Inauguration of the XFEL Facility, SACLA, in SPring-8

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Outline

- ◆ Overview
  - New XFEL facility in SPring-8, SACLA
- ◆ SACLA status
  - Beam commissioning reports on X-ray lasing
- ◆ Control system
- ◆ XFEL specific requirements
- ◆ Summary

XFEL Facility in SPring-8

SPring-8 Accelerator Complex

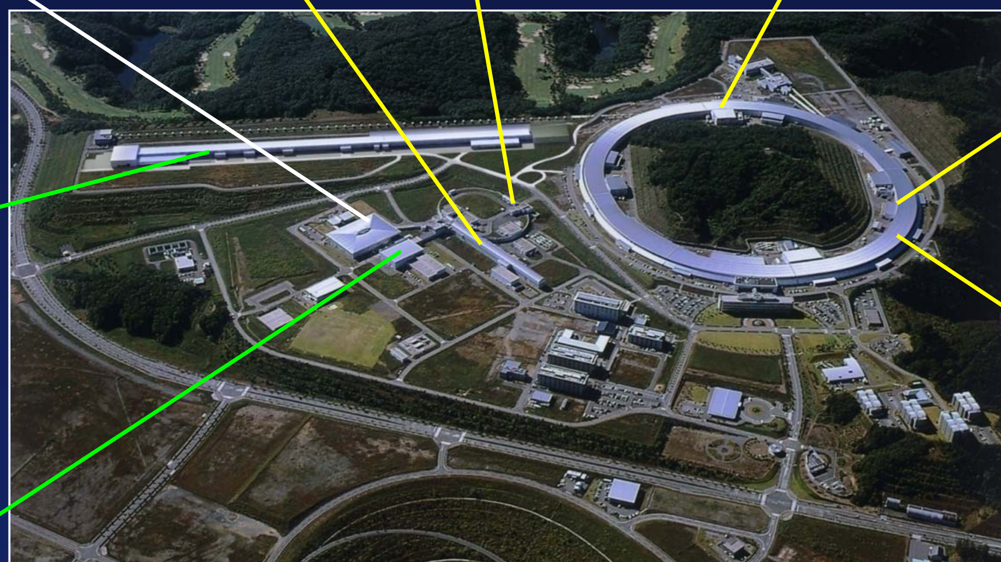
1-1.5GeV New SUBARU

1 GeV linac

1-8GeV Booster

8GeV storage ring

SACLA (Xray FEL)



Undulators & BL components

SCSS (EUV FEL)

SPring-8 is a 3rd generation light source facility, which provides Soft-X, Hard-X, EUV laser, Hard-X laser.

SACLA - XFEL facility in SPring-8

(SACLA=SPring-8 Angstrom Compact free electron LAser)

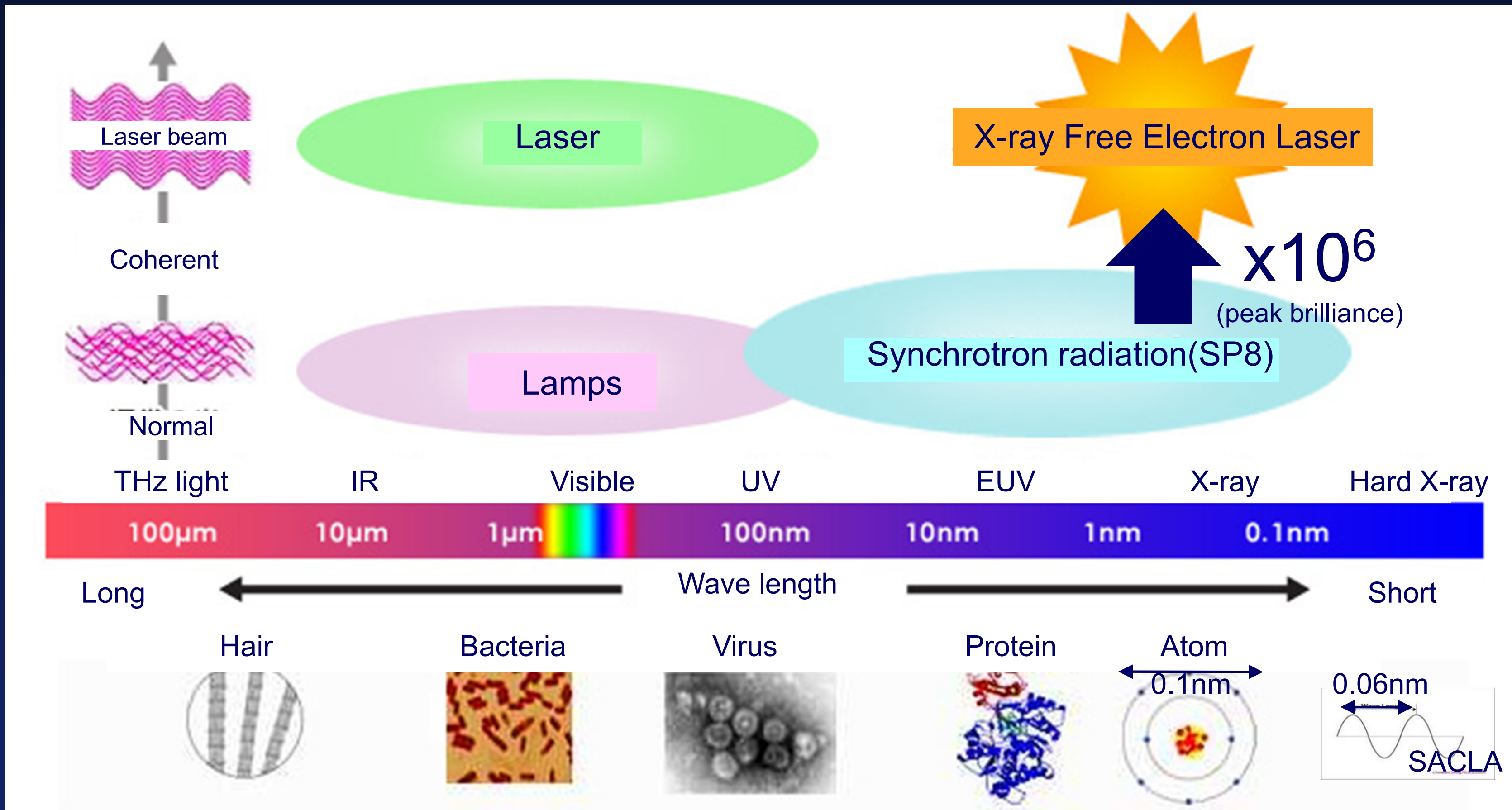
Construction of SACLA started in 2006 and finished in February 2011.
Construction cost is JPY 37B(~US$370M).

SACLA uses a C-band linac,
- accelerates e^- beams up to 8GeV with 60Hz repetition
- provides X-ray laser(0.06nm) by 30fs e^- beam bunches
- injects e^- beams to SP8 storage ring
- Pump/probe experiments are planned by using X-rays from SACLA and SP8

It's unique.

*) 1USD=100JPY

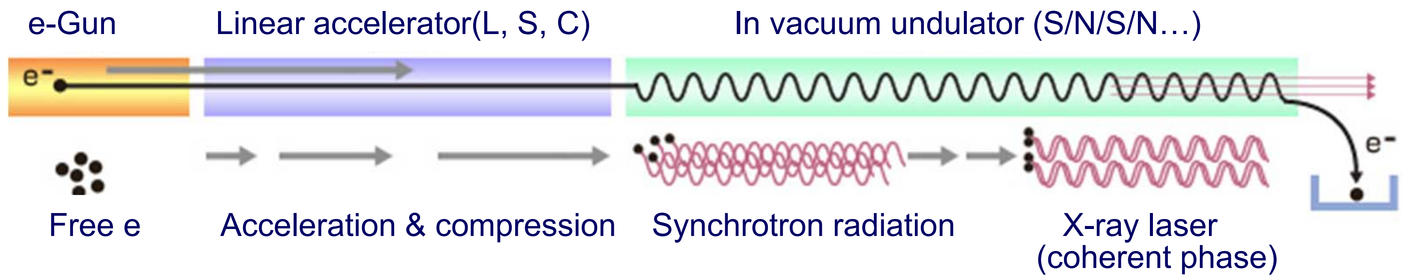
SACLA XFEL – brilliant & coherent light

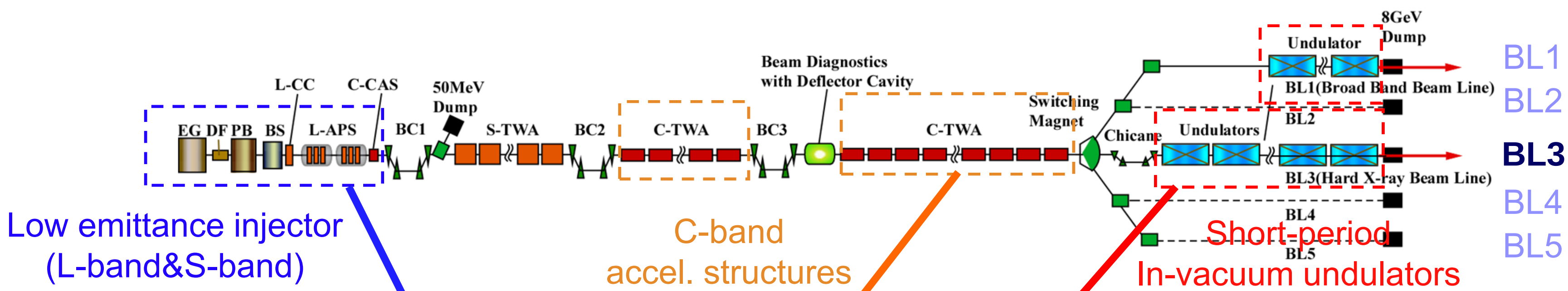


X-ray laser is available by Free Electron Lasing mechanism using a linear accelerator.

Overview of SACLA accelerator system

Laser scheme





Compression
by BC1,2,3
1ns/3000
= 300fs
(30fs/peak)

CeB6 e-Gun, buncher

5.7GHz C-band x64

5m x18 units

400m

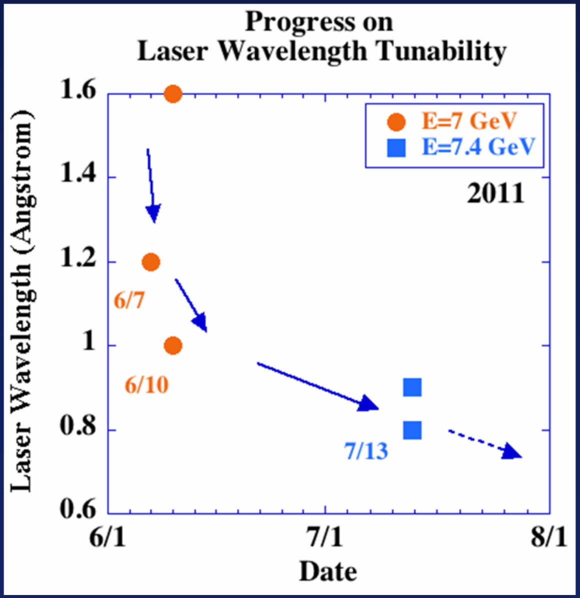
230m (+exp.)

Operation Status

SACLA operation status

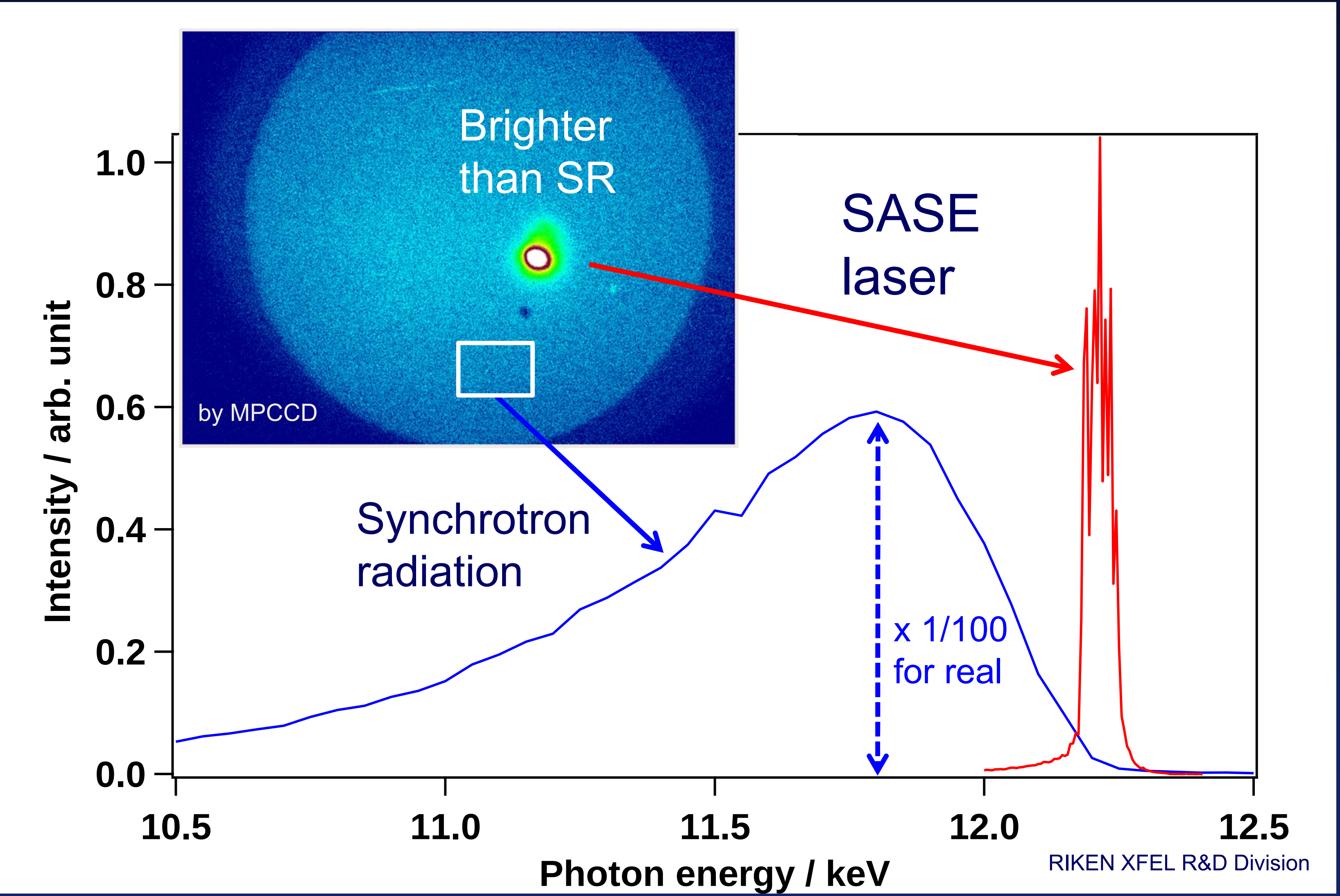
- Electron beam commissioning has started in March, 2011.
- Full energy acceleration of 8 GeV is achieved.
- Laser power amplification is observed with max power ~4GW
- Laser wavelength improved from 0.16nm to 0.08nm.
- Laser is reproducible.

Memorial photo at the first lasing (not all)
SACLA commissioning is going on at the local control room nearby.



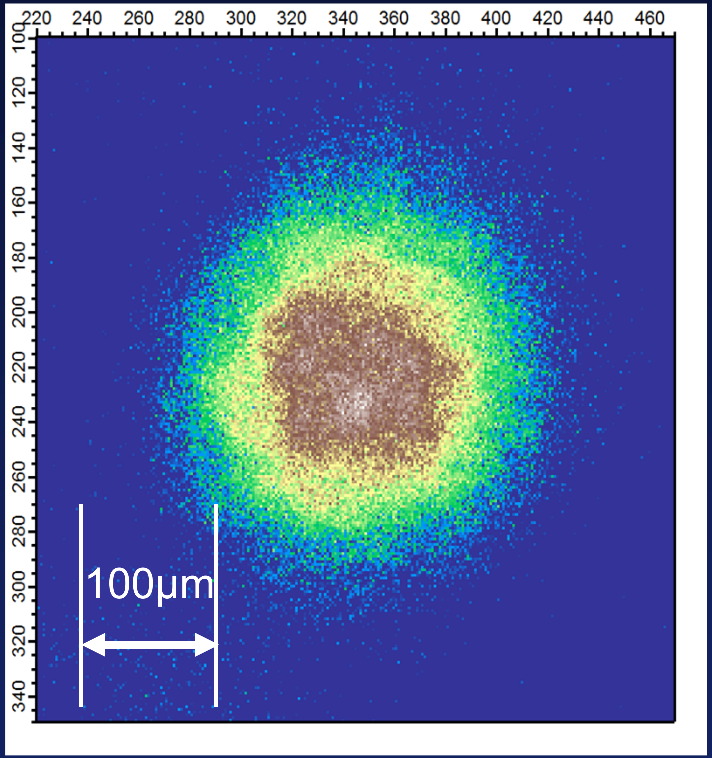
Laser wavelength improvement from June to July

Observed laser beam spectrum



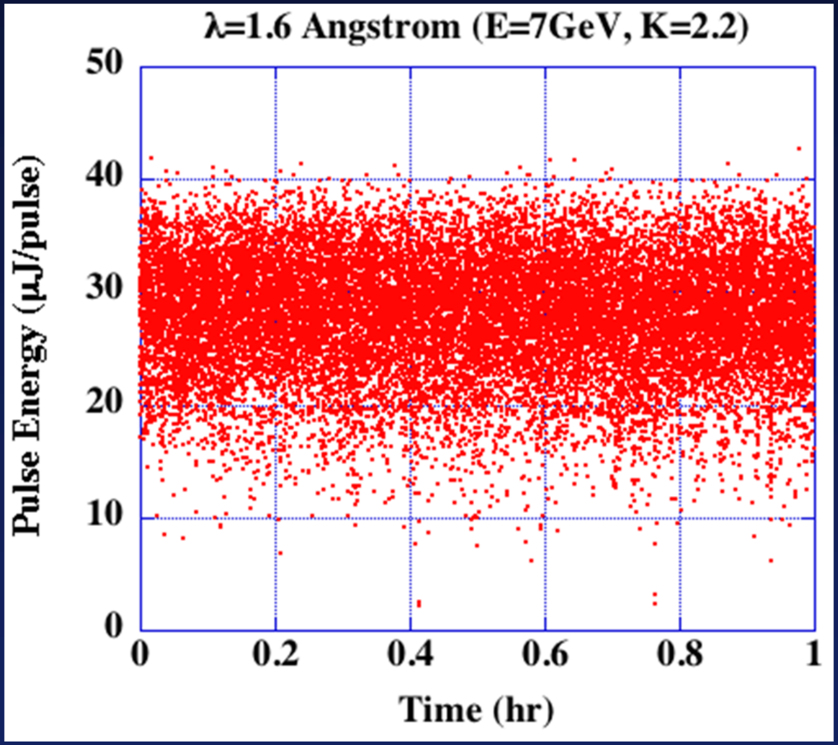
SASE laser profile and stability

Uniform and round shape



Photon energy: 10 keV
110m from the exit of ID

Stable laser intensity



Intensity fluctuation ~18%

Control System

SACLA control architecture

Use **MADOCA** framework for SACLA

MADOCA is built on

"3-tier standard model"

Device I/F ⇔ Middleware ⇔ GUI

⇒Scalable, adaptive

⇒Expandable by distributed architecture

SACLA beam repetition

10Hz: commissioning

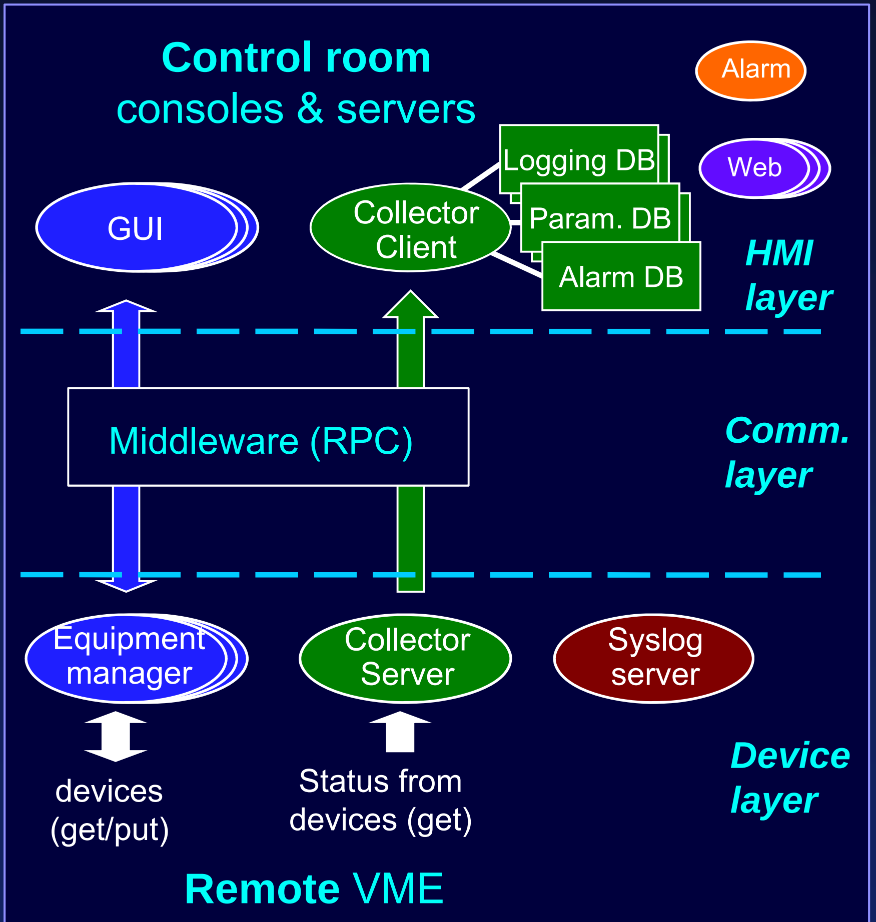
60Hz: user experiments

120Hz: update

300Hz: future option

MADOCA should meet the requirements, so we work on.

Control system determines the facility performance,
like the nerve system of top athletes.



(MADOCA
=Message and Database Oriented Control Architecture)

Control System Components in SACLA

- **Operator consoles**
  SUSE Linux
- **Servers**
  Sybase (RDBMS)
  NAS for NFS
  Blade server for virtual machines
- **VME systems**
  Solaris OS+Intel CPU
  Shared memory network (synchronized DAQ)
  FL-net & Devicenet for fieldbus
- **Interlock systems**
  PLC (PPS, MPS)

Machine status

Take signals with 16ms ~ 60sec interval.
Keep data into On-line DB for monitoring
Store sampled data to Archive DB forever

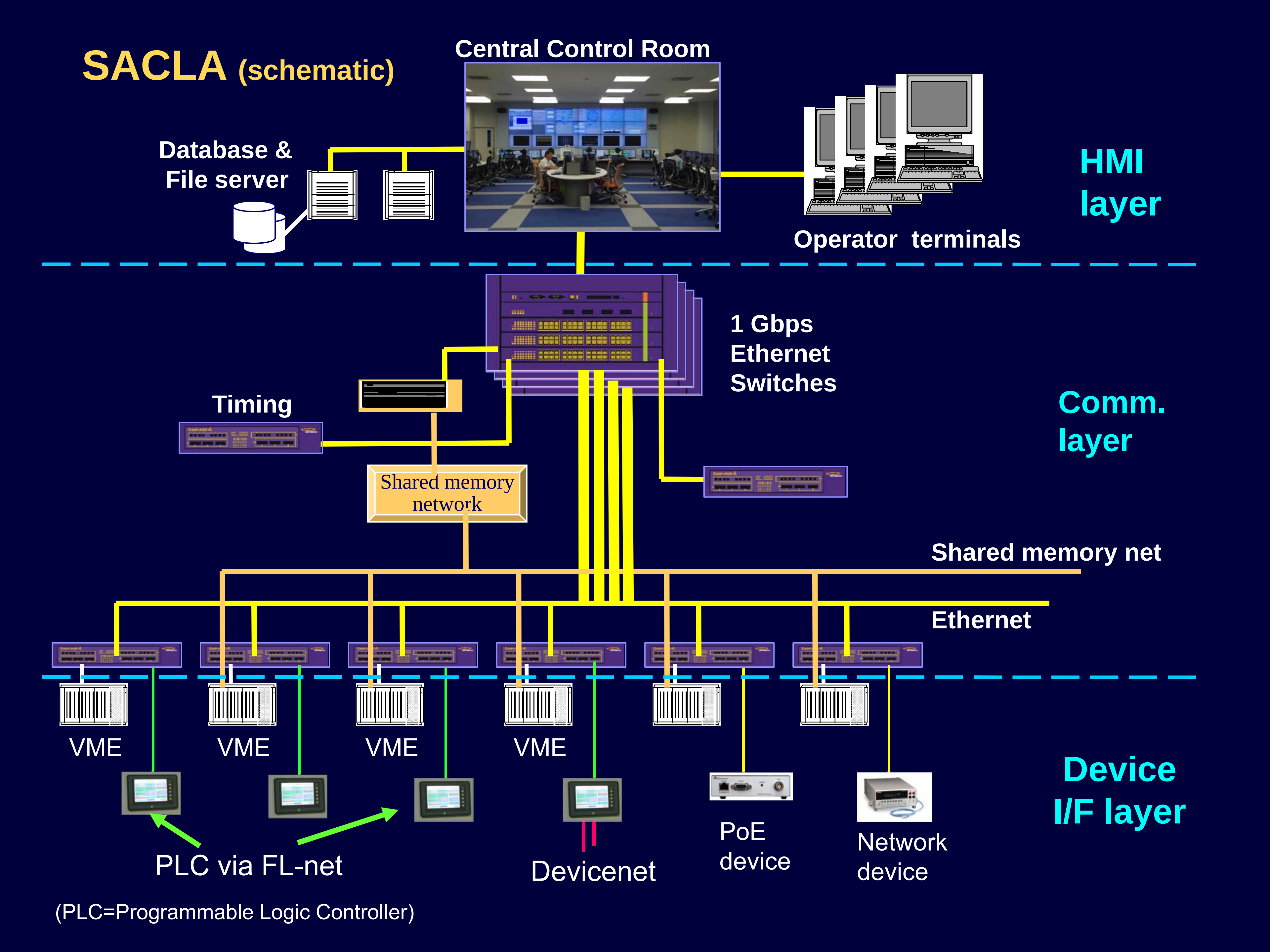
of control points

Digital signals: SACLA(SP8)=230k(90k)

Analogue signals: SACLA(SP8)=22k(20k)

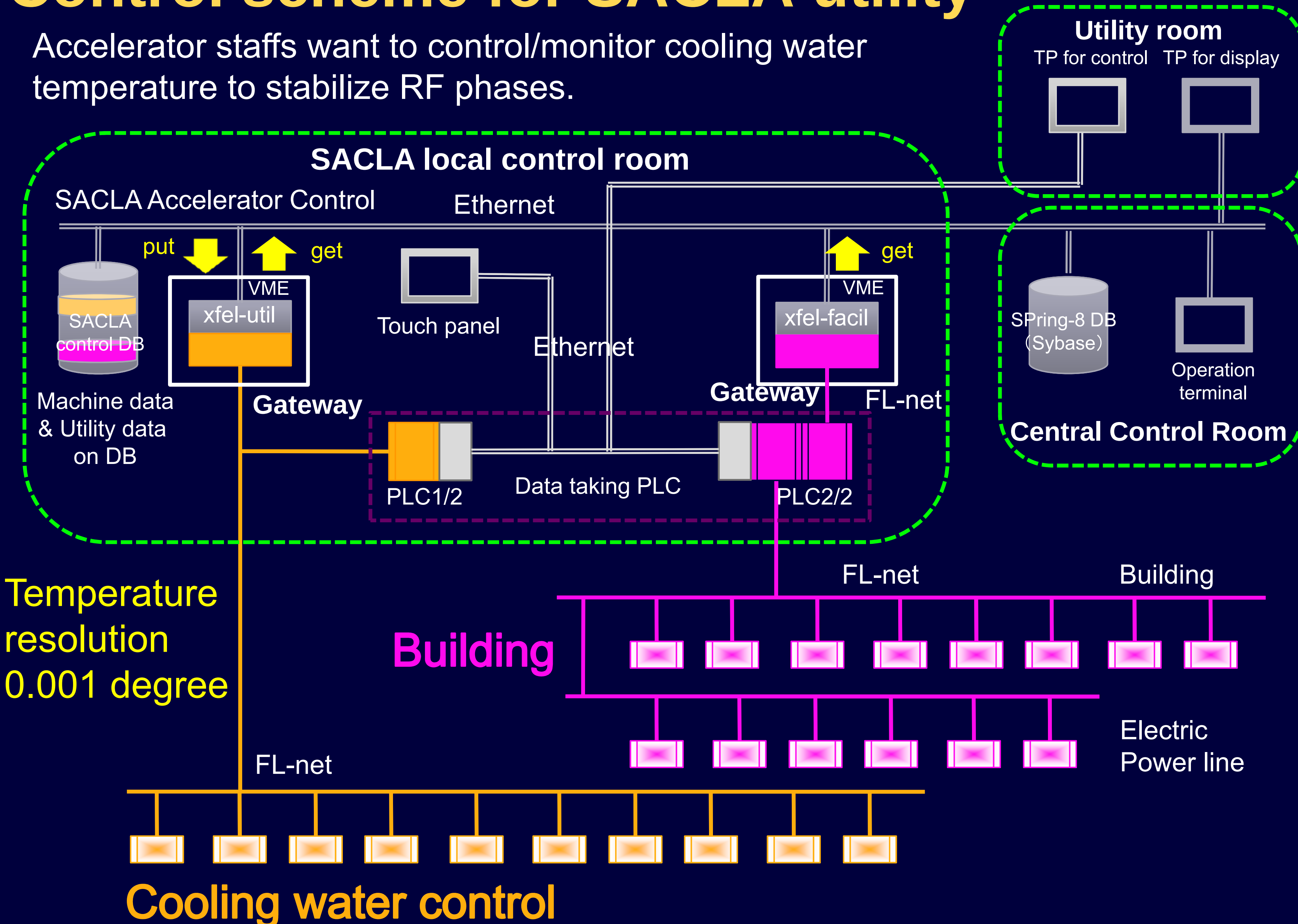
Many points come from a large number of RF accelerating structures in SACLA.

	SCSS, SACLA, SP8	No. of Unit
Computers 		**332**
	Central control	40
	Beamline	165
	Network	21
	Status information	79
	SCSS+XFEL	27
VME systems 		**450**
	Accelerators	129
	Beamline	126
	SCSS	20
	XFEL	175
Interlock units 		**812**
	Accelerators	38
	Beamline	414
	SCSS+XFEL	122
	Access control	238
Network switch 		**758**
	Control LAN	337
	Public LAN	166
	Safety LAN	74
	SCSS+XFEL LAN	181


SACLA (schematic)
Central Control Room
Database &
File server
Operator terminals
HMI
layer
1 Gbps
Ethernet
Switches
Timing
Comm.
layer
Shared memory
network
Shared memory net
Ethernet
VME
VME
VME
VME
Device
I/F layer
PLC via FL-net
Devicenet
PoE
device
Network
device
(PLC=Programmable Logic Controller)

Control scheme for SACLA utility

Accelerator staffs want to control/monitor cooling water temperature to stabilize RF phases.



Adaptive Accelerator Control System

MADOCA-based accelerator controls are successful.

1. MADOCA control systems in SPring-8 work well (Li, Sy, SR).
2. MADOCA applied for SACLA accelerator and beamline controls too.
3. Use MADOCA for utility control because accelerator scientists required to get the utility data and tune the set points (ex. cooling water temperature).

(Q) Do we have to apply MADOCA to the DAQ system for X-ray detector?

(A) Yes, we do this because,

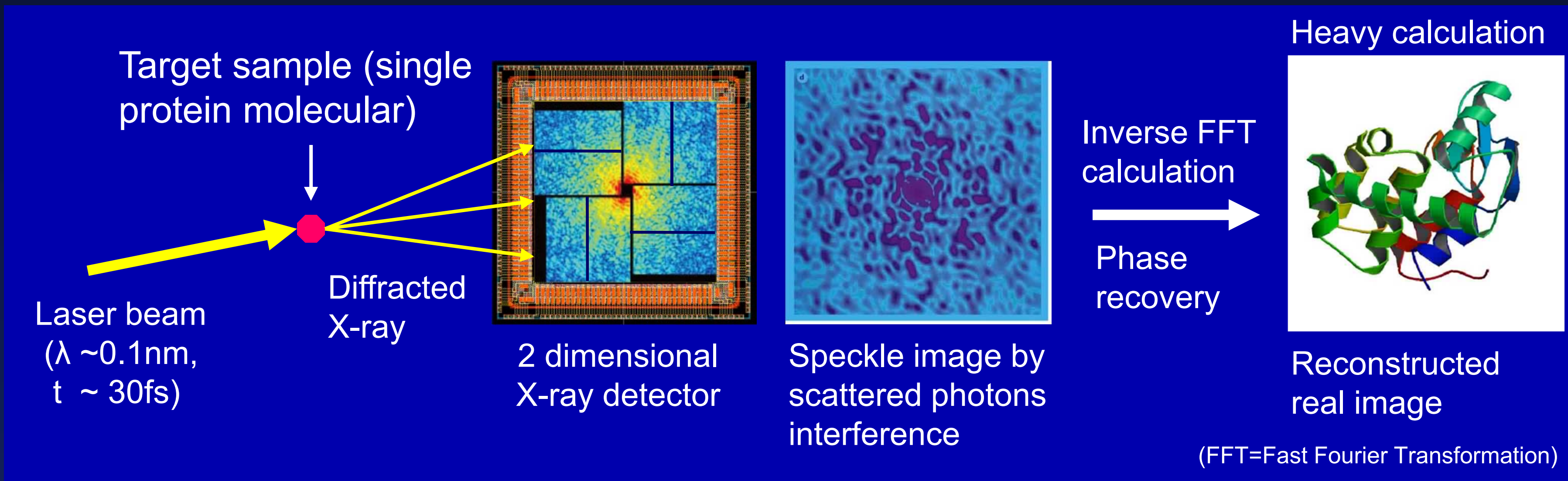
XFEL users needs electron beam information (beam# etc.) for event builder and data re-arrangement.

Accelerator, beamline and detector all have to work with the same framework to interface each other.

(A linac, a series of ID, a detector and experimental DAQ have to work cooperatively as a whole - XFEL feature)

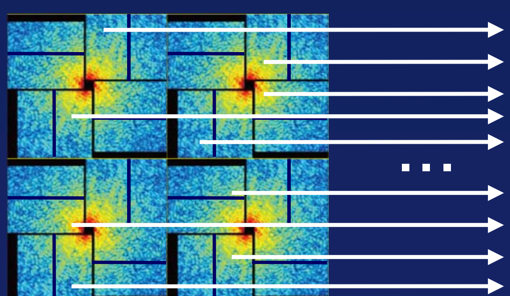
Image Detection with a 2D X-ray Detector

Experimental users take diffraction images by a multi-sensor 2D X-ray detector.

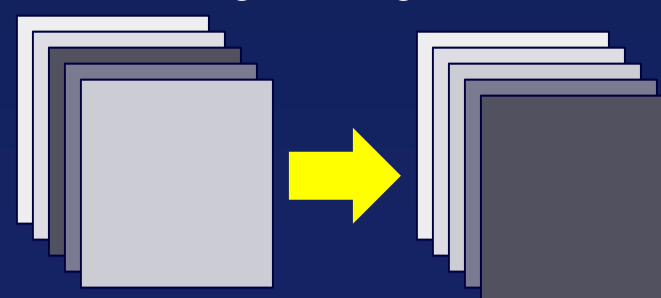


Use e^- beam # for single event building and rearrangement of shot data

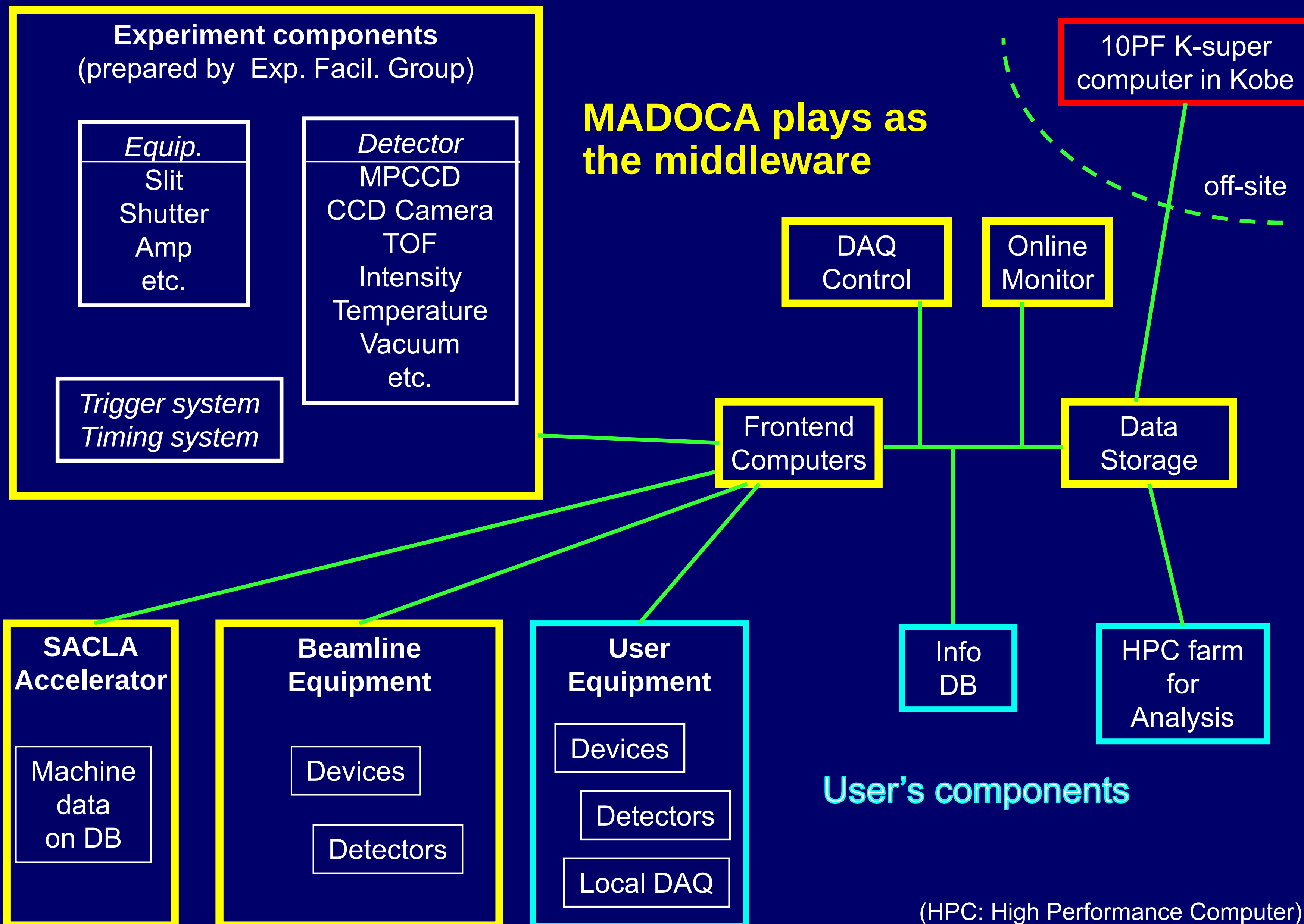
We have to read 8 ~ 80 sensors in parallel.



3D CT image of single molecular



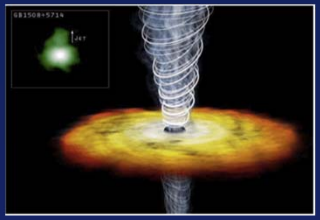
SACLA DAQ scheme

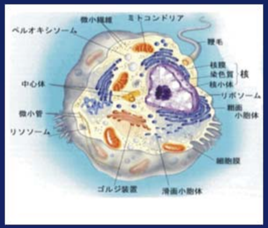


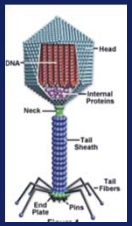
User experiments will start soon

- First user experiment is scheduled at the beginning of November this year.
  - accelerator operation is 10Hz
- SACLA utilization to the public will start in March, 2012.
  - accelerator operation will be 60Hz

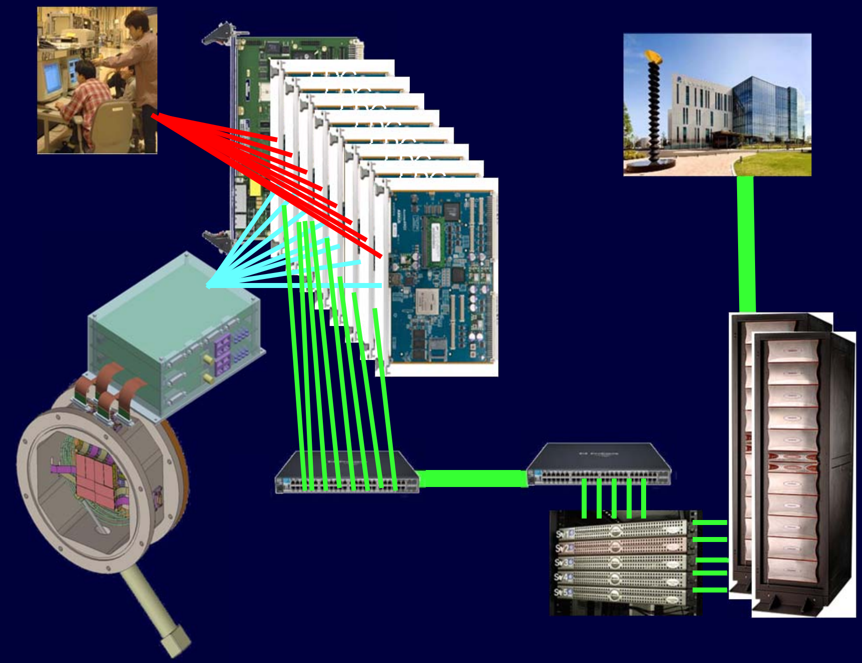
SACLA contributes to produce scientific results, we are ready to start.







DAQ is ready for experiments



2D X-ray detector will generate 480MBytes/s with 60Hz beam operation.
(as reported by TUCAUST06 Yamaga-san)

Summary

Summary

1. Construction of the SACLA finished in February 2011. Beam commissioning started in March, this year.
2. Full energy 8GeV is achieved, and SASE laser was observed in June with a wavelength of 0.16nm, improved to 0.08nm in July.
3. Three-tier control framework, MADOCA, is successfully supported SACLA commissioning.
4. The control system has to handle accelerator, beamline and experimental DAQ as a whole to get scientific results - *DAQ is new field.*
5. User experiments is scheduled at the beginning of November. Utilization to the public will start in March, 2011.

Thank you for your support and encouragement