Status of the Control System for Fully Integrated SACLA/SPring-8 Accelerator Complex and New 3 GeV Light Source Being Constructed at Tohoku, Japan

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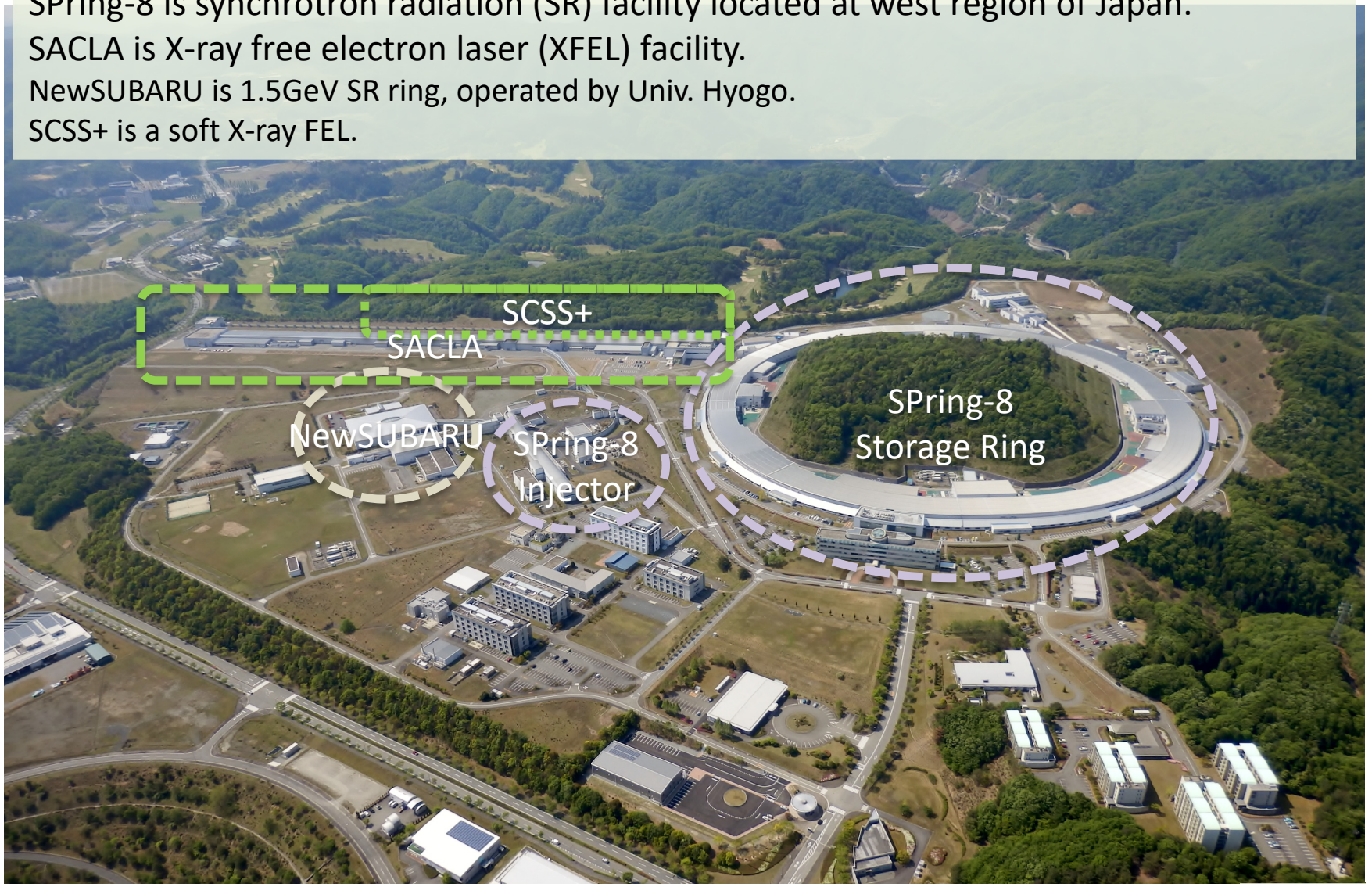
Outline

- Light Source Projects in Japan
  - SPring-8 Upgrade Project
  - 3GeV Light Source Project at Tohoku
- Control Framework Upgrade for these Light Sources
- Project Milestones and Status
  - Control Framework Upgrade
  - Light Source Upgrades

Light Source Upgrade Projects in Japan

Overview of SPring-8

SPring-8 is synchrotron radiation (SR) facility located at west region of Japan.
SACLA is X-ray free electron laser (XFEL) facility.
NewSUBARU is 1.5GeV SR ring, operated by Univ. Hyogo.
SCSS+ is a soft X-ray FEL.



SPring-8 Upgrade Project

- We have plan to upgrade SPring-8, in order to maintain top light source performance in the world.
- The upgrade project aims at 100x brilliance at hard X-ray region, compared to the present ring.
- To achieve such performance, we have studied beam optics of the storage ring.
- Since the present injector is not matched parameters of new optics, we plan to use SACLA linac as low-emittance injector to the SPring-8.

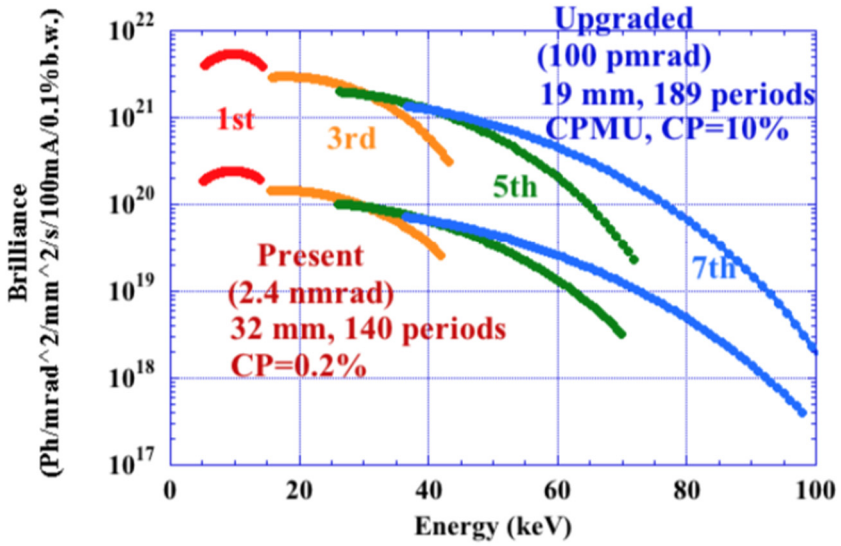


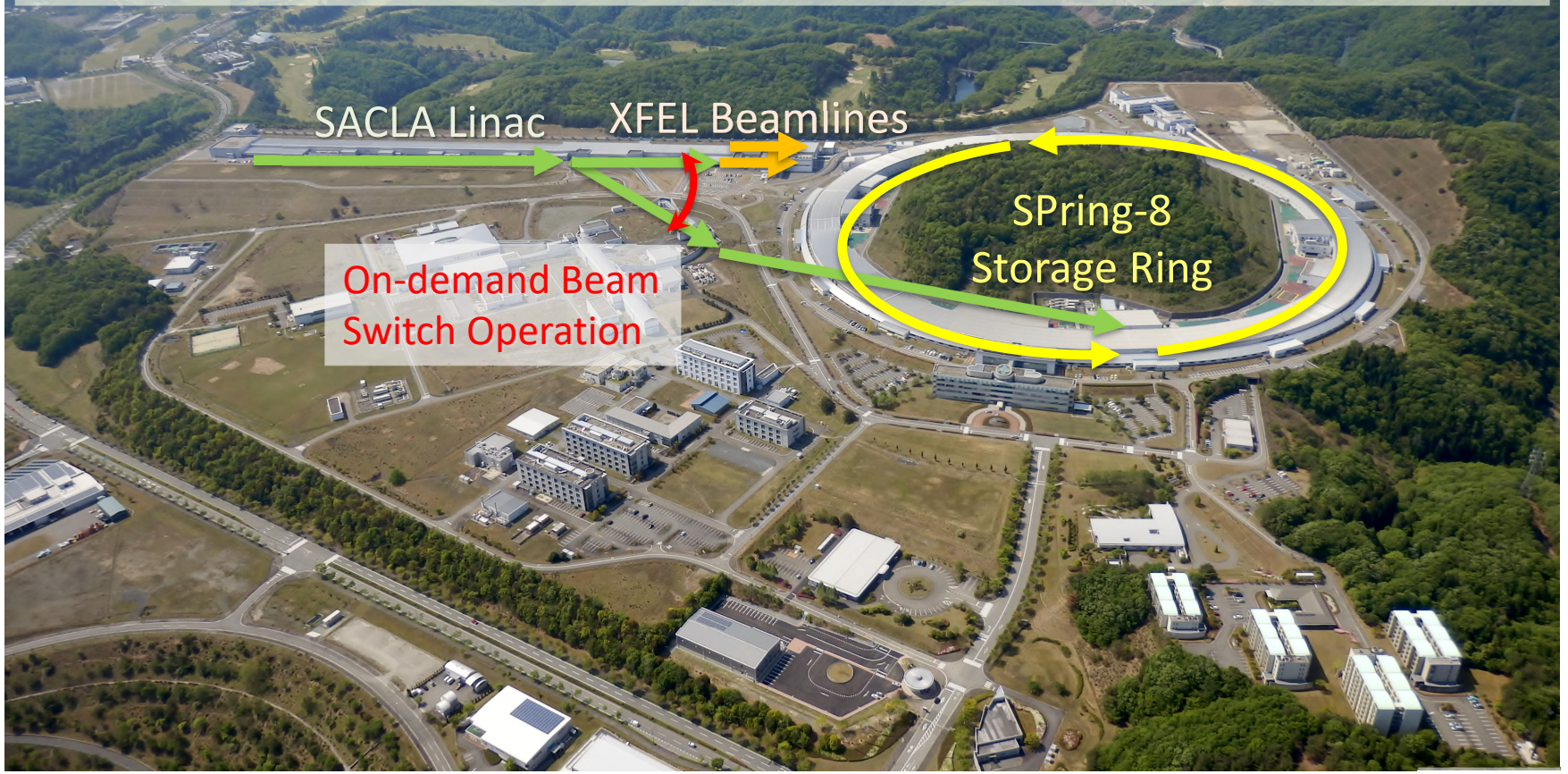
Table 1: Comparison of Main Ring Parameters

Item	Upgraded	Current
Energy (GeV)	6	8
Circumference (m)	1435.5	1436
Unit Cell Structure	5BMs	2BMs
Ring Structure	2Inj[*1]+42Unit[*2] +4Str[*3]	44Unit +4Str
ID Straight (m)	4.734	6.65
Emittance (nmrad)	0.14(0.1[*4])	2.8
HV Coupling (%)	10	0.2
Tune (νx, νy)	(109.14,42.34)	(41.14,19.35)
Chromaticity (ξ_x,ξ_y)	(-155, -146)	(-117, -47)
Mom. Compaction	3.32×10^{-5}	1.59×10^{-4}
Beam Lifetime	~10	10~100

H. Tanaka, et al., Proc. of IPAC2016, WEPOW019

Injection Test from SACLA to SPring-8

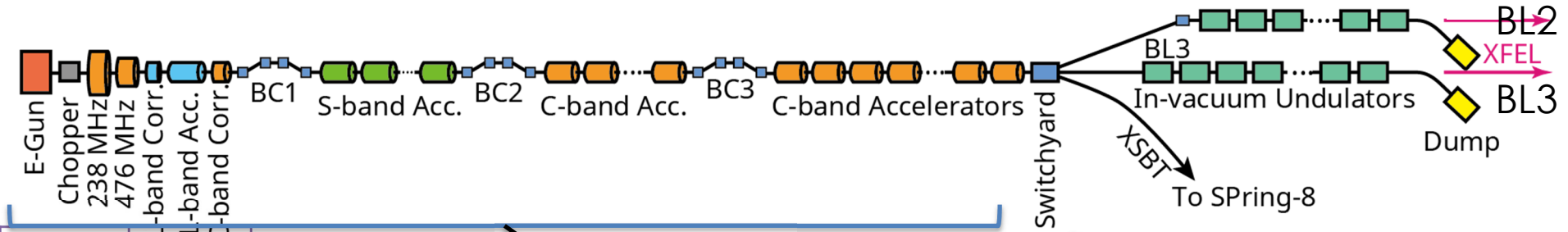
Before changing SPring-8 optics, we plan to test injection from SACLA linac to *present* storage ring in 2020.
To satisfy requirements from operations, we must combine control systems of each accelerator. Especially, on-demand beam switching is necessary to perform XFEL experiments and beam injection simultaneously.



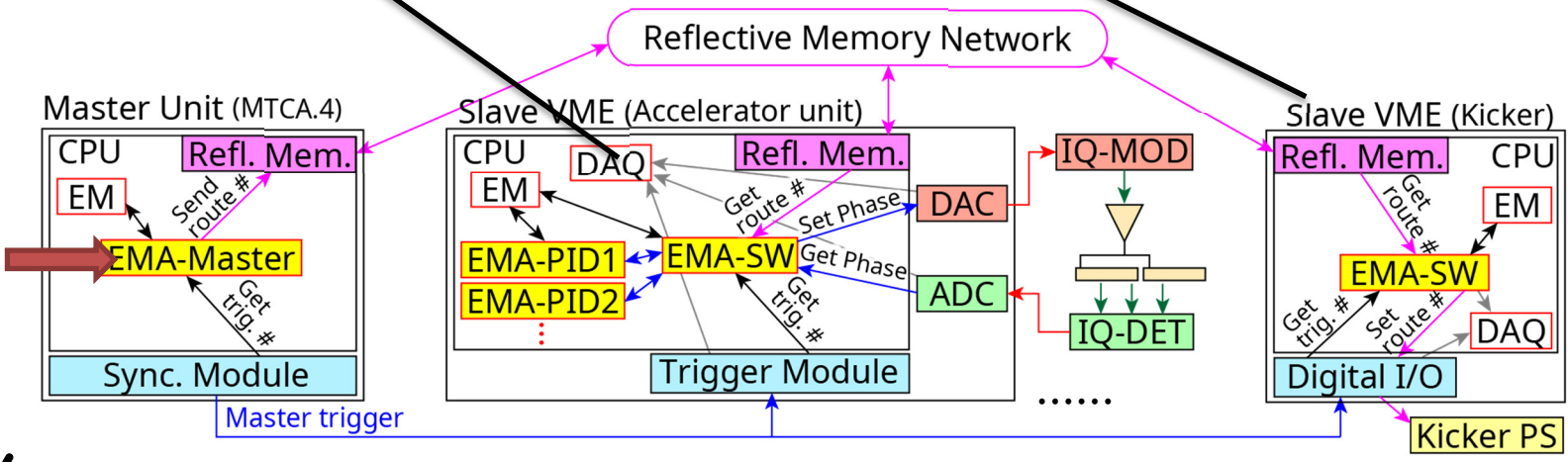
On-demand Beam Switching Operation

To support on-demand beam switching operation, we have to develop synchronized control and DAQ scheme.

Using reflective memory network and master trigger distribution, RF units and kicker magnet are tuned shot-by-shot basis at 60 Hz rate.



Trig. #	Route
0	BL3
1	BL2
2	BL3
3	BL2
4	BL3
5	**XSBT**
6	BL3
7	BL2



H. Maesaka, et al., IPAC 2019, THYYPLS1

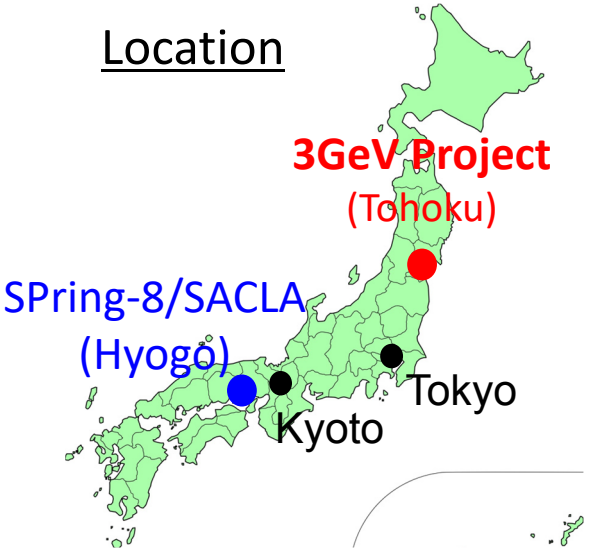
Also see the poster presentation by K. Okada, et al., ICALEPCS 2019, WEPHA112

3 GeV Light Source Project at Tohoku

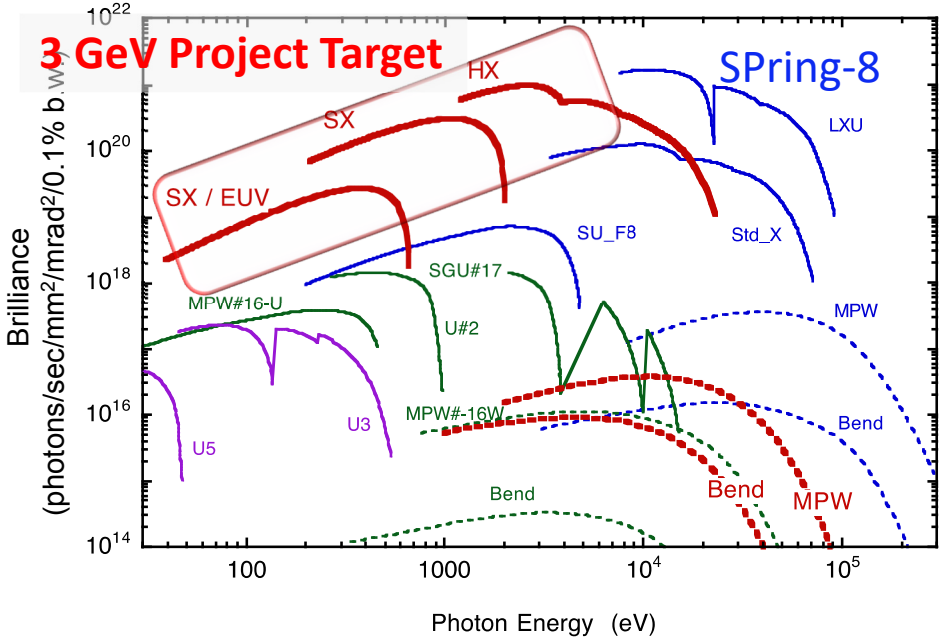
From FY2019, Japanese Government approved budget to build a new 3 GeV light source at Tohoku.

- This facility aims at high-brilliant compact light source, specialized for soft X-ray region.
  - Complement to the SPring-8 upgrade project.
- We use preceded studied components for the SPring-8 upgrade project, to launch the facility in a short time.

Location



Expected Light Source Performance



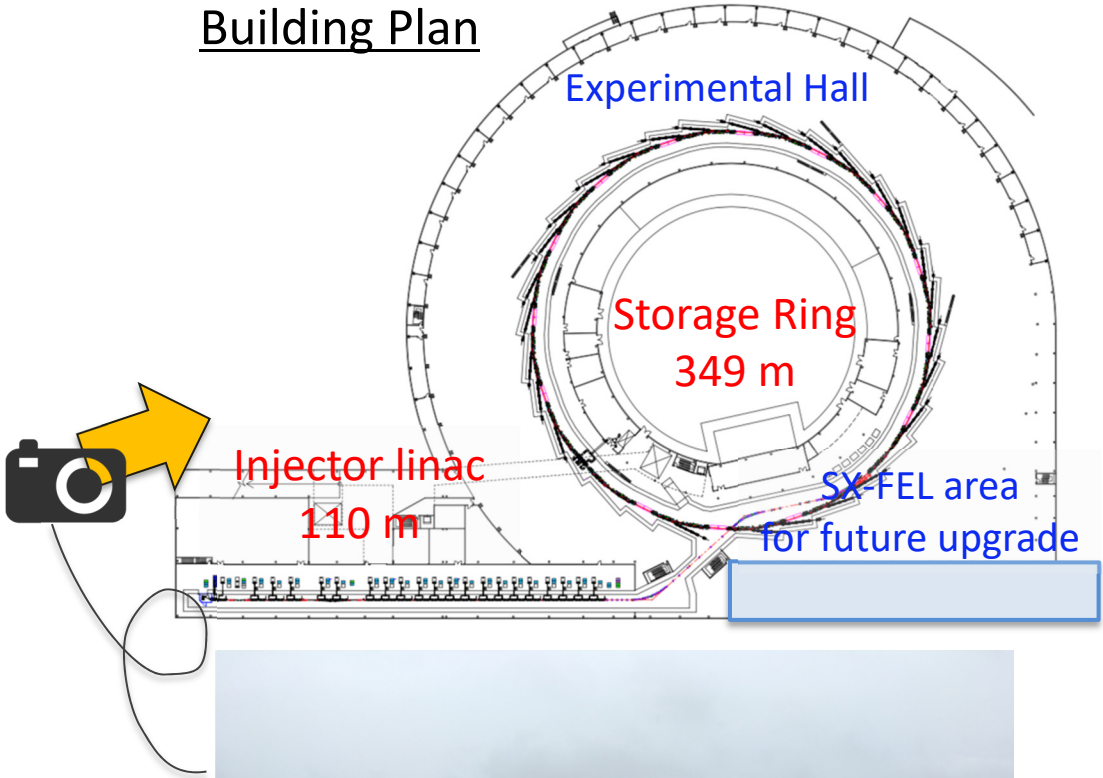
Studies for 3 GeV Light Source

Storage Ring Parameter

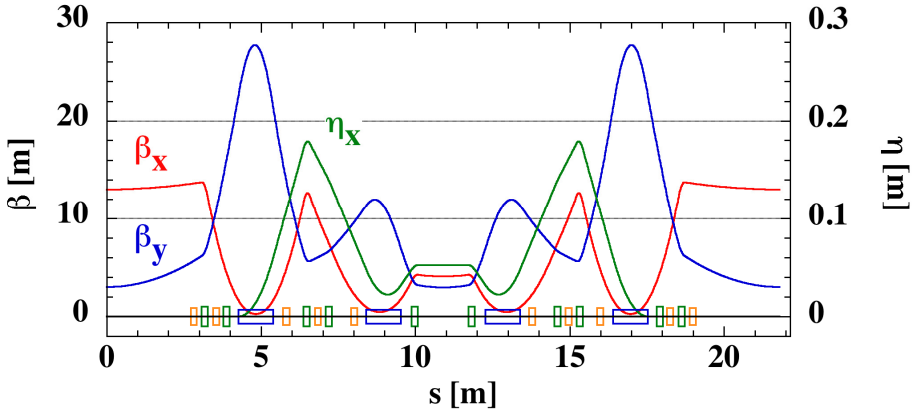
Beam energy	3.0 GeV
Stored current	400 mA
Lattice	4B-achromat
Circumference	348.8 m
Number of cells	16
Natural emittance	1.1 nm.rad
Energy spread	0.084 %
Beam size σ_x / σ_y @ ST	121 / 5.8 μm

(Coupling = 1%)

Building Plan



Optics (4 bend achromat lattice)



Land Creation (Sep. 2019)

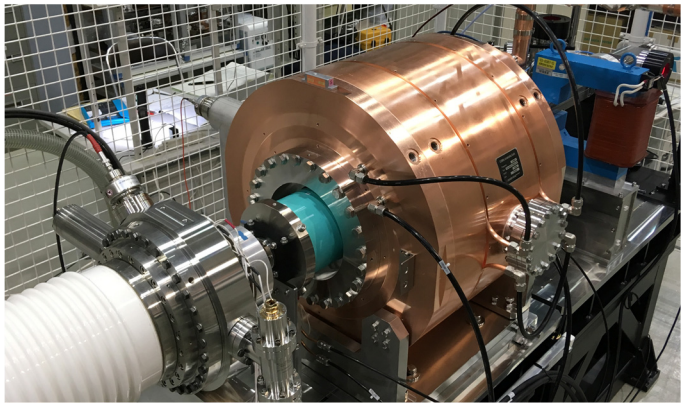
Photo by T. Watanabe

Prototype Linac at NewSUBARU

Before install 3 GeV machine at Tohoku, we will make prototype 1 GeV linac at NewSUBARU (in SPring-8 site), in order to test modified and new components.

- New thermionic gun system
- C-band accelerator system based on SACLA linac

A new gun system



T. Asaka et al.,

C-band accelerators

→ Will be tested as Injector of present NewSUBARU storage ring.

Control Framework Upgrade

Control Framework Upgrade Project

- MADOCA is control framework used for both the SPring-8 control (1997-) and the SACLA control (2011-).
- It is difficult to operate SPring-8 and SACLA as one machine owing to many restrictions.
  - Messaging implementation (based on RPC) is old fashioned
  - Restricted by database performance
  - Many subsystems, not transparent each other

It's time to upgrade the control framework

Target:

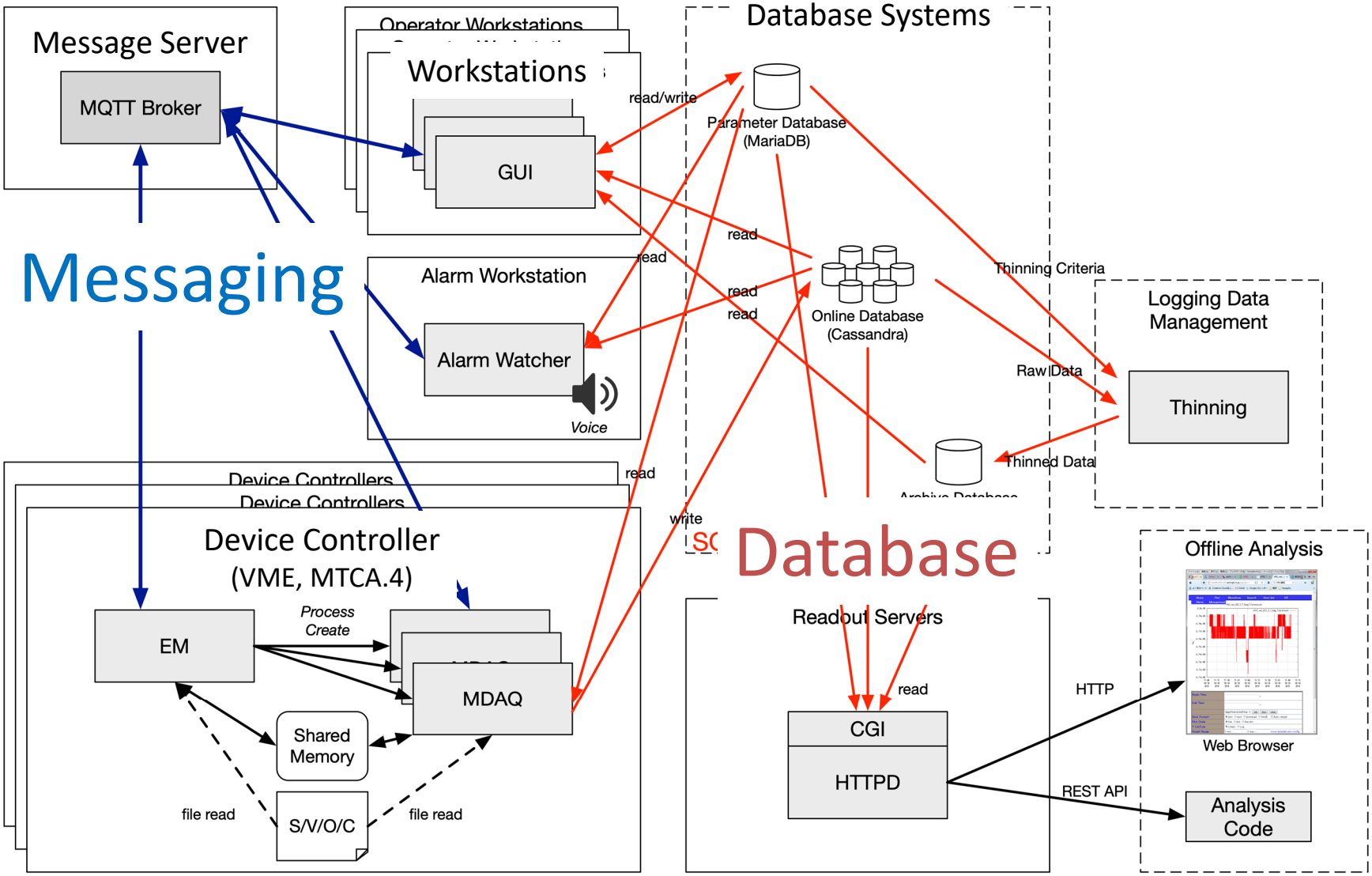
- SPring-8/SACLA combined operation
- 3 GeV Light Source operation
  - Including feasibility studies of prototype linac at NewSUBARU

Design the new control framework

- Keep concept from the MADOCA
  - Distributed control system on the network
  - Messaging and Database oriented framework
    - S/V/O/C style messaging
    - RDB based parameter management

- New features / implementations
  - Use modern messaging protocol: MQTT
  - Separate database systems according to purpose
    - parameter management: RDBMS
    - data logging: Key-value storage (performance scalability)
    - data archiving
  - Unite all DAQ subsystems into one framework, transparently
  - Implement as multi-core / multi-thread system.

Overview of the New Control Framework



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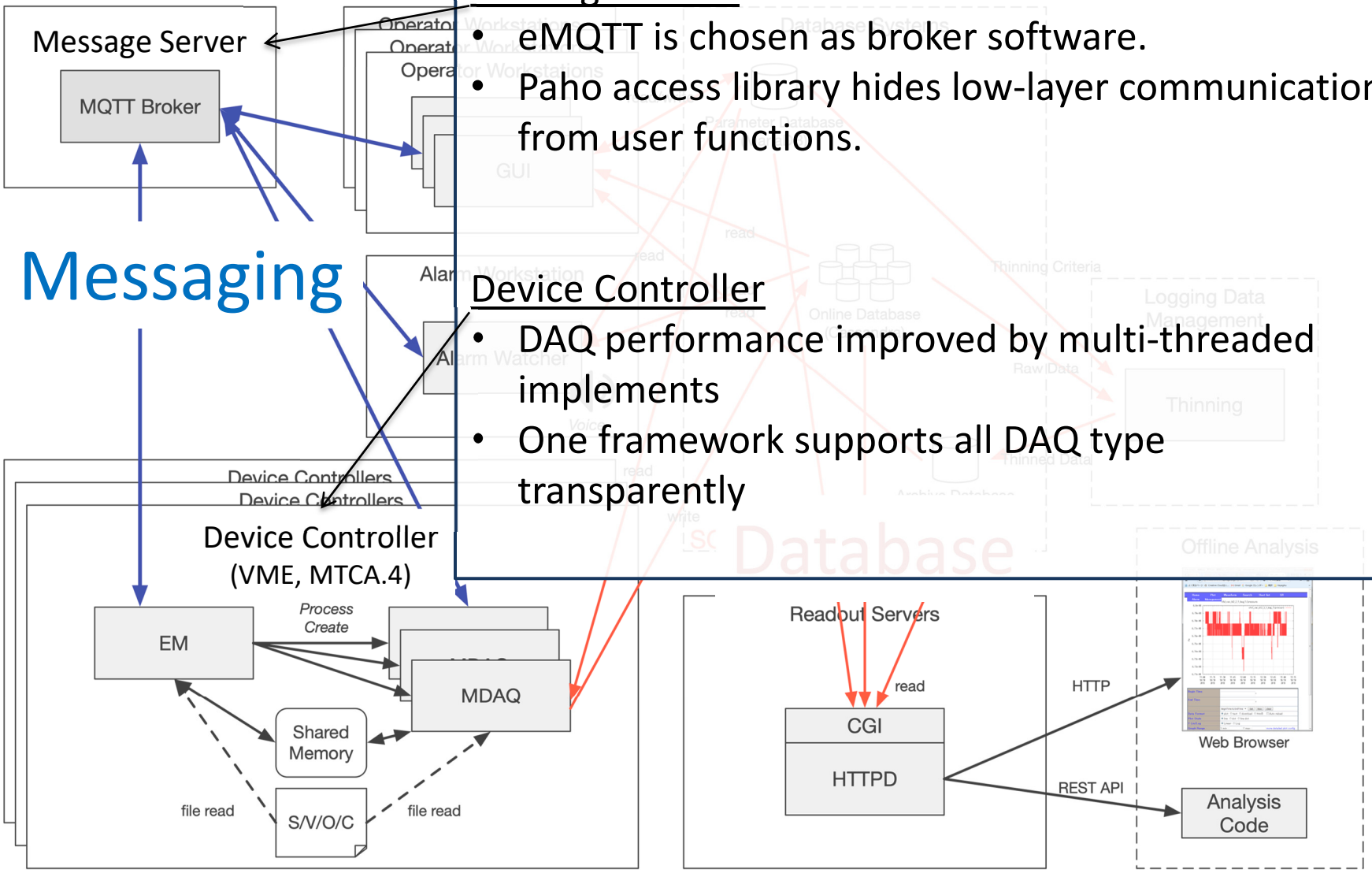


Message Server

- eMQTT is chosen as broker software.
- Paho access library hides low-layer communications from user functions.

Device Controller

- DAQ performance improved by multi-threaded implements
- One framework supports all DAQ type transparently

Overview of the New Control Framework

Parameter Database

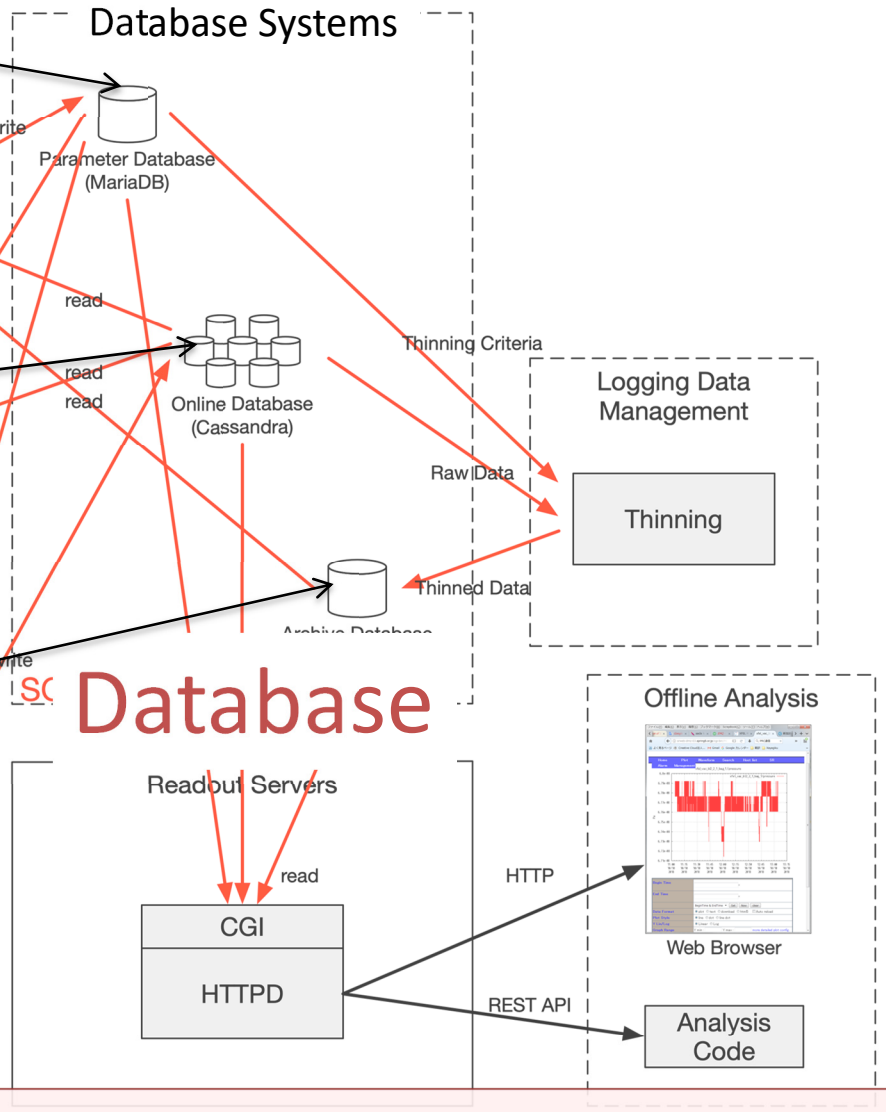
- Parameter DB is used for management of operating parameters.
- We choose MariaDB.
- The parameter DB is important to operate. We use high-available server.

Online Database

- Online DB stores logging data.
- We choose key-value storage, Cassandra.
- The Cassandra have scalability and high availability by itself.

Archive Database

- Archive DB is long-term storage for thinned logging data.
- We choose MariaDB.
- High availability is provided by replica DB.



This framework supports C, C++, Python, and REST API.
Users do not need to write SQL/CQL directly in user functions.

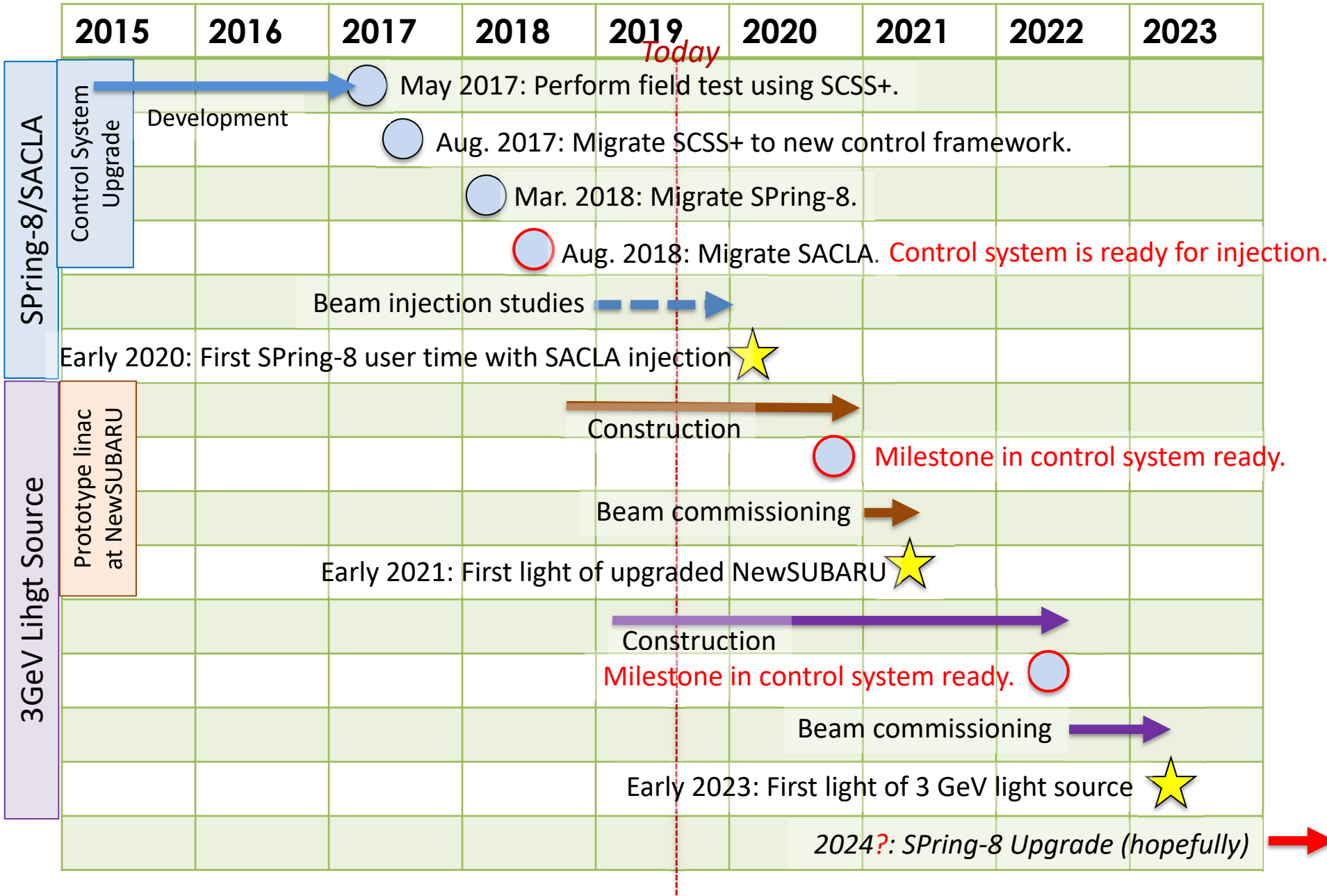
New DAQ framework

- We developed new DAQ framework, called “MDAQ”, for accelerator data logging.
- MDAQ runs with the parameter DB.
  - All DAQ parameters are recalled from the parameter DB.
- Legacy DAQ subsystems are integrated into one MDAQ framework.
  - All DAQ types are transparent to users.
- Multi-thread implementation enables us more performance.

		New DAQ Framework		Previous Framework (MADOCA)	
DAQ Type	**Data Type**	**Timing**	**Data Store**	**Timing**	**Data Store**
Poller	point	0.1-10^2 sec. period	Cassandra	1-10^2 sec. period	SYBASE
Synchronized	point	Triggered (60 Hz)	Cassandra	Triggered (60 Hz)	MySQL
Waveform	array	Triggered	NFS*	Triggered	Cassandra
Image	image	Triggered (60 Hz)	NFS*	Triggered (60 Hz)	NFS

* Metadata are stored in the Cassandra online database.

Project Milestones and Status



Summary

- Light Source Projects in Japan
  - SPring-8 Upgrade Project
  - 3GeV Light Source Project at Tohoku
    - This project use preceded studied components for SPring-8 upgrade project to launch in a short time
- Control Framework Upgrade for these Light Sources
  - Keep Concepts from MADOCA framework
  - New features using modern technologies
    - MQTT-based Messaging
    - Multi Database: We use RDB (MariaDB) and key-value storage (Cassandra)
    - Multi-thread implementation
- Project Milestones and Status
  - Control Framework Upgrade
    - Control system is ready to support light source upgrade projects in Japan.
  - Light Source Upgrades
    - SPring-8: Beam injection from SACLA is now studying.
    - 3 GeV light source: Under construction. First light is expected in 2023.