

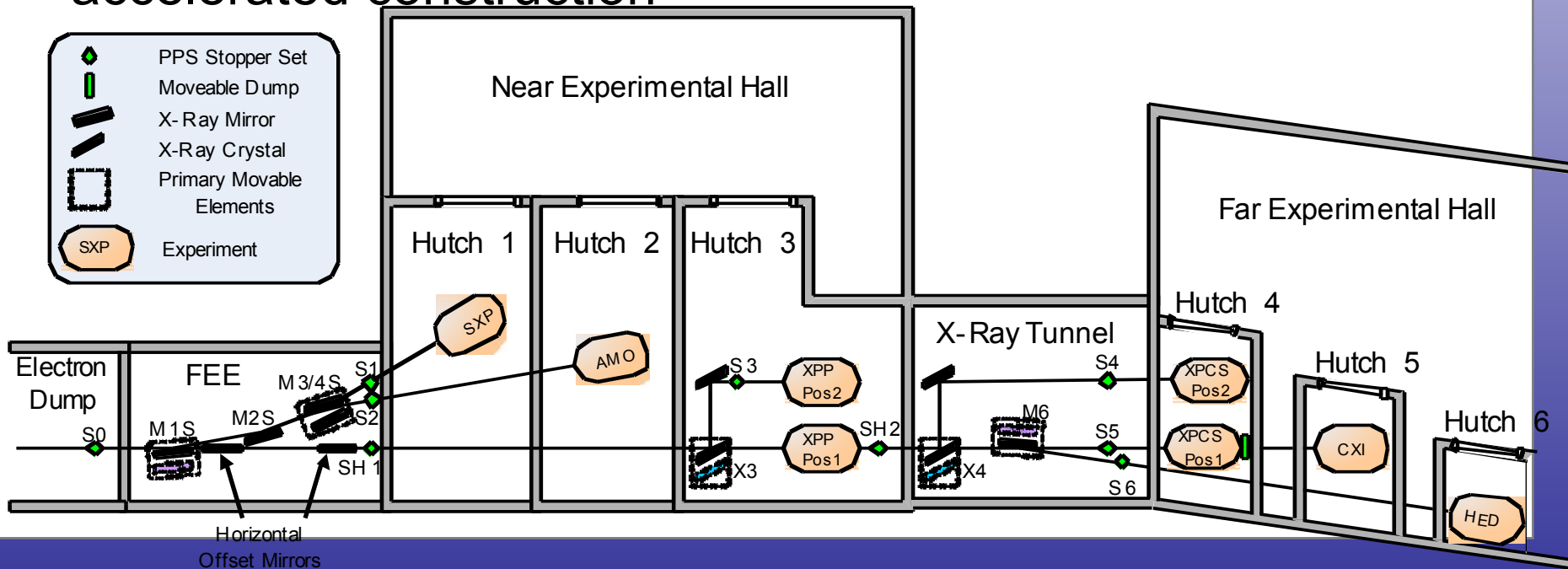
# LCLS Online and Offline Computing

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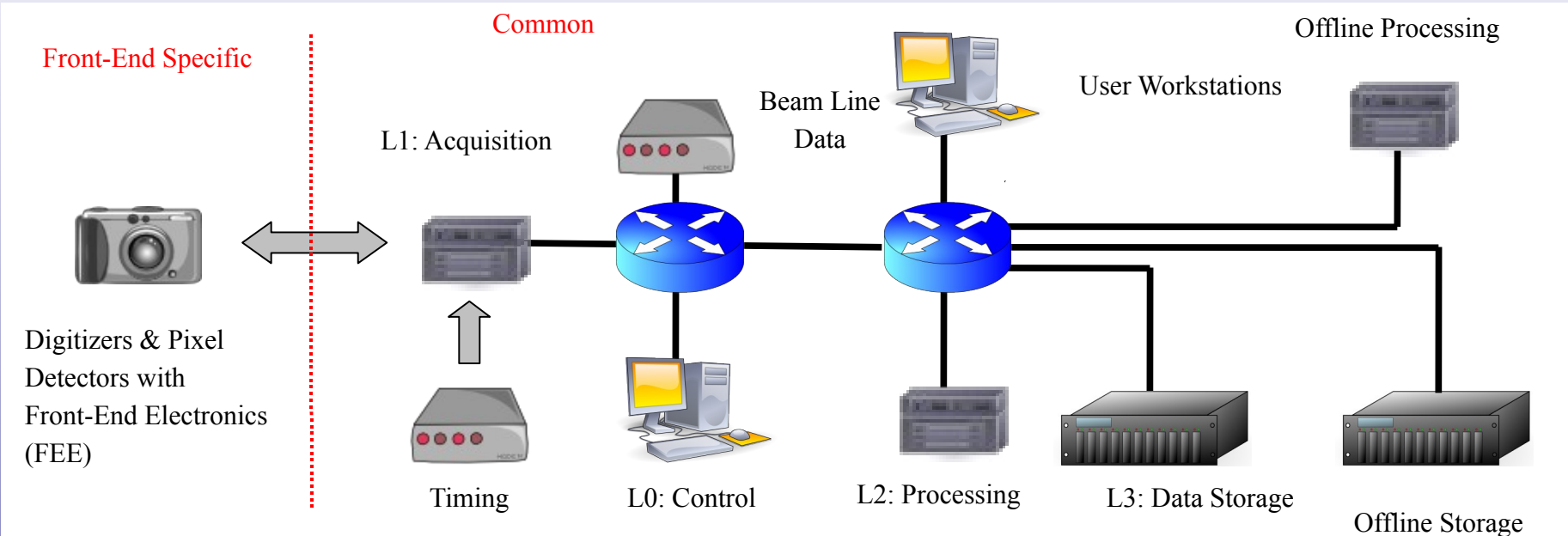


- Linac Coherent Light Source (LCLS) is being built right now
- It had its first LASER light on April 10!
- LCLS Ultrafast Science instrument (LUSI) will build instruments (detectors) for LCLS
- Funding for all 6 hutches has been granted which allows accelerated construction



- **Near-Experimental Hall (NEH):**
  - Atomic, Molecular, and Optical Science (AMOS)
  - LUSI:
    - X-ray Pump Probe (XPP)
    - Soft X-ray Research (SXR)
- **Far-Experimental Hall (FEH):**
  - LUSI:
    - Coherent X-ray Imaging (CXI)
    - X-ray Correlation Spectroscopy (XCS)
    - High-Energy Density Science (HEDS)
- **All experiments are fully funded since January 2008**

- Specifications (some of them only need to be met by 2015)
  - 120 Hz per-pulse data collection
  - < 100 fsec second timing
  - Multi-Gigabit/sec peak rate
  - Multi-Terabyte daily data volume (2011)
  - Hundreds of Terabyte yearly accumulation (2012)
  - Real-time analysis
  - Online and offline data rendering
  - Offline computation (CXI, tbd) (2011-12)



- **Detector**
  - Experiment specific
  - May be bump-bonded to ASIC or integrated with ASIC (Application Specific Integrated Circuit)
- **Front-End Electronics (FEE)**
  - Provide local configuration registers and state machines
  - Provide ADC if ASIC has analog outputs
  - FEE uses FPGA to transmit to DAQ system
- Also have cPCI based 8Gbit/s waveform digitizer front-end acquisition

- Level 0: Control
  - DAQ operator consoles
- Provide different functionalities:
  - Run control
    - Partition management, data-flow
  - Detector control
    - Configuration (modes, biases, thresholds, etc)
  - Run monitoring
    - Data quality
  - Telemetry monitoring
    - Temperatures, currents, voltages, etc
- Manage all L1, L2 and L3 nodes in a given partition (i.e. the set of DAQ nodes used by a specific experiment or test-stand)

- Level 1: Acquisition, first level processing
  - Receive 120 Hz timing signals, send trigger to FEE (Front-End Electronics), acquire FEE data
  - Error detection and recovery of the FEE data
  - Control FEE parameters
  - Calibration & Correction
  - Event-build FEE science data with beam-line data
    - Beam-Line Data is 120-Hz real-time data received from accelerator, femto-second laser timing system, etc.
  - Image processing
    - Partial data reduction
    - Rejection using 120 Hz beam-line data
    - Processing both in software and firmware (VHDL)
  - Send collected data to Level 2 nodes over 10 Gb/s Ethernet

- Level 2: Processing
  - Vetoing, sorting, classification of images
  - Curvature correction
  - Histogramming
  - Feature extractions
  - Curve fitting
  - Lossless compression
  - Correlations
  - Statistical parameters (single shot and averaged)
  - High level data processing
  - Run monitoring
    - Data quality
    - Data analysis and visualization
    - Real-time feedback to experimenter
  - Error detection and recovery

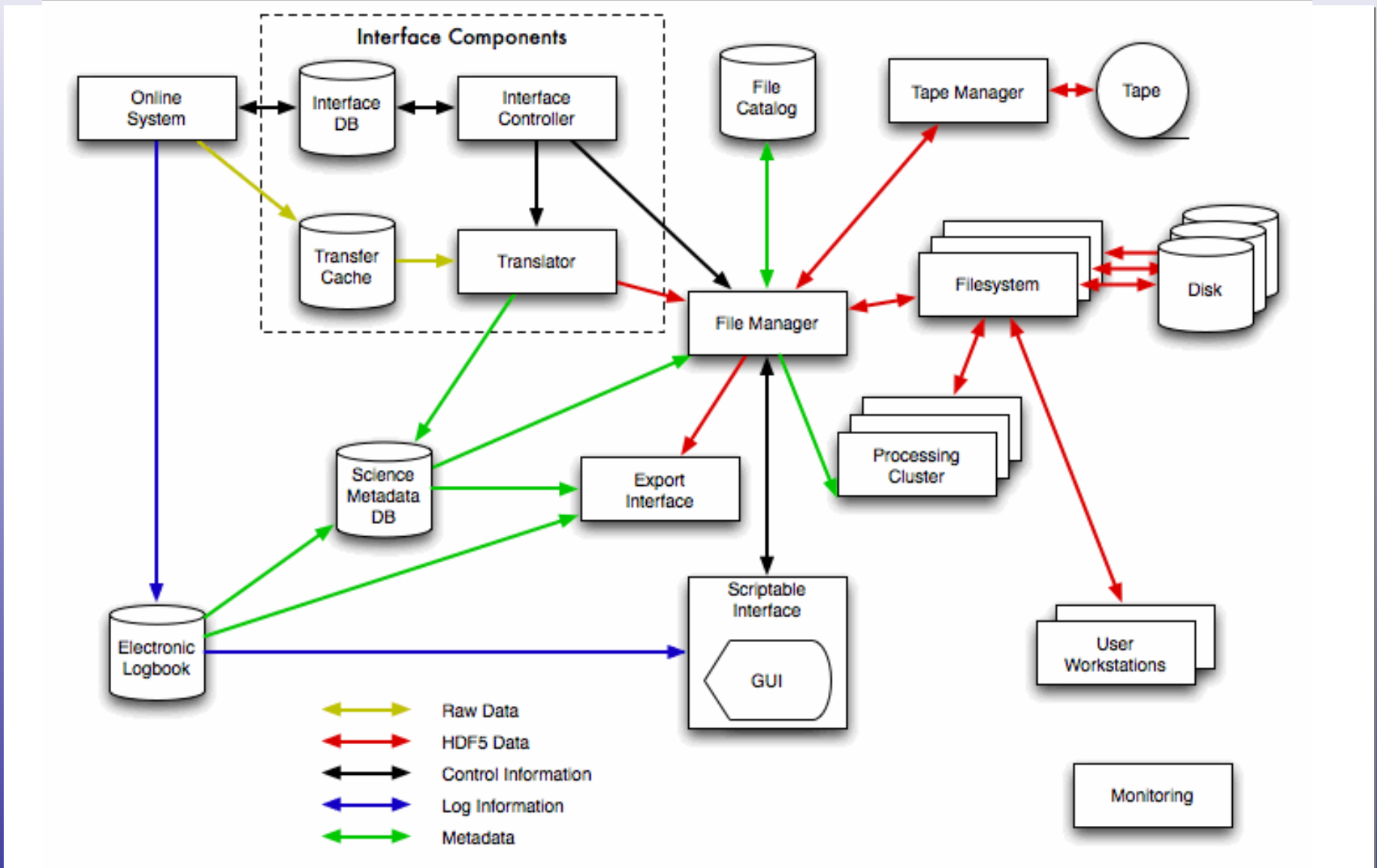


### ■ Real-Time Display

- Raw Data
- Meta Data
- Processed Data
- Radial Average
- Autocorrelation
- Peak Information
- Estimated Data Completeness

- Level 3: Short/Medium Term Data Storage
  - Provide data storage
    - Located in server room in experimental hall
  - Off-line system will transfer data from local storage to tape staging system
    - Tape staging system located in SLAC central computing facilities

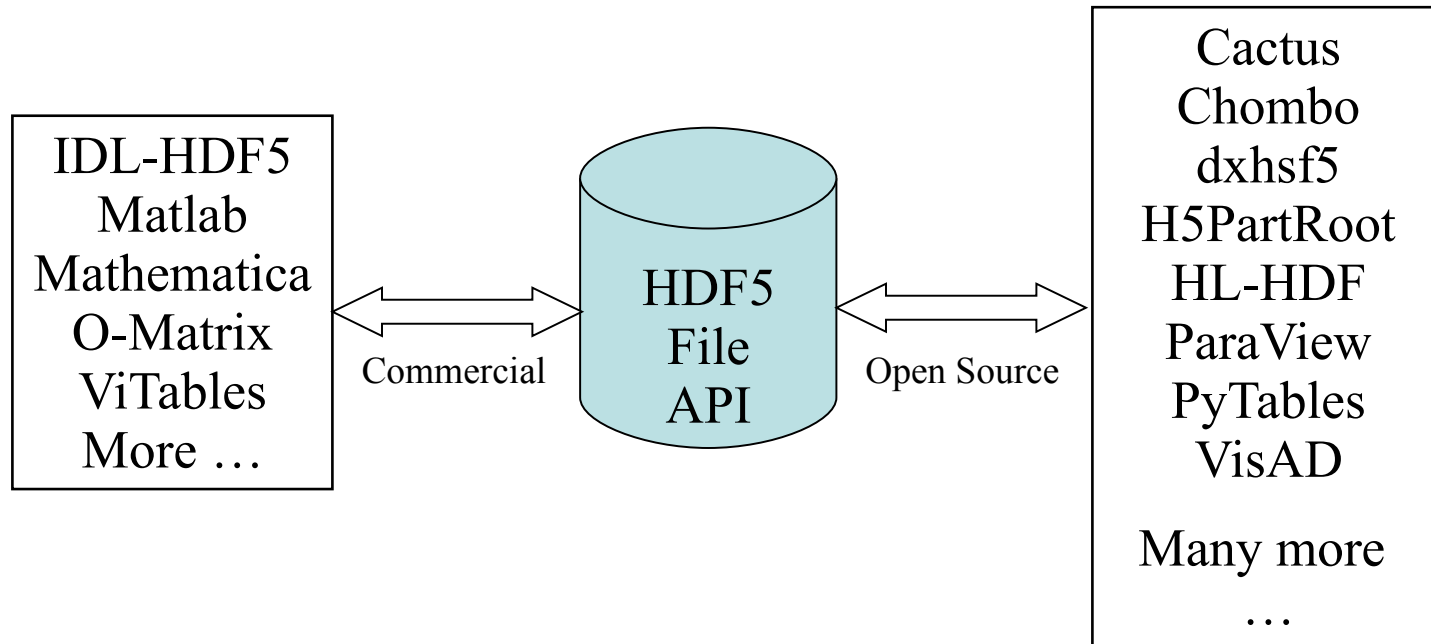
- Translate data into a form for long-term scientific access
  - Translate to HDF5 format
  - Store data attributes in a database (science metadata)
- Store translated data and archive to tape
- Provide access for scientists to stored and archived data
  - Access by attributes (science metadata)
  - Manage data ownership and access restrictions
  - Data access for:
    - Processing clusters
    - User workstations
    - Offsite export (network and other means)
- Manage derived data products



Use existing tools, libraries and SLAC infrastructure where possible, e.g.:

- Data Format
  - HDF5 chosen because of support, wide availability of language bindings
- File Manager
  - iRODS (next-generation of SDSC SRB)
- Tape Manager
  - Interface iRODS to SLAC HPSS and mass storage system (SL8500)
- High performance file systems
  - Lustre
- Databases
  - MySQL
- Monitoring
  - Ganglia
- Data transfer
  - Bbcp and other tools already in use at SLAC for the BaBar experiment

Can use HDF5 Tools and Analysis Packages



## Initial design

- 100MByte/s ingest rate
- Similar to BaBar system
- Comparable retrieval rate
- Small number of users initially accessing the data

## Scalability

- Storage capacity scalable to petabytes
  - Disk + backend tape
- Performance scalability
  - Build-out as necessary

## Status

- Design completed and reviewed
- In the process of being implemented; Prototype mostly done
- Data challenge in June (one month later than planned)

- Simulations
  - Generate diffractive images
  - Beam-sample interaction under different experimental conditions
  - Apply detector and electronics simulation
  - Instrumental will be the ability to superimpose realistic noise levels from machine and electronics
  - Need to interface with detector scientists
  
- Apply processing algorithm from online/offline chain
  - Need to interface with online and offline groups



- Processing resources required for CXI
  - First need to determine algorithm details
  - Then estimate offline resources required
    - Add e.g blades, another option to run sections of algorithms (e.g. FFT's) on SLAC ATCA RCE Modules (> 400 DSP equivalent on each module)
  - Issue only for CXI experiment in Far Experimental Hall
    - Offline processing for experiments in other hutches not a driver and is being implemented
  - CXI analysis facility at SLAC?