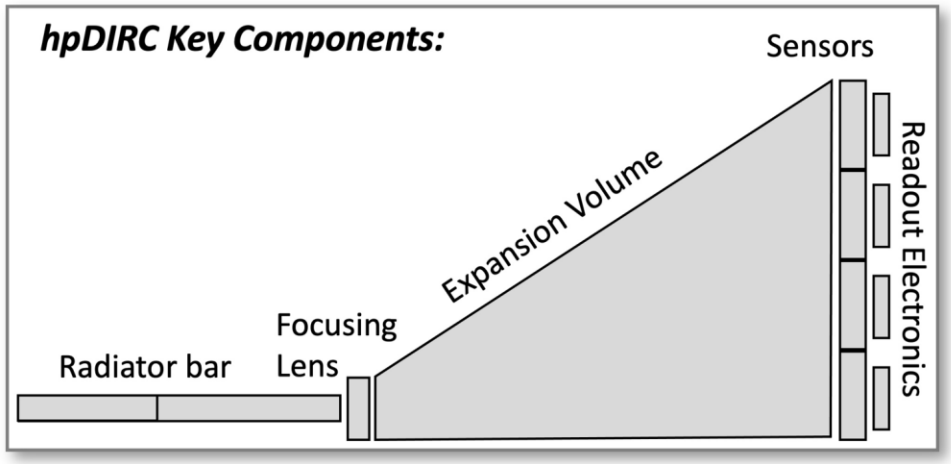
- Components R&D, purchase/production, and QA (optics, sensors, electronics)
- Mechanical Systems (design of housing and support structure; assuring integration, developing procedure for installation)
- Assembly of hpDIRC sections, installation, commissioning

Software

- Offline: simulations (DD4HEP, F4A, Standalone), reconstruction
- Online: FEE/DAQ, calibration, monitoring/slow control

What is happening:

- Reviewing and adjusting path to TDR readiness, locking design, construction, and installation (what and when)
- Reviewing committed, interested, and needed manpower
- Getting ready for PID review by EIC Project in July 2023



				Design & R&D								Production & Construction												Installation & Commissioning							
				2023				2024				2025				2026				2027				2028				2029				2030			
				Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
hpDIRC Workpackages (version 1)																																	
Project Management																																	
	hpDIRC Coordination (ePIC, eRD/EICGEN)																																
	Detector Subsystem Lead DSSL																																
	Detector Subsystem Contact DSSTC																																
	ePIC Liaisons																																
		Tracking																															
		Electronics, Readout, DAQ																															
		Software/Computing																															
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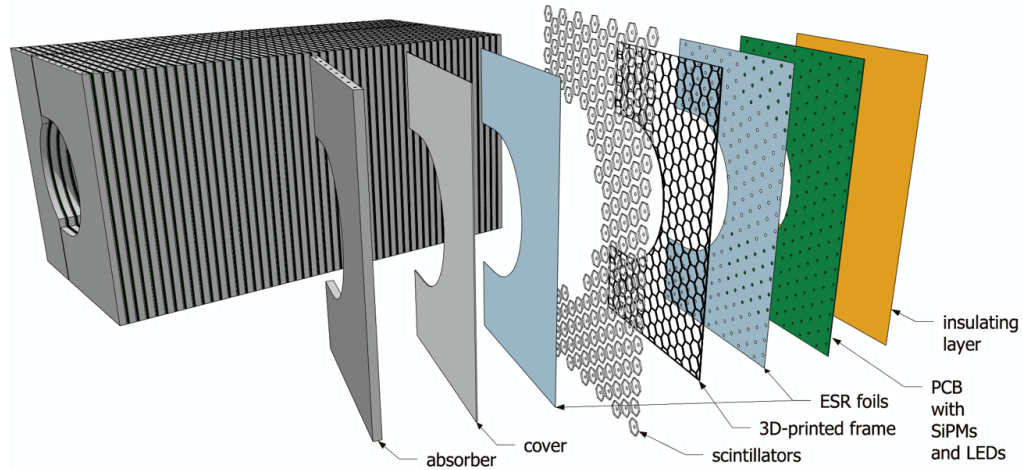
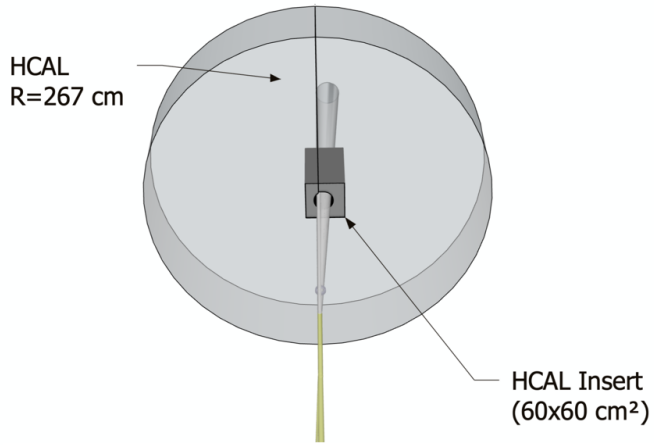
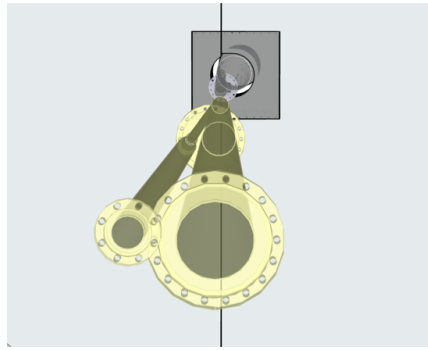
		Machine Learning Methods																															
		PID Algorithm																															
		Offline Calibration/Alignment																															
Hardware																																	
	Radiators																																
		BaBar Bars																															
		Properties/Specifications																															
		Series Production, Liaison																															
		QA																															
	Sensors																																
		eRD110/eRD109 liaison																															
		MCP-PMT R&D																															
		HRPPD R&D																															
		Series Production, Liaison																															
		QA																															
		Installation & Commissioning																															

The Calorimeter Insert for ePIC







Physics motivation similar to the HERA "plug" calorimeters:
Maximizes acceptance with high-granularity, covering 3<η<4, to improve measurement of event pT for inclusive DIS and jets.
Design key features:

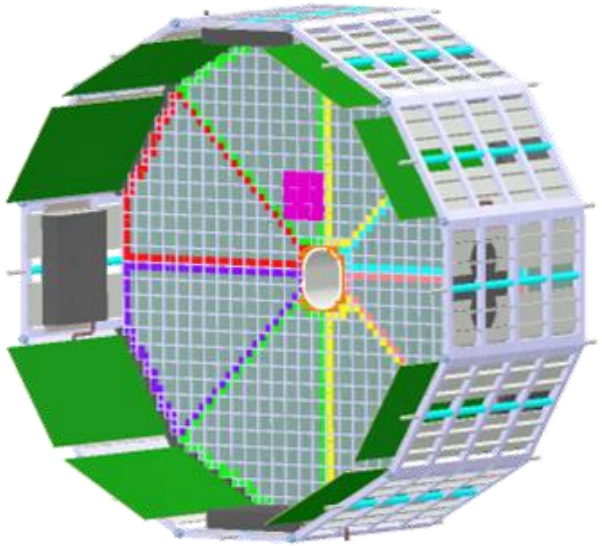
- Maximum acceptance with each layer having a distinct shape to accommodate the beam-pipe crossing angle.
- Radiation-tolerant and future-proof design: SiPMs and tiles remain accessible for annealing & upgrades / phased construction.
- High granularity enabled by "SiPM-on-tile" technology (which was not in the baseline design)

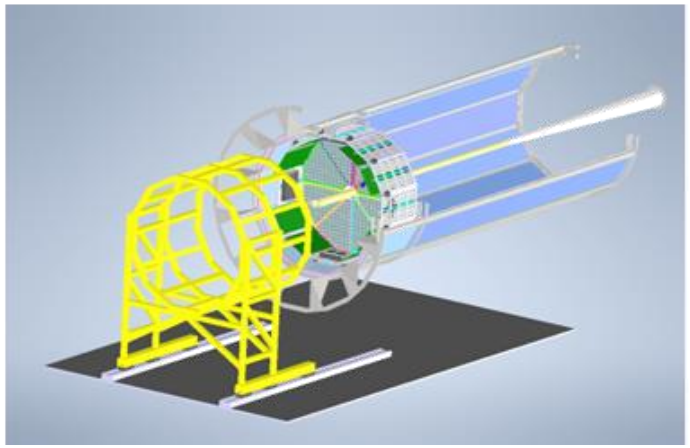
The Insert is a small, low-cost, and easy-to-build detector that represents a ***"new experimental concept and technology that improves physics capabilities without introducing inappropriate risks".***

We have presented this design and realistic simulation studies on numerous occasions, including to GD/I, in collaboration meeting, etc.
So far, we have produced a design paper (link), a building-blocks testing paper (link), and carried out first test beam at JLab (link to results).
Planned activities in near future include SiPM irradiation LBNL to determine optimal operating voltage and realistic noise for simulations, and beam tests with prototypes at JLab, FNAL and RHIC.
Interested parties in further developing and constructing this sub-detector include: UC Riverside, UCLA, and Indiana University.

Consortium: Electromagnetic Precision Calorimetry

- One of the activities of the EEEMCAL consortium is the construction of the EPIC backward EMCal
- An NSF MRSI proposal is being submitted





EEMCal in the context of ePIC DSCs

EIC-NSF Level XX (Draft)	Institution (Draft)	Major Funding	Major Team Member (Draft)
Mechanical Structure	IJCLab-Orsay MIT/MIT-Bates	International DOE	Carlos Munoz-Camacho Richard Milner
Radiator	Charles U./Prague CUA	International NSF	Miroslav Finger Tanja Horn
Front-end electronics	Lehigh U. FIU	NSF and DOE DOE	Rosi Reed Lei Guo
Back-end readout electronics, DAQ, full-chain tests	James Madison U. Ohio U. JLab	NSF NSF DOE	Ioana Niculescu Justin Frantz Vladimir Berdnikov
Prototyping, test stands, calorimeter assembly	AANL U. Kentucky Abilene Christian U.	International NSF DOE	Ani Aprahamian Renee Fatemi Larry Isenhower
Simulation, reconstruction	W&M (also Ohio U.)	NSF and DOE	Cristiano Fanelli

- Regular meetings on Fridays at 8AM ET (usually every 2-3 weeks as needed)
- Open to new collaborators/institutions!
- DSCL: Tanja Horn (CUA)
- DSCTC: Carlos Munoz (IJCLab)

Status of backward HCal DSC

Leszek Kosarzewski

Faculty of Nuclear Sciences and Physical Engineering
Czech Technical University in Prague

Inaugural Technical Integration Council Meeting 28.4.2023

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education

MINISTRY OF EDUCATION, YOUTH AND SPORTS

ČVUT
ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

FJFI

Status of backward HCal DSC

Detector Subsystem Leader

Leszek Kosarzewski
leszek.kosarzewski@gmail.com

Detector Subsystem Technical Contact

None - looking (Leszek Kosarzewski?)

Czech Technical University in Prague

- Subhadip Pal (PhD student)
  - simulations, part time
- Alexander Prozorov (Finishing PhD)
  - simulations, part time, starting now

Brookhaven National Laboratory

- Peter Hamblen - mechanical design, starting in May

- Looking now for institutions to join and more people to participate
- Getting a lot of help from other people at BNL and CTU

dRICH

Compact cost-effective solution for particle identification in the high-energy endcap at EIC

dRICH

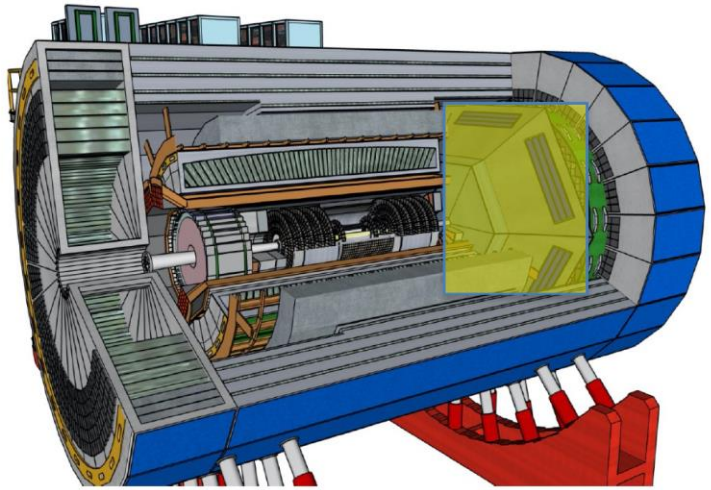
INFN

BA, BO, CS, CT, FE , GE, LNF, LNS, RM2, SA, TO, TS

Duke University

NISER

EPIC



EIC RICH Consortium

Brookhaven National Laboratory

Stony Brook University

Univerza v Ljubljani

.....

dRICH Collaboration: Board of Istitutional Representatives

DSCL: appointed (acting as TC for the moment)

dRICH Office: Contact Persons of Developing Programs

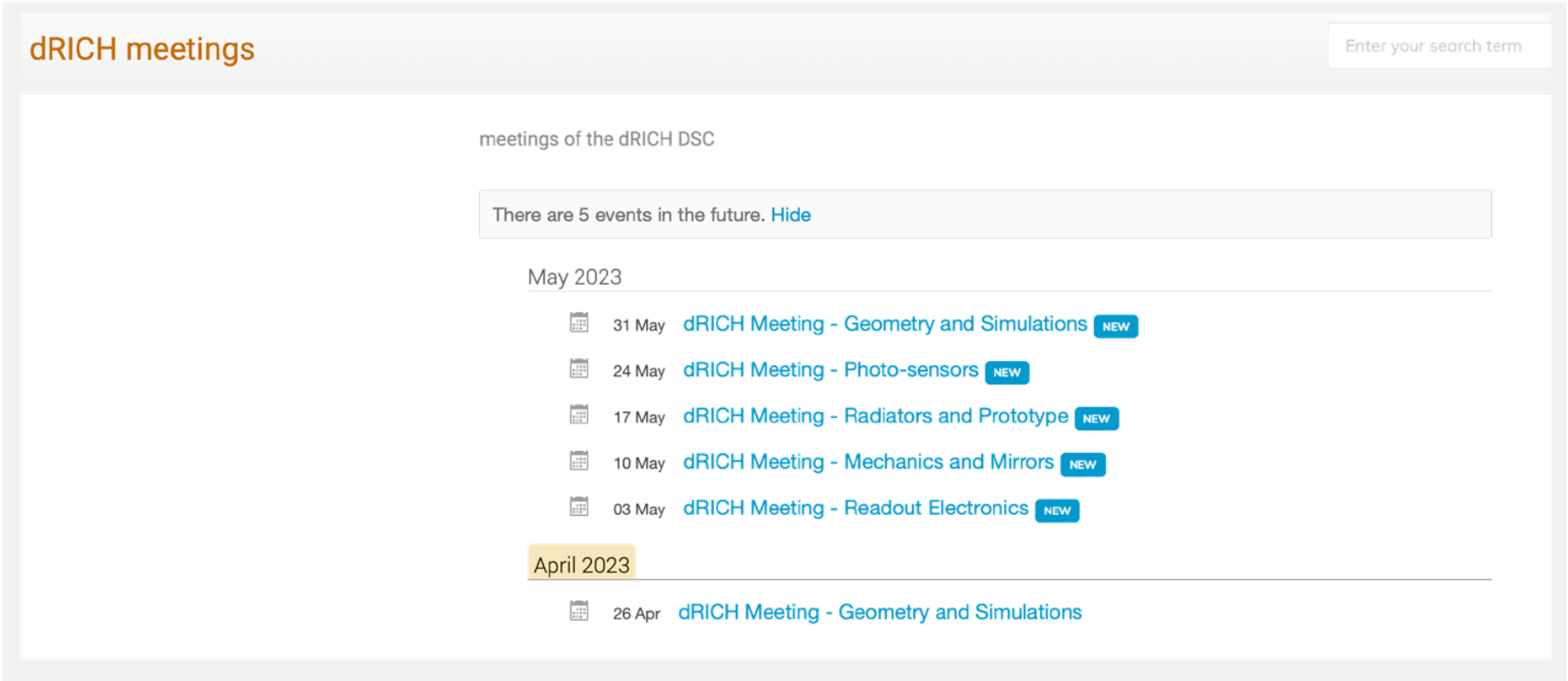
Simulations, Mechanics, Gas Radiator	⟷	Global layout
Photo-detector, Front-end Asics, Data Acquisition	⟷	Services
Aerogel Radiators, Mirrors	⟷	Internal structure

dRICH

Restructuring activity under EPIC framework :

New mailing list: Eic-projdet-drich-l

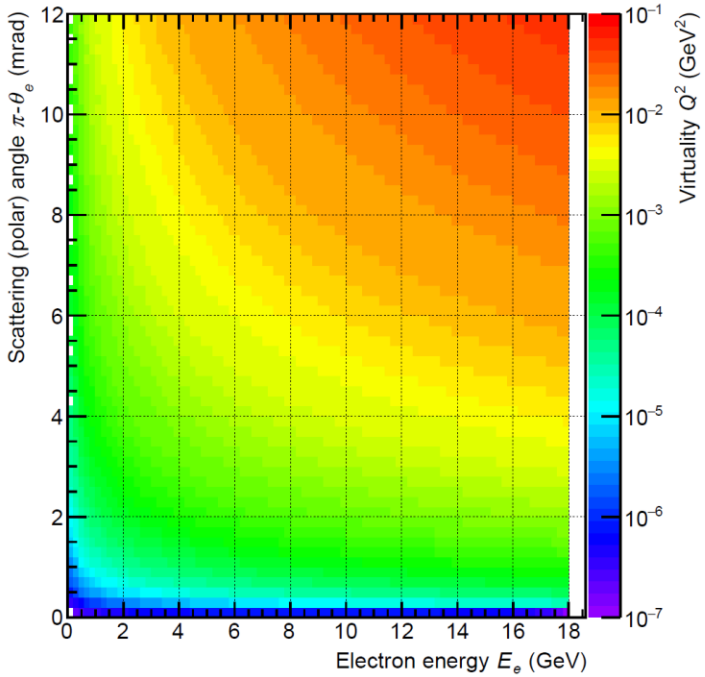
New general meeting series: https://indico.bnl.gov/category/472

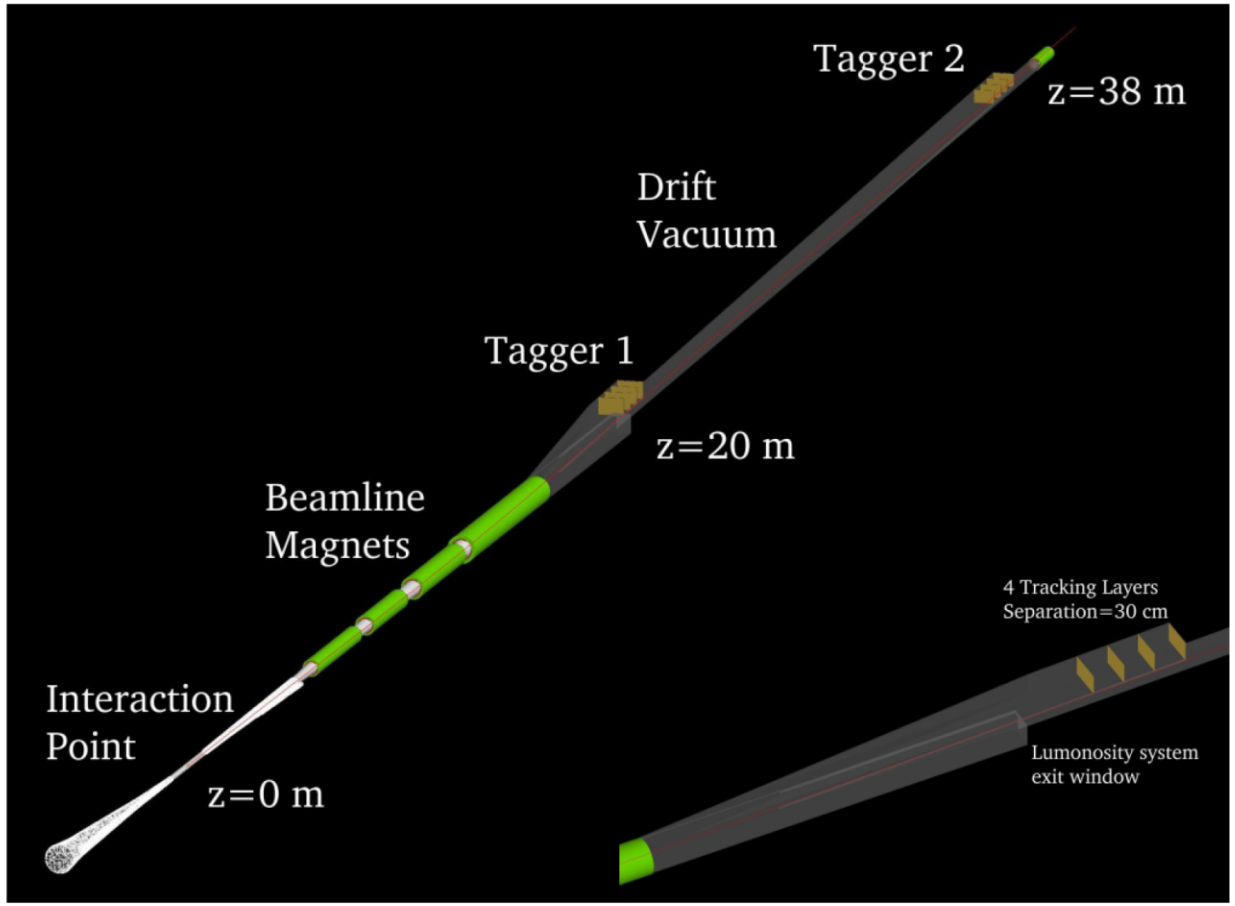


FBKWD - High Rate Tracker

Low-Q^2 detectors Tagger 1 and 2, electrons at $Q^2 < 10^{-1}$ GeV^2 and calibration for luminosity

- DSL: Jaroslav Adam, jaroslav.adam@fjfi.cvut.cz
- DSTC: Simon Gardner, Simon.Gardner@glasgow.ac.uk



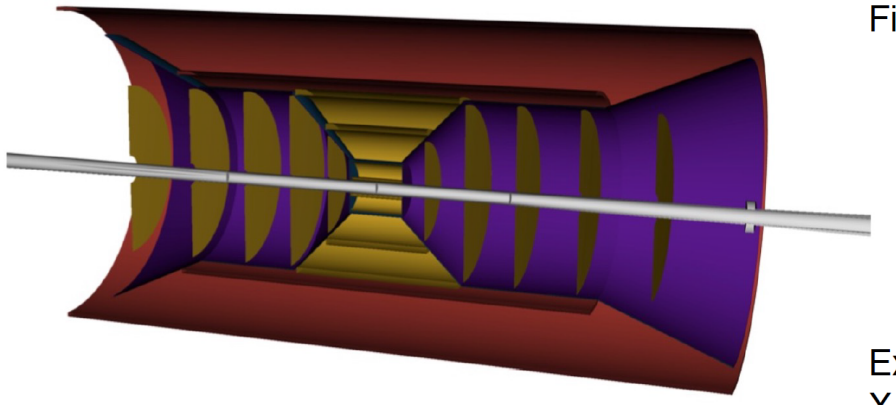


FBKWD - High Rate Tracker collaboration

- Indico: https://indico.bnl.gov/category/481/
- Mailing list (same for all FBKWD groups): Eic-projdet-farback-l, [subscription link]
- Mattermost: https://eic.cloud.mattermost.com/main/channels/det-far-backward
- Instutites: Glasgow, Daresbury, Lancaster, Krakow, Prague, JLAB
- List of collaborators: Derek Glazier, Ken Livingston, Dima Manueski, Ros McGarrie, Mos Kogimtzis, Rob Apsimon, Krzysztof Piotrzkowski, Miroslav Myska, Yulia Furletova, Anna Kowalewska + students

ePIC SVT DSC

The **S**ilicon **V**ertex **T**racker **D**etector **S**ubsystem **C**ollaboration has come together to develop, construct, and operate a well-integrated, large-acceptance, low-mass, high resolution tracking and vertexing solution for ePIC based on Monolithic Active Pixel Sensors (MAPS) in 65 nm technology,



Five barrel layers at radii r_{X0} and lengths L of

$r_{0.05\%}$ = 36, 48, 120 mm; L = 270 mm

$r_{0.25\%}$ = 270 mm; L = 540 mm

$r_{0.55\%}$ = 420 mm; L = 840 mm

Extended disk arrays, as space permits, with X_0 ~0.24% per disk

The three inner barrel layers will be constructed from ITS3 wafer-size sensors, while the outer layers and disks will make use of smaller area stitched sensors and more conventional supports.

ePIC SVT DSC (continued)

This is a large-scale and challenging effort, requiring multiple areas of R&D

- eRD113 – sensor development and characterization
- eRD104 – services reduction
- eRD111 – modules, mechanics, cooling, and integration

Several institutions are taking part:

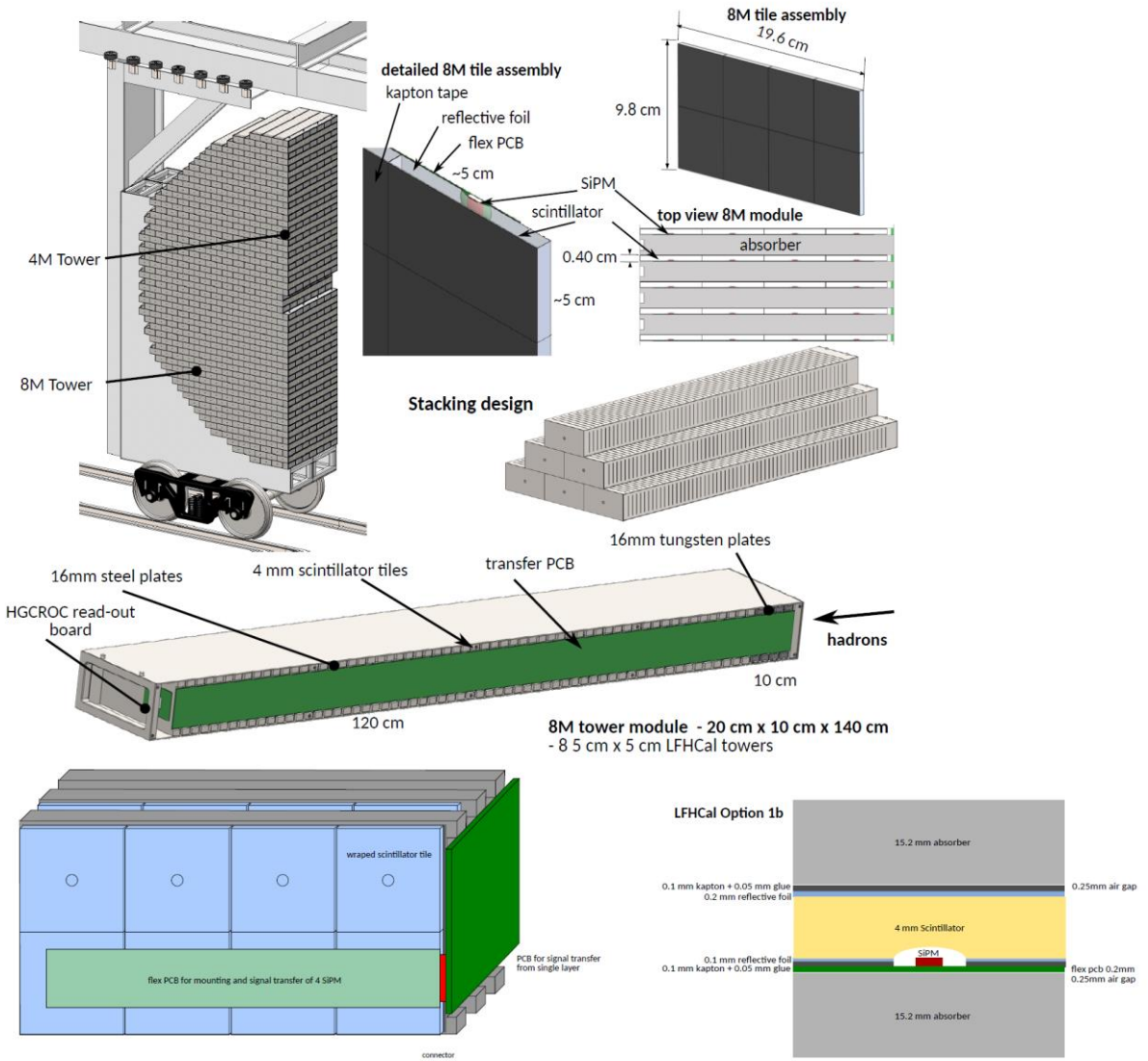
University of Birmingham, INFN, Berkeley Lab, Jefferson Lab, Brookhaven National Laboratory, Berkeley University of California, Los Alamos National Laboratory, Oak Ridge National Laboratory, UKRI Science and Technology Facilities Council, University of Liverpool, University of Oxford, Brunel University London, Lancaster University

and more are joining. SVT DSC is open to and welcoming new collaborators.

Contacts: Laura Gonnella (Birmingham, DSTC) – laura.gonella@cern.ch

Ermst Sichtermann (LBNL, DSL) – epsichtermann@lbl.gov

LFHCal



General Idea

- 4 layers of W (16 mm)-Sci plates (4mm)+ 61 layers of Steel (16 mm)-Sci plates (4mm)
- Multiple towers combined in one module to reduce dead areas, increase granularity
- Read-out:
  - SiPMs in each tile grouped in 7 signals per tower (signals combined from 10(5) Sci-plates)
  - readout position: after full HCal
- Modules of different sizes (8M, 4M) to maximize coverage & assembly efficiency

DSL: Friederike Bock

Read-out expert: Norbert Novitzky

Participating institutes:

ORNL, BNL, FNAL, ISU, GSU, Yale, UCR, UTK, Valpo

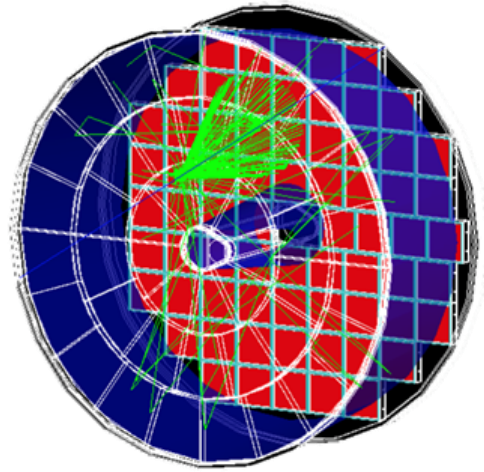
ePIC Backward RICH DSC

- Brookhaven
- Chiba
- Duke
- Glasgow
- INFN Genova
- INFN Trieste
- JLAB
- Ljubljana
- MSU
- Stony Brook
- Temple
- Yale

- *Prefer to maintain a welcoming & flexible environment, with*
  - *(1) a diverse institutional participation model, at least for the next 2+ years*
  - *(2) a well-defined group of institutions committed to the construction phase*

- Current status
  - A sufficiently detailed detector design exists
  - A detailed P6-friendly costing sheet is composed
  - A standalone modeling / reconstruction suite exists
  - A draft CDR is available
- Next week: a first meeting
  - Proceed with a re-branding (new name, mailing list, Wiki page, etc)
  - Nominate a DSC Leader (and a Technical Contact?)
  - Discuss the organization and the institutional commitments
  - Re-assess the available workforce & resume the pre-review activities

A Proximity-Focusing RICH for the ePIC Experiment
– Conceptual Design Report –
(Draft 1.1)



Babak Azmoun[1], Deb Sankar Bhattacharya[2], Daniel Cacace[1], Helen Caines[3], Chandradoy Chatterjee[2], Jaydeep Datta[4], Abhay Deshpande[4], Christopher Dilks[5,6], James Dunlop[1], Alex Eslinger[6], Prakhar Garg[4,3], Tom Hemmick[4], Alexander Jentsch*,[1], Alexander Kiselev*,[1], Henry Klest[4], Samo Korpar[7], Peter Križan[7], Jeffery Landgraf[1], Saverio Minutoli[8], Charles-Joseph Naïm[4], Mikhail Osipenko[8], Brian Page*,[1], Sanghwa Park[9], Matt Posik[10], Rok Pestotnik[7], Andrej Seljak[7], Prashanth Shanmuganathan[1], Nikolai Smirnov[3], Bernd Surrow[10], Makoto Tabata[11], Silvia Dalla Torre[2], Zhoudunming Tu*,[1], Thomas Ullrich*,[1,3], Jan Vanek[1], Anselm Vossen[5,6], Craig Woody[1], and Zhengqiao Zhang[1]

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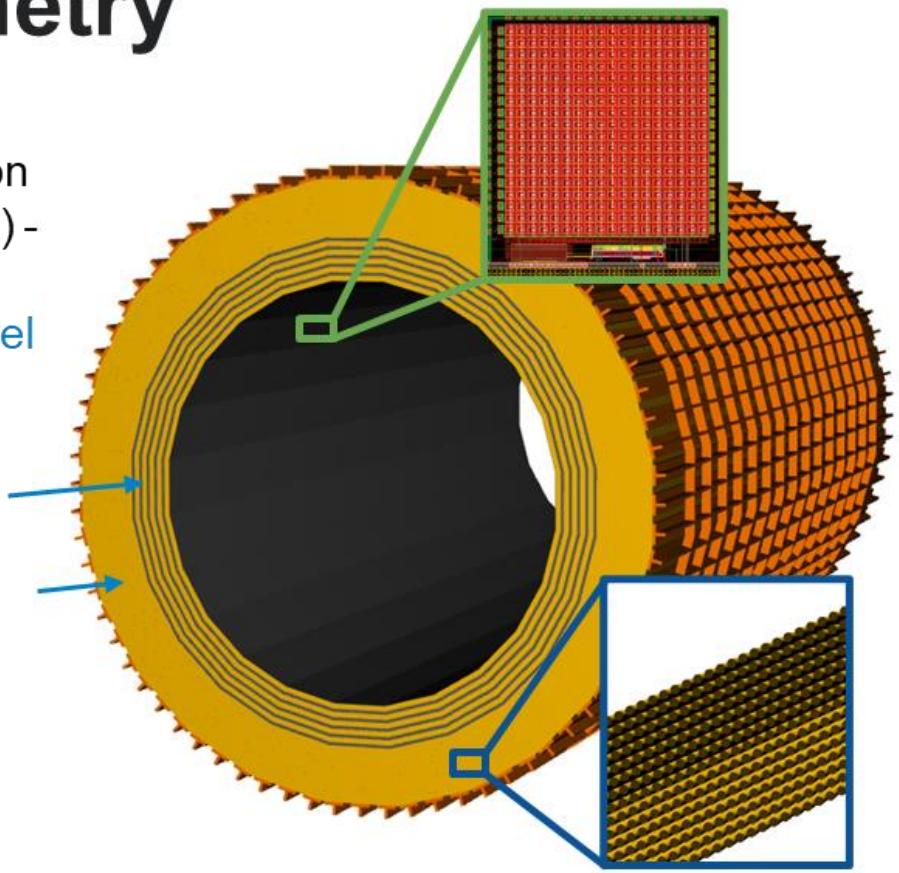
[3]Yale University, New Haven, Connecticut 06520, USA
[4]Stony Brook University, Stony Brook, New York 11794, USA
[5]Duke University, Durham, North Carolina 27708, USA
[6]Jefferson Lab, Newport News, Virginia 23606, USA‡
[7]Ljubljana University and J. Stefan Institute, Ljubljana, Slovenia§
[8]INFN, Sezione di Genova, Genova, Italy
[9]Mississippi State University, Mississippi State, Mississippi 39762, USA
[10]Temple University, Philadelphia, Pennsylvania 19122, USA
[11]Chiba University, Chiba, Japan¶

April 5, 2023

Technically, we are still in a "transition state"

Imaging Barrel EM Calorimetry

- **Hybrid concept**
  - Imaging calorimetry based on monolithic silicon sensors AstroPix (NASA's AMEGO-X mission) - 500 µm x 500 µm pixels NIM, A 1019 (2021) 165795
  - Scintillating fibers in Pb (Similar to GlueX Barrel ECal, 2-side readout w/ SiPMs) NIM, A 896 (2018) 24-42



- **6 layers of imaging Si sensors** interleaved with **5 SciFi/Pb layers** (starting with 4 layers)
- Followed by a **large section of SciFi/Pb section** (can serve as inner HCAL)
- Total radiation thickness for EMCAL of ~21 X_0 (only ~40 cm deep)

Energy resolution - SciFi/Pb Layers: 5.2% /$\sqrt{E} \oplus$ 1.0%
Position resolution - Imaging Layers (+ 2-side SciFi readout): with 1st layer hit information ~ pixel size for γ

Detector System Collaboration

Detector Subsystem Technical Contact
Si Layers: Jessica Metcalfe (jmetcalfe@anl.gov)
Pb/ScFi: Zisis Papandreou (zisis@uregina.ca)

Detector Subsystem Lead: Maria Zurek *interim* (zurek@anl.gov)

Collaborators:
Argonne National Laboratory
University of California Santa Cruz
University of Connecticut
Duquesne University
Gangreung-Wonju National University
Kyungpook National University
Pusan National University
University of Seoul
Sejong University
Sungkyunkwan University
Yonsei University
Korea University
Hanyang University
University of Giessen
University of Manitoba
University of Regina
Mount Allison University

https://eic.cloud.mattermost.com/main/channels/det-cal-barrel-imaging

Ongoing Activities

In preparation to the change control process and beyond

- **Budget and Timeline**
  - Reworking Budget to be included in P6 (A. Bazilevsky)
  - Identifying Long-Lead Procurement Items: **SiPMs and Scintillating Fibers**
    - Working on SiPM specifications based on simulations and GlueX/BCAL prototype data; coordinate with other EPIC SiPM orders
    - Contacted Scintillating Fiber vendors: cost, timelines and sample orders

- **High-Priority Simulation Tasks**
  - Coverage with forward and backward endcap ECals
  - Possibility of shortening the depth of the Pb/ScFi part (to ~ 18X0) - Cost and weight

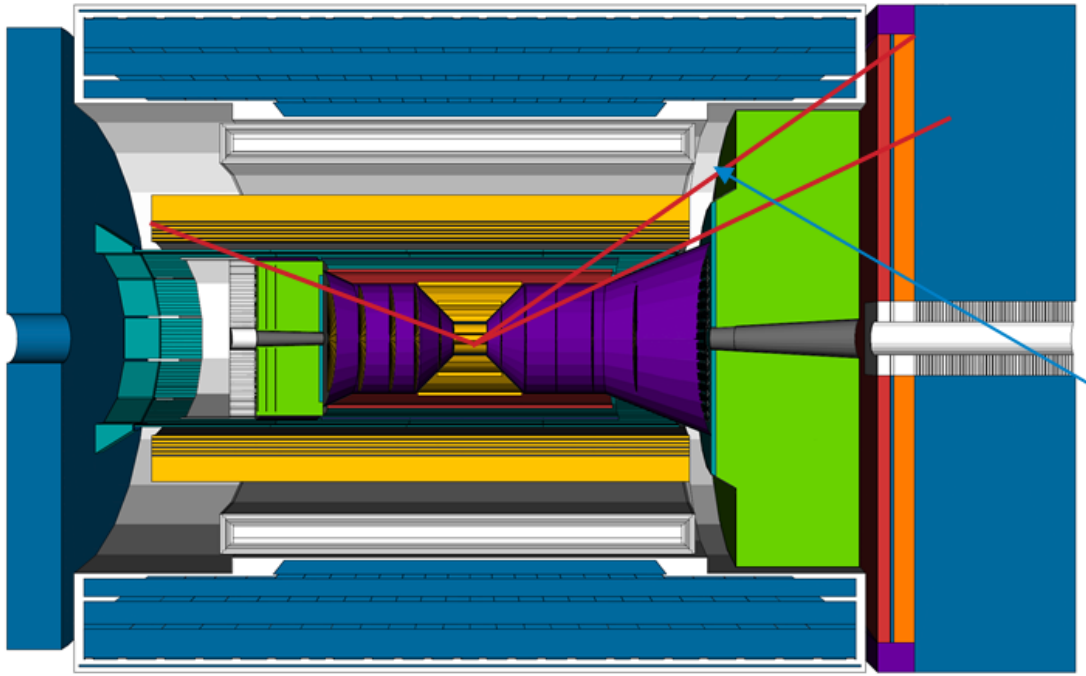
- **High-priority Integration Tasks**
  - Defining DAQ and readout chain for AstroPix with collaboration of DAQ WG
  - Mechanical integration of the barrel design with collaboration of ANL and Project Engineers

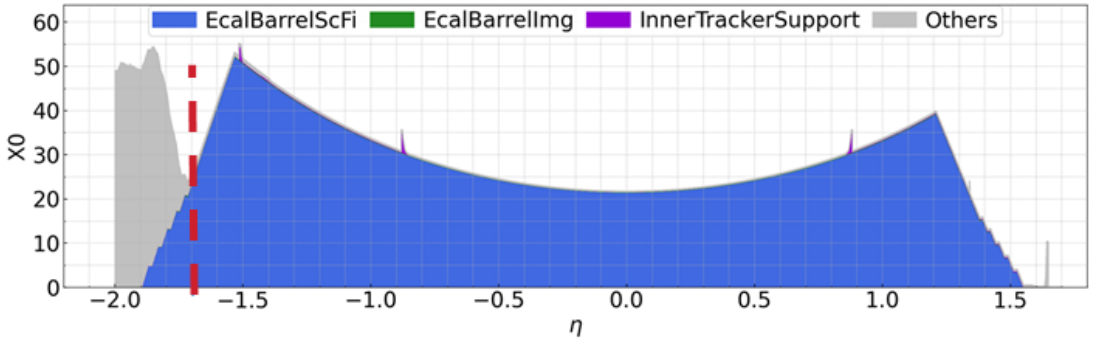
- **Defining Internal Collaboration Structure**

Next priorities for simulations (rough timeline)

1. Detailed simulation with light propagation in the ScFi (can be standalone)
2. Background studies
3. More complete implementation of the silicon sensor staves and Si drawers
4. Impact of non-sensitive areas around AstroPix chips
5. 2-sided readout for the Pb/ScFi
6. Optimization studies on the readout scheme
7. Iteration between simulation and the mechanical model of the calorimeter
8. Reconstruction studies (cluster matching, full event reconstruction, clustering algorithms, cluster merging, …)
9. Benchmark simulation against R&D tests
10. Performance impact of the imaging calorimeter on the hadronic calorimetry
11. Realistic calibration (collaboration-wide)

Integration with Forward/Backward Calorimeter





Services not present in simulations

1. Can the Barrel ECal be shorten on the h-going side?
   a. Purely from the calorimeter depth and coverage with backward ECal is looks possible
   b. But! How well can we reconstruct e/ɣ in backward ECal with all the material in front
   c. How many e/ɣ is in this area?