FERMILAB-SLIDES-25-0026-AD

Fermilab U.S. DEPARTMENT OF ENERGY | Office of Science

ACORN Applications Lab Tour

Accelerator UX Workshop @ SLAC

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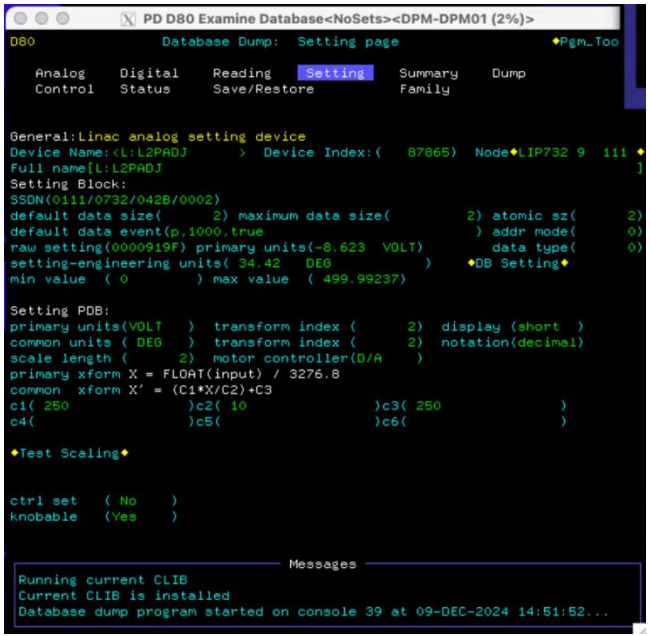
Outline

- 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



Lab Tour

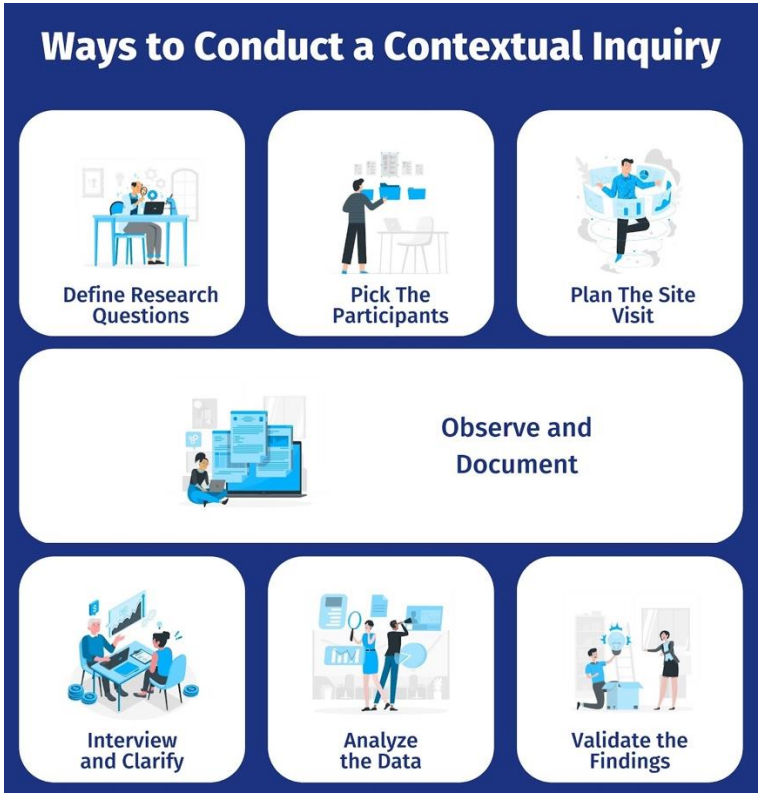
- Comparative analysis
  - Similarities, considerations, and challenges
- User research
  - Pain point evaluation
  - Clear analysis of options
  - New ideas
  - Validation of design
  - Validation of assumptions
  - Avoid faults of tried solutions
- Modernization of controls

Objectives – What do we want to learn?

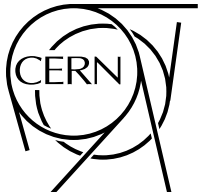
- Comparative analysis
  - Application design
  - Application tools
- User workflows
  - Alarms
  - Troubleshooting
- Roles
  - Operators
  - Engineers
  - Scientists
  - Admin
  - Remote access
- Control room design
  - Auditory environment
  - Multi-monitor support
  - Multiple human interactions to 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

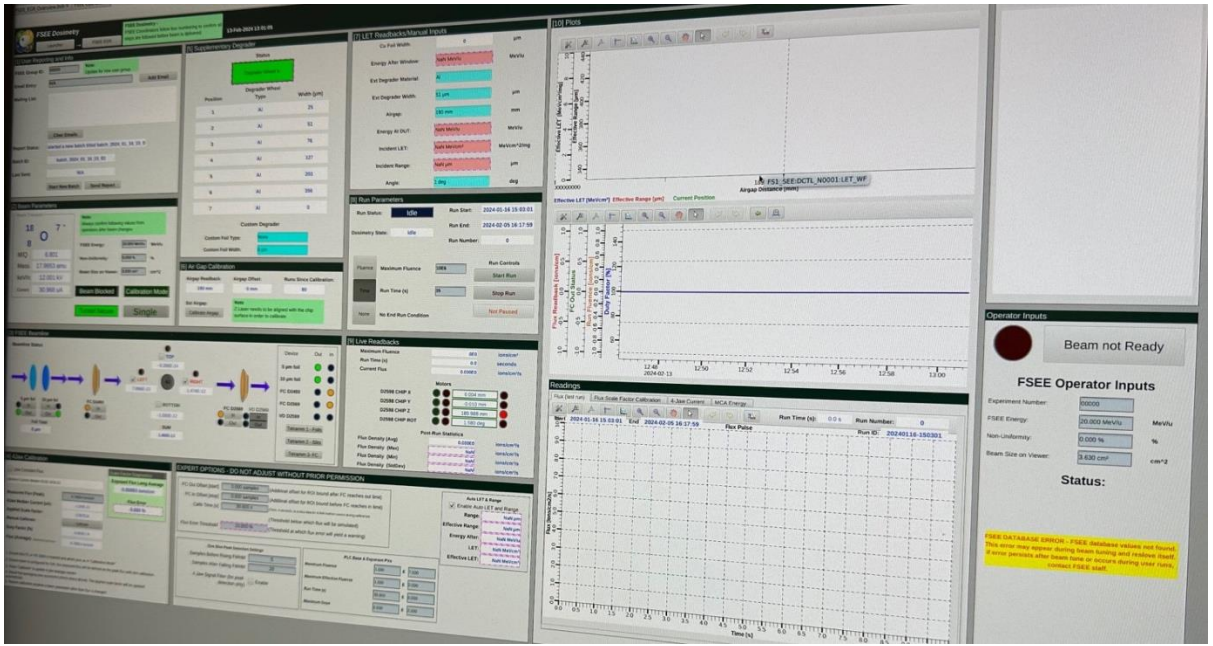
Visit flow

- 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

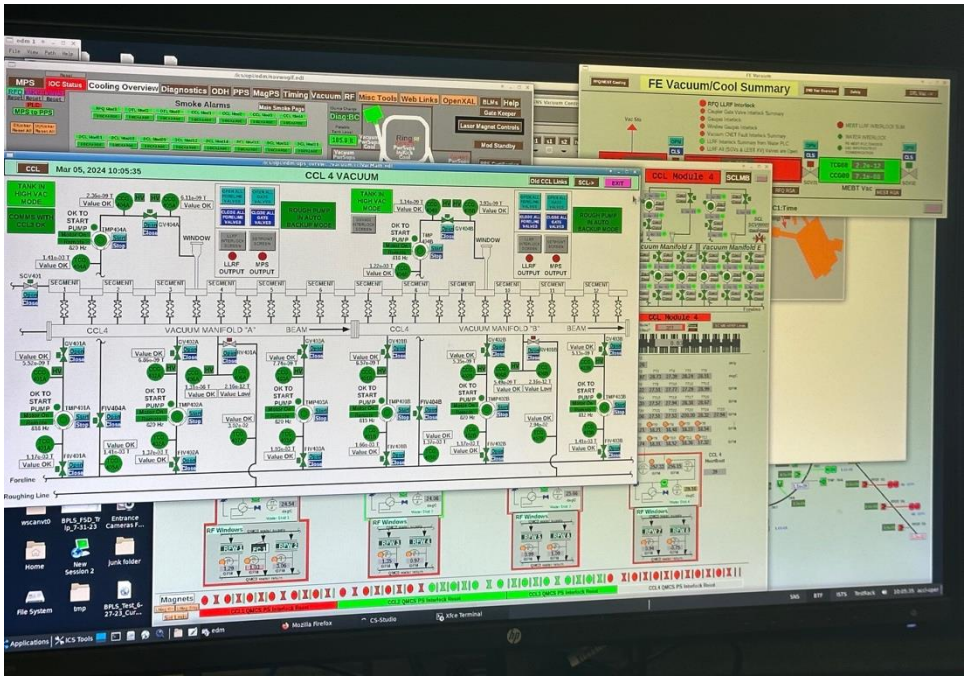
FRIB

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



ORNL

- 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

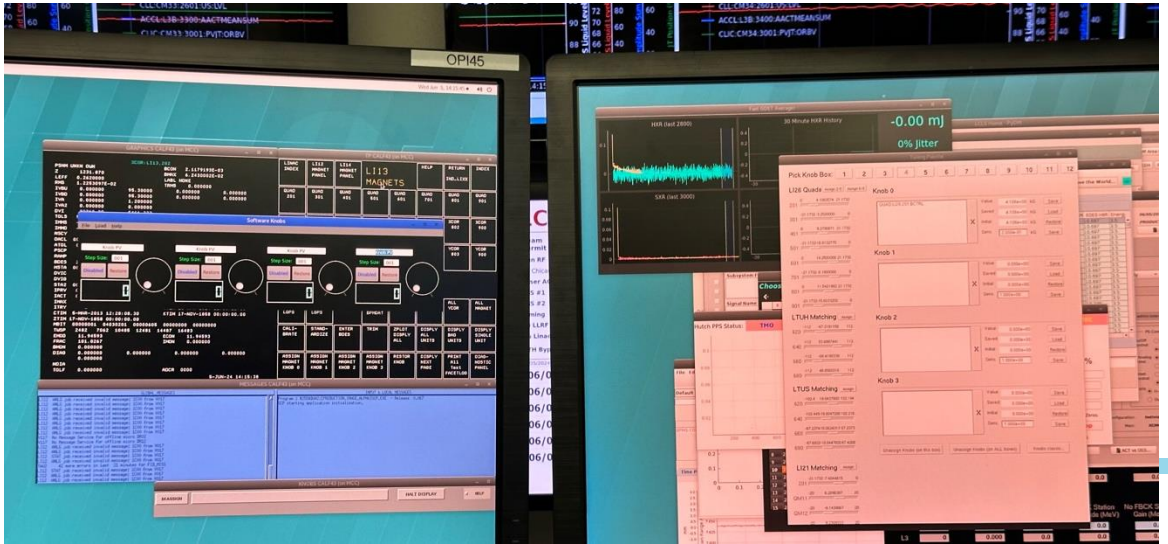
SLAC – Control Room

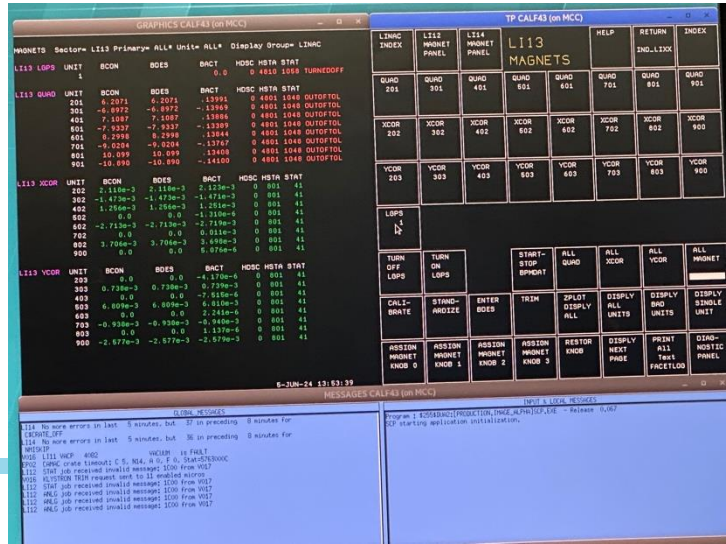
- Disconnect between what Controls provides and what the ACR needs
  - Controls makes status and overview apps
  - “High level” applications come from Operations or physics group
- Home screen shows alarms and has access to other applications
  - Can access PyDM, Matlab, and EDM
  - Seen as seamless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

SLAC


LCLSHome
Source: NC SC Destinations: HXR SXR
PRODUCTION
06/05/2024 10:40:09


LCLS Operator Dashboard
Rate Selection
Transverse Feedbacks
Longitudinal Feedbacks
MPS Stoppers
Photon Controls
Operating Summary
GUIs
MPS/BCS Summary


OPI45
LI13 MAGNETS
-0.00 mJ
0% jitter


GRAPHICS CALF43 (on MCC)
TP CALF43 (on MCC)
LI13 MAGNETS
MESSAGES CALF43 (on MCC)

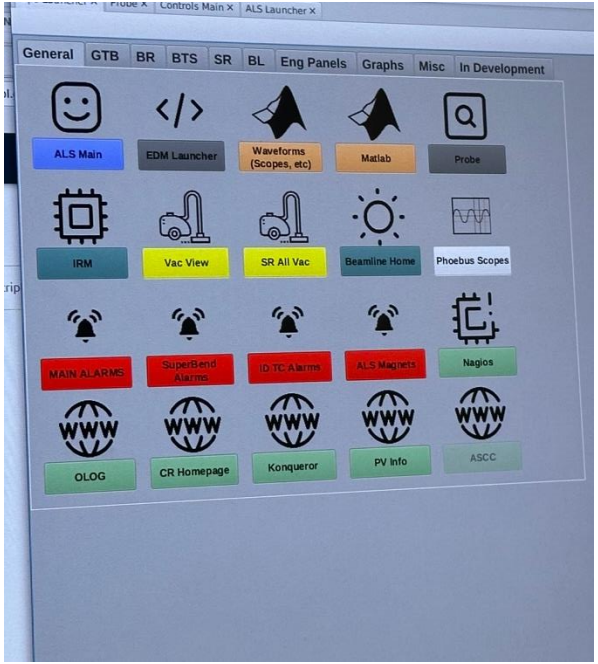
Lawrence Berkeley

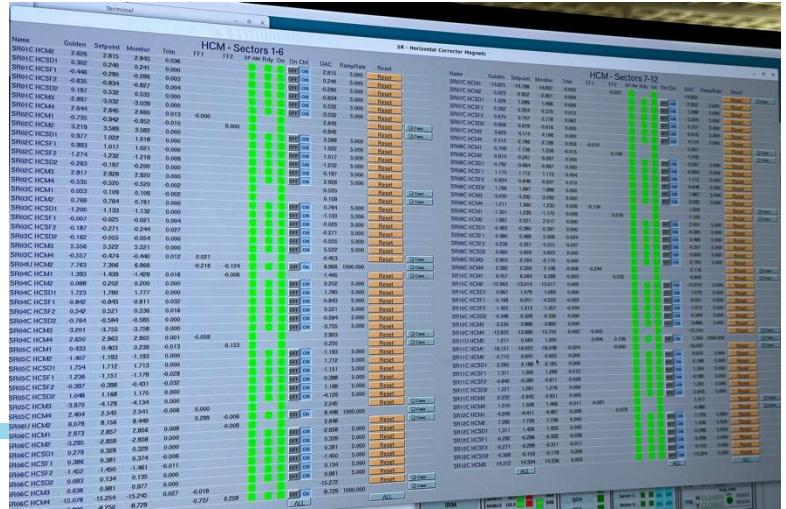
- Control room monitors beam of synchrotron only (no beamlines)
- Operators create applications for control room
  - High level that help with diagnosis
- Controls builds engineering screens
  - Low level and details operators may not need
- Experimenters build their own apps
- PHOEBUS (EDM will be converted) & 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



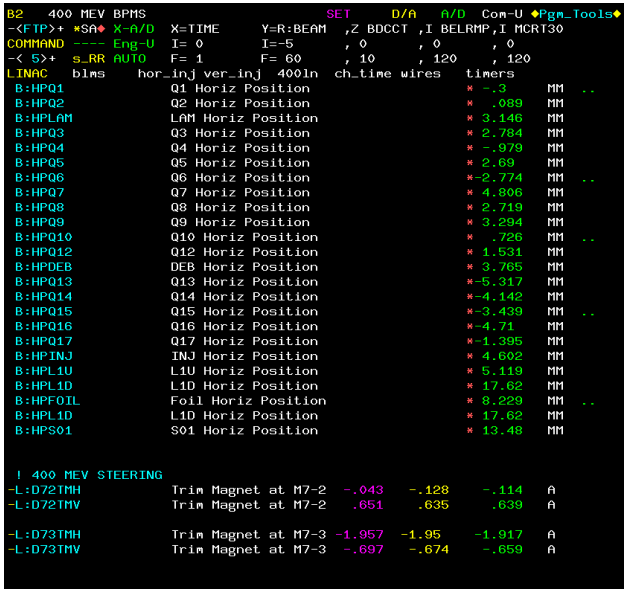


Lawrence Livermore

- 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



Fermilab's Parameter Page

Fermilab

ESRF

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

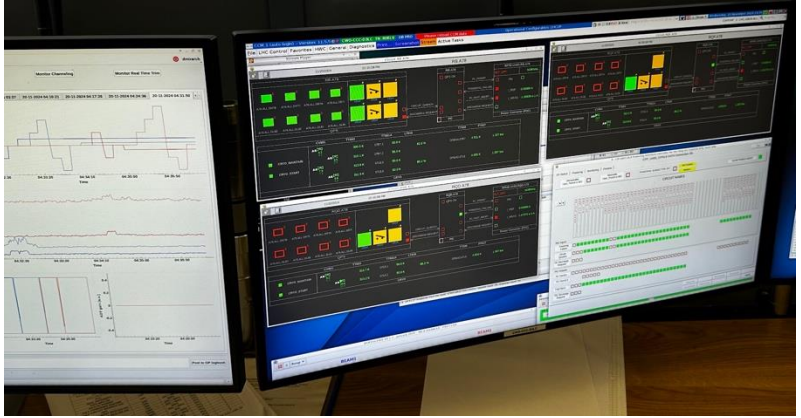
ESRF

Fermilab

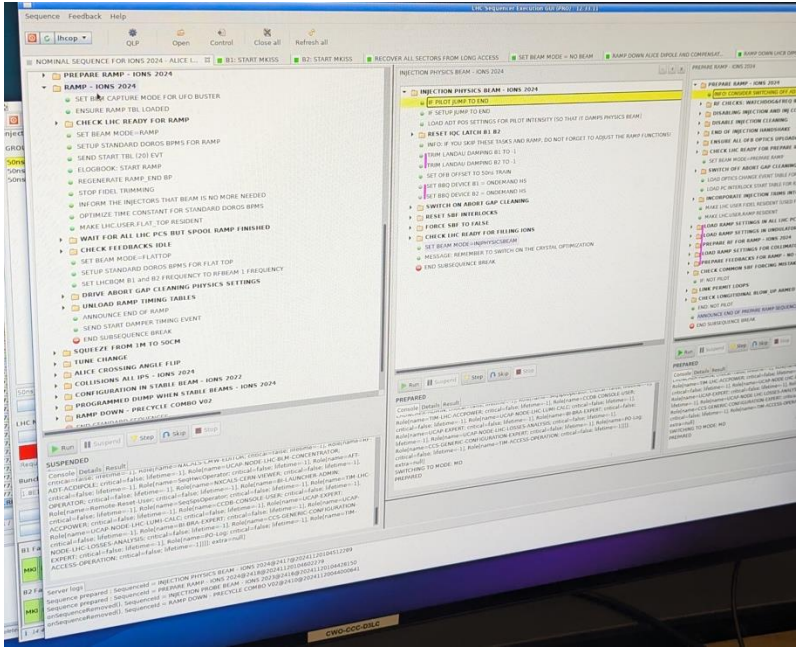
CERN Command Centre – LHC

- 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 it see 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

LHC




Beam 2
SPS-PAGE1 Current user: MD1
ION PHYSICS: NO BEAM
ION PHYSICS: NO BEAM
Comments (20-Nov-2024 07:44:19)
Quench in S23
Cryo recovery ongoing
No beam before 19

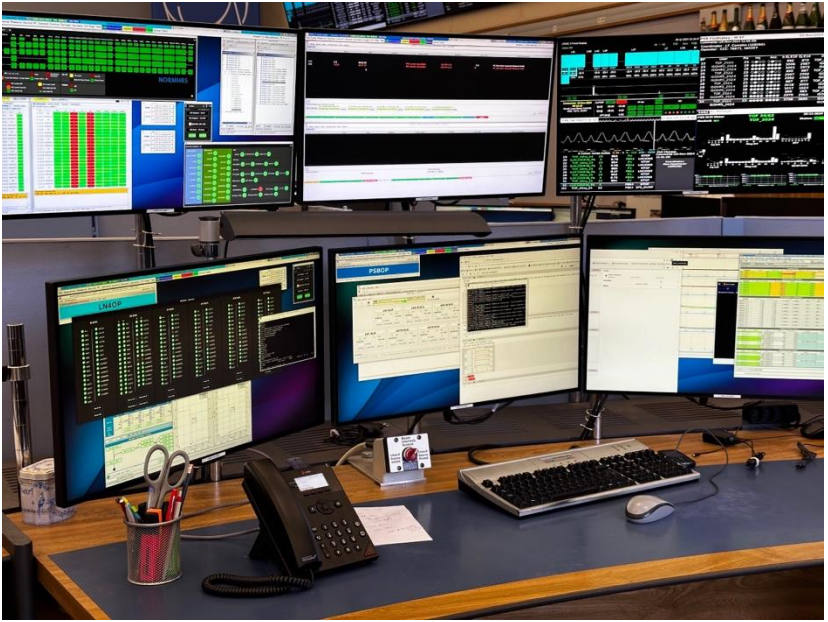

Sequence Feedback Help
PREPARE RAMP - IONS 2024
RAMP - IONS 2024
INJECTION PHYSICS BEAM - IONS 2024
SUSPENDED

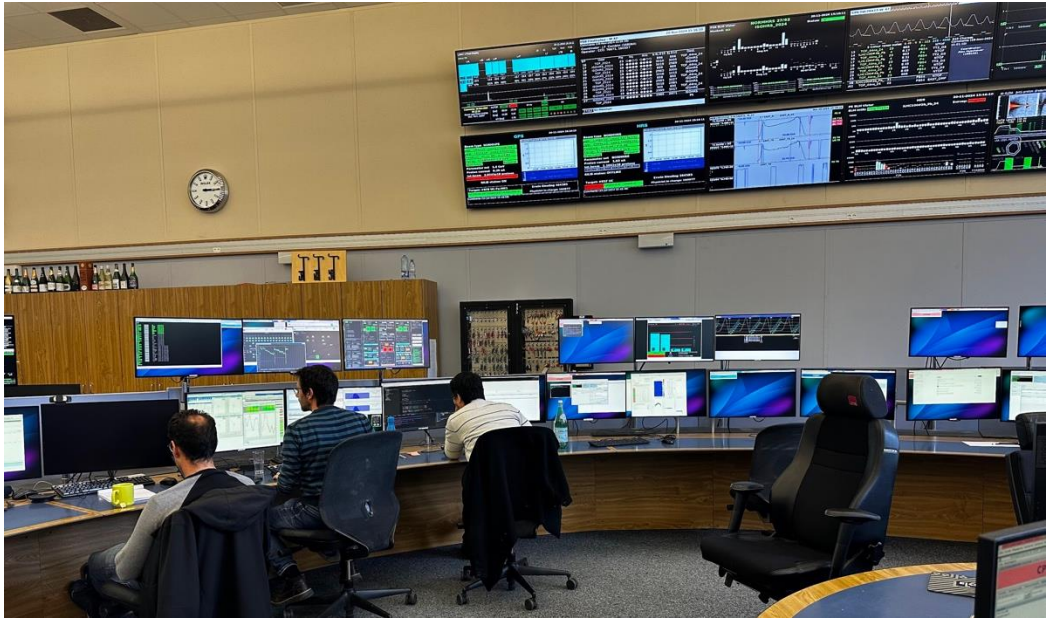

Monitoring set: SECTOR12 20 November, 2024, 14:40:54
Monitoring set: SECTOR23 20 November, 2024, 14:40:54
Monitoring set: SECTOR34 20 November, 2024, 14:40:54

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

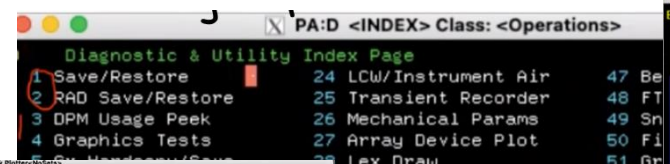


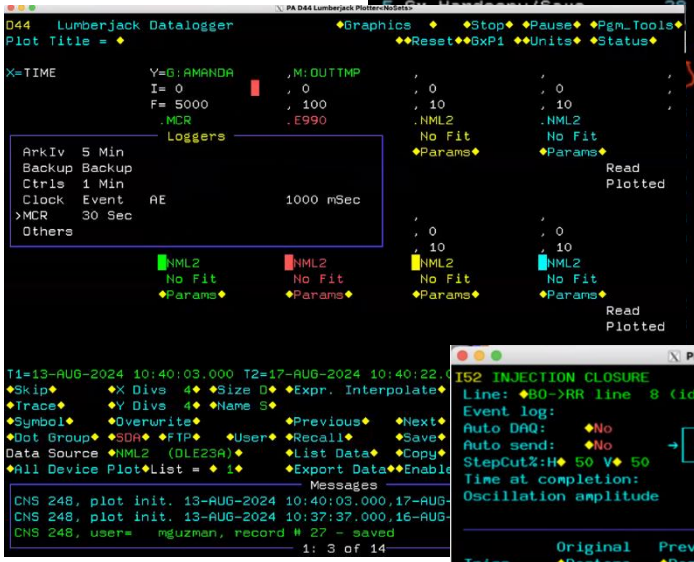


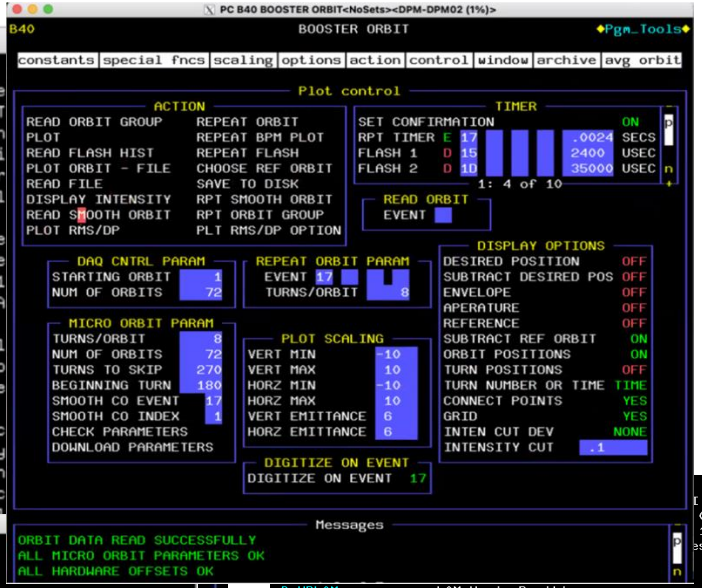
Fermilab

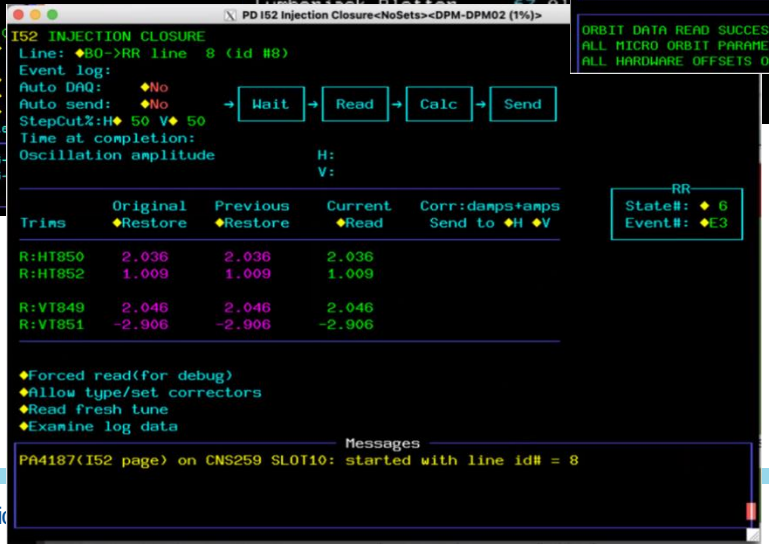
- ACNET to EPICS (for PIP-II) & console to web
- Majority of applications come from the controls department
- Heartbeat for when beam is running
- Operators rely heavily on alarms as a part of their workflow

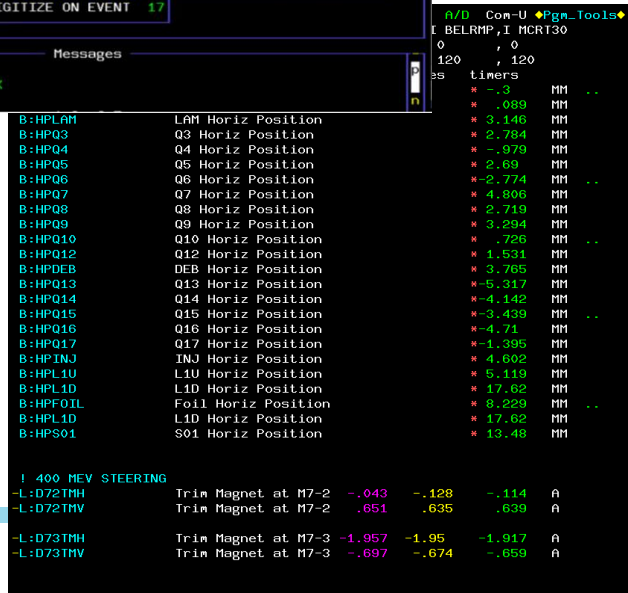
Fermilab


PA:D <INDEX> Class: <Operations>
Diagnostic & Utility Index Page
1 Save/Restore
2 RAD Save/Restore
3 DPM Usage Peek
4 Graphics Tests
24 LCW/Instrument Air
25 Transient Recorder
26 Mechanical Params
27 Array Device Plot
51 Lex Draw
52 ACL Script Menu
53 Node Poll
54 ACNET Node Poll
55 Tev Clock Display
56 Clockscope
57 Plot Annotation
58 XConsole CachePeek
59 Generic Structures
60 Curve Fit II
61 Level II Exerciser
62 GAS Test/Boot/Etc
63 BPM Diagnostics
64 Data Logging
65 Snapshot Logger
66 Lumberjack Config


D44 Lumberjack Datalogger
Plot Title = ◆
Loggers
ArkIv 5 Min
Backup Backup
Ctrls 1 Min
Clock Event AE 1000 mSec
>MCR 30 Sec
Others
Messages
CNS 248, plot init. 13-AUG-2024 10:40:03.000,17-AUG-
CNS 248, plot init. 13-AUG-2024 10:37:37.000,16-AUG-
CNS 248, user= mguzman, record # 27 - saved


B40 BOOSTER ORBIT
constants special fncs scaling options action control window archive avg orbit
Plot control
ACTION
READ ORBIT GROUP
PLOT
READ FLASH HIST
PLOT ORBIT - FILE
READ FILE
DISPLAY INTENSITY
READ SMOOTH ORBIT
PLOT RMS/DP
REPEAT ORBIT
REPEAT BPM PLOT
REPEAT FLASH
CHOOSE REF ORBIT
SAVE TO DISK
RPT SMOOTH ORBIT
RPT ORBIT GROUP
PLT RMS/DP OPTION
TIMER
SET CONFIRMATION ON
RPT TIMER E 17 .0024 SECS
FLASH 1 D 15 2400 USEC
FLASH 2 D 1D 35000 USEC
1: 4 of 10
READ ORBIT
EVENT
DAQ CNTRL PARAM
STARTING ORBIT 1
NUM OF ORBITS 72
REPEAT ORBIT PARAM
EVENT 17
TURNS/ORBIT 8
MICRO ORBIT PARAM
TURNS/ORBIT 8
NUM OF ORBITS 72
TURNS TO SKIP 270
BEGINNING TURN 180
SMOOTH CO EVENT 17
SMOOTH CO INDEX 1
CHECK PARAMETERS
DOWNLOAD PARAMETERS
PLOT SCALING
VERT MIN -10
VERT MAX 10
HORZ MIN -10
HORZ MAX 10
VERT EMITTANCE 6
HORZ EMITTANCE 6
DIGITIZE ON EVENT
DIGITIZE ON EVENT 17
DISPLAY OPTIONS
DESIRED POSITION OFF
SUBTRACT DESIRED POS OFF
ENVELOPE OFF
APERATURE OFF
REFERENCE OFF
SUBTRACT REF ORBIT ON
ORBIT POSITIONS ON
TURN POSITIONS OFF
TURN NUMBER OR TIME TIME
CONNECT POINTS YES
GRID YES
INTEN CUT DEV NONE
INTENSITY CUT .1
Messages
ORBIT DATA READ SUCCESSFULLY
ALL MICRO ORBIT PARAMETERS OK
ALL HARDWARE OFFSETS OK


I52 INJECTION CLOSURE
Line: ◆BO->RR line 8 (id #8)
Event log:
Auto DAQ: ◆No
Auto send: ◆No
StepCut%:H◆ 50 V◆ 50
Time at completion:
Oscillation amplitude
Wait → Read → Calc → Send
RR
State#: ◆ 6
Event#: ◆E3
Trims
Original ◆Restore
Previous ◆Restore
Current ◆Read
Corr:damps+amps Send to ◆H ◆V
R:HT850 2.036 2.036 2.036
R:HT852 1.009 1.009 1.009
R:VT849 2.046 2.046 2.046
R:VT851 -2.906 -2.906 -2.906
◆Forced read(for debug)
◆Allow type/set correctors
◆Read fresh tune
◆Examine log data
Messages
PA4187(I52 page) on CNS259 SLOT10: started with line id# = 8


B:HPLAM LAM Horiz Position
B:HPQ3 Q3 Horiz Position
B:HPQ4 Q4 Horiz Position
B:HPQ5 Q5 Horiz Position
B:HPQ6 Q6 Horiz Position
B:HPQ7 Q7 Horiz Position
B:HPQ8 Q8 Horiz Position
B:HPQ9 Q9 Horiz Position
B:HPQ10 Q10 Horiz Position
B:HPQ12 Q12 Horiz Position
B:HPDEB DEB Horiz Position
B:HPQ13 Q13 Horiz Position
B:HPQ14 Q14 Horiz Position
B:HPQ15 Q15 Horiz Position
B:HPQ16 Q16 Horiz Position
B:HPQ17 Q17 Horiz Position
B:HPINJ INJ Horiz Position
B:HPL1U L1U Horiz Position
B:HPL1D L1D Horiz Position
B:HPFOIL Foil Horiz Position
B:HPL1D L1D Horiz Position
B:HPS01 S01 Horiz Position
1 400 MEV STEERING
-L:D72TMH Trim Magnet at M7-2 -.043 -.128 -.114 A
-L:D72TMV Trim Magnet at M7-2 .651 .635 .639 A
-L:D73TMH Trim Magnet at M7-3 -1.957 -1.95 -1.917 A
-L:D73TMV Trim Magnet at M7-3 -.697 -.674 -.659 A

Findings & Insights

Notable Insight Areas

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

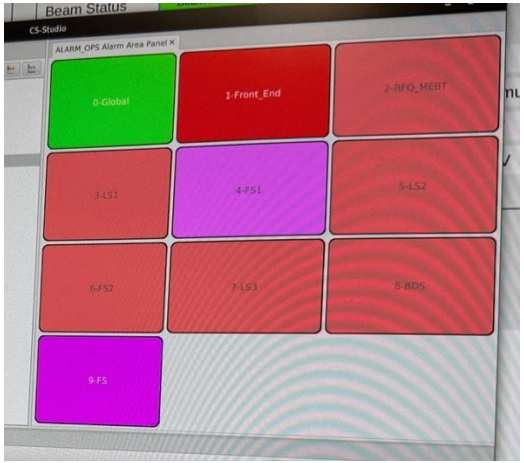
Key Findings – Operator workflows

- 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



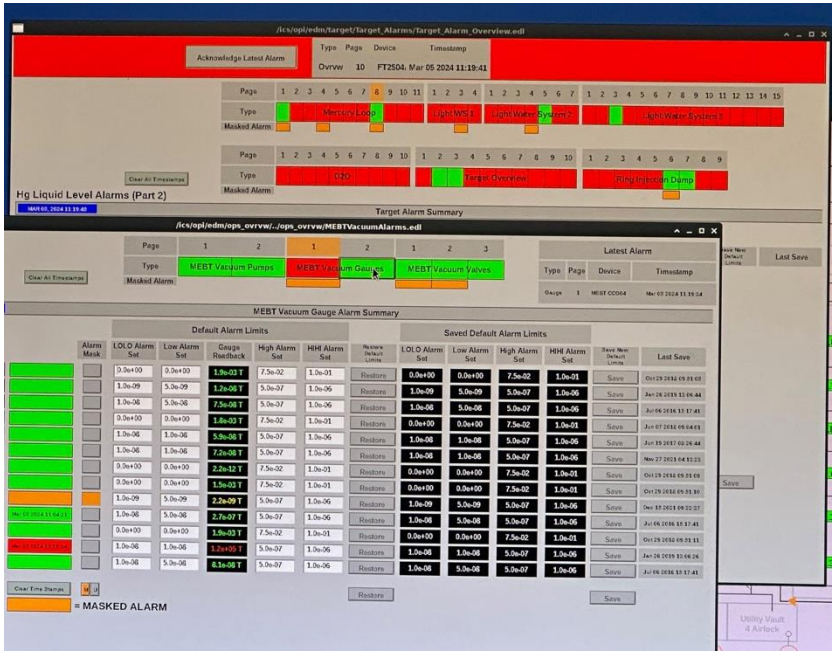
Key Findings – Alarms display and workflow

- 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



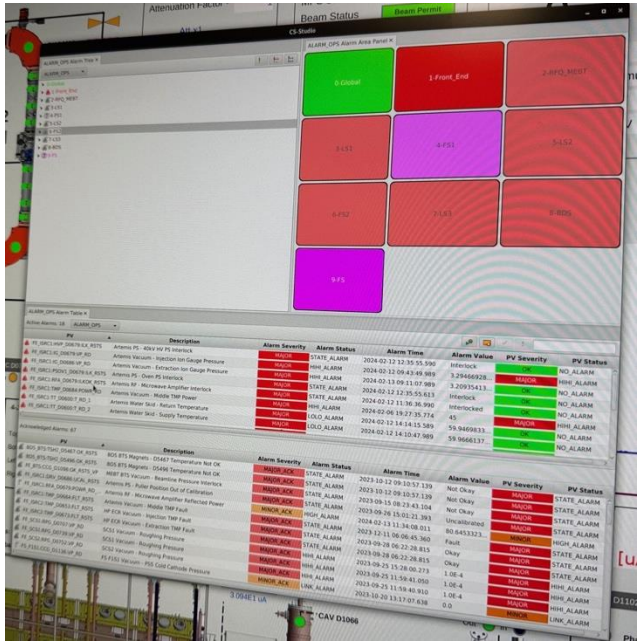
Fermilab

Key Findings – Alarms display and workflow

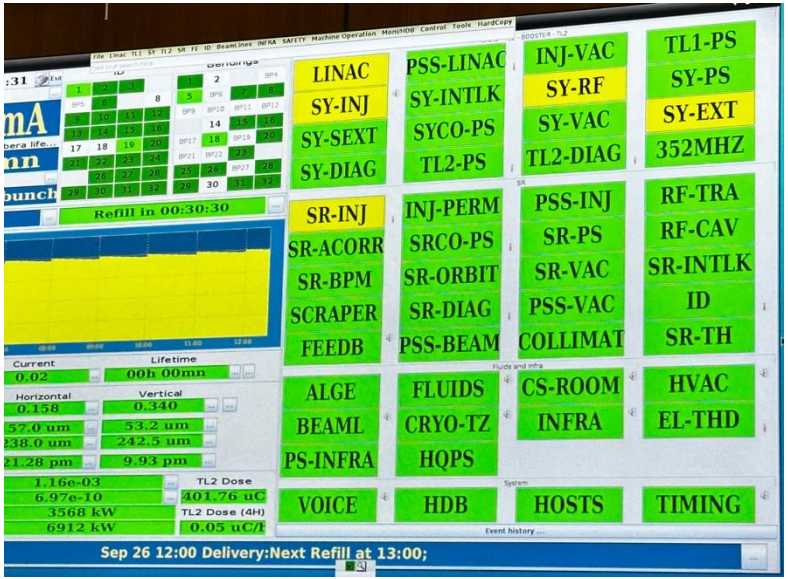
- FRIB
  - Color blocks for different groups of alarms
    - As well as alarm tree and log
  - High priority alarms have procedures and a different alarm screen
  - Experts will tell operators what to monitor and they will call operator
- ESRF
  - Color blocks that they can click into for more information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

Key Findings – Alarms display and workflow

FRIB



ESRF



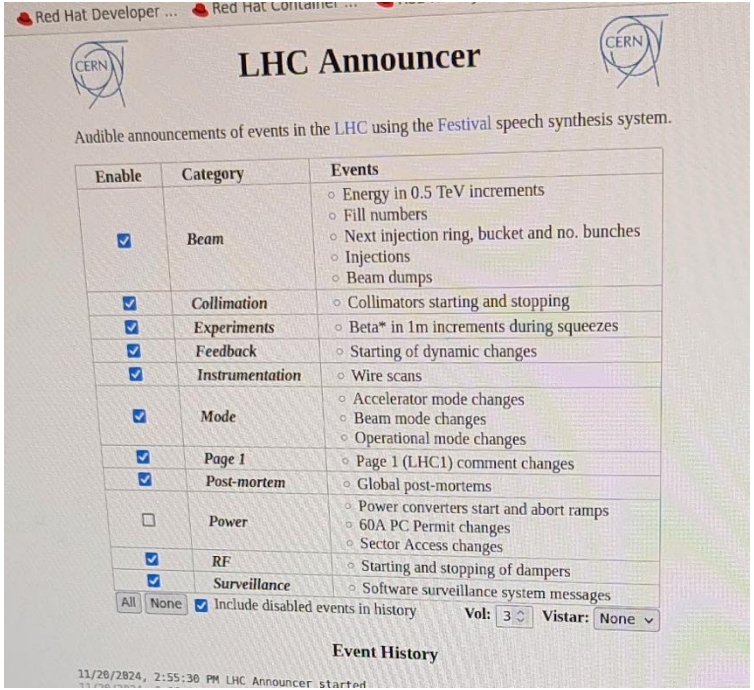
Fermilab

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



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

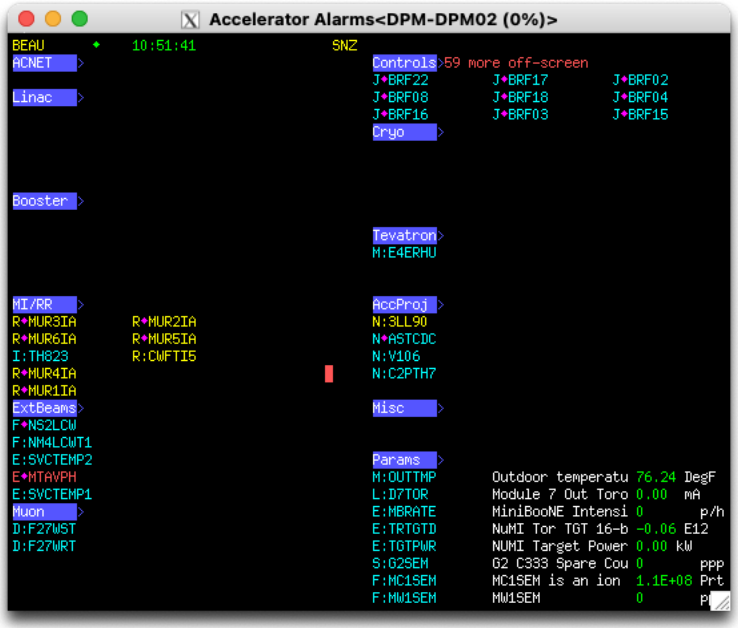
Fermilab

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: xxxxxx

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!