LCLS Beamline Control and Data Acquisition

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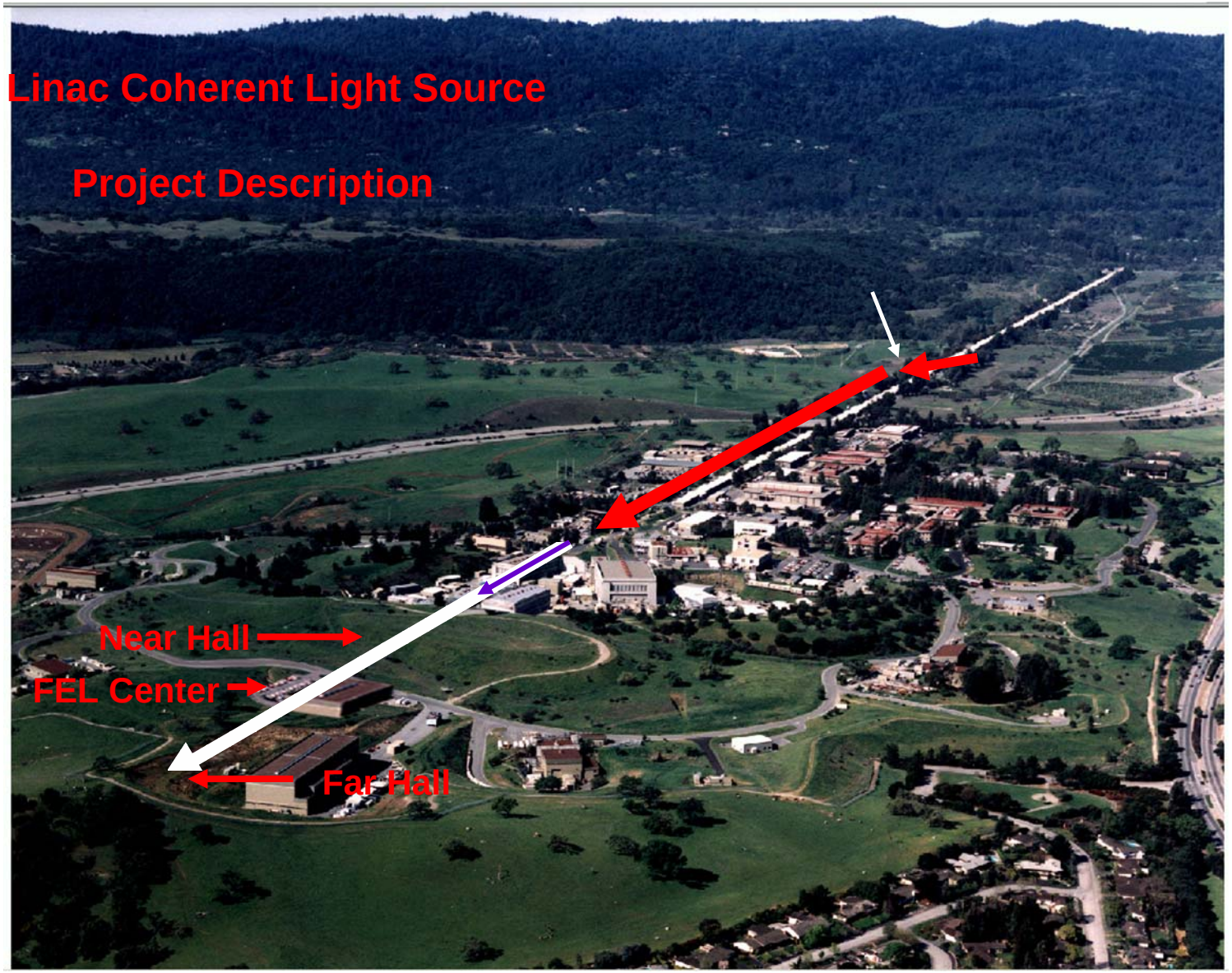
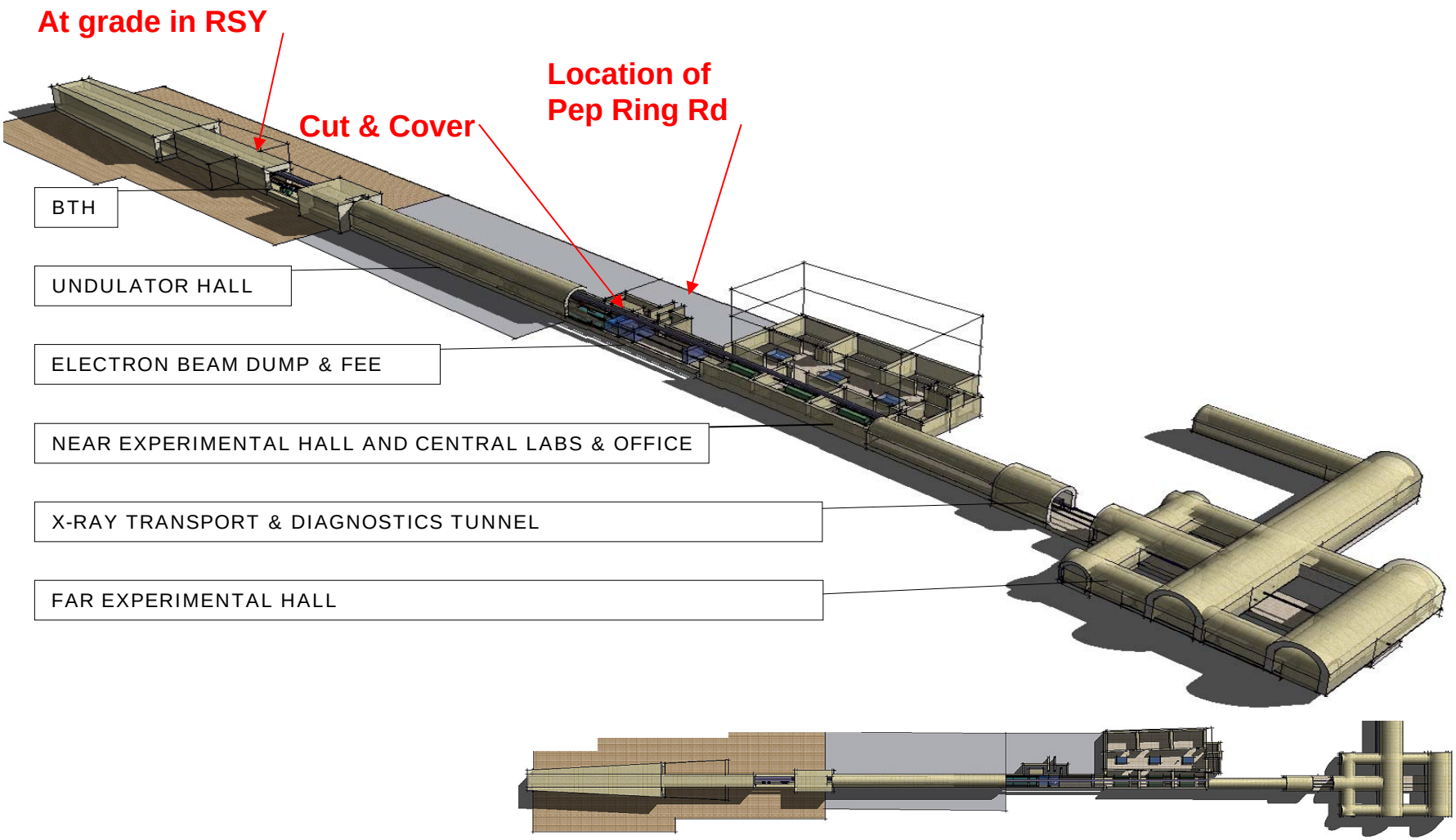
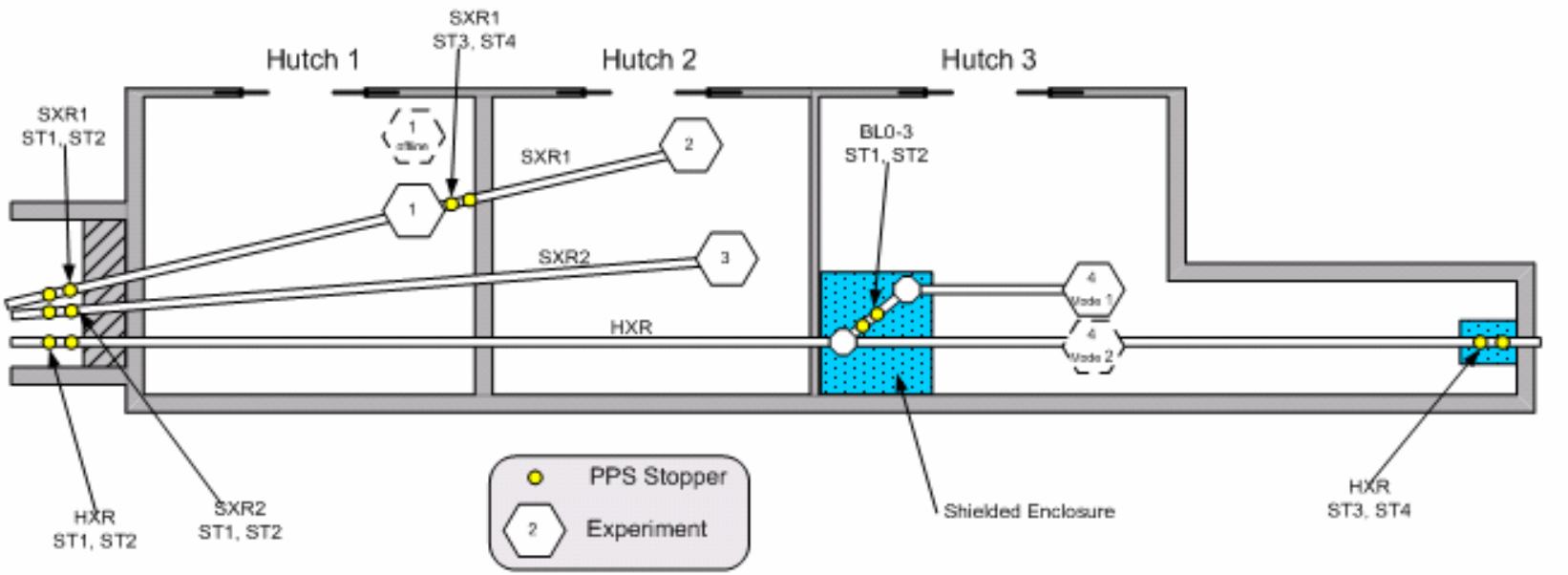

Linac Coherent Light Source
Project Description
Near Hall
FEL Center
Far Hall

LCLS Construction



NEH PPS



Hutch	Access Requirements	
	Requirements Set A	Requirements Set B (if applicable)
Hutch 1	1) SXR1 ST1 and ST2 *IN*	1) EXP 1 *offline* 2) SXR1 ST3 and ST4 *OUT*
Hutch 2	1) SXR2 ST1 and ST2 *IN* 2) SXR1 ST1 and ST2 *IN*	1) SXR2 ST1 and ST2 *IN* 2) SXR1 ST3 and ST4 *IN*
Hutch 3	1) BL0-3 ST1 and ST2 *IN* 2) EXP4 in *Mode 1*	1) HXR ST1 and ST2 *IN*
Hutch 3 Shielded Enclosures	1) HXR ST1 and ST2 *IN*	-na-

Some Considerations

- Beam pulse rate 120 Hz
- Beam length: ~200 fsecs
- Pulse to pulse energy/position variation 10-20%
- Each sample injected into the beam may have a different orientation relative to the beam
- Each pulse destroys the sample

Control System Requirements

- No 120 Hz control in experiment
  - Slow Control to Attenuators
  - Slow Position / Power Supply control
  - Only 120 Hz beam triggers to sample source and detectors
- Send 120 Hz beam related data to Data Acq.
- Save slow beam related data
- Turn off beam before next beam pulse for machine protection (8 msec)
- Disable data acquisition before next beam pulse to reduce the data flow
- Control ~200 motors, 35 power supplies, vacuum
- 120 Hz Diagnostics include paddle steering, 8 GHz 10 bit digitizer, 1 mega-pixel cameras
- 120 Hz diagnostics back to machine for control?

Proposed Control System Elements

- EPICS used for the experiment control
- VME PowerPCs running RTEMS for most control
- cPCI CPU for Acqiris Board (8 GHz, 10 bit)
- Micro Research EVRs for timing (8 nsec resolution, < 20 psec jitter)
- SCRAMNet for low latency data transport (< 1 msec)
- In-house Machine Protection System (< 3 msec)
- Hytec motor controllers for position controls (register based)
- AB Control Logix PLC for vacuum control
- Ethernet power supply control
- SynApps for scans and device control – APS
- Beamline XML display generation – Diamond
- Image analysis – Jlab

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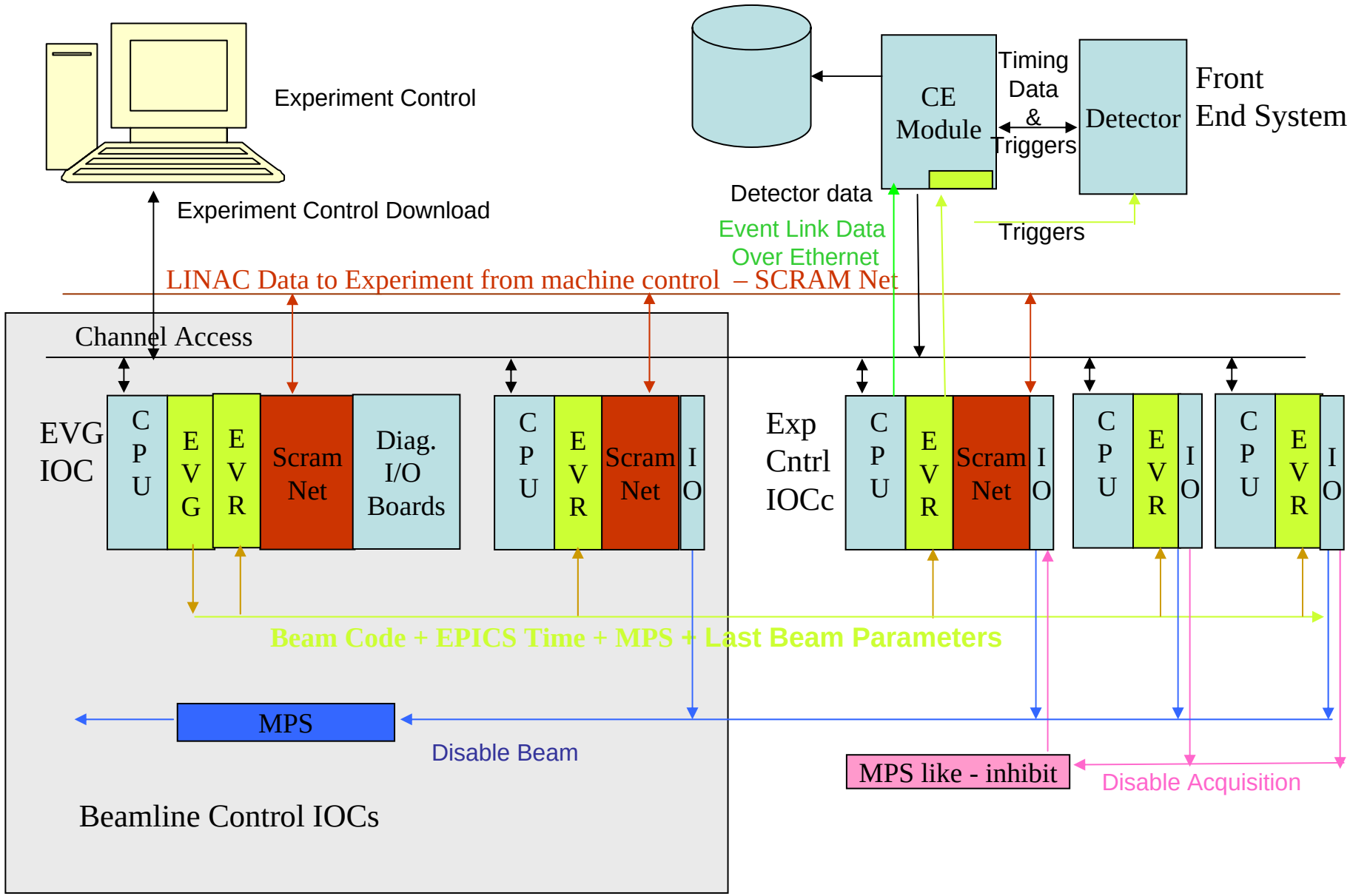

Experiment Control
Experiment Control Download
CE Module
Timing Data & Triggers
Detector
Front End System
Detector data
Event Link Data Over Ethernet
Triggers
LINAC Data to Experiment from machine control – SCRAM Net
Channel Access
EVG IOC
CPU
EVG
EVR
Scram Net
Diag. I/O Boards
CPU
EVR
Scram Net
IO
Exp Cntrl IOCc
CPU
EVR
Scram Net
IO
CPU
EVR
IO
CPU
EVR
IO
Beam Code + EPICS Time + MPS + Last Beam Parameters
MPS
Disable Beam
MPS like - inhibit
Disable Acquisition
Beamline Control IOCs

Data Acquisition Requirements

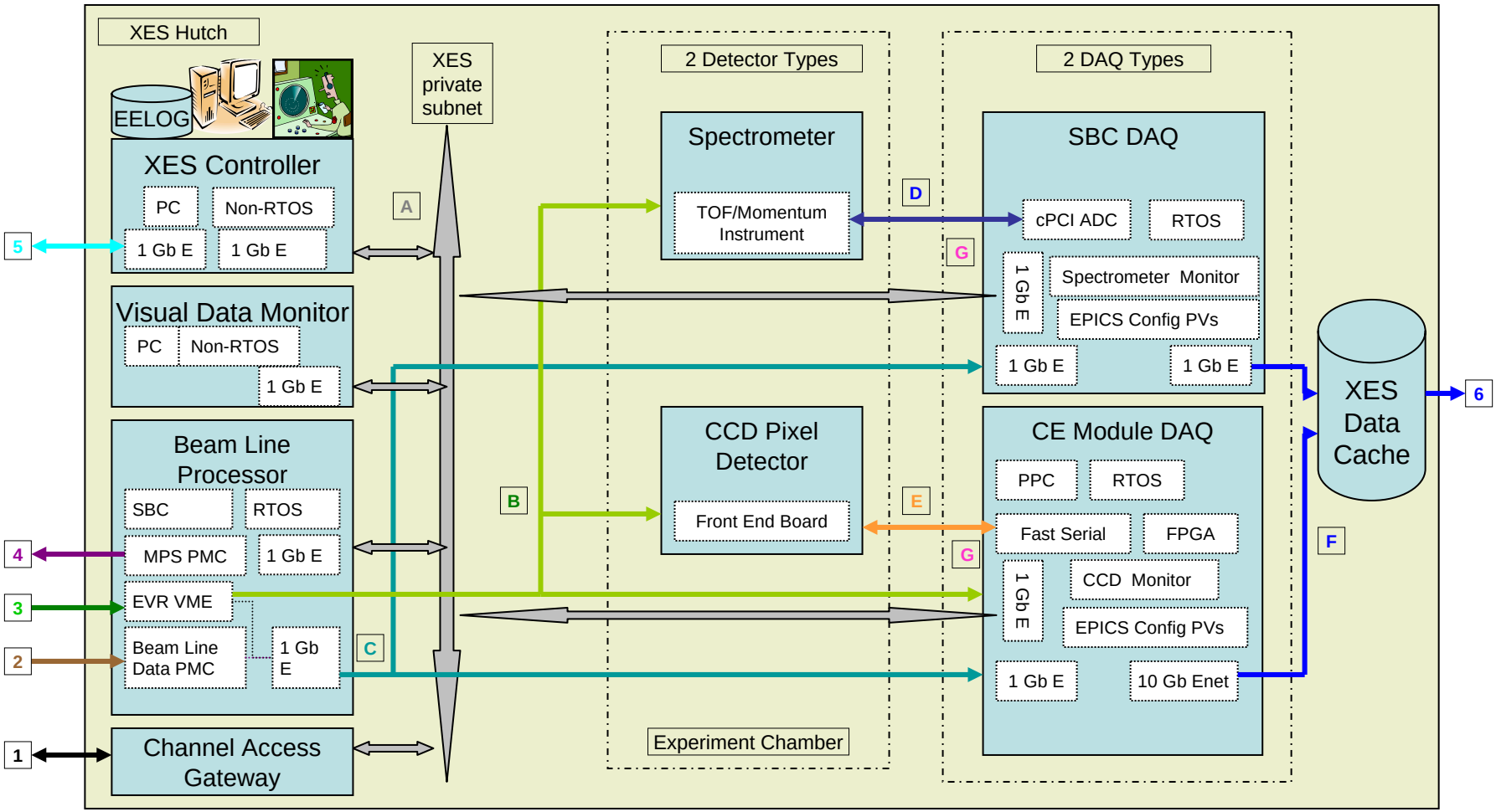
- Save multiple detector data at the beam rate including 1 mega pixel image and vector data
- 1st year: save data @ 10-30 Hz
- 2nd year save data @ 120 Hz --- 250 Mbytes per second (>2 terabytes per day)
- Future: save 10 mega pixel Images @ 120 Hz
- Save Photon (and electron) Beam Related Data with instrument data – max 200 parameters
- All data must be time stamped for event correlation
- Provide Images to operators at 5 Hz
- Support operator configuration of detector configuration / experiment parameters
- Analysis and compression of data at beam rate?
- Use Channel Archiver Data Format for ease of correlation?
- How is meta data formatted for storage with image?
- Hardware:
  - Custom made CCDs
  - Acqiris 8 GHz, 10 bit digitizer
  - 120 Hz commercial cameras?
- Limits of channel archiver / channel access? Is it a viable backup for the first year?

Data Acquisition Elements

- CE Board developed at SLAC for data acquisition
- EPICS running under RTEMS from on-board processor
- Only fast serial and Gbit Ethernet interfaces
- No on-board EVR
- All timing data and beam related data over dedicated Ethernet
- FPGAs available for beam rate analysis

XES Detail – Data Acquisition

1. Channel Access (Ethernet)
2. Beam Line 120 Hz Data
3. EVR (Fiber)
4. MPS (Reflective Memory Fiber)
5. SLAC WAN (Ethernet)
6. DAQ Data to SCCS

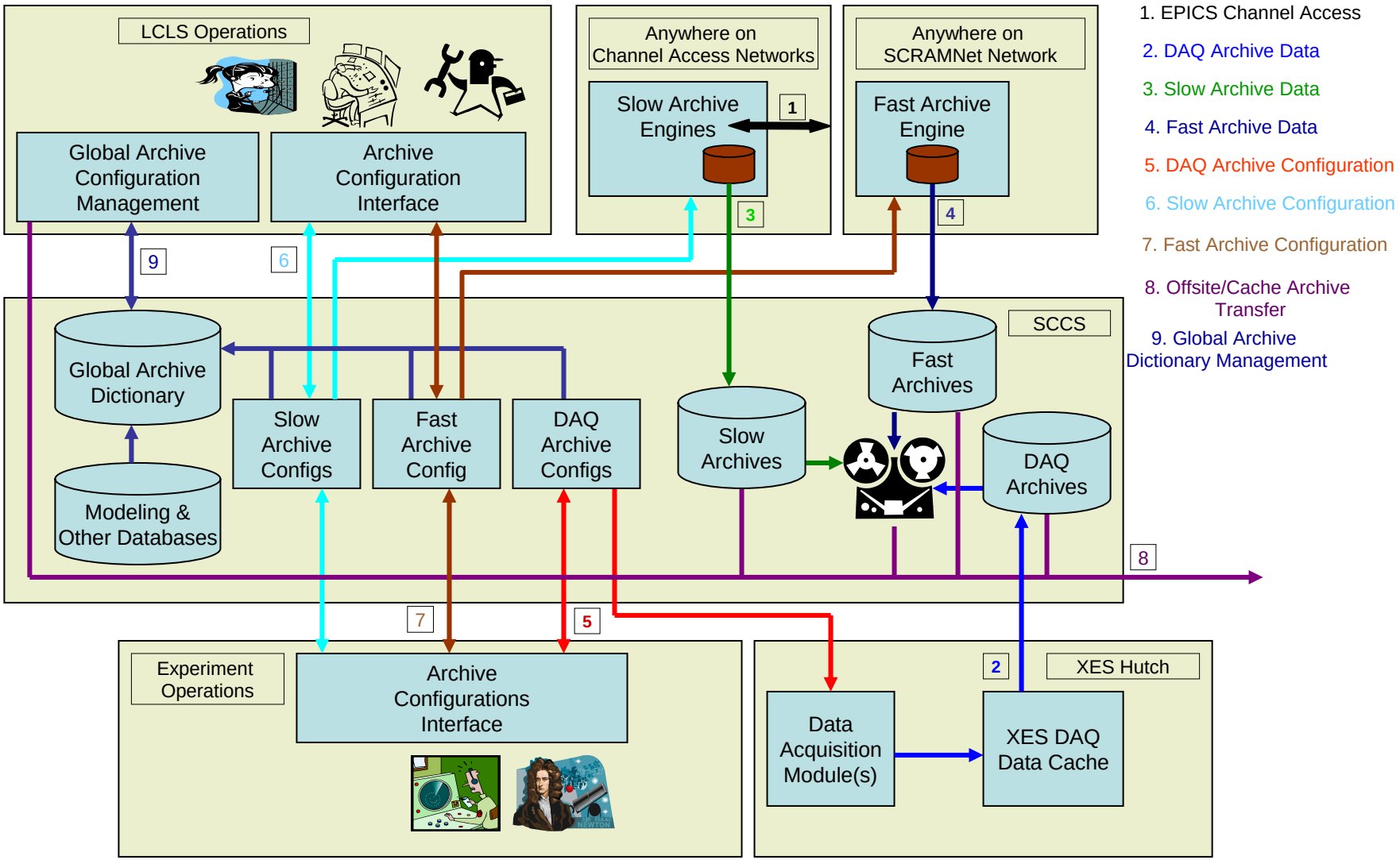


A. EPICS & Local Control (Hutch Subnet)
B. Distributed EVR Hardware Triggers
C. Beam Line & Timestamp Data (dedicated Enet)
D. ADC Control & Digitized Data
E. Detector Control & Digitized Data
F. DAQ Data to Cache
G. Visual Monitor Data

Data Retrieval Requirements

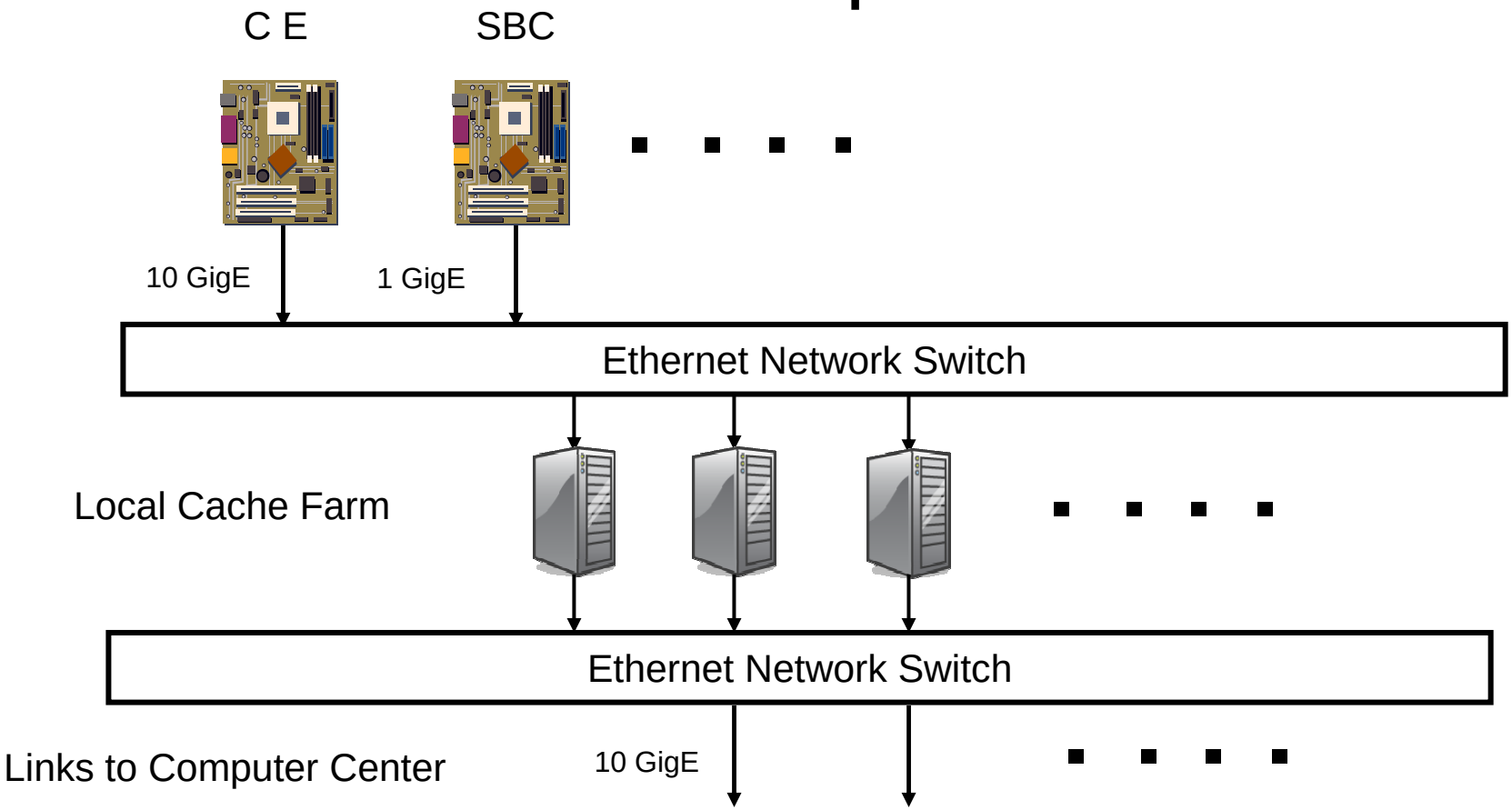
- Web access to data
- Protected access to private data
- Correlate machine diagnostics with experimental data
- Provide analysis tools
- Retain data for some period?
- Retrieval rates?
- Data Rates?

Archive Data Management System Overview

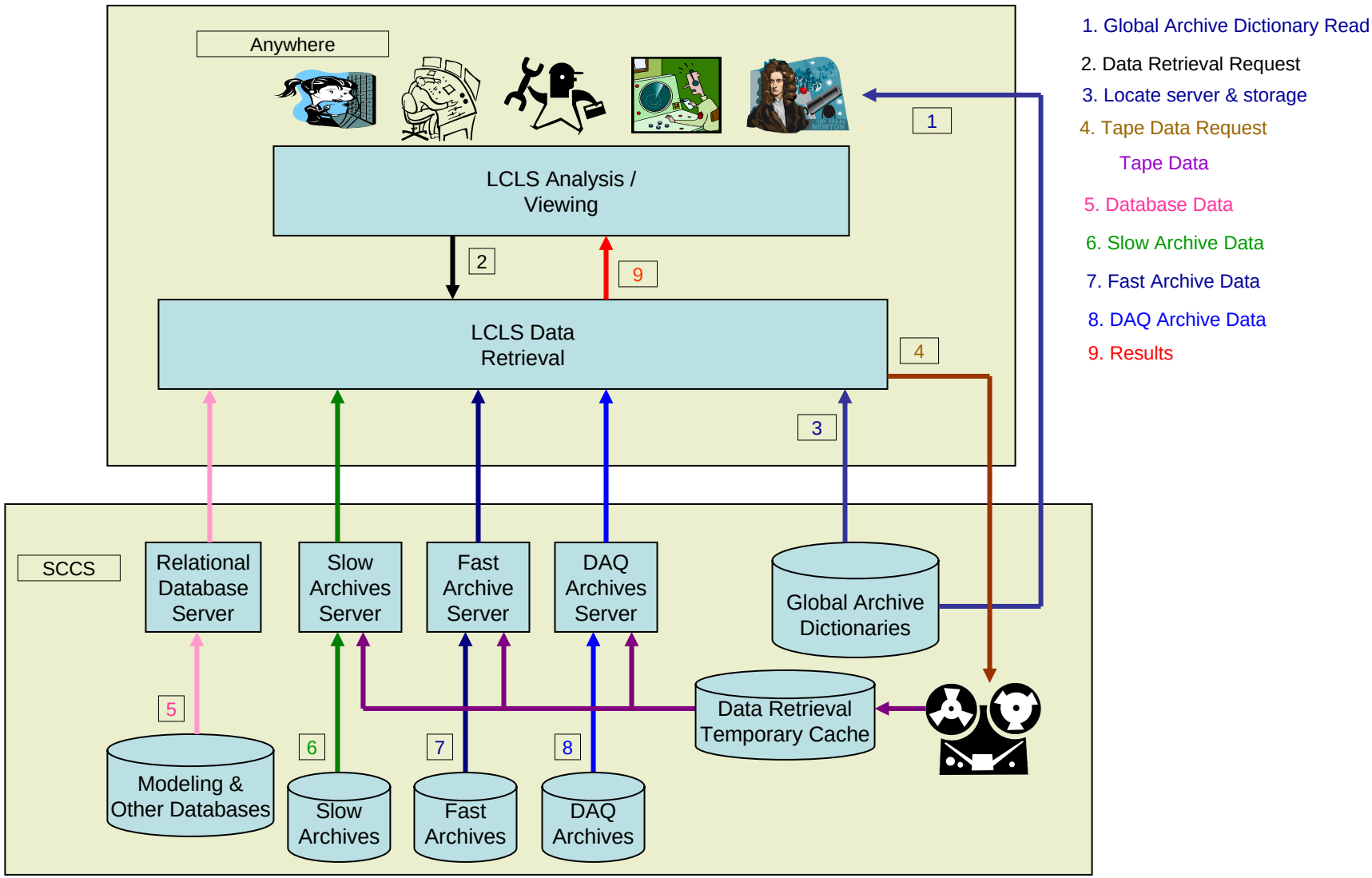


1. EPICS Channel Access
2. DAQ Archive Data
3. Slow Archive Data
4. Fast Archive Data
5. DAQ Archive Configuration
6. Slow Archive Configuration
7. Fast Archive Configuration
8. Offsite/Cache Archive Transfer
9. Global Archive Dictionary Management

Data Volume Makes DAQ Archive More Complicated



Archive Retrieval/Analysis System Overview



Conclusions

- Data acquisition requires real-time data from the experiment (120 Hz) for offline analysis
- Current requirements disable data taking when beam is not coming our way or the experimental beamline is not ready for data
- May use diagnostic data to further reduce the data rate from 250 Mbytes per second
- May need to get experimental data to the accelerator for optimizing the beam control
- There is a very close relationship between machine control and experiment control.
- The better the beam quality – the more data we have to store.
- We have an alarming amount of data to store.