Status of SuperKEKB Control System

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Outline

• Introduction of KEKB & SuperKEKB
• Upgrade of the Control System
  – OPI layer
  – IOC layer
• “CA Everywhere” --- Embedded EPICS
  – F3RP61 --- EPICS Embedded PLC
  – Other Embedded EPICS IOC
Introduction of KEKB

KEKB (1999 – 2010)
• 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 Y(4s)
  – Also operated at Y(5s), Y(2s), Y(1s)
• Mainly for CP-violation study in B meson system
KEKB --- The Luminosity Frontier

Luminosity of KEKB
Oct. 1999 - June 2010

Crab Crossing

Peak Luminosity 21.1 /nb/s

1479 /pb/day

8.43 /fb/7 days
30.2 /fb/30 days

1041 /fb

Integrated luminosity (1/fb)

Continuous Injection

Update: 7/18/2010 13:40:53
SuperKEKB

• SuperKEKB --- Upgrade of KEKB is in progress.
  – Start commissioning in FY2014
  – Aims at $8 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ Luminosity
    • 40 times higher than KEKB
  – Nano-beam Scheme
    • Squeeze $\beta_y^*$ as small as possible
      $\beta_y^* \sim 0.3\text{mm}, \varepsilon_x/\varepsilon_y \sim 4\text{nm}/9\text{pm}, \sigma_y \sim 50\text{nm}, \sigma_z \sim 6\text{mm}$
  – 7GeV / 2.6A electron, 4GeV / 3.6A positron
  – 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
KEK Electron Positron Accelerator Complex

Linac provides:
- for PF: 2.5 GeV e-
- for PF-AR: 3 GeV e-
- for SuperKEKB: 7 GeV e- 4 GeV e+

**SuperKEKB**

**PF-AR**

**Ler**

**PF**

**Belle II**

**HER**

7 GeV/c

**Linac**

**2.5 GeV/c**

**6.5 GeV/c**

**Damping Ring**

**EPICS Meeting at SLAC**

April 25, 2012
EPICS in KEKB / PF-AR / PF / Linac

- KEKB (KEK B-Factory)
  - The first application of EPICS in Japan.
  - 1994-1998 KEKB construction
- PF-AR (Photon Factory - Advanced Ring)
  - EPICS has been introduced in the upgrade in 2001.
- PF (Photon Factory)
  - EPICS has been introduced in the upgrade in 2005.
- Linac
  - EPICS has been gradually introduced.
- Control Systems of these accelerators share some hardware, software and human resources.
Upgrade of the Control System for SuperKEKB

• Inherit Good Features of KEKB Controls
  – EPICS
  – Scripting Languages
    • SAD and Python
  – Mature Subsystems are not changed
    • Ex.: ARCNET based Magnet PS control with VME/Vxworks

• New Features
  – CA Everywhere --- Embedded EPICS
  – New Timing System for Injection
    • → “Control System Achievement at KEKB and Upgrade Design for SuperKEKB”, K. Furukawa et. al. in ICALEPCS11
OPI Layer in KEKB

- **EPICS Standard Tools**
  - MEDM

- **KEK Original Tools**
  - KEKBLog (simple data archiving tool)
  - Zlog (electric logbook using Zope)

- **Scripting Languages**
  - SAD (SAD Script)
  - Python
OPI Layer in SuperKEKB

• EPICS Standard Tools
  – MEDM
  – CSS ← Start evaluation

• KEK Original Tools
  – KEKBLog (simple data archiving tool)
  – Zlog (electric logbook using Zope)

• Scripting Languages ← Still Powerful
  – SAD (SADScript)
  – Python
SAD

- **SAD** (Strategic Accelerator Design) is a computer program complex for accelerator design developed at KEK since 1986.

- 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.
IOC Layer in KEKB

• VME/VxWorks
  – Most of IOC’s are VME board computers
  – Mainly EPICS R3.13.1
IOC Layer in SuperKEKB

• VME/VxWorks continues for some subsystem.
  – Ex. Magnet Power Supply with ARCNET I/F
  – Update EPICS R3.13.1 → R3.14.x

• Embedded EPICS IOC
  – Various Embedded EPICS IOC have been developed at KEK.
  – “CA Everywhere”
    • The device itself directly talks Channel Access.
CA Everywhere

• Embedded EPICS IOC developed at KEK
  – MicroTCA LLRF module: Linux/FPGA (Odagiri…)
  – Yokogawa PLC: Linux CPU (Odagiri…)
  – Oscillo. 50Hz measurement: Windows (Satoh…)
  – MPS management :Linux/FPGA (Akiyama…)
  – Timing TDC: Linux/Arm (Kusano…)
  – Power modulator: Linux/FPGA (Kusano…)
  – Libera BPM at 50Hz: Linux/FPGA (Satoh…)
  – NI cRIO : CAS/FPGA (Odagiri…)
F3RP61 --- EPICS embedded PLC

- CPU Module of Yokogawa FAM3 series PLC
- Linux is supported
- EPICS R3.14
- Real-Time Kernel is available
- Many modules are available for FAM3 including special modules such as
  - Image Acquisition Module: F3UM02
  - Event Receiver Module (EVR) developed at SSRF → coming soon
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)
F3RP61 in SuperKEKB

• Vacuum Control → Terui’s talk on Friday
• LLRF (used with MicroTCA system)
• Interface to the Safety System
• Embedded in Large Magnet Power Supply
• Beam Mask Control
• Pulsed Q-Magnet Control
• Linac Screen Monitor Control
F3RP61 --- Example 1

• LLRF System
  – Fast feedback controller --- MicroTCA
  – Slow miscellaneous control --- F3RP61
F3RP61 --- Example 2

• Large Magnet Power Supply
  – Basic control with synchronous ramping pattern
    • → Plug-in controller (PSICM) with ARCNET I/F
  – Some power supplies have Slow Feedback Subsystem (PLC) to correct long-term drift.
    • → F3RP61 is installed to interface the subsystem
Summary

• Upgrade for SuperKEKB is in progress.
• OPI Layer is not drastically changed.
  – Scripting Languages are still Major Tools
  – Introducing CSS
• IOC Layer becomes the mixture of
  – Mature VME/VxWorks systems
  – Various Type of the Embedded EPICS IOC
    • Especially F3RP61 is widely used.
Related Talks

• Development and Deployment of CSS
  – Takashi Nakamoto, Cosylab
  – Session 2, Today

• Application of Embedded EPICS to Vacuum Control System for SuperKEKB
  – Terui Shinji, KEK
  – Session 1, Friday