Control System

June 13, 2016

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Outline

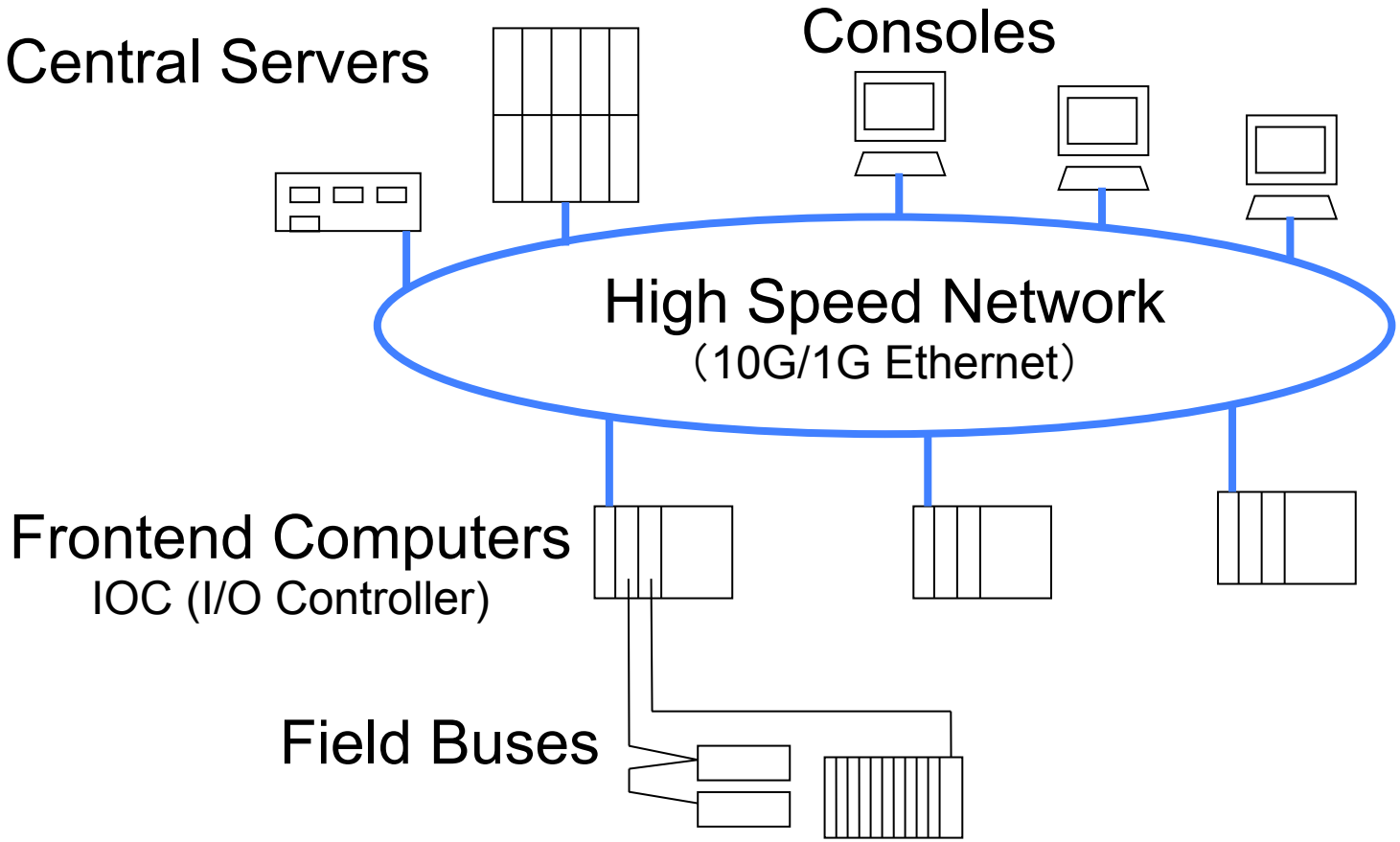
- Overview
  - Central Server Computers
  - Network
  - IOC (Input/Output Controller)
  - Field Buses
  - Other issues
- Recent Topics
  - Beam Abort Trigger System
  - Alarm System
- Tasks toward Phase-2

- Timing system, Injection control → Next talk

Overview of the Control System (Software)

- EPICS based --- Distributed System
  - **EPICS** (Experimental Physics and Industrial Control System) is a toolkit to construct control systems
  - 2 layer model
    - OPI (Operation Interface) --- operation programs on central servers
    - IOC (I/O Controller) --- equipment controls on frontend computers
  - CA (Channel Access)
    - Communication protocol over network
    - Core technology of EPICS
- Operation Programs in Scripting Languages
    - Quick and Flexible Development
    - With EPICS-CA, GUI (tk)
  - **SAD Script** (developed at KEK)
  - **Python**

Overview of the Control System (Hardware)



Overview of the Control System
Upgrade KEKB → SuperKEKB

- Network
  - 1G Ethernet → 10G/1G, Redundant, VLAN
  - Introduce wireless LAN
- EPICS system
  - R3.13 (VxWorks based) → R3.14 (multiplatform)
- IOC
  - Single platform (VME/VxWorks) → Multiplatform (VME/VxWorks, PLC/Linux, PC/Linux, μTCA/Linux, Embedded system, etc.)
- Abort Trigger System
  - Metal wire based (trunk lines were replaced with optical fibers) → Full optical connection
- High level application upgrade
  - Alarm System, Task launcher, etc.
- Renovation of the Control Room and Computing Room

Central Server Computers

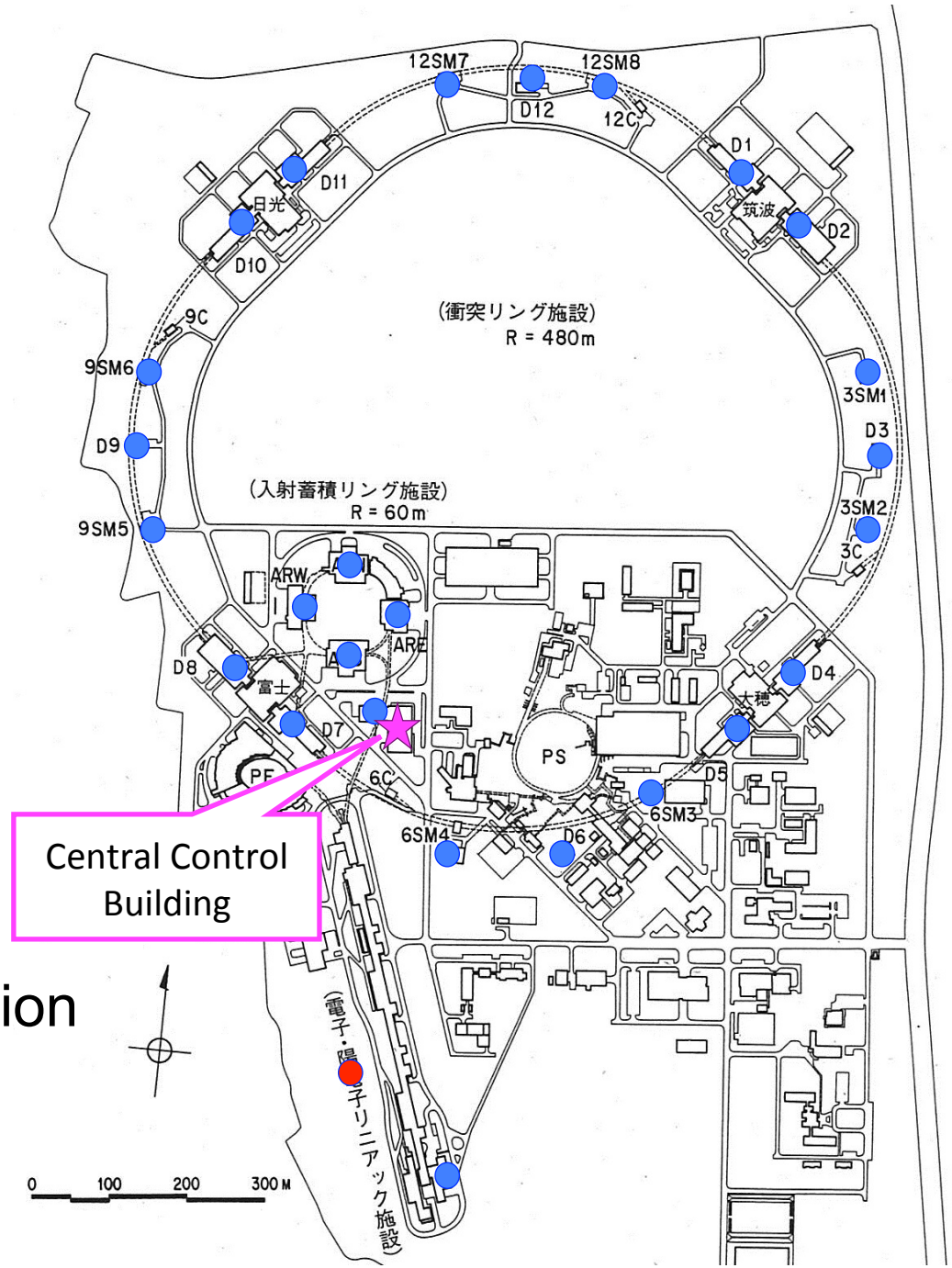
- Control Servers --- Managed by Control Group
  - Dedicated for KEKB Control / Operation
  - Currently consists of
    - Rack Mount Servers
      - 2 HP-UX (old system)
      - 3 Linux
    - Blade Servers
      - 14 Linux

- SAD Computers (SAD Cluster) --- Managed by SAD Group
  - Originally for SAD Simulations
  - Later intensively used for KEKB Operation
  - Not only for KEKB but also for other Projects (**Many user accounts !)**
  - Currently consists of
    - 7 Free BSD Servers
    - SAD-NAS (main storage)

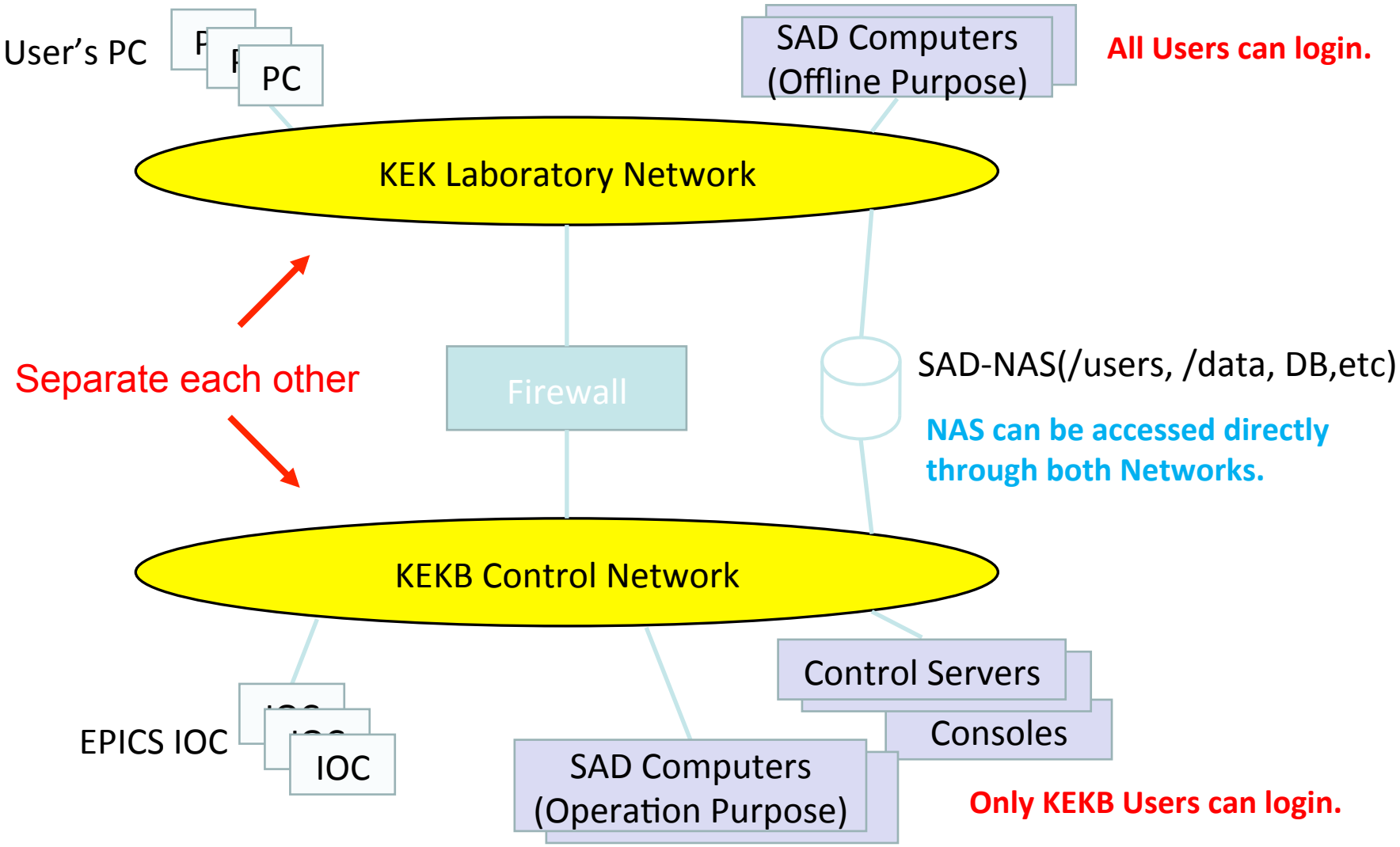
Network

Star Configuration between
★ Central Control Building
and
● 26 Local Control Rooms
New installation planned in 2016:
● DR Local Control Room

- Backbone
  - 10G/1G bps Ethernet
  - Central core switch
    - Catalyst 6509E
  - Redundant Configuration
  - VLAN



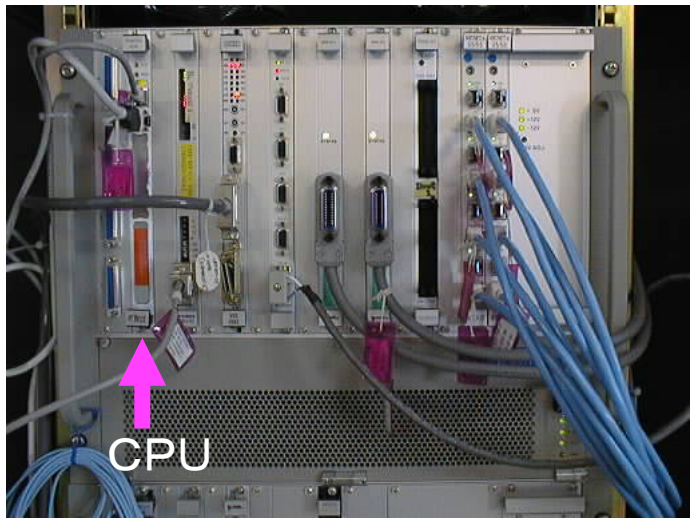
Control Network and KEK Lab. Network



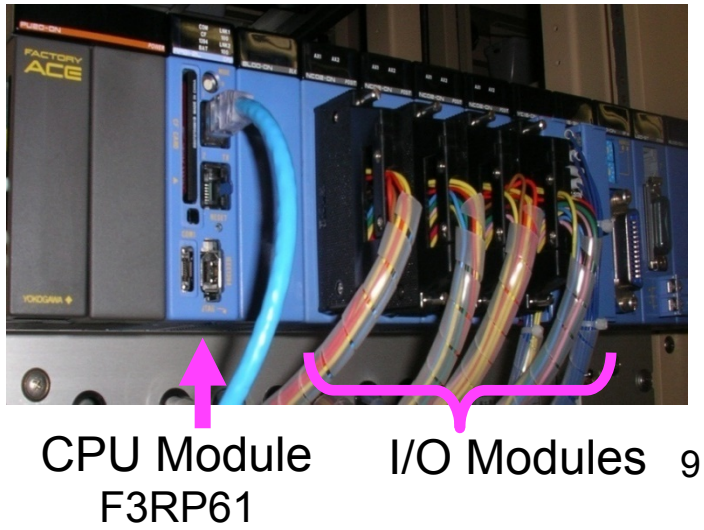
All of SAD Computers and Control Servers share same home directory.

IOC (Input/Output Controller)

- We use 2 major types
- VME/VxWorks IOC
  - CPU
    - MVME5500, MVME4100
    - Force PPC750 (old)



- PLC/Linux IOC
  - Yokogawa FAM3 series PLC
  - CPU
    - F3RP61 (Linux CPU)



F3RP61 (e-RT3 2.0)

Linux 2.6.24

PPC 533MHz

128Mbyte RAM

100BaseTx x 2

USB

IEEE1394

Serial

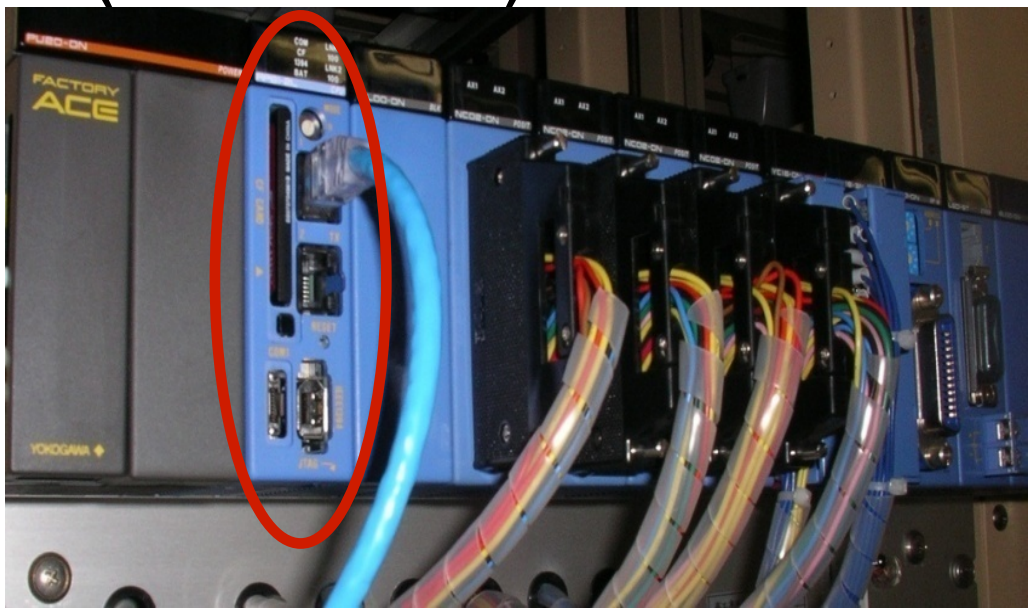
PCI

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)



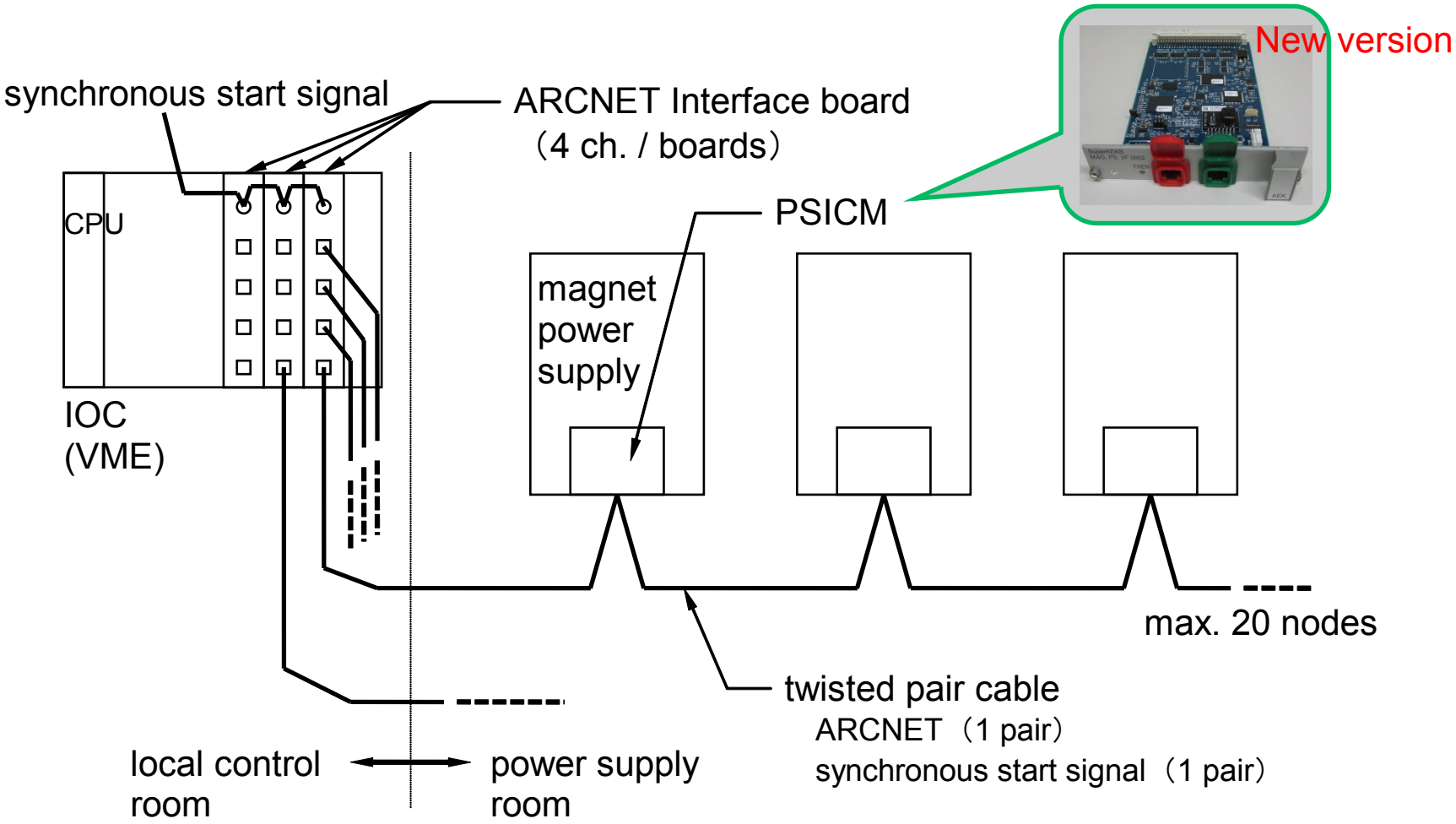
KEKB Beam mask controller

Field Buses

- CAMAC --- Too old (~30 years old), still used!
  - For BT

    → Replacement to PLC (or other Embedded EPICS Systems) are planned before Phase 2
  - For old LLRF
- Serial (Asynchronous)
- GP-IB
  - Widely used
- Ethernet
  - Widely used
- VXI/MXI
  - For BPM
- ARCNET
  - For Magnet Power Supply

ARCNET and Magnet Power Supply

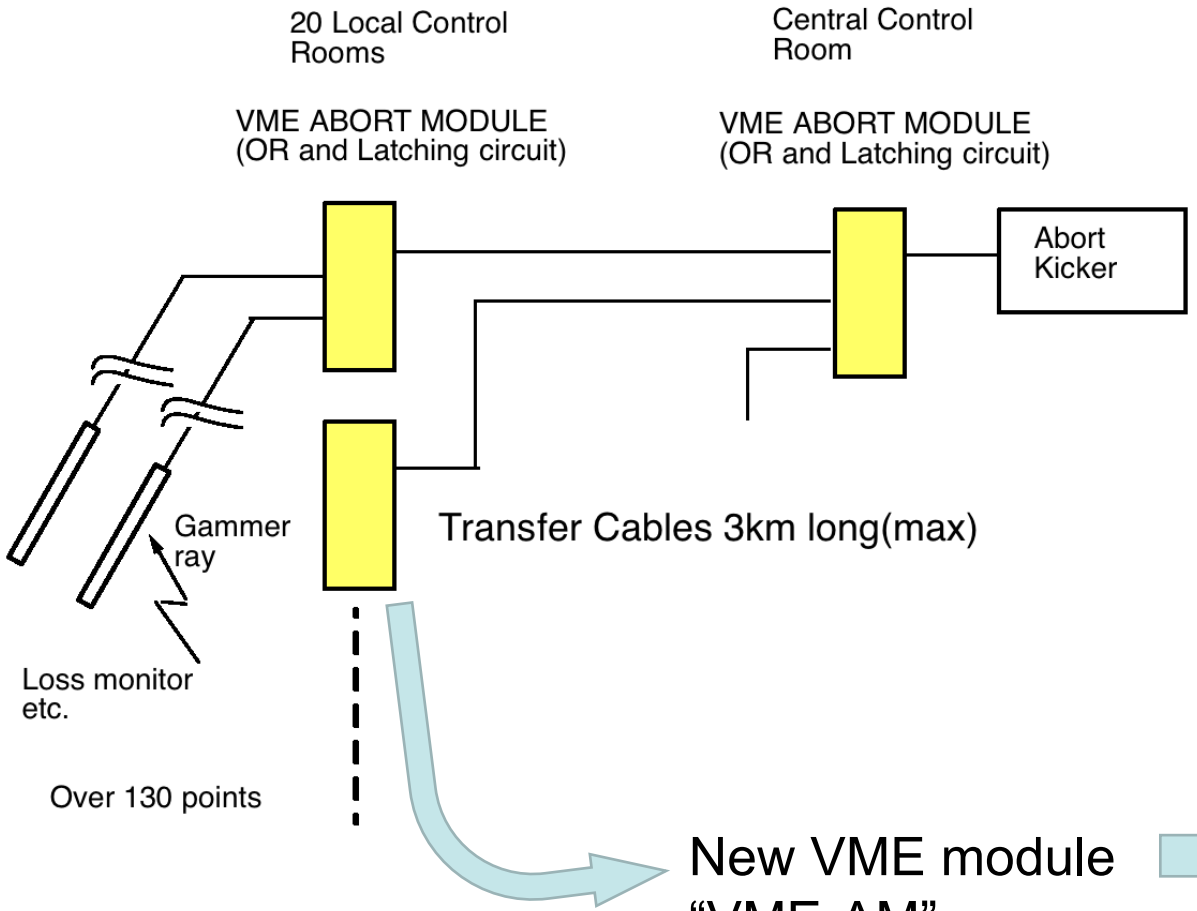


PSICM is “Power Supply Interface Controller Module”, developed at KEK.

Other Issues

- Operation Consoles
  - Central console terminals
  - Replacement of the old terminals in the Local Control Rooms are in progress
- Data Archivers
  - KEKBLog (monitoring ~100,000 channels, 4GB/day)
  - CSS Archiver is also running for R&D purpose
- Operation Log
  - “Zlog” : Zope based web application

Beam Abort Trigger System



New VME module
"VME-AM"
- 8 optical input
- 1 optical output

Improvement from the KEKB abort trigger system

1. Response time from the input to the beam abort

100us -> 20us. Previous system used low pass filters for the noise reduction, which increased the response time.

2. Optical fiber connection

Three kinds of signals(TTL, RS422, Relay contact) convert to optical signals to avoid the electrical noise. Control group maintains the signal transfer quality.

3. Time stamp

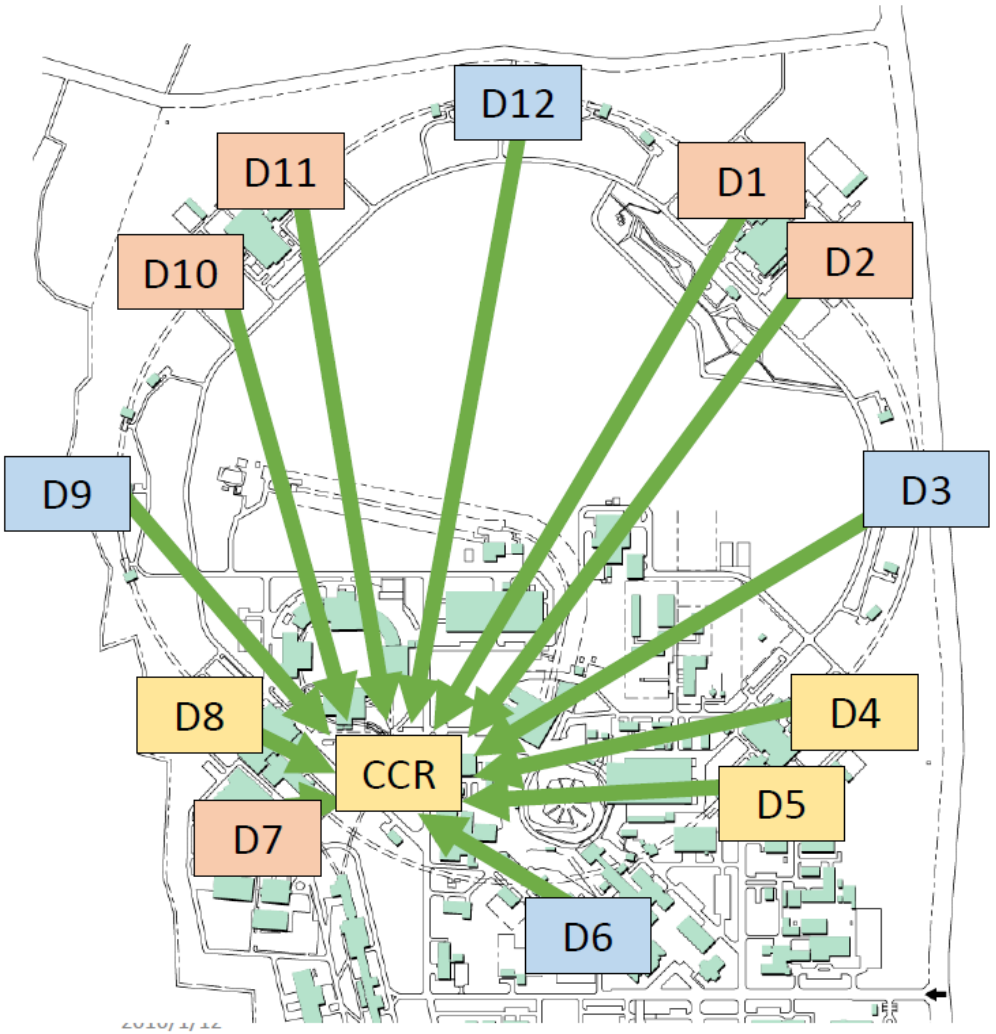
In the most of the case, the beam abort are not only one input signal but also many dependent signals. To find out the source of the beam abort, the time stamp function is added to the VME-AM, which can store the time of the abort signal with 0.1us resolution.

4. System check

To increase the reliability of this system, the system check function is installed to the VME-AM.

Abort Trigger System in Phase-1 Operation

Only half of 36 VME modules have been installed due to the limited budget. → Full installation will start for Phase-2



old modules

D1 D2 D7

D10 D11

new VME modules

D4 D5 D8 CCR

w/o modules (no aggregation)

D3 D6 D9 D12

Time stamp of the abort trigger

Abort Timestamp Log Viewer - One Table -

2016/06/07

04:33:33

MESSAGE	DATE	DELTA	RING
COHSAFE:CCC:ABORT:D10	2016-06-07 04:33:33.650817700	0.000000000	HER
COHSAFE:CCC:ABORT:CCC-2	2016-06-07 04:33:33.650818200	0.000000500	HER
COHSAFE:CCC:ABORT:D7	2016-06-07 04:33:33.650914200	0.000096500	HER
COLSAFE:CCC:ABORT:D7	2016-06-07 04:33:33.651737900	0.000920200	LER
COHSAFE:CCC:ABORT:D11	2016-06-07 04:33:33.653552700	0.002735000	HER
Soft Abort	2016-06-07 04:33:34.508969500	0.858151800	LER
Soft Abort	2016-06-07 04:33:35.375759200	1.724941500	HER

09:05:56

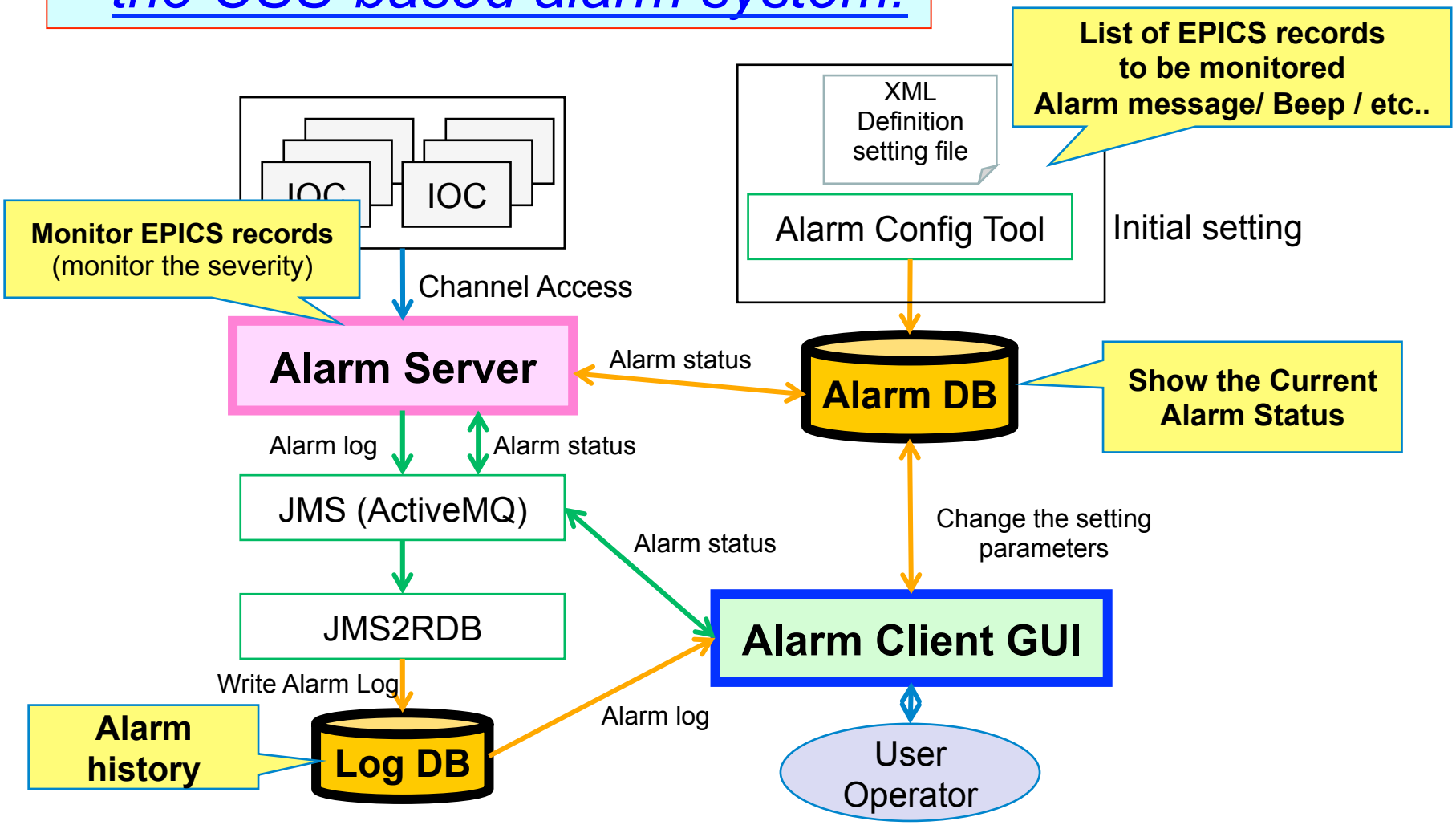
MESSAGE	DATE	DELTA	RING
COHSAFE:CCC:ABORT:D10	2016-06-07 09:05:56.754296000	0.000000000	HER
COHSAFE:CCC:ABORT:CCC-2	2016-06-07 09:05:56.754296500	0.000000500	HER
COHSAFE:CCC:ABORT:D7	2016-06-07 09:05:56.754389100	0.000093100	HER
COLSAFE:CCC:ABORT:D7	2016-06-07 09:05:56.755794200	0.001498200	LER
COHSAFE:CCC:ABORT:D11	2016-06-07 09:05:56.757117200	0.002821200	HER
Soft Abort	2016-06-07 09:05:58.383914000	1.629618000	HER
Soft Abort	2016-06-07 09:05:58.517249200	1.762953200	LER

Alarm System

- KEKB Alarm System
  - SAD-based program
  - Unstable to handle large number of channels
  - Hard to maintain
- SuperKEKB Alarm System
  - Using CSS Alarm (EPICS standard tool) + GUI panel written in Python and tk toolkit
  - Backend database : PostgreSQL
  - ~ 14,000 channels are monitored in Phase-1

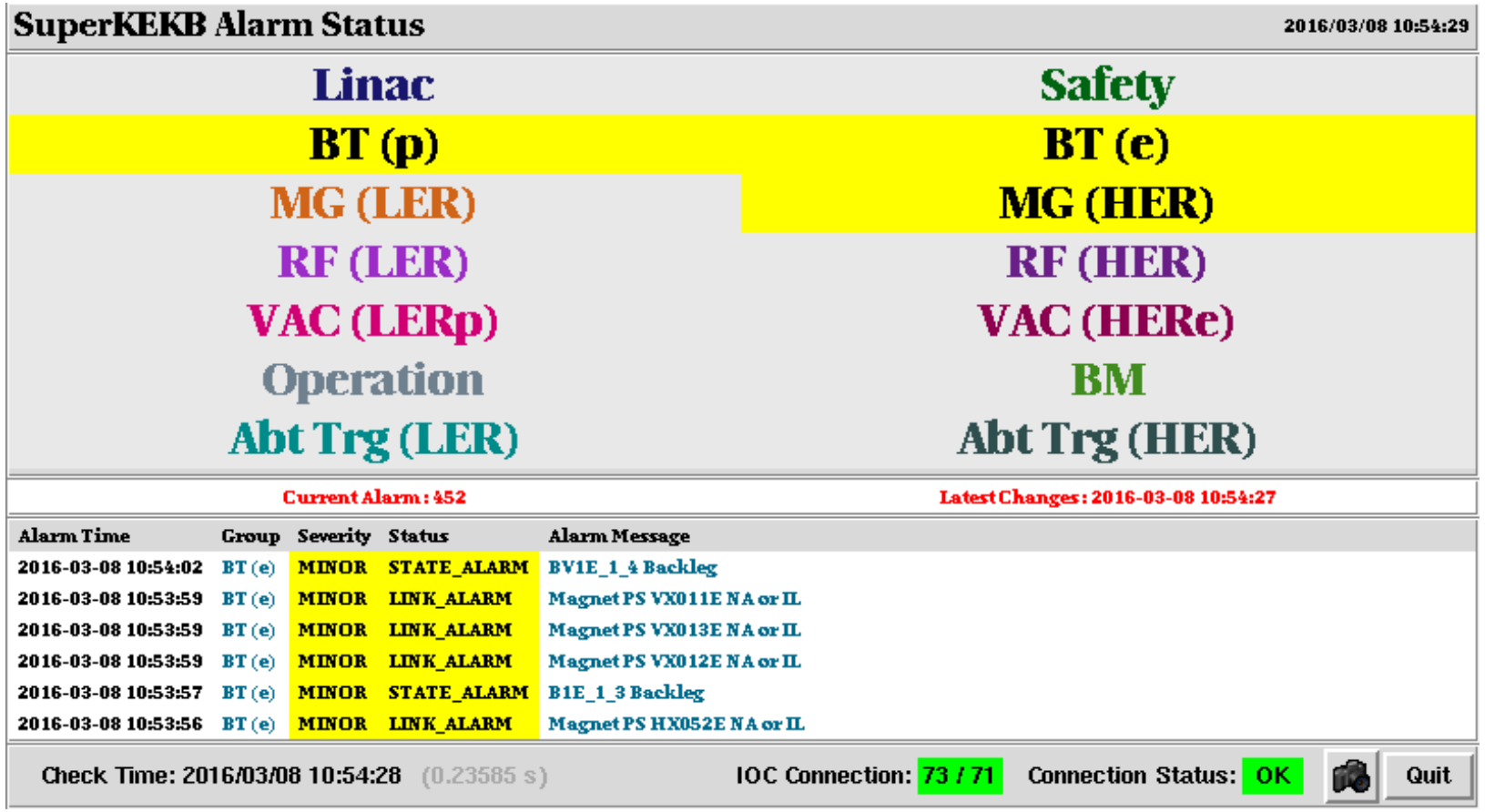
Structure of New Alarm System

- *the CSS-based alarm system.*

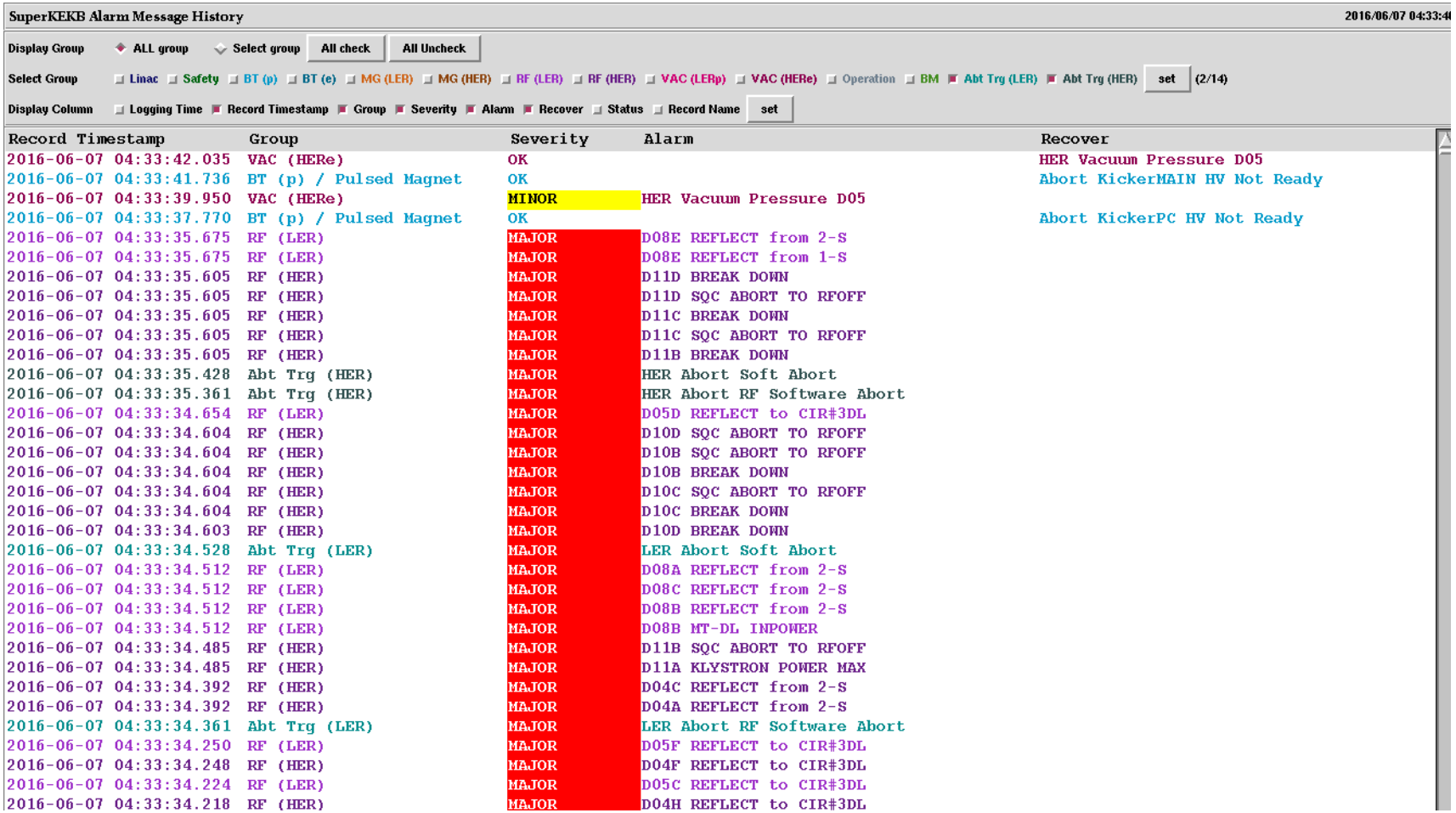


Alarm Status Panel

Appearance of the old KEKB Alarm (SAD-based Alarm) is inherited.



Alarm History Panel



Record Timestamp	Group	Severity	Alarm	Recover
2016-06-07 04:33:42.035	VAC (HERe)	OK		HER Vacuum Pressure D05
2016-06-07 04:33:41.736	BT (p) / Pulsed Magnet	OK		Abort KickerMAIN HV Not Ready
2016-06-07 04:33:39.950	VAC (HERe)	MINOR	HER Vacuum Pressure D05	
2016-06-07 04:33:37.770	BT (p) / Pulsed Magnet	OK		Abort KickerPC HV Not Ready
2016-06-07 04:33:35.675	RF (LER)	MAJOR	D08E REFLECT from 2-S	
2016-06-07 04:33:35.675	RF (LER)	MAJOR	D08E REFLECT from 1-S	
2016-06-07 04:33:35.605	RF (HER)	MAJOR	D11D BREAK DOWN	
2016-06-07 04:33:35.605	RF (HER)	MAJOR	D11D SQC ABORT TO RFOFF	
2016-06-07 04:33:35.605	RF (HER)	MAJOR	D11C BREAK DOWN	
2016-06-07 04:33:35.605	RF (HER)	MAJOR	D11C SQC ABORT TO RFOFF	
2016-06-07 04:33:35.605	RF (HER)	MAJOR	D11B BREAK DOWN	
2016-06-07 04:33:35.428	Abt Trg (HER)	MAJOR	HER Abort Soft Abort	
2016-06-07 04:33:35.361	Abt Trg (HER)	MAJOR	HER Abort RF Software Abort	
2016-06-07 04:33:34.654	RF (LER)	MAJOR	D05D REFLECT to CIR#3DL	
2016-06-07 04:33:34.604	RF (HER)	MAJOR	D10D SQC ABORT TO RFOFF	
2016-06-07 04:33:34.604	RF (HER)	MAJOR	D10B SQC ABORT TO RFOFF	
2016-06-07 04:33:34.604	RF (HER)	MAJOR	D10B BREAK DOWN	
2016-06-07 04:33:34.604	RF (HER)	MAJOR	D10C SQC ABORT TO RFOFF	
2016-06-07 04:33:34.604	RF (HER)	MAJOR	D10C BREAK DOWN	
2016-06-07 04:33:34.603	RF (HER)	MAJOR	D10D BREAK DOWN	
2016-06-07 04:33:34.528	Abt Trg (LER)	MAJOR	LER Abort Soft Abort	
2016-06-07 04:33:34.512	RF (LER)	MAJOR	D08A REFLECT from 2-S	
2016-06-07 04:33:34.512	RF (LER)	MAJOR	D08C REFLECT from 2-S	
2016-06-07 04:33:34.512	RF (LER)	MAJOR	D08B REFLECT from 2-S	
2016-06-07 04:33:34.512	RF (LER)	MAJOR	D08B MT-DL INPOWER	
2016-06-07 04:33:34.485	RF (HER)	MAJOR	D11B SQC ABORT TO RFOFF	
2016-06-07 04:33:34.485	RF (HER)	MAJOR	D11A KLYSTRON POWER MAX	
2016-06-07 04:33:34.392	RF (HER)	MAJOR	D04C REFLECT from 2-S	
2016-06-07 04:33:34.392	RF (HER)	MAJOR	D04A REFLECT from 2-S	
2016-06-07 04:33:34.361	Abt Trg (LER)	MAJOR	LER Abort RF Software Abort	
2016-06-07 04:33:34.250	RF (LER)	MAJOR	D05F REFLECT to CIR#3DL	
2016-06-07 04:33:34.248	RF (HER)	MAJOR	D04F REFLECT to CIR#3DL	
2016-06-07 04:33:34.224	RF (LER)	MAJOR	D05C REFLECT to CIR#3DL	
2016-06-07 04:33:34.218	RF (HER)	MAJOR	D04H REFLECT to CIR#3DL	

Tasks toward Phase-2

- Set up infrastructure (network, etc.) for DR
- Deployment of IOC for DR and IR
- IOC of the BT lines (except pulsed magnets) are left behind. They should be upgraded (CPU, Interface and Software)
- Full Installation of the new abort trigger modules
- DR and DR-BT magnet control system

Summary

- Our control system is EPICS-based distributed system, which has been inherited from KEKB control system.
- Network has been reinforced and reconfigured. It works well in Phase-1 operation.
- Upgrading EPICS R3.13 → R3.14, we can use multiplatform IOC, which provides more flexible configuration.
- We use several kinds of field busses. New PSICM has been installed for magnet PS control. Some old devices such as CAMAC should be replaced.
- New Beam Abort Trigger Module “VME-AM” has been developed with full optical connection and partially installed. It works well in the Phase-1 operation.
- New Alarm System has been developed with CSS Alarm and python/tk GUI. It works well in Phse-1 operation.
- We still have many tasks toward Phase-2, not only construction of DR and IR part but also the upgrade of existing part such as BT control system and so on.

backup

F3RP61 in SuperKEKB

- Vacuum Control
- LLRF (used with MicroTCA system)
- Interface to the Personnel Protection System
- Embedded in Large Magnet Power Supply
  - Digital feed back control for high current stability
- Beam Mask Control
- Pulsed Magnet (Kicker, Septum) Control
- RF Power Supply Control
- Tilting Support (SX Magnet) Control

Version up of the PSICM

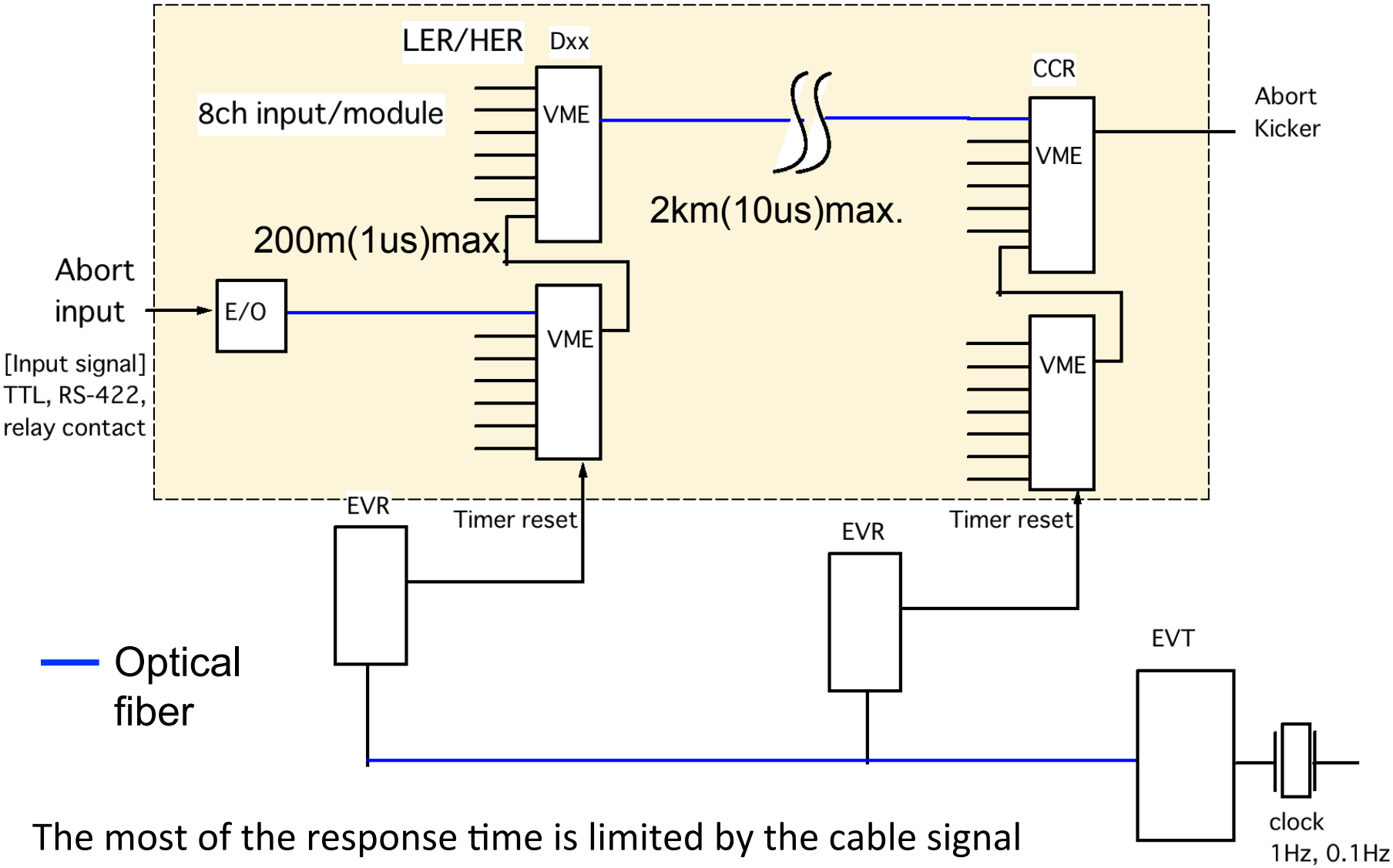
(**P**ower **S**upply **I**nterface **C**ontroller **M**odule)

- 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 

System configuration of the beam abort



The most of the response time is limited by the cable signal transfer time.

VME-AbortModule(VME-AM)

（1）BeamAbort光信号入力モジュール　;VME1幅

1．全体ブロック図