



ACORN Applications Lab Tour

Accelerator UX Workshop @ SLAC

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Outline

- Overview
- Labs visited
- Key findings
- Insights
- Collaboration Opportunities

Overview

- Current source of accelerator control system knowledge is limited to the lab
- Global & national labs have systems we can learn from as we modernize our own

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PD D80 Examine Database<NoSets><DPM-DPM01 (2%)>
D80          Database Dump: Setting page *Pgm_Too
Analog      Digital      Reading      Setting      Summary      Dump
Control     Status       Save/Restore   Family

General:Linac analog setting device
Device Name:<L:L2PADJ>  Device Index:( 87865)  Node♦LIP732 9  111 ♦
Full name:L:L2PADJ
Setting Block:
SSDN(0111/0732/042B/0002)
default data size(      2) maximum data size(      2) atomic sz(      2)
default data event(p,1000,true)                               ) addr mode(      0)
raw setting(0000919F) primary units(-8.623  VOLT)          data type(      0)
setting-engineering units( 34.42  DEG)                      *DB Setting*
min value ( 0 ) max value ( 499.99237)

Setting PDB:
primary units(VOLT )  transform index (      2)  display (short )
common units( DEG )  transform index (      2)  notation(decimal)
scale length (      2)  motor controller(D/A )
primary xform X = FLOAT(input) / 3276.8
common xform X' = (C1*X/C2)+C3
c1( 250 )c2( 10 )c3( 250 )
c4( )c5( )c6( )

♦Test Scaling♦

ctrl set  ( No   )
knobable  (Yes  )

Messages
Running current CLIB
Current CLIB is installed
Database dump program started on console 39 at 09-DEC-2024 14:51:52...
```

Lab Tour

- Comparative analysis
 - Similarities, considerations, and challenges
- User research
 - Pain point evaluation
 - Clear analysis of options
 - New ideas
 - Validation of design
 - Validation of assumptions
 - Avoid faults of tried solutions
- Modernization of controls

Objectives – What do we want to learn?

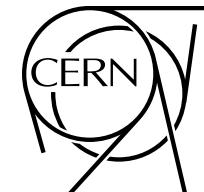
- Comparative analysis
 - Application design
 - Application tools
- User workflows
 - Alarms
 - Troubleshooting
- Roles
 - Operators
 - Engineers
 - Scientists
 - Admin
 - Remote access
- Control room design
 - Auditory environment
 - Multi-monitor support
 - Multiple human interactions to the same system
- Workflow for new functionality
 - Display builders
 - Parameter pages
 - Professionally designed application
 - Python & CLI
 - Sequencer
- Error presentation
 - Notifications
 - Alarm overflow/overload
- Browser-based applications
 - Tried it? Interested in changing to it?
- Across control system features
- Control system history
- Navigation between applications and accelerator
 - Hierarchical vs branching

Methods for user research with Operators

- Contextual inquiry
 - Observation and conversation
- Interviews
- Comparative analysis at tour milestones



Labs included



Up next:



Labs involved – Why these labs?

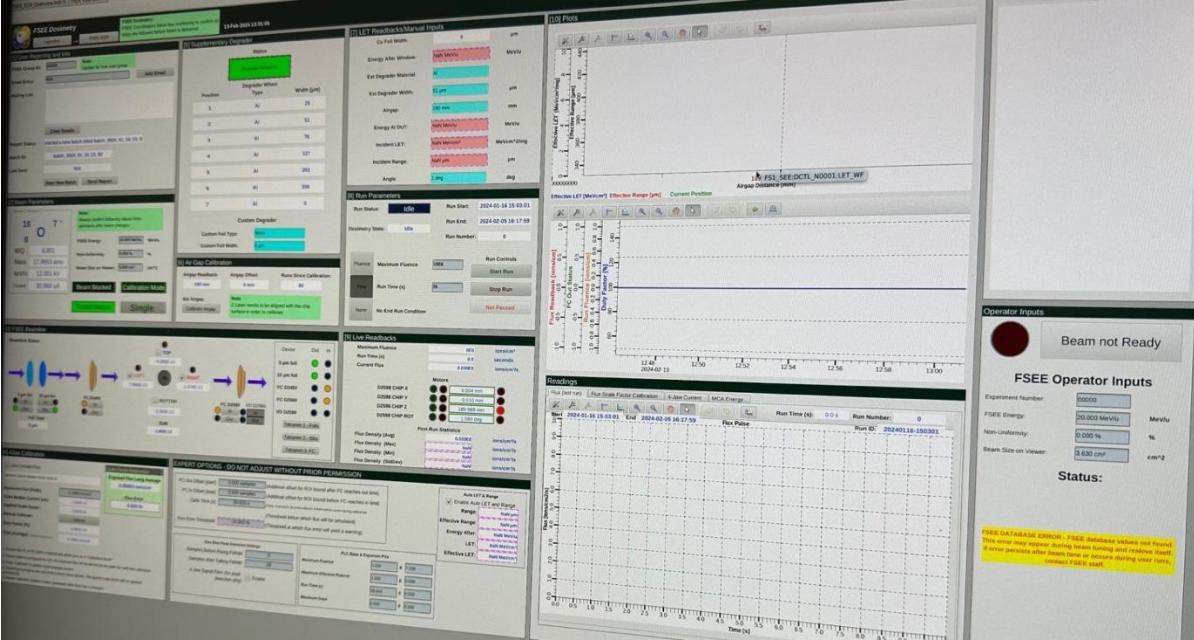
- Accelerator labs with control rooms and widespread usage of control systems
 - With exceptions
- A mix of similar and different systems and processes
 - Ability to compare experience with similar
 - Ability to gain knowledge from similar and different
 - Different brings in new ideas and possible areas we lack
- Why a global tour?
 - Value in global knowledge and learning through different processes
 - Significant labs working on similar projects and machines

Visit flow

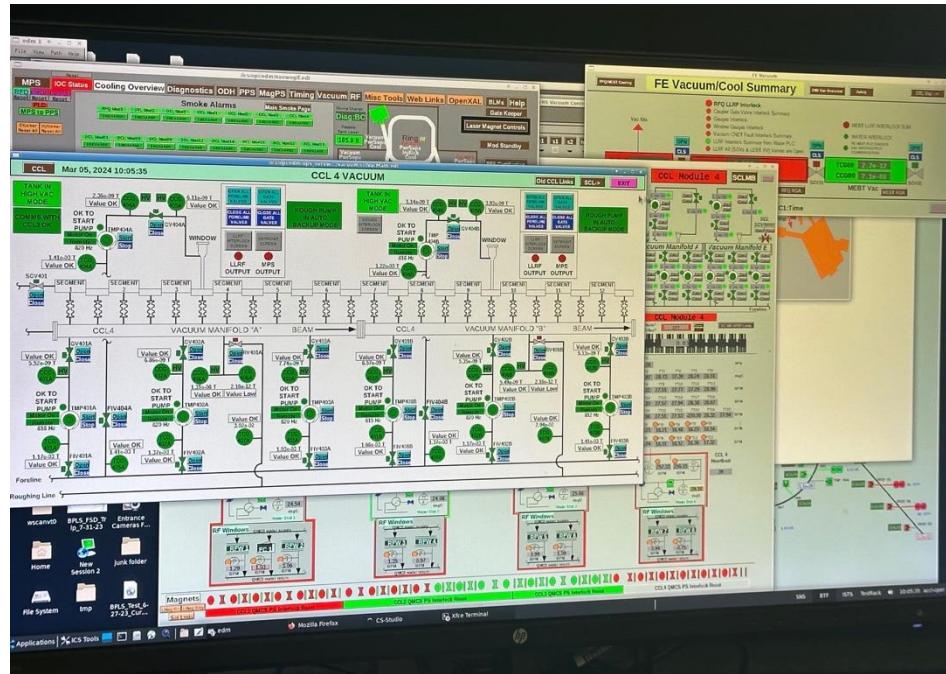
- Michael Guzman and Madelyn Polzin + INL
- We presented on ACORN applications and project for context
- Tour of facilities and discussions with Operations and Controls
 - Walkthroughs of workflow
 - Applications used
 - Control room culture
 - Communication with other roles
 - Modernization effort

Lab visits

- EPICS and CS Studio (Phoebus)
- Operators customize their own screen pulling from Controls-made screens



- EPICS and CS Studio (Phoebus)
- Controls builds engineering screens
- Operators build control room screens
 - Operators encouraged to build own screens if they do not like available options



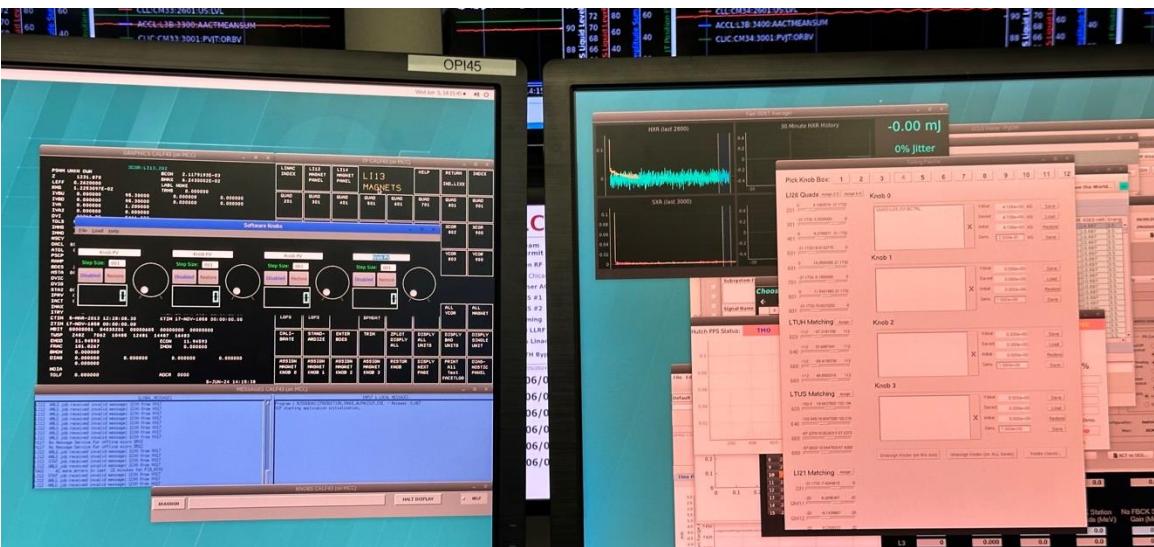
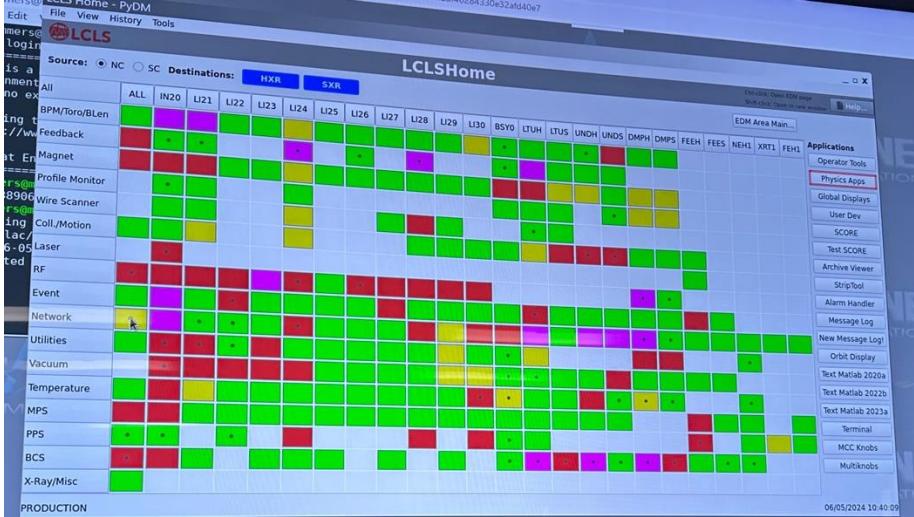
SLAC

- Control system
 - SLAC Control Program (SCP) → EPICS
 - SCP still in use by part of the linac
- Operators produce their own screens
 - Many apps share same functionality
- Controls builds engineering screens
- Hired UX expert



SLAC – Control Room

- Disconnect between what Controls provides and what the ACR needs
 - Controls makes status and overview apps
 - “High level” applications come from Operations or physics group
- Home screen shows alarms and has access to other applications
 - Can access PyDM, Matlab, and EDM
 - Seen as seamless but annoying having to use different types of applications
- Applications with automated control sequences



Lawrence Berkeley

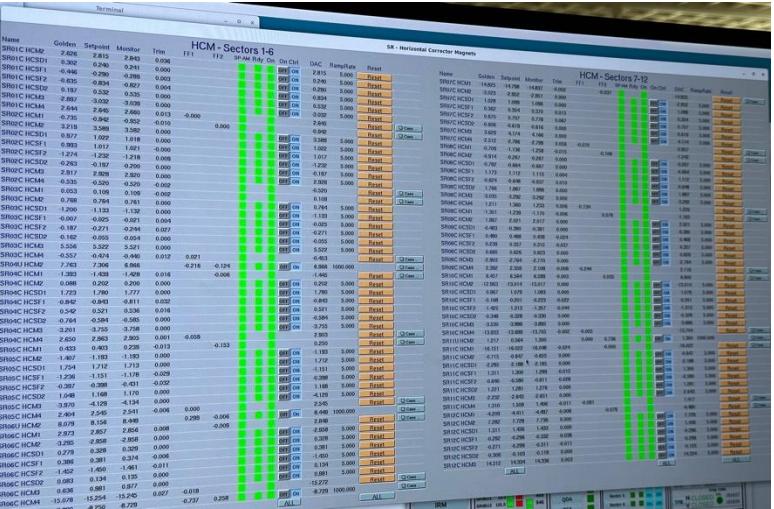
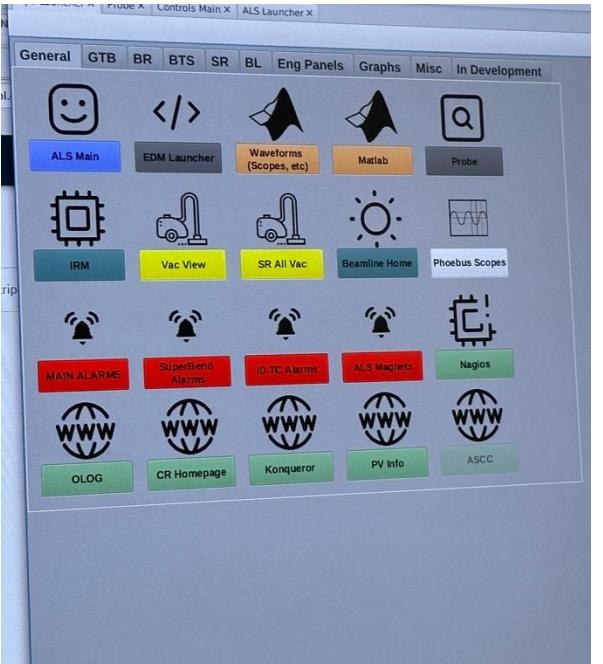
- Control room monitors beam of synchrotron only (no beamlines)
- Operators create applications for control room
 - High level that help with diagnosis
- Controls builds engineering screens
 - Low level and details operators may not need
- Experimenters build their own apps
- PHOEBUS (EDM will be converted) & Matlab
- Operations built their screens but everyone uses same applications
 - The variance lies where people might prefer to monitor different plots
 - Less customization on user level



Lawrence Berkeley

- PV Info allows operators to get metadata on PV
 - Web browser app that leads to a lot of clicking
 - Ideally would click on PV to get this info in app
- Configuration control application
 - Web based
 - Beamline status (online/offline and ready)
 - Shielding and safety
 - Start-up checklist
 - Development team was contracted
 - Agile process

Lawrence Berkeley



Lawrence Livermore

- Homemade control system
 - Ada → Java
- Controls builds all applications
 - No user customization
- Highly automated
 - Task driven
 - Some manual steps required, and operator can intervene if there are issues
 - Operator can monitor a “graph” (flow chart)
- Procedures for everything



LANL (LANSCE)

- Controls and operations tied together
- A mix of digital and analog controls
- They read and set devices on the same application as the alarm feed
 - Functionality between both sections
 - Bottom half looks similar to our Parameter Page
- There are preferences to which application you use to view the same information/complete same task
 - E.g., there is a new status app which operators influenced but some prefer old

| B2 400 MEV BPMs | | SET | D/A | A/D | Con-U | Pgm Tools |
|--------------------|------|---------------------|----------------|----------|----------------------------|-----------|
| -<FTP>+ | *SA* | X-A/D | X=TIME | Y=R:BEAM | ,Z BDCCT,I BELRMP,I MCR130 | |
| COMMAND | -- | Eng-U | I= 0 | I=-5 | , 0 , 0 , 0 | |
| -< | 53+ | s,RR AUTO | F= 1 | F= 60 | , 10 , 120 , 120 | |
| LINAC | bims | hor_inj ver_inj | 400in | ch_time | wires | timers |
| B:HPQ1 | | Q1 | Horiz Position | | | * .3 |
| B:HPQ2 | | Q2 | Horiz Position | | | * .089 |
| B:HPLAM | | LAM | Horiz Position | | | * 3.146 |
| B:HPQ3 | | Q3 | Horiz Position | | | * 2.784 |
| B:HPQ4 | | Q4 | Horiz Position | | | * -.979 |
| B:HPQ5 | | Q5 | Horiz Position | | | * 2.69 |
| B:HPQ6 | | Q6 | Horiz Position | | | * -2.774 |
| B:HPQ7 | | Q7 | Horiz Position | | | * 4.806 |
| B:HPQ8 | | Q8 | Horiz Position | | | * 2.719 |
| B:HPQ9 | | Q9 | Horiz Position | | | * 3.294 |
| B:HPQ10 | | Q10 | Horiz Position | | | * .726 |
| B:HPQ12 | | Q12 | Horiz Position | | | * 1.531 |
| B:HPQDEB | | DEB | Horiz Position | | | * 3.765 |
| B:HPQ13 | | Q13 | Horiz Position | | | * -5.317 |
| B:HPQ14 | | Q14 | Horiz Position | | | * -4.142 |
| B:HPQ15 | | Q15 | Horiz Position | | | * -3.439 |
| B:HPQ16 | | Q16 | Horiz Position | | | * -4.71 |
| B:HPQ17 | | Q17 | Horiz Position | | | * -1.395 |
| B:HPINJ | | INJ | Horiz Position | | | * 4.602 |
| B:HPL1U | | L1U | Horiz Position | | | * 5.119 |
| B:HPL1D | | L1D | Horiz Position | | | * 17.62 |
| B:HPFOIL | | Foil | Horiz Position | | | * 8.229 |
| B:HPL1D | | L1D | Horiz Position | | | * 17.62 |
| B:HPS01 | | S01 | Horiz Position | | | * 13.48 |
| I 400 MEV STEERING | | | | | | |
| -L:D72TH | | Trim Magnet at M7-2 | -.043 | -.128 | -.114 | A |
| -L:D72MV | | Trim Magnet at M7-2 | .651 | .635 | .639 | A |
| -L:D73TH | | Trim Magnet at M7-3 | -1.957 | -1.95 | -1.917 | A |
| -L:D73MV | | Trim Magnet at M7-3 | -.697 | -.674 | -.659 | A |

Fermilab's Parameter Page

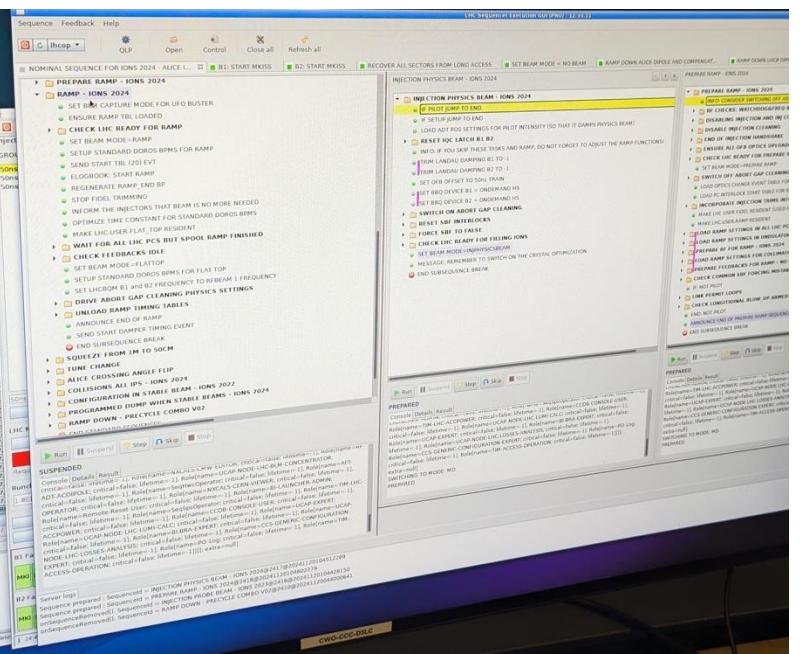
- Built with Tango
- One operator with one part time shifter (other function)
- Every hour there is an automated fill
- Efforts to be consistent





CERN Command Centre – LHC

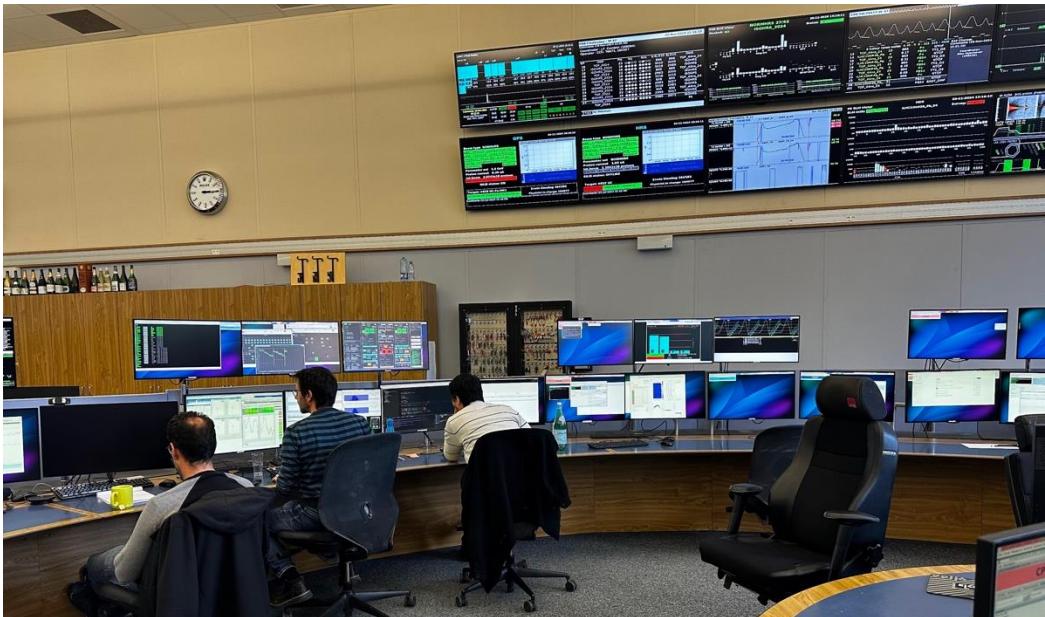
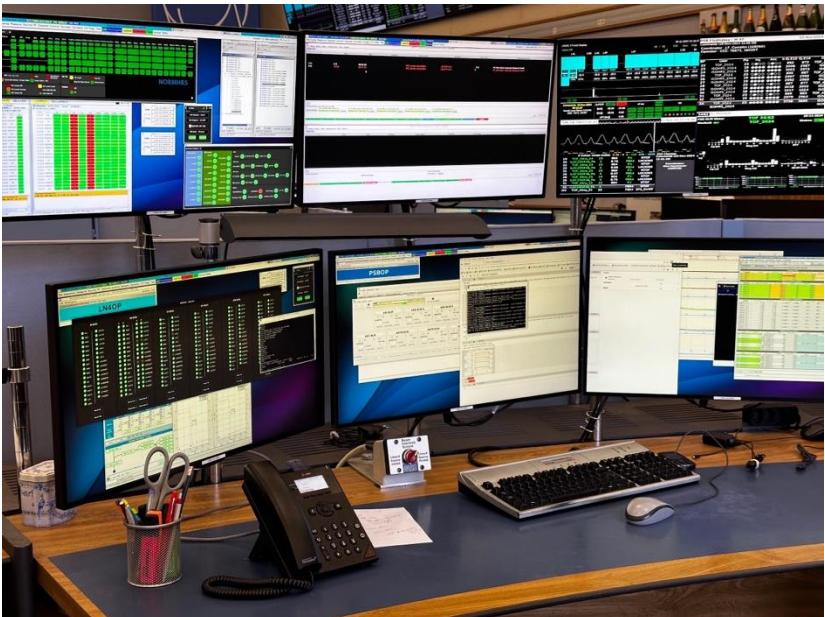
- One operator at a time
- A lot of screen real estate keeping all apps up across monitors
- Highly automated - there are not any tasks during an injection shot
- Main tasks
 - Communicate with SPS (down beam) – check if they are good to receive beam
 - Follow timeline/sequencer to look at the run – most used application
 - Script of tasks that application goes through
 - Automated checklist
- LHC operators are physicists



CERN Command Centre – Linac 4, Booster, & Proton Synchrotron (PS)

- Operators working on accelerator health monitoring tools
 - They are moving towards proactive monitoring instead of relying on alarms
 - Proactive approach to see problems before they happen
 - Holistic accelerator complex health
 - Operators are developing apps with new visualizations of machine health
 - Relying on visualizations to make qualitative decisions
- Operators are technicians

CERN Command Centre – Linac 4, Booster, & PS



- ACNET to EPICS (for PIP-II) & console to web
- Majority of applications come from the controls department
- Heartbeat for when beam is running
- Operators rely heavily on alarms as a part of their workflow



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PA:D <INDEX> Class: <Operations>
Diagnostic & Utility Index Page
1 Save/Restore 24 LCLW/Instrument Air 47 Be
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2201 Plot Control 5025437 Read 5025438 Plotted 532
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2203 Plot Control 5025441 Read 5025442 Plotted 534
2204 Plot Control 5025443 Read 5025444 Plotted 535
2205 Plot Control 5025445 Read 5025446 Plotted 536
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Findings & Insights

Notable Insight Areas

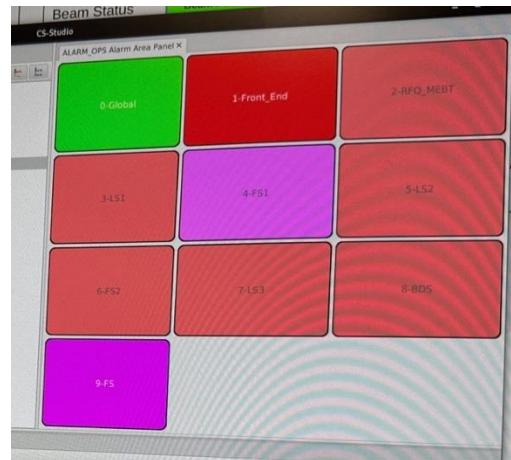
- Operator workflows
- Alarms display and workflow
- Consistency
- Pain points

Key Findings – Operator workflows

- Similar to Fermilab
 - SLAC
 - FRIB
 - ORNL
 - CERN PS island
 - ESRF
- Similar but different
 - LBNL
 - CERN LHC island
- Different
 - LLNL
- Variance in reactive vs proactive

Key Findings – Alarms display and workflow

- Alarm displays & response vary greatly which influences workflow
- Majority of labs expressed some level of frustration with their alarms
- Multiple labs use defined groups represented by status blocks on alarm screen
- Some labs rely on status indicator screens



Key Findings – Alarms display and workflow

- SLAC
 - Color box grid making it hard to notice a new alarm
 - A low-level alarm can trigger a color box to change making it hard to use with the existence of “false alarms”
 - Alarm system is no longer used as primary indication for detection, situation assessment, and response planning
- ORNL
 - Alarms have process information to help with response

Key Findings – Alarms display and workflow

SLAC



ORNL

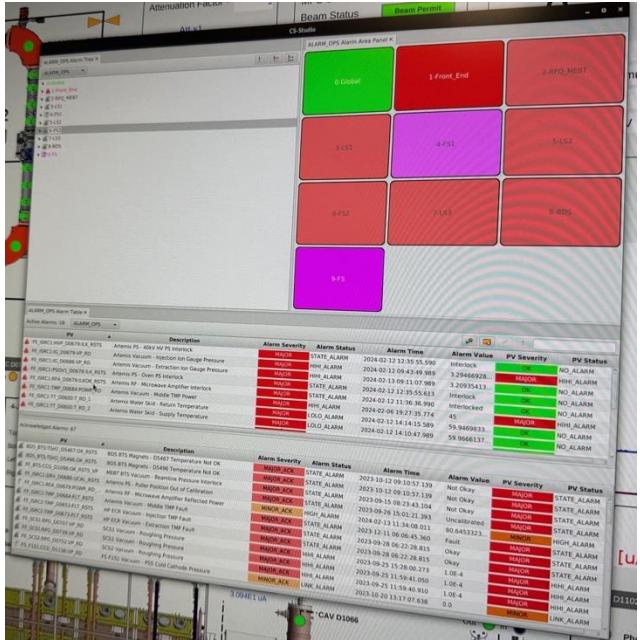


Key Findings – Alarms display and workflow

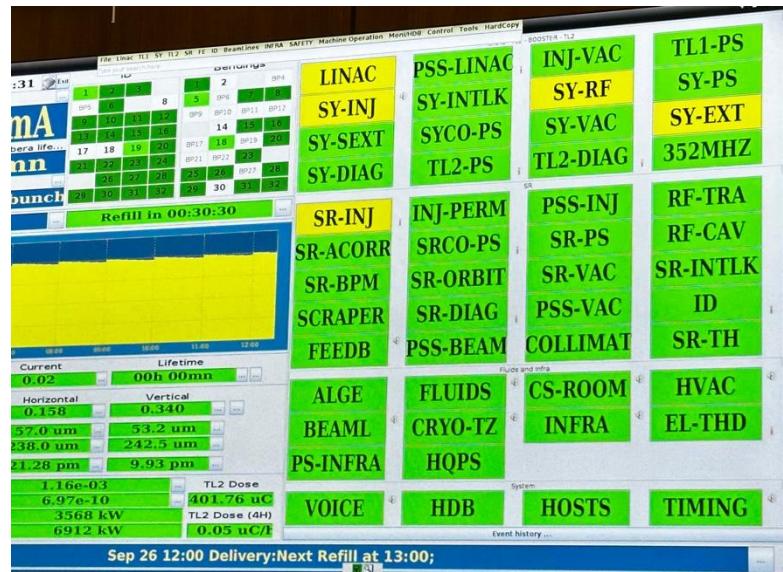
- FRIB
 - Color blocks for different groups of alarms
 - As well as alarm tree and log
 - High priority alarms have procedures and a different alarm screen
 - Experts will tell operators what to monitor and they will call operator
- ESRF
 - Color blocks that they can click into for more information and actionable items

Key Findings – Alarms display and workflow

FRIB



ESRF



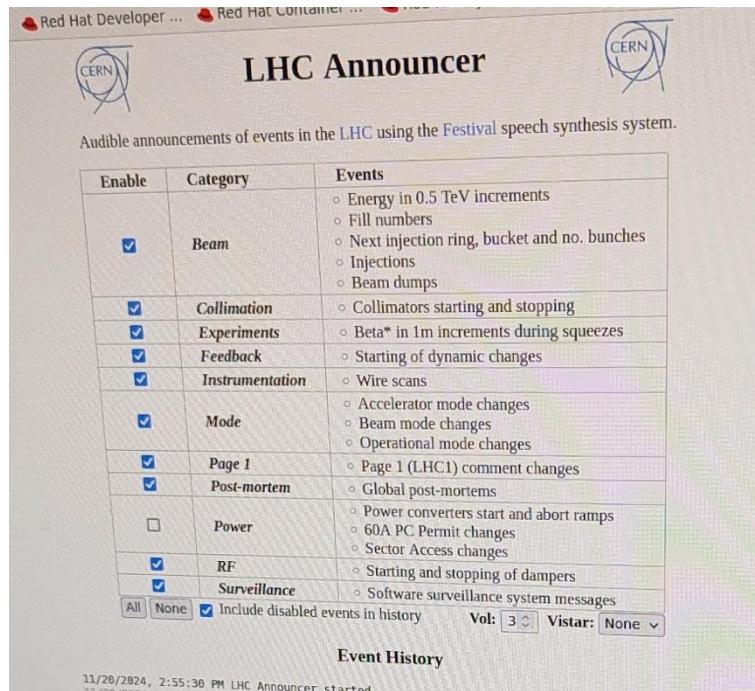
Key Findings – Alarms – LBNL

- Frustrated with current alarm handler (will silence)
- Alarm may stay in a bad state thus hard to tell when a new PV is in alarm
- Reactive to beam alarm
- Easy to diagnose a beam dump; hard to find the root cause
- Working on new alarm handler (PHOEBUS)
 - Currently, easier to diagnose issues without alarm handler (use of status indicator screens)



Key Findings – Alarms – CERN – LHC

- Beam dumping is automatically done by machine, so they don't need alarms
- No alarm screen
 - Status screens around for further investigation
- LHC Announcer
 - “Big sister” → pre interlock warning
 - “Going close to...”
 - Big events are annunciated



The screenshot shows the LHC Announcer configuration interface. At the top, there are tabs for "Red Hat Developer ...", "Red Hat Container ...", and "LHC Announcer". The "LHC Announcer" tab is active. The interface includes the CERN logo and the text "LHC Announcer". Below this is a section titled "Audible announcements of events in the LHC using the Festival speech synthesis system." A table lists configuration options for different categories:

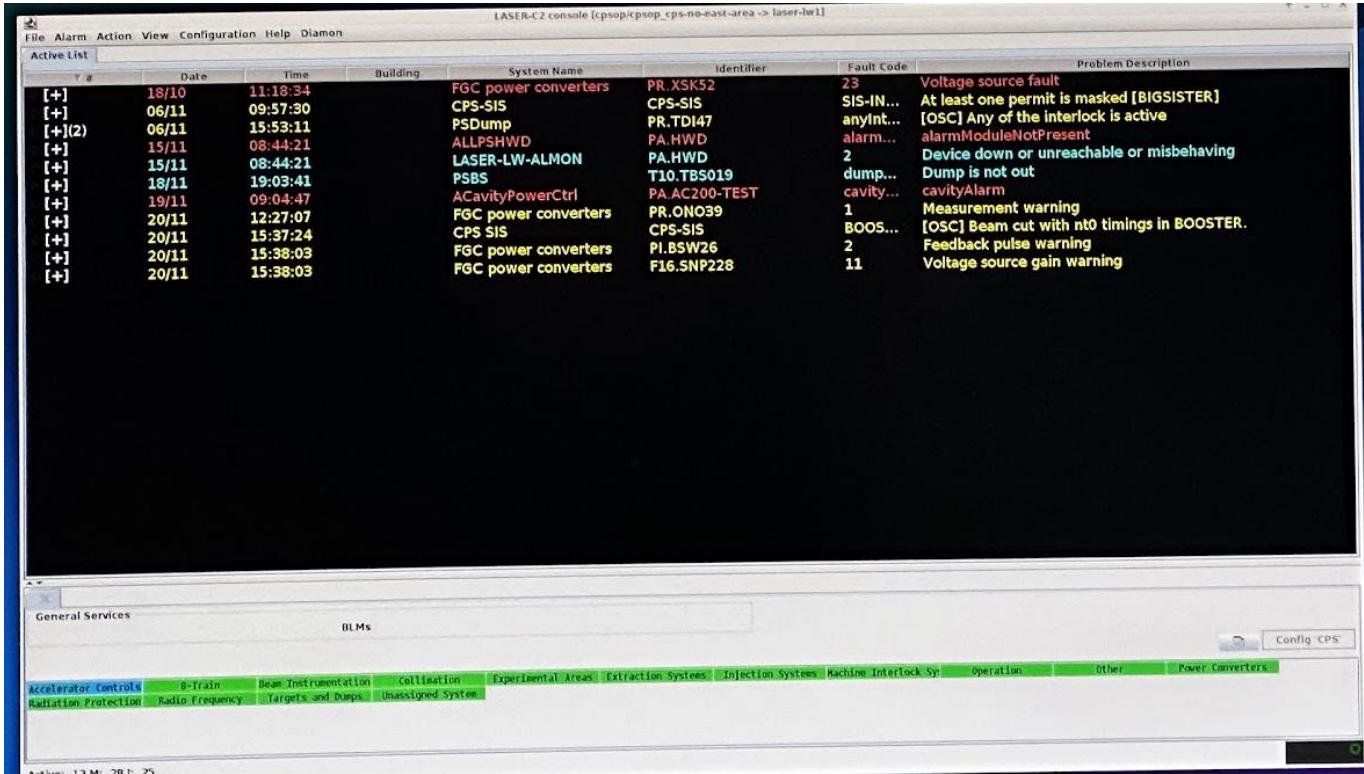
| Enable | Category | Events |
|-------------------------------------|-----------------|---|
| <input checked="" type="checkbox"/> | Beam | <ul style="list-style-type: none">Energy in 0.5 TeV incrementsFill numbersNext injection ring, bucket and no. bunchesInjectionsBeam dumps |
| <input checked="" type="checkbox"/> | Collimation | <ul style="list-style-type: none">Collimators starting and stopping |
| <input checked="" type="checkbox"/> | Experiments | <ul style="list-style-type: none">Beta* in 1m increments during squeezes |
| <input checked="" type="checkbox"/> | Feedback | <ul style="list-style-type: none">Starting of dynamic changes |
| <input checked="" type="checkbox"/> | Instrumentation | <ul style="list-style-type: none">Wire scansAccelerator mode changesBeam mode changesOperational mode changes |
| <input checked="" type="checkbox"/> | Mode | <ul style="list-style-type: none">Page 1 (LHC1) comment changes |
| <input checked="" type="checkbox"/> | Page 1 | <ul style="list-style-type: none">Global post-mortems |
| <input checked="" type="checkbox"/> | Post-mortem | <ul style="list-style-type: none">Power converters start and abort ramps60A PC Permit changesSector Access changes |
| <input type="checkbox"/> | Power | <ul style="list-style-type: none">Starting and stopping of dampers |
| <input checked="" type="checkbox"/> | RF | <ul style="list-style-type: none">Software surveillance system messages |
| <input checked="" type="checkbox"/> | Surveillance | |

At the bottom, there are buttons for "All", "None", and "Include disabled events in history", and dropdowns for "Vol:" (set to 3) and "Vistar:" (set to "None"). The status bar at the bottom shows "11/28/2024, 2:55:30 PM LHC Announcer started".

Key Findings – Alarms – CERN – Linac 4, Booster, & PS

- Moving towards status screens
- Alarm screen - LASER – legacy alarm service
 - Alarms for accelerator, ops, and equipment experts
 - Alarm screen is looked at last if they don't know what is going on
 - Not closely monitored – one operator monitoring
 - Ability to “highlight” an alarm to bring attention to technicians in the field
 - They call op to say they are doing something
 - They call op when done and op sees if alarm is gone
- No audible alarm – operators don't like it at this island
 - Audible would be good for short times

Key Findings – Alarms – CERN – Linac 4, Booster, & PS

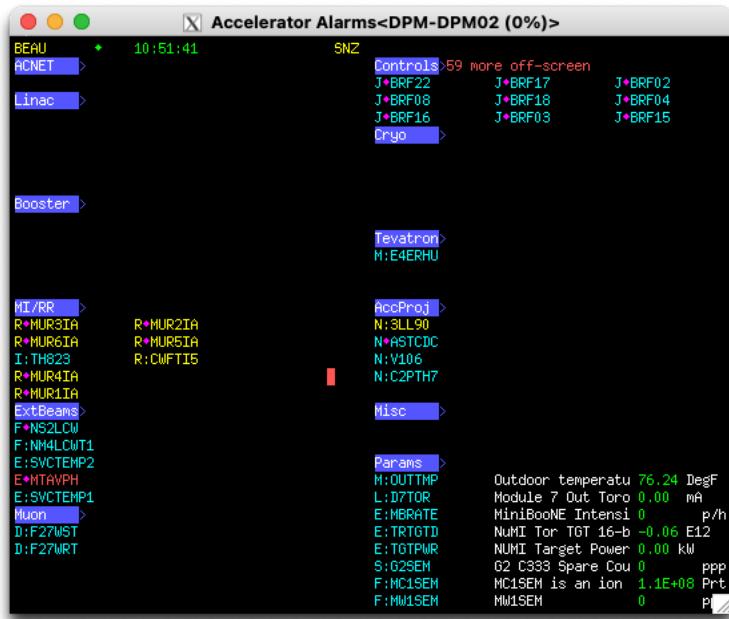


Key Findings – Alarms – LANL (LANSCE)

- No use of color blocks
- It is a scroll where new alarms that come up are on the bottom
 - Alarms are white if acknowledged or unactionable
 - Alarms are red and audible if active and actionable
- Red and audible if active and actionable
- Alarm is on the same screen as where you can see readings and settings of a device
- Mixed feelings about switching to “SNS style” of alarms

Key Findings – Alarms – Fermilab

- Devices pop up when in alarm
 - Need to know naming convention
- No tree structure aside from high-level group
- Unmapped alarms are hidden
- Color is used to show severity and status



Key Findings – Consistency in design and functionality

- Overall challenges with consistency
 - Colors, expected interactions, etc.
 - Influenced by who developed an application/screen
- SLAC: some apps have a functionality that does not translate to all apps
 - E.g., ability to copy by middle click in one app but not the other
- LLNL: They have a formula that works and is applied in their processes and design

Key Findings – Consistency in design and functionality

- FRIB & ORNL
 - Mentioned frustration with consistency
 - Both labs *had* design guidelines
- Fermilab: hidden functionality and inconsistent behavior; hard to find things

Key Findings – Pain points

- Alarm screens/handlers
- Consistency across the board
 - ORNL: Consistency adds difficulty to training
- SLAC: inconsistent tools
 - E.g., ability to copy by middle click in one app but not the other
- LBNL: PHOEBUS screen management (resizing, tabs, etc.)
- FRIB: Trouble finding application features and pages they need
- ORNL: Maintaining displays created by someone else
- LANL: xxxxxxx

Findings – Takeaways

- We share a lot of the same challenges
- Consistency is a challenge for everyone (except LLNL; they're perfect)
- Alarms are hard
- Variance at labs for whom the controls department deems users
 - Who makes the control room applications/screens?

Food for thought: Fermilab

- The relationship between Operations and Controls
 - Multiple labs have operators build their own applications
 - “We built this with controls” not “controls built this for us”
 - Sense of ownership and inclusion
- What level of customization should there be?
- Consider user acceptance/relationship when modernizing someone’s application that they heavily rely on
 - Learn from them and include them

Collaboration Opportunities

- A lot of positivity around future collaborations and exchange of knowledge
 - Interest in our findings
- Suggestions to create working meetings to address similar problems
 - *Thanks Tasha! 😊*
 - Similar workflows and systems
- Labs saw value in tour and want to have their own visits
- Very rewarding and validating that labs see the value in what we're doing
 - Excitement in the mutual benefits

Closing thoughts

- Successful trips
 - New ideas and gained knowledge in approaches to similar problems
 - Future collaboration
- Validations
 - Lab visits
 - Incorporating users early into our processes
 - Task-based pages
 - Style guide development

Thank you!