Experiences Adopting EPICS from a New User Perspective for EIC

EPICS Collaboration Meeting

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Apr 24th, 2023

Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY

Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

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Personal Background

- Shift Operator / Coordinator for Main Control Room @ Brookhaven National Laboratory Alternating Gradient Synchrotron/Collider-Accelerator Department, 1998 – 2007
  - Supported HEP/HIP beam ops for fixed target experiments
  - Participated in Relativistic Heavy Ion Collider (RHIC) commissioning
  - Supported NASA Space Radiation Laboratory (NSRL) commissioning
  - Learned basics of proprietary Accelerator Device Object (ADO) software development
- Software Developer / Group Leader for BNL C-AD Controls Front End Computer Software Group, 2007 – 2022
  - Learned about VME platform, VxWorks 5.5/6.5
  - Exposed to XILINX/Zynq SoC platforms
  - Participated in eLens, Energy Recovery Linac (ERL), Coherent electron Cooling (CeC), and Low Energy RHIC electron Cooling (LEReC) Controls development and commissioning
  - Supported existing RHIC and Injector controls based on ADO and older standards
- Control Account Manager for Controls, Electron Ion Collider (EIC) Project, 2022 - now

Perspective on Controls Systems

- What you build tends to stick around, warts and all
  - Legacy systems aren't removed till they're unsupportable, funding ends, or a major upgrade gets approved
  - Legacy support comes at a premium, and the associated knowledgebase is rapidly disappearing through attrition
- Core systems need developers with deeper skill sets than other roles
  - Finding people is a challenge
  - Retaining people is a challenge, perhaps with greater impact for a proprietary system
- Proprietary means you answer to no one aside from the local bosses / users
  - But you own it, and need to maintain the talent base accordingly
    - Efficiency, focus, and R&D efforts tend to be impacted negatively
  - Many ideas and tools are brought in from outside the organization, but perhaps to a lesser degree for proprietary systems
  - Rough edges tend to get worked out if you have the right experts, or you end up with some lingering workarounds
- Cybersecurity is increasingly considered a core component of a Controls System, and this is being encouraged at various levels by DOE requirements
  - We're looking forward to participating in the Cybersecurity workshop on Friday

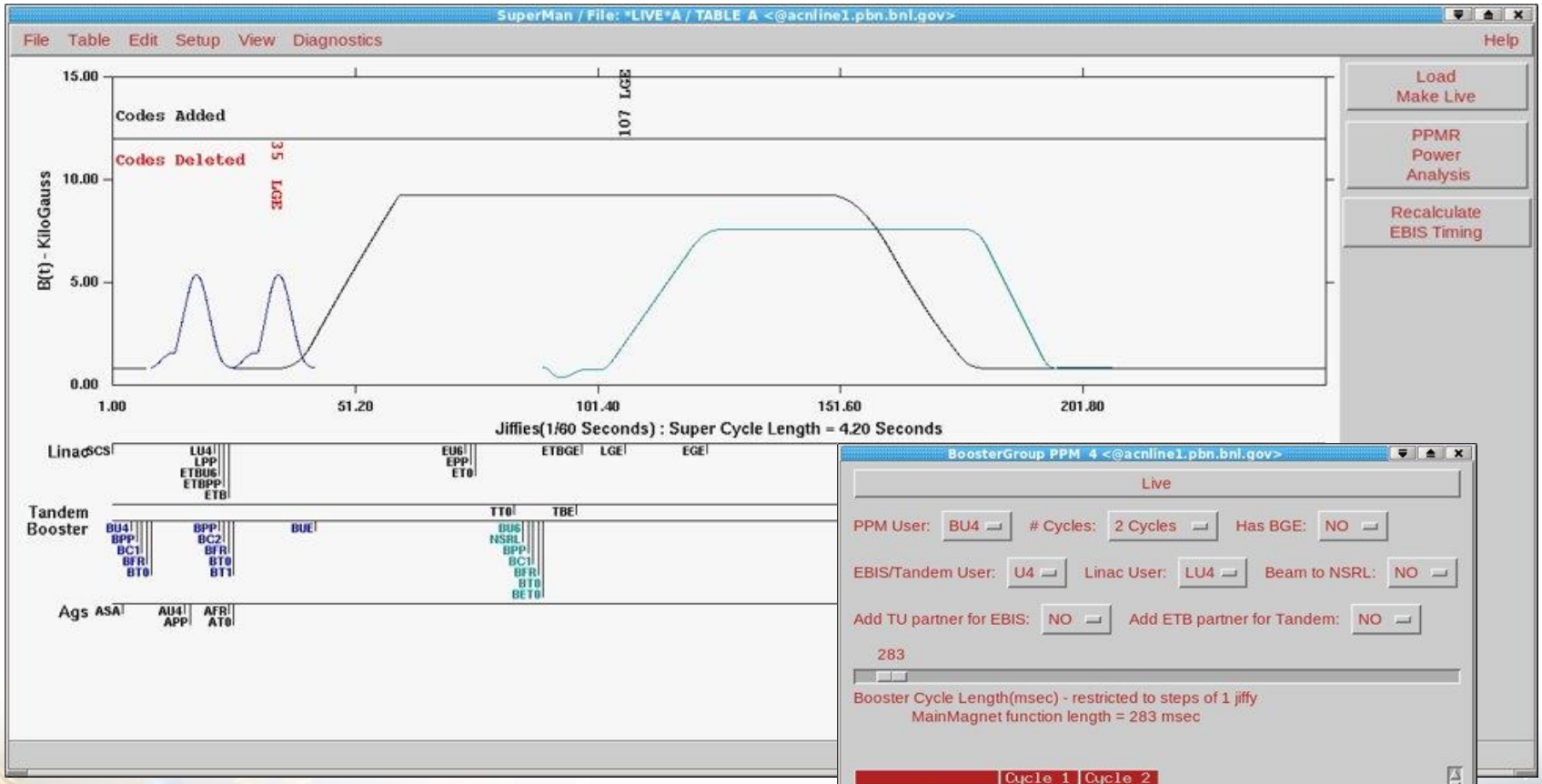
EPICS: Basic Observations

- EPICS records provide management of the rate of data delivery that ADOs lack, in terms of a general design standard
  - Standards are extremely helpful towards establishing consistency at multiple levels, and in this case, it serves a very practical role in tuning performance
- Many of the technical challenges that have been addressed in EPICS have a similar treatment in ADOs
- EPICS software has been doing a more uniform job of keeping up with modern standards, due to its larger pool of talent and a broader set of interests
  - The flip side is that Core functionality has been retired that may yet be of interest for legacy systems, but this seems like a reasonable tradeoff

What's Missing… PPM Standard (1/3)

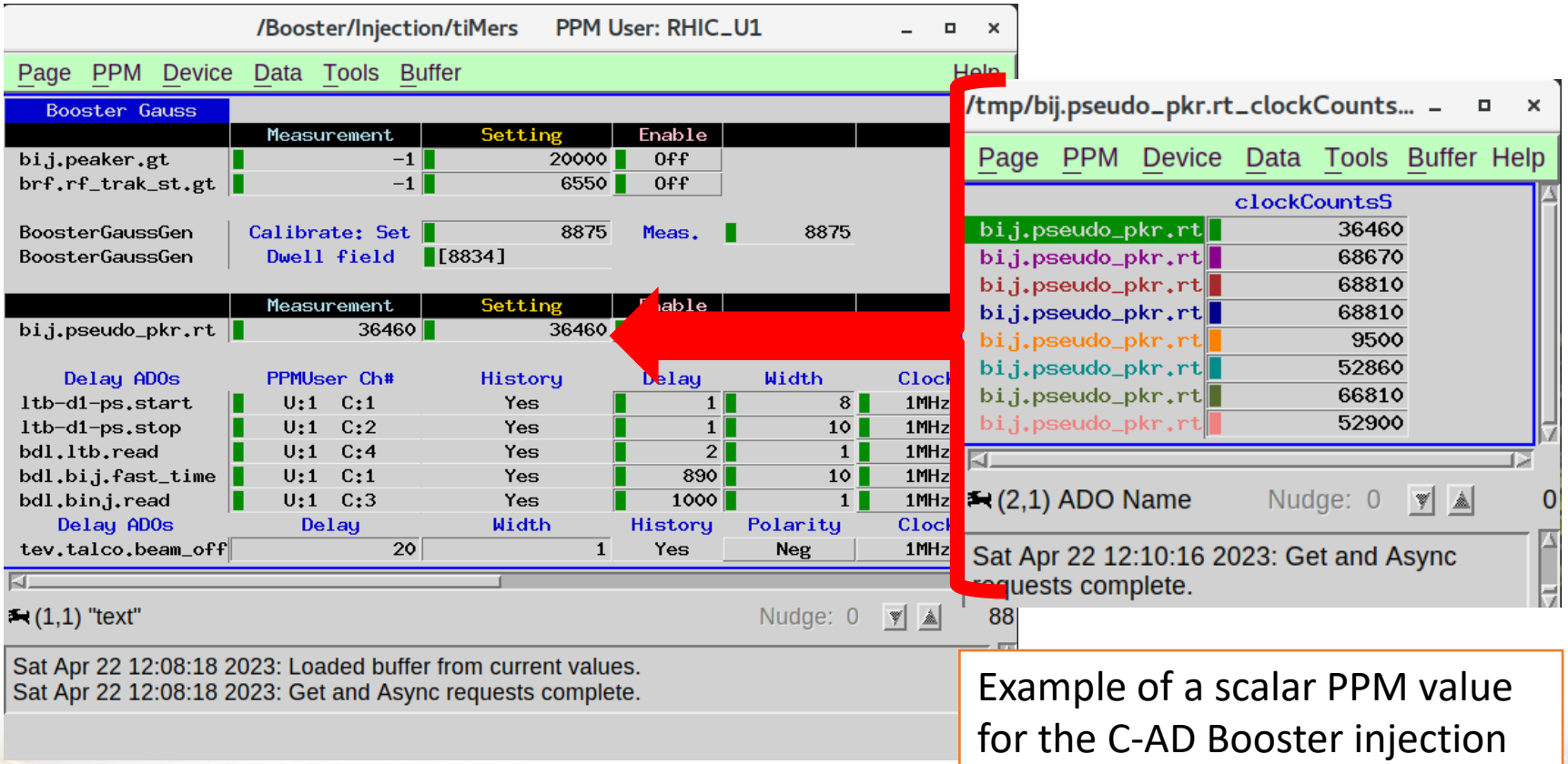
- Some facilities would benefit from a standard implementation required to support "fast context switching"
  - Facilities have shared their proprietary solutions at past EPICS collaboration meetings, which may not be easily ported to other locations
  - C-AD has a solution referred to as Pulse to Pulse Modulation (PPM)
    - Selected subsystems are designed to support PPM in the HW and SW stack, in order to meet context switching timing requirements
      - Primarily, this includes RF, power supplies, timing controls, and some instrumentation systems
    - Timing for the equipment is periodic, with a short cycle length (ex. 100ms – 10 s depending on application/machine)
    - PPM equipment utilizes multiple sets of control points, where each set is assigned a "user" number up to the limit allowed by the Controls System (typically 8 at C-AD)
    - The timing system publishes events to the equipment that inform which PPM user is being activated for a particular machine (ex. "start playing back Booster user 3 waveform")
    - This allows the user to define a supercycle incorporating multiple machines, which is essentially a recipe that can be started and stopped as desired, as the facility needs change
      - More critical for Controls Systems where gross changes need to happen quickly
        - Species changes
        - Beam energy changes
        - Optics changes
        - RF changes
        - Alternate modes of operation… physics, development, training, etc.
        - Bread and butter for multi-user facilities that require "simultaneous" operations
  - EIC anticipates utilizing a form of PPM control
    - The Rapid Cycling Synchrotron (RCS) is expected to switch contexts quickly
    - The Strong Hadron Cooling (SHC) machine is expected to change modes between hadron injection cooling and store cooling modes, albeit without speed concerns due to the slow Hadron Storage Ring (HSR) ramp time

What's Missing… PPM Standard (2/3)



C-AD SuperMan timing control app, with PPM "recipe" knobs

What's Missing… PPM Standard (3/3)



Example of a scalar PPM value for the C-AD Booster injection delay from BT0 on user 1, along with a list of delay values on all users that may or may not be included in the active recipe

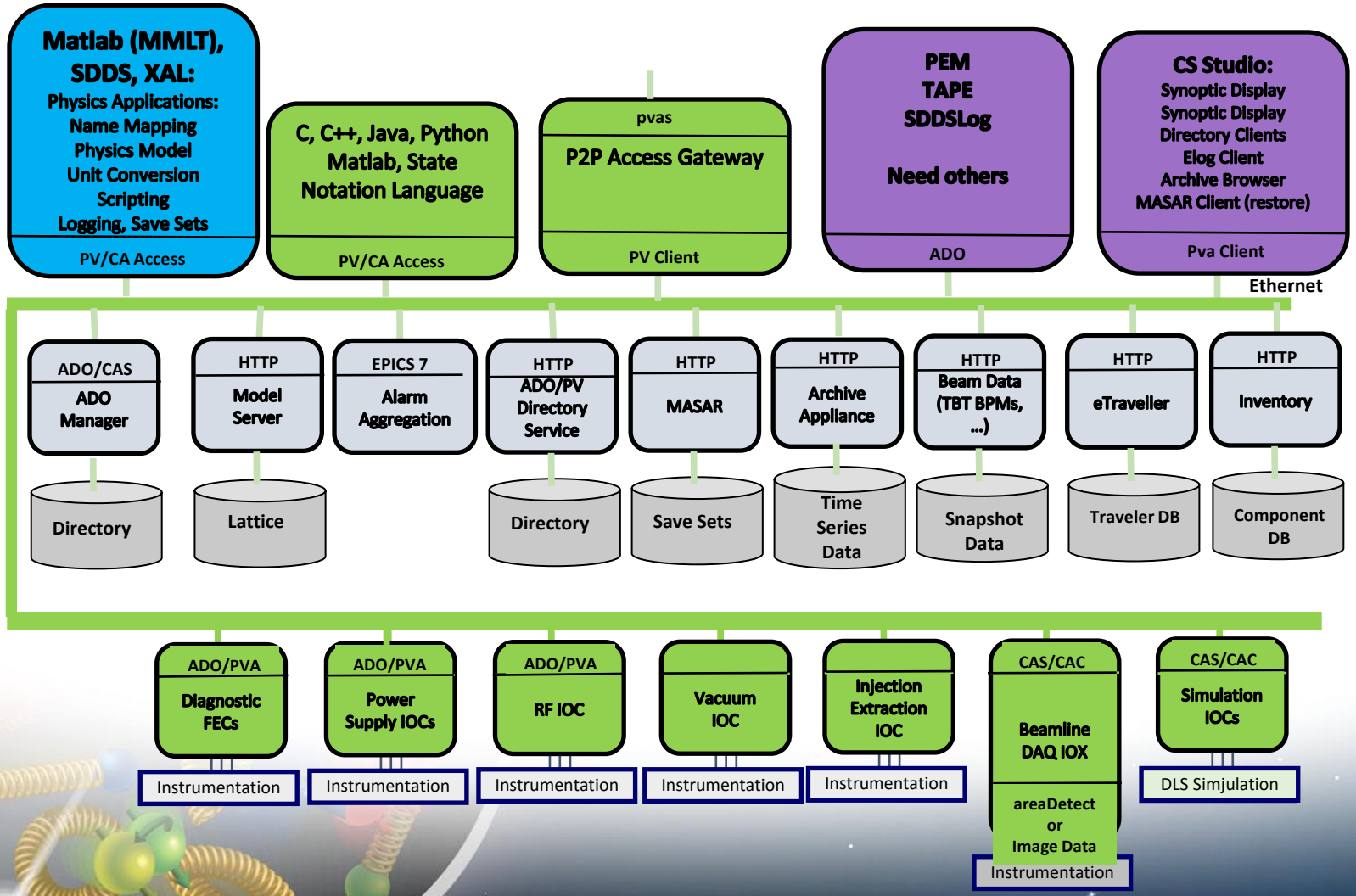
New User Hurdles

- Naming conventions are a likely concern for any sort of an ADO / EPICS hybrid environment
  - Characters not supported by ADO names
    - : ; ^ ~ ` ‘ “ , < > / \ [ ] { } ( ) & * % # @ | !
  - Characters supported in ADO names
    - _ - + . ?
    - Example… “bc1-ki-ps”, “lecs1-gun.gmt”
    - Note that ADOs host multiple parameters which each have multiple properties, which map closest to individual PVs
    - Example of a specific ADO value… “lecs1-gun.gmt:dataCh1M:value”
  - PV name examples from NSLS-II:
    - AS-AM{RadMon:0}Trig:1min-Calc_ - 1 minute calculation trigger
    - AS-AM{RadMon:1}Dose:1h-I - 1 hour integrated dose
    - AS-AM{RadMon:1}Dose:24h-I - 24 hour integrated dose
  - Discussion with the EIC community suggests that we may want to leverage portions of the existing RHIC convention

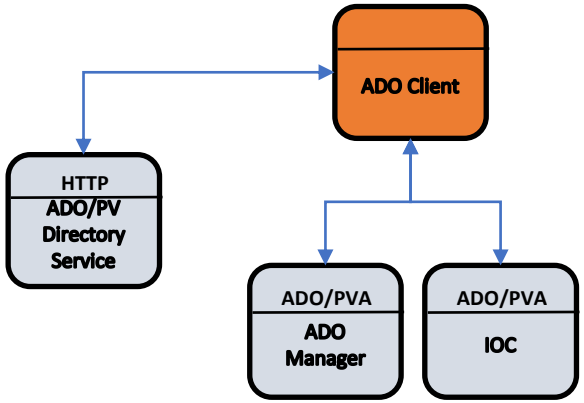
Applying EPICS7 to EIC

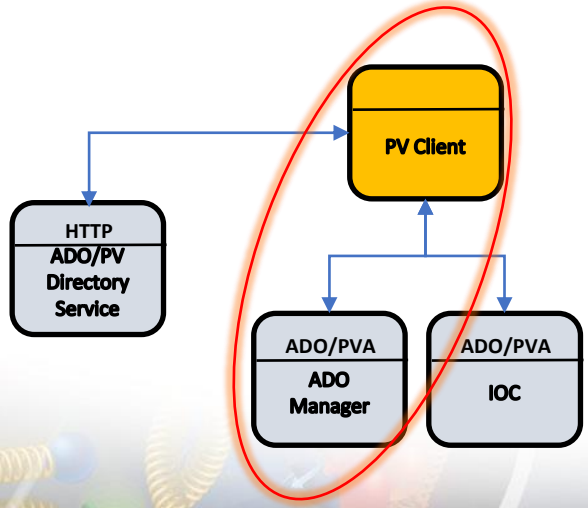
- EIC will have a large number of PVs
  - This will be discussed in the talk, *Considerations Involving the High Level Applications Services for the EIC Project,* abstract #143
- Anticipating plenty of overlap between field equipment support needs and available IOC software
  - Some equipment may of course require new development
  - EIC is not a greenfield project
  - There may be some systems where an ADO interface already exists where we may elect to use it, though the related scope appears to be more limited at this stage of the planning process
- We have standard mid-to-large facility requirements for data logging, setting tracking, user interfaces, access restrictions, and modelling
- There's the potential for tools developed with CAD ADOs to be extended for use with EPICS PVs where EIC and community needs might encourage it

Potential EIC Architecture



Hybrid Architecture Detail





- We need to consider if ADO Client applications will be a fundamental part of the EIC Controls System
- Will ADO managers and IOCs need to directly interface with one another?
  - For example, middleware for aggregating orbit data
  - May be easy to avoid, and beneficial to do so
- Michael Davidsaver helped demo an ADO manager / PV Client interface in 2021
  - Support for PPM ADO parameters was included

Current Focus

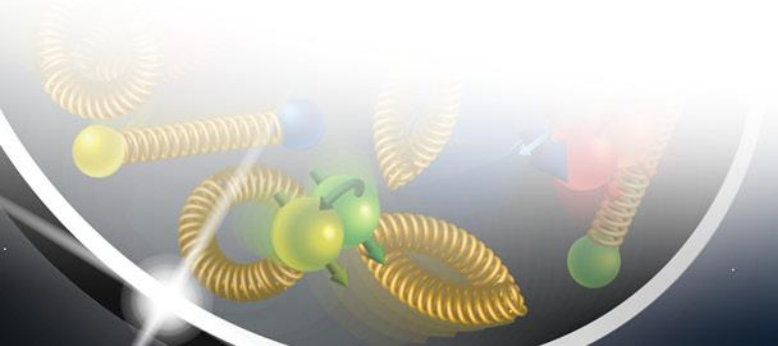
- Establish Name Lookup strategy
- Understand time series data logging requirements and evaluate use of Archiver
- Develop a strategy for alarm handling that would include support for ADOs and EPICS
- Reevaluate the scope of a hybrid design based upon the items above, as well as the state of the developing RHIC upgrade plans
- Get up to speed on EPICS7, and understand how EIC development efforts might benefit from or contribute to the collaboration

Conclusions

- It's still an early phase of the EIC project, but there are some key decisions about the level of Controls hybridization between RHIC ADOs and EPICS PVs that need to be established soon
- EPICS7 is already an important piece of the EIC Controls plan
- We're looking forward to actively participating in the EPICS collaboration, and the many benefits that will come from it
  - A standard Pulse to Pulse Modulation (PPM) scheme might be an early contribution from EIC, with hopefully more to come
- There are a lot of shared challenges that we can address more effectively together, including Core development support amidst a challenging labor environment

Thanks to...
Seth Nemesure, Ted D’Ottavio (BNL/CAD)
Kunal Shroff (BNL/NSLS-II)
Michael Davidsaver, Bob Dalesio (Osprey)

Any Questions?



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