

Summary of EPIC Collaboration Meeting (DAQ Perspective)

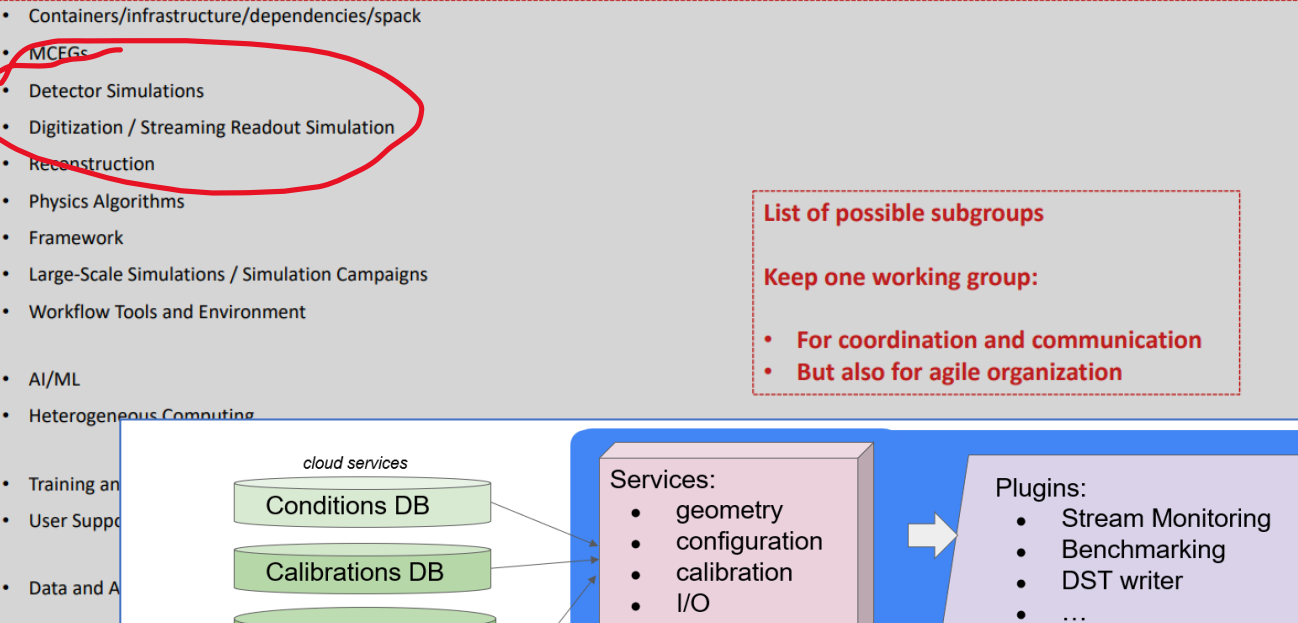
Jeff Landgraf

Software / Computing

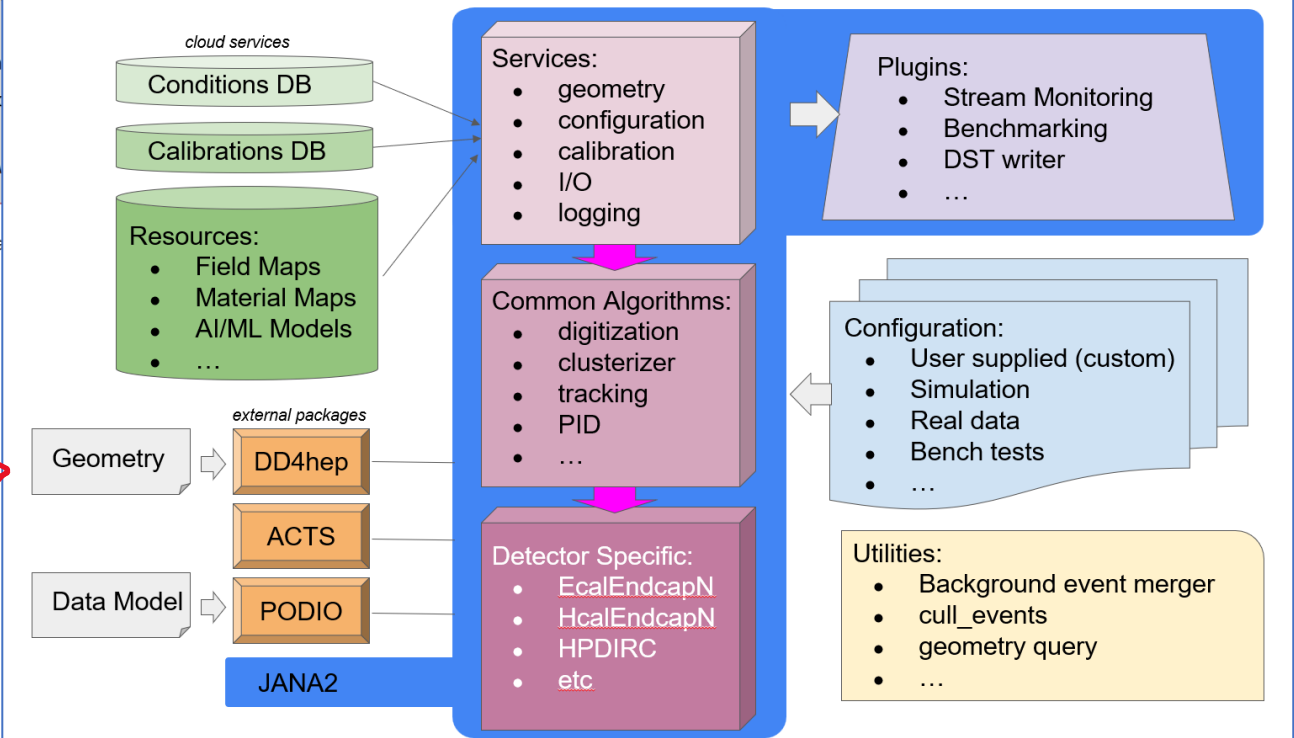
Subgroups: Shared Leadership and Responsibilities

Markus Diefenthaler:

- Subgroups
- Digitization / Streaming Readout



EPIC Collabor



Nathan Brei:

- Jana2 (framework)
 - Providing information
 - QA & other processing
 - DAQ integration?

Tracking

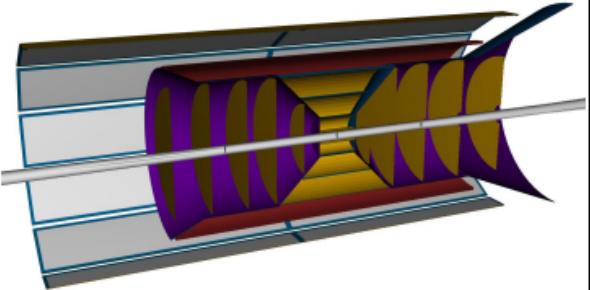
Kondo Gnanvo, Stephen Maple, Wenqing Fan:

- Some updates to detector (minor from DAQ point of view)
- Lots of tracking studies
- MAPS integration time unknown but assumed $\sim 2\mu\text{s}$

Rehnier Cruz-Torres:

- Background results starting to come out...
- DAQ attention needed
 - Need to convert to Data Volumes
 - Need to convert to electronics impacts
 - Need to estimate noise/dark currents

ePIC end cap trackers: Current configuration



❖ Number of disks in the electron direction increased to **improve acceptance at high eta/increase number of points on track.**

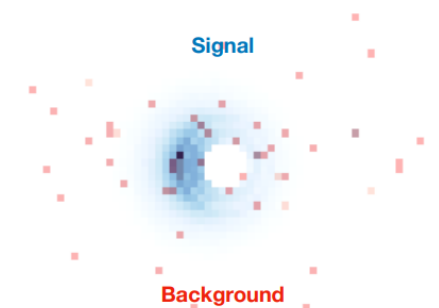
- At $|\eta| \geq 3$ in the electron going direction, hits on three disks only in reference detector. Insufficient considering noise and inefficiency.

❖ Use all available space in z to **increase lever arm.**

- The table below show the current layout implemented in simulation.

DISKS	+z [mm]	-z [mm]	X/X0 %
Disk 1	250	-250	0.24

Background and track reconstruction studies



Reynier Cruz-Torres
Lawrence Berkeley National Laboratory

Presenting work done by lots of people: J. Adam, E. Aschenauer, W. Deconinck, J. Huang, A. Jentsch, K. Kauder, D. Lawrence, J. Nam, J. Osborn, B. Sterwerf, Z. Zhang, ...



Electron Proton-Ion Collider Experiment Collaboration
January 10th, 2023



Calorimetry

Joshua Crafts, Maria Zurek

- The Barrel Ecal technology still not decided, but lots of details of each technology described

Miguel Arratia:

- Insert not in baseline
- Argued that it should be, and if it shall ever be installed **must** be in baseline
- No clarification regarding the two competing readout schemes (HDCROC32 for all vs ADC/FPGA for some)

EIC Barrel EMCAL Mechanical Design

The design is based on that of the PANDA Barrel EMCAL taking into account the different needs of the EIC

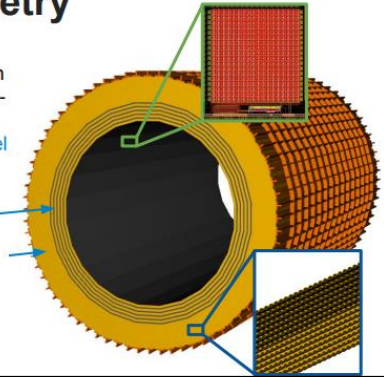
▪ PANDA

▪ EIC BEMCal

- 68 Sci-Glass blocks per slice with 6 family variations.
- Central section (family 1 & 2) reduced in length to 40cm to allow

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**
- Followed by a **large section of SciFi/Pb section** (can serve as inner HCAL)
- Total radiation thickness for EMCAL of $\sim 21 X_0$ (only ~ 38 cm! deep)

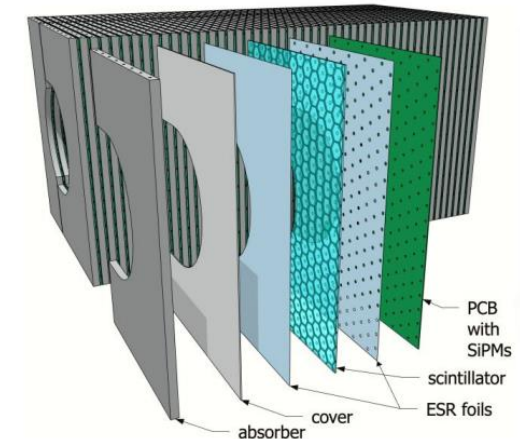


Calorimeter Insert for ePIC

Miguel Arratia,
on behalf of the insert team



January 10th 2023, EPIC collaboration meeting



Cherenkov PID

Pietro Antonioli:

- LAPPD technology for mRICH/pfRICH
- mRICH vs pfRICH not determined
- LAPPD or MCP-PMT for hpDIRC
- SiPM dark currents better than previous estimates by $\sim x5$ because of continuous/semi-continuous annealing.

Christopher Dilks:

- Outer ring ~ 7 hits... To be found in high noise environment for dRICH

the candidates table (June 2022)



[eRD110 presentation](#) shown at "From RICH to EIC" / AGS/RHIC user meeting – June 2022

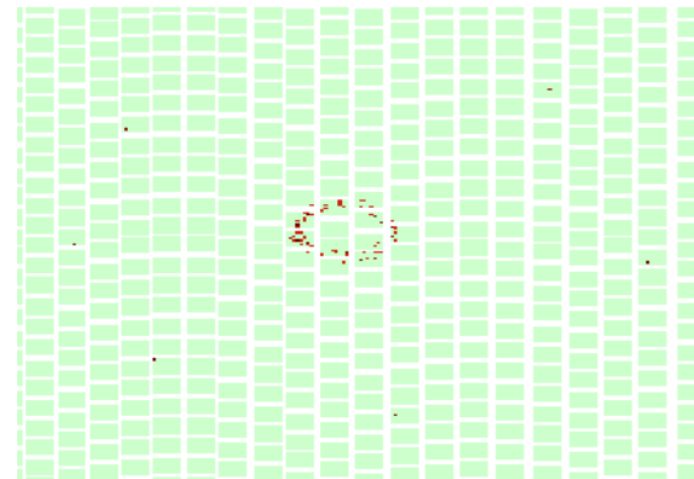
	MCP-PMT/Planacon	SiPM	LAPPD
B-field (LAPPD)	5x5 cm ²	Tiles available 5.76 cm ²	20x20 cm ²
Pixel		3x3 mm ²	25 x 25 mm available → 3x3 mm in future?
Radiation (SiPM))	Magnetic field: Seen drop in collection efficiency at angle > 10 deg	insensitive	7 T on 20 μm MC seems ok, depending orientation. Smaller MCP's for larger field
	Radiation: insensitive	needs test + assess mitigation protocol (annealing)	No data, but reasonable to expect not a problem
commercially available (ex.: Planacon XP85122) with (< 100 ps time resolution) are ok. Problem is price tag (hpDIRC)	Availability: In stock*	In stock*	"In-stock" for 20 μm
	Manufacturers: Photonis/Photek	many (HPK, OnSemi, FBK/L-Foundry, Ketek/Boradcom)	Incom
	Price: \$ 15-20 k\$ each (few units)	1 k\$ / (8x8 tile 3x3 mm)	\$25-50k each LAPPD (20x20 cm ² or 10x10 cm ² similar price)
	Unit price: 16 k\$/25 cm ² = 600 \$/cm ²	≈50-100 \$/cm ²	62.5-500 \$/cm ²
	Concerns: cost	DCR increase with radiation	Cross talk, integration, availability
move from prototypes to "production" (LAPPD)	Risks: None	None if mitigation of DCR increase "manageable"	Achievable with risk, time schedule challenging

Jan 10 2023 – ePIC meeting

P. Antonioli – Cherenkov PID: photosensors

3

Event Display: digitized hits



- Digitization:
 - Quantum Efficiency (20-40%)
 - Pixel gap cuts (88%)
 - Safety factor (70%)
- # hits << # photons
- Still does not include SiPM noise!

Far Backward

Igor Korover, Jae Name, Dhevan Gangedharan:

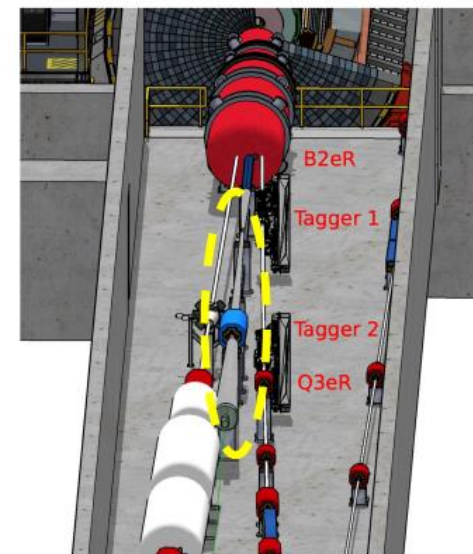
- Detectors physical positions changing
- Still shifting in terms of technologies (or perhaps it's my understanding that is shifting 😊)

Luminosity Monitors

The luminosity measurement provides the required normalization for all physics studies.

- Absolute cross sections.
- Combine different running periods.
- Relative luminosity of the different bunch crossings.

Accuracy of the order of 1% is required
(or relative luminosity exceeding 10^{-4} precision)



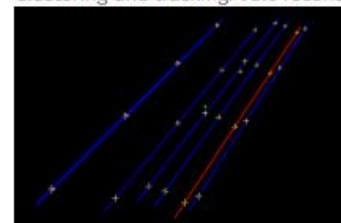
Simon Gardner (Low Q^2 Taggers):

- 320 Gb/s is about 3x previous estimates
 - More FELIX must be allocated
 - Define analysis, Organize Analysis (data in separate computers?), ensure resource for analysis.

TRACKING & RATES

Typical bunch crossing (18x275 maximum luminosity)

Contains ~ 12 electrons
 ~ 7 are accepted by Tagger 2
Clustering and tracking: 95% reconstruction efficiency

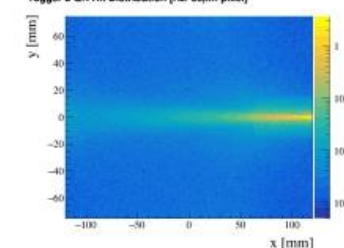


e^- from Quasi-Real scattering event among e^- from Bremsstrahlung

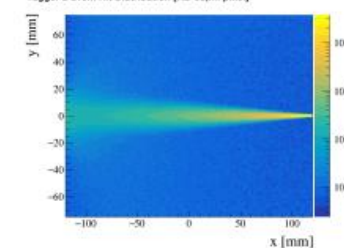
Rates

Maximum rate per $55\mu\text{m}$ pixel: 20 kHz
Maximum pixel rate per layer from MIPs: 2.5 GHz
At 64 bits per pixel = 320Gb/s. (Big but Timepix4 + SPIOR4 can do this)

Tagger 2 QR Hit Distribution [Hz/55 μm pixel]



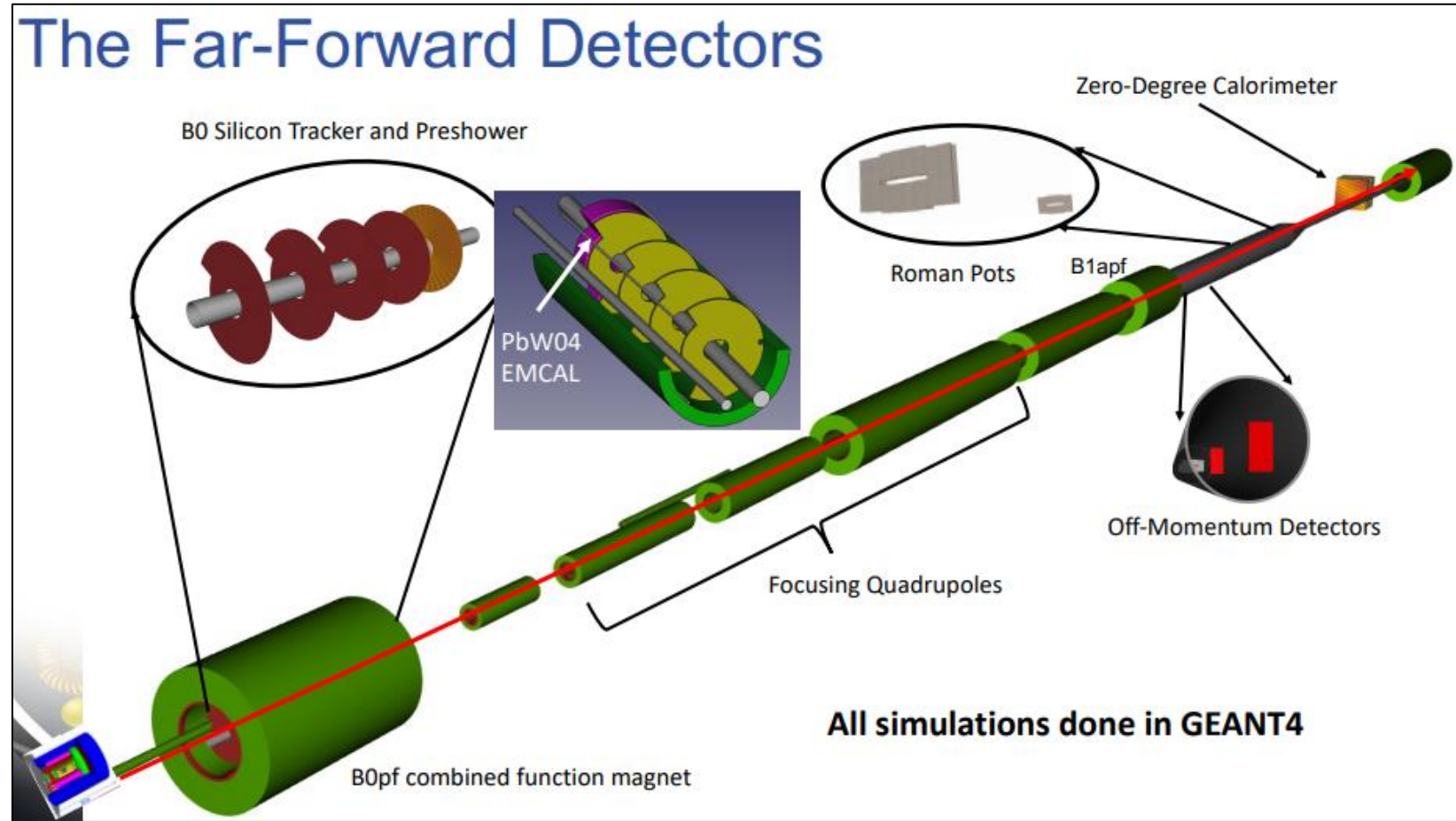
Tagger 2 Brem Hit Distribution [Hz/55 μm pixel]



Far Forward

Alexander Jentsch:

- Focus was on tracking & detector performance



TOF

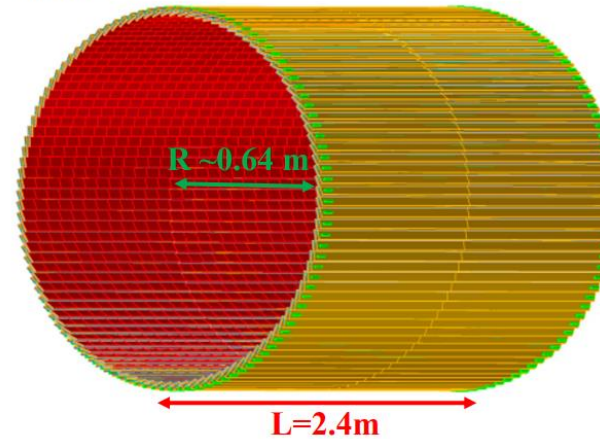
Zhenyu Ye:

- Decisions
 - Strips for barrel
 - Pixels for Endcap
 - No Backward Endcap (LAPPD RICH readout)

- Refers to DAQ plans (via tonko)

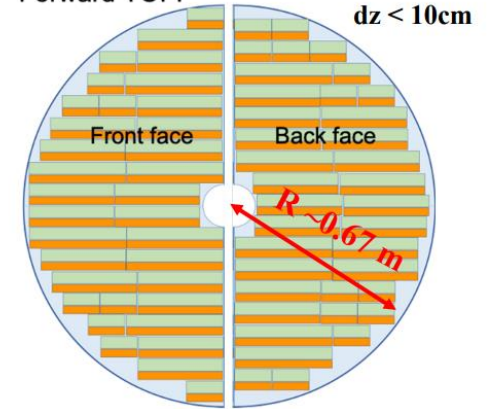
TOF Layout

Barrel TOF:



More details: <https://indico.bnl.gov/event/16765/>
<https://indico.bnl.gov/event/17336/>

Forward TOF:



- 288 staves, each with 32 strip sensors wire-bonded to 64
- 212 modules, each with 24 to 96 bump-bonded

from
Po
fo

On-detector Electronics Development

Approved R&D proposal (eRD109) includes readout electronics work from ORNL. Further PED request by BNL, Rice and other institutions through DAQ group is anticipated

- ORNL: Readout R&D for barrel implementation
 - Targeting kapton flex design for minimal material budget
 - Integration into barrel mechanics
- BNL:
 - Readout board reference prototype
 - Precision clock distribution
- Rice: Readout board implementation for TOF endcap, power board
 - Based on CMS-ETL service hybrids



DAQ (1):

Markus Diefenthaler:

- Comment from Rolf on point:
 - Need to actually define what these points look like in detail
- Direct conversations:
 - Lots of interest in what this will look like for analysis

Streaming Workshop X – Vision and Opportunities for Streaming Readout at EPIC



Summary

Markus Diefenthaler

mdiefent@jlab.org

We are working to **accelerate science!**

- **Goal** Analysis-ready data from the DAQ system.
- **Solution** Seamless data processing from DAQ to analysis using streaming readout and AI/ML in near real-time.
- We have the **advances in scientific computing**, we now need to organize and to collaborate to take full advantage of these advances.
- How will the **EPIC Computing and Software** and **DAQ and Electronics WGs** work together?

Many opportunities for **autonomous control and experimentation**.

Jefferson Lab



DAQ (2):

Jeff Landgraf:

- Focus on status / plans

Working Towards CD2/3A

- 60% Design Maturity
 - Working towards pre-TDR (or draft of TDR)
 - Defined and Defendable Cost
 - Naming, Defining, & Counting the components
 - Define how DAQ will operate
 - Describe and defend that the system will work. Answer questions like:
 - What will the data volume on this link, and what kind of safety margin do you have?
 - Will radiation destroy your components, or make them misbehave?
 - How can you ensure that the data from these two detectors correspond to the same collision?
- What happens if you get a hot channel?

EPIC Electronics / DAQ

Standard Component Names and Functions

Name	Sensor	Adapter	Front End Board (FEB)	Readout Board (RDO)	Data Aggregation Module (DAM)	Computer
Sharing	Detector Specific	Detector Specific	Detector Specific	Few Variants	Common	Common
Function	-Multi-Channel Sensor	-HV/Bias distribution -HV divider -Interconnect routing	-Amplification -Shaping -Aggregation -Digitization -Data Readout -Zero Suppression	-Communication -Aggregation -Formatting -Data Readout -Config & Control -Clock & Timing	-Computing Interface -Aggregation -Software Trigger -Clock & Timing -Config & Control	-Data -Run -Calib -QA / -Collid -Event -Softw -Moni
Attributes	-MAPS -AC-LGAD -MCP-PMT -SiPM -LAPPD	-Sensor Specific -Passive	-ASIC/ADC -Discrete -Serial Link	-FPGA -Fiber Link	-Large FPGA -PCIe -Potentially Ethernet	

Global Timing Unit (GTU)

- Interface between collider, Run Control,
- Config & Control
- Clock & Timing

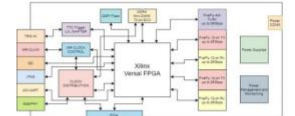
Summary of Current and Pending Activities

- Hardware Acquisition and Development
 - Have the opportunity buy 1 or 2 FELIX-182 boards being assembled for the ATLAS FELIX upgrade (Thanks to Hao Xu)
 - Obtaining FPGA Development Kits, Timing modules (which combined with existing electronics) will be sufficient to stand in for 5 GTU/DAM/RDO chains
- Evaluate Timing Synchronization Feasibility
 - Transmit clock by reconstructing it from data transmitted on fiber
 - 5ps jitter
 - Phase stability (even across power cycles)
 - Must demonstrate it is possible using the <\$300 FPGAs for use in RDO.
 - Formed RDO/Synchronization and Timing group to demonstrate this
 - Jo Schambach, William Gu, Marius Wensing, Tonko Ljubicic, & Pietro Antonioli
 - First active development towards working RDO

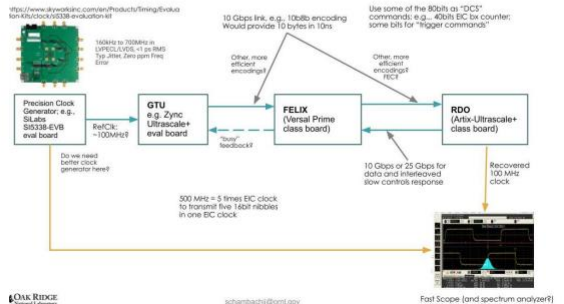
Prototype: FLX-182

FPGA: Xilinx Versal Prime XCVM1802-1MSEV5VA2197 production device

- PCIe Gen4 x16: PL and CPM compatible
- 24 FireFly links with 3 possible configurations
 - 24 links @25 Gbs
 - 24 links @10 Gbs (CERN-B-Y12)
 - 12 links @25 Gbs + 12 links @10 Gbs
- 4 FireFly links with 2 possible configurations
 - LTI interface
 - 100GbE
- Electrical signals on front panel
 - 3 inputs and 3 outputs
- 1 DDR4 Mem-LUDIMM
- USB-JTAG/USB-UART



Block diagram of FLX-182




DAQ (3):

Proposals

- Five (5) proposals were received and originated from various EIC sub-detector groups. These cover the R&D efforts for ASICs and Electronics in support of the EIC detector readout:

Proposal	File	Authors	Sub-Detector	Sensor Type	Readout Solution
A	eRD109_pECAL_readout_prototype_FINAL	G. Visser (IU), et al.	Calorimeter	SiPM	Discrete, COTS, ASIC
B	eRD109CalorimeterReadout	N. Novitzky (ORNL), et al.	Calorimeter	SiPM	ASIC (HGCROCV3)
C	eRD109-alcOR	M. Ruspa (INFN), et al.	dRICH	SiPM	ASIC (ALCOR)
D	ACLGAD_ASIC_Electronics_FY23	Z. Ye (UIC), et al.	Central, Far-Forward	AC-LGAD	ASIC (EICROC1, FCFD1, 3 rd Party)
E	eRD109_SALSA_proposal_vfinal1	D. Neyret (CEA), et al.	Micromegas , GEM, MicroRWell	MPGD	ASIC (SALSA)

- For further details, refer to the documentation submitted for each of the proposals.



Summary of eRD109 Activities

Fernando Barbosa (JLab), L3 CAM Electronics
ePIC Collaboration Meeting
11 January 2023

Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY
Jefferson Lab
U.S. DEPARTMENT OF ENERGY Office of Science

The slide features a dark blue background with a glowing blue nebula at the top right. On the left, there is a large, detailed illustration of a detector component, possibly a calorimeter, with various colored spheres (red, green, blue, yellow) and gold-colored spiral structures. Above this, there is a smaller illustration of a nucleus (black and blue spheres) and a diagram of an atom with a central nucleus and orbiting electrons. The text is in white and light blue, with logos for Brookhaven National Laboratory, Jefferson Lab, and the U.S. Department of Energy Office of Science at the bottom.