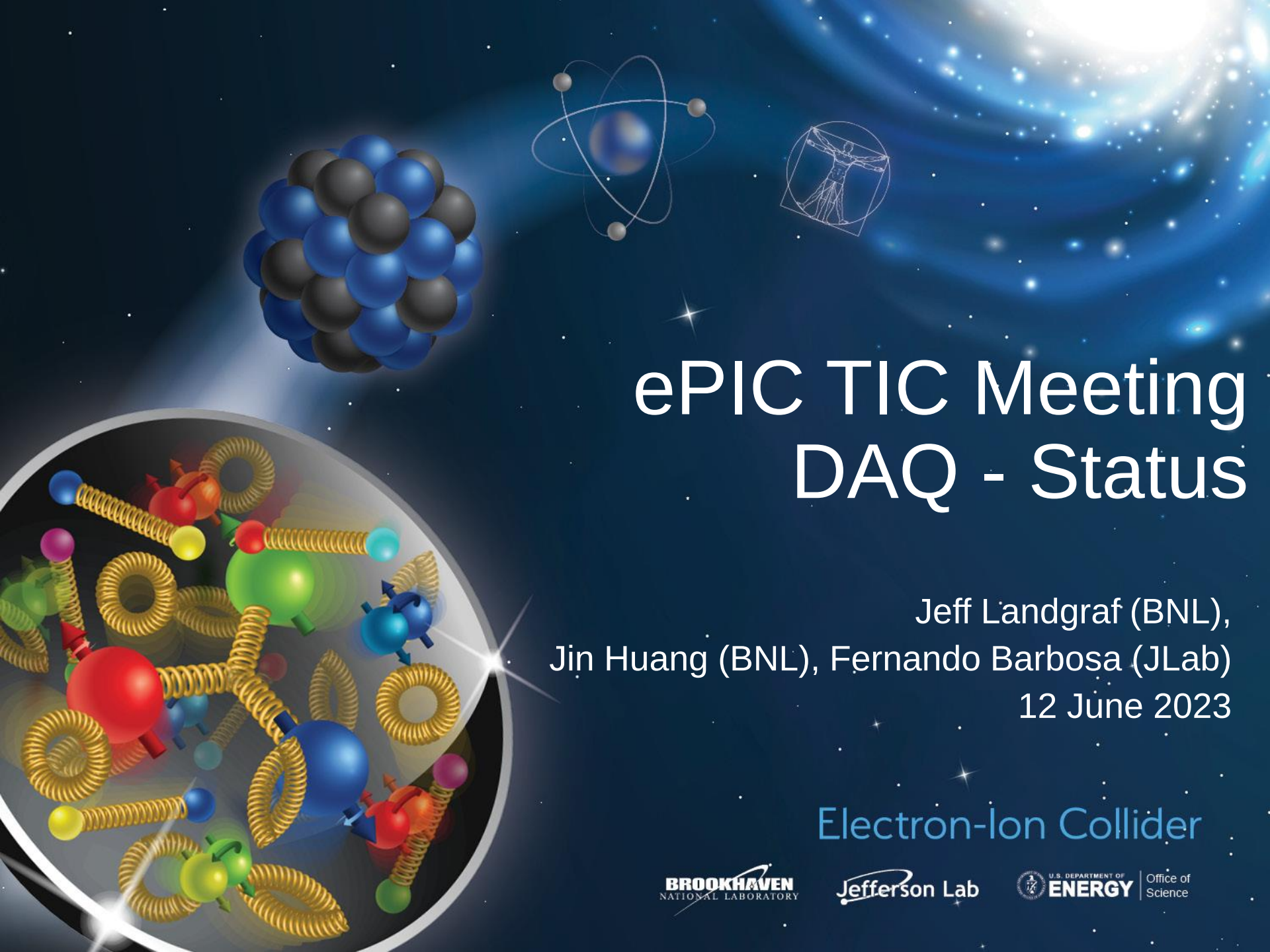

ePIC TIC Meeting
DAQ - Status

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Jin Huang (BNL), Fernando Barbosa (JLab)

12 June 2023

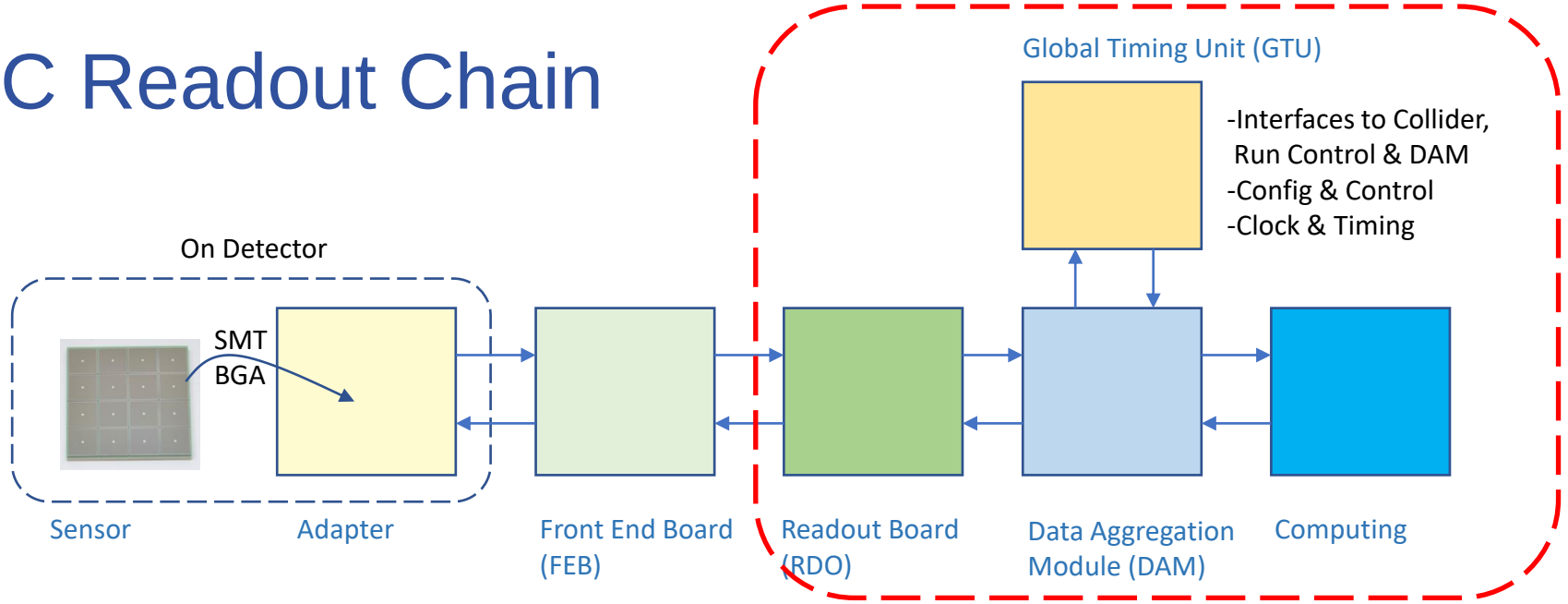
Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY

Jefferson Lab

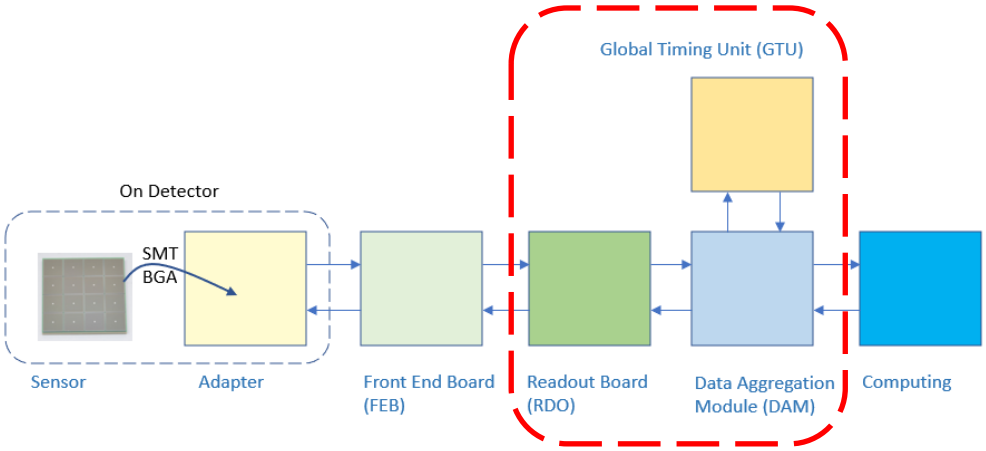
U.S. DEPARTMENT OF ENERGY | Office of Science

EIC Readout Chain



Name	Sensor	Adapter	Front End Board (FEB)	Readout Board (RDO)	Data Aggregation Module (DAM)	Computing
Design	Detector Specific	Detector Specific	Detector Specific	Few Variants	Common	Common
Function	-Multi-Channel Sensor	-HV/Bias Distribution -HV divider -Interconnect Routing	-Amplification -Shaping -Digitization -Zero Suppression -Bias Control & Monitoring	-Communication -Aggregation -Formatting -Data Readout -Config & Control -Clock & Timing	-Computing Interface -Aggregation -Software Trigger -Config & Control -Clock & Timing	-Data Buffering and Sinking -Calibration Support -QA/Scalers -Collider Feedback -Event ID/Building -Software Trigger -Monitoring
Attributes	-MAPS -AC-LGAD -MPGD -MCP-PMT -SiPM -LAPPD	-Sensor Specific -Passive	-ASIC/ADC -Discrete -Serial Link	-FPGA -Fiber Link	-Large FPGA -PCIe -Ethernet	-COTS -Ethernet

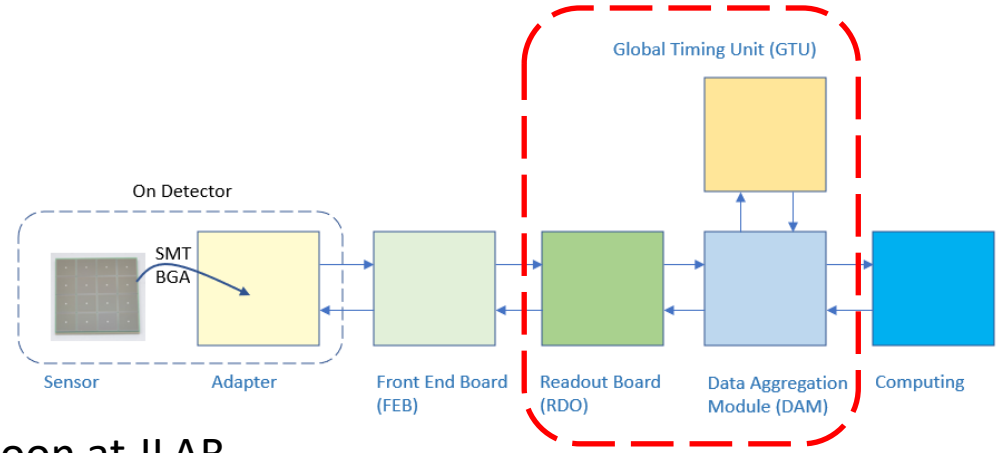
Timing Subgroup



- GTU/RDO/DAM
  - Inter-related boards
    - Fiber interconnects
    - DAQ optical protocol
  - 3 Functions
    - Timing & Synchronization
    - Configuration (of FEB/RDO)
    - Data transfers
- Timing & Synchronization Requirements
  - Two flavors of detectors
    - Physics driven, High Timing Resolution (TOF, pfRICH, FF): 5ps jitter/phase from actual BX. Power cycle stability of phase.
    - Driven by need to resolve BX: 10ns BX time, but assumed resolution in 50-100ps range
  - Two potential schemes
    - Reconstructed clock using the timing of data bits on the fiber to build the clock (e.g. gbt, allowing single link but with complications)
    - Dedicated clock fiber (requiring an additional fiber link)

Timing Subgroup

- Small Group within DAQ
  - Jo Schambach, William Gu, Marius Wensing, Tonko Ljubicic, Pietro Antonioli

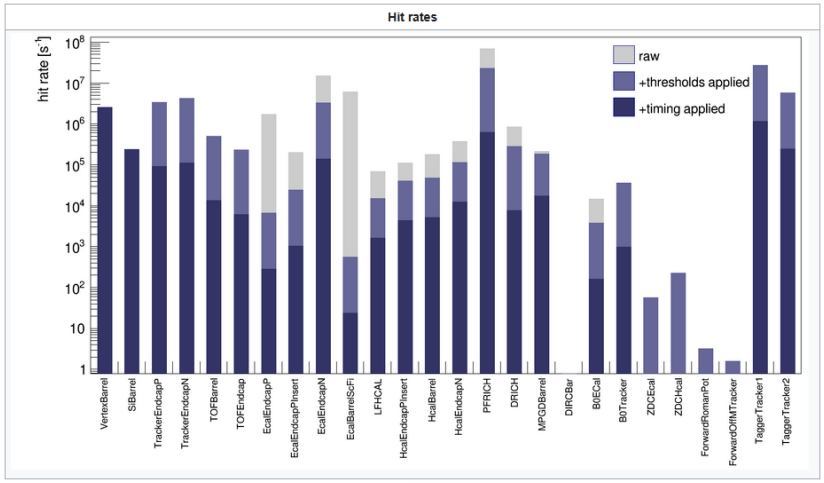


- Hardware Orders Arrived/Arriving soon at JLAB
  - 1 FELIX 182 board (a second board may be available end of 2023)
  - Handful of selected FPGA development kits to mockup GTU/RDO/DAM
  - Starting to setup loan agreements and distribute hardware
- Charges
  - Evaluate timing resolution to determine the method (reconstructed vs dedicated)
    - Develop and/or select fiber protocols
    - Starting point for RDO firmware
    - Initial development of RDO test stands both with/without FELIX boards
- Obstacles
  - Lots of expertise, but also lots of time commitments! Group members have little time before “summer/fall”

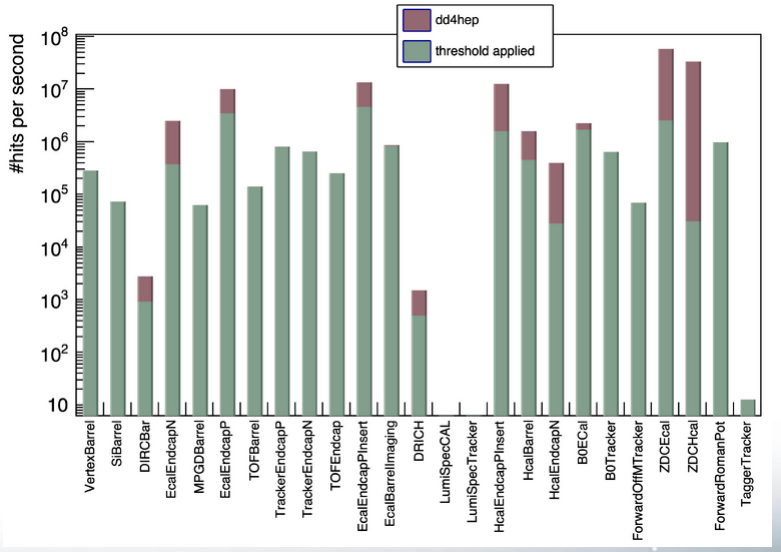
Data Rates and Background Simulations

- Lots of continuing work from the Background Group (https://wiki.bnl.gov/EPIC/index.php?title=Background)
  - Beam Gas/Synchrotron Radiation/Neutron Flux available
  - Are extending to provide collision data as well
- Electronics and DAQ lags behind
  - Need to apply digitization concept / hit size to convert to data volume
  - Need to evaluate the rates at the channel/FEB/RDO level
    - Initially can get a density and apply a grid
    - Eventually will need real mapping of sensors for each detector
  - Need to evaluate potential radiation damage at position of components
  - Need to implement these as Metrics in EPIC software

Electron Beam Gas



Hadron Beam Gas



RDO Locations

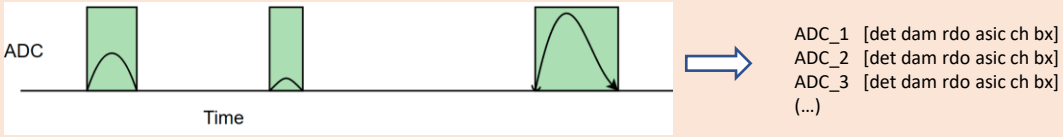
- There is a very important effort starting with the goal of defining the locations of the RDO's for all detectors.
  - Locations are critical because of
    - Tight space constraints in the ePIC detector
    - Evaluation of radiation hardness needs
    - Power/Cooling
- The RDO will be a "standard board" but we assume it might need variations
  - Optical transceiver
  - Size / shape
  - # of FEB connectors
  - If necessary, could be integrated in a FEB
  - Will need firmware implementation for specific ASICs
- Electronics and DAQ have agreed to specify features of the default standard RDO
  - Size of board (I am assuming something around 4x4 inches or less)
  - Type and number of connectors
  - Length of drive (depends on rate/cables/voltages)
  - Power need
  - Maximum radiation level for proper functioning
- We will then ask each DSC to define the specific locations

Streaming Readout Architecture

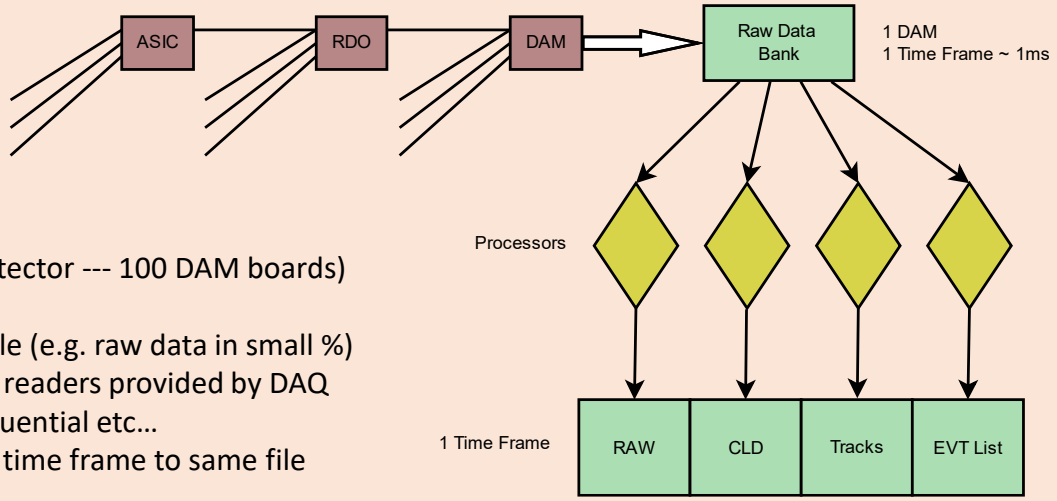
- Two definitions of “Streaming Readout”
  1. No L0 trigger
     - No dedicated trigger hardware making decisions within ns of the BX
     - No event defined by hardware
       - Elimination of dedicated hardware and ability to select events based upon the full detector are the main advantages.
       - Exposure to background and noise is the main challenge
     - ➢ This has been the design of the front end electronics specified since the Yellow report and will be the design of the ePIC DAQ
  2. Quasi-real time reconstruction activities
     - Online final physics calibrations
     - Integration of computing facilities and reconstruction
     - Adds requirements such as the need for event selection & quasi-real time monitoring of physics results
     - ➢ This is less defined at the moment
  3. These are not strictly linked although they do blur the boundary between offline/DAQ
     - Event selection can be done offline/online or both
     - Offline code may run in DAQ computers
     - Monitoring responsibilities can be shifted

Streaming Readout Architecture

Naïve Strawman:
(Unformatted stream of hits)



More Likely:
(multiplexed data & packetized)

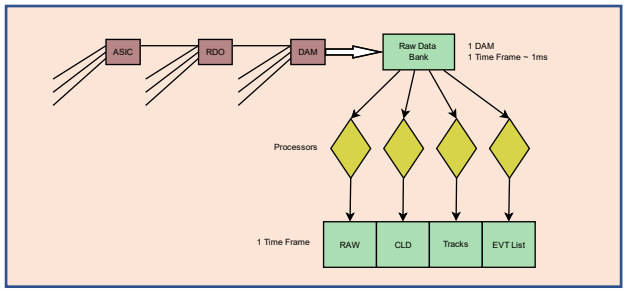


Base unit of data is the time frame:

- ~1ms (about 1MB for the full detector --- 100 DAM boards)
- 0, 1, or more events
- Bank list per time frame is variable (e.g. raw data in small %)
- Banks format source dependent, readers provided by DAQ
- Time frames can be ordered, sequential etc…
- I support building all DAMS from time frame to same file

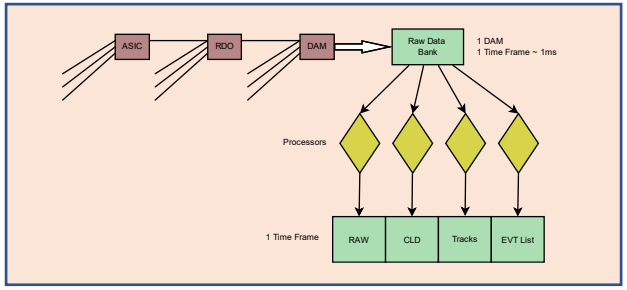
Streaming Readout Architecture

There are ~100 DAM boards reading out ~25 detectors, so the processing and recorded data may be quite different for different detectors. Examples:



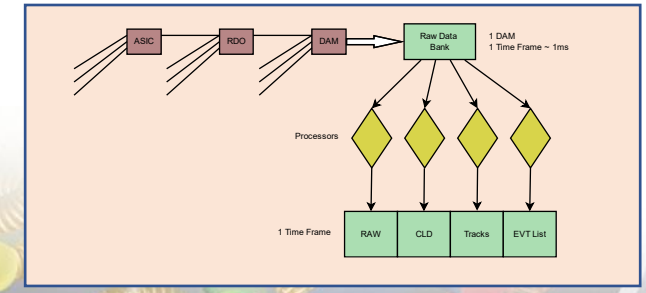
dRICH: (20 DAM Boards)

- 50-100Gbit/sec to DAM board
- Must apply event selection at DAM/Readout computer to reduce noise.
- Data Banks: trgRAW



Lumi Detector: (2-3 DAM boards)

- ~100-200Gbit/sec for detector due to bremsstrahlung
- produce histograms for lumi monitoring
- Event selection to readout selected bunch crossing of RAW
- Data Banks: lumiSum, trgRAW



Roman Pots: (1 DAM Board)

- Low data volume. No processing needed, but ???
- Data Banks: RAW

Streaming Readout Architecture

- Streaming Readout Working group to address these issues

Streaming Computing Model (Marco Battaglieri, Jin Huang**)**:

- **Charge**: Development of the computing model for the compute-detector integration using streaming readout, AI/ML, and multi-architecture computing (CPU, GPU, …) with a specific focus on the data flows after the FEE layer.
- **Priorities for 2023**:
  - Define baseline system for CD3A and CD2/3 that meets the ePIC physics requirement
  - Establish a collaborative dialogue with the Electronics and DAQ WG, as well as with the teams on streaming simulation, embedding, background simulation, and analysis
  - Define requirements and high level design for streaming readout capable of enabling accurate data processing with rapid turnaround, leveraging external computing resources including international partners, and allowing for evolution of features including automated calibration, online reconstruction support, and QA.
  - Define event selection model to present to analysis from streaming data
  - Coordinate activities on prototyping streaming computing systems.

- I was also asked to help out due to Jin's participation in sPHENIX startup
- Conveners have met but, WG activities yet to start…

Summary

- I’ve listed the most important activities to do (at the moment) related to the “backend” of the ePIC DAQ.
  - The evaluation of the timing synchronization scheme
  - DAQ optical protocols for
    - Configuration
    - Timing synchronization
    - Data transfer
  - Evaluation of the collision/background data rates
  - RDO
    - More detailed specification
    - Definition of specific locations within ePIC
  - Definition of the streaming architecture