Communications

- Next TIC Meeting 10/30:
  - Focus on risk mitigation tracking solutions
  - Preceded by Tracking WG discussion on 10/26

- Collected outstanding DSC requests:
  - https://wiki.bnl.gov/EPIC/index.php?title=DSC_Requests
  - Please try to respond as quickly as possible

- Closed Session – TIC/PTR/CC WG Conveners
  - Immediately following today’s open TIC session

ePIC TIC Oct. 23, 2023
Test Beam Needs
Simulation Thresholds

Combined DSC Slides

SPOKESPERSON'S OFFICE
J. Lajoie (ISU), Spokesperson
S. Dalla Torre (INFN), Deputy Spokesperson

TECHNICAL COORDINATOR
Silvia Dalla Torre (Acting)

dRICH
DSL/DSTC: Marco Contalbrigo (INFN)

hpDIRC
DSL/DSTC: Greg Kalicy (CUA)

BACKWARD RICH
DSL/DSTC: Alexander Kiselev (BNL)

FAR FORWARD
DSL: Alex Jentsch (BNL)
DSTC (B0): Zvi Citron (Ben-Gurion)
DSTC (Roman Pots/OMD):
Alex Jentsch (BNL)
DSTC (ZDC): Yuji Goto (RIKEN)

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

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

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

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

BACKWARDS HCAL
DSL/DSTC: Leszek Kosarzewski (CTU)

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

BARREL HCAL
DSL/DSTC: John Lajoie (ISU)

FORWARD ECAL
Co-DSL/DSTC: Oleg Tsai (UCLA)
Co-DSL: Huan Huang (UCLA)

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

AC-LGAD TOF
DSL: Zhenyu Ye (UIC)
Deputy DSL: Satoshi Yano (Hiroshima)

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

ePIC

Detector Subsystem Collaborations

Need for test beams 2026 to 2029

Test Beam availability: https://cern.ch/international-facilities

Sub-Detector	week 2024	week in 2025	weeks in 2026	weeks in 2027	weeks in 2028
dRICH	3	2 (contingency)	2	2 (contingency)	2
hpDIRC					
Backward RICH	2(3)	2(3)	2(3)	2 (optional)	
Far Forward					
FarBackward PairSpectrometer			2 to 4	2 (contigency)	2
FarBackward Luminosity					
FarBackward Low-Q2-Tagger					
Si Trackers	No EIC LAS yet, ITS3 sensor test beams organised by ITS3	1 to 2 (EIC LAS v1)	3 to 4 (EIC LAS v1 + v2)	2 (EIC LAS v2)	2 (EIC LAS prod, contingency)
MPGD	2 to 4	2 to 4	2 to 4	2 to 4	2
Backward ECal	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4
Backward HCal			2 to 4 (if STAR tiles available)	2 to 4	2 to 4 (contingency)
Barrel ECal	4 (FNAL)	4 (FNAL)	4	2	2
Barrel HCal		4(FNAL)	4(FNAL) contingency		
Forward ECal	2	2			2
Forward HCal	2	2 to 4			2 to 4
AC-LGAD ToF	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4

Need for test beams 2026 to 2029

Test Beam availability: https://cern.ch/international-facilities

Sub-Detector	hadron beam	electron beam	energy in GeV	
dRICH	pion, kaon, proton	electron	3 to 60	2024: pro-TDR, 2026: initial real-scale components, 2028: one fully equipped detector box. Electrons are optional.
hpDIRC				The current plan is to do the assembly of bar boxes in SBU and we are finishing Cosmic Ray Telescope there that could be used for validation/QA.
Backward RICH	pi/K/p	yes (optional)	hadrons: 1 - 20, electrons: 1 - 5	Assume three beam tests at Fermilab in 2024-2026 suffice, unless EICROC is delayed
Far Forward				2024: pre-FDR; 2025/2026/(2027) - refinements (e/pi separation, ASIC readout)
FarBackward PairSpectromete		electron	1 to 6/12	2026 testing prototype 2027 for any additional test, 2028 full detector test
FarBackward Luminosity				
FarBackward Low-Q2-Tagger				
Si Trackers	yes (protons, pions)	yes	few to ~hundred GeV	Info inserted by Laura. Test beam for EIC LAS v1, v2 and procdution (the latter is mostly contingency) are in the table. It is assumed that test beams for the ITS3 sensor for the ePIC inner barrel will be organised by ITS3 as ePIC uses the ITS3 sensor.
MPGD	MIPS for tracking	yes (optional)	~ GeV	
Backward ECal		yes	0.5 to 20 GeV	
Backward HCal	proton, pion, neutron?	electron	0.5-20 GeV	2026 only if STAR EEMC tiles are available and refurbished, 2027-2028 more likely
Barrel ECal	proton (MIPS, tracking), pion	electron	1 - ~20 GeV (upper limit not that crucial)	
Barrel HCal	pions, muons (MIP tracking)		1 = ~20 GeV	Use sPHENIX prototype mockup with spare tiles, new SiPMs and HGCROC readout - chain test more for the electronics than the detector
Forward ECal	pion, proton	electron beam	1-20 GeV	
Forward HCal	proton, pion	electron	0.5 - 50	small prototype testing before CD-3 (FNAL/CERN), + engenering article and pre-production article testing with readout after CD-3
AC-LGAD ToF	proton	electron	high p (beta~1)	

dRICH DSC

dRICH 2024 Test-beam plans

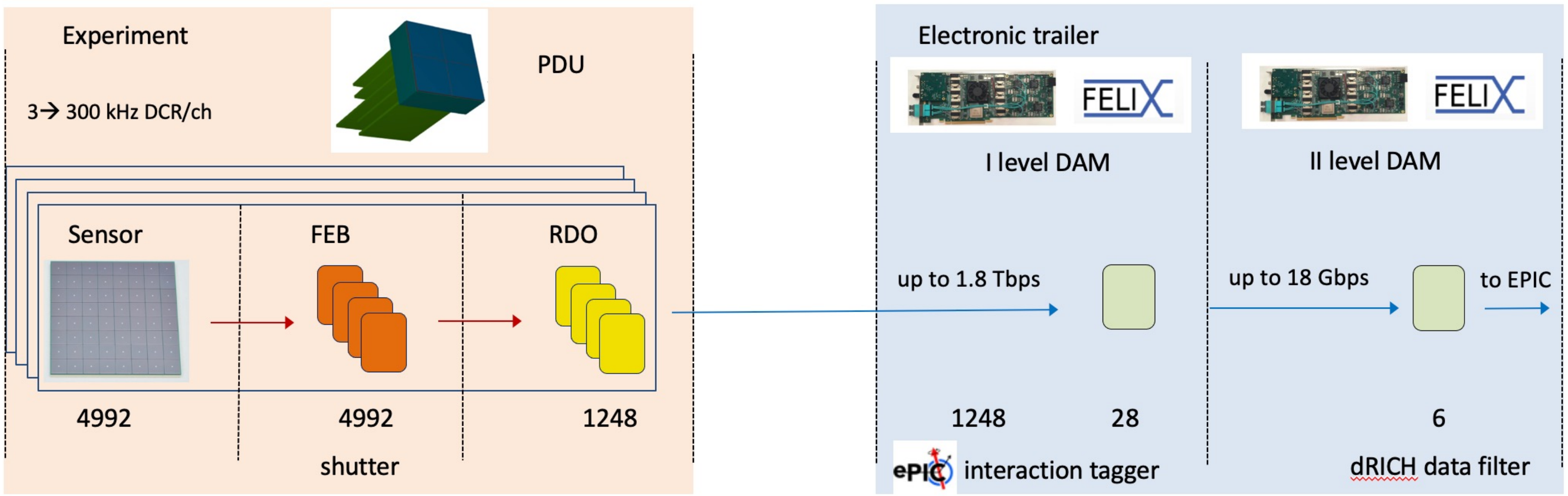
Two test beam planned **at CERN**:

May-June (1 week): optical performance with EIC-driven detector

September-October (2 weeks): real-scale prototype & RDO board + contingency

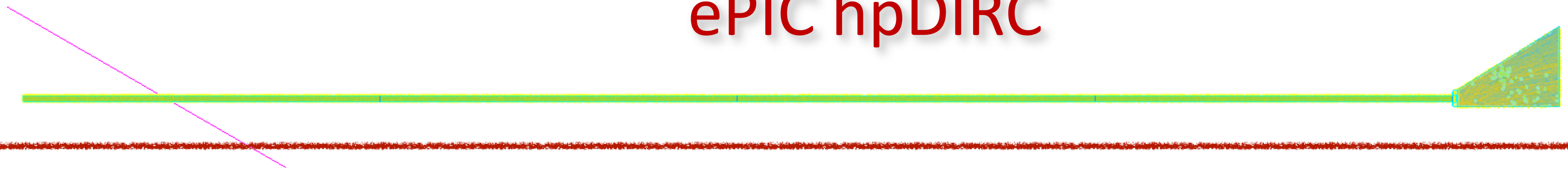
dRICH Threshold Settings

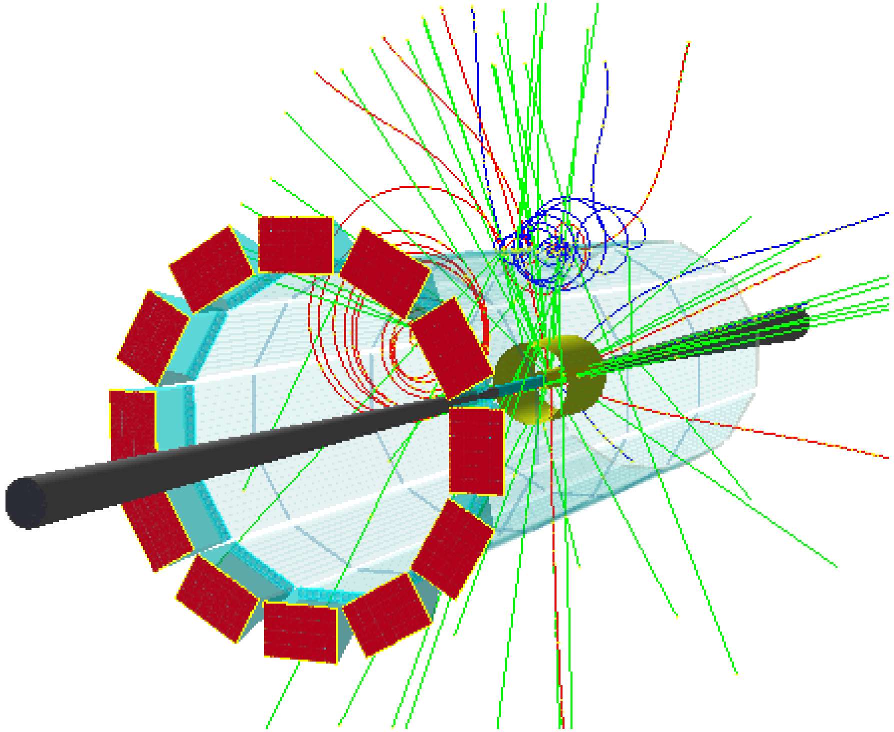
dRICH should work at **Single Photon Level**
Readout is sensitive to the dark coun rate increasing with radiation damage
Data rate is limited at DAM level by minimum-bias tagger and high-level data filter
The maximum rate per channel is driven by the maximum acceptable dark count rate and is set to 300 kHz, corresponding to 10 background hits per sector per event in a ~ 1 ns time window

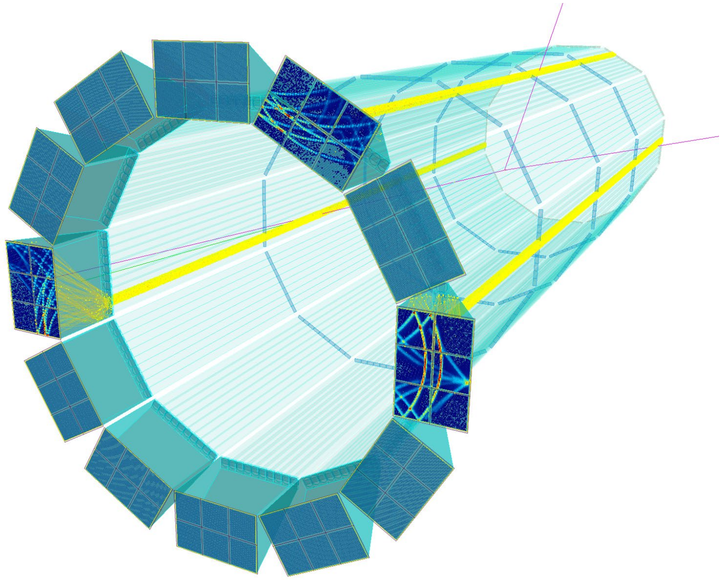


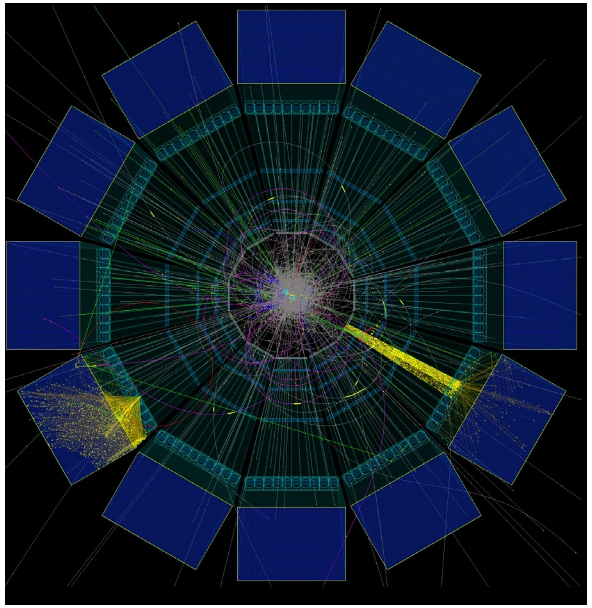
hpDIRC DSC

ePIC hpDIRC









Greg Kalicy

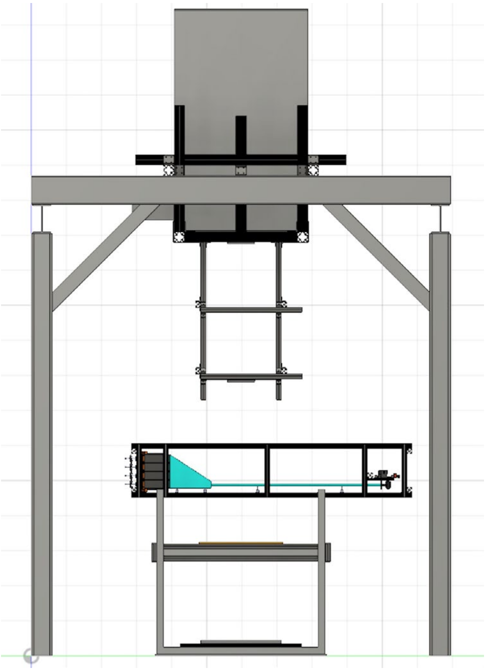
CUA

hpDIRC Prototype Plans

- Current status of readout development and availability of small pixel sensors does not allow for meaningful test beam dedicated to hpDIRC in near future.
- Panning to take part in pfRICH tests to gain experience with EICROC + HRPPDs combination
- Initial prototype at SBU CRT with bar from PANDA Barrel DIRC
- Disassembled BaBar DIRC bars will be tested in the prototype
- Prototype with two bars simultaneously will allow to study additional aspects of performance, increase statistics
- Two radiation-hard 3-layer lenses are in hand and will be tested for the first time in prototype
- Ultimate CRT goal: test of fully assembled ePIC hpDIRC modules (gluing of bars and assembly of hpDIRC barboxes planned at SBU)

DIRC lab/CRT space at SBU

CRT setup schematic



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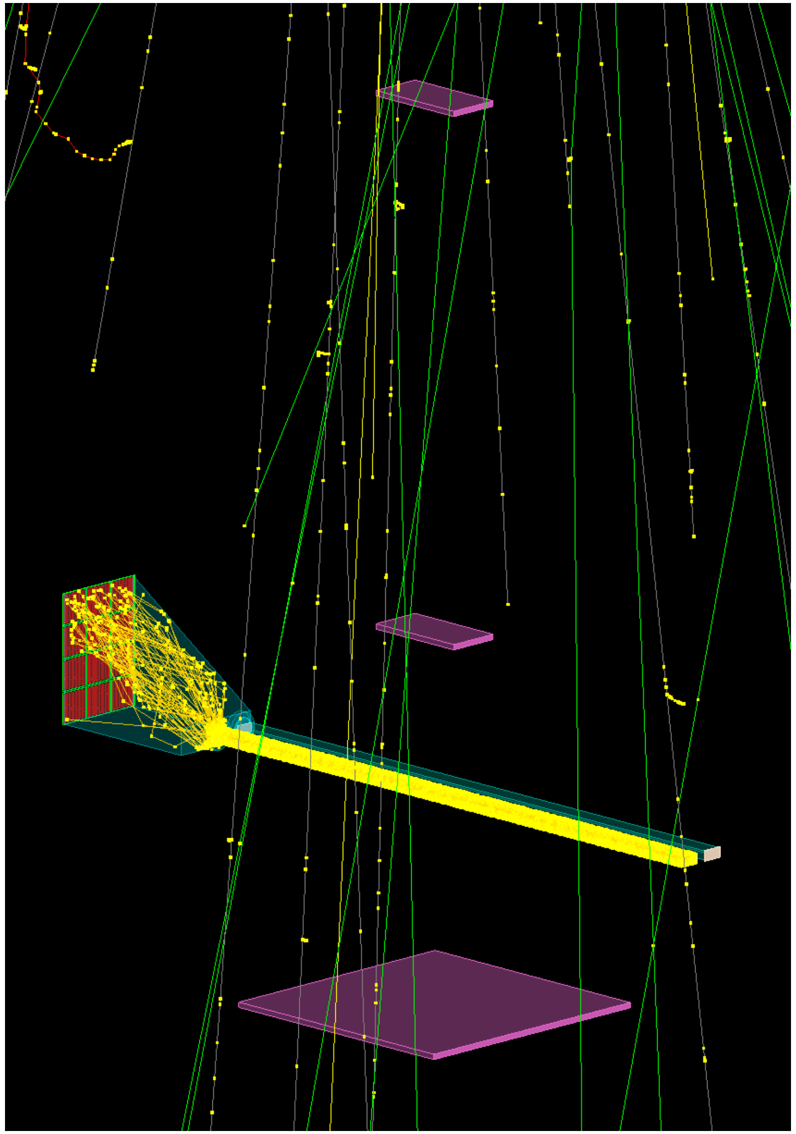
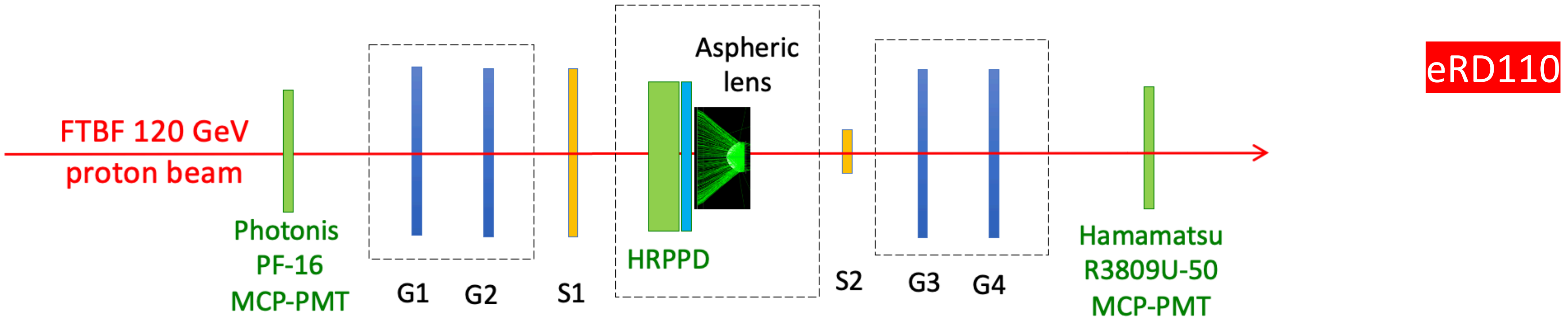
Simulation of hpDIRC Prototype with 2 bars in CRT



pfRICH DSC

Beam test at Fermilab in May 2024: week #1

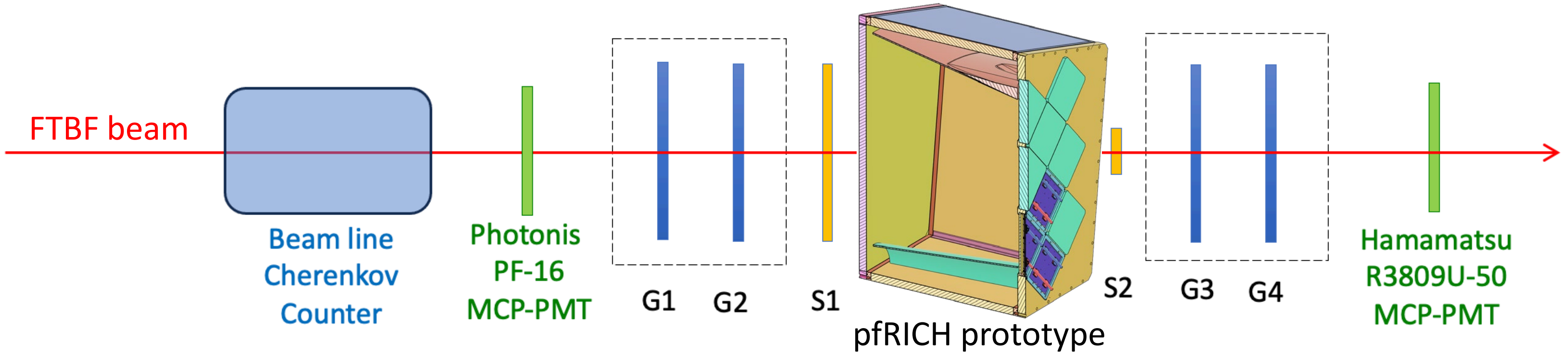


- Use well-established technique and equipment, in a bare minimum setup with a single HRPPD
  - GEM tracker (G1 .. G4), scintillators (S1, S2) & reference MCP PMTs
  - High performance scope & 512 channels of V1742 DRS4 electronics
  - [Passive HRPPD interface board with MCX connectivity]

- **Main objectives**:
  - First beam test experience with the new EIC HRPPDs:
    - Excitation of a single sensor by multiple coherent single photons, evaluation of timing distribution tails (hpDIRC)
    - Performance in a mixed single- and multi-photon environment (pfRICH)
  - A direct assessment of HRPPD timing performance

Beam test at Fermilab in May 2024: weeks #2-3

pfRICH



- Recycle an already debugged “week #1” tracker & reference MCP-PMT setup, except for
  - Make use of a low momentum MT6 hadron beam (and a beam line Cherenkov counter)
  - Install a fully fledged pfRICH prototype (aerogel, mirrors, five HRPPDs as a “sensor plane”)
  - Make use of ~5k channels of newly built HGCROC3 ASIC electronics

- **Main deliverable** is a direct simultaneous demonstration of
  - >3σ π/K separation reach up to ~ 7 GeV/c via aerogel Cherenkov photon imaging
  - HRPPD performance as a t_0 reference sensor for ePIC ToF subsystems
    - <50 ps timing resolution using aerogel Cherenkov photons
    - O(10ps) timing resolution using a sapphire window Cherenkov photon flashes

Far Forward DSC

Roman pots, B0, & Off-Momentum Detector Test Beam Needs (all AC-LGADs)

- Test beams at Fermilab hoped-for in Spring 2024.
    - Plan to test AC-LGAD + EICROC0 ASIC to extract performance for both timing and spatial resolution (with charge sharing) using MIP beams.
- Need space to install ~VME-sized board into telescope containing control board with AC-LGAD + ASIC bonded.
- Very important to assess performance of sensor with different geometry (e.g. pitch) and to test response of 4x4 channel EICROC0 to collect information for next iteration of the ASIC.

➢RHIC (STAR) could be a suitable alternative with MIP pions → need to verify what can be provided in that scenario by STAR.

Roman Pots, Off-Momentum Detectors, B0 thresholds

- Originally set at 1 keV for all three systems – this is likely aggressively low.
  - Average particle momentum in RP/OMD is > 100 GeV (> 200 GeV for top beam energy), and > 41 GeV in the B0.
  - Energy deposits average > 20 keV/hit from simulations → 10 keV likely a good starting point to remove obvious background hits.
    - Checked in raw DD4HEP output and in standalone simulations.
  - Thresholds especially important for the B0 where backgrounds will be substantial.
  - No feel for the level of common noise from electronics right now → something to evaluate in test beam with AC-LGAD + EICROC0.

Luminosity DSC

Far Backward High Rate Tracker DSC

SVT DSC

SVT-DSC – Test beams

- 2024: no EIC-LAS; ITS3 wafer scale sensor TB organized by ITS3
- 2025: 1 to 2 weeks, EIC-LAS v1
- 2026: 3 to 4 weeks, EIC-LAS v1 and v2
- 2027: 2 weeks, EIC-LAS v2
- 2028: possibly 2 weeks, EIC-LAS production
- Updated in test beam spreasheet

- Irradiation, latch-up tests, etc. at local facilities (i.e., available within SVT-DCS) are not explicitly considered here.

SVT-DSC – Simulations, software

- **Channel count** updated
- **Threshold on individual hit level**: to be reduced from 0.65 keV to 0.54 keV, being confirmed with designers
- **Threshold on summed energy**: not applicable
  - Sensor provides only binary, i.e. hit/no hit information
- **Pedestal position/cut on sigma of pedestal**: not applicable
  - Sensor provides only binary, i.e. hit/no hit information
- **Intrinsic/dark noise rate at this threshold**: < 10^{-3} per pixel per second (conservative upper limit) – no update

SVT-DSC – Simulations, software

- **Charge sharing**: 1.2 at 90 degrees – no update
- **Gate-on time (integration time)**: 2 μs target – no update
- **Gate-off time (deadtime)**: no estimate at this time

- Updating in the EPIC Detector Digitization Model.10.2023
    - Note that we updated the information also in OLD.EPIC Detector Digitization Model.09.2023 by mistake

- Shujie Li remains the main contact

Backwards ECAL DSC

Backward ECAL : plans for beam tests

- Timeframe: summer/fall 2024
- Goal: test read-out electronics (both discreet and ASIC), linearity, energy resolution
- Anticipated system: 5x5 prototype equipped with 4 SiPM per crystal (10um pitch)
- Possible facilities: JLab Hall D, DESY (GeV-scale electron facilities)

Backward ECAL: Pedestal Position & Cut on σ of Pedestal - Width

Threshold on individual hit level [keV, MeV or p.e.]	Pedestal Position in ADC chanels and in Energy [keV, MeV and p.e.]	Cut on sigma of Pedestal - Width	What is the relation of the segmentation given by reco-hits to readout channels
	pedMeanADC = 20 ch	pedSigmaADC = 1 ch	1 RecoHit is 1 readout channel (tower)

- Assumed 14-bit ADC and 5 MeV - 18 GeV dynamic range

Backwards HCAL DSC

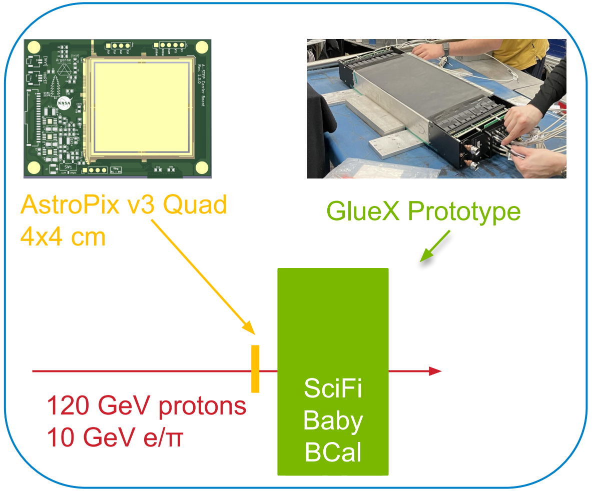
Barrel ECAL DSC

TIC Meeting, 10.23.23

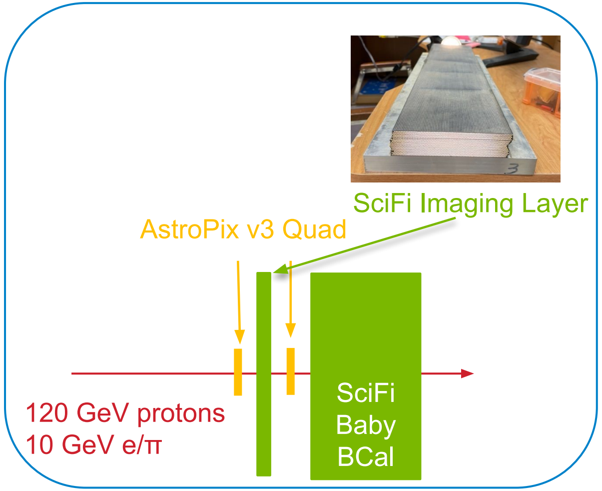
Barrel Electromagnetic Calorimeter

Barrel ECal - FTBF Original Plans FY24

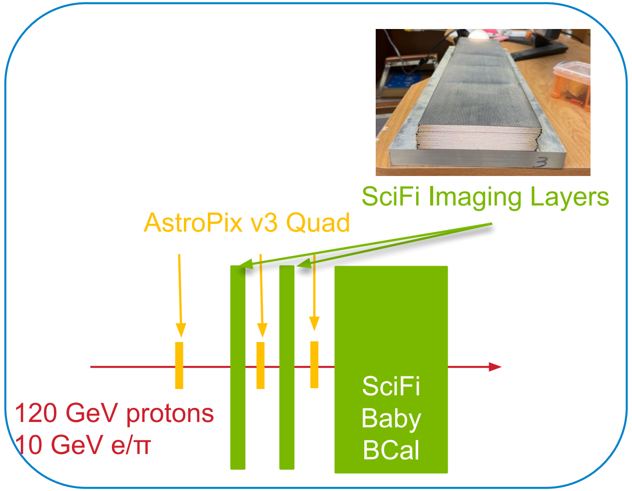
Stage I



Stage II



Stage III



- **Prior to installation at FTBF:** characterize used AstroPix v3 Quad sensor on the bench; take cosmics with Baby BCal, develop and test integrated readout system
- **At the FTBF with proton and e/π beam:**
  - Every stage requires **commissioning** of the whole system in the beam: MIPs - **120 GeV protons**
  - **2 important benchmarks** with Baby BCal and integrated system: benchmark **response to pions** in simulations, evaluate e/π separation (with Cherenkov FTBF detector) - **10-5 GeV e/π beam**

Barrel ECal - FTBF Original Plans FY24

FTBF Beam original estimated schedule (**1 full week each**, i.e. 2 weeks of half-day shifts), **together with ATLAS Telescope program** (Experiment T1224 in MTest 6.2 Enclosure):

- Stage 1: Estimated Winter ‘23 , Stage 2: Estimated Spring ‘24, Stage 3: Estimated Summer ’24

If only Spring ‘24 is available → proton (MIPs commissioning) and e/π beam (5-10 GeV) needed

- Try to use cosmics, as much as possible, to integrate AstroPix & Baby BCAL. However, we need to also commision the readout system in high-occupancy environment of the beam (MIPs).
- Realistically we will be probably able to run in stage I and maybe II.
- First physics benchmark will be to test the response to pions (we can fold it in the simulation and benchmark e/π response). The e/π benchmark with Cherenkov will depend on how much time we can potentially get with e/π beam.

We try to consider alternatives - we need beam test + Cherenkov/PID detector (need to know momentum of the beam, and identify pions)

- CERN(?) - Do not have any experience in beamtest there + significant logistical endeavour with transporting the whole setup. Any advice?
- JLab(?) - Maybe Hall C/A? Started exploring with the hall leaders, but doesn’t look very promising as of now.

Thresholds for Barrel ECal

Subsystem	Region	Channel Count	Threshold on summed Energy [keV, MeV]
AstroPix	**Barrel**	**~360M pixels**	15 keV
ScifiPb	**Barrel**	**5760**	5 MeV

https://github.com/eic/EICrecon/blob/main/src/detectors/BEMC/BEMC.cc

Thresholds for AstroPix:
3 MeV / 8192 ADC channels * 41(channels) = ~**15 keV** ✅
Threshold for SciFi:
1500 MeV / 16384 ADC channels * 5(channels) = ~0.5 MeV; 0.5 MeV/10% (fsam) = **5 MeV** ✅

EcalBarrelScFiRecHits and EcalBarrelImagingRecHits can be taken as the estimate for the rates.

The SciFi response currently implemented as true dE (not 2-side attenuated). The calculated rates using EcalBarrelScFiRecHits will be **per-side of the SciFi/Pb calo**. The total rate from the system should be taken as **2 x the estimated rate**.

Thresholds (RecoHit), pedestal mean and sigma (Digi) has been revisited (and out into the spreadsheet)
https://github.com/eic/EICrecon/pull/1078

Barrel HCAL DSC

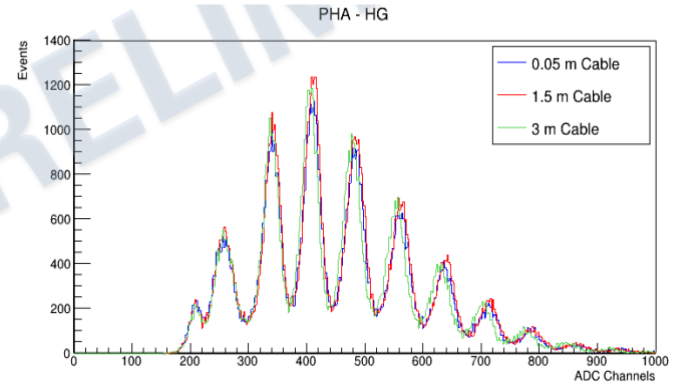
Barrel HCAL Test Beam Needs

- The barrel HCAL is an existing detector, performance already measured a test beam and we will have sPHENIX experience to inform us as well.
- The test beam needs for the barrel HCAL center on the new H2GCROC based electronics chain (reading single tiles).
  - Equip sPHENIX test beam detector with new electronics
  - Ideally measure performance for pions 2-40 GeV to match prior test beam results.
    - FTBF is probably ideal for this.
    - Muon studies can probably be done with cosmics
  - Timing for this depends on electronics readiness (maybe 2024, certainly 2025)

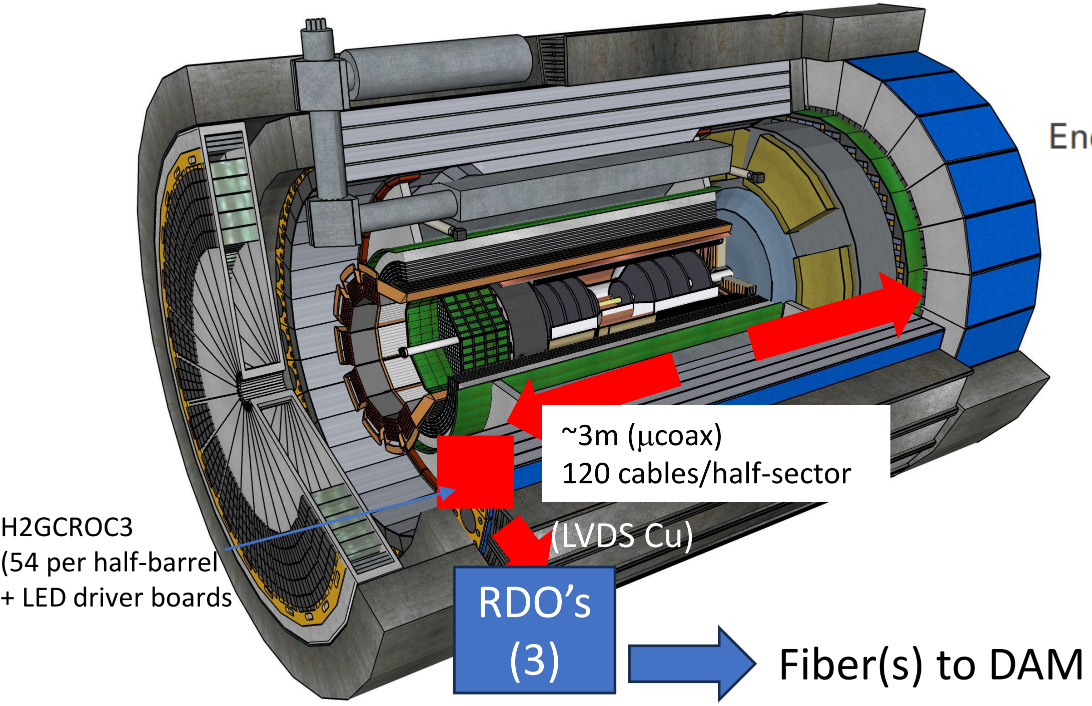
Readout Chain

Cable SiPM’s out to end of barrel HCAL to keep accessible for maintenance.

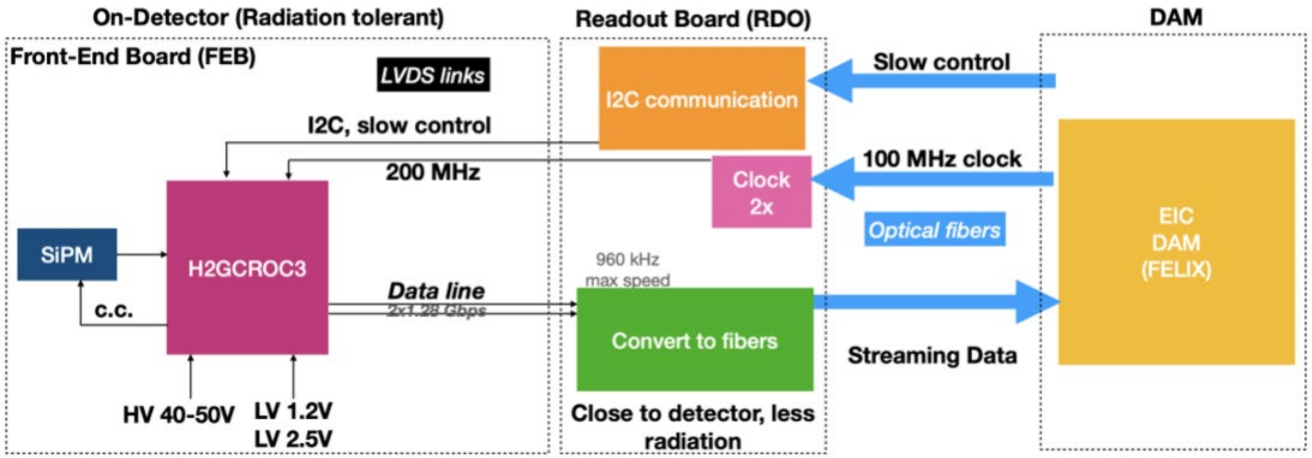
One half-sector -> 54 H2GCROC3 boards (72 channels each), collected into three RDO’s (up to 24 ASICS ea.)



Energy loss along a cable with remote SiPM



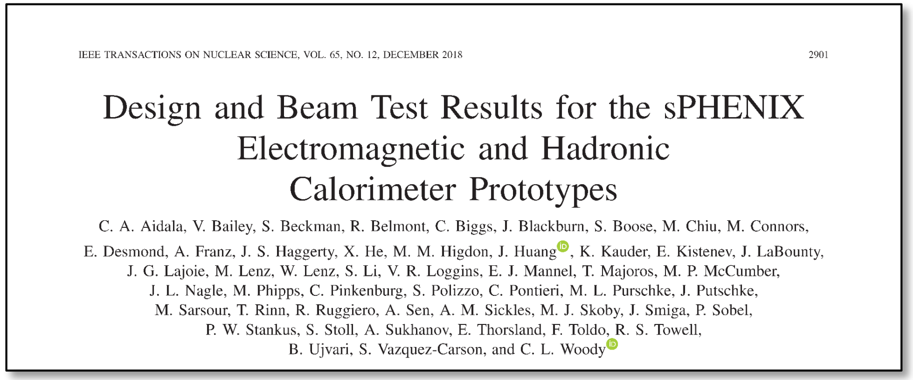
LFHCal readout hierarchy (after the upgrade)



Combined with the dynamic range of fired pixels the collected charge range we will see is
The H2GCROC3 expected range is

Prior Test Beam Results

PERFORMANCE REQUIREMENTS		
Name	**Description**	**Parent**
Barrel HCAL		
P-DET-HCAL-BAR.1	Should have a moderate energy resolution s(E)/E ~ 100%/sqrt(E) + 10% constant term.	**F-DET-HCAL-BAR.1**

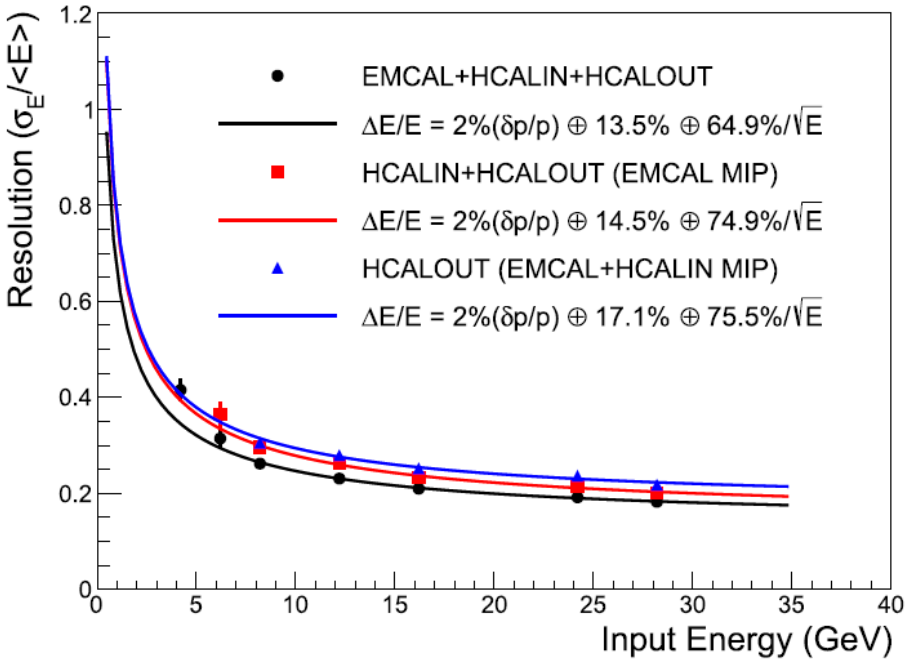

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 65, NO. 12, DECEMBER 2018 2901

Design and Beam Test Results for the sPHENIX Electromagnetic and Hadronic Calorimeter Prototypes

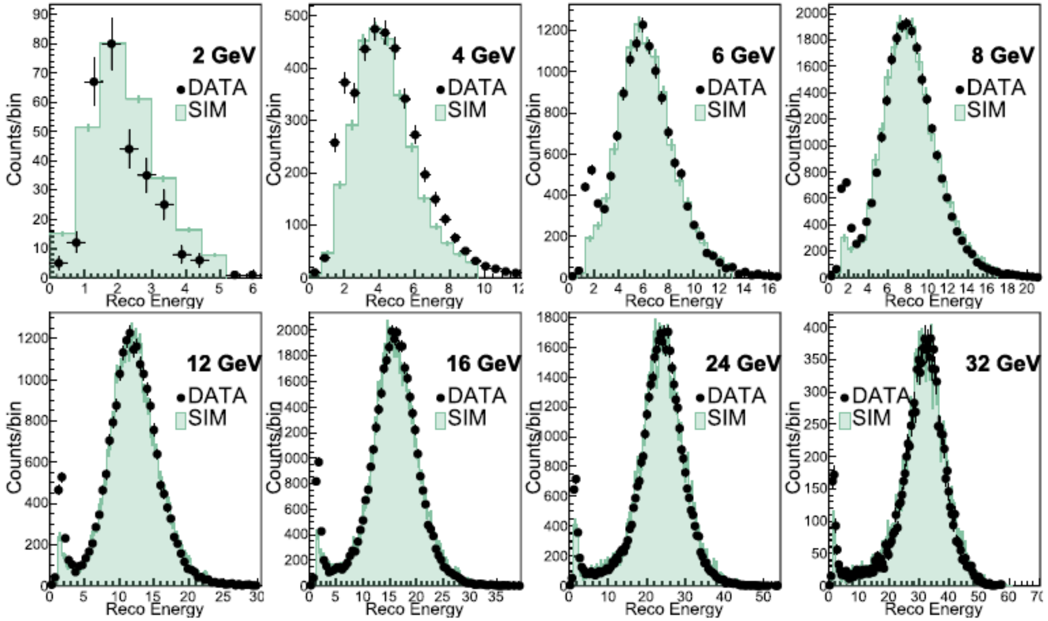
C. A. Aidala, V. Bailey, S. Beckman, R. Belmont, C. Biggs, J. Blackburn, S. Boose, M. Chiu, M. Connors, E. Desmond, A. Franz, J. S. Haggerty, X. He, M. M. Higdon, J. Huang, K. Kauder, E. Kistenev, J. LaBounty, J. G. Lajoie, M. Lenz, W. Lenz, S. Li, V. R. Loggins, E. J. Mannel, T. Majoros, M. P. McCumber, J. L. Nagle, M. Phipps, C. Pinkenburg, S. Polizzo, C. Pontieri, M. L. Purschke, J. Putschke, M. Sarsour, T. Rinn, R. Ruggiero, A. Sen, A. M. Sickles, M. J. Skoby, J. Smiga, P. Sobel, P. W. Stankus, S. Stoll, A. Sukhanov, E. Thorsland, F. Toldo, R. S. Towell, B. Ujvari, S. Vazquez-Carson, and C. L. Woody

Detailed studies of performance and comparison with simulations done in test beam (T-1044).

Performance of full device will be measured in sPHENIX. We should achieve a reduced constant term due to tighter control on the scintillator variation in a tower for production sectors.



Data vs. Monte-Carlo comparison



BHCal Thresholds in EICrecon (ca. 10.23.2023)

- **Threshold on Summed Energy:**
  - 5 MeV
  - This is half-MIP, or about 20 SiPM pixels
- **Pedestal Mean/Position**:
  - Set to 10 ADC counts in EICrecon
    - About 0.150 MeV (for 15 keV/count)
  - Expect MIP peak at ~10 MeV
    - About 40 SiPM pixels…
- **Pedestal Sigma:**
  - Set to 2 ADC counts
- **Cut on Pedestal Sigma:**
  - Set to 5
  - thresholdADC = (thresholdFactor x pedSigmaADC) + minADC
    - thresholdFactor = 5
    - pedSigmaADC = 2
    - minADC = 1

- **Clustering:** threshold on minimum energy of tile to be added to cluster
  - 5 MeV (or 30 MeV for central tile)
- **Note:** ADC threshold given by:
  - threshold = (cutOnSigma x pedSigmaADC) + minADC
    - cutOnSigma = 5
    - pedSigmaADC = 2
    - minADC = 1
- **Note:** keV/ADC count calculated via
  - perCount = dynamicRange / capADC
    - Dynamic range = 1 GeV
    - capADC = 65536

Backup | BHCal Reconstruction in EICrecon1.6.2

```
app->Add(new JChainMultifactoryGeneratorT<CalorimeterHitDigi_factoryT>(
  "HcalBarrelRawHits", {"HcalBarrelHits"}, {"HcalBarrelRawHits"},
  {
    .eRes = {},
    .tRes = 0.0 * dd4hep::ns,
    .threshold = 5.0 * dd4hep::MeV,
    .capADC = 65536,
    .capTime = 100, // given in ns, 4 samples in HGCROC
    .dyRangeADC = 1.0 * dd4hep::GeV,
    .pedMeanADC = 10,
    .pedSigmaADC = 2.0,
    .resolutionTDC = 1.0 * dd4hep::picosecond,
    .corrMeanScale = 1.0,
    .readout = "HcalBarrelHits",
  },
  app   // TODO: Remove me once fixed
));
```

BHCal HitDigi Configuration

```
app->Add(new JChainMultifactoryGeneratorT<CalorimeterHitReco_factoryT>(
  "HcalBarrelRecHits", {"HcalBarrelRawHits"}, {"HcalBarrelRecHits"},
  {
    .capADC = 65536,
    .dyRangeADC = 1.0 * dd4hep::GeV,
    .pedMeanADC = 10,
    .pedSigmaADC = 2.0,
    .resolutionTDC = 1.0 * dd4hep::picosecond,
    .thresholdFactor = 5.0,
    .thresholdValue = 1.0,
    .sampFrac = 0.033, // average, from sPHENIX simulations
    .readout = "HcalBarrelHits",
    .layerField = "tower",
    .sectorField = "sector",
  },
  app   // TODO: Remove me once fixed
));
```

BHCal HitReco Configuration

Backup | BHCal Reconstruction in EICrecon1.6.2

```
app->Add(new JChainMultifactoryGeneratorT<CalorimeterIslandCluster_factoryT>(
  "HcalBarrelIslandProtoClusters", {"HcalBarrelRecHits"}, {"HcalBarrelIslandProtoClusters"},
  {
    // Magic constants:
    //  24 - number of sectors
    //  5  - number of towers per sector
    .adjacencyMatrix =
      "("
      "  abs(fmod(tower_1, 24) - fmod(tower_2, 24))"
      "  + min("
      "      abs((sector_1 - sector_2) * (2 * 5) + (floor(tower_1 / 24) - floor(tower_2 / 24)) * 5 + fmod(tile_1, 5) - fmod(tile_2, 5)),"
      "      (32 * 2 * 5) - abs((sector_1 - sector_2) * (2 * 5) + (floor(tower_1 / 24) - floor(tower_2 / 24)) * 5 + fmod(tile_1, 5) - fmod(tile_2, 5))"
      "    )"
      ") == 1",
    .readout = "HcalBarrelHits",
    .sectorDist = 5.0 * dd4hep::cm,
    .localDistXY = {15*dd4hep::mm, 15*dd4hep::mm},
    .dimScaledLocalDistXY = {50.0*dd4hep::mm, 50.0*dd4hep::mm},
    .splitCluster = false,
    .minClusterHitEdep = 5.0 * dd4hep::MeV,
    .minClusterCenterEdep = 30.0 * dd4hep::MeV,
    .transverseEnergyProfileMetric = "globalDistEtaPhi",
    .transverseEnergyProfileScale = 1.,
  },
  app   // TODO: Remove me once fixed
));
```

BHCal Clustering Configuration

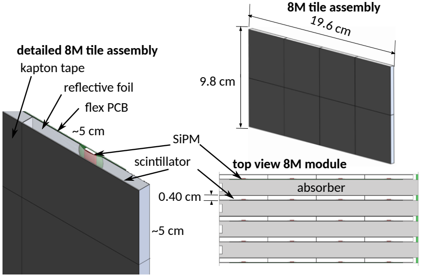
Forward ECAL DSC

Forward HCAL DSC

LFHCal & insert: Test Beam Plans 2023 - 1)

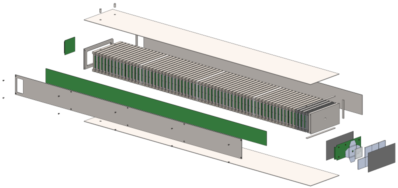
Requested time: 1-2 weeks May
Main purpose: First full module test & H2GCROC tests
Location: Fermilab or together with FoCal CERN SPS
Setup:

- Full 8M module testing 65 layers of absorber & scintillator per layer 8 channels (swapping scintillator geometry either 8M module or insert)
- Readout with multiple CAEN DT5202 64ch CITIROC SiPM readout units or H2GCROCs



Main expected measurements:

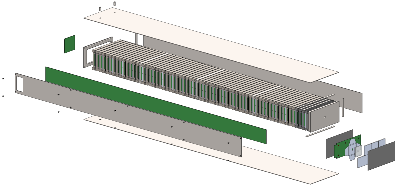
- Energy resolution estimates for hadrons and electrons for full length module
- Assessment of longitudinal leakage
- Longitudinal shower development
- Read-out validation
- Ideally part of the campaign with the addition of the ECal in front

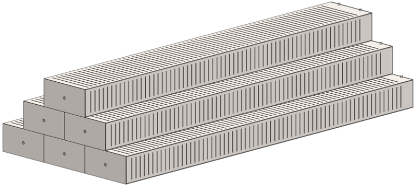


LFHCal: Test Beam Plans 2023 - 2)

Requested time: 1-2 weeks September/October
Main purpose: Resultion studies
Location: CERN SPS
Setup:

- 4-8 full 8M modules (ideally 40x40x140 cm), optionally with ECal upfront
- Readout with H2GCROCs





Main expected measurements:

- Energy resolution for hadrons and electrons
- Assessment of longitudinal/transversal leakage
- Longitudinal shower development
- Final-Flexible PCB validation & first long PCB validation
- Ideally part of the campaign with the addition of the ECal in front

Insert: Test Beam Plans 2023 - 2)

1) **Parasitic test at the east-side alcove of the STAR hall during the RHIC 200 GeV pp run in 2024 (January-June). Goals:**

- Operating and calibrating the prototype in realistic conditions, as well as quantifying system degradation due to radiation damage.
- Demonstrating mitigation strategy for radiation damage (annealing, large SIPM, etc)
- Measurement of MIP response using isolated tagged charged hadron.
- Measurement of core of hadronic shower using isolated tagged charged hadron.
- Measuring π0 invariant mass and spectra to verify calibration and showcase the separation of two showers with a fine 3D shower shape.

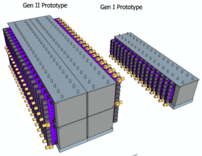
2) **Second test with 4 GeV positrons at JLab (Hall-D) during Fall 23. Similar to our first test beam done in Jan 2023 (arXiv:2309.00818) but with x10 more channels**

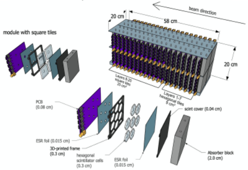
- Test hexagonal, staggered design and HEXPLIT algorithm (arXiv:2308.06939)
- Demonstrate 3D shower shape measurement with better granularity and x10 more channels compared to our first test beam.

3) **Test beam with hadrons and electrons at FNAL (when available).**

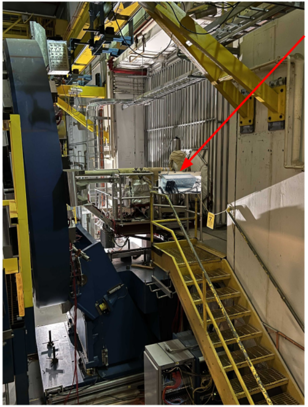
- Combined performance study with ECAL (WSciFi) module.

We will be testing our Insert "gen-II" prototype:



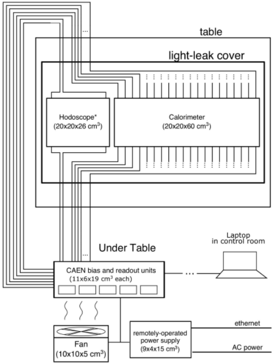


Insert: Test Beam Plans 2023 - 2)



We plan to mount prototype here

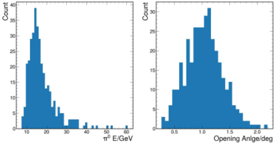
- Prototype will cover 3.5<η<4.3 and and +/- 25 degrees in azimuthal angle
- Prototype large Enough to capture Pi0 and EM core of hadronic showers



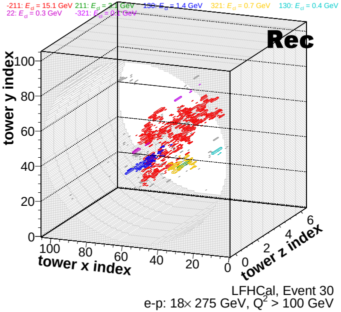
Strategy:
Fully standalone DAQ & trigger.

Trigger:
- Charged-particles with hodoscope
- Calorimeter trigger for pi0

Pythia8 sim with prototype acceptance cuts



LFHCal & insert: Readout thresholds



parameter	LFHCal 8M & 4M modules	insert modules
inner x,y (R)	-20 cm $> x >$ 40 cm, -30 cm $> y >$ 30 cm	$R >$ 17 cm
outer R (x,y)	$R <$ 270 cm	-20 cm $> x >$ 40 cm, -30 cm $> y >$ 30 cm
η acceptance	$1.2 < \eta < 3.5$	$3.5 < \eta < 4.4$
tower information		
x, y	5 cm	$\approx$ 3 cm
z (active depth)	130 cm	130 cm
z read-out	$\approx$ 7 cm	$\approx$ 7 cm
interaction lengths	6.5 λ/λ_0	7.5 λ/λ_0
# towers	8704	
# modules		2
8M	1050	
4M	76	
# read-out channels	7 x 8704 = 60,928	23400

- **8M & 4M modules**:
  read out in 7 layers longitudinally (5 or 10 SiPMs summed)
  desirable min measurable tower energy $<$ 0.5 MIP/segment, max. $\approx$ 1500 MIP/segment
  ideally even just 1 MIP in tile detected
  $\rightarrow$ 565,760 SiPMs, 60,928 read-out channels
- **insert modules**:
  read out every single tile
  desirable min measurable energy $<$ 0.5 MIP/tile , max. $\approx$ 500 MIP/tile
  23400 SiPMs/tiles & read out channels
- 1 MIP $=$ 600-700MeV in LFHCal tile & 500 MeV in insert tile
- pedestral for summed layers to be validated (only guess right now)
- intrisic noise will dependent on rad. damage

	LFHCal	insert
thresholds [E_{summed}]	0.3-0.35 MeV	0.25 MeV
thresholds [E_{layer}]	0.3-0.35 MeV	0.25 MeV
pedestral [ADC]	layer: 5-10 ADC $\pm$ 2 ADC seg: 50-100 ADC $\pm$ 5-10 ADC?	10 ADC $\pm$ 2 ADC
dark noise rate	$<$ 50 Hz	?

AC-LGAD TOF DSC

Gaseous Trackers DSC

MPGD - Beam Test Plans 2024 and beyond

	ePIC Planar uRWELL trackers (Thin gap / hybrid)	ePIC Cyl. Micormegas (Francesco Bossu / Saclay)
FY24	• Design of full-size barrel outer µRWELL module & end cap disc prototypes ➔ **No needs or plans for beam test** • Will seek test beam opportunity at in Hall D @JLab (or at CERN) for test of existing small thin gap hybrid MPGD & cylindrical µRWELL prototypes	• Likely beam test in Mainz (driven by the R&D for the P2 experiment ➔ EIC will profit of it • Ongoing discussion on the need for test in proton beams ➔ Ressources and manpower are stretched
FY25	• **2 - 4 weeks at Fermilab FTBF** for first characterization of full-size ePIC µRWELL prototypes (outer barrel and end cap) • Will also test small / medium size EIC Generic R&D Thin gap Hybrid prototypes. • Beam: mainly 130 GeV primary protons, as well as lower energy secondary hadron beam • Would welcome opportunity for GeV electron beam @ JLab	**2 - 4 weeks at Fermilab / CERN:** Tentatively
FY26	• **2 - 4 weeks at Fermilab FTBF** for complete characterization of full-size ePIC µRWELL prototypes (including readout electronics • Beam: mainly 130 GeV primary protons, as well as lower energy secondary hadron beam • Would welcome opportunity for GeV electron beam @ JLab	**2 - 4 weeks at Fermilab / CERN:** Tentatively

Threshold settings for realistic background rate estimation

- Threshold for all ePIC MPGD trackers is estimated at **250 eV.**
- This number is based on a crude estimation of how signal develop in MPGD detectors and our current understanding on the parameters for the front-end electronics based on the SALSA chip for the gaseous trackers.