# Status of the SuperKEKB Accelerator Control System

*M. Iwasaki (KEK)*

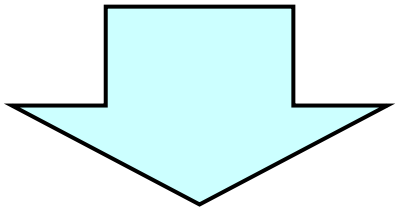
*for the SuperKEKB accelerator control group*

# Introduction

**The KEKB accelerator is upgraded to SuperKEKB**

***x40 higher luminosity***

- More precise, reliable, and robust accelerator control system is required.
- Many accelerator components are upgraded.



***Reliable and robust network system*** *is required.*

***Device controllers*** *(software/hardware) for the accelerator components should be upgraded.*

# What we did in JFY2013

## *1. New network system construction*

Wider band-width (100MbE → 10GbE),
Redundant system, New network configurations,
Wireless LAN system installations, …

## *2. Device controller upgrade & implementation*

Vacuum system, LLRF, Magnet power supply,
Safety system, QCS cryogenic monitoring system, …

## *3. Additional new data archiving system*

## *4. Beam abort system R&D*

## *5. Timing system R&D*

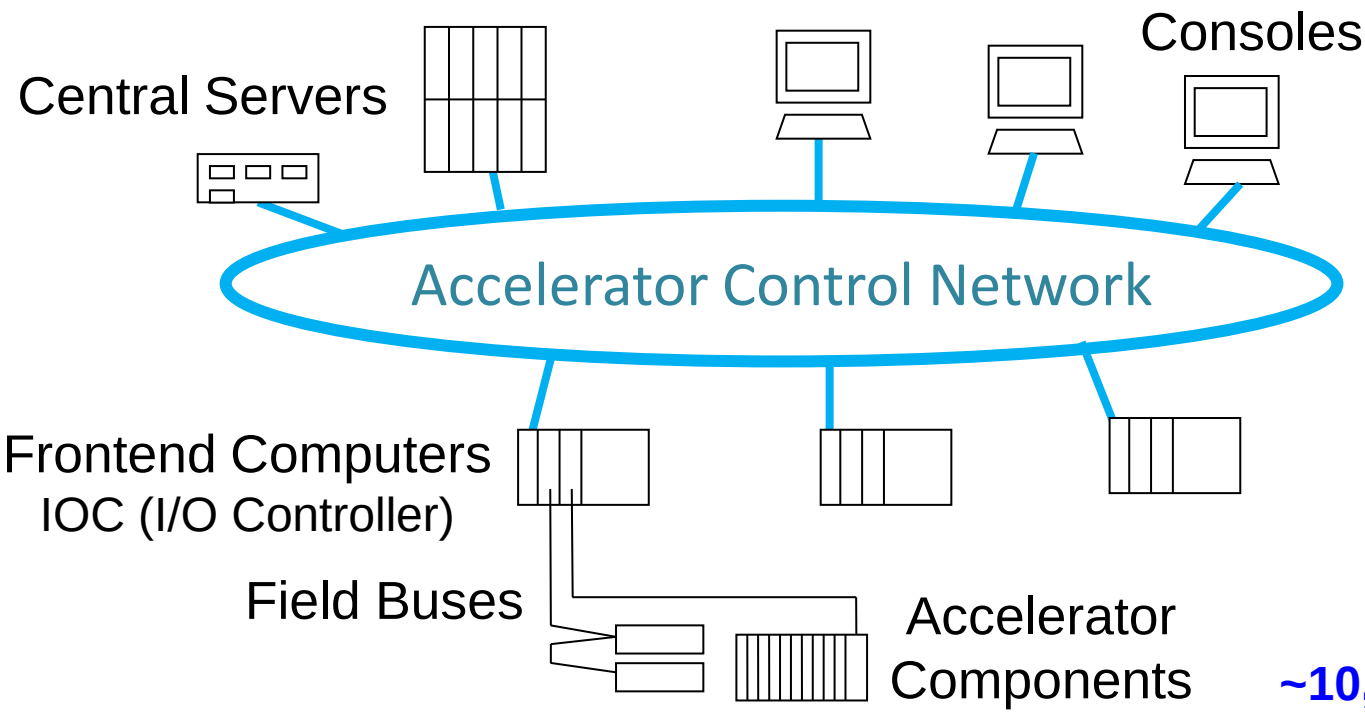
## *6. Renovation of the computing room*

# SuperKEKB Control System

- **EPICS is used as the main software to control the accelerator**

  2 layer model
  - **OPI (Operation Interface)** --- operation programs on central servers
  - **IOC (I/O Controller)** --- equipment controls on frontend computers
- **Scripting Languages are used for the operation programs**

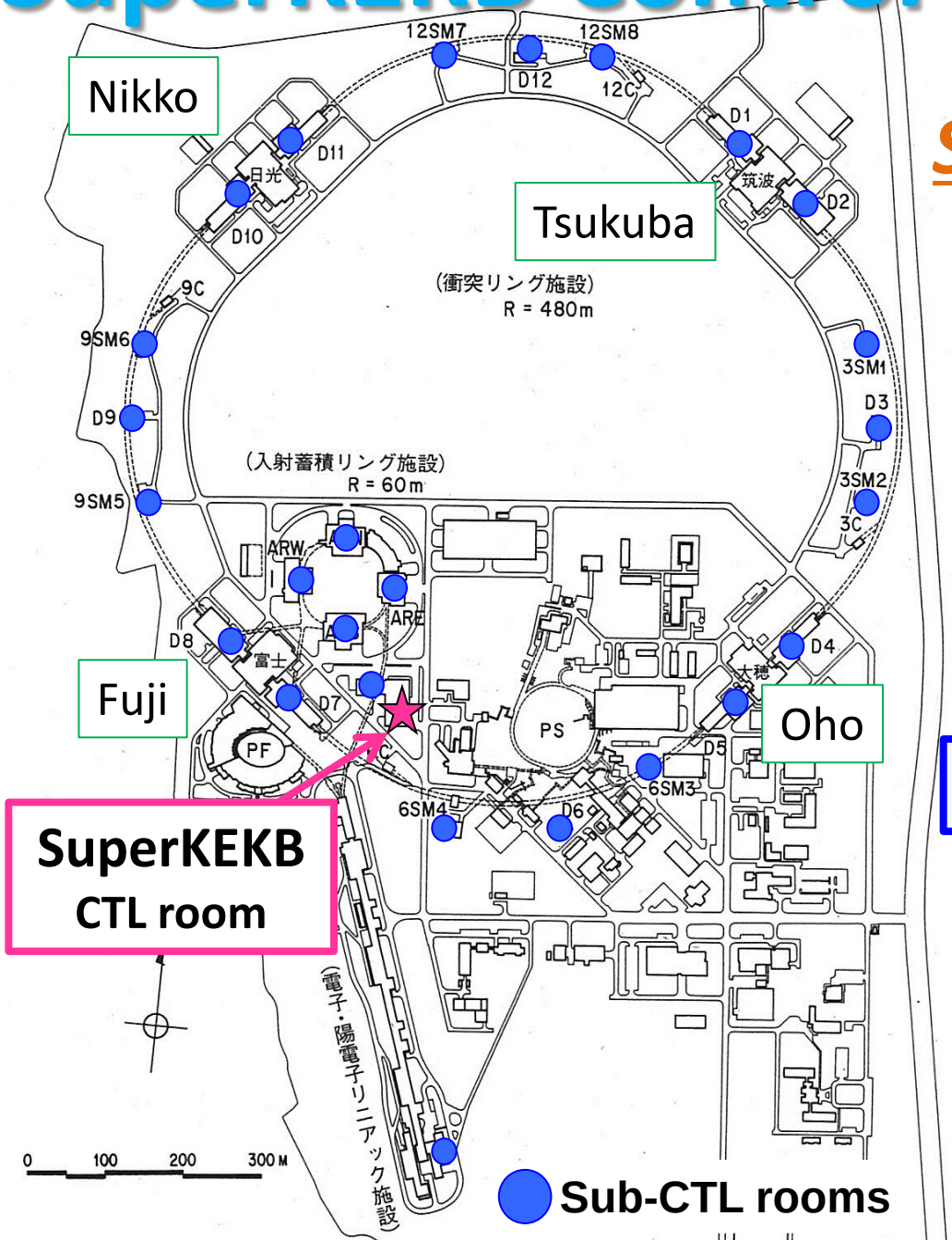
  **SAD Script/Tk Python/Tk Tcl/Tk**




**~10,000 components**

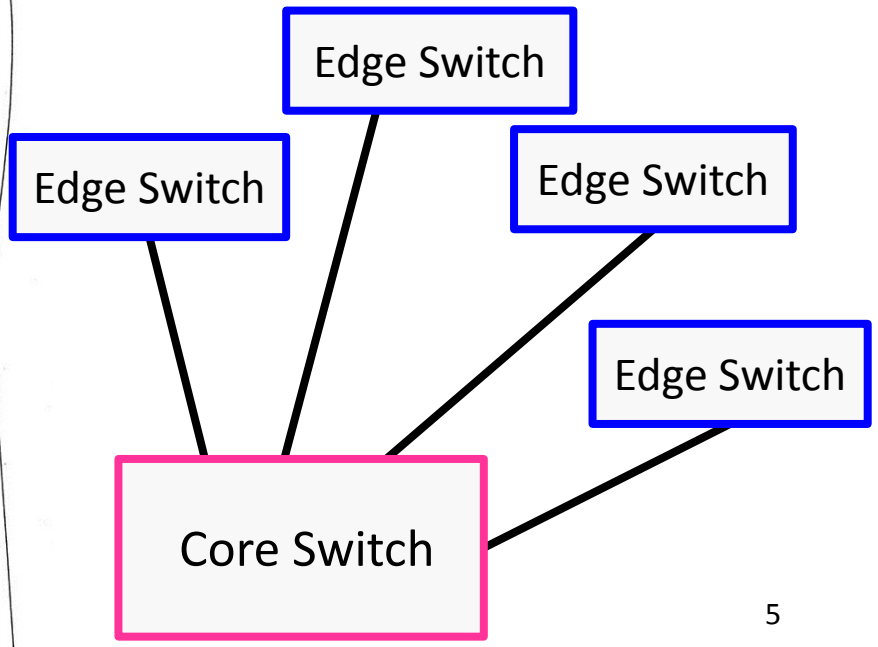
**# signals to control → ~200,000**

# SuperKEKB Control Network System




## *Star network topology*

- Main network switch (core switch) is located at the SuperKEKB CTL room.
- All network switches (edge switches) in the 26 sub CTL rooms connect to the main network switch.

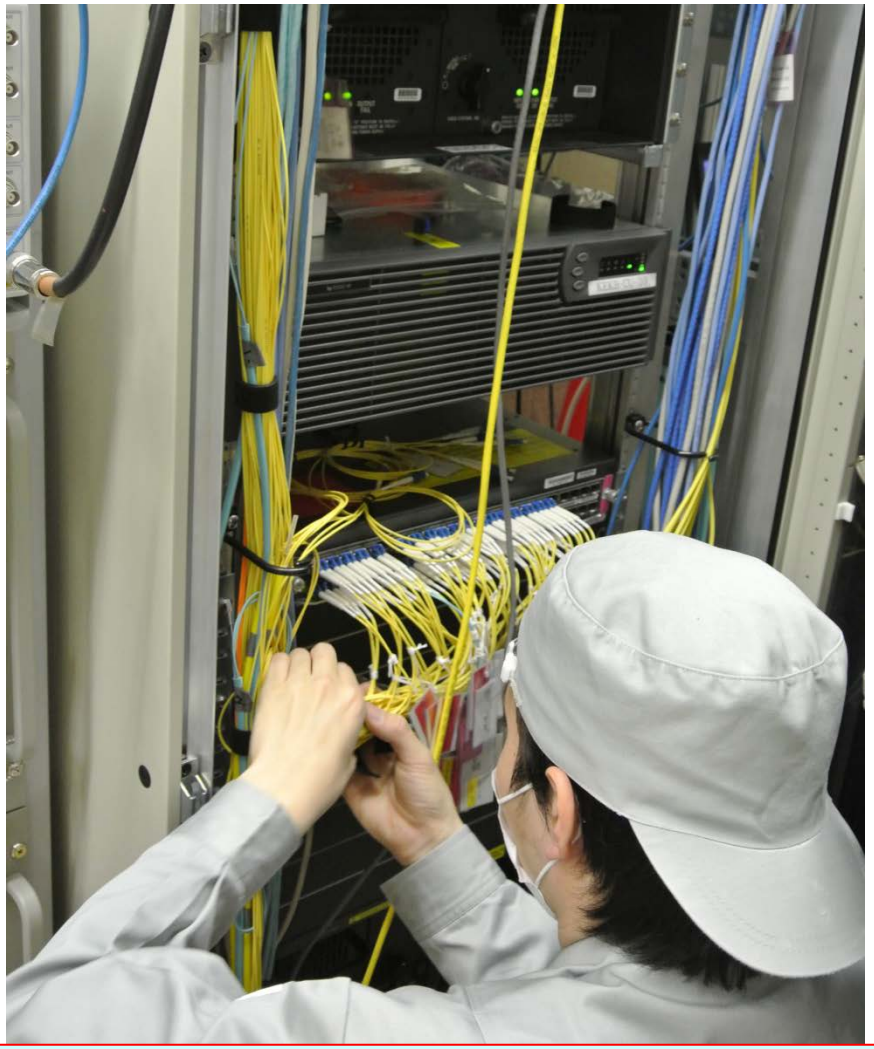


# Upgrade of the network system

***In JFY2013, the control network system is upgraded.***

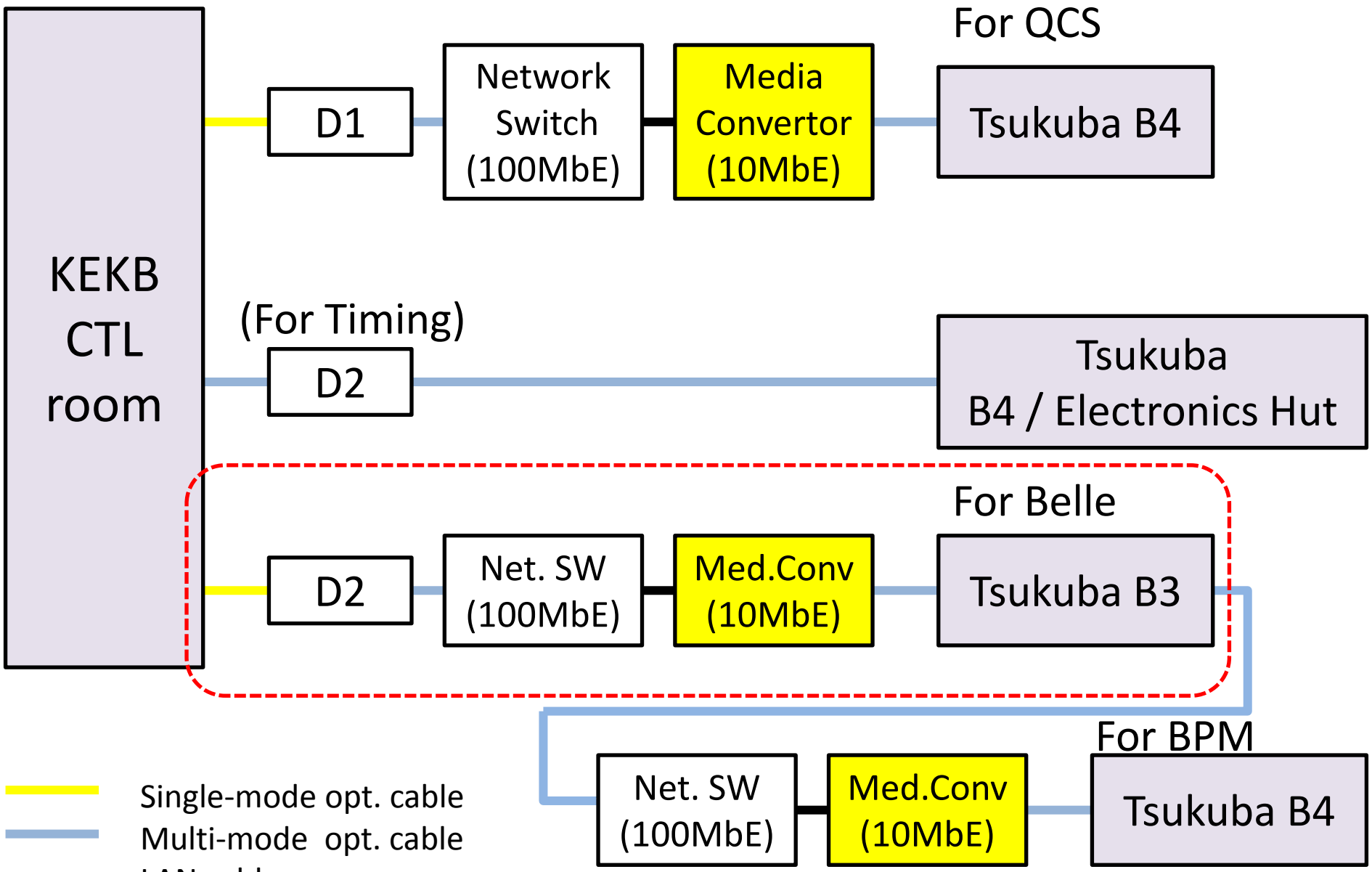
1. **Wider band-width data transfer (100MbE → 10GbE)**
   Replace 100MbE switches to 10GbE ones.
2. **Redundant system**
   - Install additional optical cables.
   - All edge switches are connected to the core switch via both 10GbE and 1GbE lines, and form the active/standby configuration.
3. **Direct connection btw SuperKEKB and BelleII**
   - Install optical cables to make direct connections.
   - Install 10GbE switches for higher speed data transfer.
4. **New network configuration**
   - Apply VLAN segmentation into the SuperKEKB control network.
   - Change Network connections btw SuperKEKB control network and KEK laboratory network to enhance network security.
5. **Wireless LAN system installation**
   SuperKEKB tunnel, AR, sub-control rooms, power equip. buildings

# 10GbE Network Switch Installation

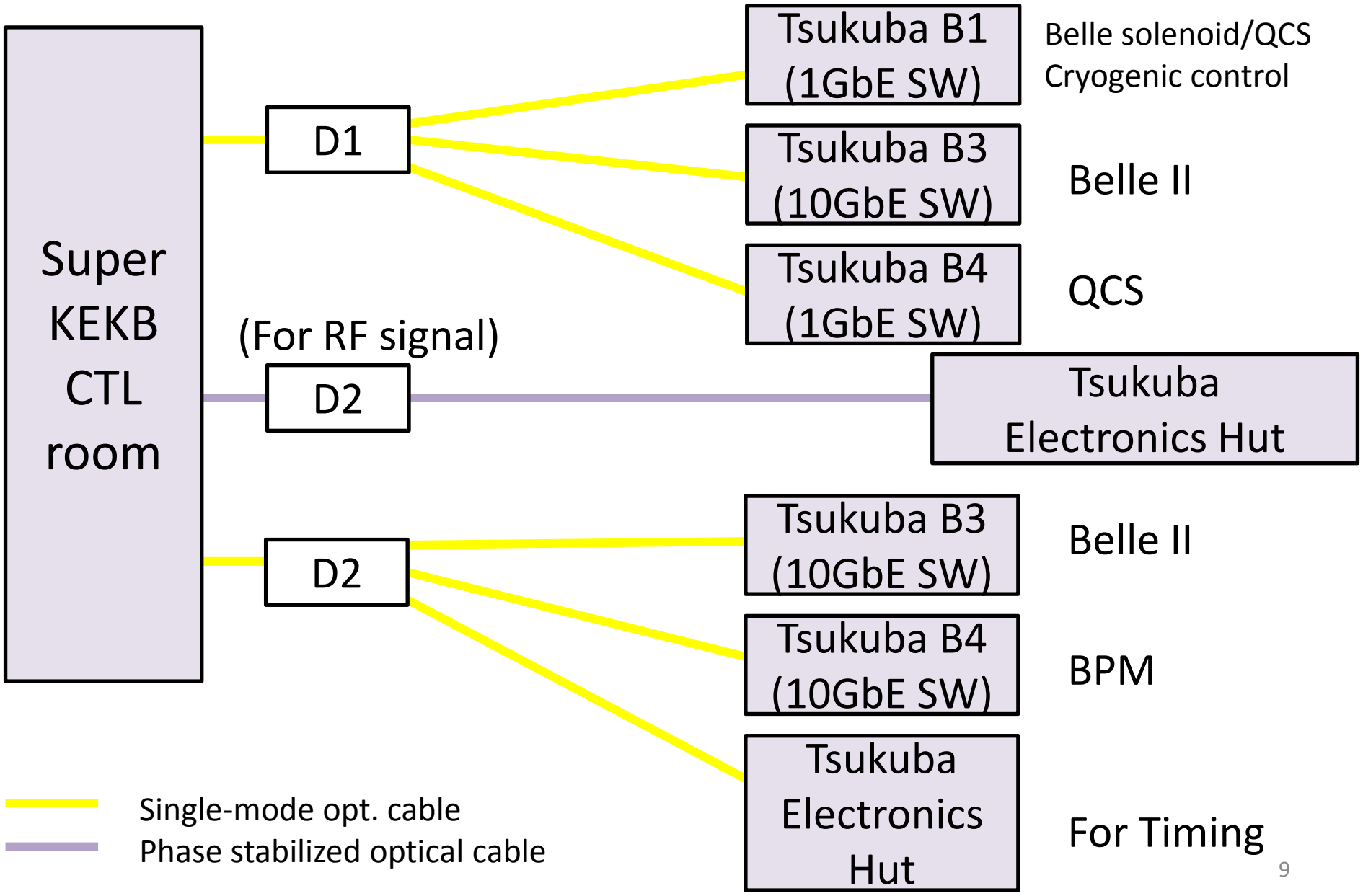




We install ~30 10GbE switches in Feb. 2014,
and change the network configurations.
(Redundant connections, VLAN segmentations)

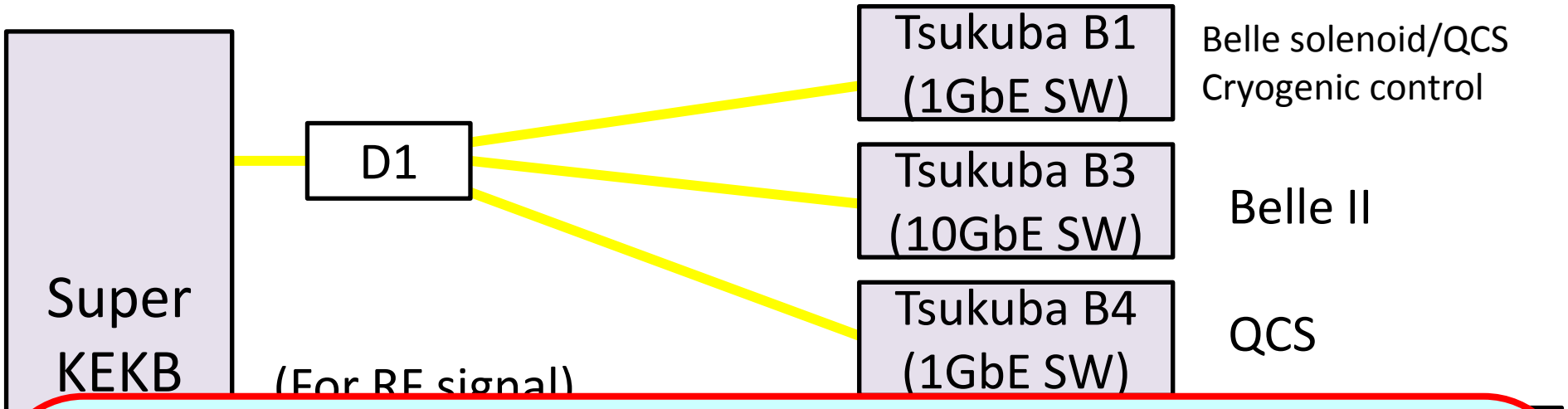
# KEKB-Belle Network Connection



# SuperKEKB-BelleII Network Connection



# SuperKEKB-BelleII Network Connection




**- SuperKEKB & BelleII are directly connected**

**- Wider bandwidth data transfer (10MbE → 10GbE)**

Optical cables are installed in Dec. 2013

Network switches are installed in Feb. 2014

# VLAN segmentation for SuperKEKB

- **We use EPICS to control the accelerator.**
- **EPICS uses UDP broadcasts to communicate btw IOC & OPI.**

  Many UDP broadcast packets in the control network.
  (~90% of the total network traffic)
- **More UDP broadcasts in the SuperKEKB network.**

  Accelerator components with Ethernet interface also receive the UDP broadcasts, and cannot work properly.

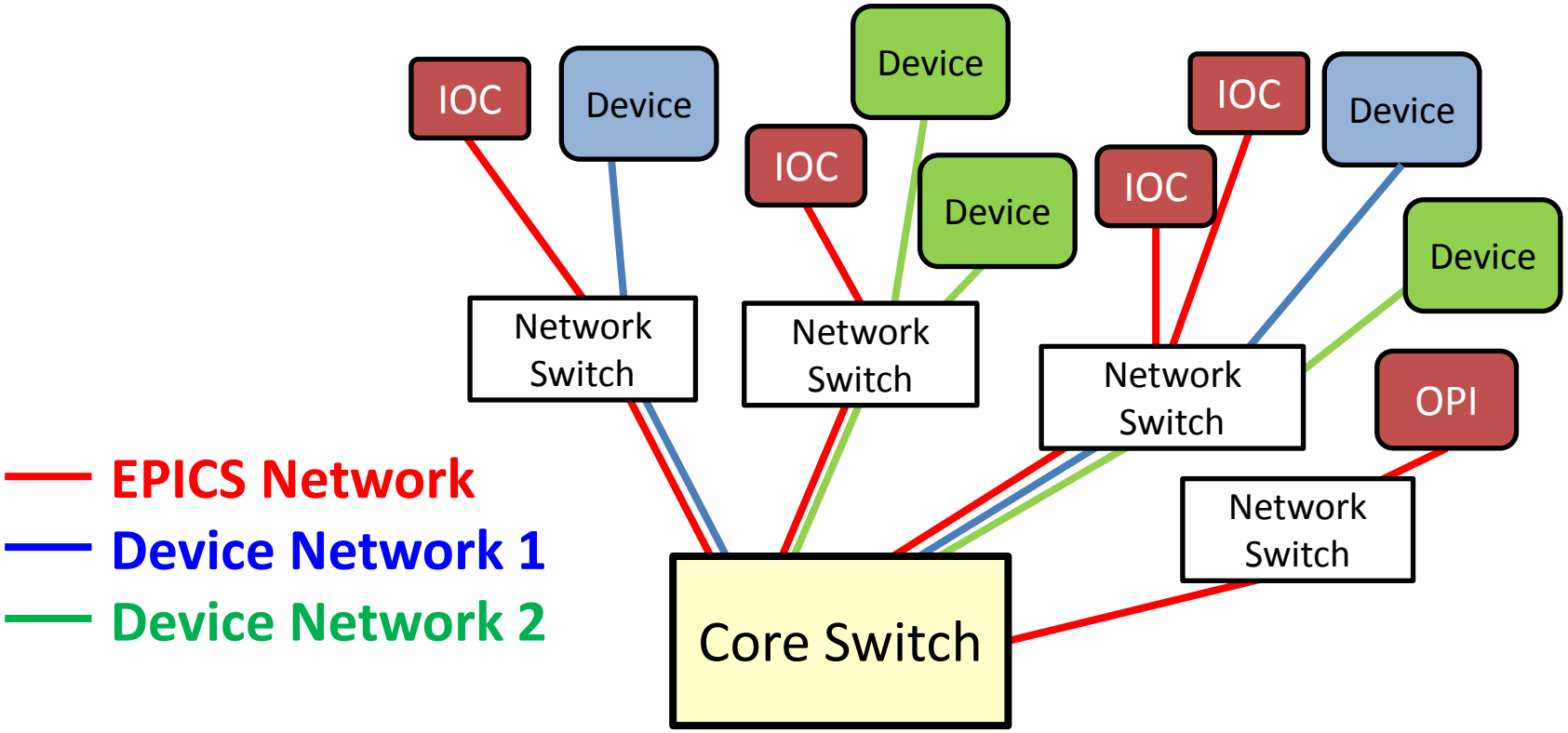
**We apply VLAN segmentation to protect the accelerator components**

SuperKEKB control network consists of

1. EPICS network (for EPICS IOC and OPI)
2. Device networks (for accelerator components)

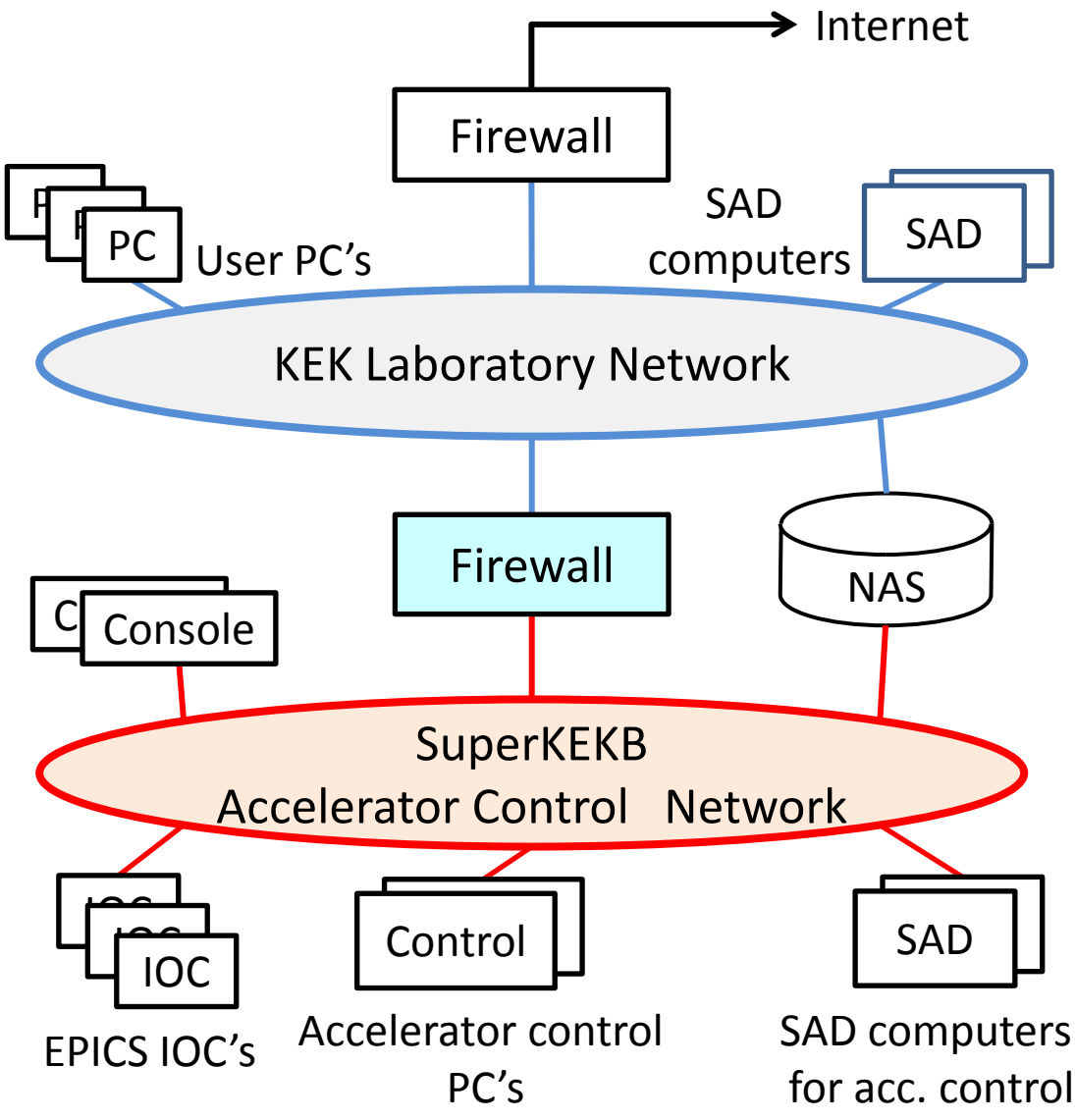
# VLAN segmentation for SuperKEKB

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.

# Network reconfiguration to connect with the KEK network




We changed the network configuration in Aug. 2013.
→ ***Enhance the security***

*KEKB*
Many computers connect to both KEK and KEKB control networks

*SuperKEKB*
Computers in acc. control network don't directly connect to the KEK network

# Wireless LAN system installation

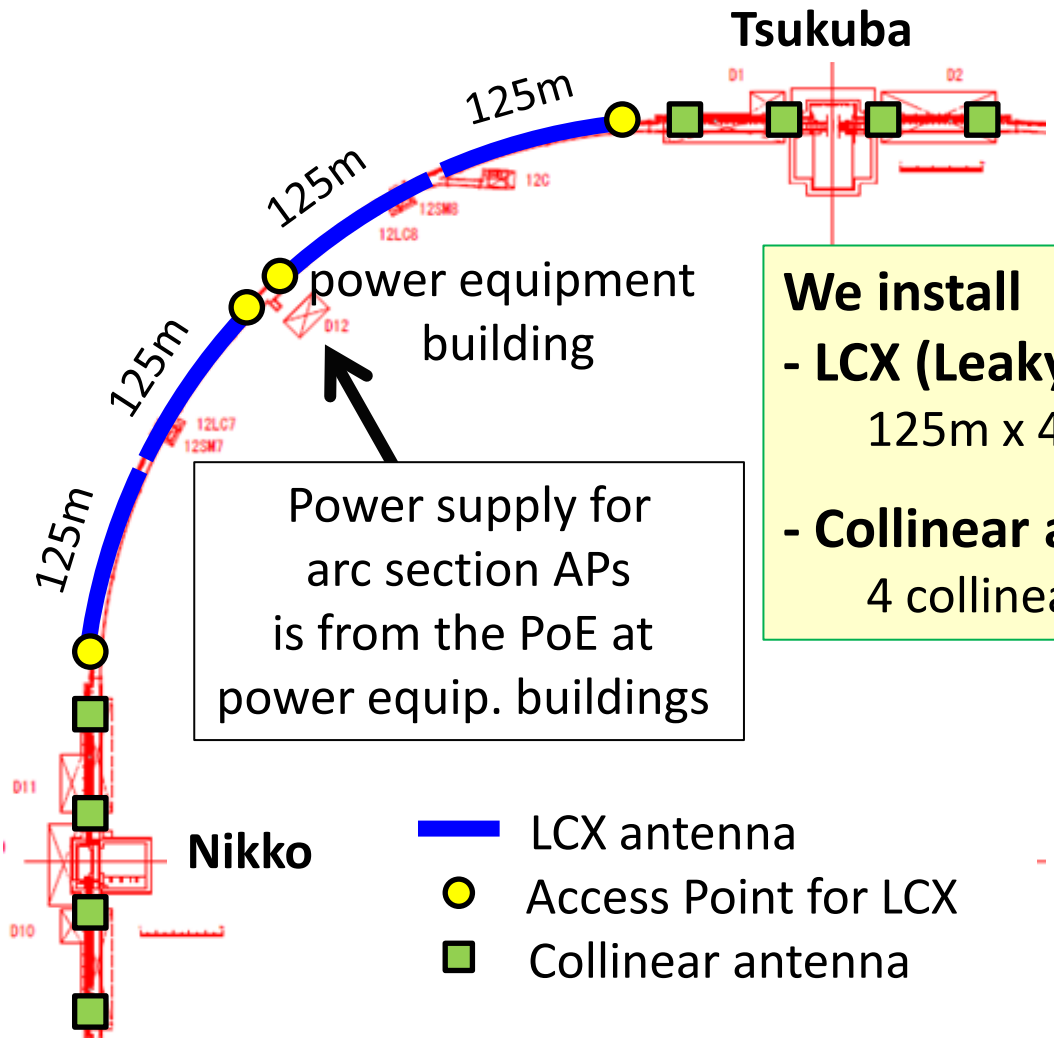
In JFY2012 – 2013, we installed wireless LAN into

- Whole SuperKEKB tunnel
- AR tunnel
- Power equip. buildings

for construction and maintenance of the accelerator.

All access points (~70) as well as Linac's
are controlled by 1 controller.

# Wireless LAN system into the whole 3km tunnel area




**We install**

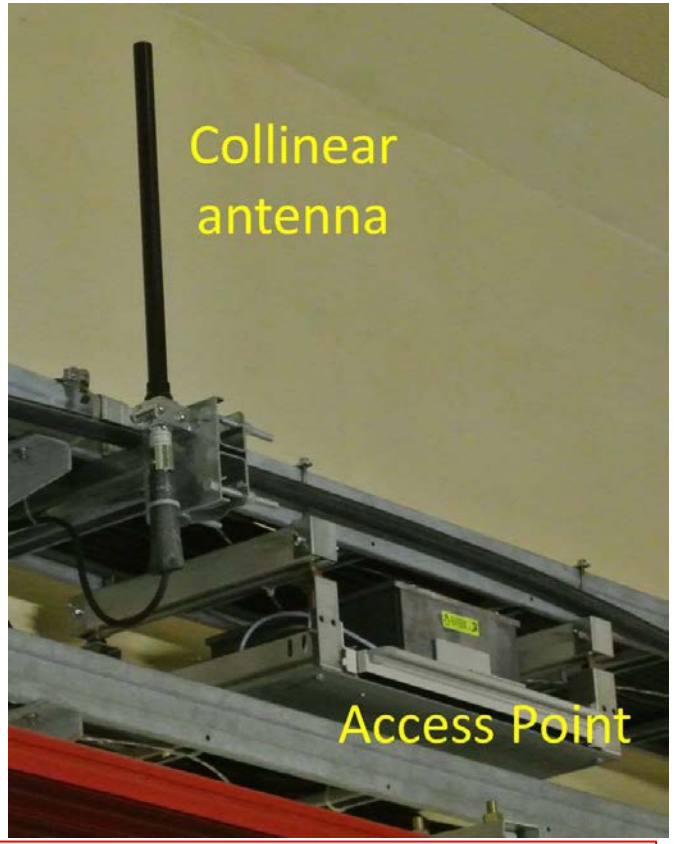
**- LCX (Leaky CoaXial cable) antennas for arc**

125m x 4 LCX antennas / one arc section

**- Collinear antennas for straight sections**

4 collinear antennas / one straight section

# LCX and Collinear antennas in the SuperKEKB tunnel


- Select LCX and Collinear antennas with radiation hardness >1MGy.
- APs and PoEs in the tunnel are installed within lead boxes.
- Connector connections are wrapped with lead sheets and fixed with polyetheretherketone (PEEK) cable ties.

# Device Controller for SuperKEKB

**In KEKB, we mainly used VME/VxWoks IOC (I/O Contoroller)**

**In SuperKEKB, we use**

**1) VME/VxWorks IOC**

CPU is upgraded

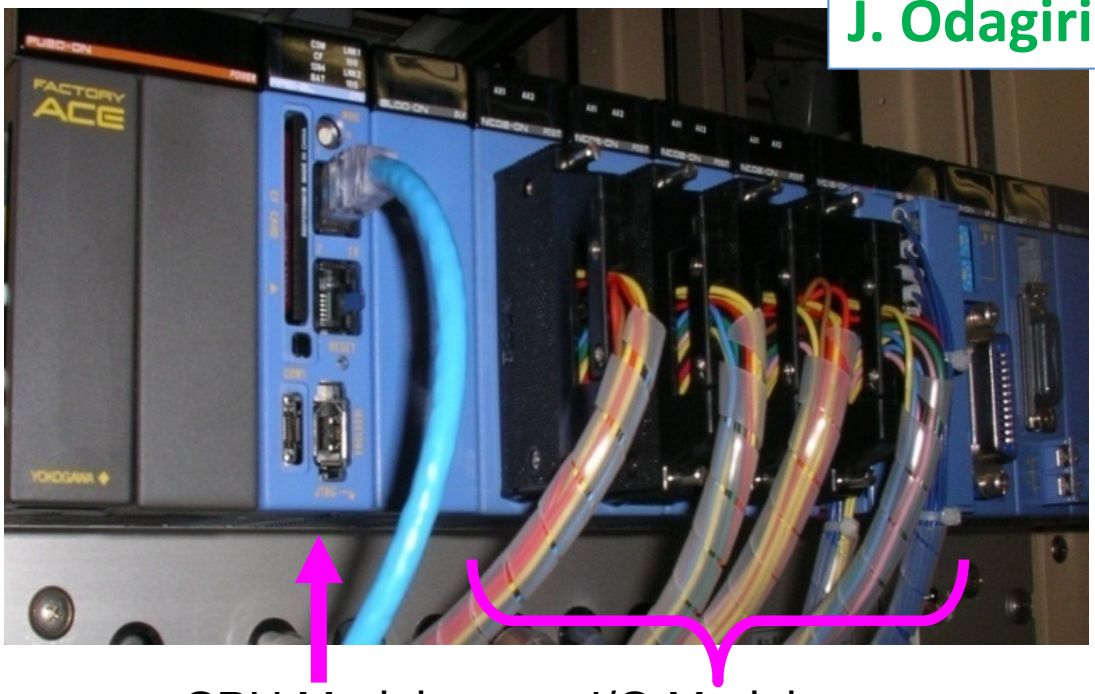
**2) PLC/Linux IOC**

- Yokogawa FAM3 series
- Linux running on the CPU module(F3RP61)

Apply for Vacuum system, Beam collimators, LLRF, Safety system, Magnet PS, …

**3) PC/Linux IOC**

J. Odagiri



# Status of IOC Upgrade & Implementation

- **Full Replacement in progress**
  - Vacuum Control VME IOC + CAMAC → PLC IOC
  - LLRF Control VME IOC + CAMAC → μTCA IOC + PLC IOC
  - Interface to PPS VME IOC → PLC IOC
- **CPU Upgrade of VME IOC**
  - Magnet PS in progress
  - BPM start soon
  - BT planning
- **VME IOC implementation**
  - Beam Abort System in progress
- **PLC IOC development & implementation**

→ Next page

# Status of F3RP61 (PLC CPU module) Implementation

J. Odagiri

## FY2013

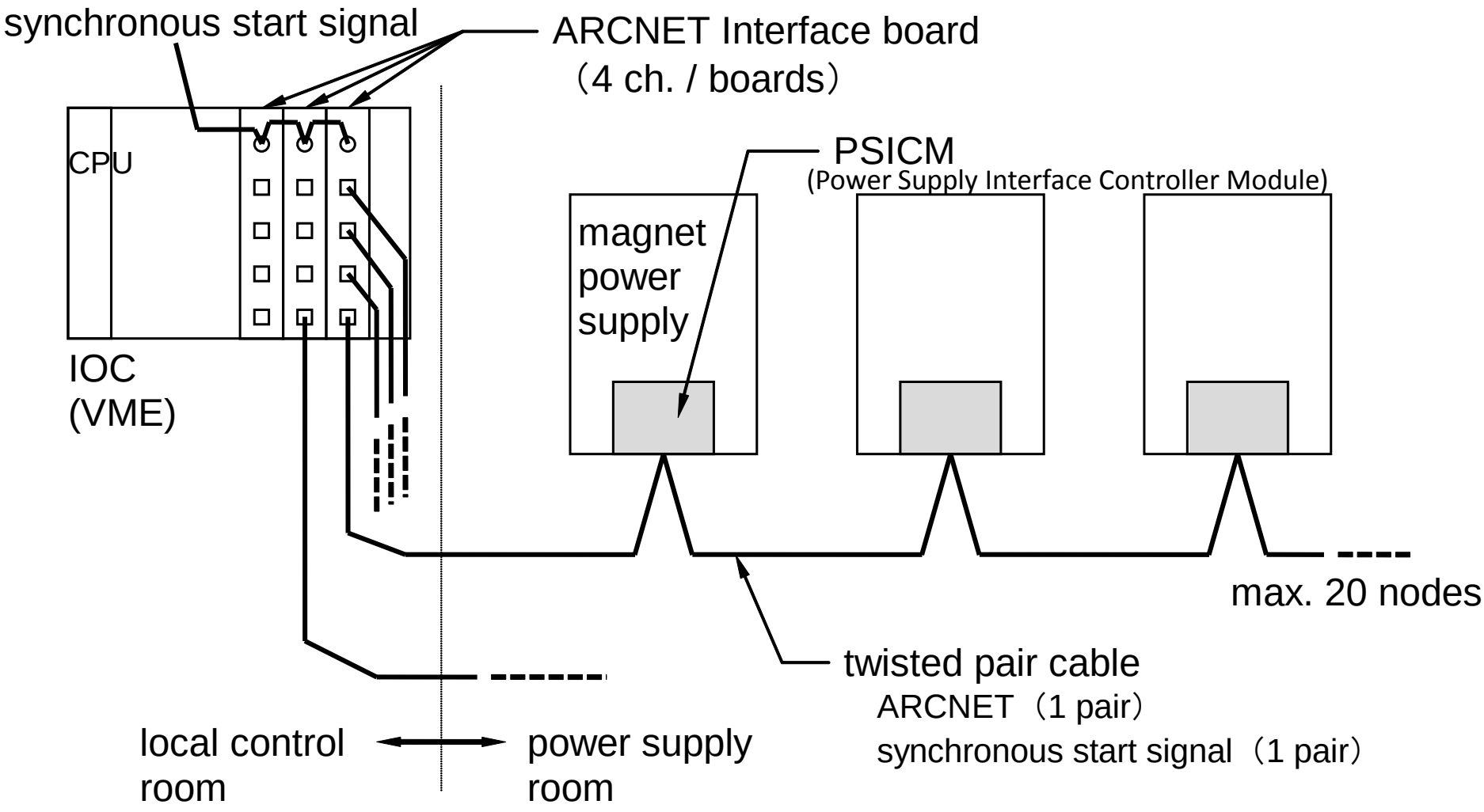
- Interface to the Personnel Protection System
- LLRF (used with μTCA system)
- Vacuum system
- Current stability controller for the high current Magnet PS

## Things to do in FY2014

- Interlock system for the Magnet PS system
- Tilting Support (SX Magnet) Control
- BT
- Dumping Ring

T. T. Nakamura, A. Akiyama

# ARCNET and Magnet Power Supply



T. T. Nakamura, A. Akiyama

# Version up of the PSICM
## (Power Supply Interface Controller Module)

- 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)

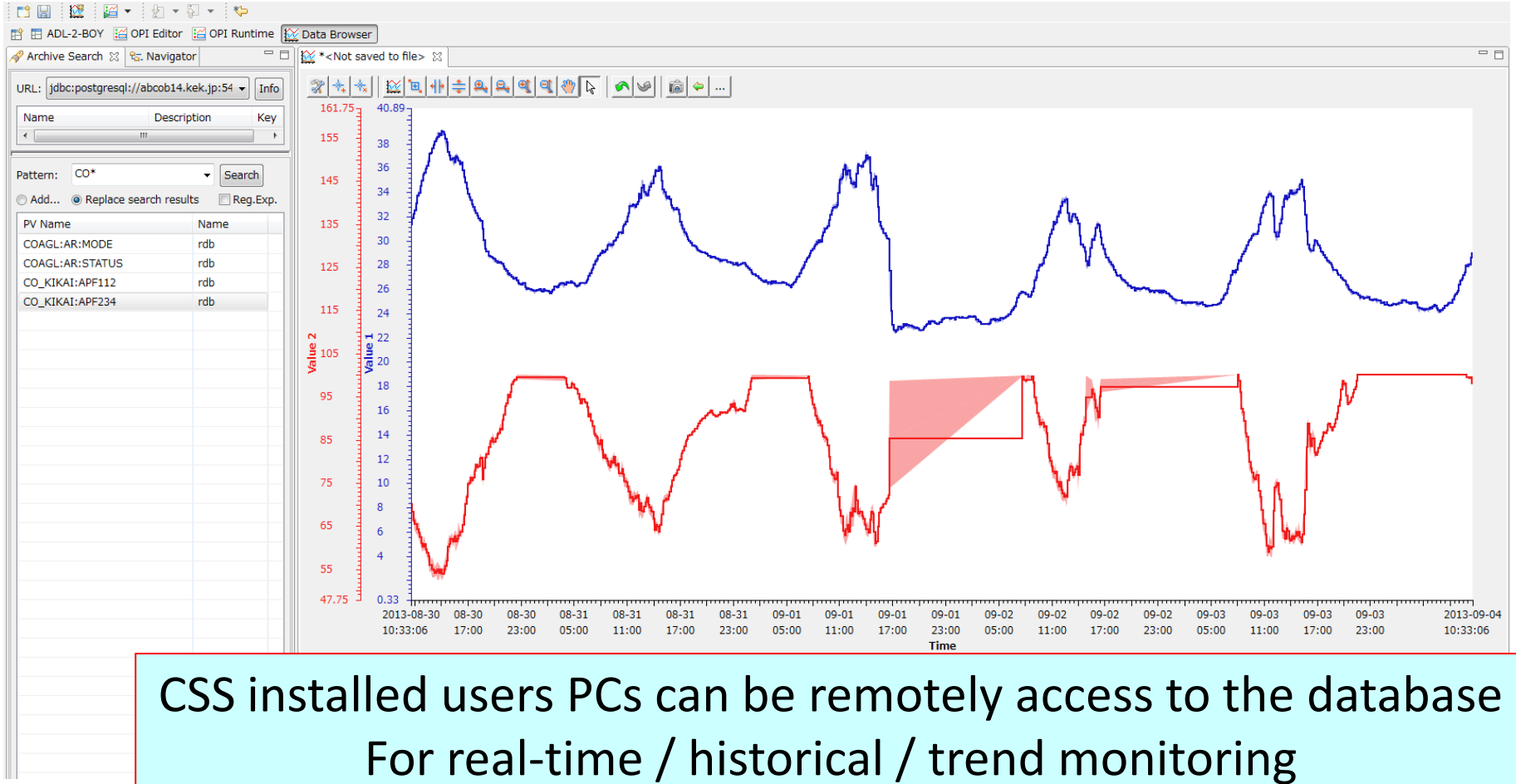
T. T. Nakamura, A. Akiyama

# Magnet PS Control System

- FY2013 Status
  - New PSICM
    - Development of the prototype ver.2 → done
    - Final tuning of the firmware → in progress
    - First mass production (1000 pcs.) → in progress
- FY2014 Plan
  - New PSICM
    - Second mass production (2000 pcs.)
      → depends on budget
    - Installation
  - IOC/OPI Software development
    - modification from KEKB version

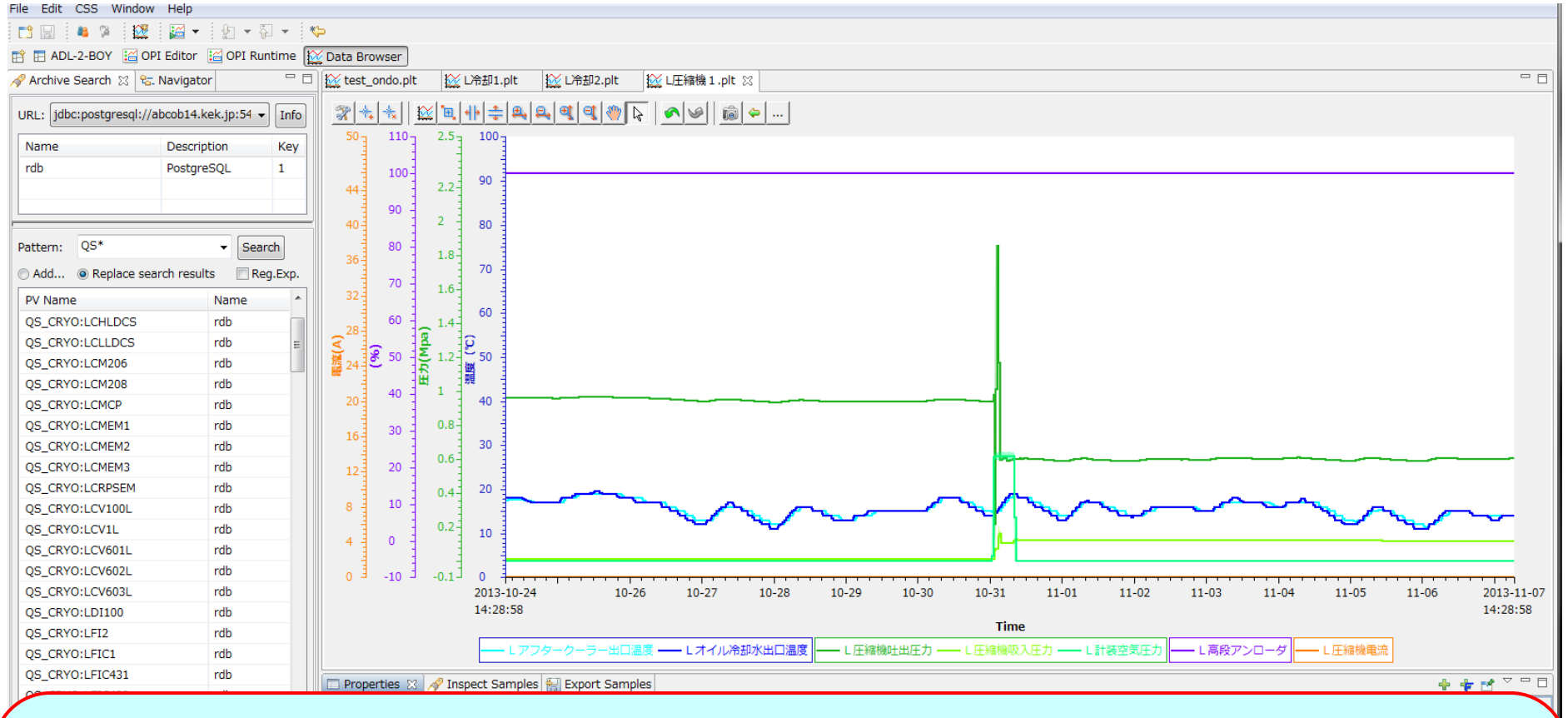
# Data Archiving System

- **KEKBLog as a primary data archiving system** (file based logging system)
- **CSS(Control System Studio)-based Archiver + PostgreSQL**
  **as the 2nd option data archiving system**




CSS installed users PCs can be remotely access to the database
For real-time / historical / trend monitoring

# Data Archiving System




**From October 2013, we monitor the QCS cryogenic system with the new archiving system (CSS + PostgreSQL).**

**→ Store ~300 points data every 5 seconds.**

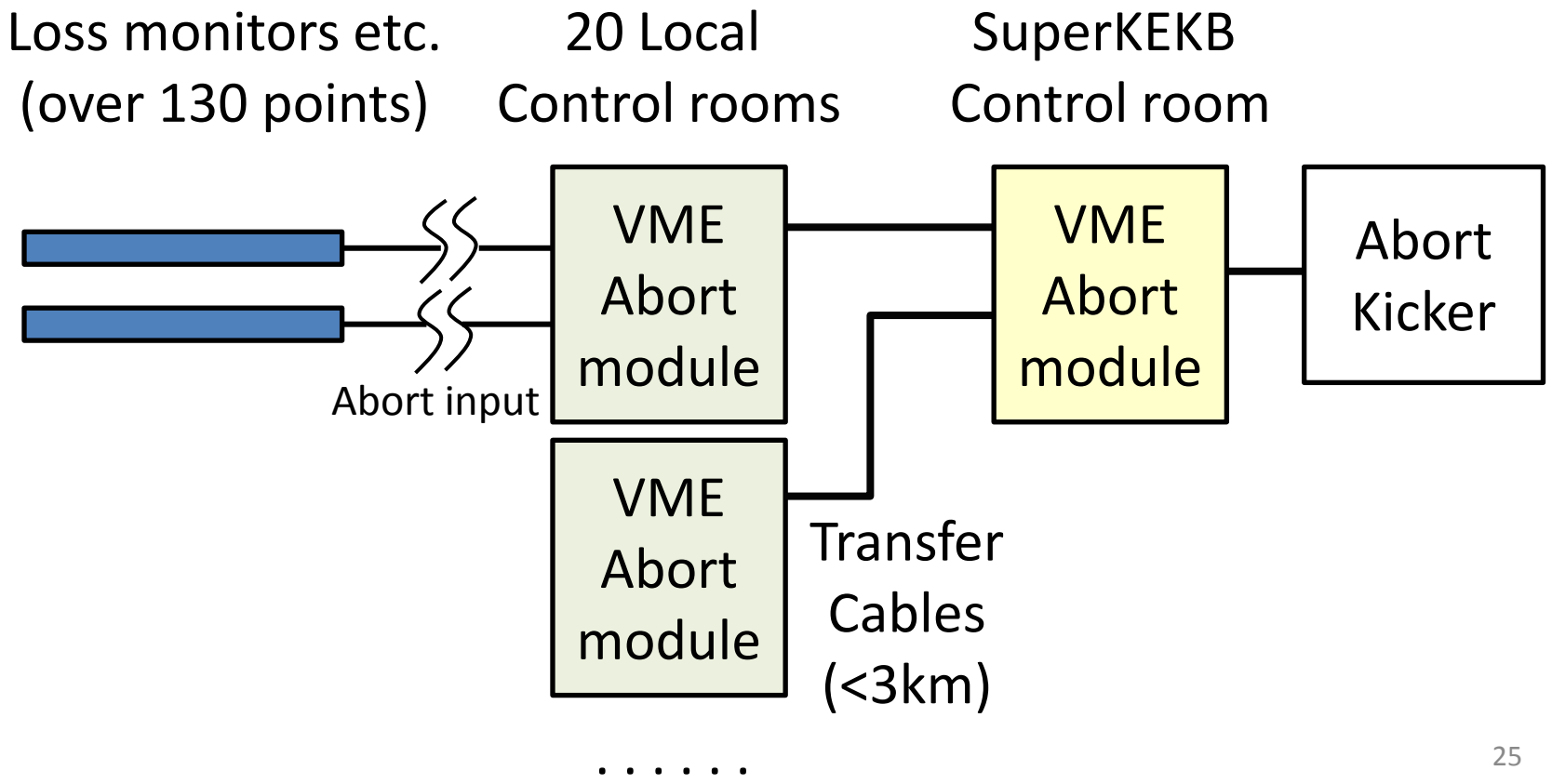
# Beam Abort System

T. Naito, A. Akiyama, S. Sasaki

**We have developed the faster response Beam Abort System for SuperKEKB**

E/O conversion, optical cable to transfer the signal, remove low-pass filters

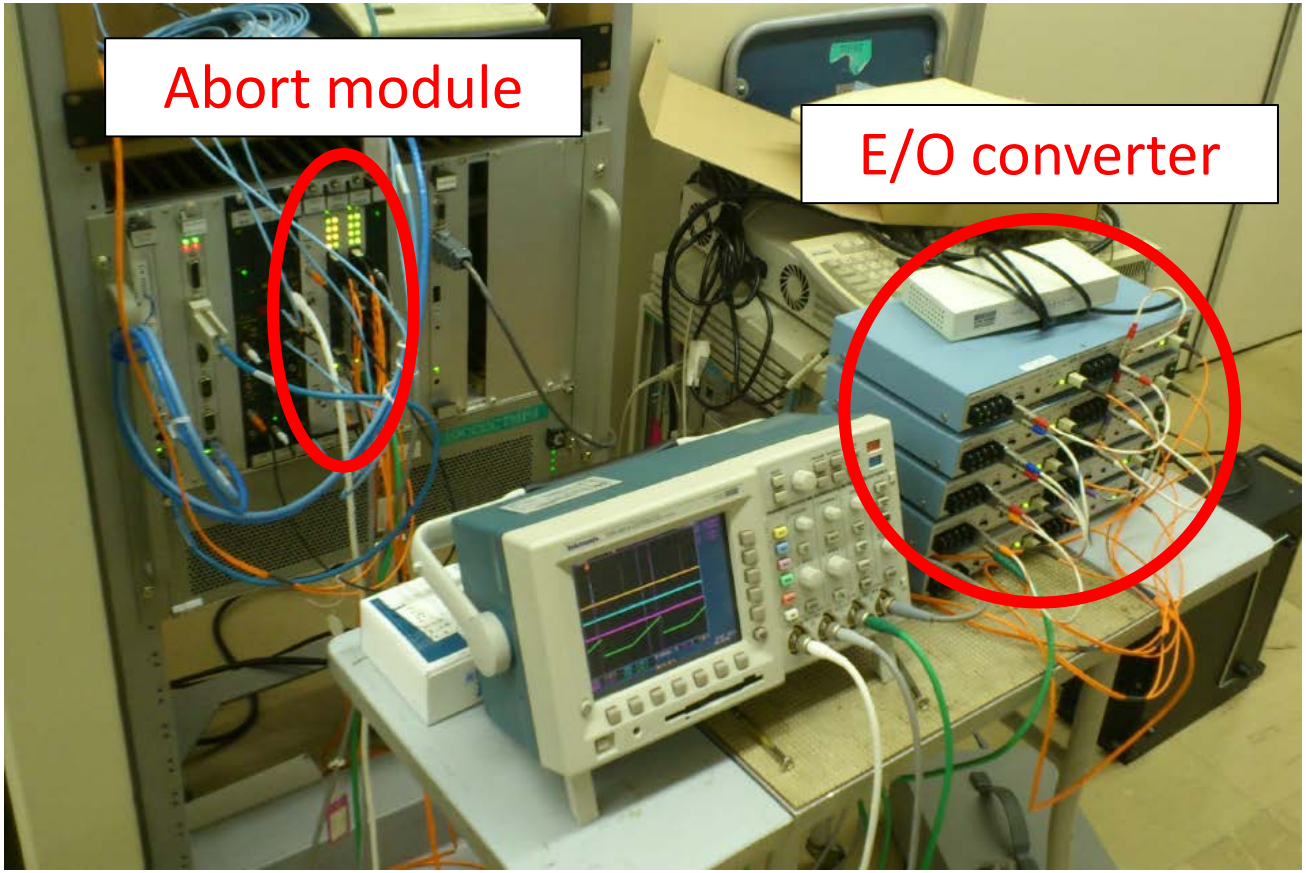
→ **Response time improved from 100μs to 20μs**



# Beam Abort System

T. Naito, A. Akiyama, S. Sasaki

- JFY2013 System check using the prototype system.




- JFY2014 Installation of the new beam abort system.

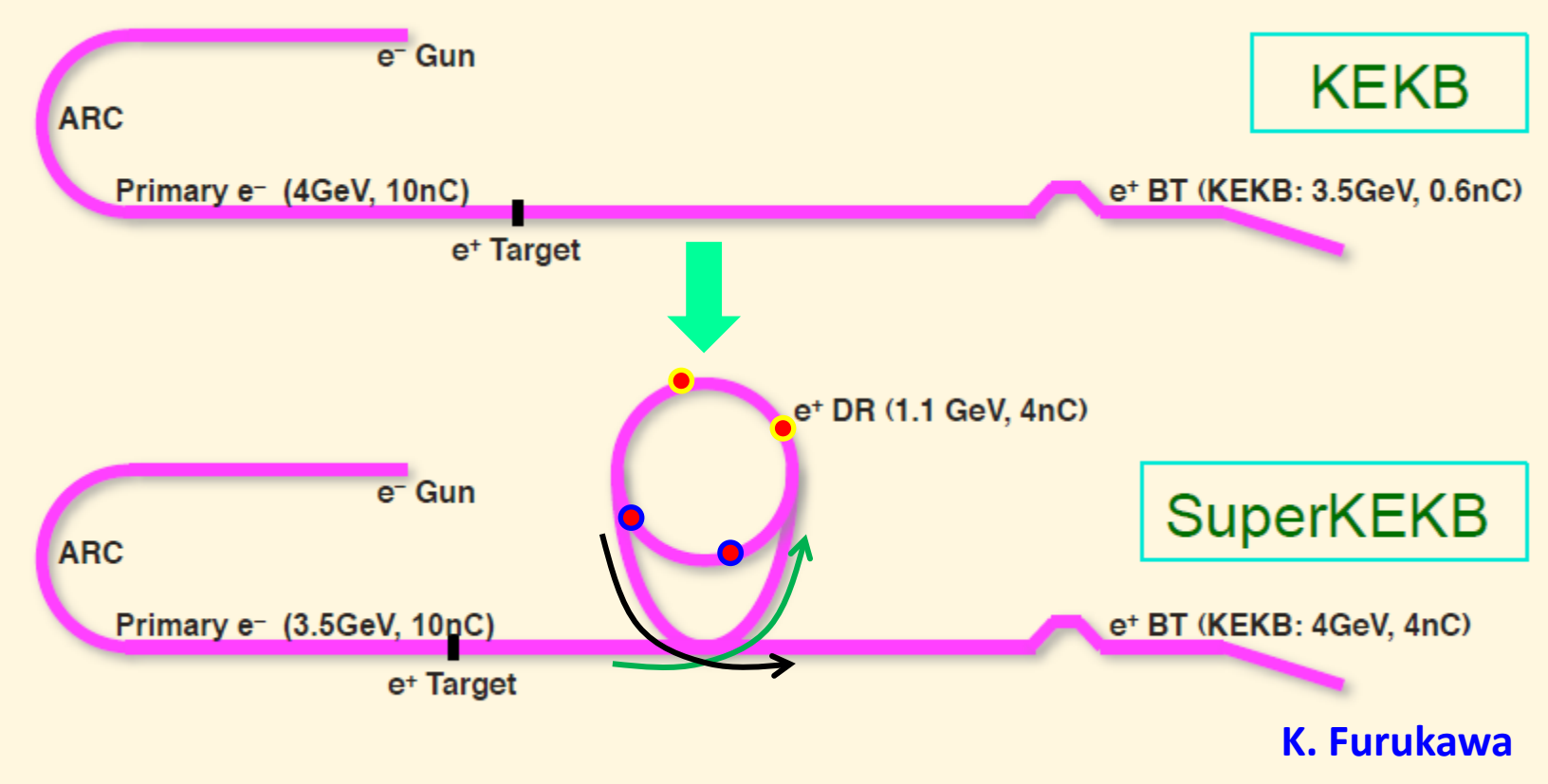
# Timing System for positron injection

**H. Kaji, K.Furukawa** (Details in the Kaji-san's talk)

In SuperKEKB, we construct **the positron Damping Ring**

→ Positron injection timing scheme become complicated

**To account for DR, new timing system for $e^+$ injection is required**



# Wire Scanner System

H. Kaji

## Wire scanners are used as beam profile monitors at Linac and BT.

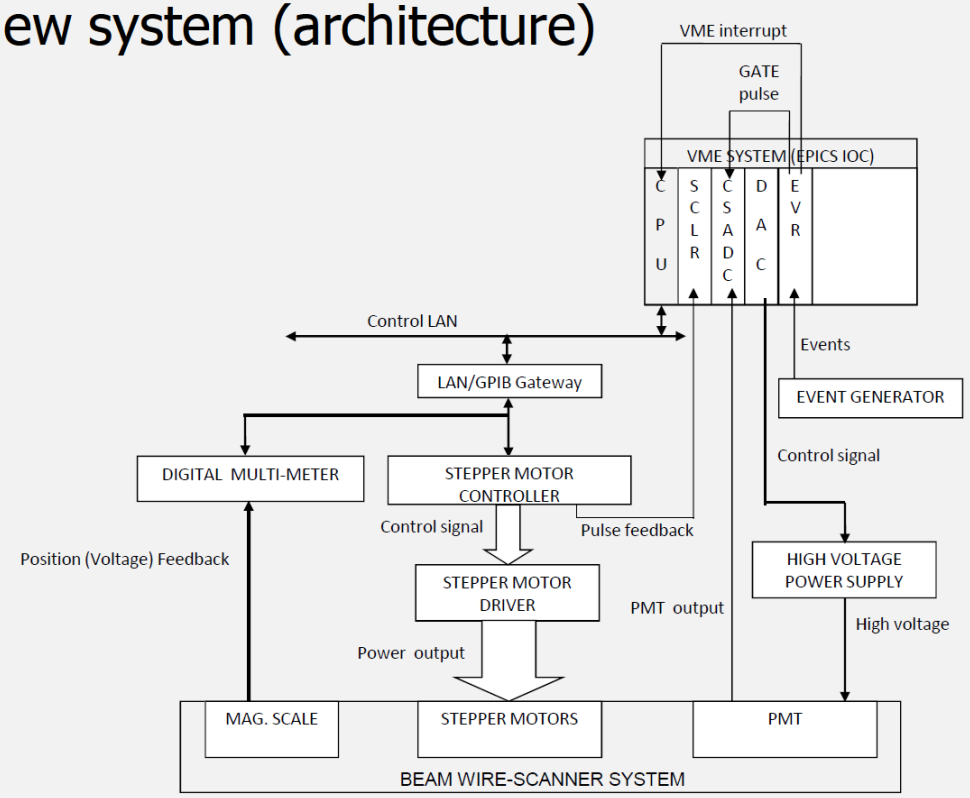
## Control System is upgraded

**1. CAMAC retired.**

**2. Event Receiver is installed.**
- It enables the multi-beam operations.
- The 1st IOC using the new version of FPGA and firmware
  ⇒ This experience is helpful for upgrade of the Main Trigger Station.

**3. New functions are integrated**
- Change wire speed during the scan.
- Capability for multi-mode operation
- Synchronization with BPM *on-going*
  ⇒ for collection of beam position and current, pulse-by-pulse.

New system (architecture)



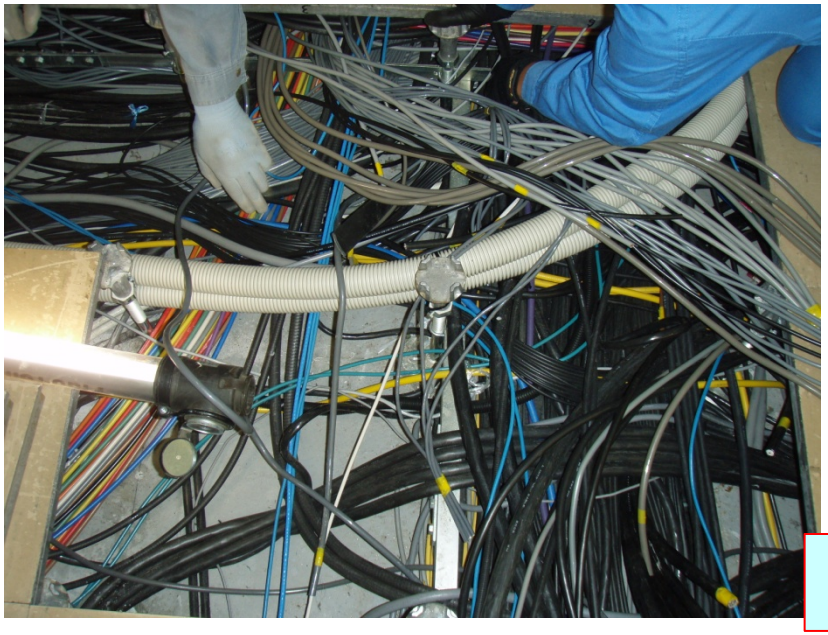

Three systems have already installed and two of them are operated.
Installations of a few more wire scanners are planned.

# Renovation of the computing room

# Renovation of the computing room

Last summer, we removed old server racks,
old electrical panel boards, power and signal cables.

# Renovation of the computing room



We removed old cables (3t in total).

# Renovation of the computing room

Electrical panel boards are renewed


# Renovation of the computing room

New server racks in the computing room

# Summary

***Upgrade of the accelerator control system for SuperKEKB is in progress***

In JFY2013, we did

- New network system construction
- Device controller upgrade & implementation
- Additional new data archiver construction
- Beam abort system R&D
- Timing system R&D
- Renovation of the computing room

# Summary

In JFY2014, we should do

- Network system for damping ring
- New computing server system
- Device controller upgrade & implementation
- Beam abort system installation
- Timing system upgrade
- Renovation of the control room console system
- Accelerator operation equipment

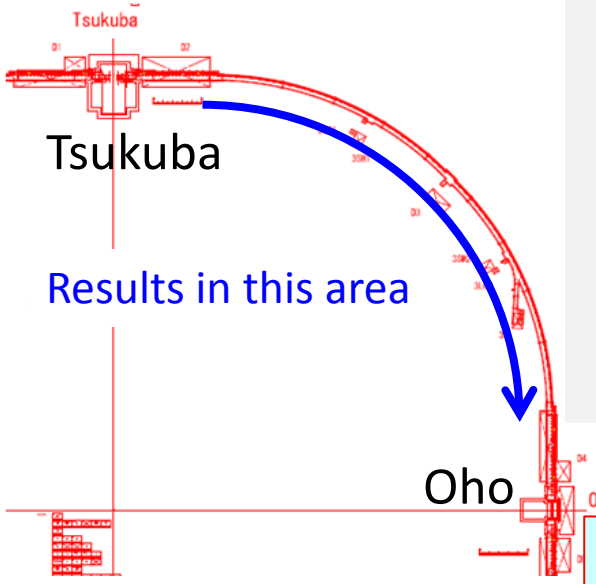
  New alarm system, task launcher, operation panels, …

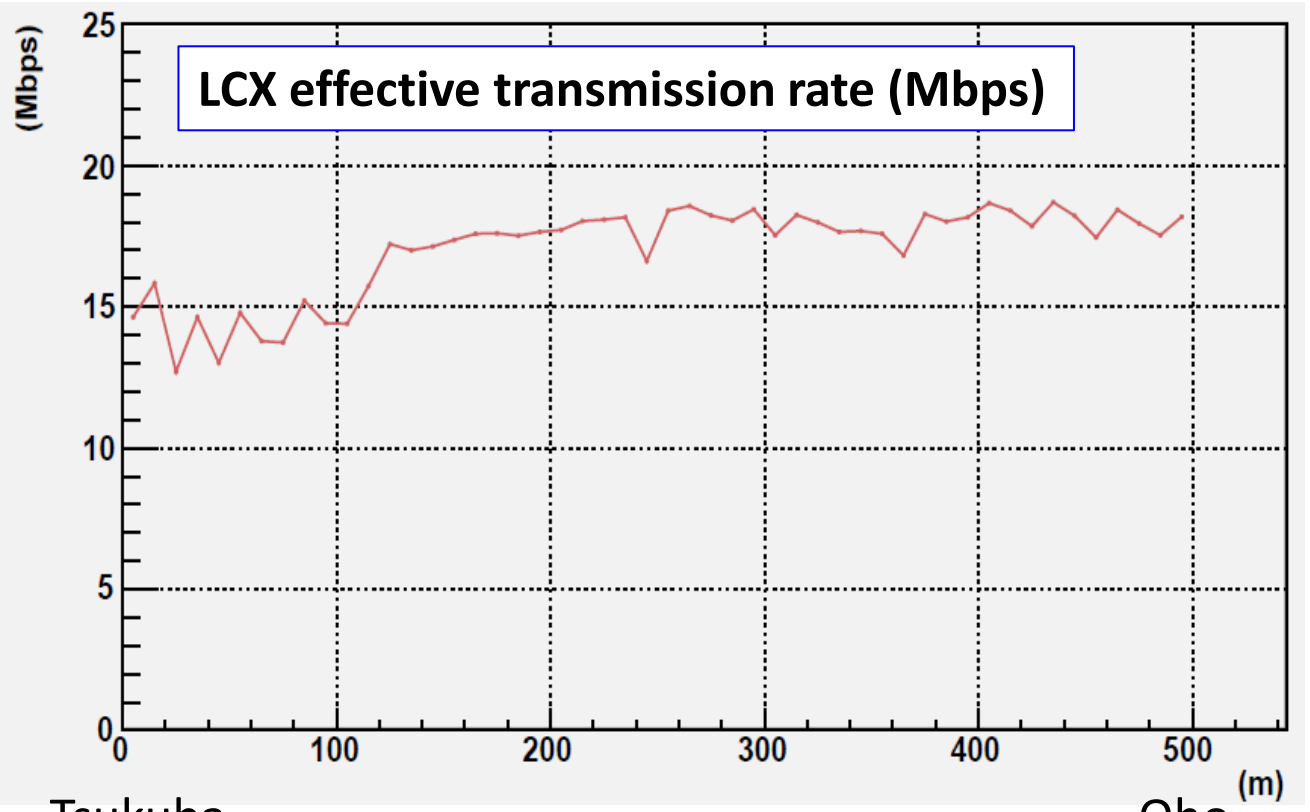
***for the 1st SuperKEKB operation in 2015.***

# Backup slides

# Wireless LAN in the SuperKEKB tunnel

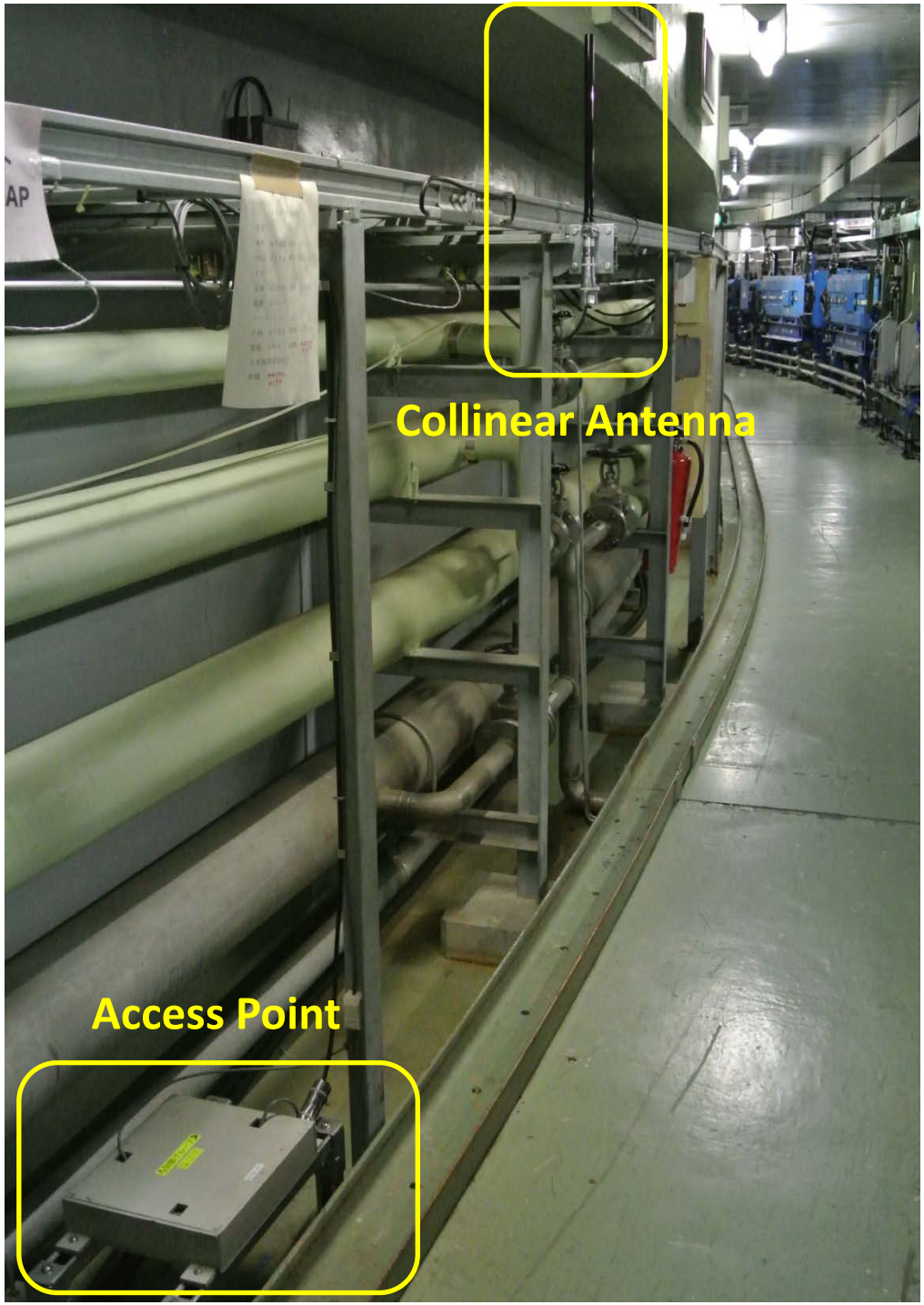
**We measured the wireless LAN network speed in the SuperKEKB tunnel.**

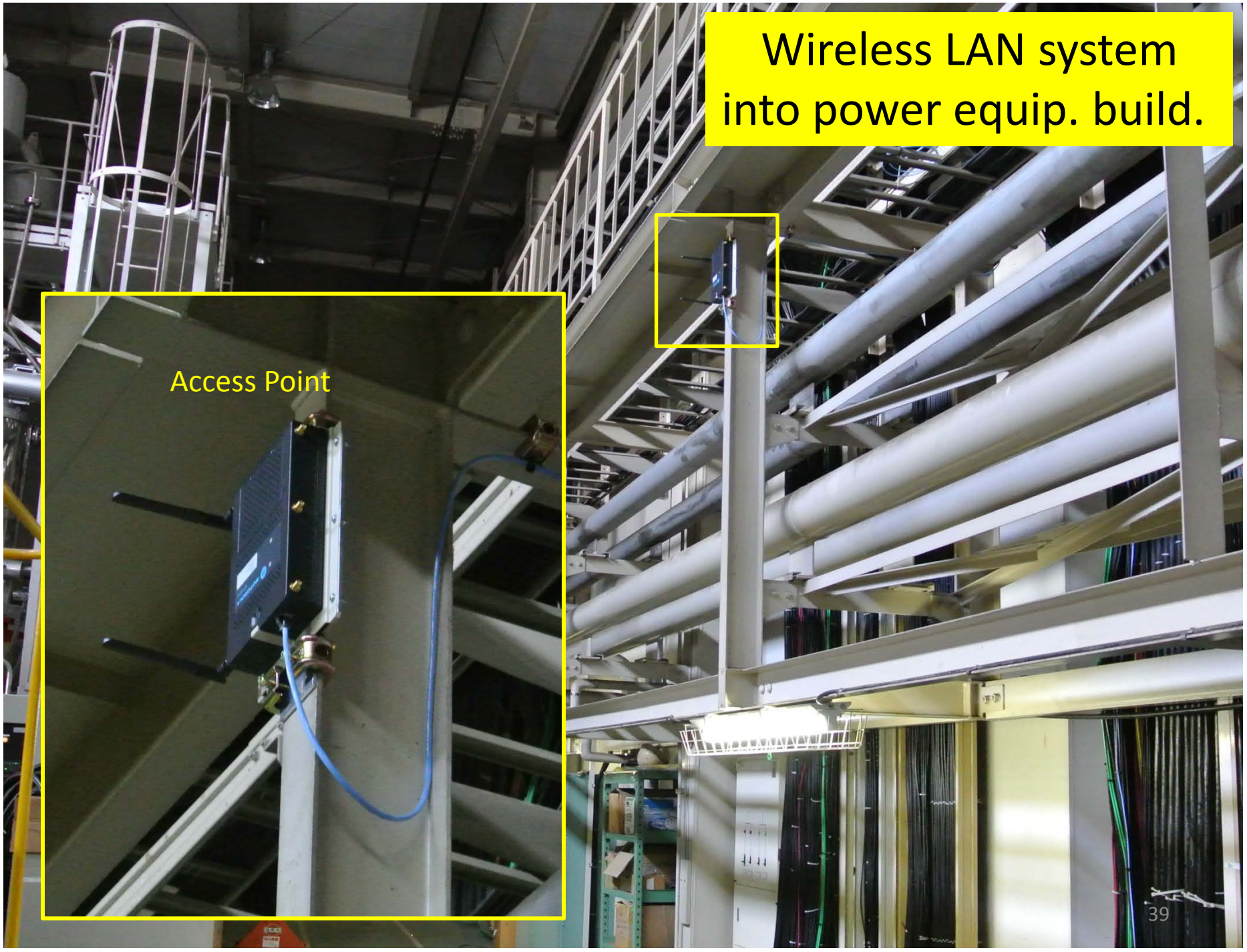



Good network speed performance of ~18Mbps in the whole tunnel area

# Wireless LAN system Installation into AR





Wireless LAN system into power equip. build.
Access Point

# EPICS on PLC

- VxWorks CPU was available on PLC (Yokogawa, Mitsubishi)
  - Besides normal sequence / ladder CPU
- Yokogawa starts to provide Linux (2.6) on PLC CPU (F3RP61)
  - Brave enough to choose open source environment
    - We negotiate with Yokogawa to remove any license issues
  - Odagiri/KEK, Uchiyama/SHI-RIKEN, Yamada/KEK made much effort to realize EPICS implementation, (but no need for asynchronous records)
  - Takuya-Nakamura/MSC-KEK, et al, tailored the environment for KEKB
    - Procserv, pcmon, NFS, ...
- Four F3RP61-based IOCs are used in KEKB operation
  - Three since September 2008, and another later, four in total
  - Beam mask controllers and Pulsed-quad controllers
  - No trouble at all, they run more than 8 months
- ~20 new IOCs are also used in J-PARC operation now

# F3RP61 (e-RT3 2.0)

Linux 2.6.24

PPC 533MHz

128Mbyte RAM

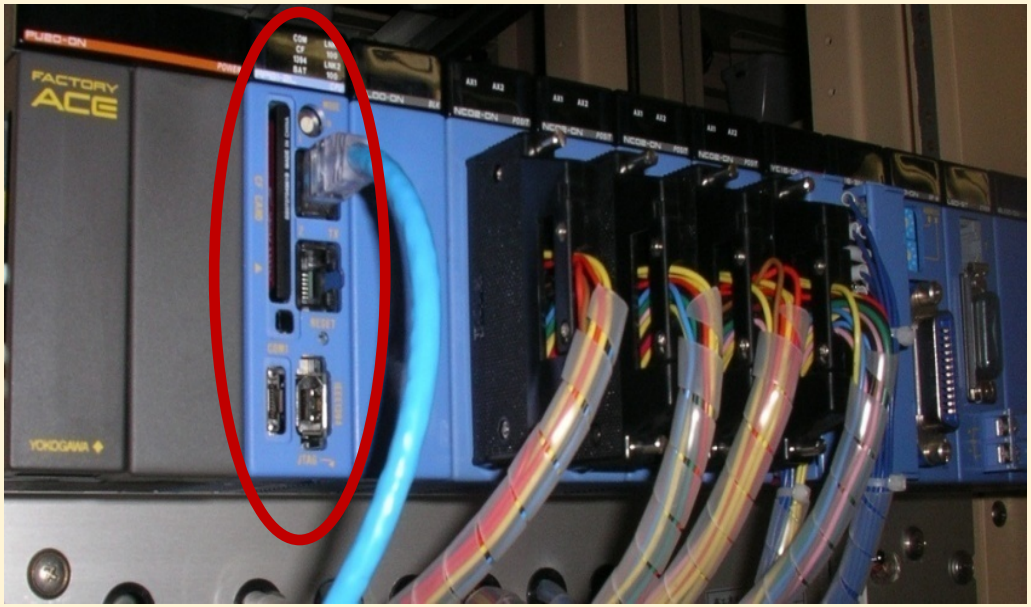
100BaseTx x2

USB

IEEE1394

Serial

PCI




KEKB Beam mask controller

I/O Bus for FAM3 Module Interface

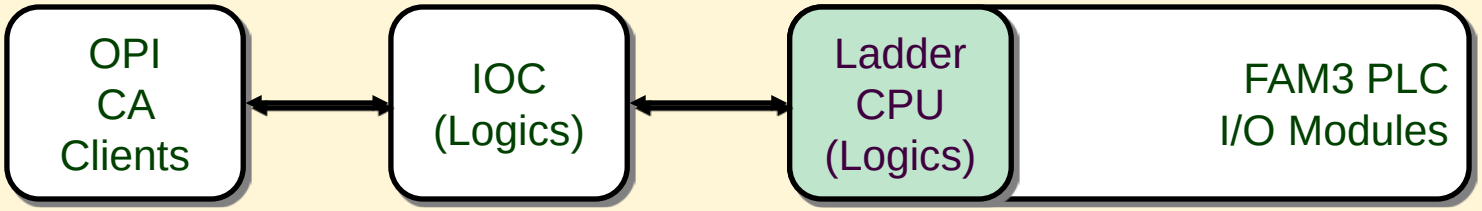
can access to mature FAM3 I/O Modules

Can be combined with conventional ladder CPU

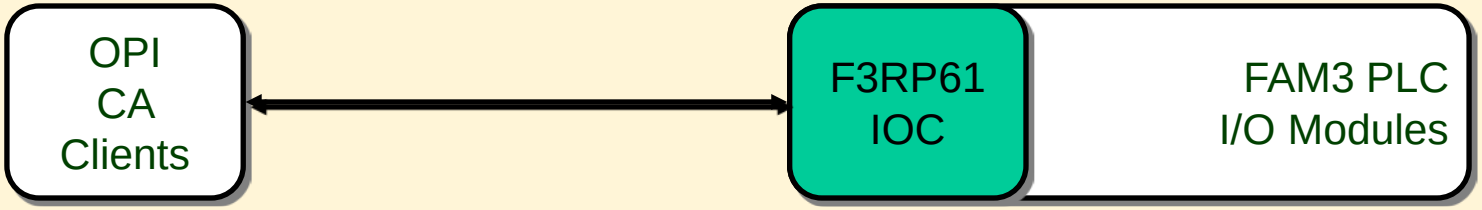
Software development environment (ELDK)

# Simple Usage under EPICS

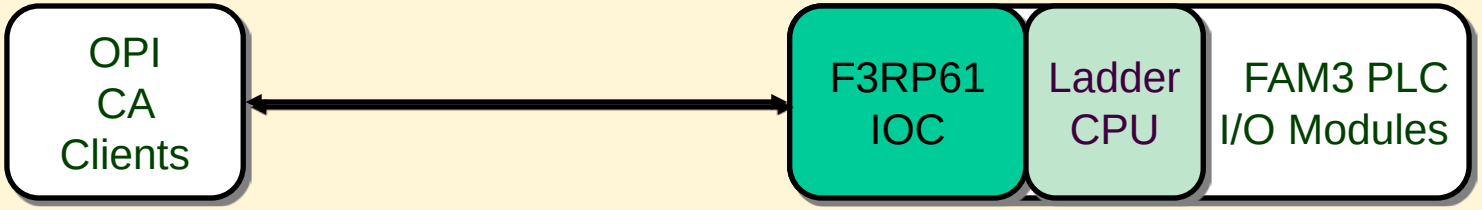
Conventional PLC usage with asynchronous access




PLC usage with F3RP61 with only synchronous access and maybe with sequencer




If necessary, we can combine



# Number Of F3RP61-based IOC

| Group | Expected numbers（at T = 0） |
|---|---|
| RF (including LLRF) | 13 + 2 |
| Vacuum | 14 |
| Magnet/Magnet Power Supplies | 11 + 3 |
| Personnel Protection System | 8 |
| Beam Monitor | 1 + (？) |
| BT | 2 + (？) |
| Dumping Ring | ？ |
| Helium Refrigerator | 1 |
| Total | > 39 + (？) |