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LCLS Data Systems

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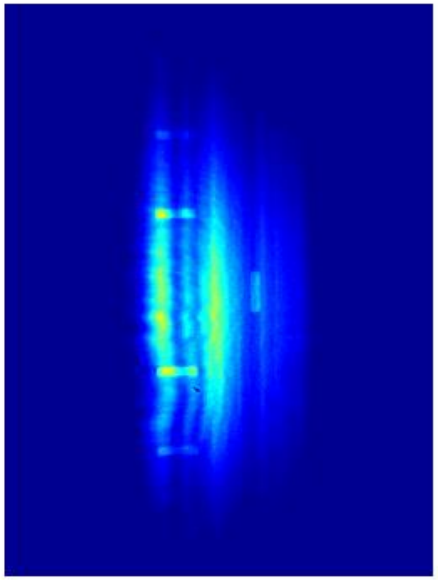
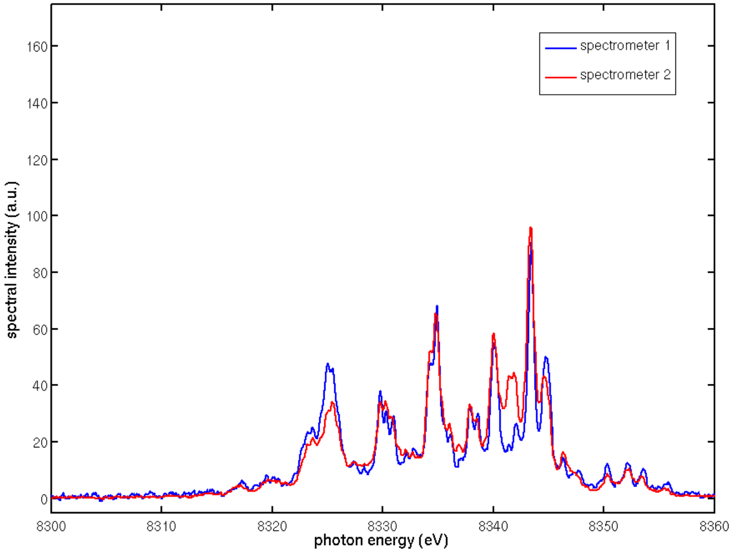
LCLS Source Fluctuations (movie)

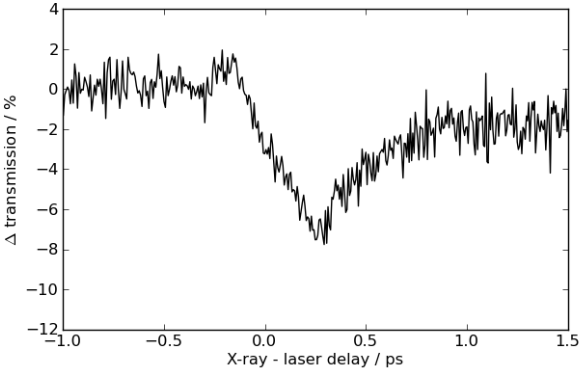
Spatial

Spectral

Temporal



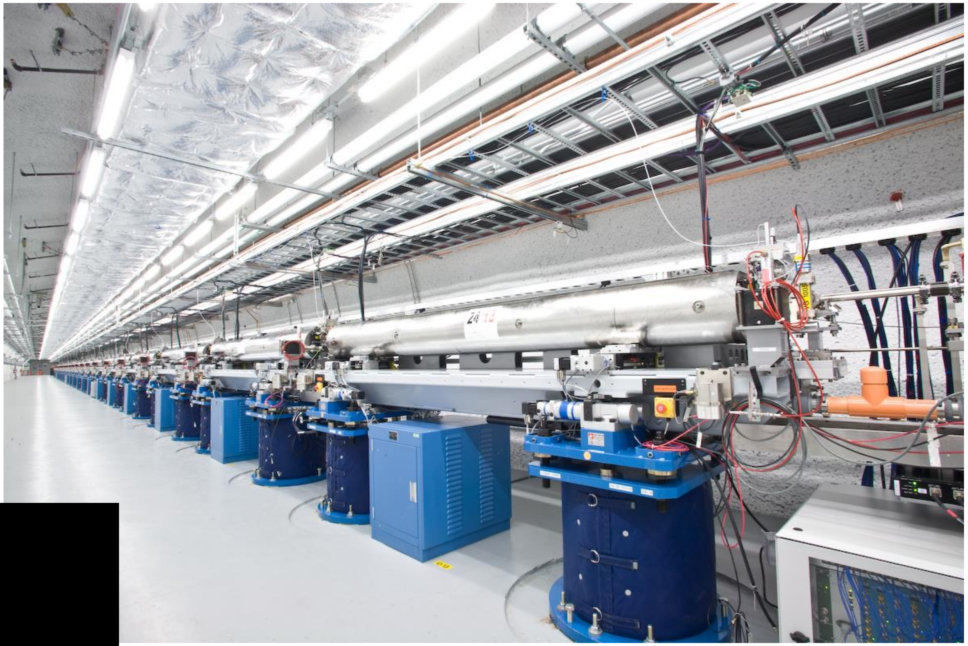


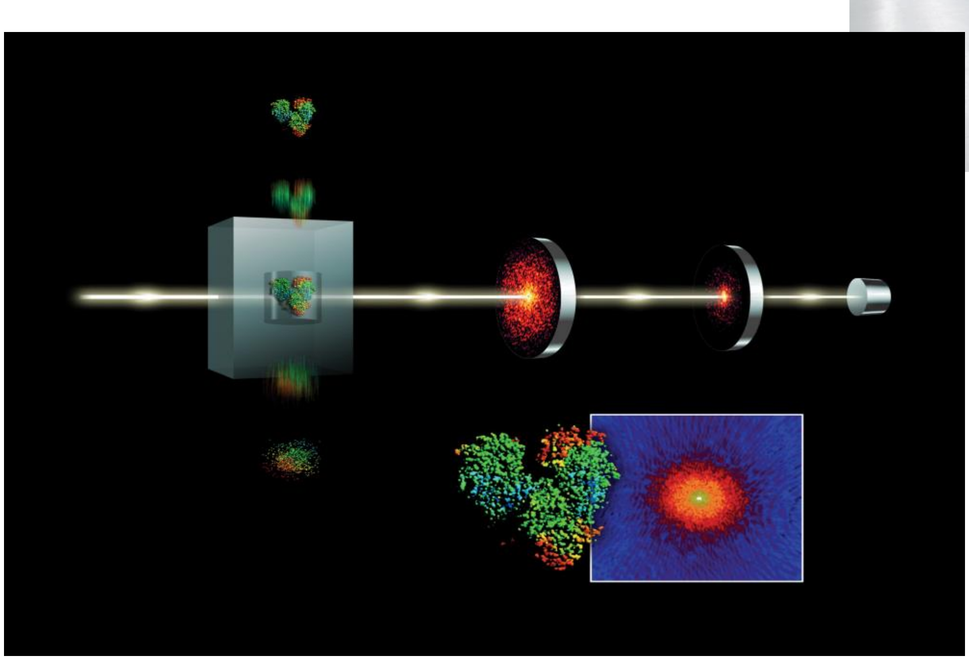


Per pulse readout of detectors and diagnostics is crucial

LCLS Parameters

X-Ray range	**250 to 11,300 eV**
Pulse length	**< 5 - 500 fs**
Pulse energy	**~ 4 mJ**
Repetition Rate	**120 Hz**

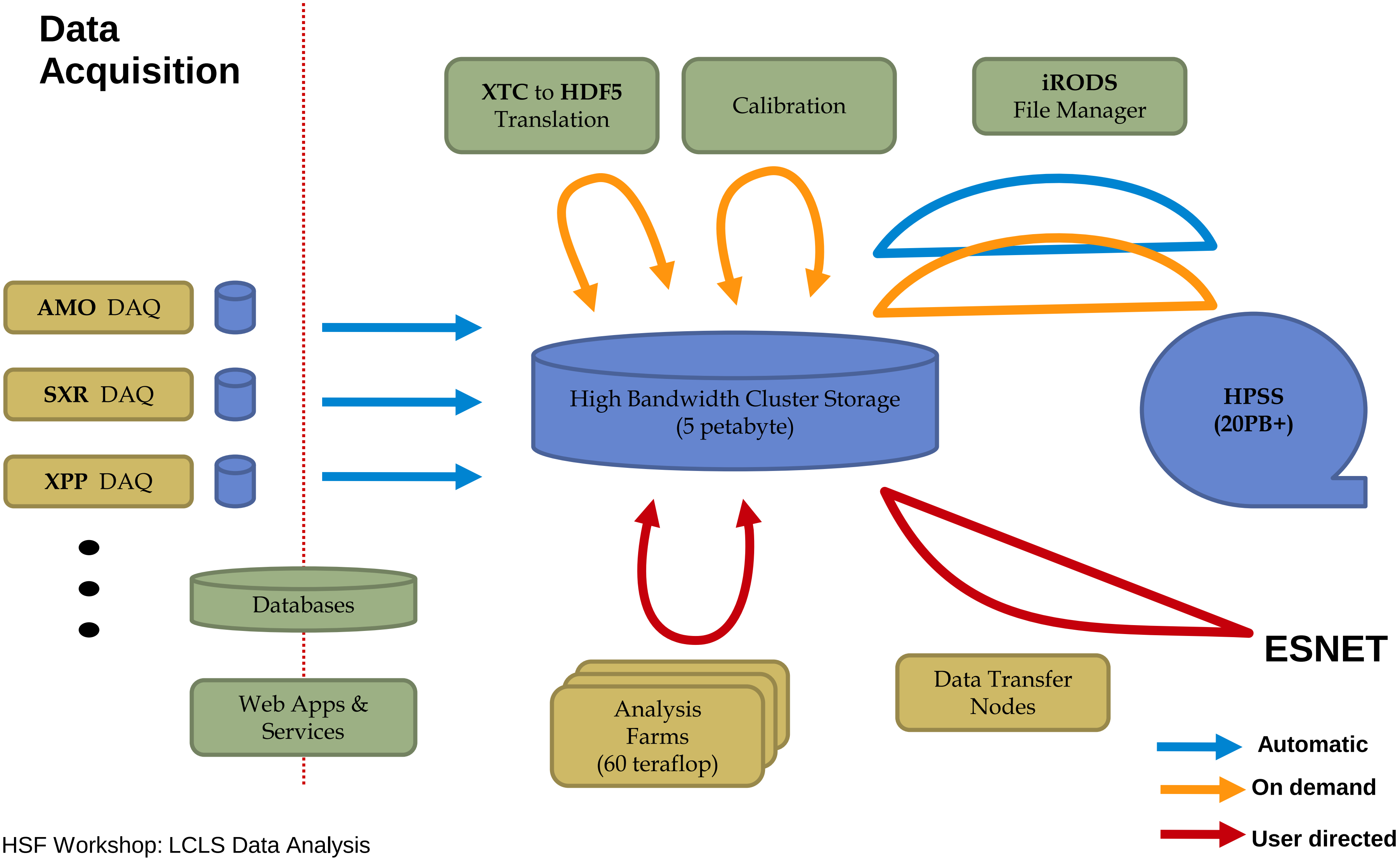




LCLS Data Infrastructure

- **DAQ systems dedicated per hutch, user analysis system shared across instruments**
- **Four storage layers**
  - Online cache (flash), fast-feedback (disk), medium term (disk), long term (tape)
  - Medium-term storage currently 5 petabytes
    - Each PB aggregated throughput of 12GB/sec
  - Long-term storage uses tape staging system in the SLAC central computing facilities
    - Can scale up to several petabytes
- **Science data files policies:**
  - Kept on disk for 2 years (quota enabled after 6 months), on tape for 10 years
  - Access to the data for each experiment granted only to members of that experiment
- **60 teraflop processing farm**

Data Systems Architecture



LCLS Data Management Framework

- **Data Management system handles all content-opaque operations**
  - Moves data across storage layers (online cache, fast-feedback, offline storage, tape)
  - Handles data policies (security, access, retention)
  - Handles DAQ generated data or data resulted from centralized processing (eg HDF5 translation, compression, filtering)
  - File catalog and tape operations are based on iRODS
  - File migration implemented as a collection of distributed services written primarily in Python
  - Using LSF for processing HDF5 translation services and other operations
- **Currently handling 11PB LCLS data, raw and user generated**
  - 5PB on disk, 6PB on tape
- **User accessible through LCLS web-portal (electronic logbook)**
  - Web front-end based on HTML5, CSS3, JavaScript, and a bunch of modern JavaScript tolkits/libraries
  - Server-side backend: RESTful Web services, mostly PHP and relevant libraries, Pylons (Python-based Web framework for some Web services), MySQL, LDAP and Apache

LCLS User Data Analysis

- **Main data analysis framework is `psana`**
  - Event-driven batch framework to parse the raw data
  - Allows mixing of python and C++ modules
  - Powerful, but, until recently, not widely adopted, threshold too high for many users
    - Many groups used `myana` (simple C++ program developed by DAQ group to parse the raw data), `Matlab`, `ami` (this is the the same framework used for on-the-fly data monitoring but run against data on disk), `cass` (originally developed for CAMP detector) and `cheetah` (CFEL)
- **Beside parsing the data, currently providing basic capabilities:**
  - Calibration modules
  - Modules for time-correlation analysis
  - Data browser
  - Peak finding algorithms
- **We are currently looking at two main projects in the data analysis arena:**
  - Develop advanced algorithms for LCLS users
  - Build an ecosystem for data analysis at FEL facilities

LCLS User Data Analysis (continued)

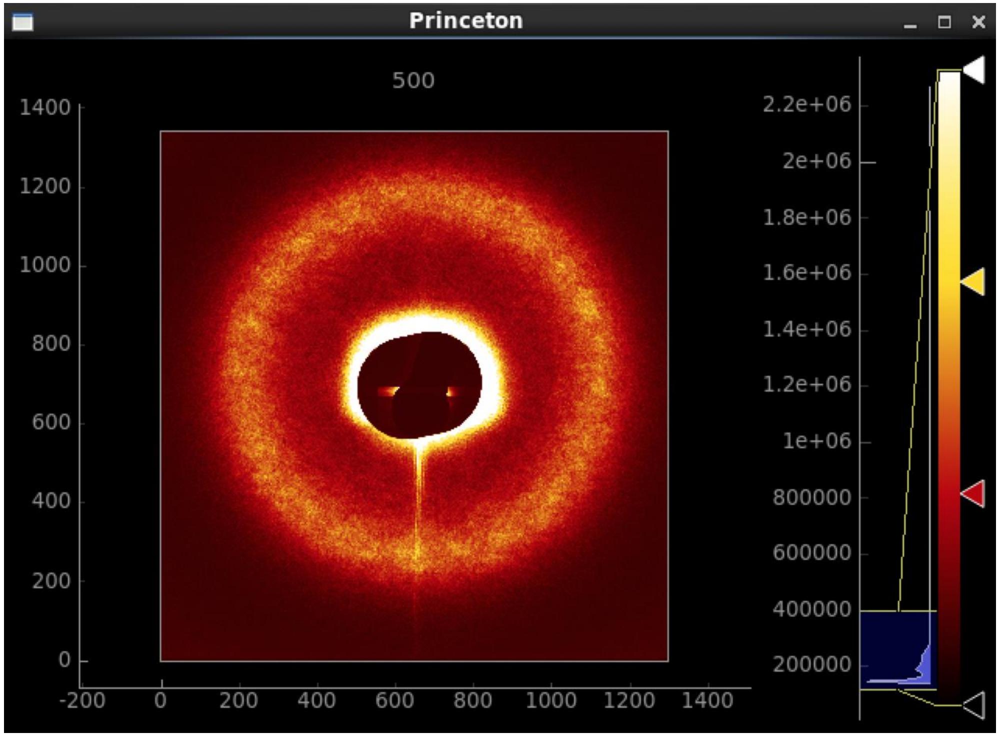
Developed python based interactive framework `ipsana` to complement the psana batch framework

Adoption of `psana` significantly increased after `ipsana` was introduced:

- Can write analysis code with simple python scripts
- All documentation on one page:

`https://confluence.slac.stanford.edu/display/PSDM/psana+-+Python+Script+Analysis+Manual`

- Can run the same simple scripts offline and online (with real-time plotting)
- Can analyze a run (online and offline) in parallel on hundreds of cores using MPI
- Many experiments have used this to analyze all 120Hz, online in real-time



Lesson Learned 1 or Why Vetoing Events for FEL Experiments Can Be Tricky

- **Very hard to implement effective trigger/veto system**
  - Not a technical/computing issue: the ability to veto events is already implemented in the system
  - Vetoing based on beam parameters not effective (most pulses are good)
  - Hard to get help from users in setting veto parameters which define event quality
    - Users themselves often don't know what these parameters or their thresholds should be
    - Users are usually very suspicious of anything which can filter data on-the-fly
- **Benefit of vetoing events based on the event data potentially very large for those experiments with low hit rate**
  - factor 10-100

Lesson Learned 2 or Why HEP Style Online-Offline is Not Enough

- **HEP style online/offline separation doesn't work**
  - The core online monitoring is not enough for many experiments
  - The skill level required to write on-the-fly analysis code is too high for most users
  - As a consequence some experiments felt they were flying blind
- **Critical to provide users the ability to run offline style code for fast feedback**
  - This was an issue for:
    - High data volume combined with low hit rate experiments: offline designed to keep up with DAQ only in average, not instantaneously; fast feedback nodes which look at subset of the data don't provide enough statistics
    - HDF5 based experiments: must wait for additional translation step