Status of Control System

Hiroshi Kaji

Introduction

The aim of control system is to increase “integrated luminosity”, which directly affects the accuracy of physics results.

Our control system are required followings:

- of course, the functions should be precise and reliable,
- robust system to avoid down time of accelerator,
- excellent drivability for commissioning

to promptly realize the target luminosity ($8 \times 10^{35} \mathrm{cm}^{-2}\mathrm{s}^{-1}$), even though many accelerator components are upgraded.

EPICS based system

We choose EPICS based control system.

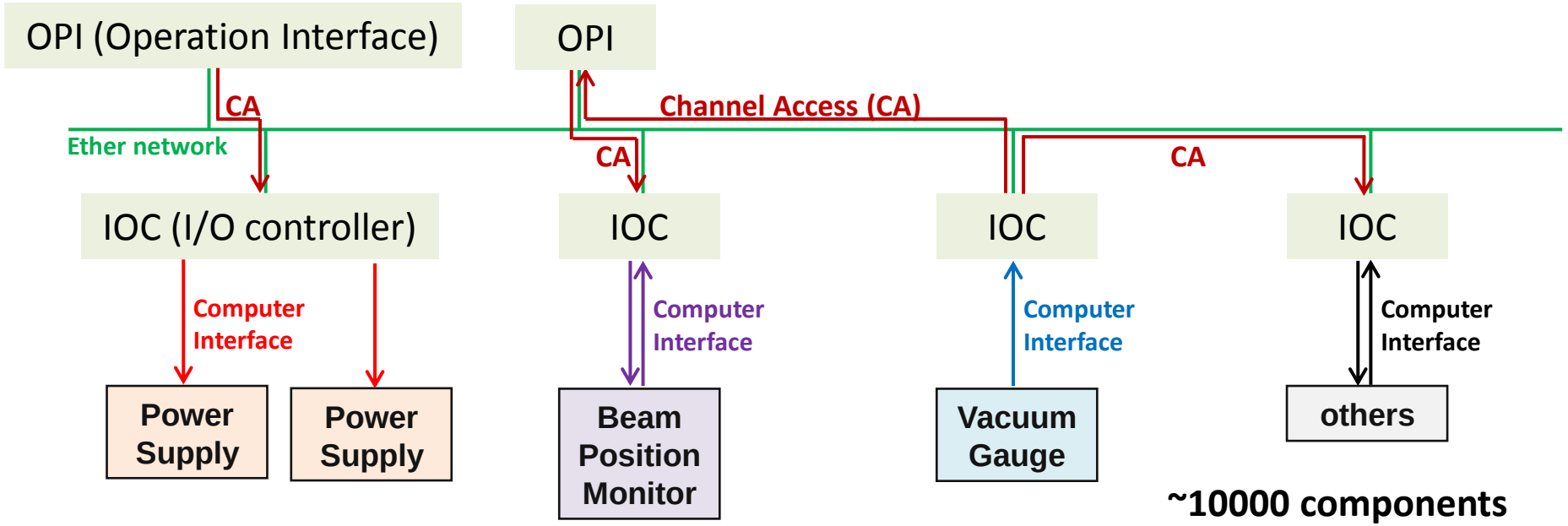
- unify communication protocol as Channel Access (CA)
- all user can easily control all hardware.

⇒ **Efficient commissioning and operation**

Role sharing

	Control	Others
Operation software		✓
OPI, Console	✓	✓
Network	✓	
IOC	✓	✓
Interface software	✓	✓
Hardware	✓ †	✓

† We take care of timing system and abort system.



~10000 components

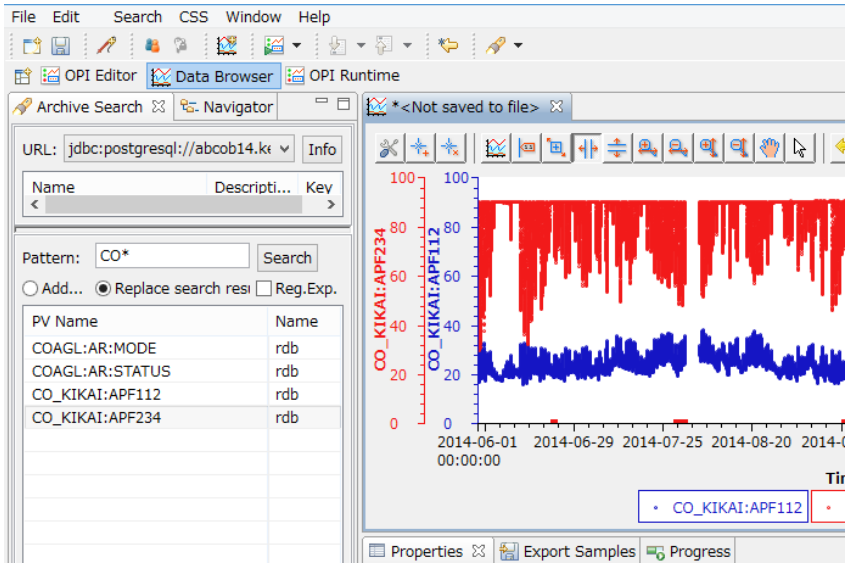
Data archiving system

We prepare two archiving system:

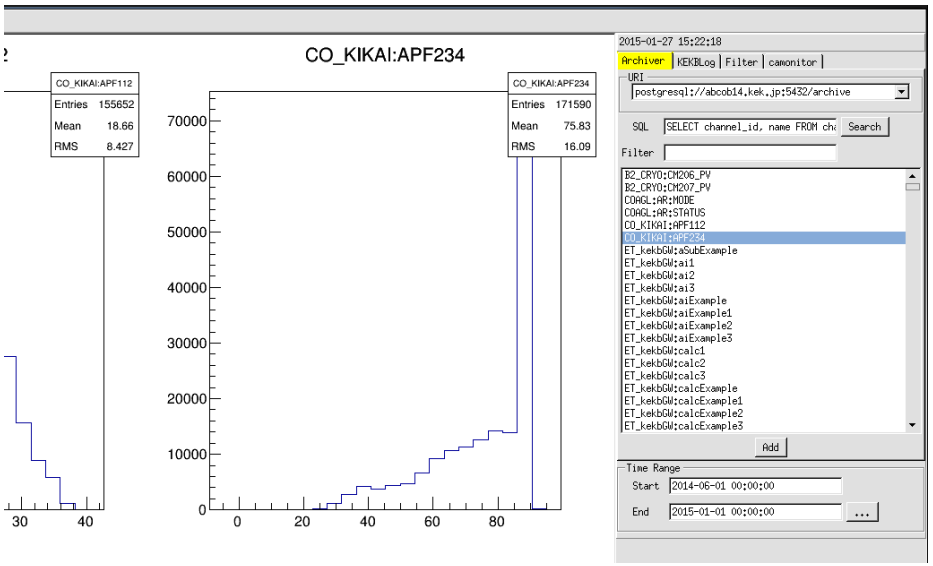
- KEKBLog ← main archiving system
- RDB(PostreSQL) stored with the CSS archiver

← Users can easily access from their PC with CSS or ROOT for real-time/historical/trend monitoring.

Data Browser based on CSS

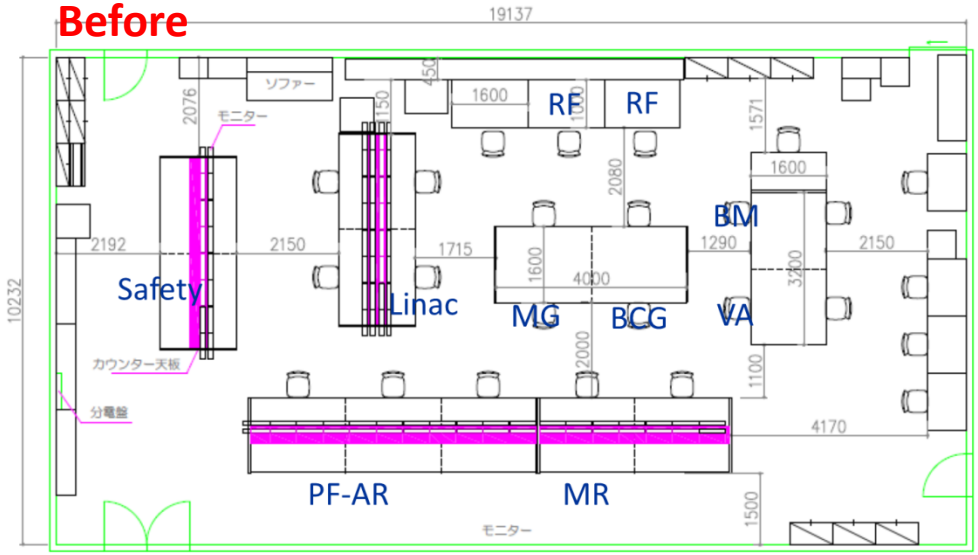


Data Browser based on ROOT

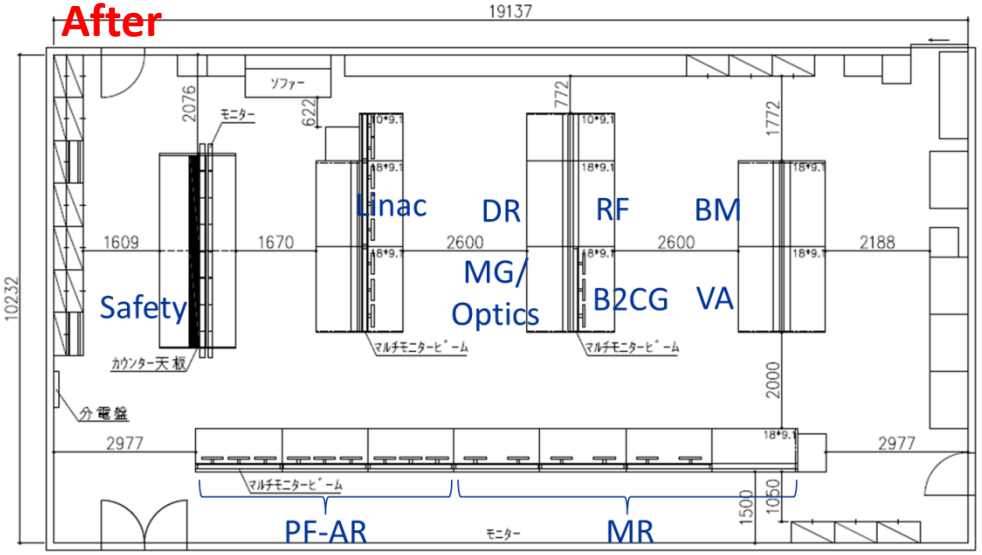


CCR layout

Before

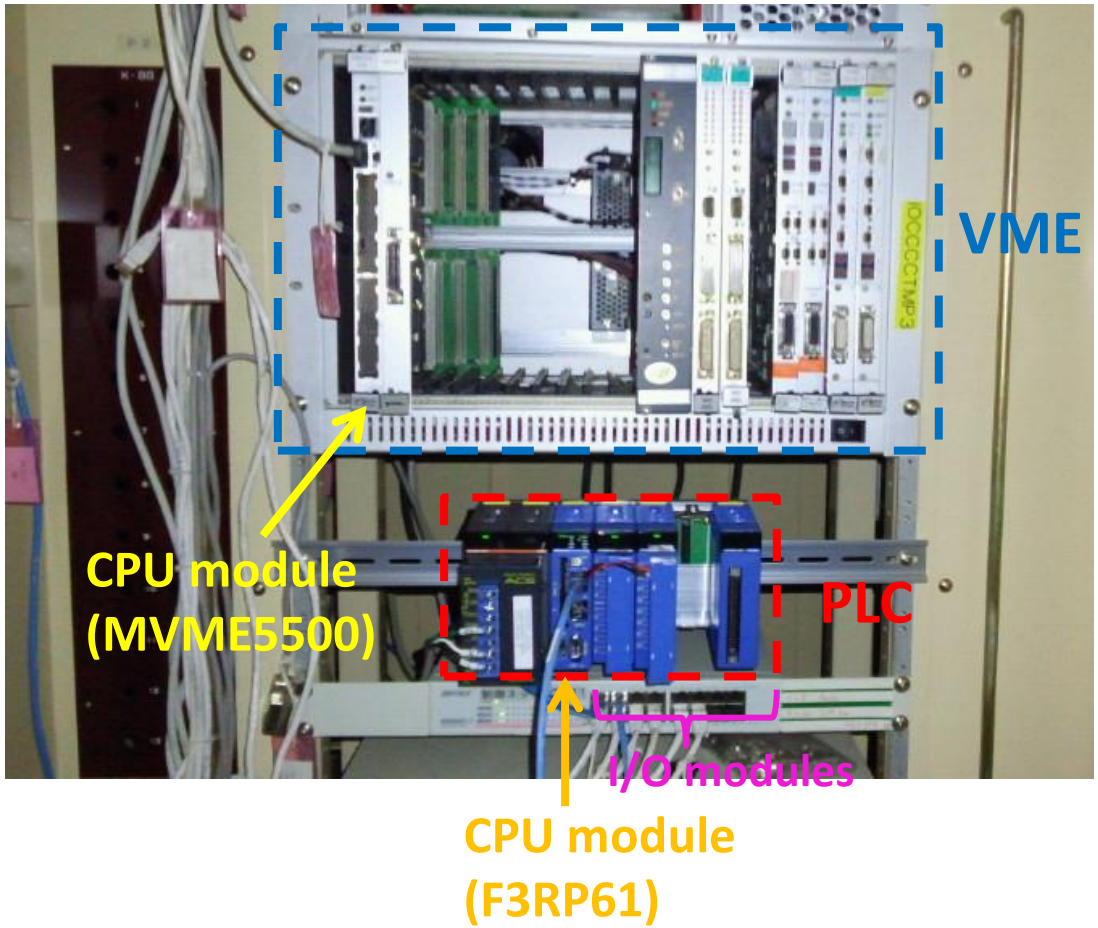


After



Standard IOC

We develop two kinds of IOC as “SuperKEKB standard”.
They are deployed to individual component groups.



VME IOC
CPU: MVME5500
OS: VxWorks
Advantage:
real-time OS

PLC IOC
CPU: F3RP61
OS: Linux
Advantage:
low cost, small size
low power consumption

Comment on 19th review – 1

As part of the upgrade many control functions originally packaged in VME or CAMAC are migrating to commercial IOC or uTCA form. This use of commercial standards is very attractive economically but the lifetime of commercial products can be very short compared to accelerator facilities.
As in past reviews we suggest that the team consider the necessary investment in spares that will be needed in the operating years, as direct replacements for some functions will not be so easily available.

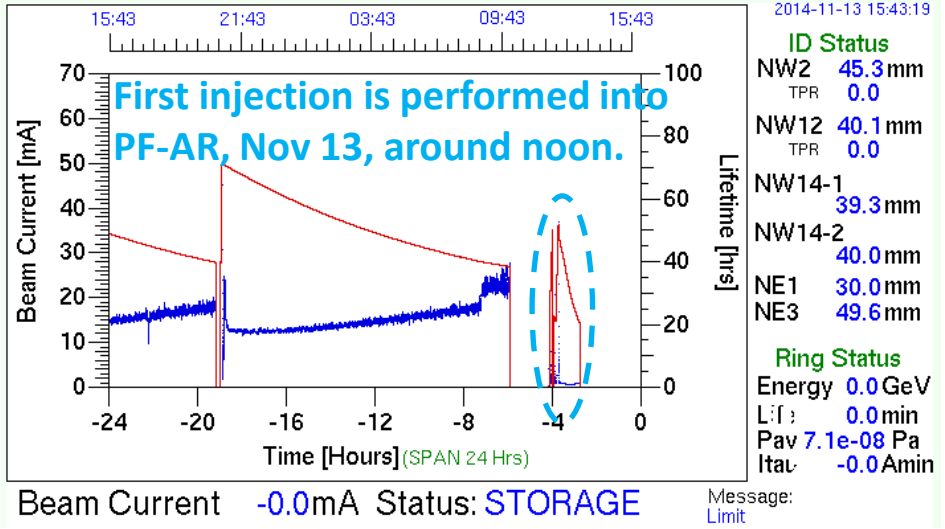
We always have ~10 spare modules and keep making additional purchases.
However we do not have a huge amount of spares.
We simultaneously study about substitute device.

We choose appropriate actions from followings when vender terminates production,

- purchase necessary spares
- apply substitute device at the part of control system
- the maintenance contract with vender.

Timing System

We utilize Event Timing System for triggering accelerator components and frequently changing their parameters.



We had a large progress in this fiscal year.

- New timing system is successfully operated at Linac.
- **Injection into PF and PF-AR are performed during machine study.**

  ⇒ regular operation with new system is very soon.
- We switch beam modes between PF and PF-AR pulse-by-pulse

  "during Linac machine study".

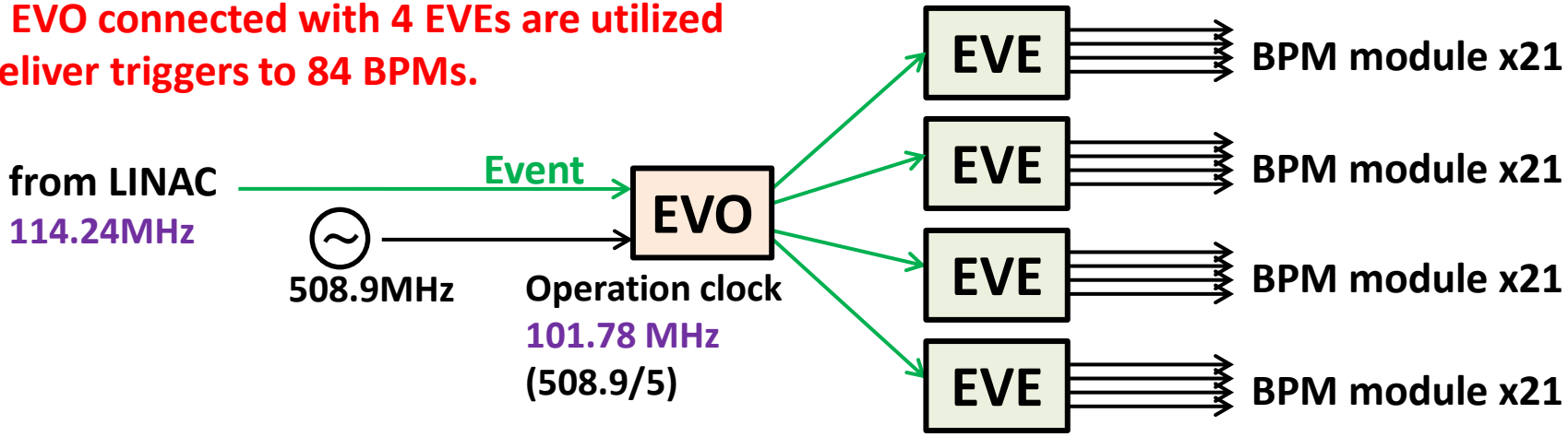
  ⇒ **important mile stone for the top-up operation at PF-AR.**

New modules are developed for sub timing system at DR and MR.
One of difficulties is difference of RF frequency,

Linac: 2856MHz (operation Event clock: 114.24MHz)
MR/DR: 509MHz (101.78MHz).

DR timing system

We develop new Event modules with SINAP for DR.
One EVO connected with 4 EVEs are utilized to deliver triggers to 84 BPMs.

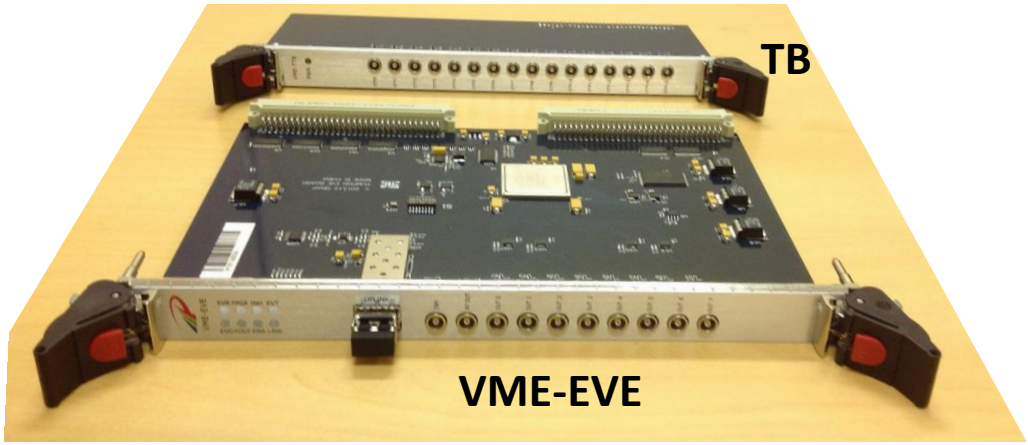


EVO

- directly receive an Event as trigger from upstream module.
- can be operated in different Event clock from that of upstream module.

EVE (+Transition Board)

- 24 output with fine delay setting(<1ns)
- they can be set up from upstream EVO.

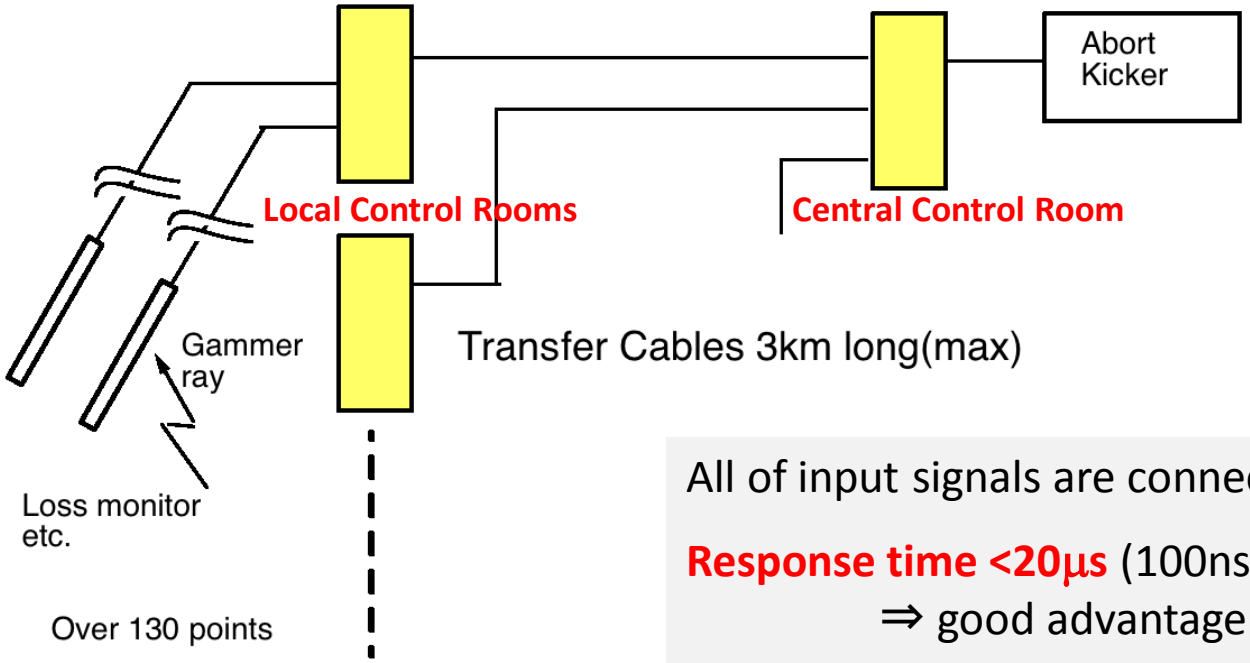


Test of proto-type module will be finished within a few month.
Distributed shared memory will be integrated in 2015 summer to satisfy the future requirement.

New beam abort trigger system

VME ABORT MODULE
(OR and Latching circuit)

VME ABORT MODULE
(OR and Latching circuit)



All of input signals are connected with optical fibers.

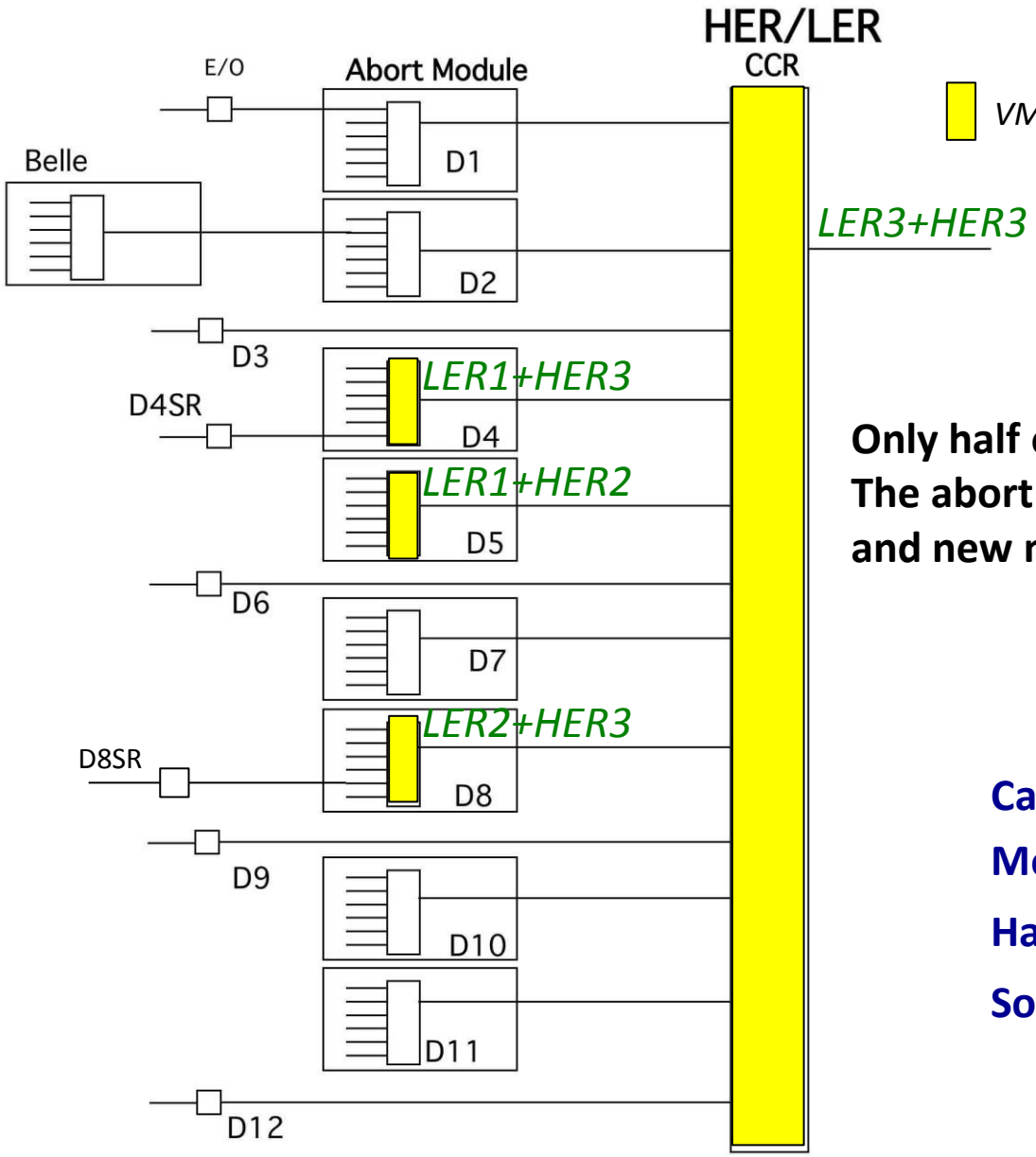
Response time <20μs (100ns for each module + cable),
⇒ good advantage to requirement†.

More than 130 points of input signal are processed.

Time stamp function to distinguish the order of input.

† Required response time for entire abort system: 100μs (10 turns).

Installation schedule of new modules



VME Abort module

Only half of 36 modules are installed in 2015. The abort system becomes mixture of current and new modules in phase-1.

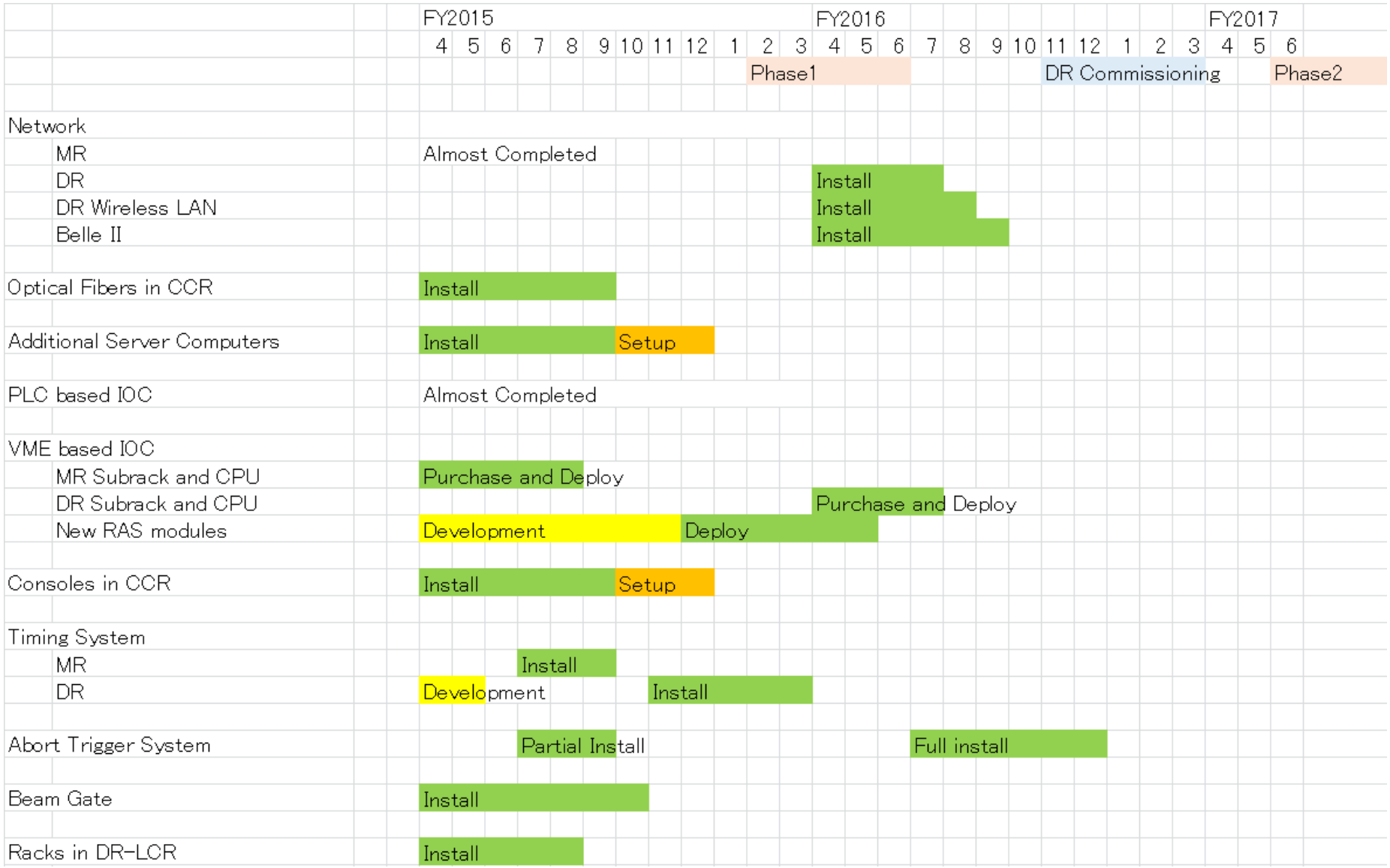
Cabling in July/2015

Modules installation in July/2015

Hardware check in Sep/2015

Software check in Sep/2015

Schedule for phase-1 and phase-2

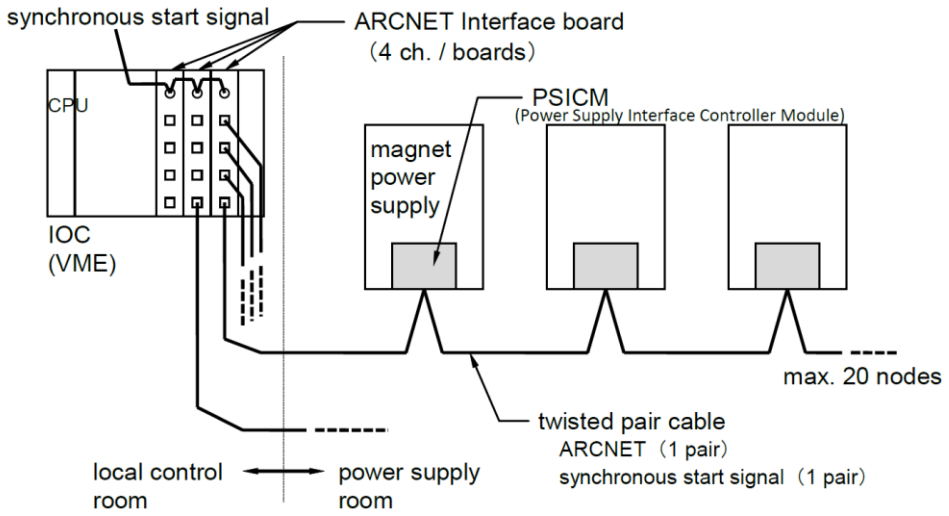


Interface to other groups

Individual members also work as an interface to other groups and support construction of control system for them.

A. Akiyama	Abort, Magnet
M. Iwasaki	Abort, Belle II, Beam Gate, QCS
H. Kaji	Timing
T. Naito	Abort
T.T. Nakamura	BT, Magnet
J. Odagiri	RF, Safety, Vacuum
S. Sasaki	Abort, Beam Gate

Status of Magnet Control



We utilize new PSICM (Power Supply Interface Controller Module).
The 1000 PSICMs are ready.

- The KEKB software (EPICS 3.13) has been ported to the upgraded IOC (MVME5500 w/ EPICS 3.14).
- First power supply test has been successfully done at DR-BT.
- Development of the (PLC based) interface IOC to the Magnet Interlock is in progress.

Plan for FY2015

- We will install new PSICMs. However both old and new modules are used in phase-1.
- Modification of software from KEKB version
- EPICS database configuration for SuperKEKB magnets.

The second mass production (2000 modules) for full installation depends on budget.

Comment on 19th review – 2

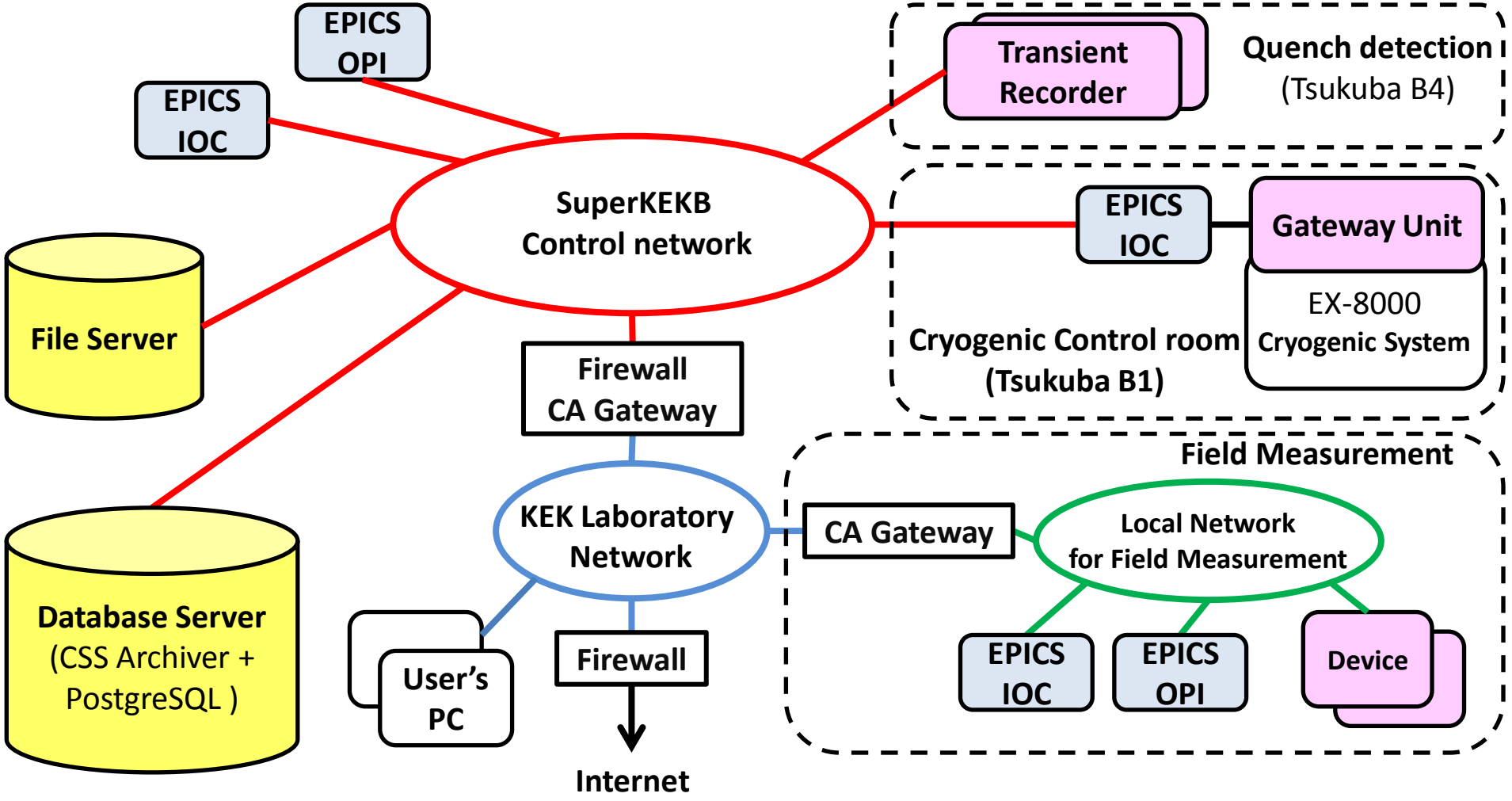
The presentation showed a power supply control board PSICM that is going to be widely used, roughly 3000 boards. This is an excellent implementation with useful upgraded features. We wonder if there is a plan to have the vendor doing fabrication test these boards (does the board design have loopback and self-test functions?), so that the team at KEK does not have to find manufacturing faults or do testing of so many discrete systems.

We designed the PSICM module and study its feasibility at KEK.
However, for mass production, we order it to vender.
The vender will test all modules before delivery.

So we do not perform initial test by ourselves.

Works related to QCS

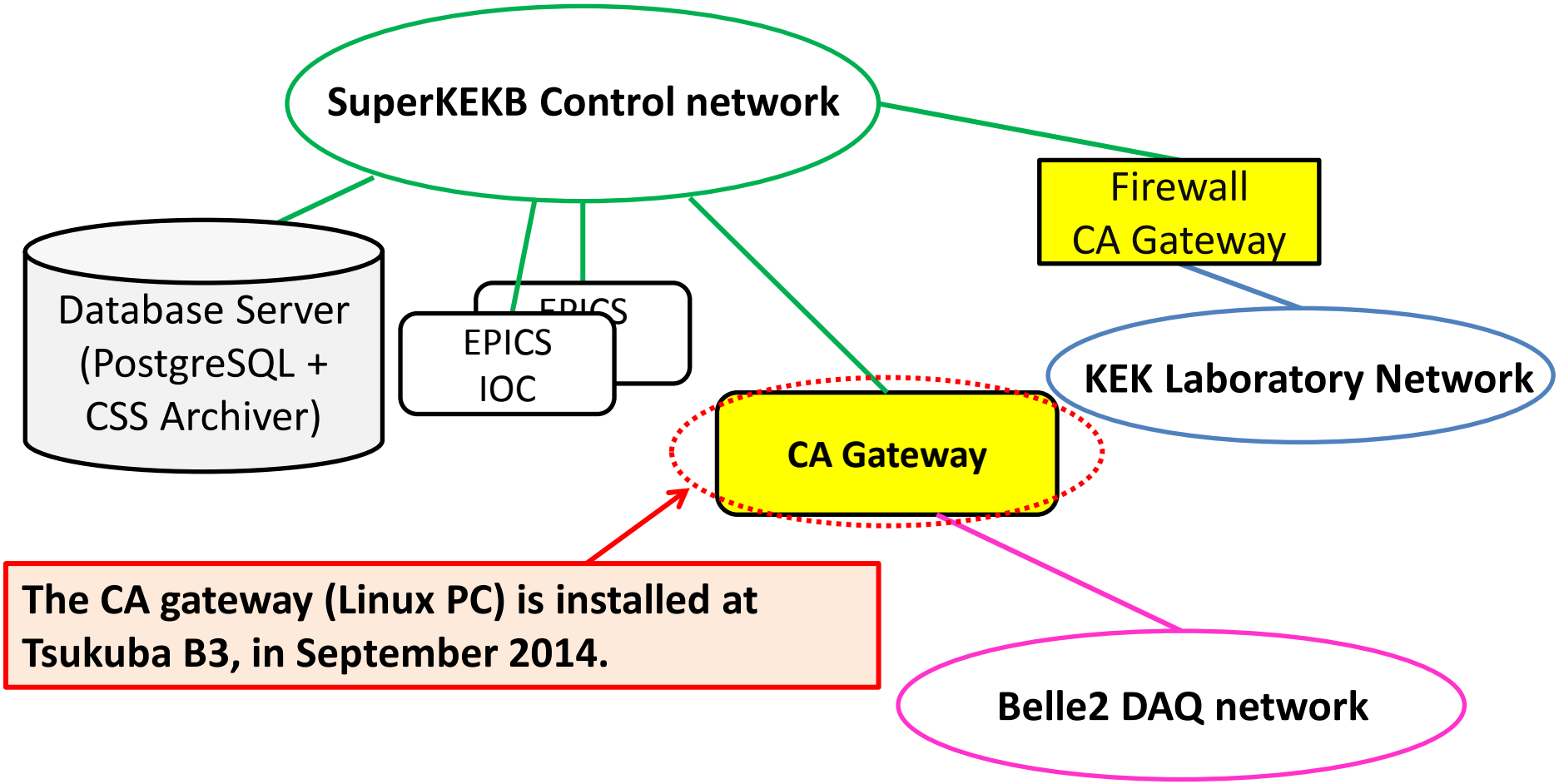
Based on EPICS, we have constructed
1) Quench monitoring system, 2) Cryogenic system monitoring, and
3) Control/monitoring system for the Field measurement.



Status of BT Control

- MR-BT
  - Upgrade of the Septum and Kicker Control System using PLC based IOC is in progress.
  - For the other part of MR-BT Control System, upgrade is scheduled after Phase 1. Because…
    - Almost no modification of the BT components (only some magnets are added) are planed.
    - Upstream part of the KEKB BT is shared with the PF-AR BT and PF-AR is in operation until the construction of new PF-AR injection line starts.
- DR-BT
  - Development of the Septum and Kicker Control System is in progress. PLC based IOC is mounted in each Power Supply.
  - ARCNET and PSICM are also used for BT (DC Magnet Control).
  - Designing of the Screen Monitor Control System starts.
  - For the other part of DR-BT Control System, Developments start in FY2015

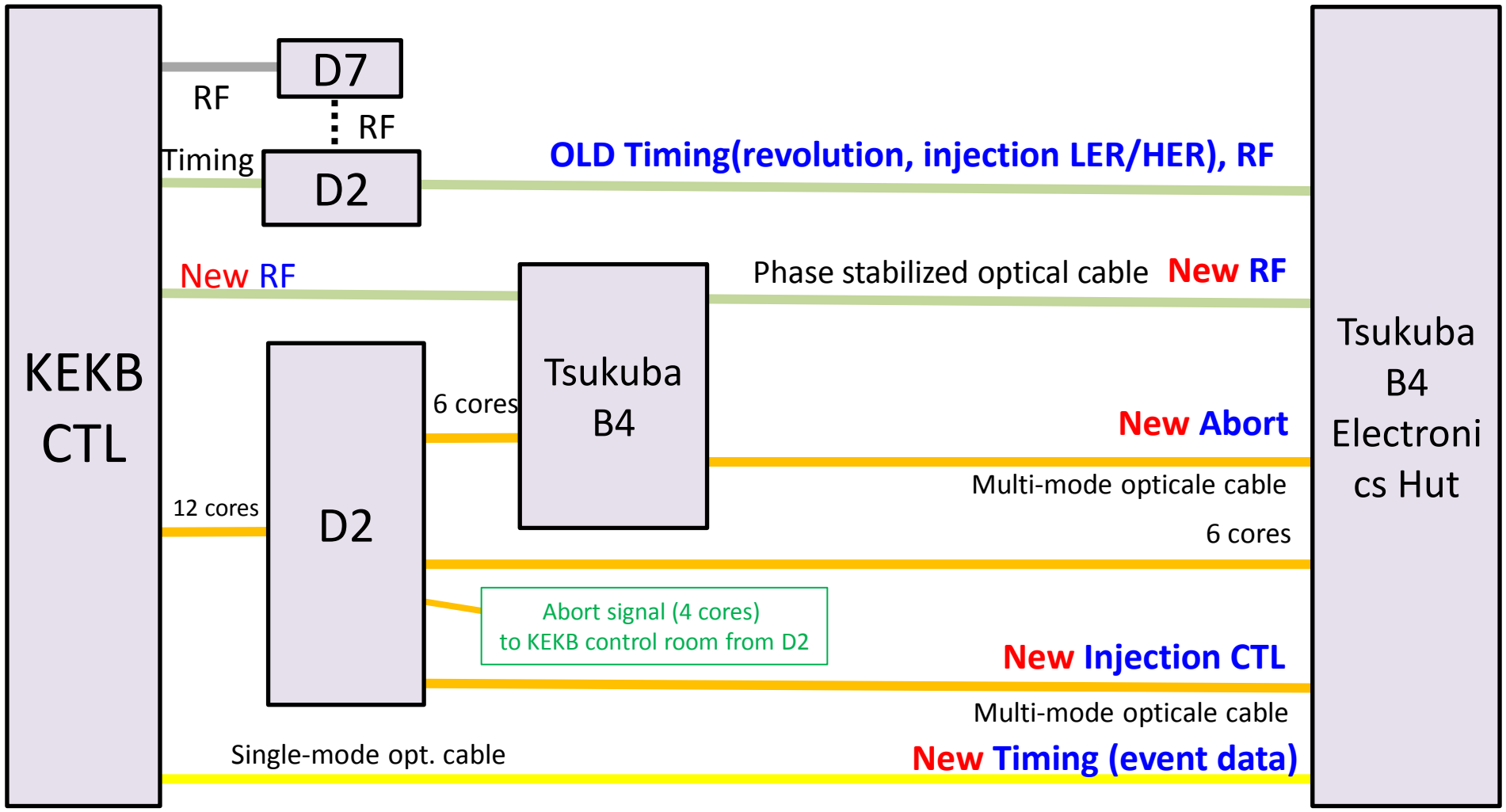
CA gateway between SuperKEKB and Belle II



The Belle2 and SuperKEKB EPICS records can be directly (read only) accessed from the SuperKEKB and Belle2 network, respectively.

Hard-wired signal

We installed optical cables for RF, timing signal, abort and injection control, in 2014 September.



More

Vacuum:

PLC-based IOCs are now under testing along in the various vacuum subsystem.

LLRF:

Fully-embedded-EPICS-based LLRF control system has undergone the test of high power RF components without any serious problems

PPS:

PLC-based personnel protection monitoring system has partly completed and been already in operation

Beam gate with new FPGA board:

⇒ see Ring Commissioning talk by Y. Funakoshi.

Summary

We develop control system based on EPICS.
- New OPI tools are developed.
- Setup of new console at CCR is on-going.

We take care of some hardware (timing/abort/beam gate).
- New Event Timing System is successfully operated at Linac.
- We develop new Event module for DR.

We also work as an interface with other groups and help their construction of control system.
- First power supply test of PSICM has been successfully done at DR-BT.
- CA gateway is installed between SuperKEKB and Belle II.

We postpone some works because of budget.
- Abort system becomes mixture of old and new modules in phase-1 operation.
- Preparation of IOC and network for DR is scheduled in the next-to-next JFY.
- Second mass production of PSICM depends on budget.

Version up of PSICM

(**P**ower **S**upply **I**nterface **C**ontroller **M**odule)

- Interface/Controller card plugged in power supply
  - Microprocessor is embedded
  - ARCNET controller and driver
  - Timing signal input to start synchronous ramping
- New version of PSICM
  - Support high speed communication (10/5/2.5Mbps)
  - Support high resolution Power Supply (24/20/18/16bits DAC)
  - Fully compatible to the current version for the Magnet PS
  - Redundant timing signals
  - More reliable connectors

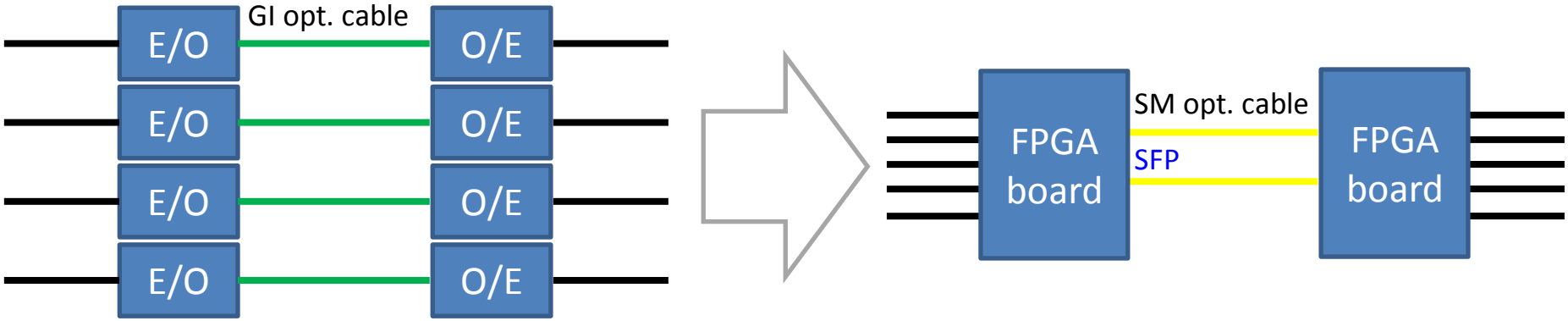
Old Version

New Version
(Prototype)

New signal transfer scheme

For satisfying the future request to increase number of signal,

Currently we have developed the new signal transfer scheme based on the sampling and parallel/serial conversion using FPGA.

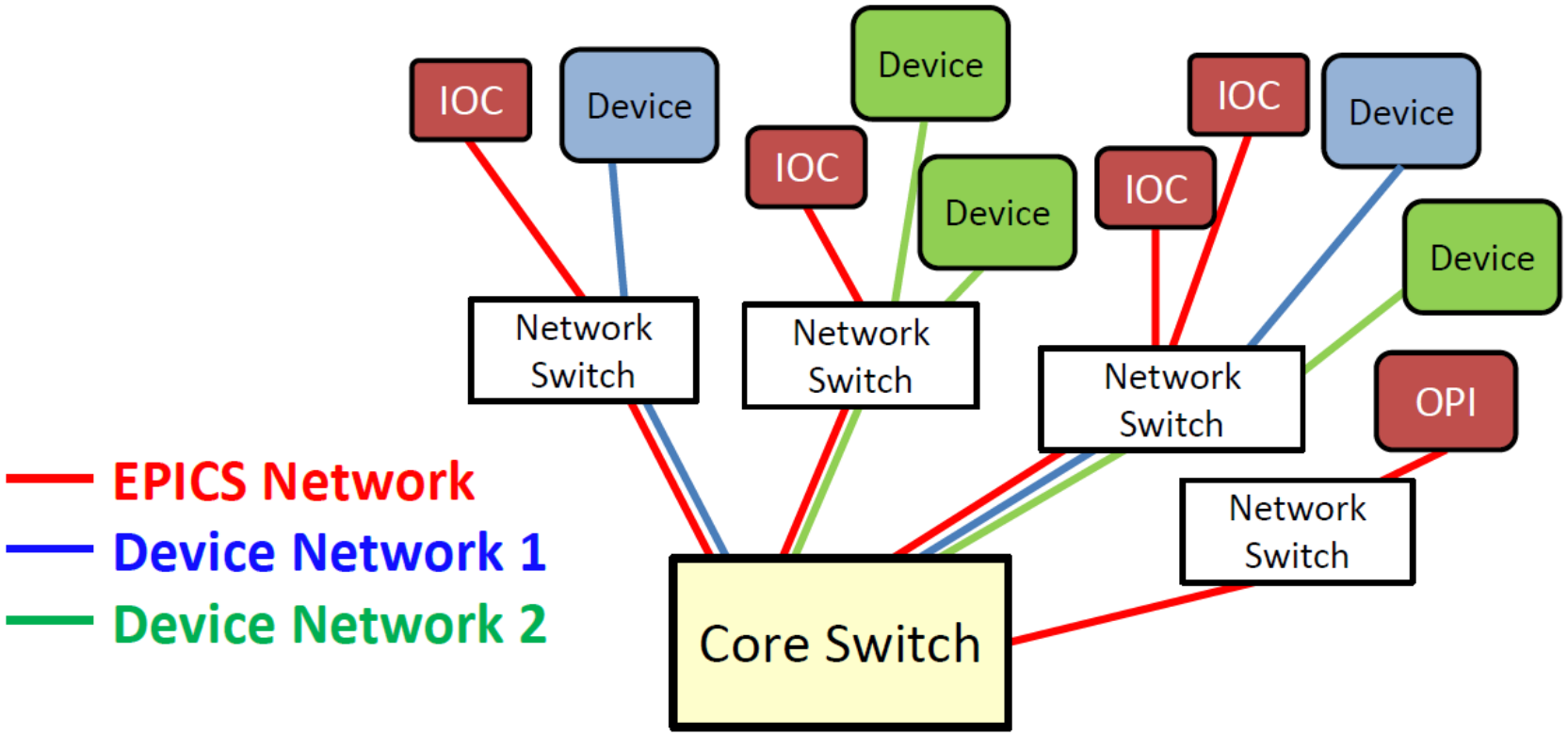


# of optical cables = # of signal

# of optical cables = 2

VLAN segmentation

In Feb. 2014, we apply VLAN segmentation for the SuperKEKB control network.



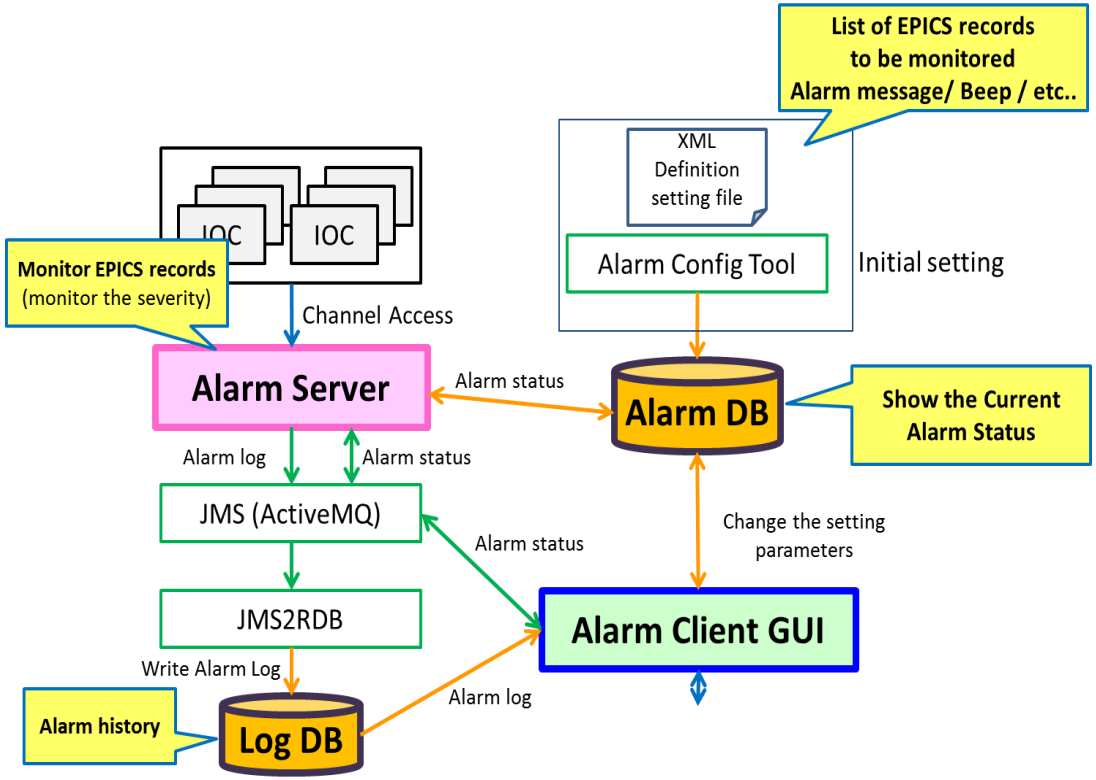
We have tested the new VLAN segmentation

→ IOCs in the EPICS network can control the devices in the device network.

CSS-based alarm system

Alarm system based on CSS

- Used at PF-AR from 2011 fall. ← operated with no problem so far
- Recently installed at Linac.
- J-PARC is also considering to install the system.



To apply to SuperKEKB

We must make sure that it operates under the several 10 thousands alarm data points.
⇒ We did load tests and confirmed stable operation with 50000 points.

We must develop the software tools to meet our operation system.