ATHENA DAQ parameters

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Beam parameters

Species	p	e	p	e	p	e	p	e	p	e
Beam energy [GeV]	275	18	275	10	100	10	100	5	41	5
$\sqrt{s}$ [GeV]	140.7		104.9		63.2		44.7		28.6	
No. of bunches	290		1160		1160		1160		1160	
	High divergence configuration									
RMS $\Delta\theta$, h/v [μrad]	150/150	202/187	119/119	211/152	220/220	145/105	206/206	160/160	220/380	101/129
RMS $\Delta p/p$ [10^{-4}]	6.8	10.9	6.8	5.8	9.7	5.8	9.7	6.8	10.3	6.8
Luminosity [$10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$]	1.54		10.00		4.48		3.68		0.44	
	High acceptance configuration									
RMS $\Delta\theta$, h/v [μrad]	65/65	89/82	65/65	116/84	180/180	118/86	180/180	140/140	220/380	101/129
RMS $\Delta p/p$ [10^{-4}]	6.8	10.9	6.8	5.8	9.7	5.8	9.7	6.8	10.3	6.8
Luminosity [$10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$]	0.32		3.14		3.14		2.92		0.44	

Table 10.1: Beam parameters for e+p collisions for the available center-of-mass energies $\sqrt{s}$ with strong hadron cooling. Luminosities and beam effects depend on the configuration. Values for high divergence and high acceptance configurations are shown.

Species	Au	e	Au	e	Au	e	Au	e
Beam energy [GeV]	110	18	110	10	110	5	41	5
$\sqrt{s}$ [GeV]	89.0		66.3		46.9		28.6	
No. of bunches	290		1160		1160		1160	
	Strong hadron cooling							
RMS $\Delta\theta$, h/v [μrad]	218/379	101/37	216/274	102/92	215/275	102/185	275/377	81/136
RMS $\Delta p/p$ [10^{-4}]	6.2	10.9	6.2	5.8	6.2	6.8	10	6.8
Luminosity [$10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$]	0.59		4.76		4.77		1.67	
	Stochastic cooling							
RMS $\Delta\theta$, h/v [μrad]	77/380	109/38	136/376	161/116	108/380	127/144	174/302	77/77
RMS $\Delta p/p$ [10^{-4}]	10	10.9	10	5.8	10	6.8	13	6.8
Luminosity [$10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$]	0.14		2.06		1.27		0.31	

Table 10.2: Beam parameters for e+Au collisions for the available center-of-mass energies $\sqrt{s}$. Luminosities and beam effects depend on the cooling technique. Values for strong hadronic and stochastic cooling are shown.

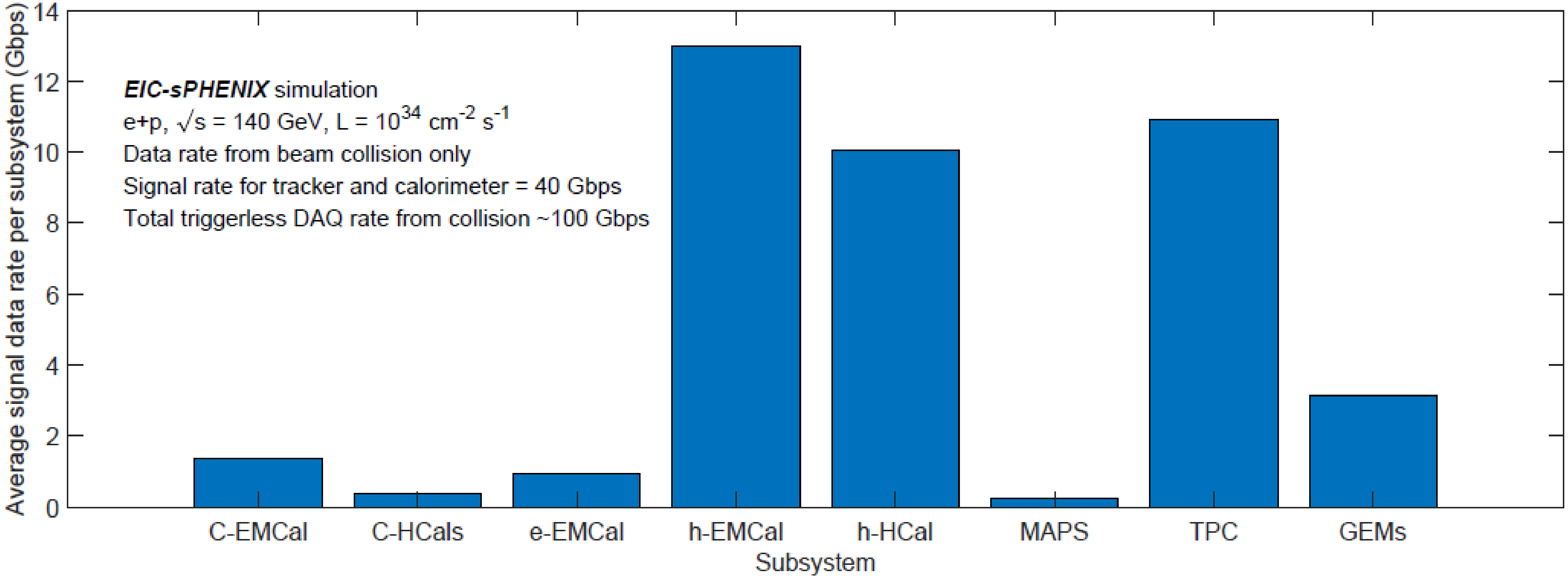
Beam parameters

Beams	Collision energy modes (GeV)							
	E_e	E_h	E_e	E_h	E_e	E_h	E_e	E_h
$e+p$	18	275	10	100	5	100	5	41
$e+d$	18	135	10	100	5	100	5	41
$e+{}^{3}\mathrm{He}$	18	110	10	110			5	41
$e+{}^{4}\mathrm{He}$	18	110	10	110			5	41
$e+\mathrm{C}$	18	110	10	110			5	41
$e+{}^{40}\mathrm{Ca}$	18	110	10	110			5	41
$e+\mathrm{Cu}$	18	110	10	110			5	41
$e+\mathrm{Au}$	18	110	10	110			5	41

Beam parameters

$\sigma_{tot}(\mu b)$		E_e [GeV] 5	E_e [GeV] 10	E_e [GeV] 18
E_p [GeV]	41	25.9	30.1	35.0
	100	32.1	37.1	41.6
	275	39.4	44.6	49.3

Expected data rates sPhenix configuration



Physics requirements

η	Nomenclature			Tracking: Resolution	Tracking: Allowed	Tracking: minimum-pT	Tracking: Si-Vertex	Electrons and Photons: Resolution σE/E	Electrons and Photons: PID	Electrons and Photons: min E	π/K/p: p-Range	π/K/p: Separati	HCAL: Resolution σE/E	HCAL: Energy	Muons
-6.9 to -5.8			low-Q2 tagger	σθ/θ < 1.5%; 10-6 < Q2 < 10-2 GeV2											
-5.0 to -4.5						300 MeV pions									
-4.5 to -4.0			Instrumentation to separate charged particles from photons			300 MeV pions		2%/√E(+1-3%)		50 MeV					
-4.0 to -3.5	↓ p/A	Auxiliary De				<100MeV pions, 135MeV kaons				50 MeV			~50%/√E + 6%		muons useful for bkg, improve resolution
-3.5 to -3.0		Central Detector	Backward Detector	σpT/pT ~ 0.1%⊕0.5%	~5% or less X				π suppression up to 1:1E-4	50 MeV	≤ 7 GeV/c	≥ 3 σ	~45%/√E+6%	~500 MeV	
-3.0 to -2.5							σ_xy ~ 30/pT µm + 40 µm			50 MeV					
-2.5 to -2.0				σpT/pT			σ_xy ~ 30/pT µm + 20 µm	2%/√E(+1-3%)		50 MeV					
-2.0 to -1.5				σpT/pT 0.05%⊕0.5%				7%/√E(+1-3%)		50 MeV					
-1.5 to -1.0								7%/√E(+1-3%)		50 MeV					
-1.0 to -0.5			Barrel	σpT/pT ~0.05%×pT+0.5%			σxyz ~ 20 µm, d0(z) ~d0(rΦ) ~ 20/pTGeV µm + 5 µm	(10-12)%/√E(+1-3%)		50 MeV	≤ 10 GeV/c		~85%/√E+7%		
-0.5 to 0.0										50 MeV			~85%/√E+7%		
0.0 to 0.5										50 MeV			~85%/√E+7%		
0.5 to 1.0										50 MeV	≤ 15 GeV/c		~85%/√E+7%		
1.0 to 1.5			Forward Detectors	σpT/pT ~0.05%×pT+1.0%			σ_xy ~ 30/pT µm + 20 µm		3σ e/π	50 MeV	≤ 30 GeV/c		35%/√E		
1.5 to 2.0										50 MeV	≤ 50 GeV/c				
2.0 to 2.5										50 MeV					
2.5 to 3.0				σpT/pT ~ 0.1%×pT+2.0%			σ_xy ~ 30/pT µm + 40 µm			50 MeV	≤ 30 GeV/c				
3.0 to 3.5							σ_xy ~ 30/pT µm + 60 µm			50 MeV	≤ 45 GeV/c				
3.5 to 4.0	↑ e	Auxiliary Detectors	Instrumentation to separate charged particles from photons	Tracking capabilities are desirable for forward tagging						50 MeV					
4.0 to 4.5			Neutron Detection			300 MeV pions				50 MeV			35%/√E (goal), <50%/√E (acceptable)*, 3mrad/√E (goal)		
4.5 to 5.0								4.5%/√E for photon energy > 20 GeV	<= 3 cm granularity	50 MeV					
>6.2			Proton Spectrometer	σintrinsic(|t|)/|t| < 1%; Acceptance: 0.2 < pt < 1.2 GeV/c											

Possible DAQ architecture

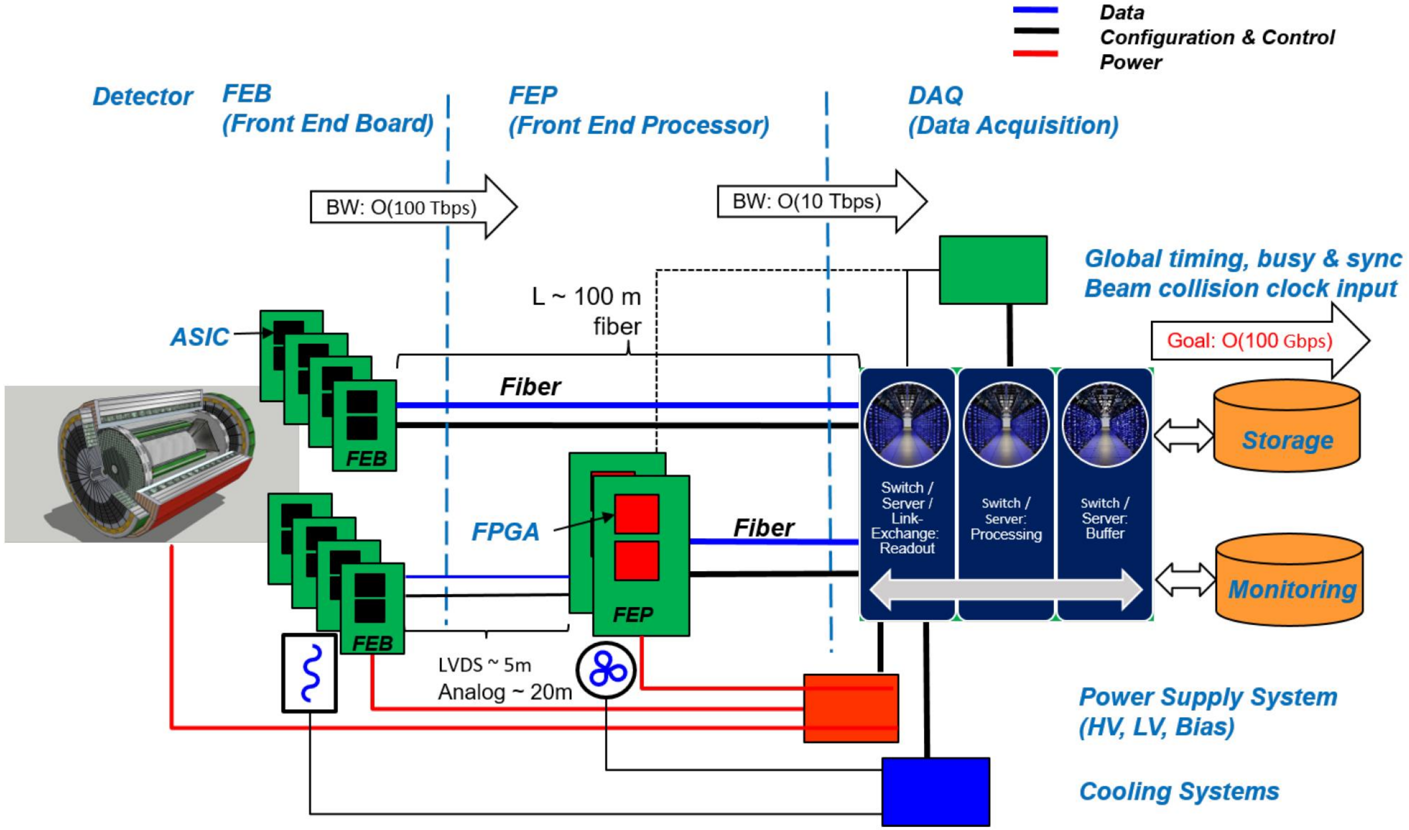
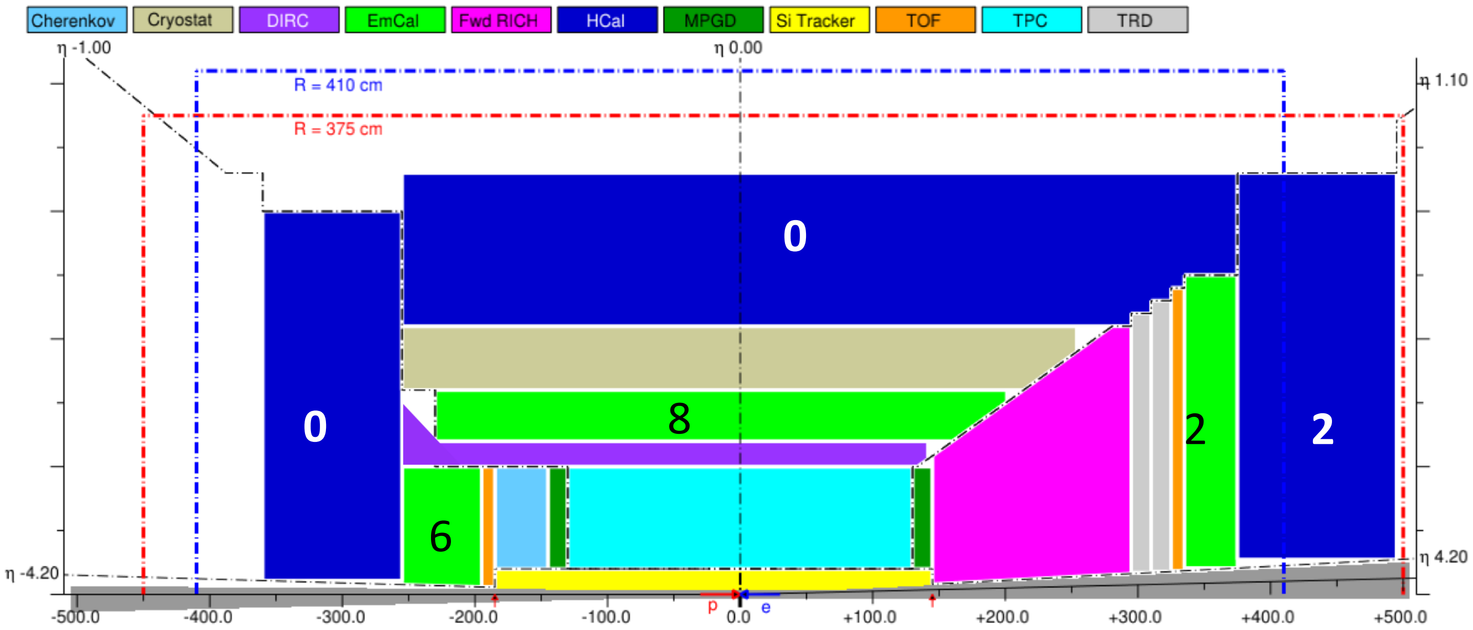


Figure 11.134: Possible scheme for the EIC Readout Architecture

ATHENA subsystems

- Central detector
    - Calorimetry
    - Tracking
    - PID
- Far forward
    - Roman pots (high timing resolution ~ 20 ps)
    - ZDC
    - B0
- Far backward
    - Tagger
    - Luminosity monitor



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78	UCLA	USA	* Huan Zhong Huang	huang@physics.ucla.edu	0	0	0	0	1	1
79	UC Riverside	USA	* Ken Barish	Kenneth.Barish@ucr.edu	0	0	0	0	1	1
89	University of Kentucky	USA	Renee Fatemi	rhfate2@g.uky.edu	1	0	1	0	0	0
95										
96					6	0	8	0	2	2

Current EICatIP6_Institutions Calorimetry List.

- 15 Institutions. (5 in YR, 4 in EIC Calor R&D)
- RECAL and BECAL in reasonable shape, base manpower wise.
- FECAL, FHCAL need to grow.
- BHCAL, RHCAL need to identify leading group.

Usually HCals are Lab type projects (large, heavy, expensive, engineering, part of infrastructure etc…)

- Pressing issue #1 for EIC@IP6 is to get more groups involved

(STAR Forward Calorimetry System ~ 10 institutions)

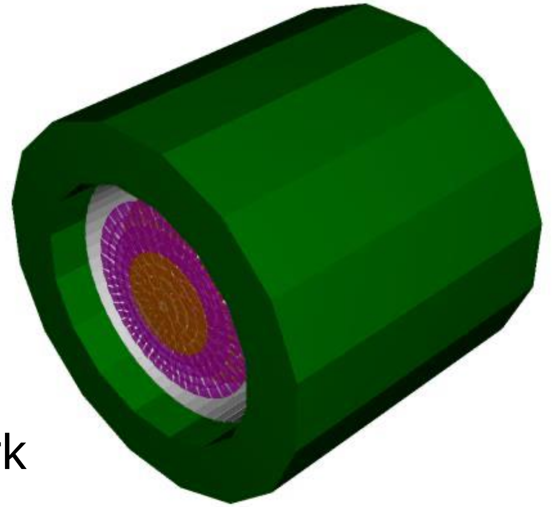
Proposal wise, YR Calorimetry – had ~ 10 active participators. We need about the same level for proposal.

Imaging calorimeter based on monolithic silicon sensors

AstroPix (developed for NASA, off-the-shelf)

- Have no stringent power and cooling requirements (used in space)
- Energy resolution: 2% within dynamic range (20 keV ~ a few MeV)
- Time resolution: 50 ns

https://arxiv.org/pdf/2101.02665.pdf

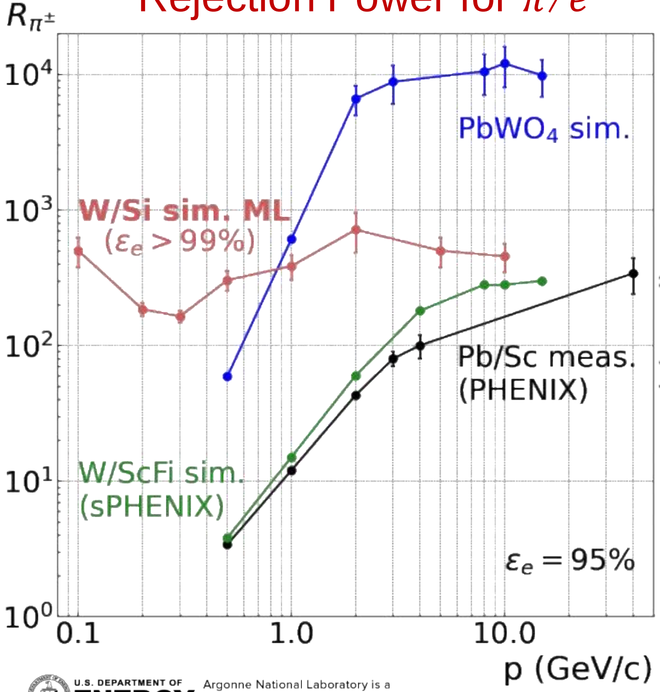


Ongoing design optimization using the simulation with IP6@EIC software framework

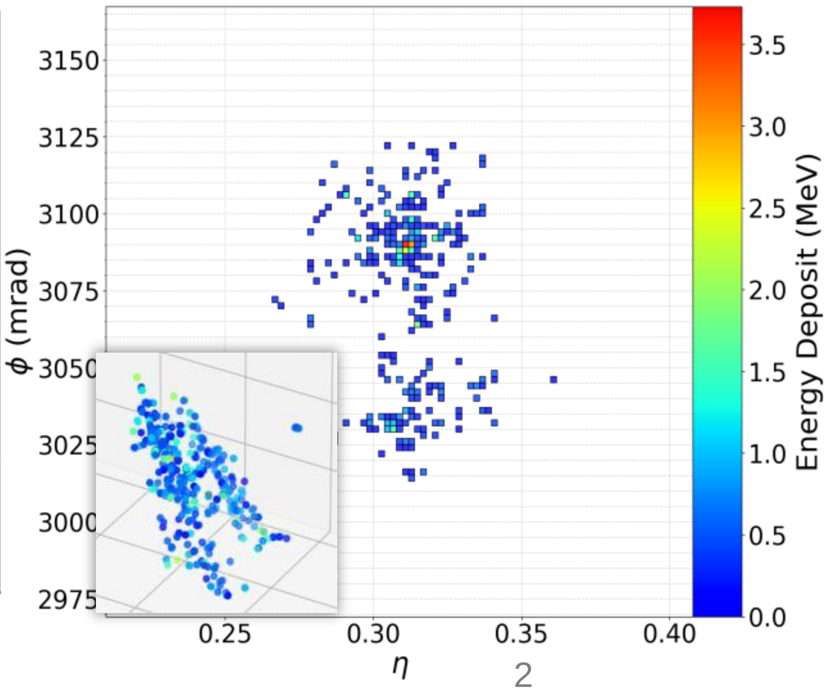
AstroPix digitization, 3D clustering, ML algorithms, …

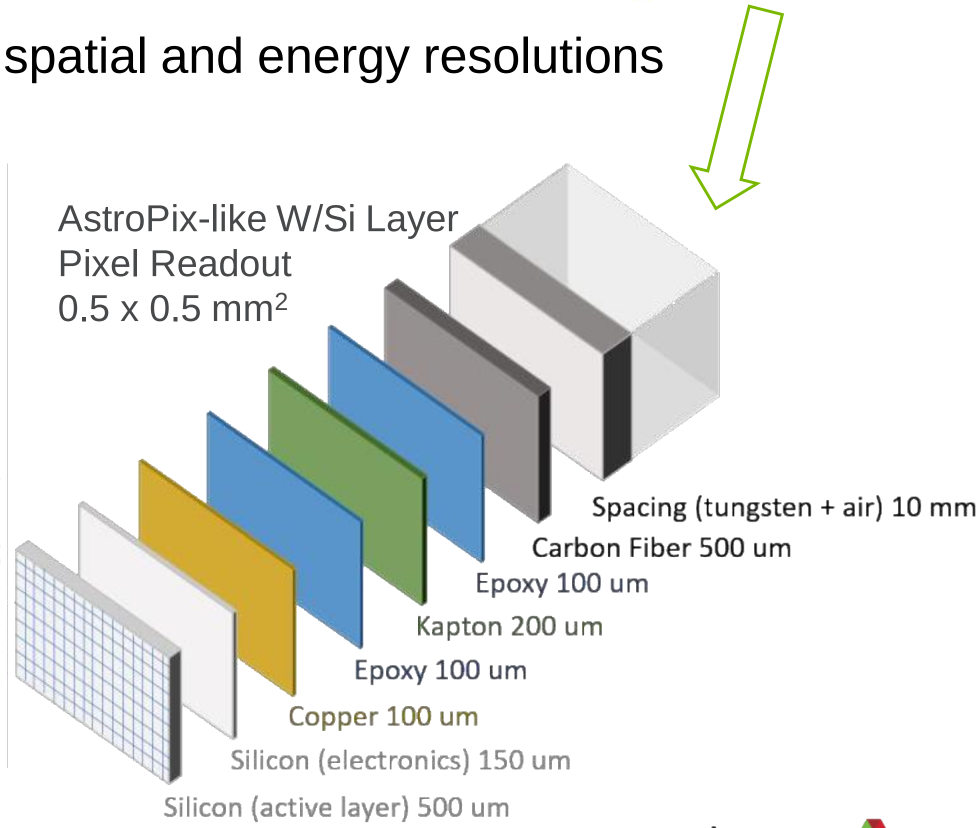
Tests against YR benchmarks: e/π separation, shower separation, spatial and energy resolutions

Rejection Power for π/e

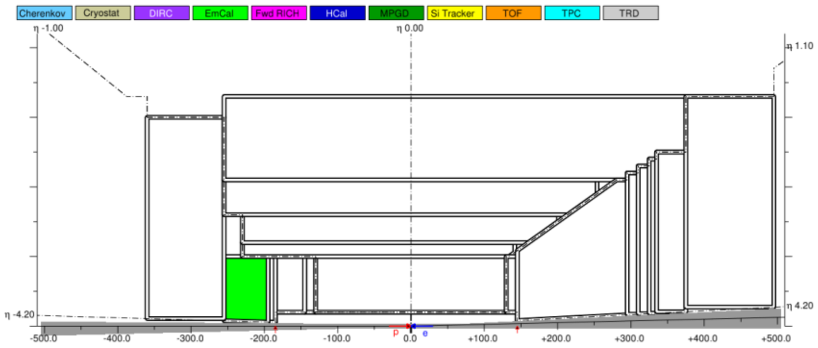


$\pi_0 \rightarrow \gamma\gamma$ Event Sample (5 GeV)

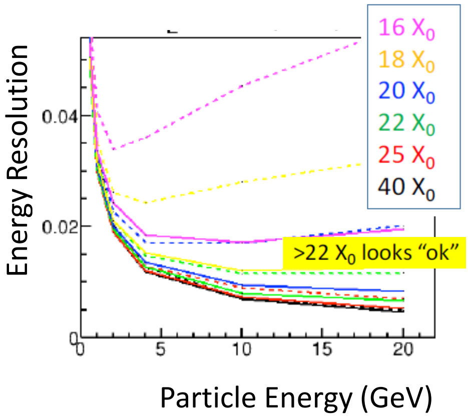


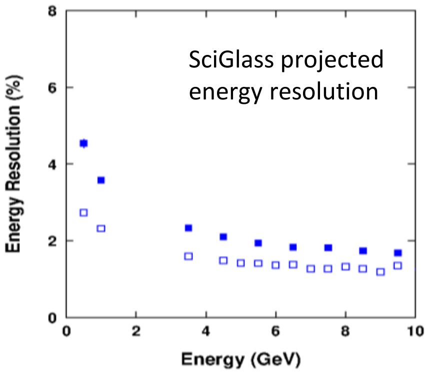


Electron Endcap EM Calorimeter for Electron Detection - Goal



We aim to design and construct the scattered electron detection in the Lepton Endcap covering pseudorapidity -3.5 to -1 with an electromagnetic calorimeter (**EEEMCal**).





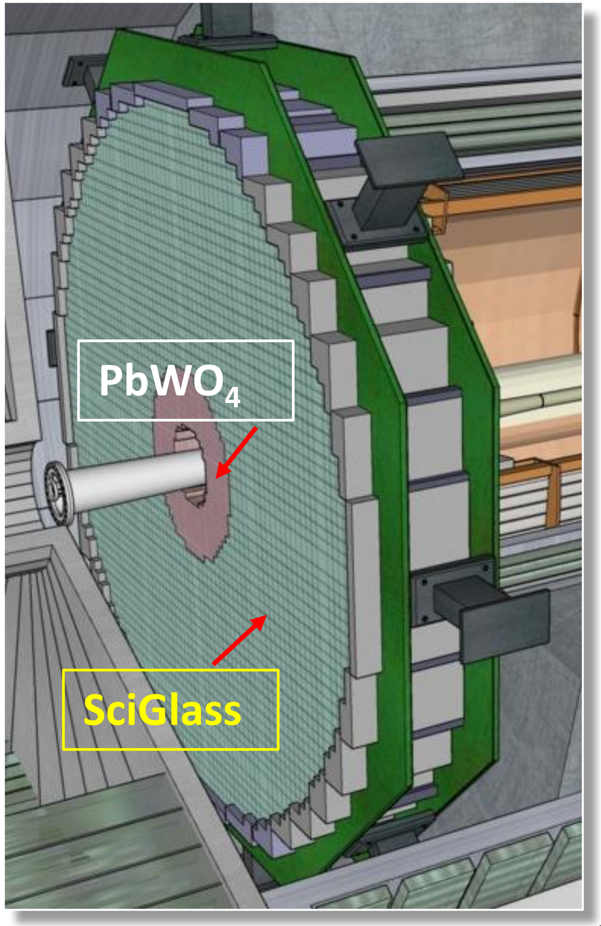
REFERENCE

$PbWO_4$ crystals (inner)

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

SciGlass (outer)

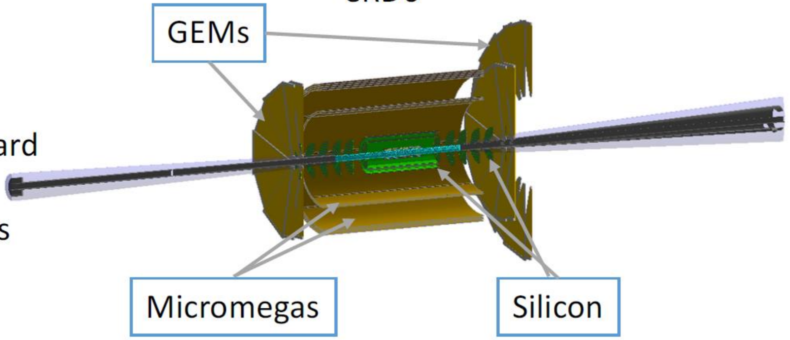
- EIC eRD1
- radiation hard, luminescence yield similar or better than crystals depending on longitudinal length
- Sensor: SiPMs (TBC)



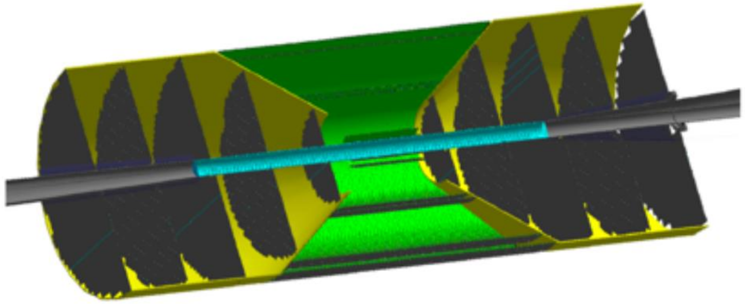
How do you see global tracking for detector 1?

- Very high granularity, low mass silicon MAPS vertex tracker
- Either **compact all-silicon** or **Si-MPGD hybrid** configurations
  - Si-MPGD Hybrid: MAPS-based inner barrels and forward/backward disks complimented with large MPGD barrel and endcap trackers
- Silicon and MPGD detectors outside barrel region ($|\eta| > 1$)

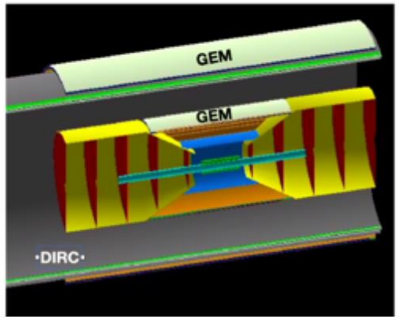
eRD6



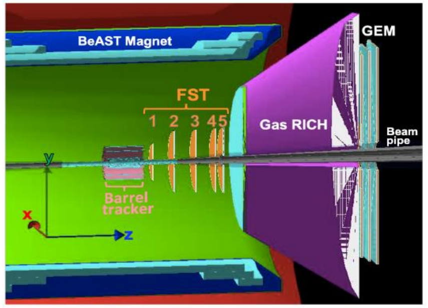
All Silicon



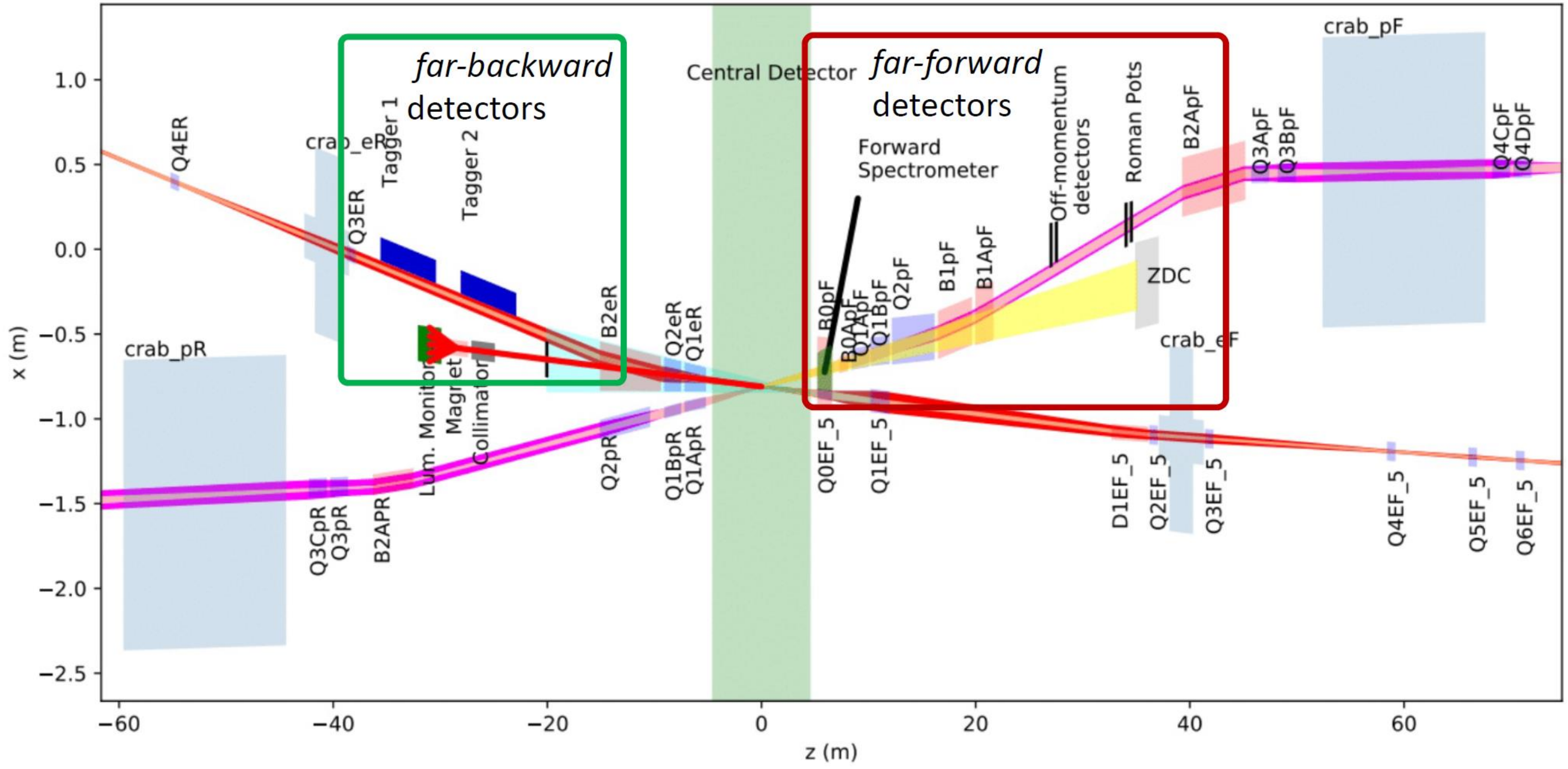
LBNL



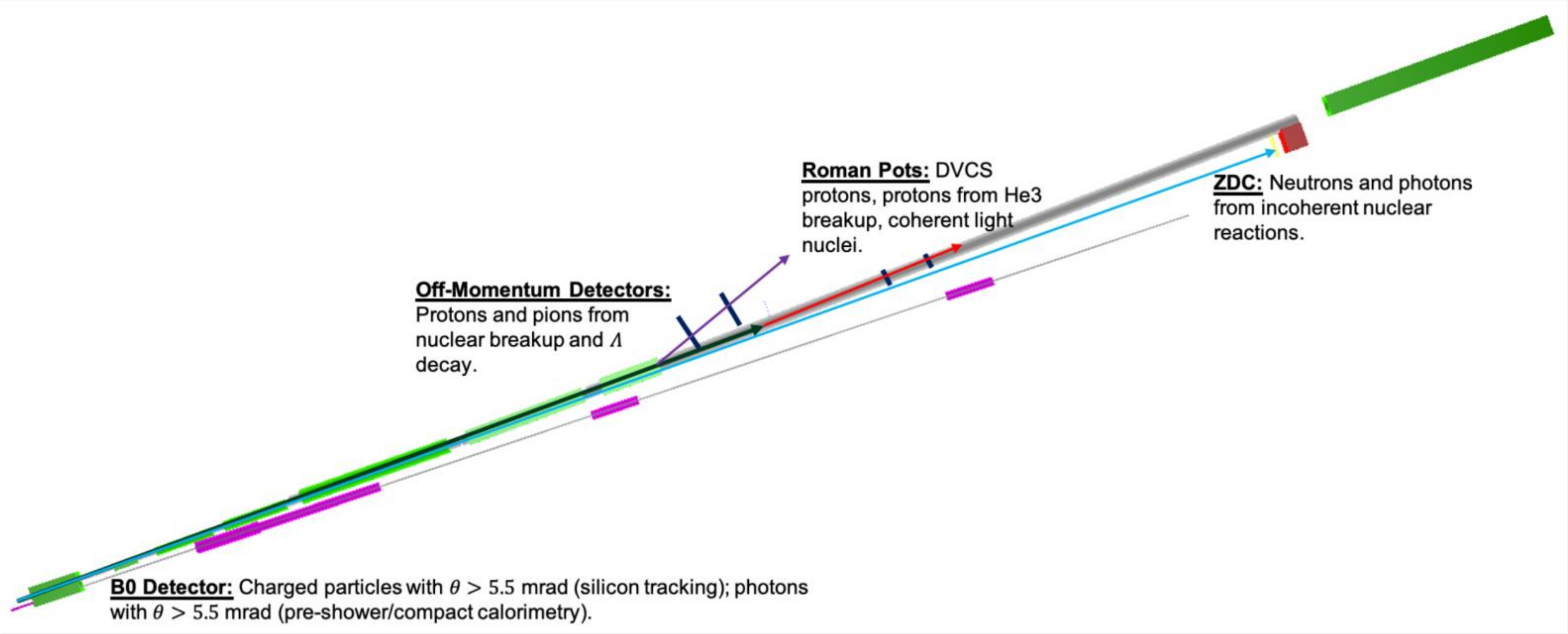
LANL



Far forward and backward detection



Far forward detection



Far backward

- Proposing adequate detector technologies for the FB system.
- Defining tentative requirements for the readout and DAQ electronics, including data (pre-)processing aspects.

- **How do you see globally Far-Backward project for Detector 1?**
  - Precise luminosity measurements are central for the physics program at the EIC, but are very challenging – the FB system requires an optimal design and dedicated instrumentation and variety of diagnostic tools
  - Photoproduction tagging is an important part of the exclusive physics program, but it also poses very serious experimental challenges
  - Possible significant support from the Polish Ministry of Education and Science toward building the Far Backward detectors.