# KEKB Control System

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# Outline

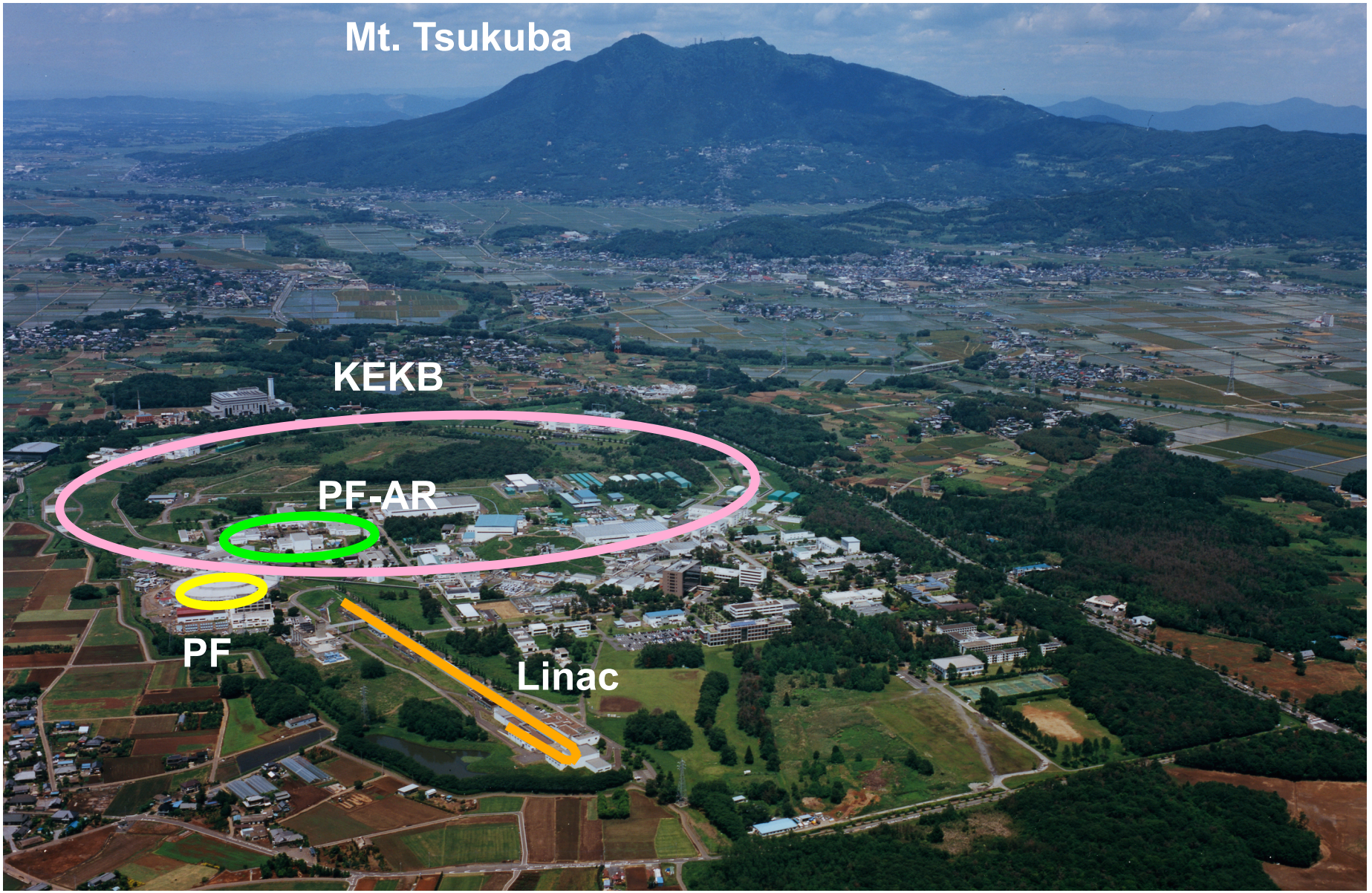
- KEKB Introduction
- KEKB Control System Overview
  - Host computers (OPI layer)
  - VME computers (IOC layer)
  - Field Buses
  - Software in KEKB
- Control System toward the SuperKEKB

# KEKB Introduction

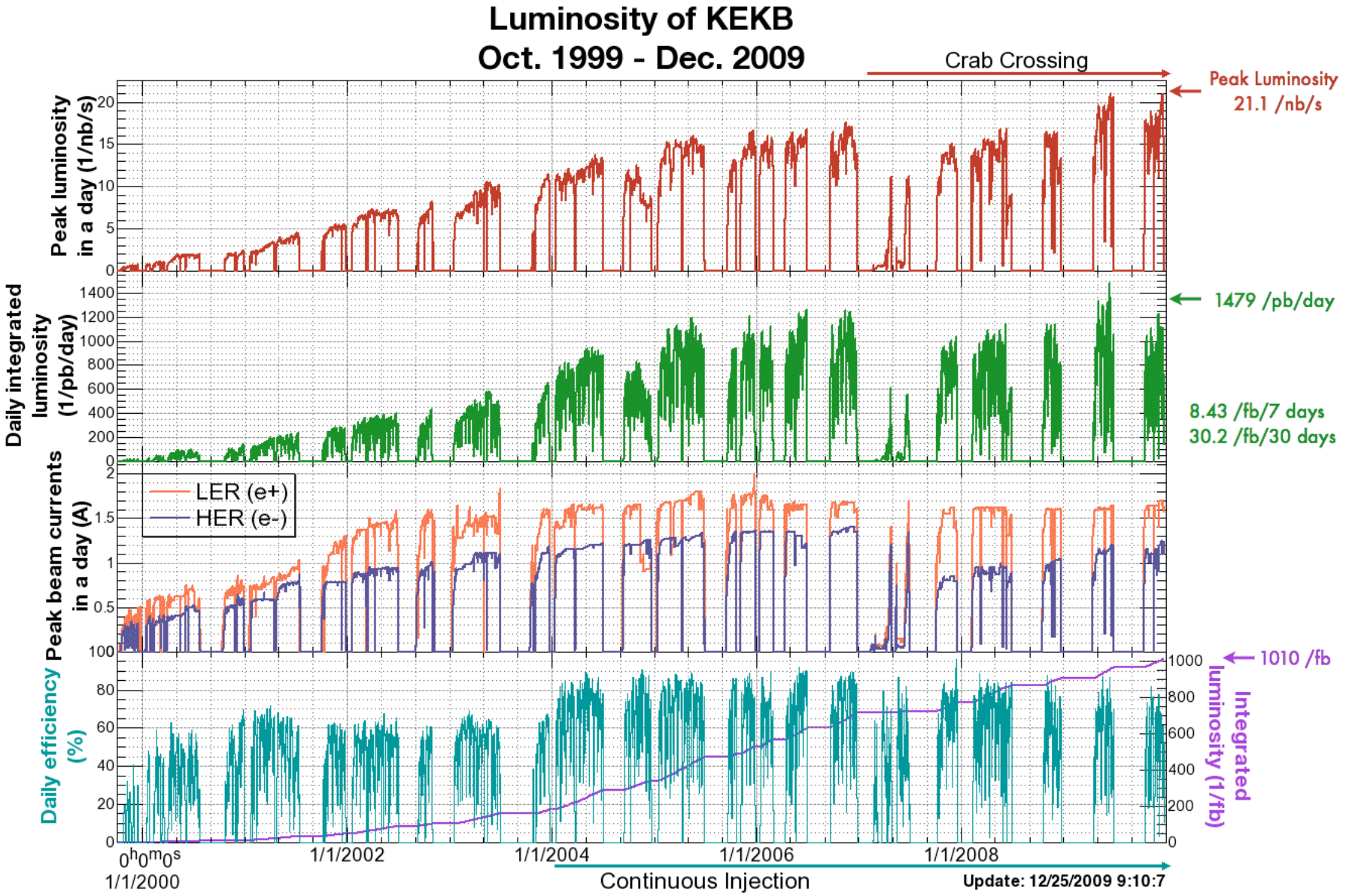
KEKB

- B-factory for Belle experiment
- Electron/Positron asymmetric collider
- ~3km dual rings
  - HER: electron (8GeV ~1.4A)
  - LER: positron (3.5GeV ~1.8A)
- Optimized to produce B meson pairs at $\Upsilon(4s)$
  - Also operated at $\Upsilon(5s)$, $\Upsilon(2s)$, $\Upsilon(1s)$
- Mainly for CP-violation study in B meson system

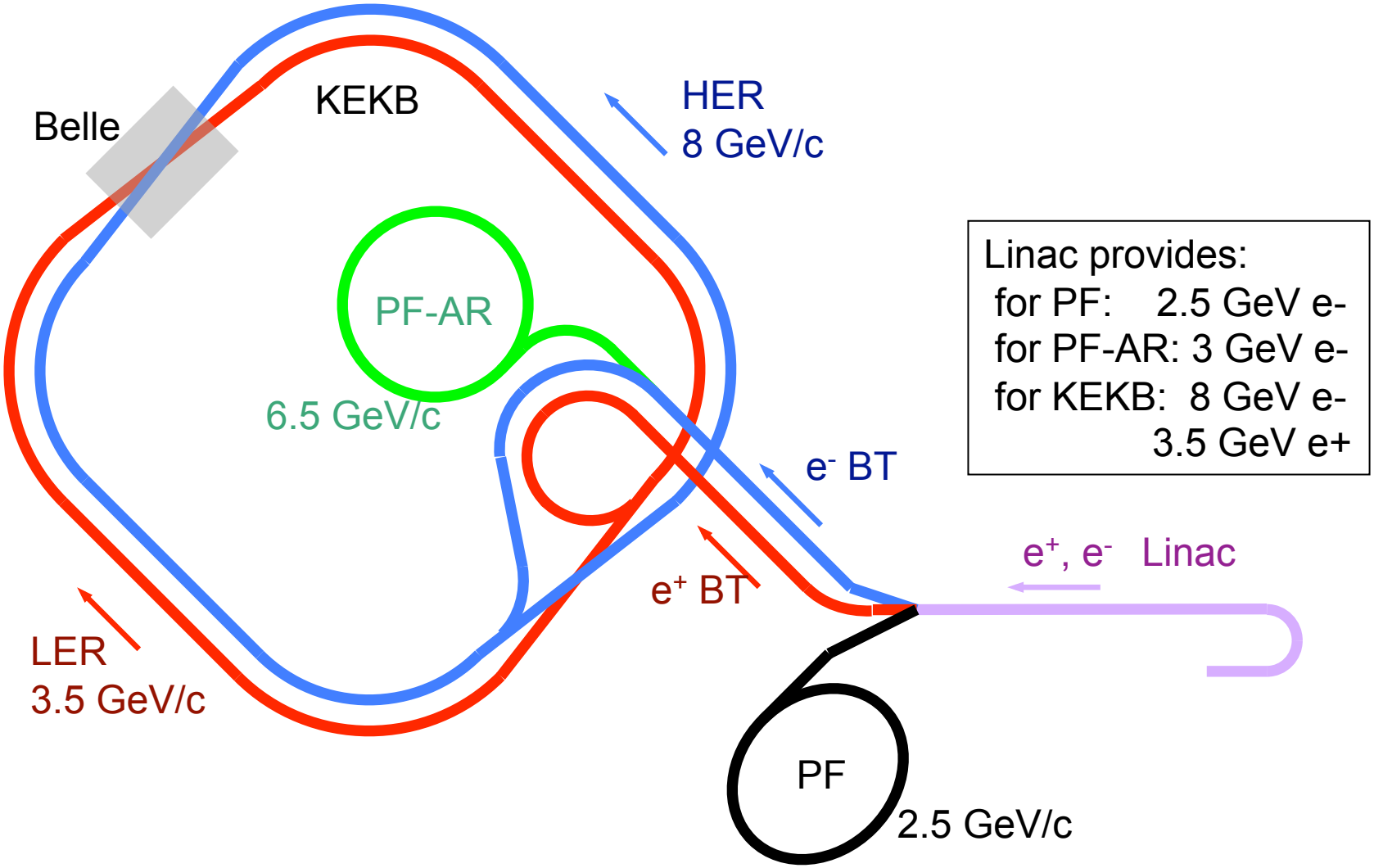
# KEK Tsukuba Campus



# KEKB --- The Luminosity Frontier



# KEK Electron Positron Accelerator Complex

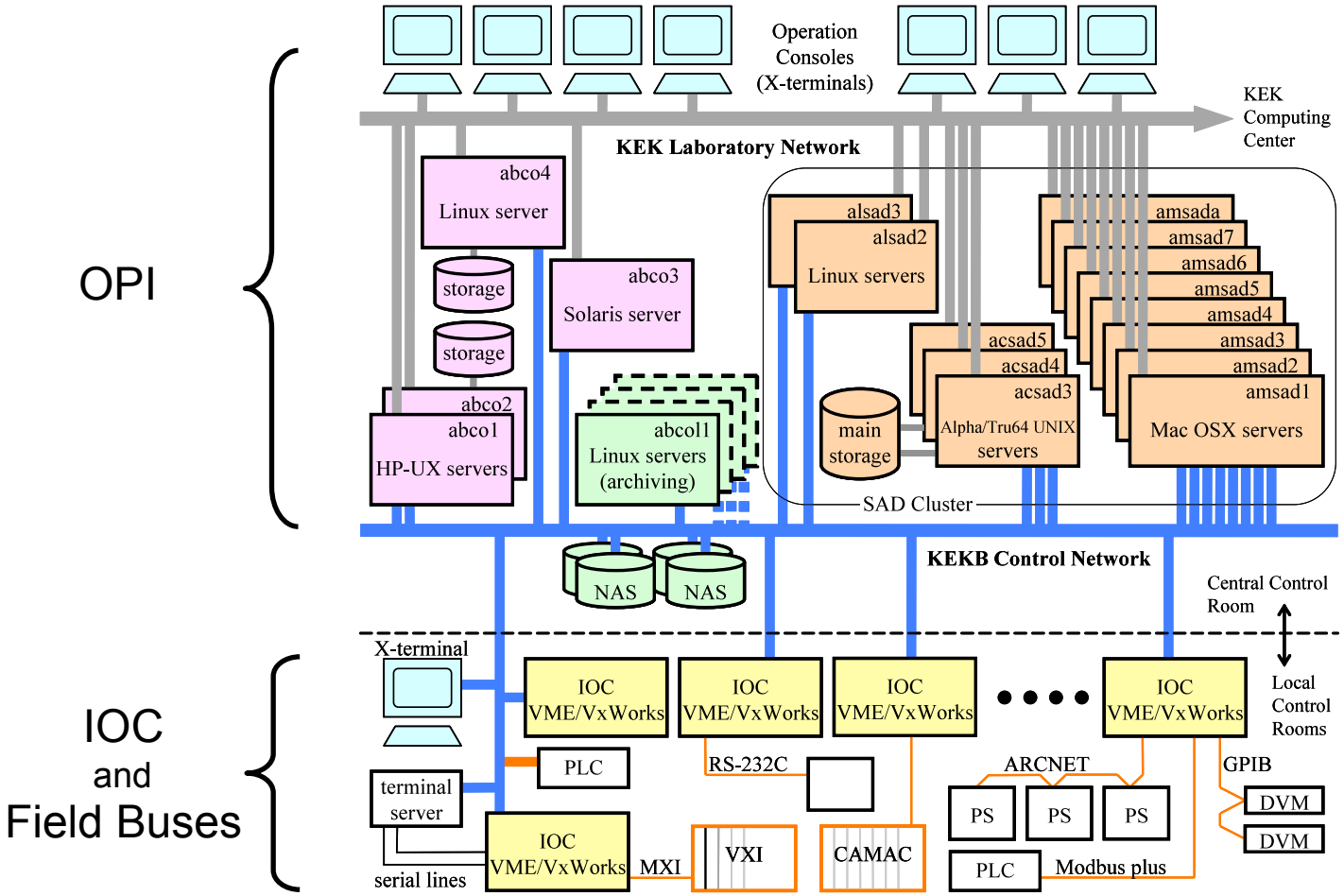



Linac provides:
for PF: 2.5 GeV e-
for PF-AR: 3 GeV e-
for KEKB: 8 GeV e-
3.5 GeV e+

# **EPICS** in KEKB / PF-AR / PF / Linac

- KEKB History --- The first application of EPICS in Japan
  - 1994-1998 KEKB construction
  - Mar. 1998 part of e- BT line commissioning
  - Jun. 1998 part of e+, e- BT lines commissioning
  - Dec. 1998 KEKB rings commissioning started
- PF-AR upgrade (introducing EPICS)
  - 2001 PF-AR 1 year shutdown for upgrade
  - Jun. 2002 operation of PF-AR restarted
- PF upgrade (introducing EPICS)
  - 2005 PF upgrade
- Linac --- gradually introducing EPICS

# KEKB Control System Overview




Hardware Configuration of the KEKB Control System in 2006

# Host Computers (OPI layer)

- Main Servers for Control System
  - HP-UX, Solaris, Linux Servers and Linux Blade Servers
    - EPICS Software Development
    - File Management / RDBMS
    - CA Client programs (medm, python)
- Operation Servers (“SAD Cluster”)
  - Alpha/Tru64,  Mac/OSX servers
    - SAD programs for operation
  - NAS (main file server)
- Special purpose miscellaneous servers
  - Data Archiving Servers
  - Zope Servers

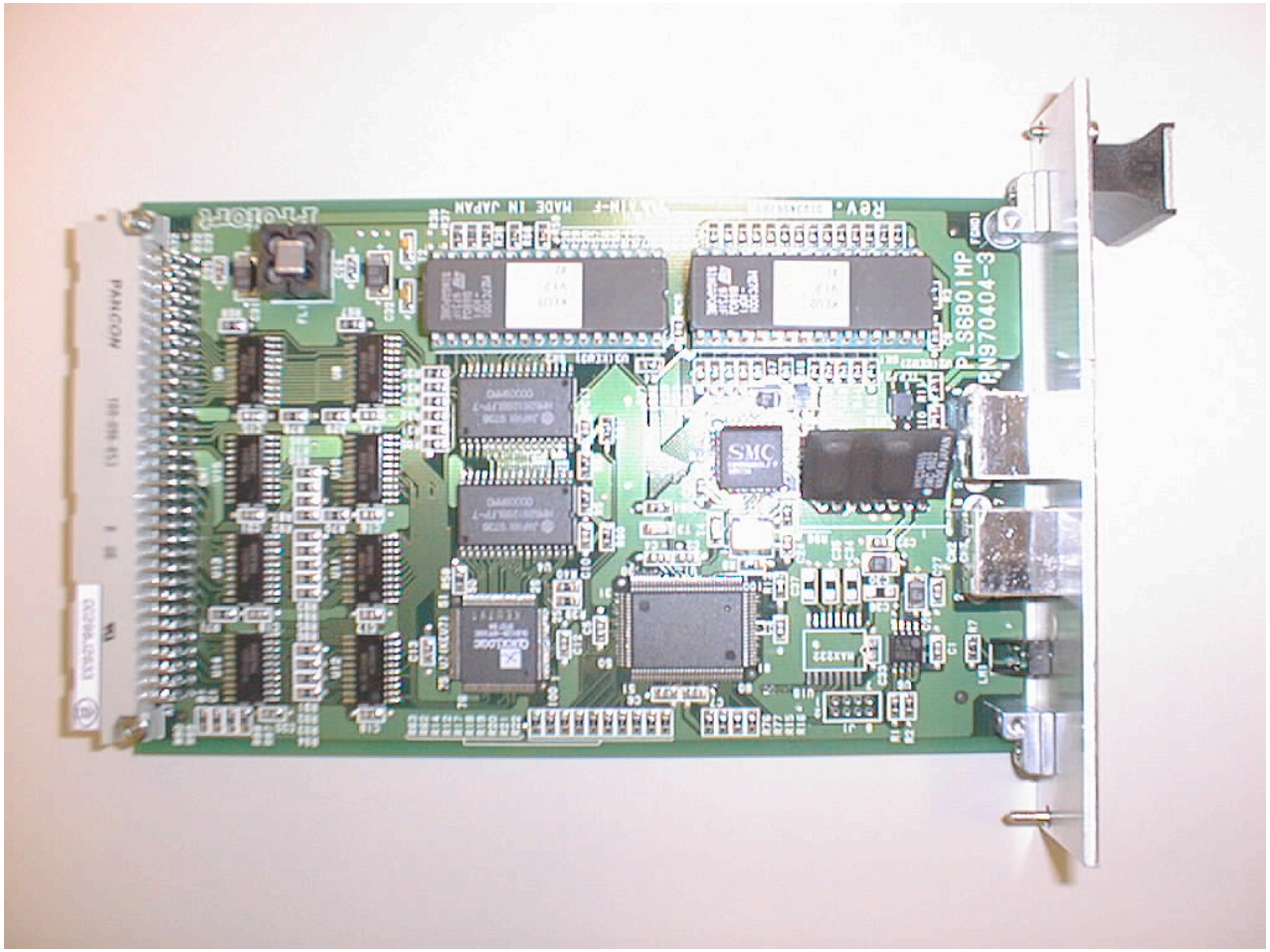
# VME computers (IOC layer)

- ~ 100 PowerPC (603e, 750) CPU board
  - Force PowerCore6750, PowerCore6603e
- A few 68040,68060 CPU board are still in use.
  - Force CPU64, CPU40
- Most of them are VxWorks 5.3.1/EPICS R3.13.1
- Some non-VME IOCs are also installed
  - PC/Linux IOC
    - For Software records / Ethernet devices (NetDev)

# Field Buses

- **VXI/MXI** for BPM
- **ARCNET** for 2500 magnet PS with **PSICM** (Power Supply Interface Controller Module)
- **CAMAC** for RF, BT and vacuum control
- **GPIB** for many purpose (DVM, motor control, data logger, etc.)
- **Modbus plus**, **RS-232C** or **GPIB** link to several types of PLC
- Several devices are connected through **Ethernet**

# PSICM (Power Supply Interface Controller Module)



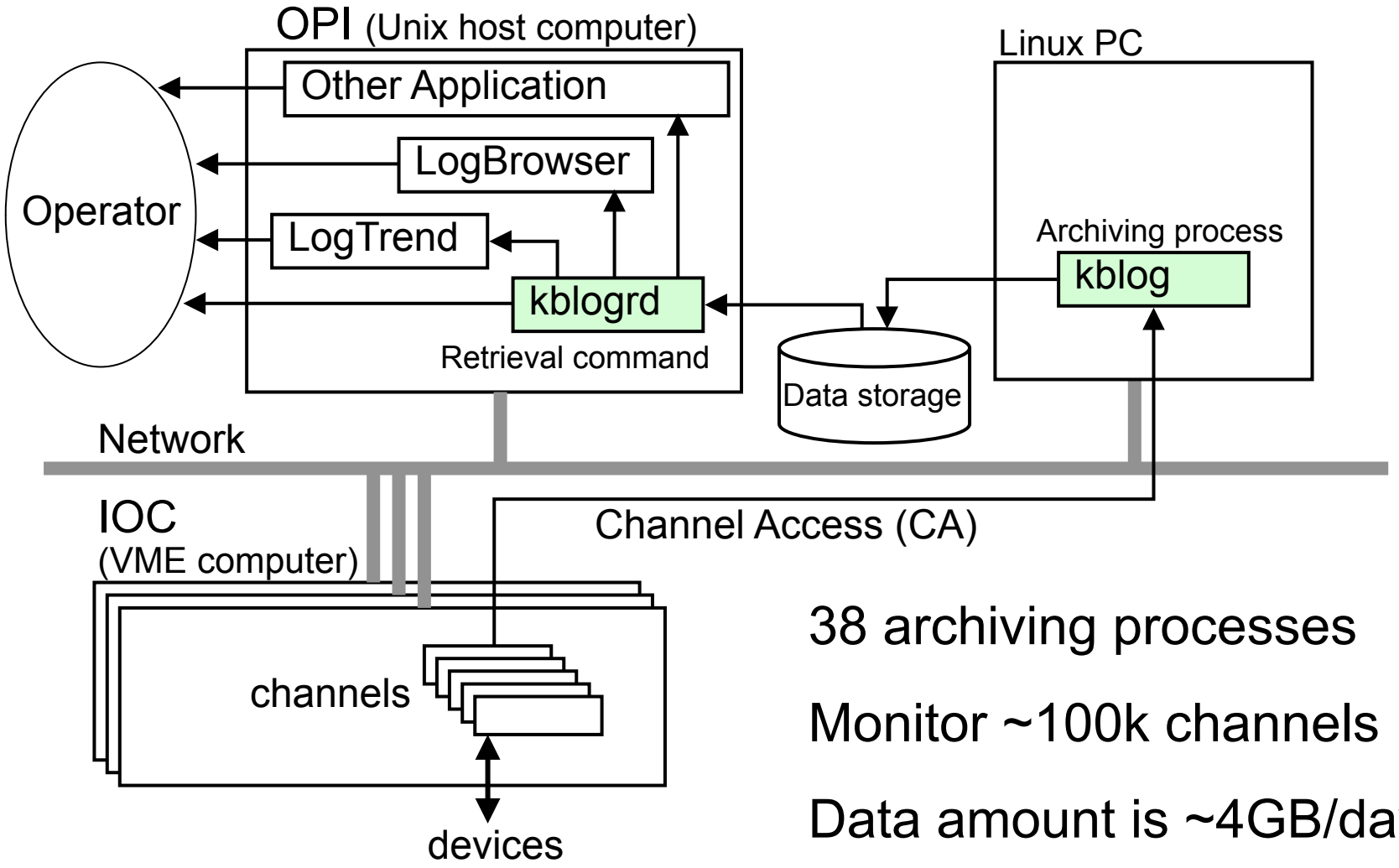
# Software in KEKB

- EPICS standard tools
  - capfast
  - medm
- Non-standard tools (developed at KEK)
  - Alarm display
  - Data archiving tool (KEKBLog)
  - Electronic logbook (Zlog)
- Scripting language
  - SAD (SADScript)
  - Python

# SAD

- **SAD** (Strategic Accelerator Design) is a computer program complex for accelerator design developed in KEK since 1986.
  - http://acc-physics.kek.jp/SAD/sad.html
- SAD has **SADScript**, which is the programming Interface in Mathematica style.
  - Tcl/Tk interface for GUI
  - EPICS CA interface
- Most of the high level applications for operation are developed by SADScript.

# KEKBLog --- Data archiving tool




38 archiving processes

Monitor ~100k channels

Data amount is ~4GB/day

# Zlog

**Zlog** is …

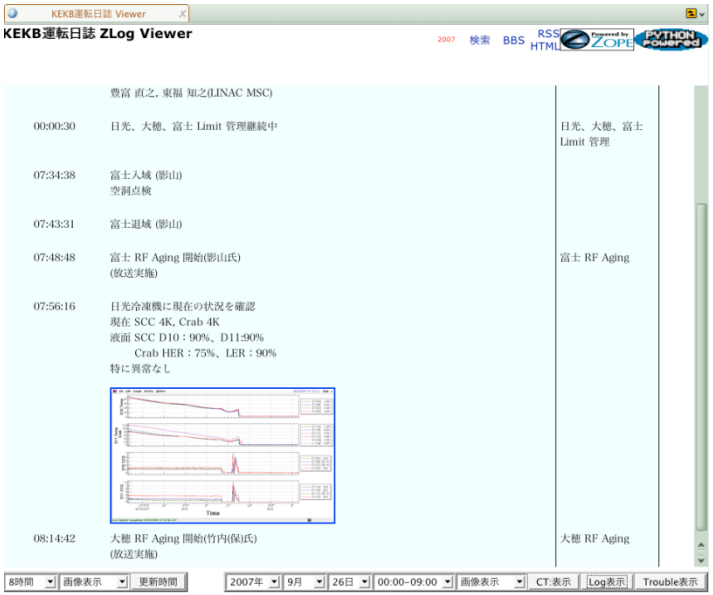
- An **electronic logbook** system
- Developed at KEK
- **Zope** based
- Designed mainly for daily operation of KEKB/PF-AR accelerator complex
- But also usable for many purposes

What is **Zope** ?

- Python-based open source web application server.
- Available on Mac, Unix and Windows.
- Ready-made Products are available.
  - Application Templates
  - plug-in Zope components
- Through-the-Web development & management.

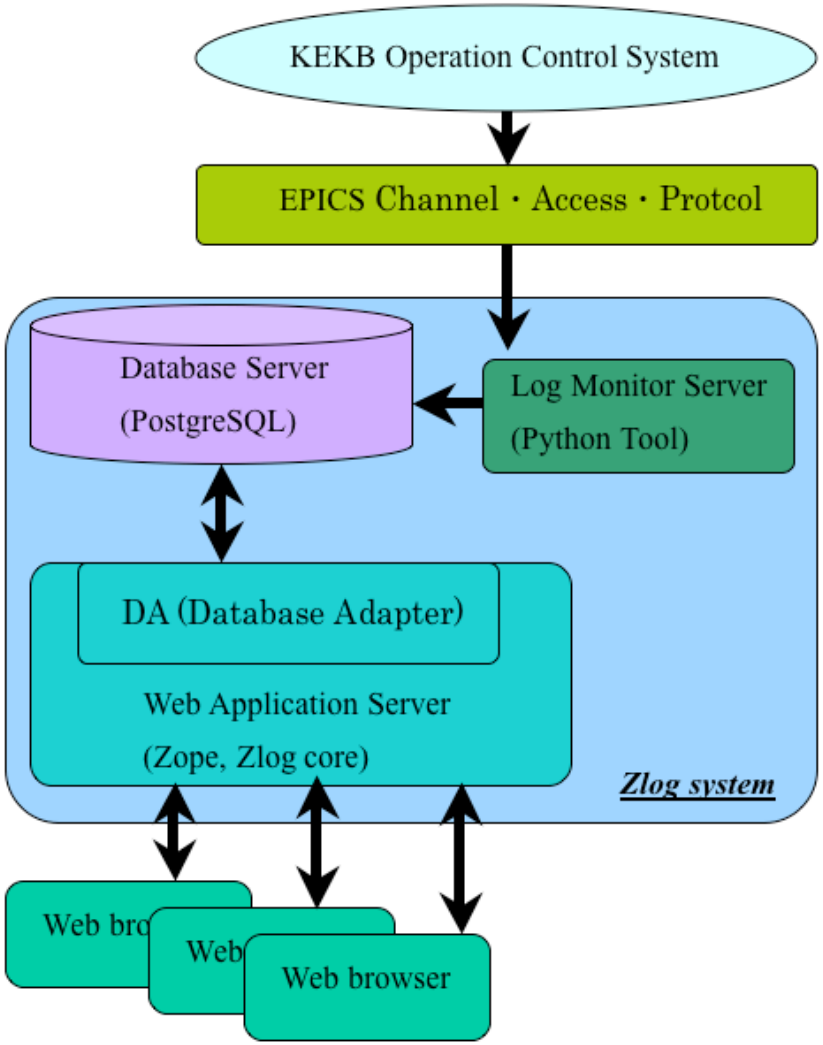
# Zlog user interface


Input and Edit




Viewer

# Structure of Zlog System




## Frontend

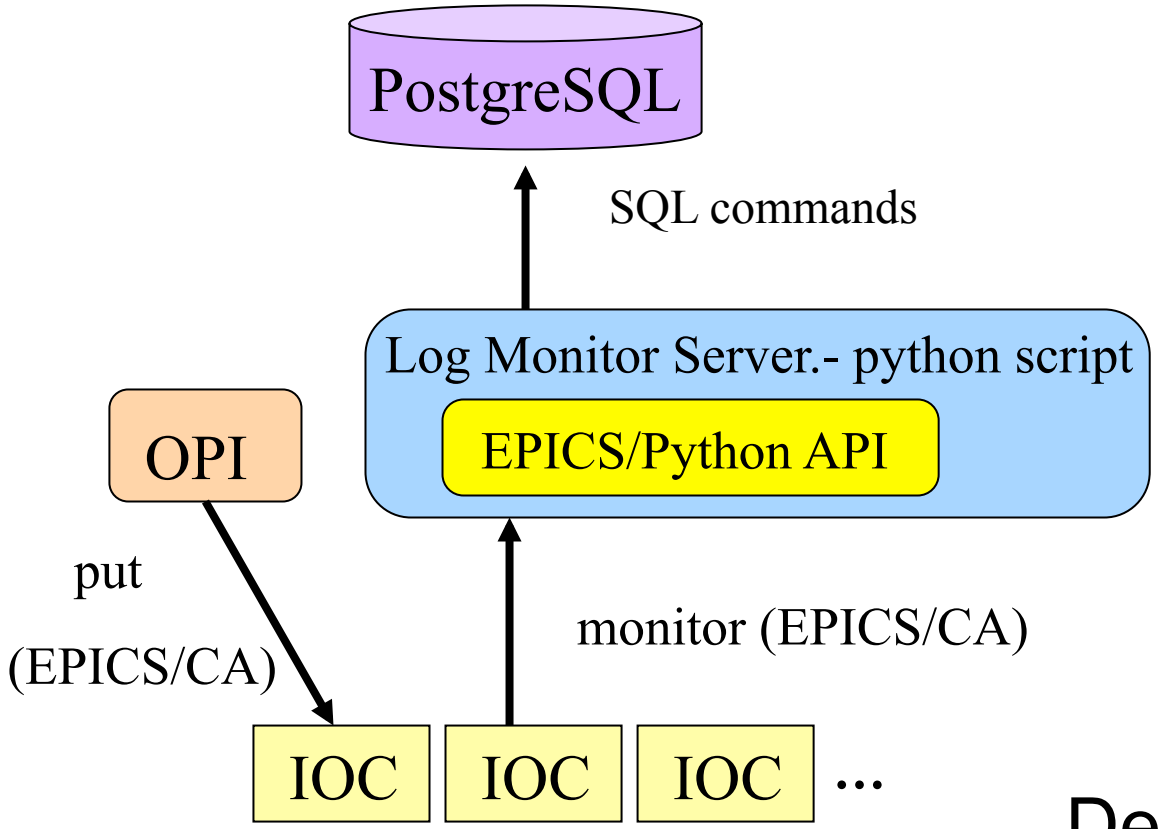
**Zlog Core** (Zope based)
(Web Application for user interface)

## Backend

**PostgreSQL**
(Database server)

**Log Monitor Server**
(Server for automatic data entry)

# Log Monitor Server




## Automatic entries

- Start/Stop of Injection
- Injection rate
- Start/Stop of Physics run
- Peak Luminosity
- Start of Beam Tuning
- Alarm Events
- etc….

## Developed in Python

# SuperKEKB

- SuperKEKB --- Upgrade Plan of KEKB
  - Aimed at 8 $\times 10^{35}$ $cm^{-2}s^{-1}$ Luminosity
    - 40 times higher than current KEKB
  - Nano-beam Scheme
    - Squeeze $\beta_y^*$ as small as possible
  - Upgrade many components
    - Low emittance gun and new positron source
    - Damping ring
    - New lattice design
    - TiN-coated beam pipe with antechambers
    - New beam pipe and bellows
    - New IR design
    - Add/modify RF system for higher beam current

# Upgrade of the Control System

- We are developing new type IOC.
  - F3RP61 --- EPICS embedded PLC
  - EPICS Embedded Oscilloscope
- Replacements of the VME computers
  - Force PowerCore6750 → MVME5500 (or MVME4100)
  - VxWorks 5.3 → VxWorks 5.5
  - EPICS R3.13 → R3.14
- Replacements of Field buses
  - CAMAC : too old to maintain. (>20 years old system )
  - PSICM → Ethernet-based PSICM
- Replacements and/or Version up of any other outdated components
  - Server computers, Network, Software components, …

# New Type IOC

- **EPICS** can be **embedded** in various devices --- New trend of EPICS IOC
- F3RP61 --- EPICS embedded PLC
  - Yokogawa FAM3 series PLC
  - Linux is supported
  - EPICS R3.14
  - Real-Time Kernel (coming soon)
  - Applications in KEKB (Current Status)
    - Beam Mask Control
    - Pulsed Q-Magnet Control

# F3RP61 (e-RT3 2.0)

Linux 2.6.24

PPC 533MHz

128Mbyte RAM

100BaseTx x 2

USB

IEEE1394

Serial

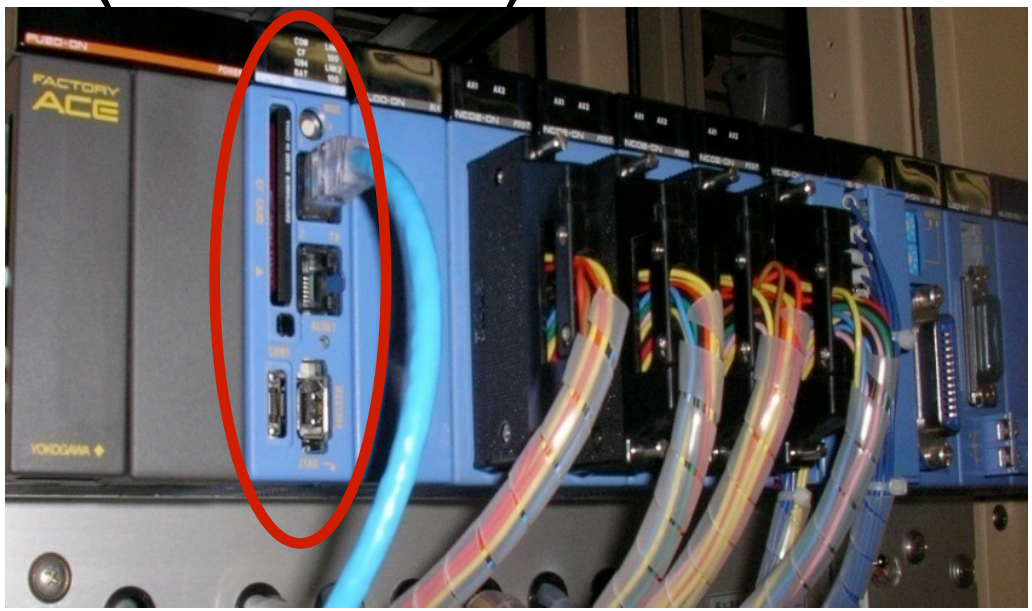
PCI

I/O Bus for FAM3 Module Interface

can access to mature FAM3 I/O Modules

Can be combined with conventional ladder CPU

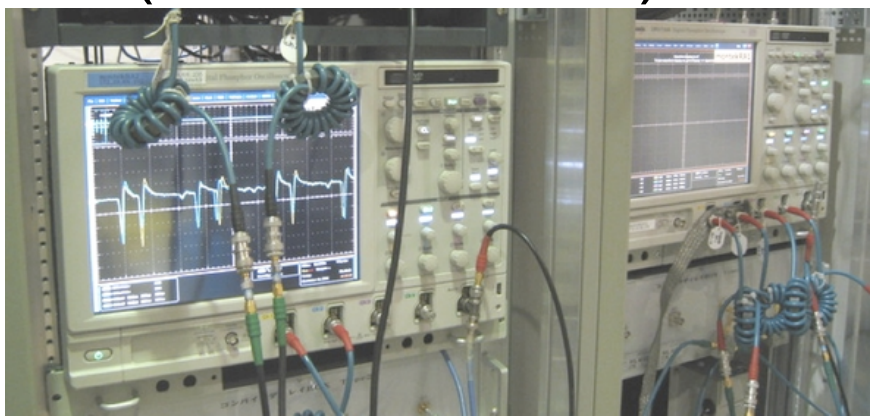
Software development environment (ELDK)




KEKB Beam mask controller

# New Type IOC

- EPICS Embedded Oscilloscope
  - Tektronix DPO7104
  - Windows embedded
  - EPICS R3.14.8.2
  - Applications in KEKB (Current Status)
    - Linac BPM
    - BT BPM



# Replacement of Field buses

- CAMAC
  - At the beginning of KEKB, CAMAC system is good heritage from TRISTAN system.
  - But, currently it become hard to maintain. (>20 years old system )
  - Candidate of replacement
    - EPICS embedded PLC (F3RP61)
    - Handling of high density signal cables is a problem
- New LLRF system
  - Development of new LLRF system is in progress.
    - Completely new design including control system
  - Embedded EPICS on the new LLRF card (μTCA)

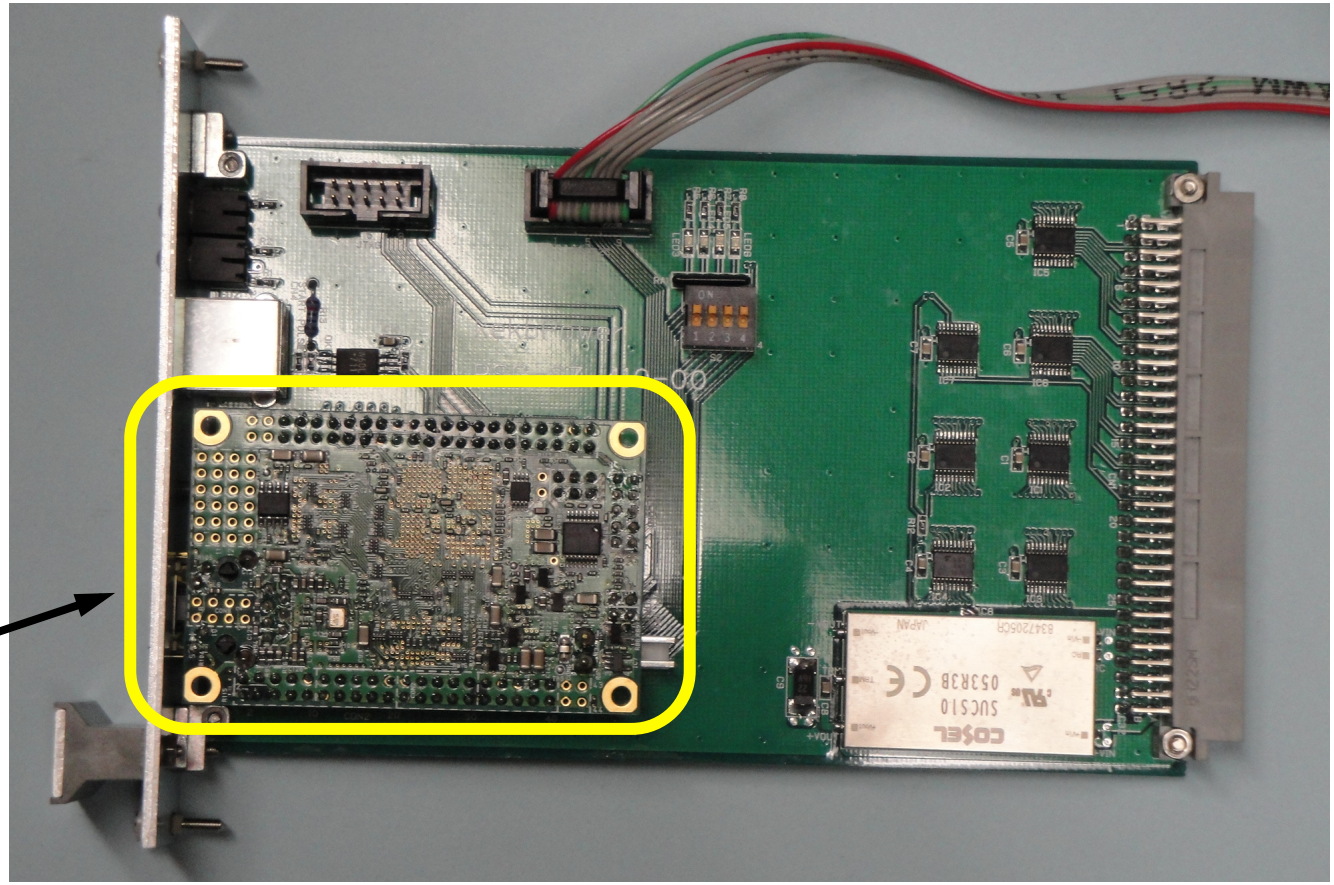
# New interface for Magnet PS

- PSICM (Power Supply Interface Controller Module)
  - Interface card plugged in power supply
    - Microprocessor is embedded
    - ARCNET controller and driver
    - Timing signal input to start synchronous ramping
  - Design plan of the New version --- “ePSICM”
    - Ethernet (100Mbps) instead of ARCNET
    - High level communication protocol (commands) is compatible
    - Fully compatible to the current version for the Magnet PS

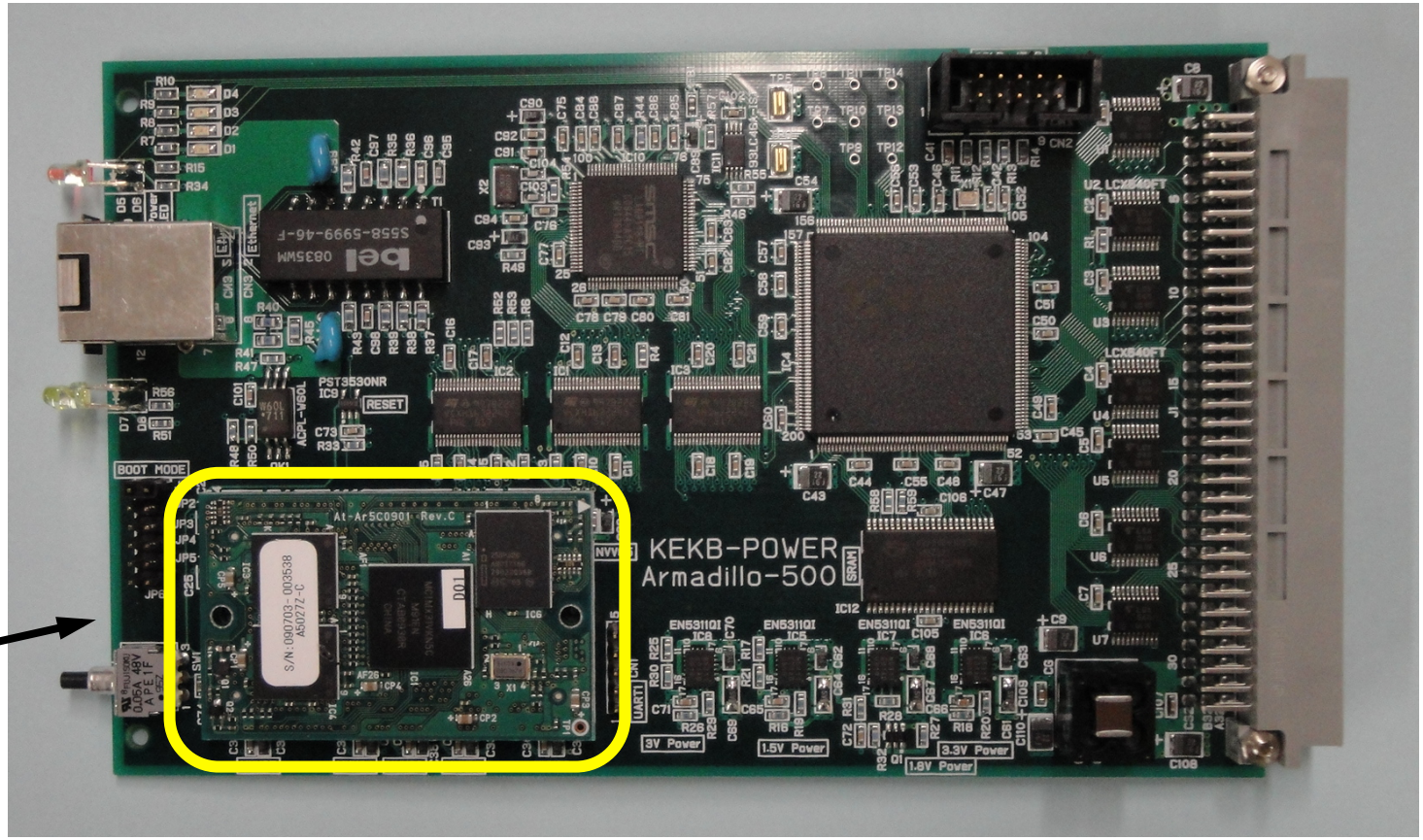
# New PSICM (continued)

- Current status --- developing prototypes
  - Prototype using Suzaku
    - Suzaku: FPGA(Vertex-4) with CPU(PowerPC405)
  - Prototype using Armadillo
    - Armadillo: CPU(ARM11)
  - Rapid prototyping
    - Linux / EPICS embedded
    - EPICS CA as the low level communication protocol
      - Socket programming is not necessary.

Prototype of the ePSICM using Suzaku

# Prototype of the ePSICM using Armadillo




Armadillo

# Summary

- The KEKB Control System has been operated more than 10 years.
- In the KEKB Control System :
  - VME computers are mainly used as IOC.
  - Various kinds of field buses are used.
  - Scripting Language, SAD Script and Python, are intensively used.
  - Original Software such as KEKBLog, Zlog has been developed.
- Toward the SuperKEKB, Replacements and/or Version up of the outdated components are necessary. Some of them have started.
  - VME CPU (with EPICS R3.13 → R3.14)
  - CAMAC
  - Server Computers, Network, Software components, …
- Developments of the new type IOC, interface modules, equipments are in progress.
  - F3RP61 --- EPICS embedded PLC
  - EPICS Embedded Oscilloscope
  - ePSICM --- Ethernet-based Power Supply Interface Controller Module
  - EPICS on μTCA card (New LLRF)