Streaming Computing: Calibrations

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Compute-Detector Integration to Accelerate Science

- **Problem** Data for physics analyses and the resulting publications available after O(1year) due to complexity of NP experiments (and their organization).
  - Alignment and calibration of detector as well as reconstruction and validation of events time-consuming.
- **Goal** **Rapid turnaround of 2-3 weeks for data for physics analyses**.
  - Timeline driven by alignment and calibrations.
- **Solution** Compute-detector integration using:

AI for autonomous alignment and calibration as well as reconstruction and validation for rapid processing.

Streaming readout for continuous data flow of the full detector information.

Heterogeneous computing for acceleration.

Alignment and Calibration of the ePIC Detector

Premature to fully define **alignment and calibrations**:

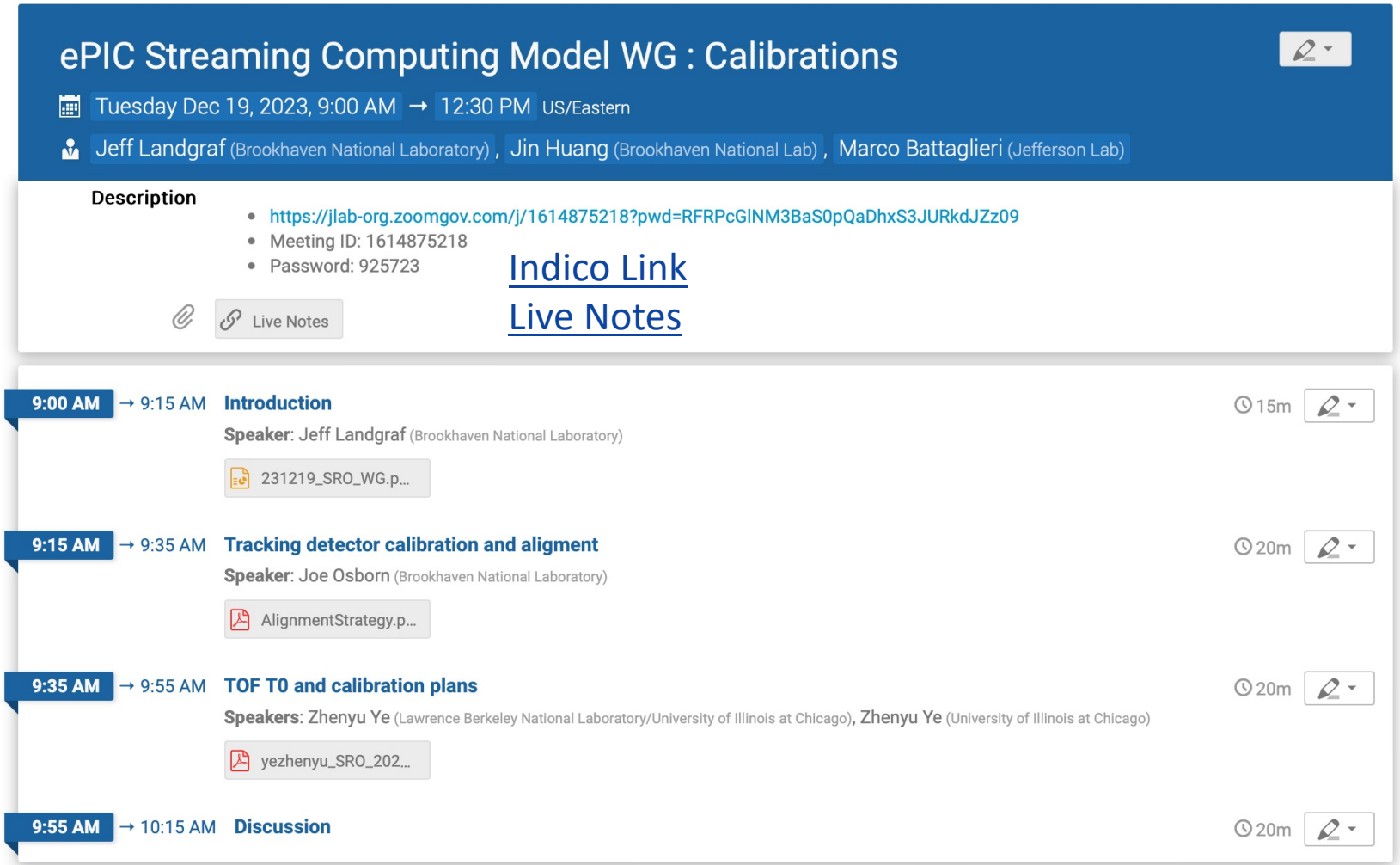
- Detectors still being designed and characterized.

However:

- Considerable automatization required to facilitate prompt reconstruction.
- Necessitate a thorough understanding of the alignment and calibration processes and methods to expedite them.

Strategy:

- **Review examples** for alignment and calibrations.
- Utilize these examples to **consider the necessary types of support** for integration into Streaming Computing.



Alignment Example

Summary of Joe Osborn's (BNL) presentation on *"Alignment Calibrations"*:

- Alignment calibrations are iterative in nature.
- Goal is to have this done autonomously once we are in steady state production.
- Will need O(100ks) of tracks to reach 5 micron precision:
  - Important to have a wide variety of tracks from cosmics, regular beam conditions, low luminosity beam conditions…
- Will need a robust conditions DB that can be continuously updated with the latest and greatest.
- Don't expect large needs from upstream DAQ process as these calibrations are primarily determined for reconstruction/analysis.
- Only need to be well integrated into the full online-to-offline workflow to ensure proper synchronization.

Calibration Example

Summary of Zhenyu Ye's (LBNL) presentation of "TOF T0 and calibration plans":

AC-LGAD TOFs can provide both precise timing and spatial measurements. To do so, there are a number of effects that need to be well understood, characterized and corrected for. In terms of calibrations:

- **If there is external data you need?** Yes, track impact Z-position on BTOF from tracking for TOA, vertex position from vertexing for T0, electron TOA from pfRICH for T0.
- **If you need specific beam conditions?** Probably not, or least not critical.
- **If you need other detectors to be calibrated before you start?** Yes, tracking, vertexing, pfRICH.
- **What the time scales you need (does the calibration go continuously, getting better every day, or do you take n-events and call it done!)** Some calibrations will be done at the beginning and end of a running period, some at every fill, some continuously.
- **How much data you need to finish the calibration?** Hard to tell now.
- **Do you need human intervention, or can it be done automatically?** Some yes, some no.
- **If you do need human intervention, is there support from the SRO group that can make this human intervention easy (and fast)?** Yes.
- **What are the results of the calibration (do they have to be put into the early DAQ process before data files are finished being constructed, or are they applied during reconstruction, or applied during analysis)?** Mix of all.
- **Do you need external storage or DBs, and if so do they need to store multiple data versions of calibrations applying to the same time periods?** Yes.

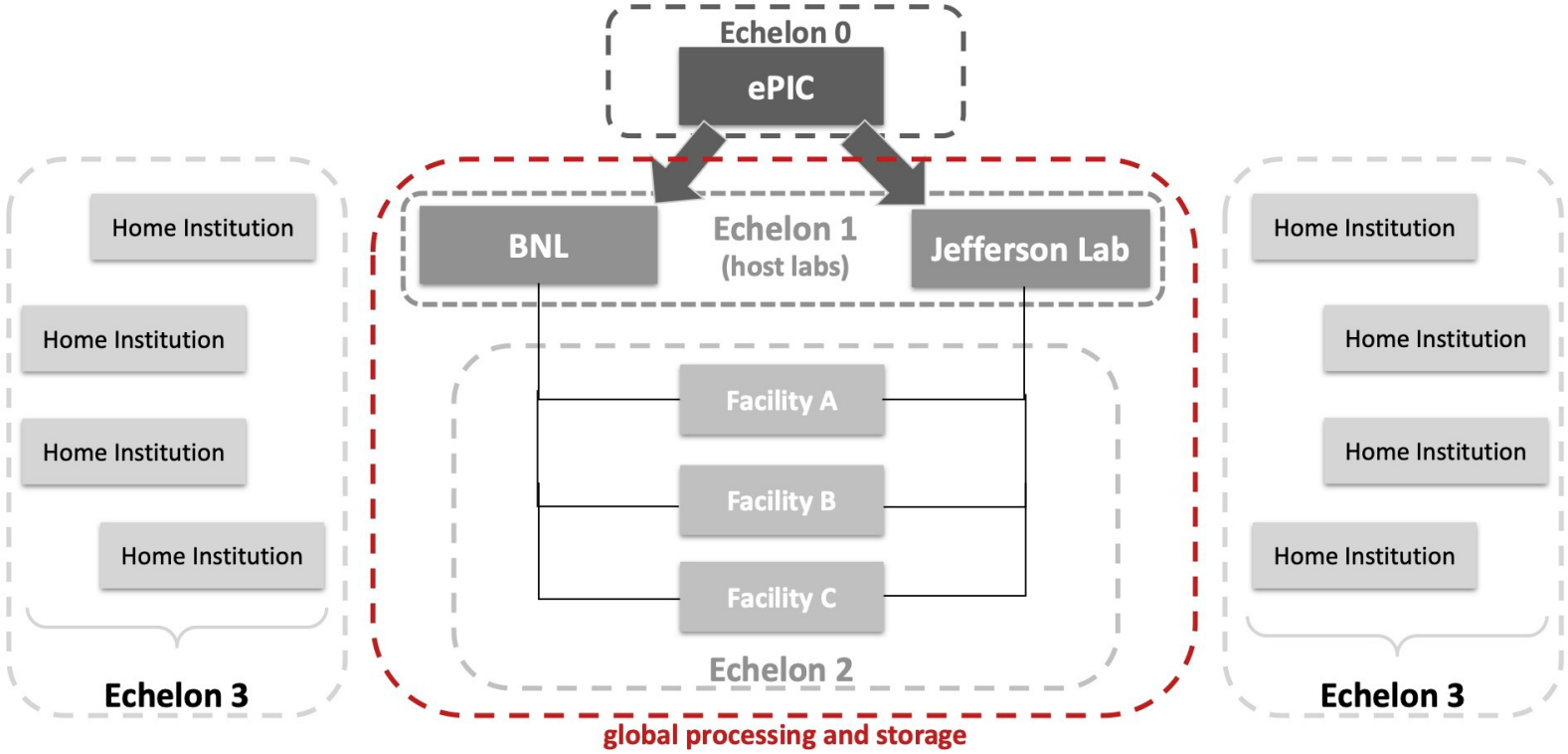
Notes from Derek Anderson (Iowa State) on BHCal Calibration Needs:

- **MIP Calibration**
  - Calibration to EM scale derived from studying MIPs in cosmics.
  - Done pre-installation, and cosmic data taken during running period to validate calibration.

- **Gain Monitoring**
  - Gains will be monitored w/ LED and Test Pulse system as is currently being done in sPHENIX.
  - There, took regular LED runs during running period to assess detector health.

- **“Fast” (ML) Calibration**
  - Uses ML to combine information from other subsystems into physical particle energies.
  - Should be very hands-off so long as gains are stable:
    - “Garbage-in, Garbage-out”

Use Cases

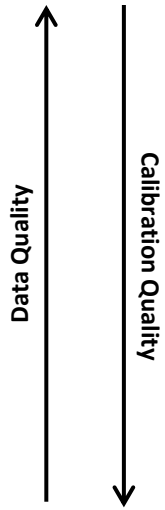


Use Case	Echelon 0	Echelon 1	Echelon 2	Echelon 3
Streaming Data Storage and Monitoring	✓	✓		
Alignment and Calibration		✓	✓	
Prompt Reconstruction		✓		

Calibration Organization (taken from Jeff Slides)

Use Case	Echelon 0	Echelon 1	Echelon 2	Echelon 3
Streaming Data Storage and Monitoring	✓	✓		
Alignment and Calibration		✓	✓	
Prompt Reconstruction		✓		

Calibration Organization According to **Location**	**Examples**
Detector	HV adjustments for gain corrections
Electronics (ASICS, FEB, RDO)	Thresholds, pedestals, timing offsets
Echelon 0	Slewing corrections, gain corrections (relative)
Echelon 1	Global alignments, gains, slewing, timing, acceptance, beam effects…
Echelon 2	Support role for Echelon 1

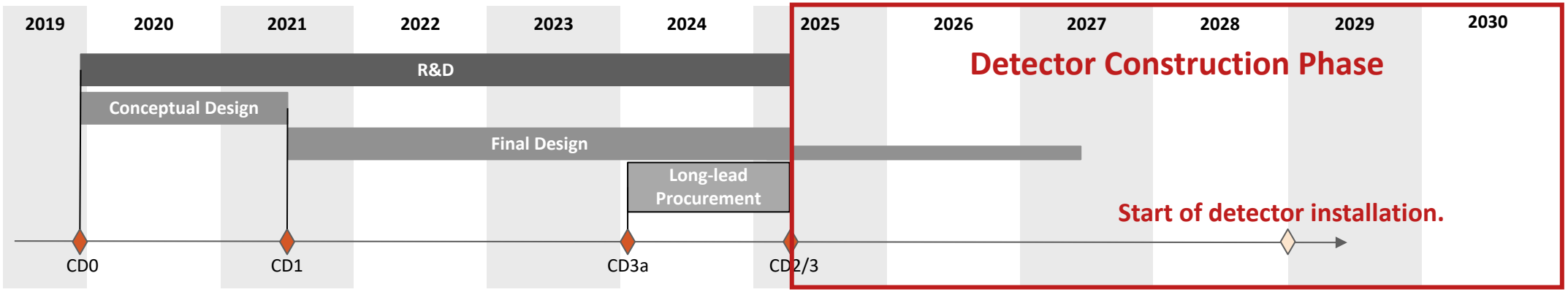


Questionnaire for Alignment and Calibration

- **If there is external data you need?**
- **If you need specific beam conditions?**
- **If you need other detectors to be calibrated before you start?**
- **What the time scales you need** (does the calibration go continuously, getting better every day, or do you take n-events and call it done)?
- **How much data you need to finish the calibration?**
- **Do you need human intervention, or can it be done automatically?**
- **If you do need human intervention, is there support from the SRO group that can make this human intervention easy** (and fast)**?**
- **What are the results of the calibration** (do they have to be put into the early DAQ process before data files are finished being constructed, or are they applied during reconstruction, or applied during analysis)**?**
- **Do you need external storage or DBs, and if so do they need to store multiple data versions of calibrations applying to the same time periods?**

Is the questionnaire complete? Are there any questions we would like to add?
Fill out questionnaire for **various detector subsystems** to gain a thorough understanding of the alignment and calibration processes, as well as to identify methods for expediting them

Autonomous Alignment and Calibrations as Part of Milestones



Milestones During Detector Construction Phase

- Provisioning DAQ and software sufficient for test beams, which can serve as small scale real-world testbeds for the developing DAQ and software.
- Streaming challenges exercising the streaming workflows from DAQ through offline reconstruction, and the Echelon 0 and Echelon 1 computing and connectivity.
- Data challenges exercising scaling and capability tests as distributed ePIC computing resources at substantial scale reach the floor, including exercising the functional roles of the Echelon tiers, particularly Echelon 2, the globally distributed resources essential to meeting ePIC's computing requirements.
- **Analysis challenges exercising autonomous alignment and calibrations.**
- Analysis challenges exercising end-to-end workflows from (simulated) raw data to exercising the analysis model.

Autonomous Calibrations in INDRA-ASTRA

OUR APPROACH

1. **Identify different data-taking periods** Use the start of distinct data-taking periods based on changes in the mean of the data stream. Explored ADWIN2 and multiscale algorithms for change detection.

2. **Calibrate different data-taking periods to a baseline** Calibrate w.r.t. baseline calibration due to lack of features for fast calibrations in DIS. measurement.