Changing Horses Mid-Stream

Upgrading the LCLS Control System During Production Operations

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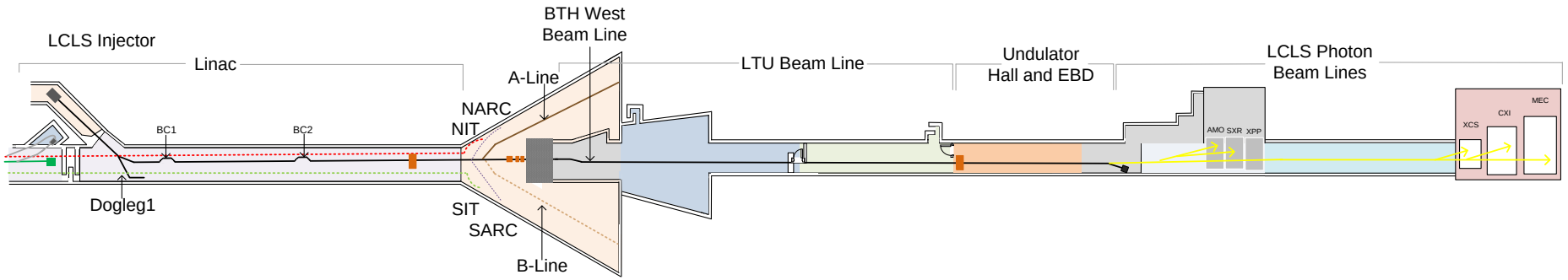
Overview

- Introduction
- Background of control system
- Upgrade project
- Implementation
- Status
- Conclusions

Introduction to LCLS

- Linac Coherent Light Source (LCLS)
  - X-ray free electron laser
  - SLAC National Accelerator Laboratory (SLAC)
- 3 km Linear Accelerator (Linac)
  - Constructed in 1960s
  - Accelerates electron and positron beams
  - Last 1 km recently repurposed for the LCLS

LCLS Overview



LCLS Control System

- Construction of the LCLS began in 2006, beam commissioning in 2007
- EPICS control system used for the newly-built areas of the LCLS
  - EPICS IOCs
  - RTEMS and Linux operating systems
  - VME hardware
  - EDM, Java, Matlab

LCLS Control System

- Linac used legacy control system
  - Built for SLAC Linear Collider (SLC) in early 1980s
- Linac magnets and beam position monitors upgraded to EPICS
- Some functions are still under control of the legacy system
  - Accelerating RF and its timing
  - Diagnostic signals (temperatures, vacuum)
  - Interface to safety systems

Legacy Control System

- Distributed RMX microcomputers (“micros”)
- CAMAC hardware
- Alpha 6600
  - VMS operating system
  - Centralized database
  - Handles user requests

Pre-Upgrade Legacy Data Access

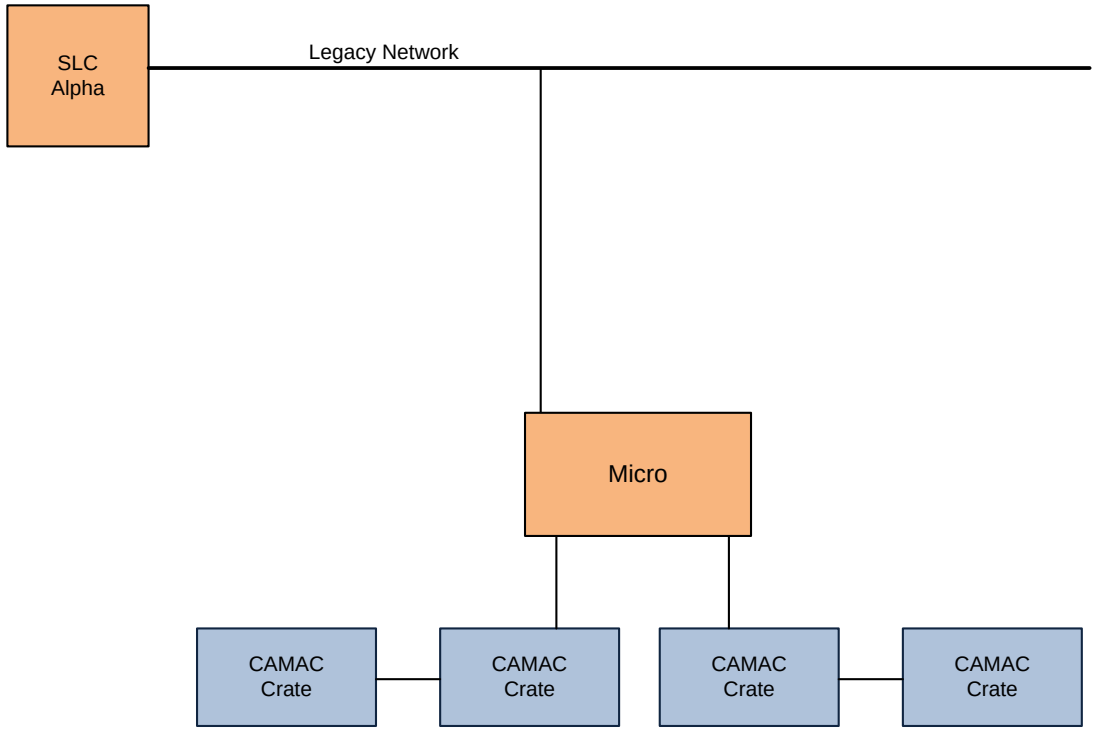
- Tools provide access to legacy system variables from EPICS
  - SLCCAS – SLC Channel Access Server
    - Read access to Channel Access clients
  - AIDA – Accelerator Integrated Data Access
    - Read and write access to Java programs, Matlab, scripts
- Primary interface
  - Graphical user interface
  - SLC Control Program (SCP)

Upgrade Project

- Upgrade remaining legacy system functions to EPICS
  - Remove dependency on legacy system
  - Improve LCLS uptime and reliability
- Upgrade the Linac controls in 2 phases
  - Replace micros with EPICS IOCs
    - Subject of this talk
  - Upgrade CAMAC hardware
    - To be done later; project in progress

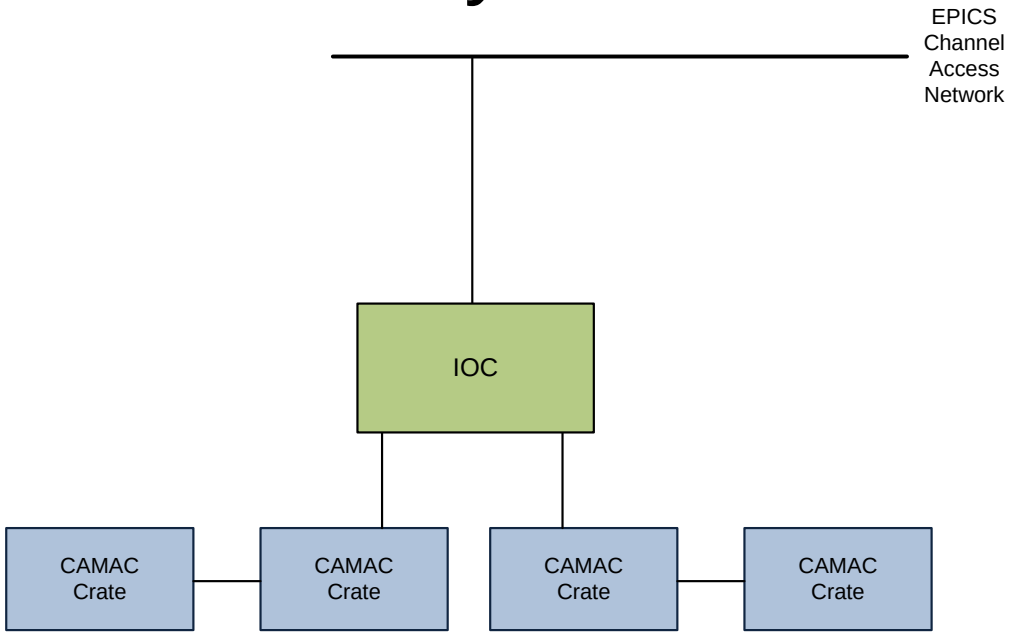
Linac Control System

- LCLS Linac divided into 11 “sectors”
- Each sector
  - RMX micro
  - 4 CAMAC crates



Upgrade Plan

- Replace micros with standard LCLS IOCs
- Fully integrate CAMAC controlled devices into the LCLS EPICS control system



Challenges

- Legacy control system refined over decades and feature-rich
  - Reproducing this functionality
- Thousands of signals ported to EPICS
  - Accurately copying data
- Upgrade during LCLS user run
  - Meet strict uptime requirements

Design

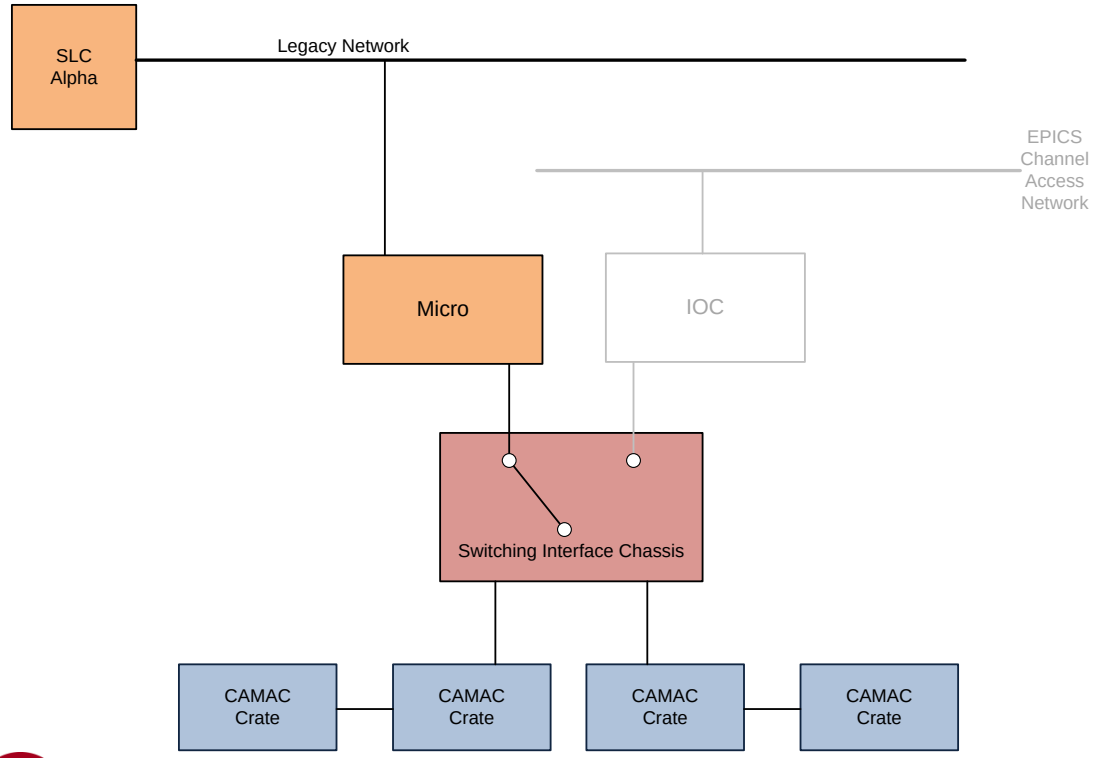
- Serial CAMAC driver board
- CAMAC software drivers
- High-level IOC software
- RTEMS IOCs
  - CAMAC
- Soft IOCs
  - Additional support of RF and timing
- User displays

Implementation

- Switching interface chassis
- Transition
- Automated data transfer
- API
- Quick switching
- Testing

Switching Interface Chassis

- Determines whether CAMAC controlled by micro or IOC
- Remote and local control
- Enables upgrade of individual sectors, facilitates testing



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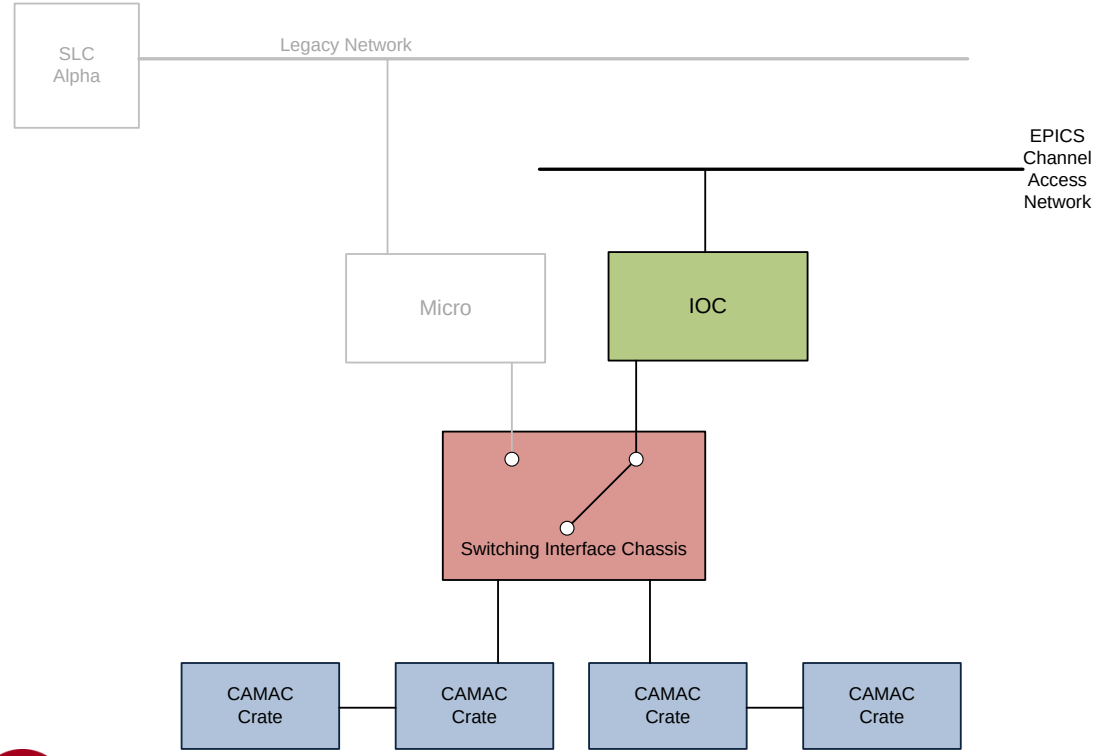

Transition Infrastructure

- Some infrastructure released months before upgrade
  - PV gateway
    - Translates old SLCCAS PV names to future EPICS PV names
    - Allows clients to use new names in advance
  - Data archiving
    - Provides access to months of data in new system
  - User interfaces
    - New and modified displays released to production
    - Original displays remained available as comparison or backup
  - Alarms
    - Automatically disabled depending on whether sector was under EPICS control

Automated Data Transfer

- To reduce errors, used scripts to transfer data
  - Generate EPICS databases from legacy database
  - Copy variables values from legacy to new system during switchover
  - Modify existing user displays
    - Replace SLCCAS PV names with new names

Application Programming Interface

- Before upgrade, many software applications used AIDA
  - These applications did not need to be modified
    - AIDA updated to read and control these variables through EPICS
    - AIDA made aware of which system was controlling each sector
- Applications that used SLCCAS PVs did have to be modified to use the new names

Switchover Tool

- Fully switching between systems requires many steps
- Scripts were written to perform most of these
- Using these, switching takes less than 10 minutes
  - Reconfigure and restart PV gateway
  - Update AIDA directory service
  - Boot IOCs
  - Copy settings over
  - Restart some Channel Access clients
- Available from operator displays

Development Testing

- Initial testing in lab test stand
  - IOC
  - Two CAMAC crates
- Two sectors of Linac available for months of testing
  - RF systems not on
  - Not all software could be tested

Production Testing

- Testing on LCLS Linac
  - During scheduled maintenance periods and physics studies
- To date
  - 25 hours during maintenance periods
  - 60 hours during physics studies
  - All sectors under EPICS during 2 month scheduled downtime
    - Allowed maintenance groups to become more familiar
    - Did not allow extensive testing as most systems were off

Present Status

- Half the sectors under EPICS control
  - Fixing small bugs
  - Finishing up remaining features
- Switch remaining sectors in next month or two
- Design to be used for other Linac areas

Conclusions

- Quick switching between EPICS IOC and legacy micro helpful in multiple ways
  - Allows real-time debugging
  - Reduces downtime if problems require switching back
    - Helps meet goal of minimal interruption to LCLS program