Recent progress at KEK and Plans for SuperKEKB

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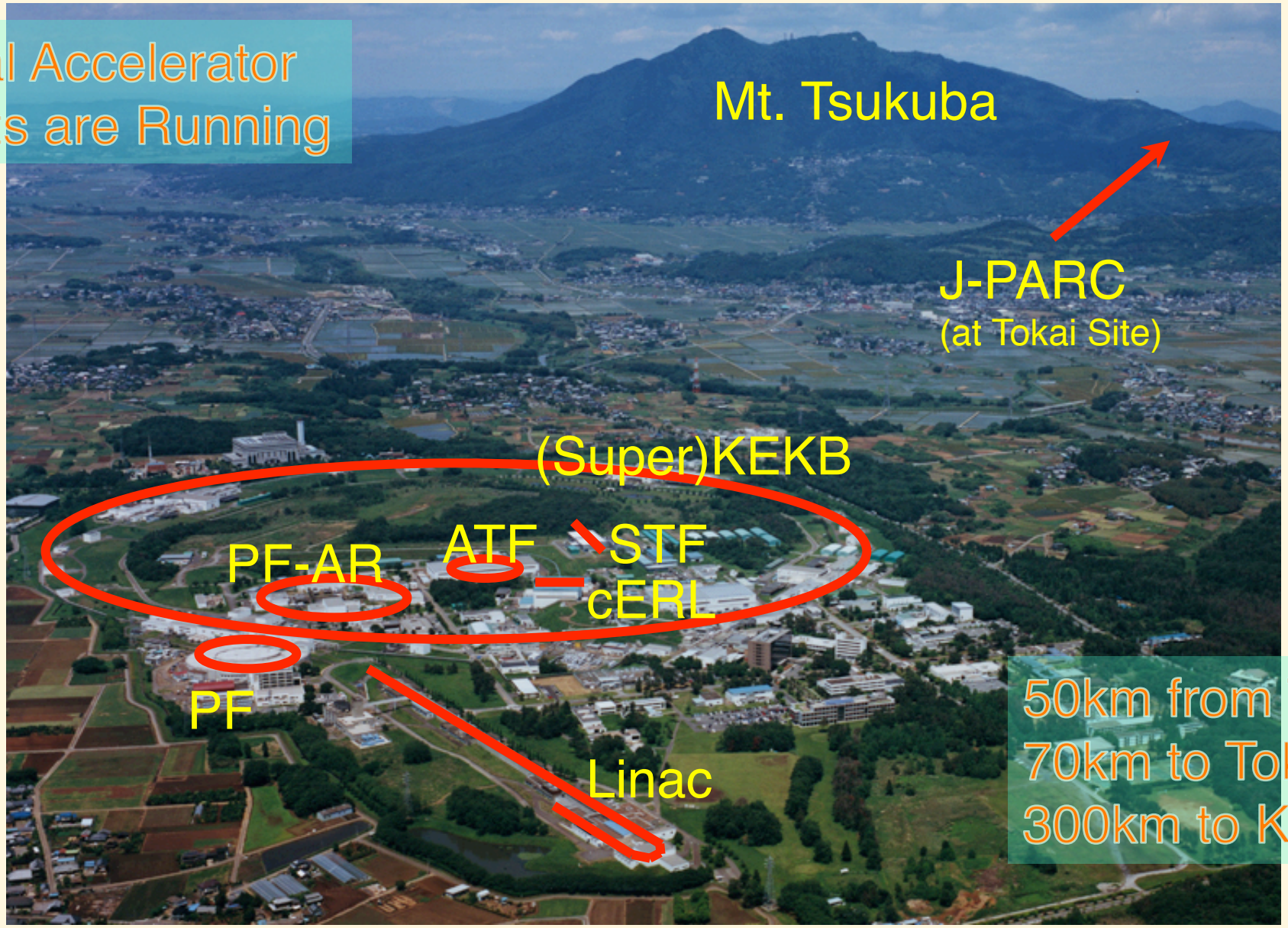
October 11, 2010.

Accelerators at KEK

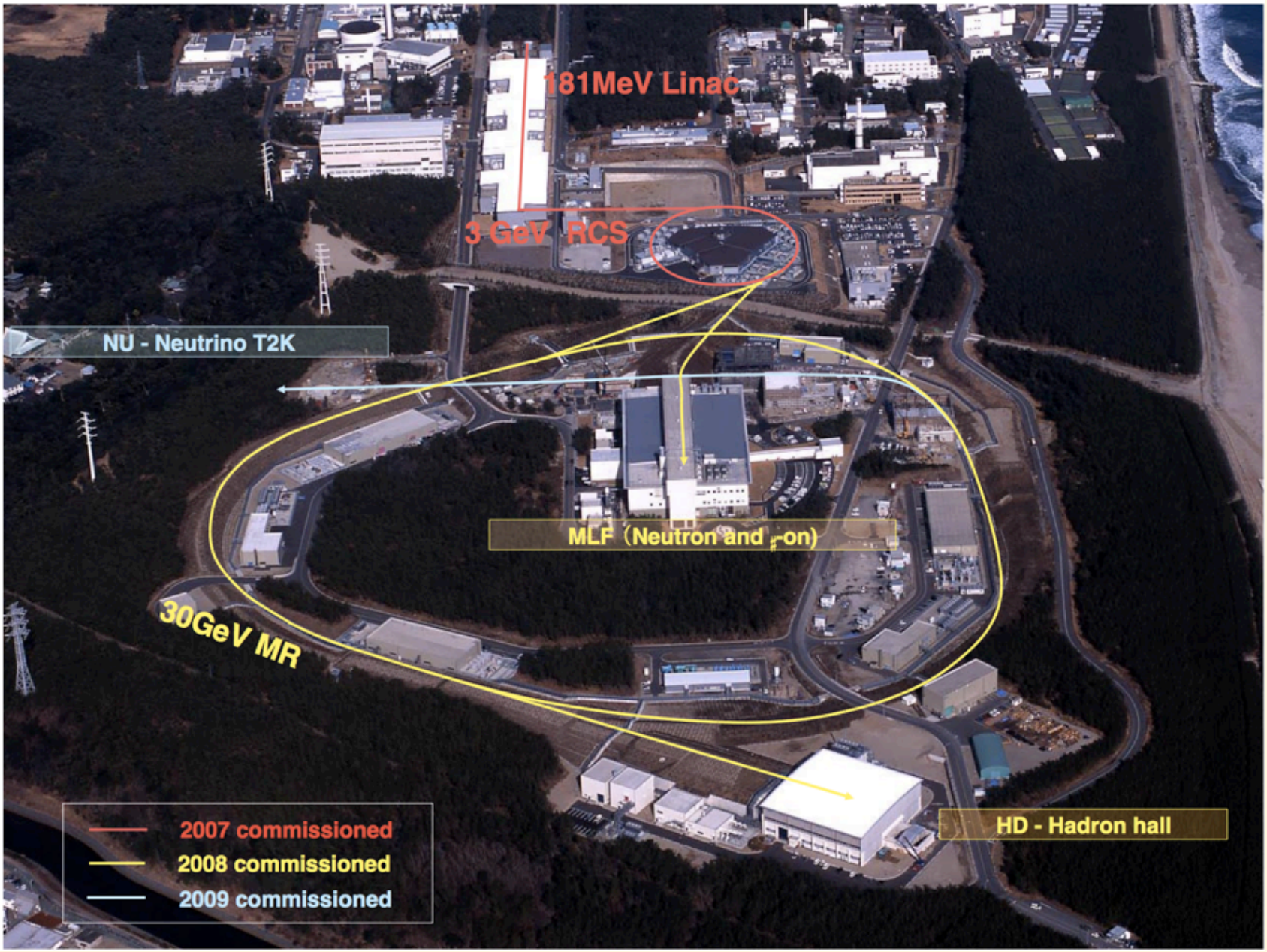
Several Accelerator Projects are Running

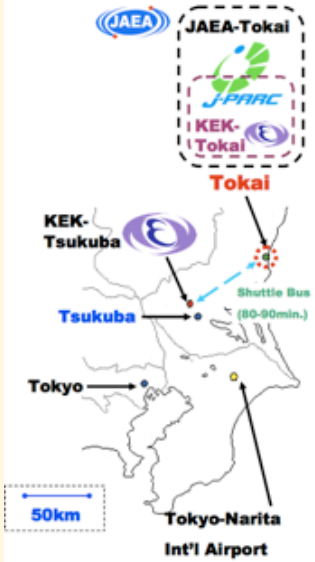


50km from Tokyo
70km to Tokai
300km to Kamioka

J-PARC Japan Proton Accelerator Research Complex

Yamamoto/
Kamikubota

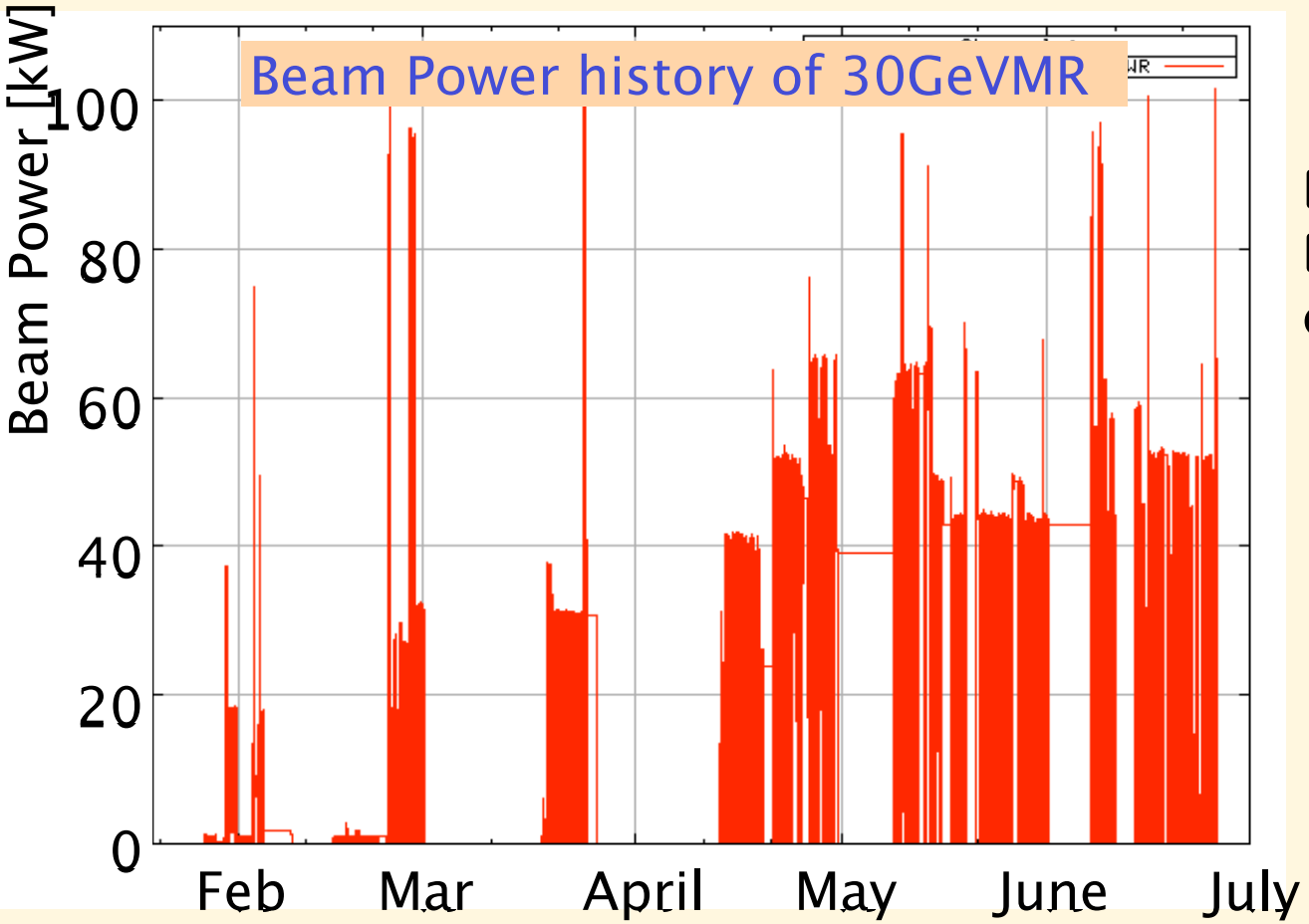




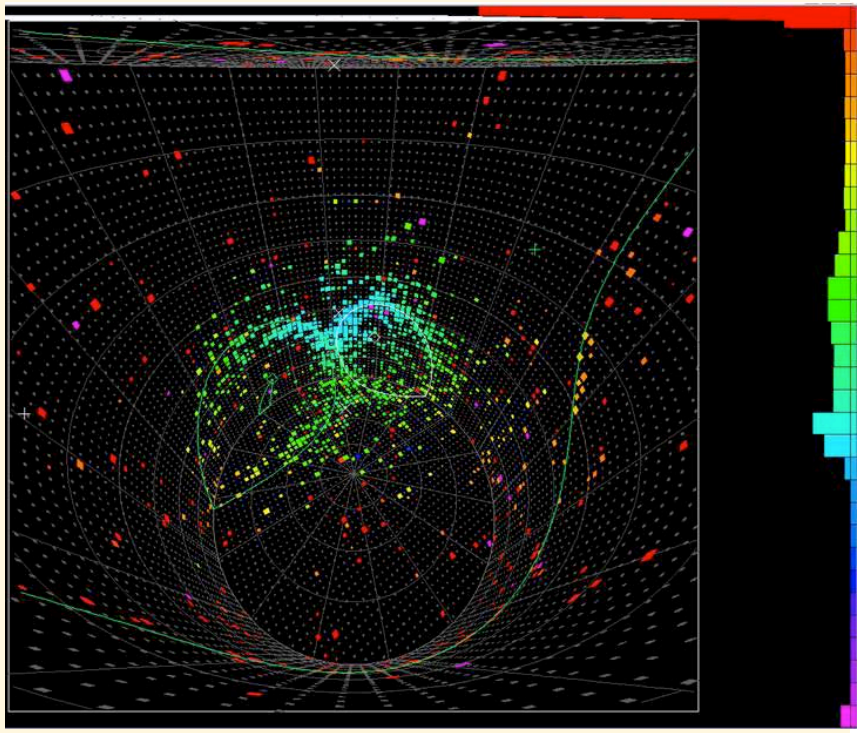
Bird's eye photo
in January of 2008

2010 Operational Highlights

Yamamoto/
Kamikubota



Feb. 24, 2010
First Neutrino Event from J-PARC observed at Super Kamiokande

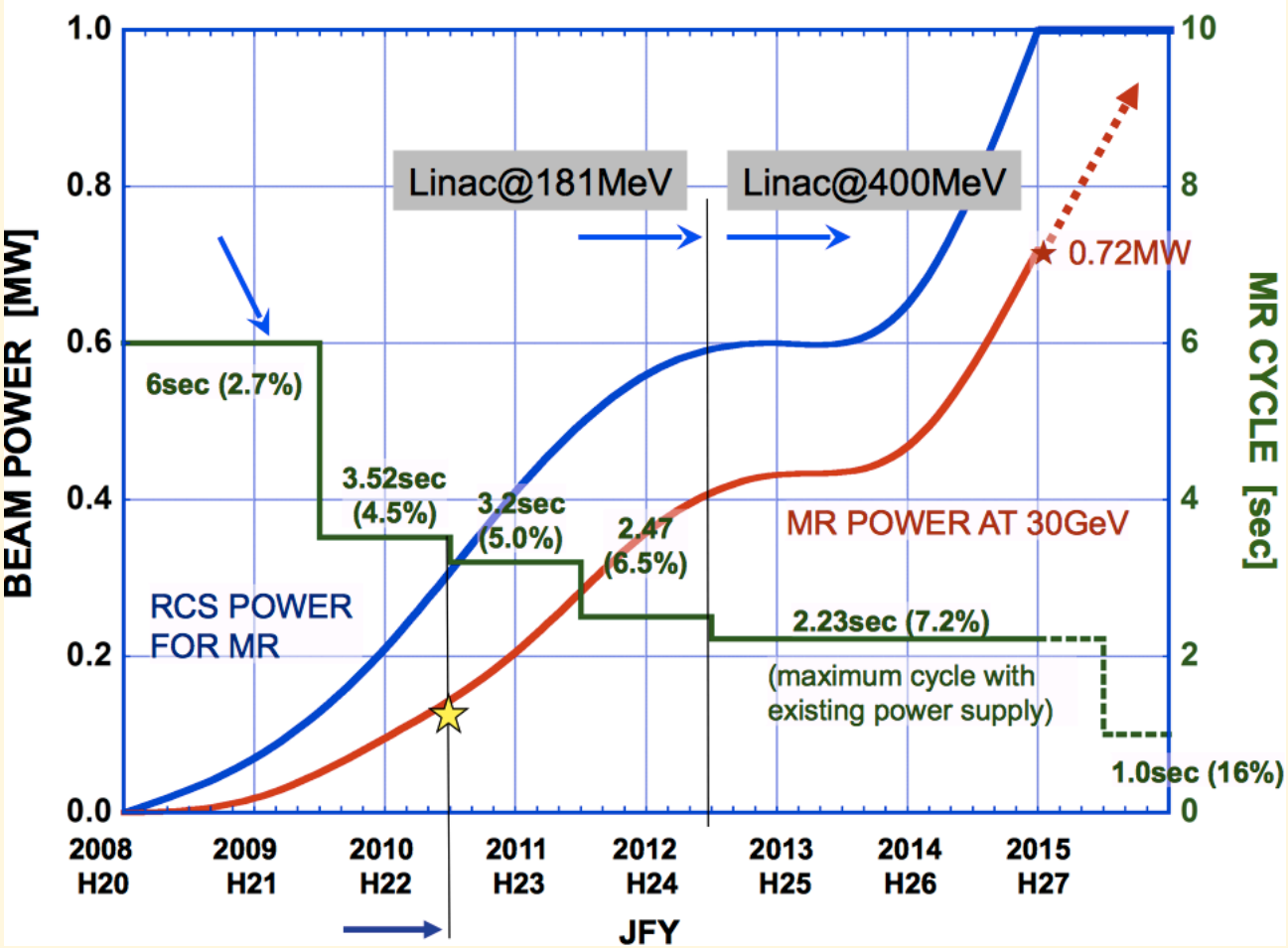


Delivers beam at 50KW to Nu. Exp.

EPICS

Plan for Future

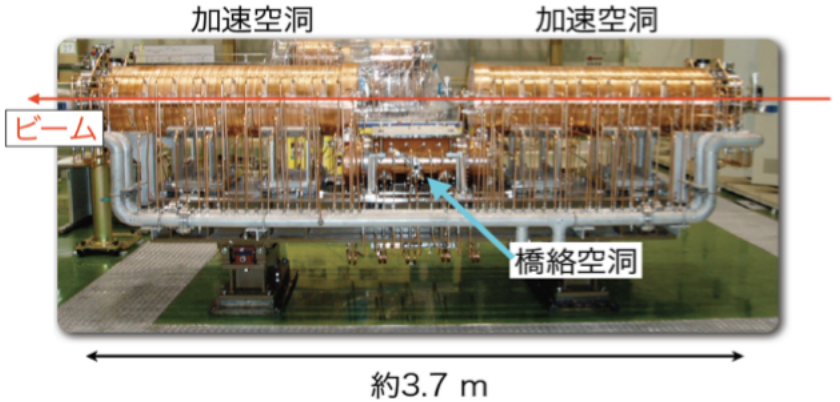
Yamamoto/
Kamikubota



Current status

Plan for MR Beam Power for Nu Exp.

- Linac 400 MeV upgrade for Higher RCS beam power
- Higher MR rep. rate

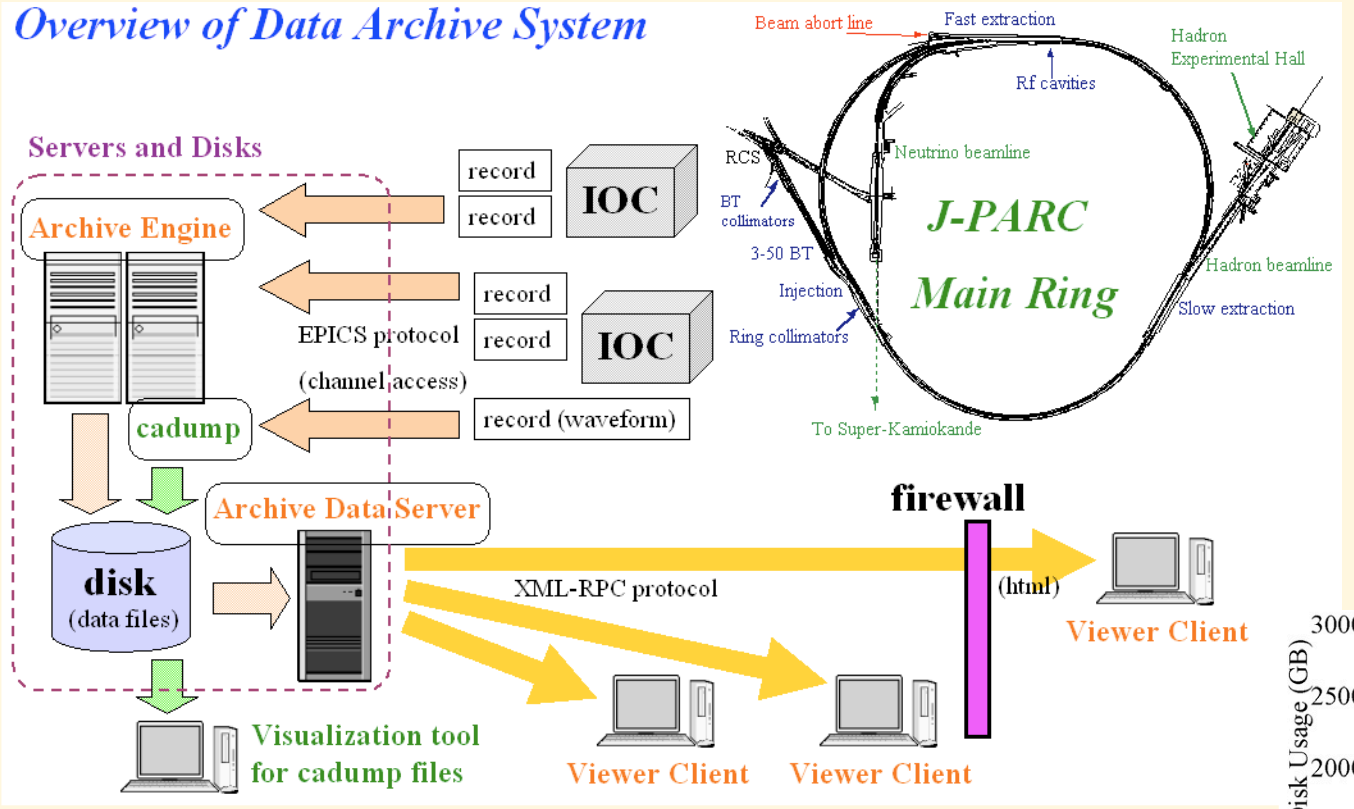


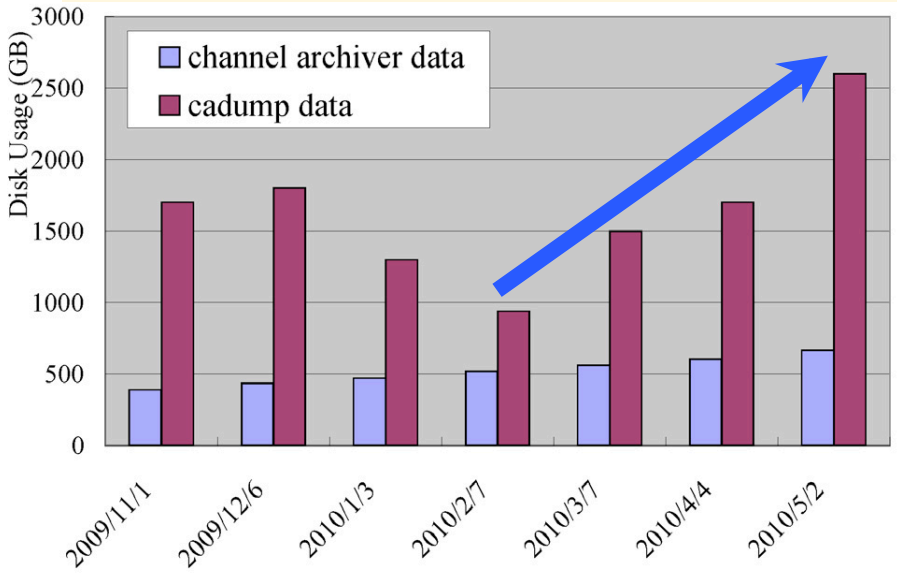
ACS: Acceleration Structure for 400MeV Linac Upgrade

EPICS

Data Archiving in J-PARC MR control system

Yamamoto/
Kamikubota





Overview of J-PARC MR data archive system: "cadump" is a program storing snapshot data, including waveform, into disk system. ROOT and SAD data formats are supported. It also use data compression, after Feb. 2010.

EPICS From "DATA ARCHIVE SYSTEM FOR J-PARC MAIN RING" by N. Kamikubota et al.,Proceedings of IPAC'10, Kyoto, Japan

Control Systems at KEK/Tsukuba (1)

- **SuperKEKB**
  - Will inherit resources from KEKB (and TRISTAN)
    - Partial budget for positron was approved (?)
- **Linac (electron/positron)**
  - Inject beam to (Super)KEKB, PF, PF-AR
    - Pulse-to-pulse beam modulation
- **PF (Photon Factory)**
  - Moved to EPICS environment
    - Mainly with Linux-VME
- **PF-AR (Photon Factory Advanced Ring)**
  - Mostly the same environment as KEKB
    - Many CAMAC installations

Control Systems at KEK/Tsukuba (2)

- ATF (Accelerator Test Facility)
  - Vista Controls environment with CAMAC
    - Linux and socket environment with some EPICS devices
- STF (Superconducting RF Test Facility)
  - Test facility for ILC
    - EPICS with Linux, ATCA test, PLC, …
- cERL (Compact ERL)
  - Being built for ERL development
    - May share the resources with other accelerators
- Sharing resources as much as possible

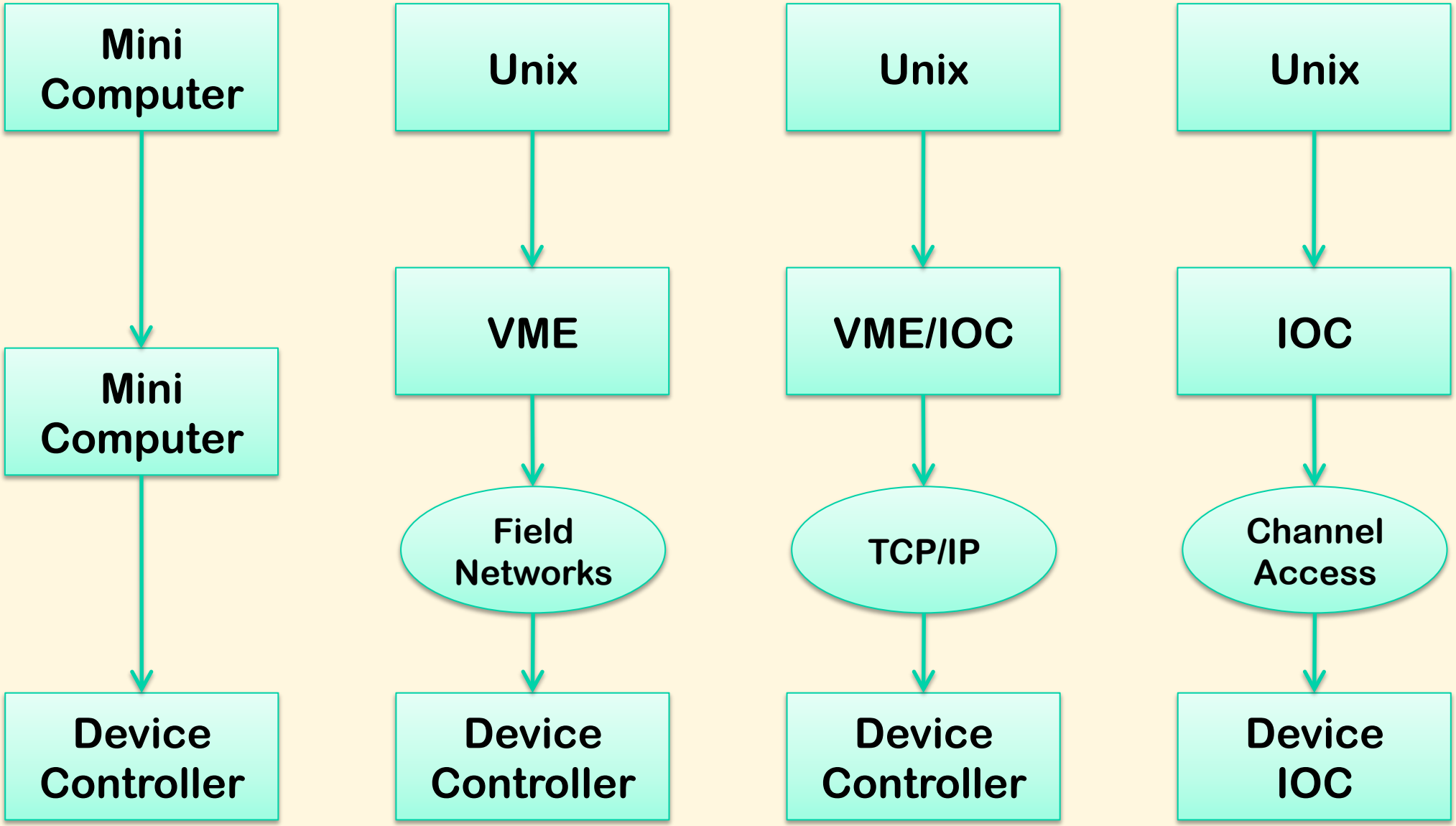
Accelerator Controls

- VME + Unix (~1995)
  - Standard EPICS configuration
    - With many third layer field networks

- Every controller on network (1993~1997)
  - Single layer in physical, two layer logical

- Every controller with EPICS IOC (2005~)
  - Channel Access everywhere
    - For longer term maintenance

Transition of Controls

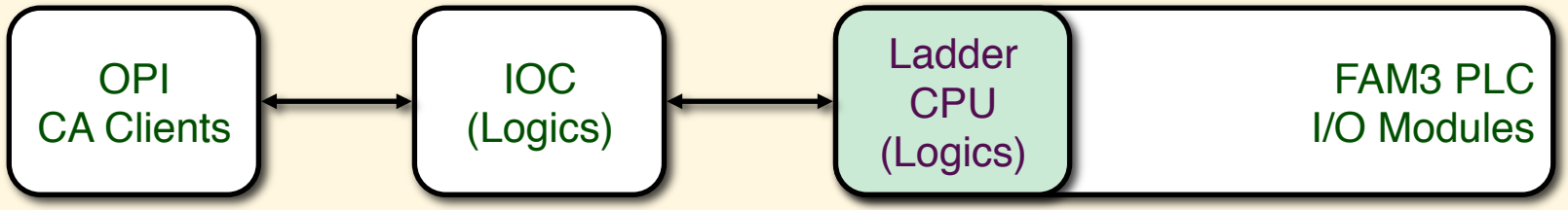


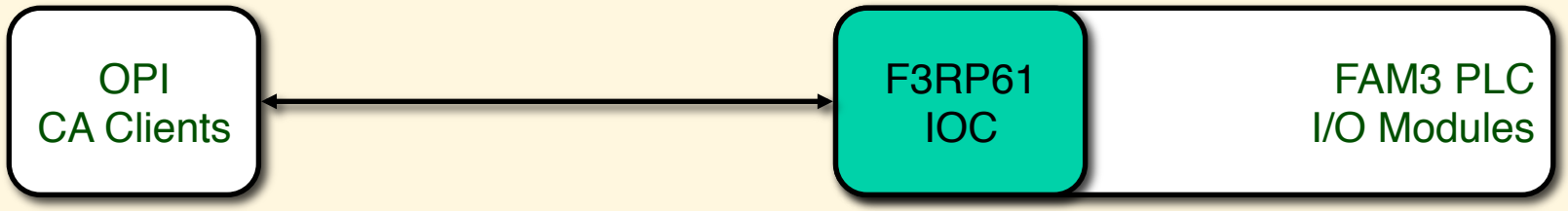
Embedded IOC in Yokogawa's PLC

- More than 150 PLCs were employed at Linac
  - All through TCP/IP network since 1993
    - Successful to reduce resource consumption
- Now Linux CPU is available (2008~)
  - 533MHz PPC, 128MB RAM, 2xEthernet, USB
  - Utilize realtime feature of Kernel 2.6 (J. Odagiri et al)
    - EPICS PV response time <150μsec (incl. module delay)
- Ladder sequence CPU can coexist
  - Variable sharing possible

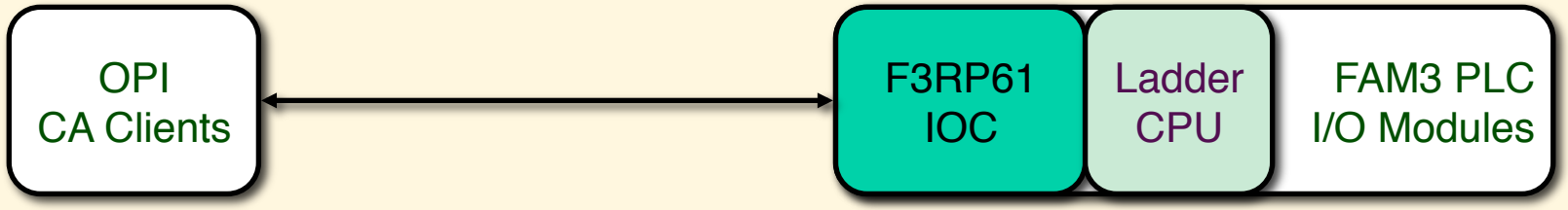
Simpler PLC Usage under EPICS

Conventional PLC usage with asynchronous access



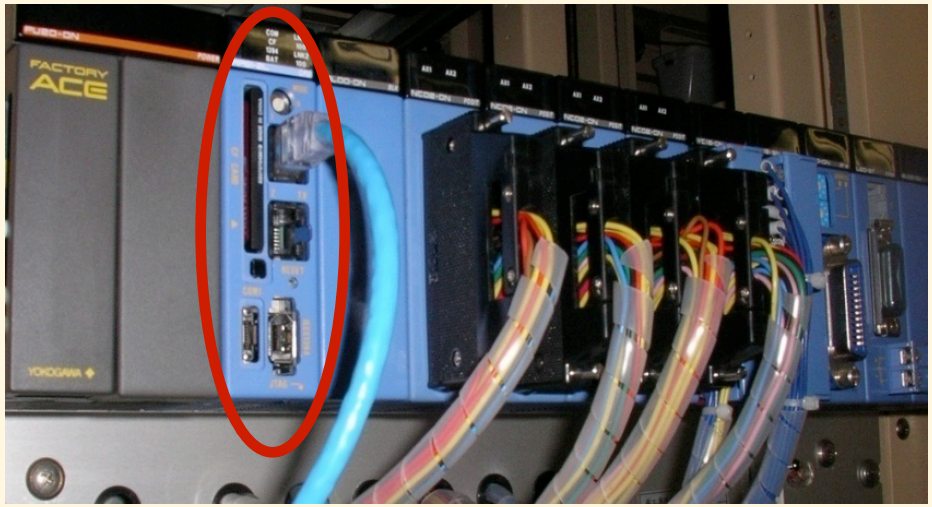


If necessary, we can combine



Logics are confined in PLC, and management is easier

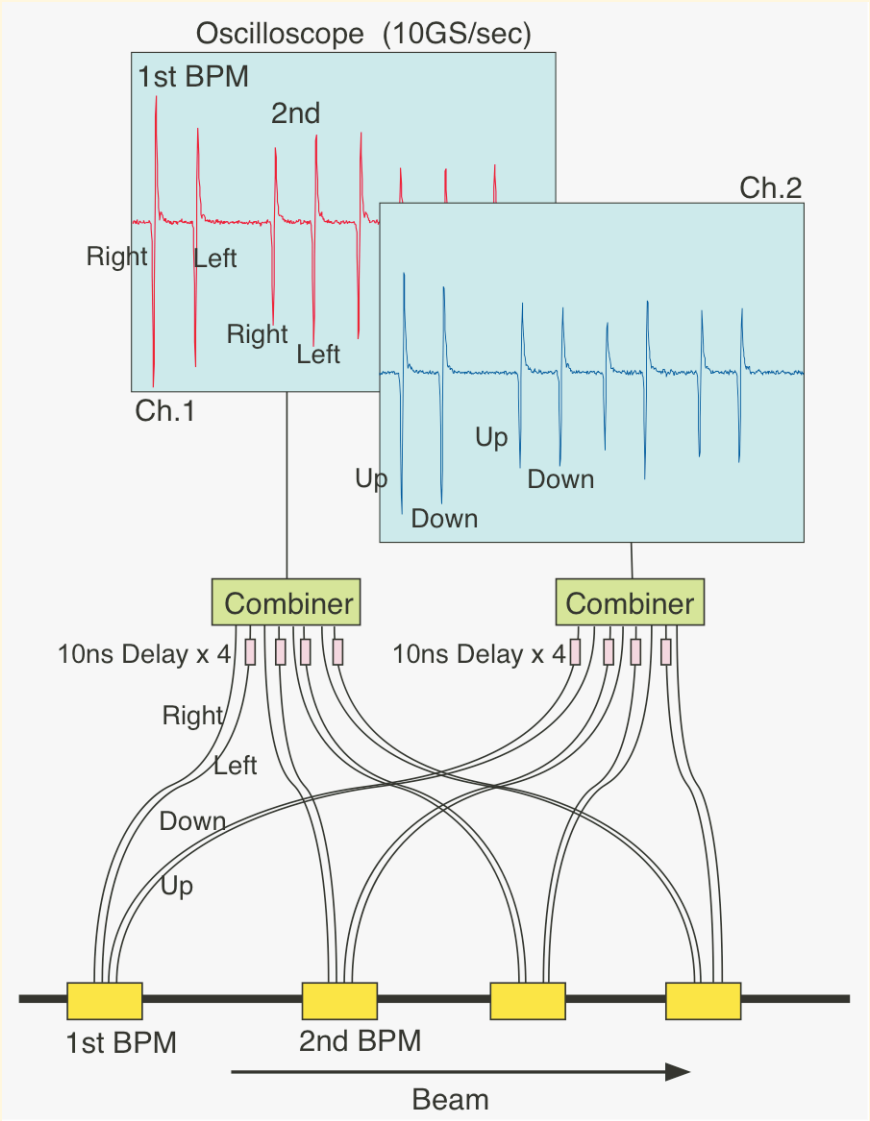
- Many medium-speed controllers implemented
  - KEKB, Linac, J-PARC, PF, cERL, …, Taiwan/TLS, (Korea/PAL, Beijing/IHEP)



- Image processing module available
- Discussing on EVR module with SSRF/ Shanghai
- <http://www-linac.kek.jp/cont/epics/f3rp61/>

BPM at Linac and BT

- BPM need only 0.1mm resolution
  - Using ~30 coefficients per BPM
- Many signals are combined into one waveform digitizer
- Again reduction of resources
- Recent Embedded IOC Solution
  - Much helped by Dr. Yong Hu



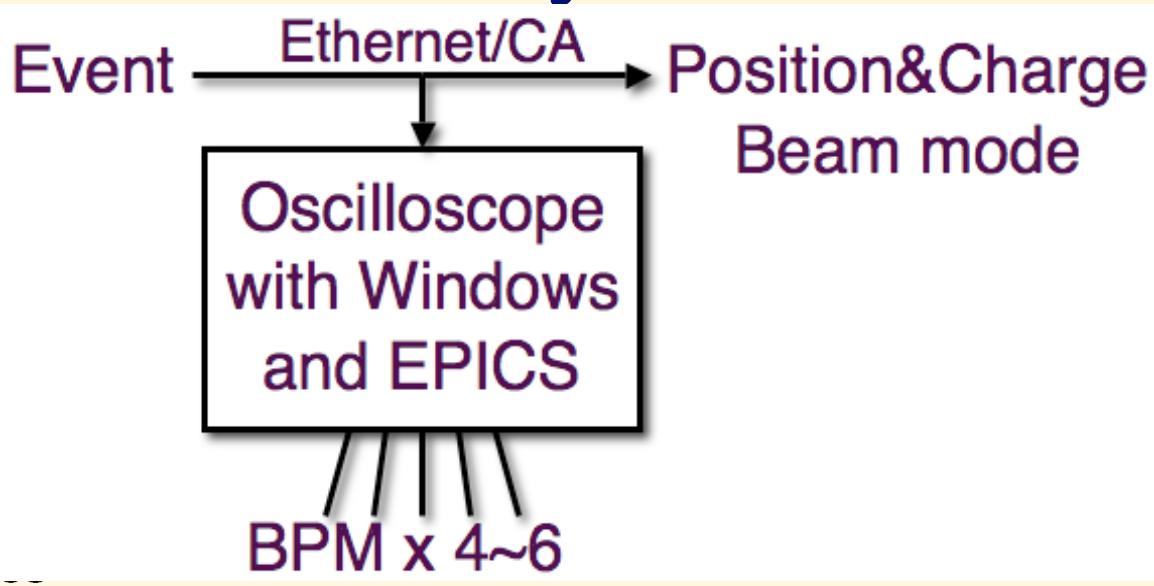
100 BPMs — 24 x DPO7104 — Clients

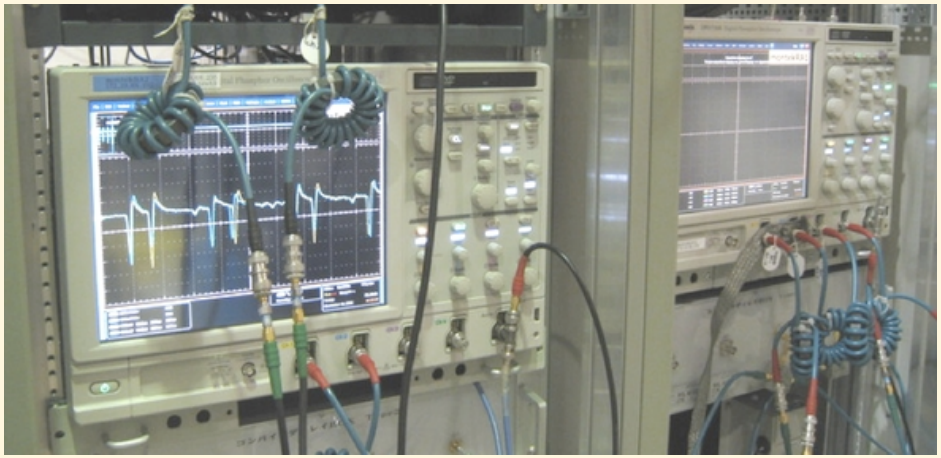
- Old configuration

100 BPMs — 19 x TDS680B — 19 VMEs — ~5 Unix — Clients

BPM DAQ

- Tektronix DPO7104 can acquire data at >50Hz.
  - With embedded EPICS, under pulse-to-pulse beam modulation
- Beam modes are recognized by events through CA network.
  - Missed less than once in million times
- Clients can monitor data of an interested beam mode.
- 24 oscilloscopes are installed for Linac, and 4 for BT.
- 200 BPMs are synchronized for Linac and BT.

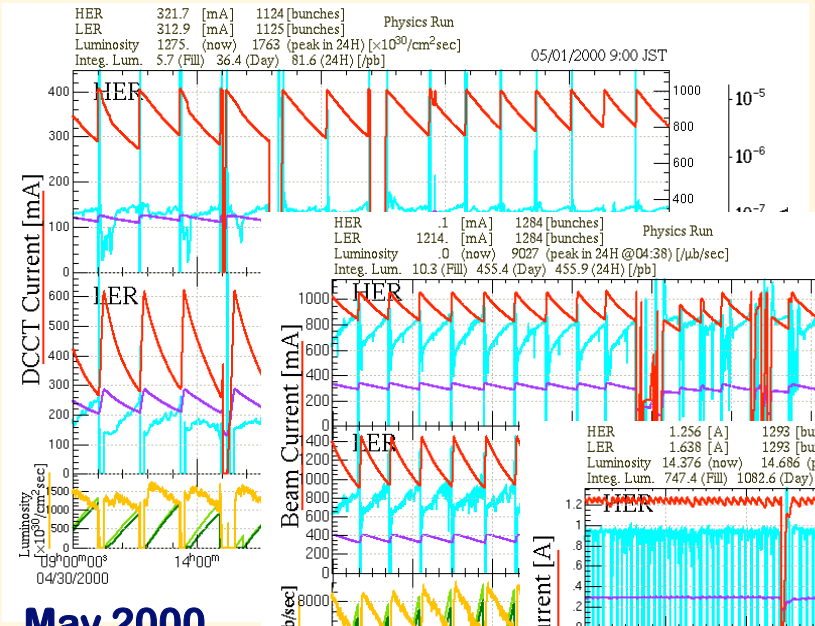




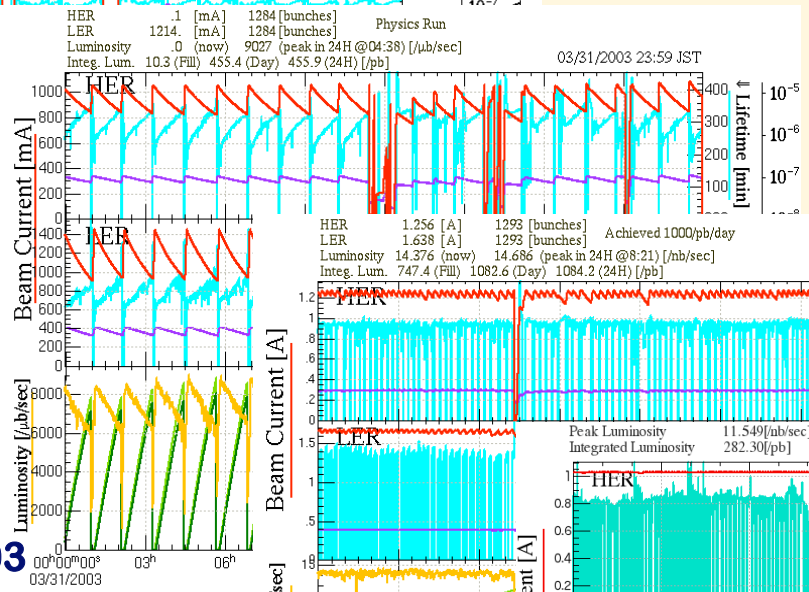
Many other Embedded IOC

- Other oscilloscope-based IOCs
  - For pulsed device monitors (M. Satoh et al)
- TDC/Linac with Linux/ARM (Armadillo)
  - Timing consistency surveillance (S. Kusano et al)
- MPS manager with Linux/FPGA (Suzaku)
  - For J-PARC and cERL, etc (A. Akiyama et al)
- Magnet PS with Linux/ARM(or FPGA)
  - Two prototypes for SuperKEKB (T. Nakamura et al)

KEKB Operation Improvement (base of SuperKEKB)

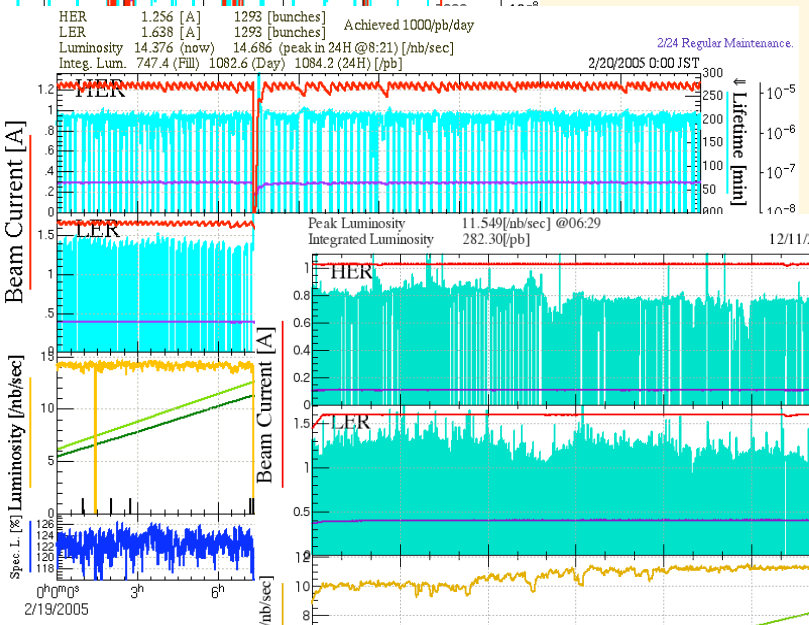


May.2000



Apr.2003

Dual Bunch e+



Feb.2005

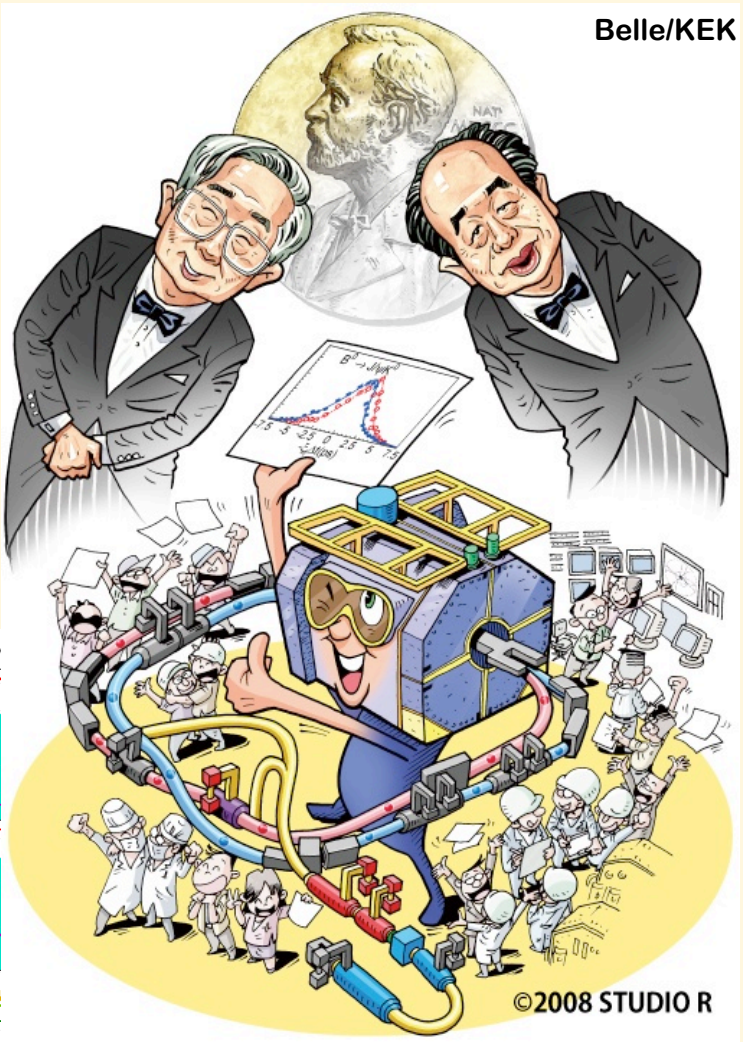
Continuous

Injections

Dec.2008

Crab Cavities and

Simultaneous Injection



EPICS

SuperKEKB Plan (1)

- For nano-beam scheme with 40-times higher luminosity
  - Many new facilities should be required
- Start based on the existent environment
  - With additional concept of CA everywhere
- Help device groups to have better global controls
  - Replacement of old installations such as CAMAC
  - Solutions not only VME but also other types of controllers, embedded EPICS if possible
- Faster networks for the groups who can build controllers by themselves
- Better connection to operational environments
  - Keeping SAD environment, etc
  - Monitoring at offices

SuperKEKB Plan (2)

- **Archiving scheme and viewer**
  - Maybe existing KEKBlog and channel archivers
    - New viewer should be developed
- **Alarm handler**
  - CSS or Python (to simulate KEKBalarm)
    - Should evaluate soon
- **Operational Log**
  - In house, two versions with different origins
    - Postgres + (Python/Zope and Flash/Flex)
- **Scripts**
  - SADscript/Tk, Python/Tk, (decreasing Tcl/Tk)
- **Displays**
  - Edm and/or CSS

SuperKEKB Plan (3)

- Interviews to each device groups
  - Planning to have monthly meeting and training
    - To collect user requirements
  - Partially successful for old hardware replacements
    - Not yet effective for new functionalities
      - Whether both sides do not have experiences
- ex. Global orbit feedback
    - We don't need to stabilize the orbit other than the collision point
  - Monitor group is basically responsible for this
    - Under development with several candidates
    - But they still need some data path

Simultaneous Injection

- SuperKEKB injections with shorter lifetime
- PF top-up injection for higher quality experiments

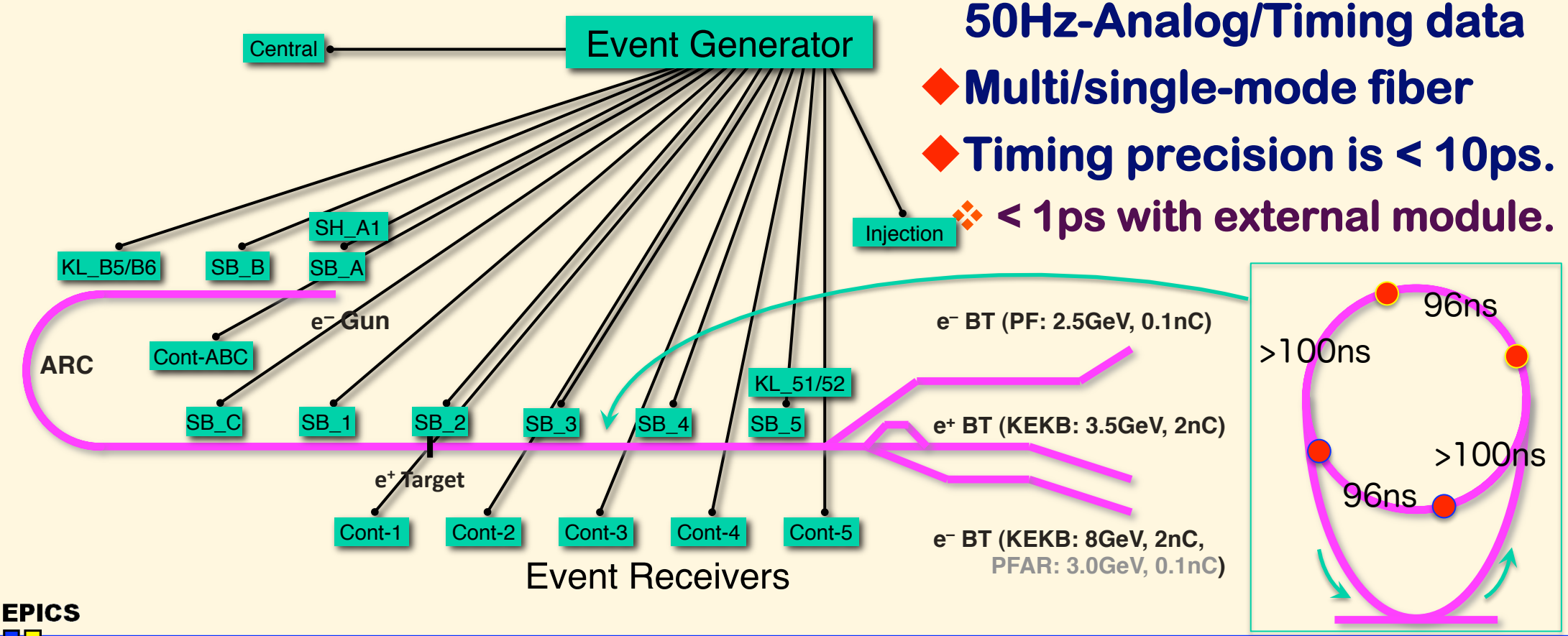
- Enjoyed Hardware and Software Installation One by one
- Reduced the Beam Switch Time from 10-120 seconds to 20ms
- Beam currents are kept within 1mA (~0.05% for KEKB), 0.05mA (~0.01%, PF)

- Much more complicated with bucket selections at damping ring and main ring
- Should add PF-AR as well (4rings! with different beams)

Event System for Simultaneous Injection

- MRF's series-230 Event Generator / Receivers
- VME64x and VxWorks v5.5.1
- EPICS R3.14.9 with DevSup v2.4.1
- 17 event receivers up to now

- 114.24MHz event rate, 50Hz fiducials
- More than hundred 50Hz-Analog/Timing data
- Multi/single-mode fiber
- Timing precision is < 10ps.
  - < 1ps with external module.



EPICS

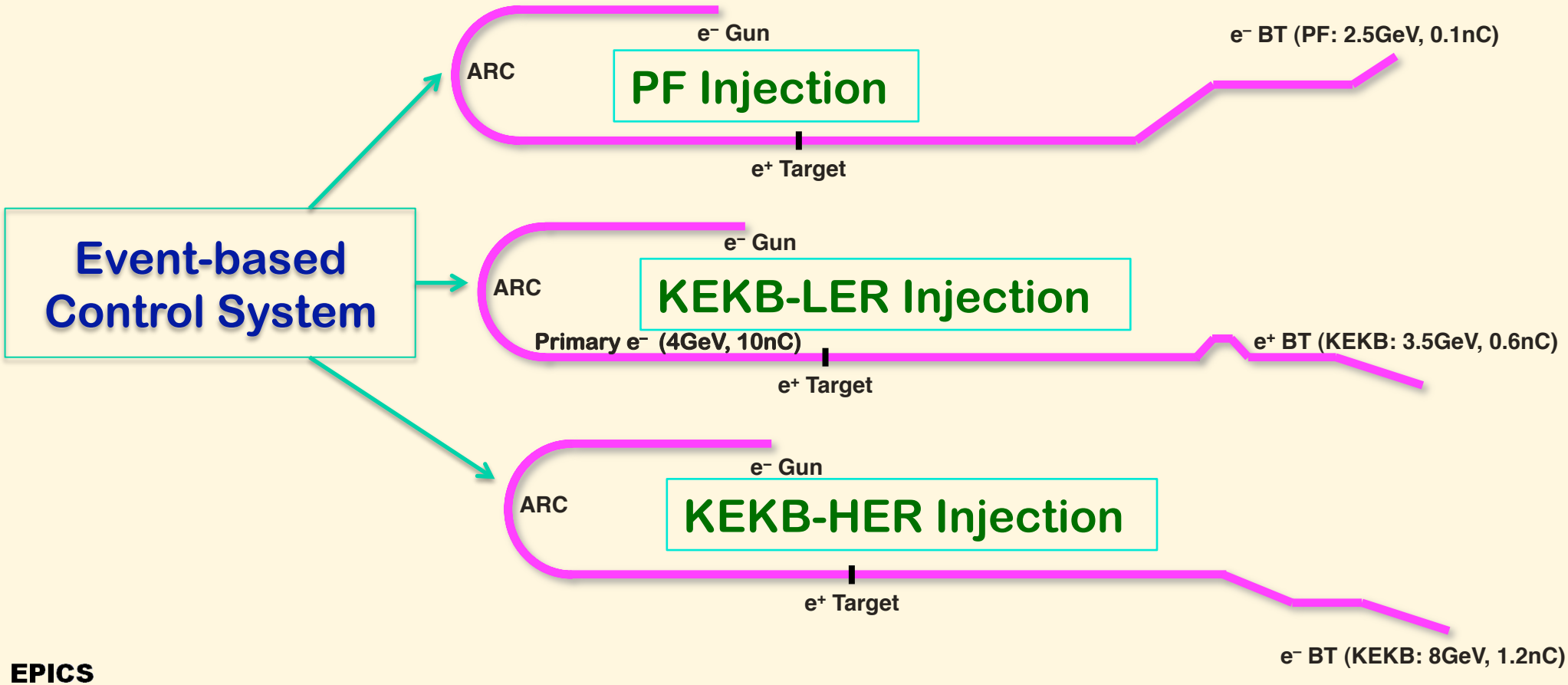
Parameters

- **Parameters switched via event system**
  - LLRF phase/timing : 14x4
    - Overall energy profile, dual-bunch energy equalization, final energy adjustment
  - HP RF timing : ~60
    - Energy profile and backup management
  - Gun voltages, picosecond delay : 4
    - Beam charge selection, dual bunch selection, bunching
  - Pulsed magnets/solenoid : 14
    - Beam transport selection, orbit controls, positron focusing
  - Injection phase interface : 2
  - Bucket selection interface : 2
  - BPM : ~100x3
- **Sufficient for fast beam mode switching**
- **Integrity monitors soon**

EPICS

Three Virtual Accelerators

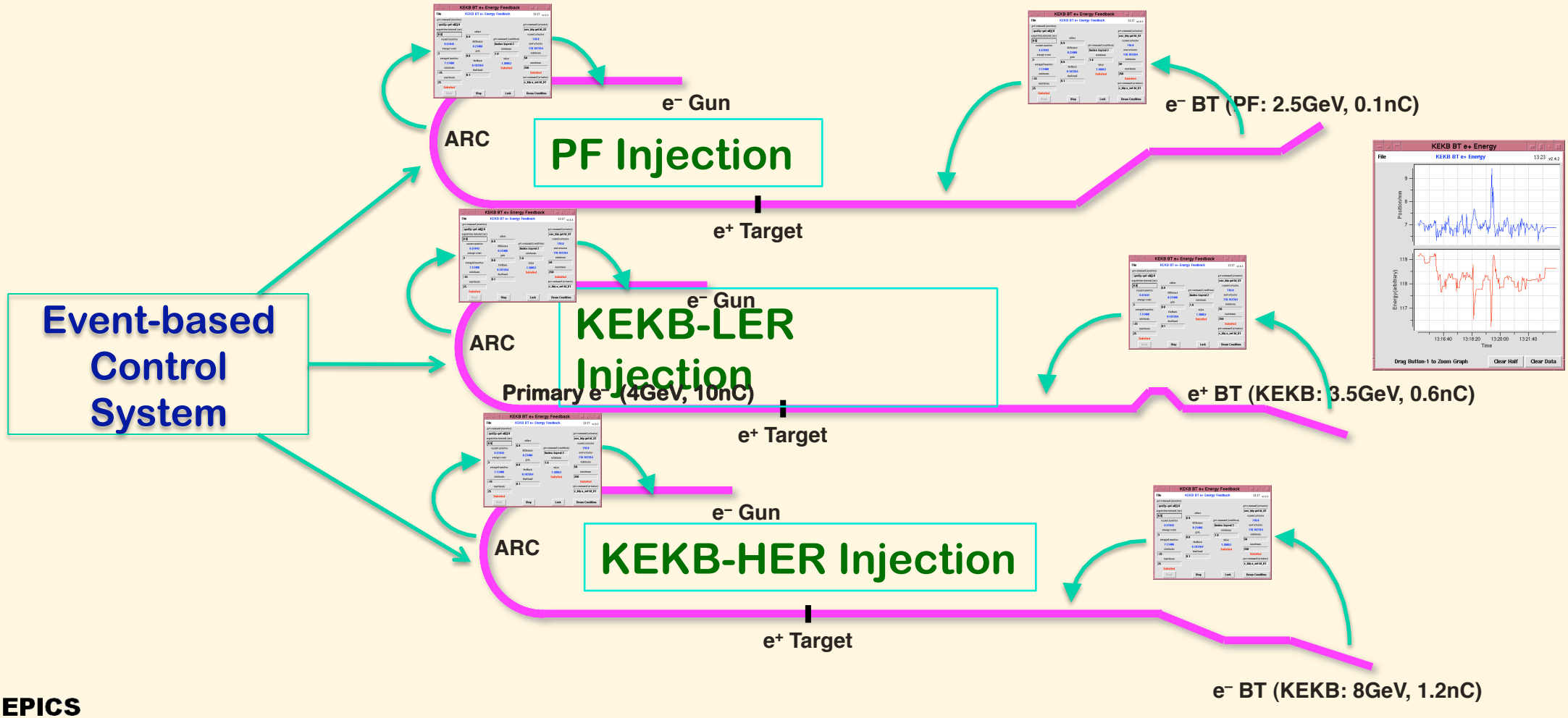
- Controls and instrumentations are essentially mode-dependent, and mutually independent
- Selecting a real machine out of three virtual machines
  - Managing three parameter sets (four under SuperKEKB environment)



EPICS

Three-fold Independent Closed Loops

- **Feedback loop software act on one of three virtual machines**
  - **Managing independent parameter sets**



EPICS

Summary

- Controls Have Interface to Every System in Accelerators
  - We can Enjoy Accelerator
- There should be Room to Establish Further Controls Utilizing Beam Monitors, RF Monitors, and More
  - With Phronesis, Ability to understand the Universal Truth

Thank you