LCLS Control System Status
EPICS Collaboration Meeting
December 8-10, 2004

Outline
- Project Overview
- Control System Goals
- Resources
- Design Slides for Global Systems
- Tools/ Standards to adopt from the community for LCLS
- Next 6 months
- Conclusions
The World’s First Hard X-ray Laser

X-FELs open the Ultra-Small and Ultra-Fast Worlds

Ultra-Small

Nature

Technology

Ultra-Fast

Nature

Technology

Bob Dalesio
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1992: Proposal (Pellegrini), Study Group (Winick)
1996: Design Study Group (M. Cornacchia)
$1.5M/year, 4 years
2000: LCLS - the First Experiments (Shenoy & Stohr) SLAC-611
2001: DOE Critical Decision 0
2002: LCLS Conceptual Design
DOE Critical Decision 1
$36M for Project Engineering Design
2003: DOE Critical Decision 2A
$30M in 2005 for Long Lead Procurements
2004: DOE 20-Year Facilities Roadmap
Critical Decision 2B - Define Project Baseline
2005: Spend $30M Long Lead Acquisitions
2006: Groundbreaking
2007: First Light
2008: Project Completion
Capabilities

Spectral coverage: 0.15-1.5 nm
To 0.5 Å in 3rd harmonic
Peak Brightness: $10^{33}$
Photons/pulse: $10^{12}$
Average Brightness: $3 \times 10^{22}$
Pulse duration: <230 fs
Pulse repetition rate: 120 Hz
Upgrade – more bunches/pulse
LCLS Construction Collaboration
Project Management Responsibilities Delegated to Partner Labs
Linac Coherent Light Source

Project Description

Stanford Linear Accelerator Center
Stanford Synchrotron Radiation Laboratory

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$273M Total Estimated Cost

$315M Total Project Cost

- **FY2005** Long-lead purchases for injector, undulator
- **FY2006** Construction begins
- **FY2007** FEL Commissioning begins
- **September 2008** Construction complete – operations begins

FY2001
FY2002
FY2003
FY2004
FY2005
FY2006
FY2007
FY2008
FY2009

Project Engineering Design
Long-Lead Procurement
Construction
Operation

CD-0
CD-1
CD-2a
CD-2b
CD-3a
CD-3b

CD-4

LCLS - Estimated Cost, Schedule

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Femtochemistry

Nanoscale Dynamics in Condensed matter

Atomic Physics

Plasma and Warm Dense Matter

Structural Studies on Single Particles and Biomolecules

FEL Science/Technology

Program developed by international team of scientists working with accelerator and laser physics communities

“the beginning.... not the end”
LCLS Control System Goals

- Provide a fully integrated control system to support the construction, test, installation, integration, operation and automation of the LCLS Accelerator.
- Standardize all devices and components across all subsystems.
- Identify all data either by pulse id, beam pulse related time stamp, or 500 msec rough time stamp.
- Full integration with the SLC – timing, use of LCLS data in SLC high level applications, and use of SLC data in LCLS.
## Personnel – Resources FY 2005

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<th>Q3</th>
<th>Q4</th>
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</table>

- Continuing Resolution: take care of prototyping 1.75 in other WBS
- Ramp up Over 6 months to full complement
Integration with the SLC Control System

SLC Alpha
All High Level Apps

MPG
micro
Camac I/O
RF reference clock

PNet (Pulse ID / User ID)

SLC Net over Ethernet (Data Transfer)

EPICS WS
Distributed High Level Applications

CA Gateway

Micro I/O
(SLC-aware)

EVG

Micro emulator

CA over Ethernet (EPICS Protocol)

Fast Feedback

Timing

EVG

Micro emulator

I/O

I/OC

EPICS W/S
Distributed Applications

EPICS W/S
Distributed Applications

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Global Communication Buses

SLC
Alpha
Apps

EPICS WS
Distributed
High Level
Applications

Fast Feedback over Ethernet?
SLC-Net over Ethernet

Channel Access

IOC

CPU

E N T

EV
G

EV
R

LLRF

CPU

EV
R

Diag

CPU

EV
R

Pwr
Supply
Ctrl

CPU

Vacuum
Ctrl

MPG

Drive
Laser
Off

Machine Protection

Beam Code + EPICS Time + EPICS Events

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# Environment

- EPICS Release: 3.14.n
- R/T OS: RTEMS
- Workstation OS: LINUX
- EPICS ADE (CVS): Simple??
- Compilers: GNU
- Bug Report / Tracking: Artemis
- Naming Standard: PEP II
- Name Service: Name Server JLAB
- Documentation: Web Area
- Test stations: FFTB

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**December 8-10, 2004**

**EPICS Collaboration Meeting Tokai**

**Bob Dalesio**

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Client Tools

- Display Manager: EDM
- Archiver: Channel Archiver
- Alarm Handler: ALH
- Message Logger: CMLLog
- Electronic Log Book: DESY, Babar, JLAB?
- Stripchart: StripTool
- Web based viewing: SPEAR, A-Beans, JoiMint, AIDA??
- Image Analysis: Matlab format?
- Save / Restore: ?
- RDB: SNS (leaning)
- Gateway: 3.14.6 Gateway
High Level Applications

- Matlab  

- Python  

- High Level Apps
  - SLC  
  - XAL  
  - Matlab based

- Top priorities to move into EPICS
  - Which ones make the SLC-aware IOC easier
  - Which are the most useful
  - Which are the easiest to pick off
**Hardware Direction – Buy/Steal/Make**

<table>
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<tr>
<th>Type</th>
<th>Description</th>
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<tr>
<td>In-House</td>
<td>VME version of the PNET</td>
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<tr>
<td>Commercial</td>
<td>BPM - Echotek and Libera Electronics</td>
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<tr>
<td>Community</td>
<td>Timing System (Diamond/SLS/APS)</td>
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<tr>
<td>Community</td>
<td>Digital Power Supply Controller (SLS)</td>
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<tr>
<td>Commercial</td>
<td>LLRF - Digitizers</td>
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<tr>
<td>Commercial</td>
<td>Machine Protection System in PLC? 8msec</td>
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<tr>
<td>Commercial</td>
<td>Video – evaluate several options (30 Hz)</td>
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<tr>
<td>Commercial</td>
<td>Conventional Facilities through AB PLC</td>
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<tr>
<td>Community</td>
<td>Wire Scanners ??</td>
</tr>
<tr>
<td>Commercial</td>
<td>Fast feedback in shared memory?</td>
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</tbody>
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Next 6 Months

- Complete SLC-aware IOC (30% Complete)
- Complete PNET Prototype (75% Complete)
- Complete BPM Prototype (5% Complete)
- Complete Timing Prototype (5% Complete)
- Complete Power Supply Prototype (30% Complete)
- Complete Video Prototype (10% Complete)
- Design Document for Machine Protection System – determine if there is something that we can evaluate
- Integrate Facility Controls, XRay Transport, Experimental Hall into the control system.
Conclusions

- We hope to base all of our hardware on developments from the community or those commercially available.
- Integration with the existing SLC system is a critical step to allow SLAC operators to use the existing tools while we are adopting and modifying replacements.
- We are using standard EPICS tools for core development and engineering interfaces.
- We are adopting all we can from the community and we will use our resources to extend them as we can.
LCLS Software Tasks – Development

- SLC-aware IOC
- Drivers for all new hardware
- Machine Protection / Mitigation
- Master pattern generator
- Fast Feedback Communication
- High Level Applications
  - Correlation Plots
  - Fast Feedback Loops
  - Emittance reconstruction from wire scans and profile monitors
  - Profile monitor image analysis for slice emittance with the transverse cavity
  - Beam Steering and online orbit modeling
  - Beam Steering “scans” to emittance reconstruction from wire scans and profile monitors
LCLS Software Tasks – Standardize/Acquire

- Data Archiving to support all phases of the project
- Operator Display Tools / Synoptic, Plots, Waveform, Image
- Alarm Management
- Electronic Log
- High Level Application Support: Matlab, XAL, Python
- Control System Configuration Tools
- Relational Database Management in all project aspects
LCLS Software Tasks – Control Programmer

1 RF Control
2 Diagnostics
   2.1 Toroids & Faraday Cups
   2.2 Beam Stops
   2.3 Profile Monitors & Video Devices
   2.4 Wire Scanners
   2.5 Bunch Length Monitors & E/O Diagnostics
   2.6 Beam Position Monitors
   2.7 Collimators
   2.8 All other stops
3 Gun Laser and Drive Control
4 Vacuum
5 Magnet Power Supply Control IOC and software
6 Beam Containment / Personnel Protection / Machine Protection
LCLS Hardware Tasks

1 Global
   - New timing boards – Master Pattern Generator and Event Receiver Boards
   - Machine Protection System
2 RF Control – New LLRF Control
3 Diagnostics
   - 2.1 Toroids & Faraday Cups
   - 2.2 Beam Stops
   - 2.3 Profile Monitors & Video Devices
   - 2.4 Wire Scanners
   - 2.5 Bunch Length Monitors & E/O Diagnostics
   - 2.6 Beam Position Monitors
   - 2.7 Collimators
   - 2.8 All other stops
4 Gun Laser and Drive Control
5 Vacuum Standards
6 Magnet Power Supply Controllers
7 Beam Containment / Personnel Protection