Large-bandwidth Data-acquisition Network for XFEL Facility, SACLA

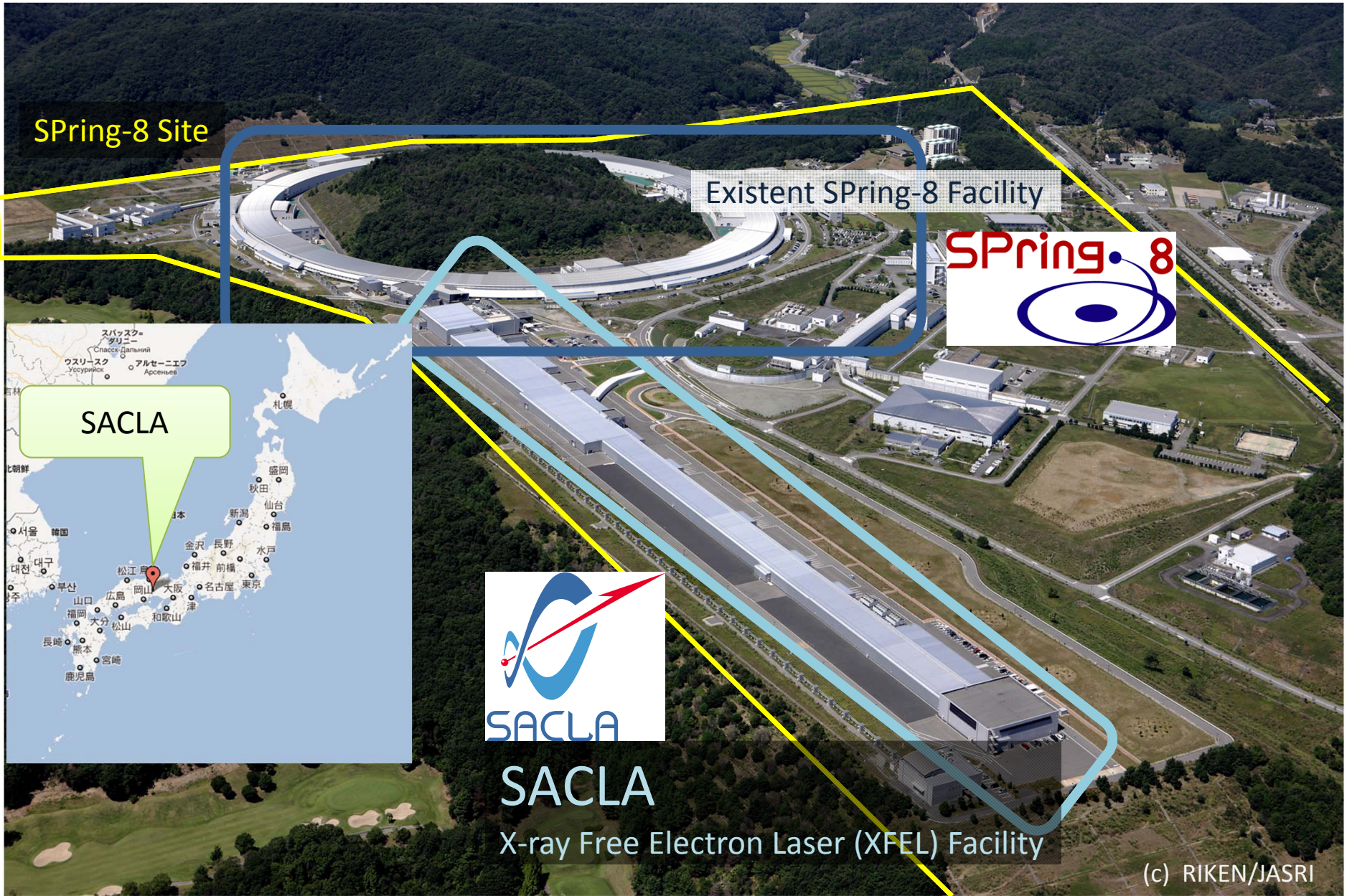
T. Sugimoto, Y. Joti, T. Ohata, R. Tanaka,
M. Yamaga (JASRI/SPring-8, Japan)
T. Hatsui (RIKEN/SPring-8, Japan)

13th International Conference on Accelerator and Large Expereimental Physics Control Systems (ICALEPCS2011), WTC Grenoble, France, 12 October 2011.

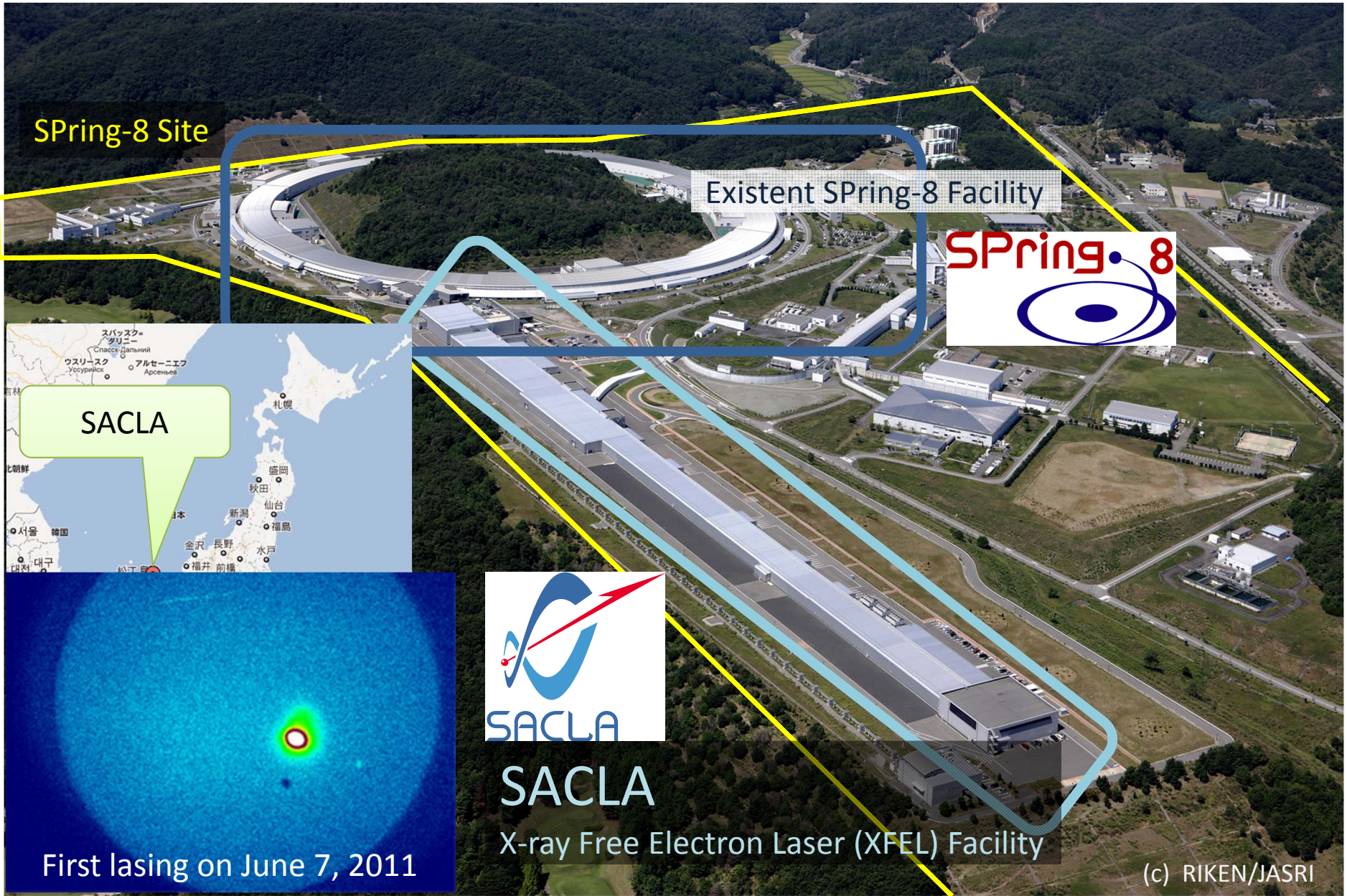
Contents

- SACLA and its Scientific Applications
- Experimental Requirements
- SACLA DAQ Network
- Data Analysis Plan
- Summary

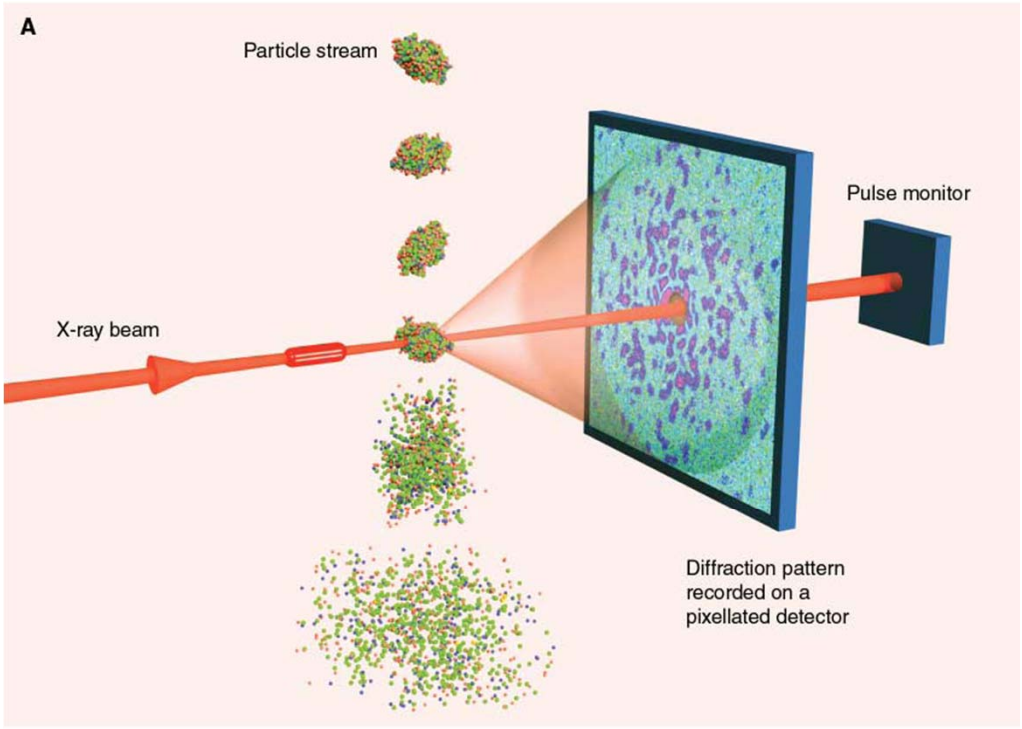
Overview of SACLA

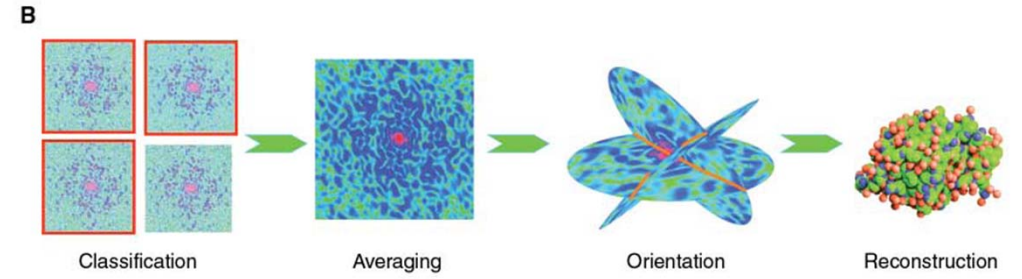


Overview of SACLA



Scientific Application of the SACLA: (1) 3-D coherent diffraction imaging





K. J. Gaffney and H. N. Chapman, Science 316, 1444 (2007)

Original algorithm for classification and determining orientation have been developed.

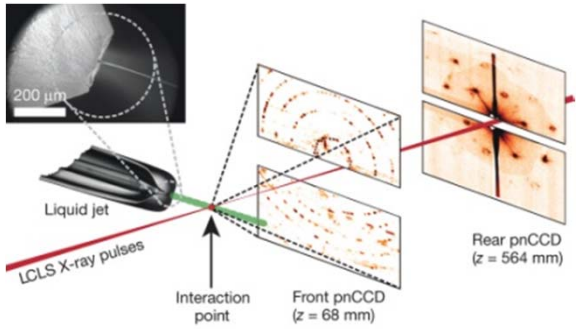
The developed algorithm enables to detect signal for classification in the noisy experimental data as low as 1/20 photons per an effective pixel.

Molecular length: 300Å
Incident Intensity: 2.6×10^{20} photons/pulse/mm^2
wavelength: 1 Å
Nessary number
of 2D patterns : > 10^6

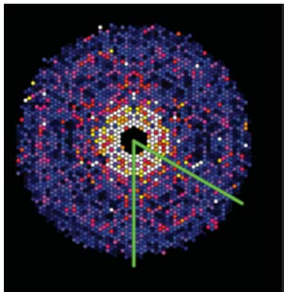
Experimental user want to take > 10^6 shots data.

Scientific Application of the SACLA: (2) Protein nano-crystalography

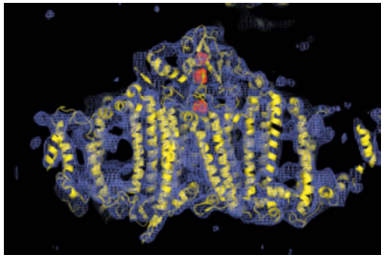
Femtosecond nanocrystallography HN Chapman *et al. Nature* **470**, 73-77 (2011)



Hit ratio:20%, 3x10^6 shots



Diffraction pattern after annotation and averaging



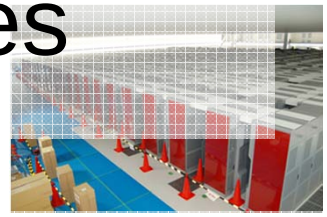
0.8nm resolution structure of photosystem I

Experimental user want to take > 3x10^6 shots data.

We provide large-bandwidth DAQ system using Ethernet.

To analyze such huge data, huge computing power is necessary.
Thus, we also provide large-bandwidth network between storage and supercomputer.

SACLA Control Network Zones



Off-site Supercomputer
"K computer"

Internet

VPN

Office-LAN

Firewall

PC-Cluster-LAN
(10G)

Open Network

Closed Network

High-speed Storage

DAQ Network

DAQ-USER-LAN

Firewall

DAQ-LAN (1G)

DAQ-LAN (10G)

Data file server

MPCCD

CNTL-LAN

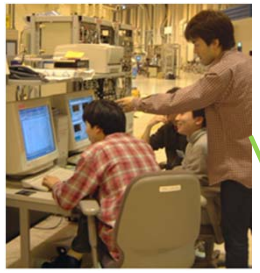
Acceleator DBs

Experimental Requirements

- A lot of images (typically ~10x10^6 shots) are necessary to reconstruct 3-D image.
- 2-D detector has ~ 2000x2000 pixels with 16 bit data per pixel.
  - We use 8+4 MPCCD (512x1024) sensors
    - Data rate of single MPCCD is 480Mbps with 60Hz cycle.
      → Total throughput is 5.8Gbps (with 12 sensors max. setup)
    - Single MPCCD sensor outputs 1 MBytes/frame.
      → 8 MBytes/shot (with 8 sensors min. setup)

- DAQ system requires
  - To guarantee the data rate at 5.8 Gbps
  - To store 80 TBytes data

SACLA DAQ System



Control

User instruments

Max. 5.8Gbps data rate

10Gbit Ethernet

1Gbit Ethernet

Data file server

(8+4) x 0.5 Gbps (CameraLink)

VME CPU board

12 x 0.5 Gbps 1Gbit Ethernet

FibreChannel

MPCCD

PrPMC

FPGA Lossless compression

High-Speed Storage

512x1024 pixels
16bit data depth
8+4 sensors
60Hz

Front-end system:
VME Camera Link Board

100TBytes
4.8Gbytes/s (38Gbps)

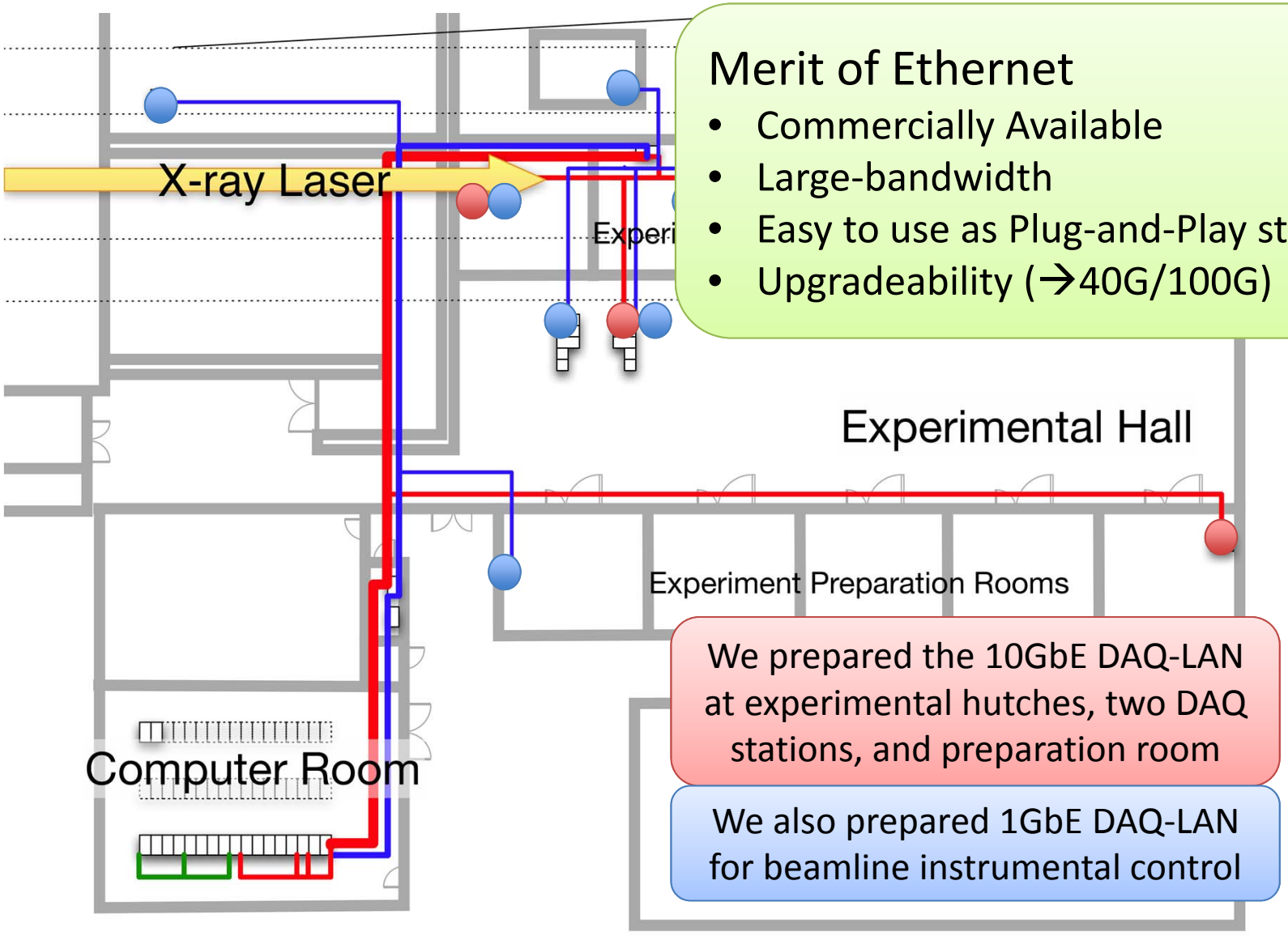
The DAQ System requires…

- Bandwidth (> 5.8Gbps)
  - We prepared dedicated data-transfer 10GbE line.
  - We also prepared 1GbE low-latency instrumental-control line.

- Flexibility

  << Experimental setup is changed within 1 week. >>
  - Experimental users want to perform experiments like a plug-in-play style at any experimental hutches.
  - Experimental users want to use several camera models.
- Access Control and Security
  - DAQ system can access the accelerator DBs.
  - Experimental users can control DAQ system.
  - Experimental users can access PC-Cluster system.

Bandwidth and Flexibility –
Ethernet is a Good Solution



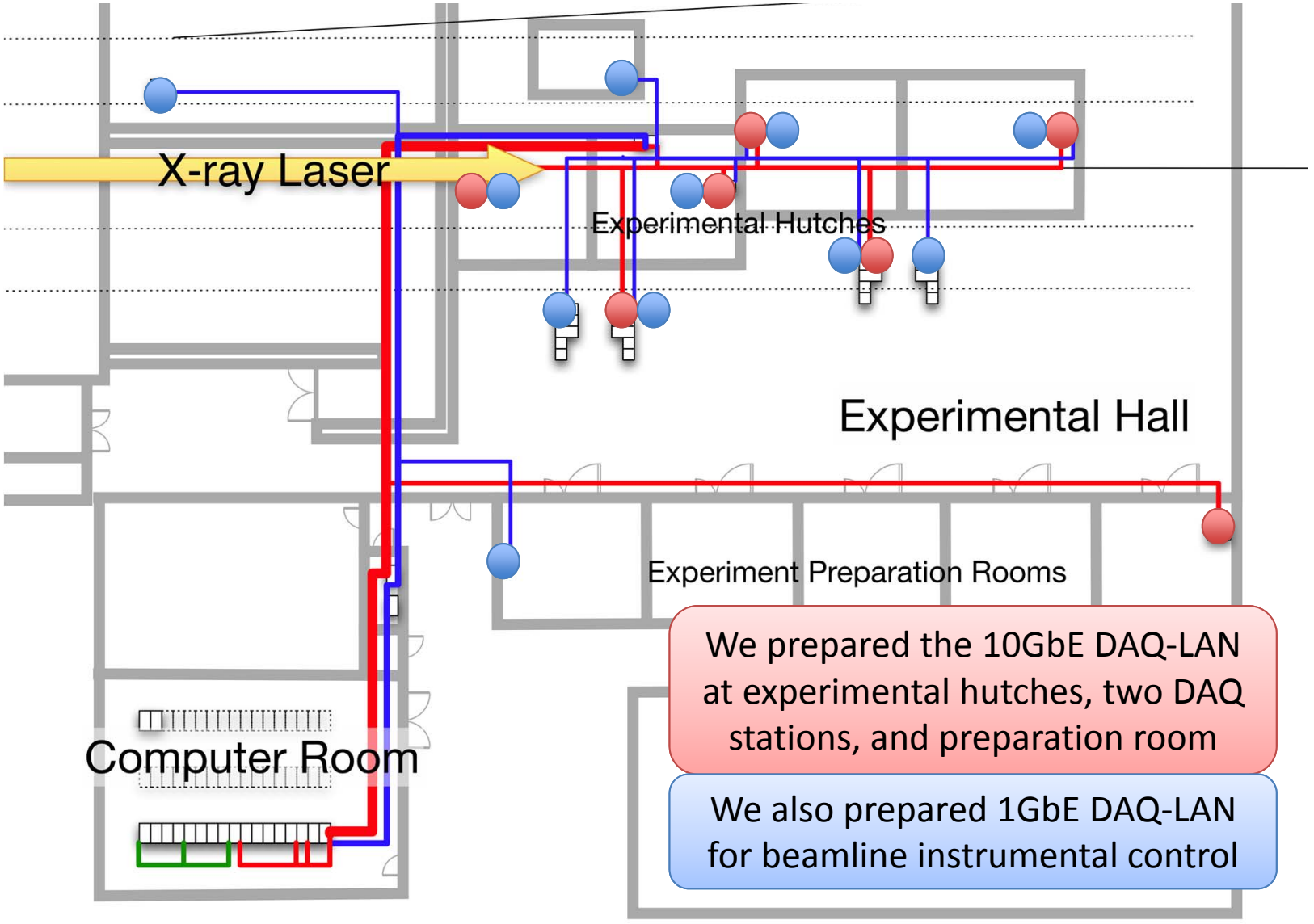
Merit of Ethernet

- Commercially Available
- Large-bandwidth
- Easy to use as Plug-and-Play style
- Upgradeability (→40G/100G)

We prepared the 10GbE DAQ-LAN at experimental hutches, two DAQ stations, and preparation room

We also prepared 1GbE DAQ-LAN for beamline instrumental control

Bandwidth and Flexibility –
Ethernet is a Good Solution

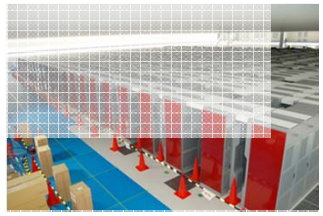


We prepared the 10GbE DAQ-LAN at experimental hutches, two DAQ stations, and preparation room

We also prepared 1GbE DAQ-LAN for beamline instrumental control

Access Control and Security –

Utilize Firewalls



Off-site Supercomputer
"K computer"

Internet

VPN

fice-LAN

Firewall

PC-Cluster-LAN
(10G)

Open Network

Closed Network

High-speed Storage

DAQ-USER-LAN

Firewall

DAQ-LAN (1G)

DAQ-LAN (10G)

Data file server

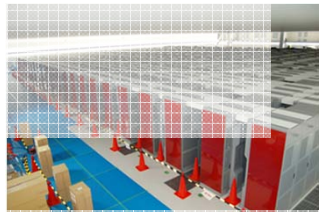
MPCCD

CNTL-LAN

Acceleator DBs

Access Control and Security –

Utilize Firewalls



Off-site Supercomputer
"K computer"

Internet

VPN

fice-LAN

Firewall

PC-Cluster-LAN
(10G)

Open Network

Closed Network

High-speed Storage

DAQ-USER-LAN

Firewall

Data file server

DAQ-LAN (1G)

DAQ-LAN (10G)

CNTL-LAN

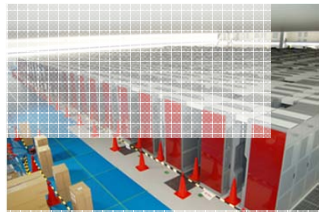
Acceleator DBs

MPCCD

DAQ system can access the accelerator DBs.

Access Control and Security –

Utilize Firewalls



Off-site Supercomputer
"K computer"

Internet

VPN

ffice-LAN

Firewall

PC-Cluster-LAN
(10G)

Open Network

Closed Network

High-speed Storage

DAQ-USER-LAN

Experimental user can control DAQ system.

Firewall

DAQ-LAN (1G)

DAQ-LAN (10G)

Data file server

MPCCD

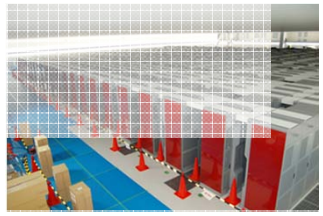
CNTL-LAN

Acceleator DBs

DAQ system can access the accelerator DBs.

Access Control and Security –

Utilize Firewalls



Off-site Supercomputer
"K computer"

Internet

Experimental user can login PC-cluster system.

VPN

ffice-LAN

Firewall

PC-Cluster-LAN (10G)

Open Network

Closed Network

High-speed Storage

DAQ-USER-LAN

Experimental user can control DAQ system.

Firewall

DAQ-LAN (1G)

DAQ-LAN (10G)

Data file server

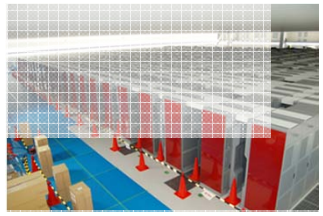
CNTL-LAN

Acceleator DBs

DAQ system can access the accelerator DBs.

MPCCD

Data Analysis Plan



Off-site Supercomputer
"K computer"

Internet

VPN

Office-LAN

Firewall

PC-Cluster-LAN
(10G)

High-speed Storage

DAQ-USER-LAN

Firewall

CNTL-LAN

Acceleator DBs

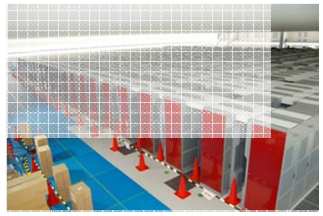
DAQ-LAN (1G)

DAQ-LAN (10G)

Data file server

MPCCD

Data Analysis Plan



Off-site Supercomputer
"K computer"

Internet

VPN

Office-LAN

Firewall

PC-Cluster-LAN

PC Cluster Network and Supercomputer

High-speed Storage

DAQ-USER-LAN

Firewall

Data file server

DAQ-LAN (1G)

DAQ-LAN (10G)

MPCCD

CNTL-LAN

Acceleator DBs

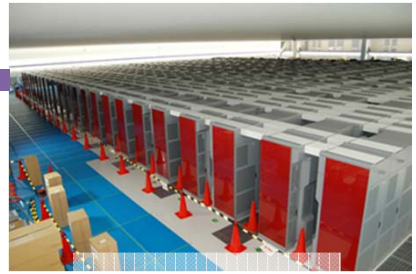
Data Analysis Plan –
We Plan to Use Supercomputers

80km away

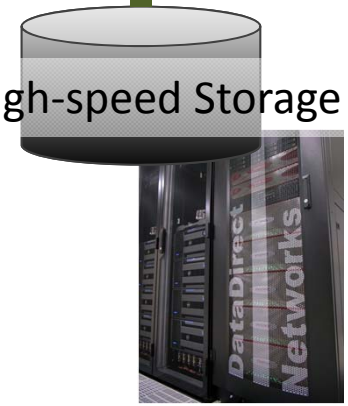
On-site PC Cluster

10Gbit Ethernet

10Gbit WAN
or
Dedicated Line



K computer



High-speed Storage

FOCUS

e-Science

Data Analysis Plan –
We Plan to Use Supercomputers

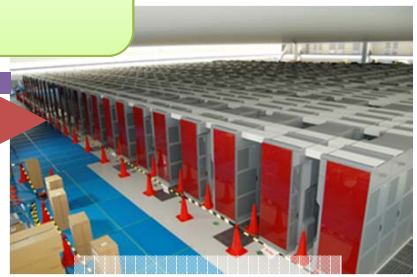
80km away

We perform 2-D image preprocessing.

We perform 3-D image reconstruction.

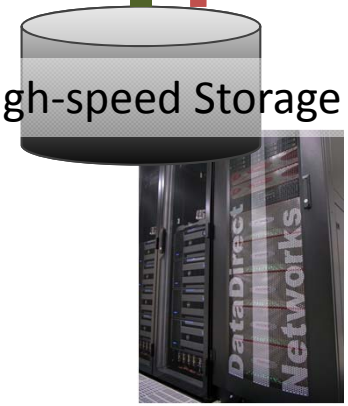
On-site PC Cluster

10Gbit WAN
or
Dedicated Line



K computer

10Gbit Ethernet



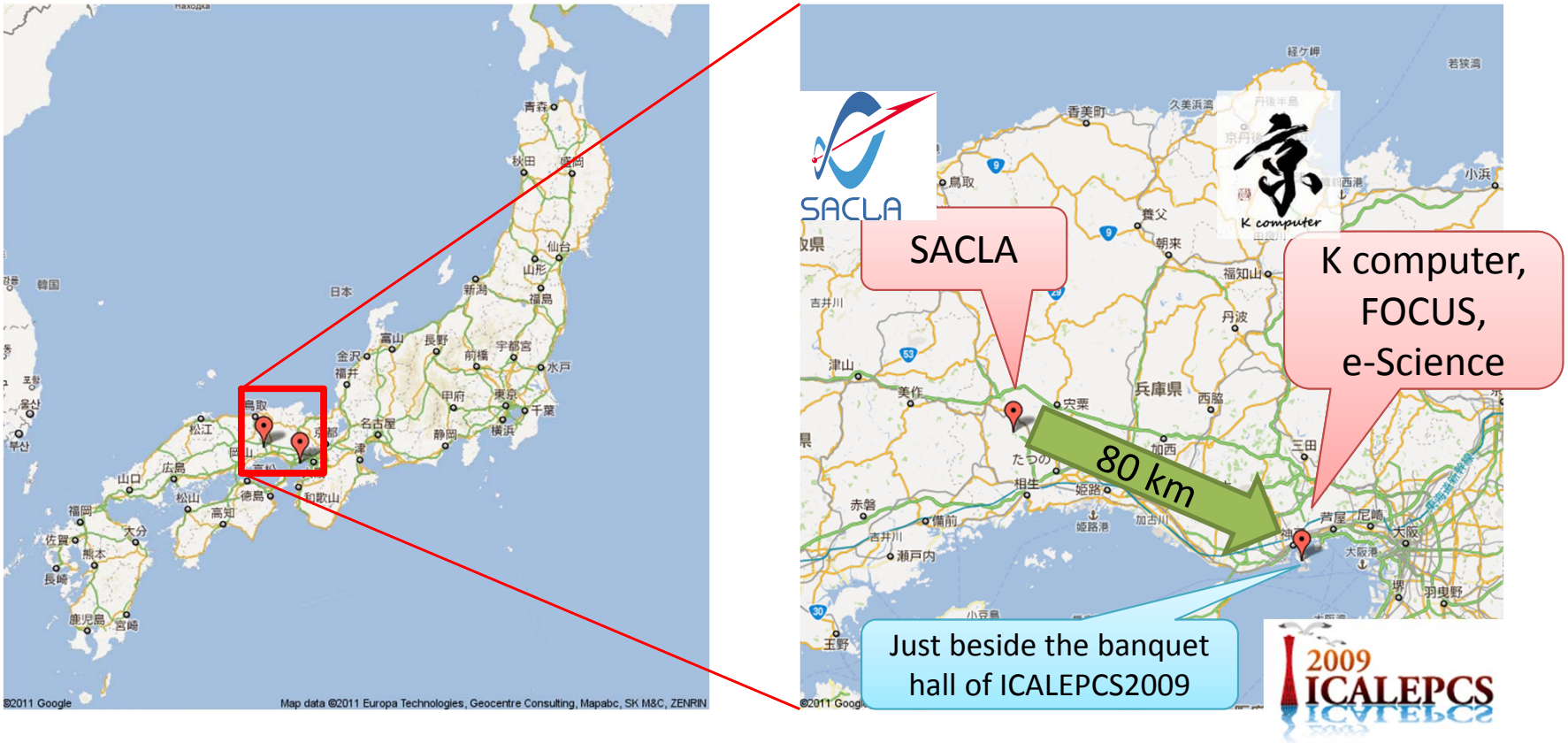
High-speed Storage

FOCUS

e-Science

Near Future Plan

- In early of 2012, we plan to evaluate data-transfer bandwidth and to perform test analysis using “FOCUS” and “e-Science” supercomputers at Kobe.



Summary

- We developed a large-bandwidth DAQ network (DAQ-LAN), and are developing another network for data analysis (PC-Cluster-LAN).

- The DAQ-LAN satisfied experimental requirements.
  - Bandwidth (> 5.8Gbps)
  - Flexibility (plug-in-play style, support several cameras)
  - Access Control and Security

- We plan to use off-site supercomputers to analyze huge image data.