=== Injector Upgrade ===
for Fast Beam-Mode Switch

M. Satoh (Linac Control G.)
for the Injector Upgrade (IUC) WG members
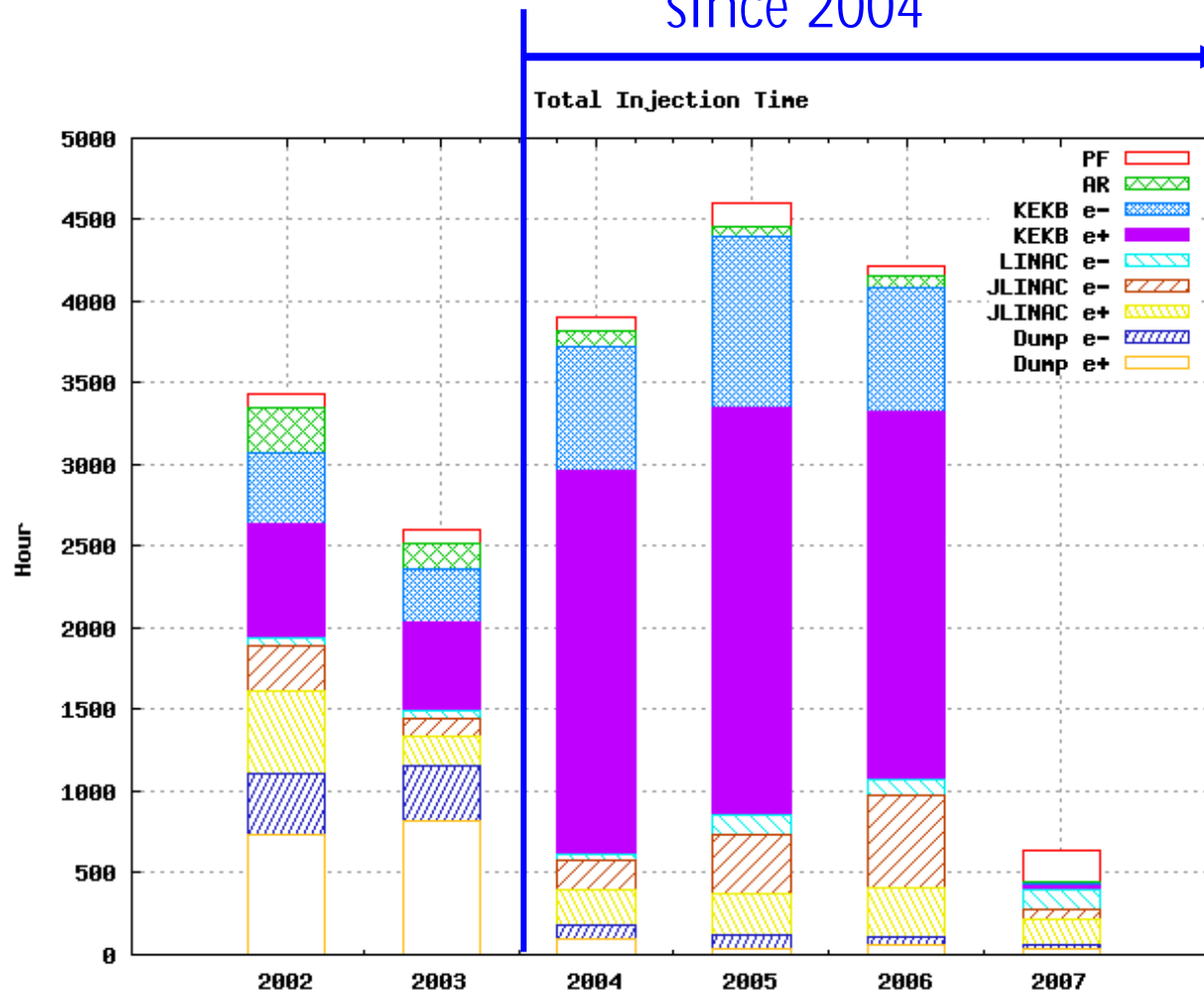
M. SATOH/ KEK Linac Control

KEK Injector Linac:

- J-like shaped Linac (600-m-long)

- Injector for 4-rings:

  - PF (2.5-GeV e-/ 0.1-nC) Once/ day

  - PF-AR (3-GeV e-/ 0.1-nC) Twice/ day

  - KEKB HER (8-GeV e-/ 1-nC) CIM

  - KEKB LER (3.5-GeV e+/ 1-nC) CIM
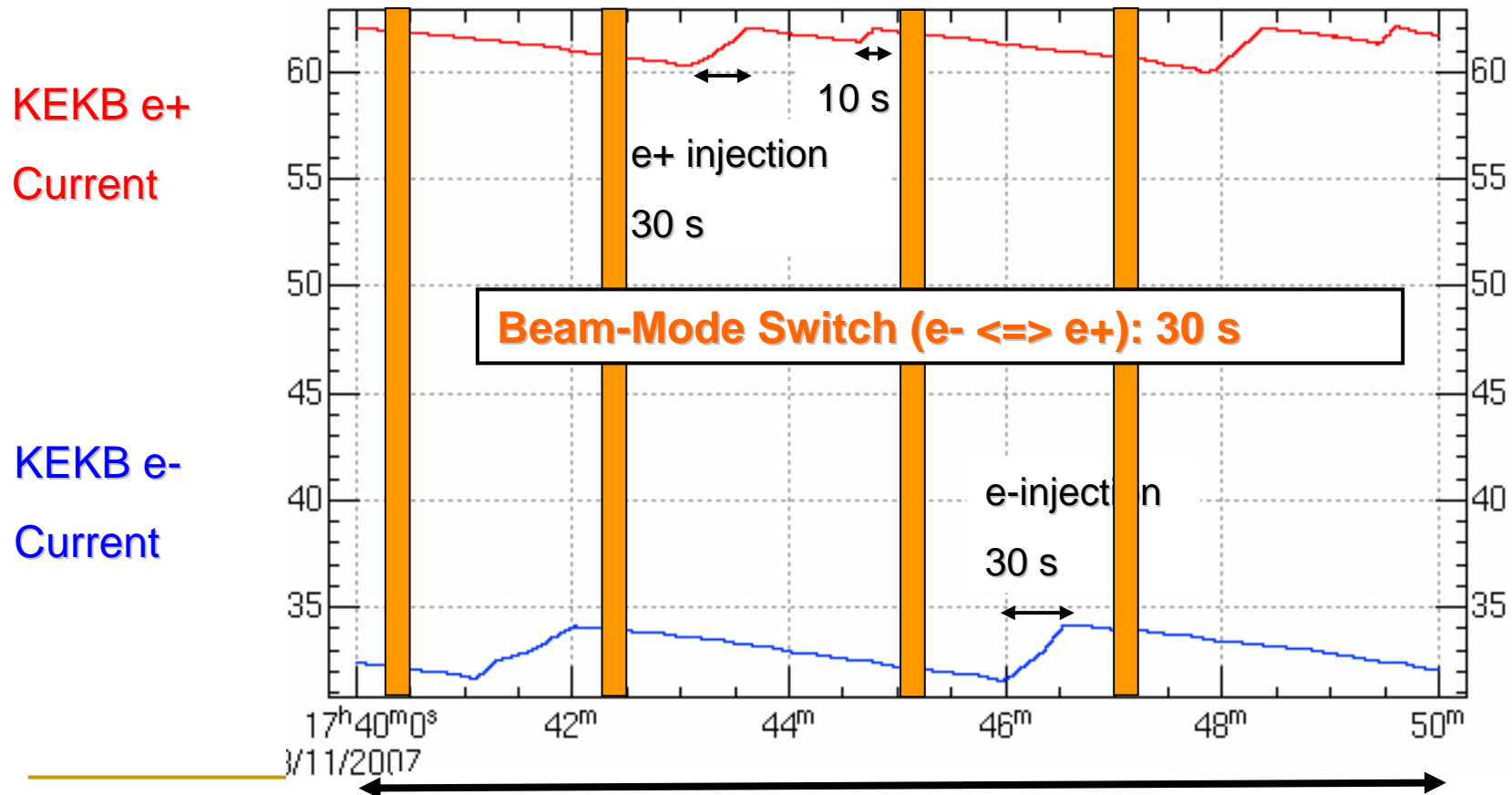
PF

e- Gun (A1 Gun; for KEKB)

#3 Switchyard

e- Gun (CT Gun; for PF/ PF-AR

KEKB/ AR

Beam Operation Statistics of Linac

Continuous Injection Mode (CIM) since 2004

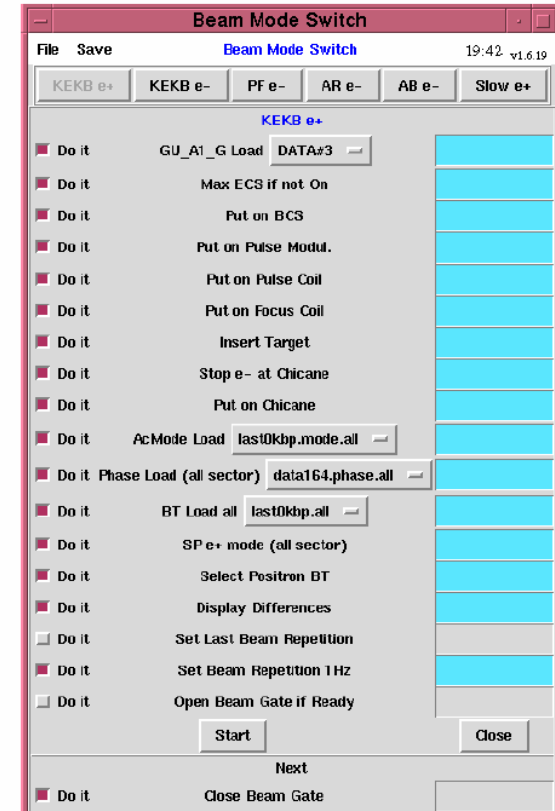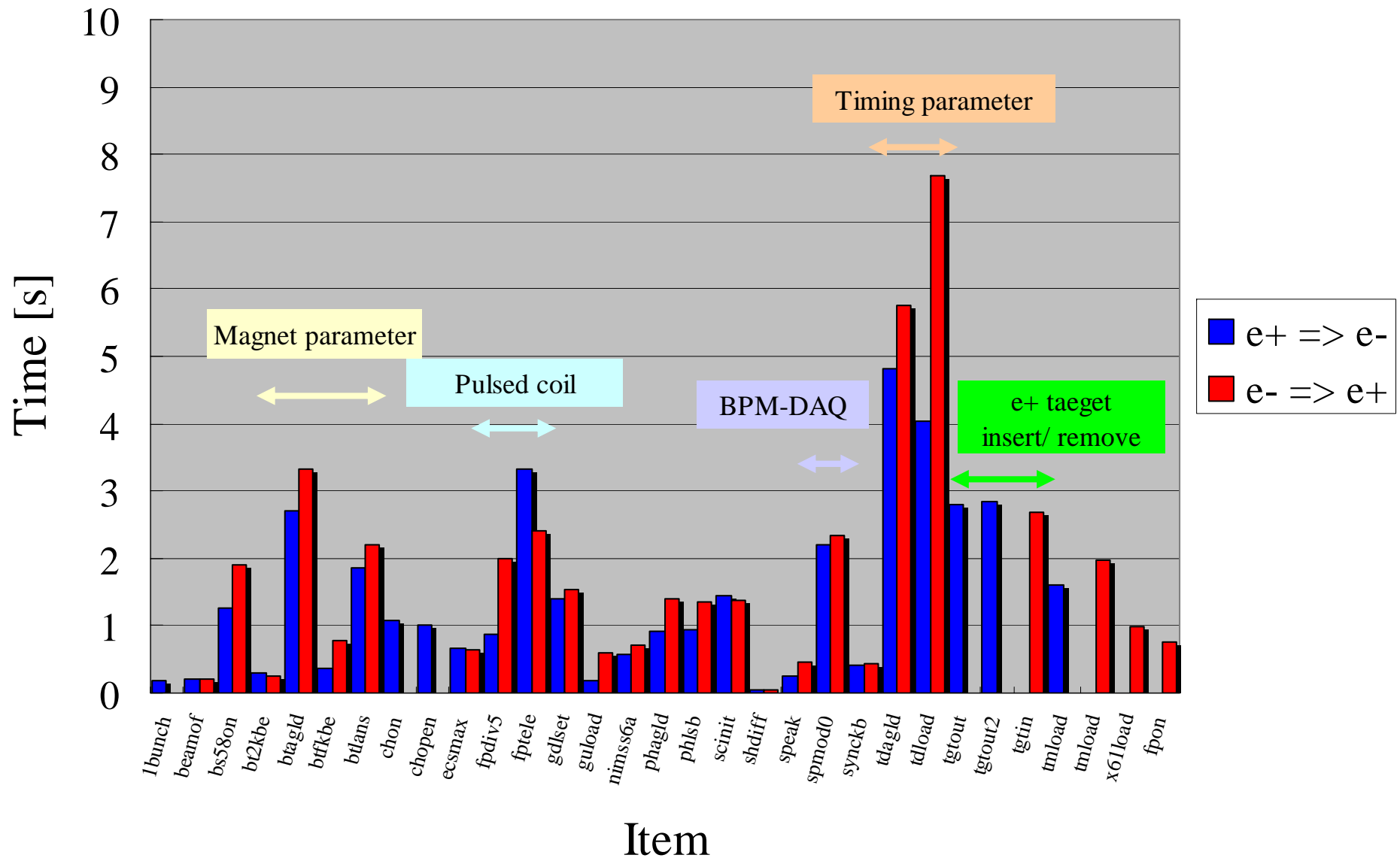# KEKB Injection (CIM)

- **Frequent Switch of Linac Beam-Mode:**

view Committee,
)7

10 min.

= Beam-Mode Switch =

- **Change magnetic field**
- **Change timing**
- **Insert/ Remove e+ target (e-/ e+)**
- **Klystron mode** (Acceleration/ Standby mode)
- **Klystron (Sub-Booster Klystron) phase**
- **Etc.**

Table 1: Devices at the KEK linac

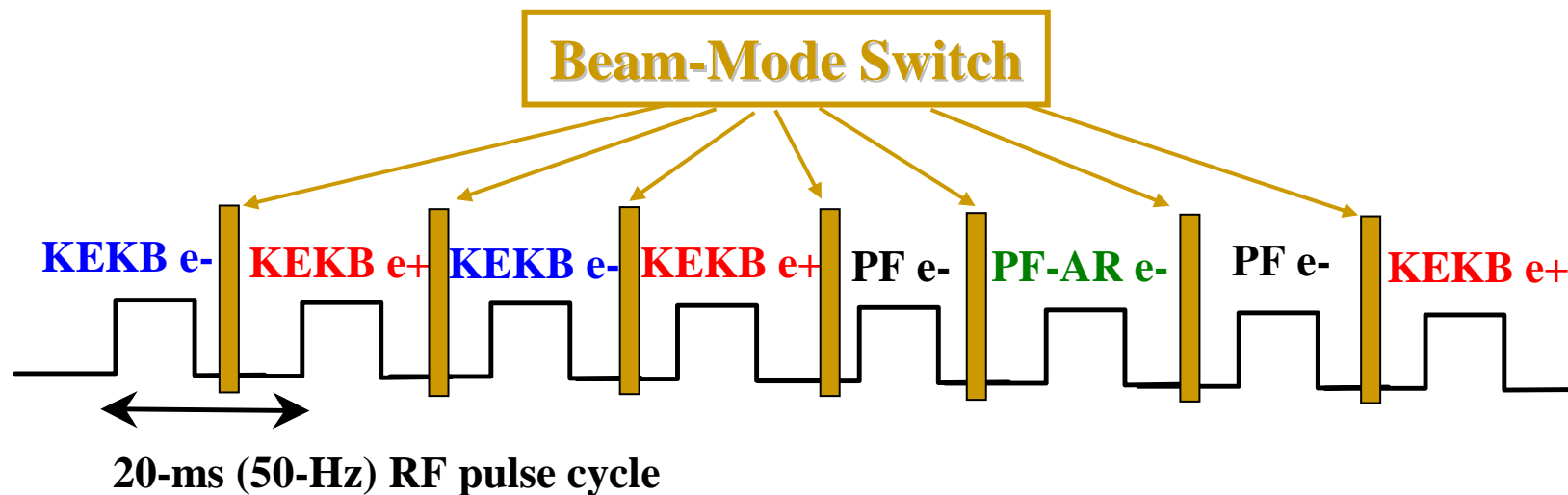| Device	total number	Front-end
beam-position monitor (BPM)	89	19 x VME
klystron	69	69 x PLC
magnet power-supply	499	45 x PLC
vacuum (ion pump)	284	17 x PLC
trigger-delay (timing signal)	141	5 x VME 11 x CAMAC

Consumed Time for Parameter Switch

= Why need to Upgrade Injector Linac? =

- PF ring needs Top-up Injection under KEKB CIM.

- PF-AR ring needs CIM for Machine Study.

- **Fast Beam-Mode Switch scheme is strongly required. (Simultaneous Injection)**

Beam-Mode Switch

KEKB e-   KEKB e+   KEKB e-   KEKB e+   PF e-   PF-AR e-   PF e-   KEKB e+

20-ms (50-Hz) RF pulse cycle

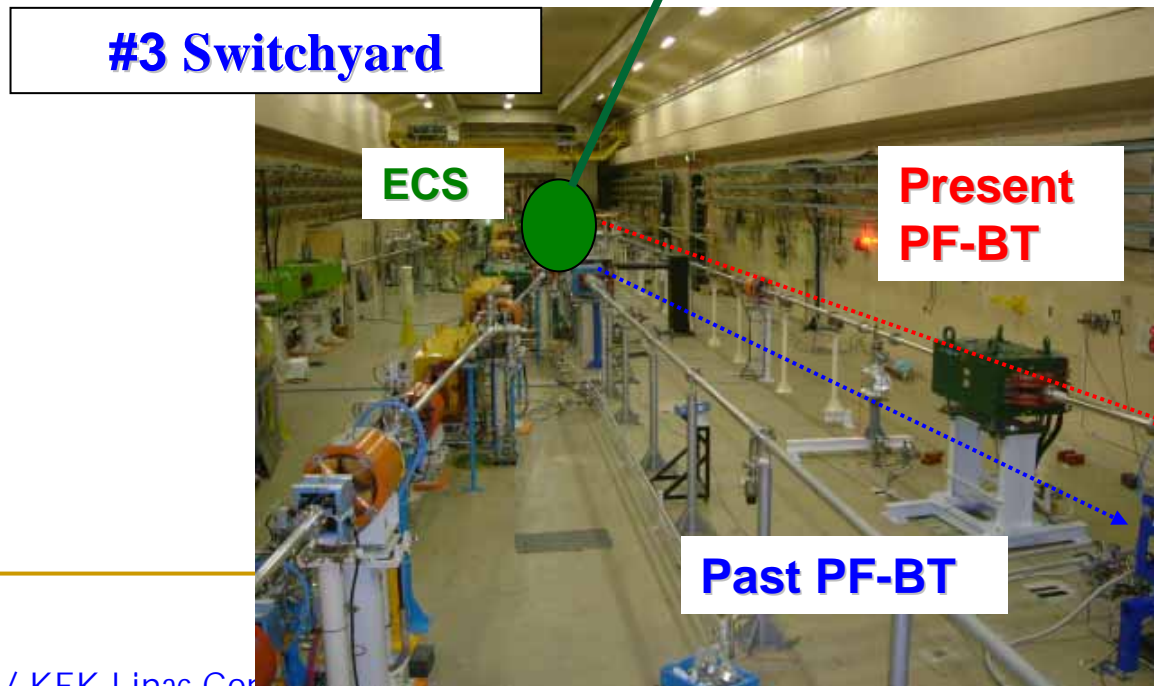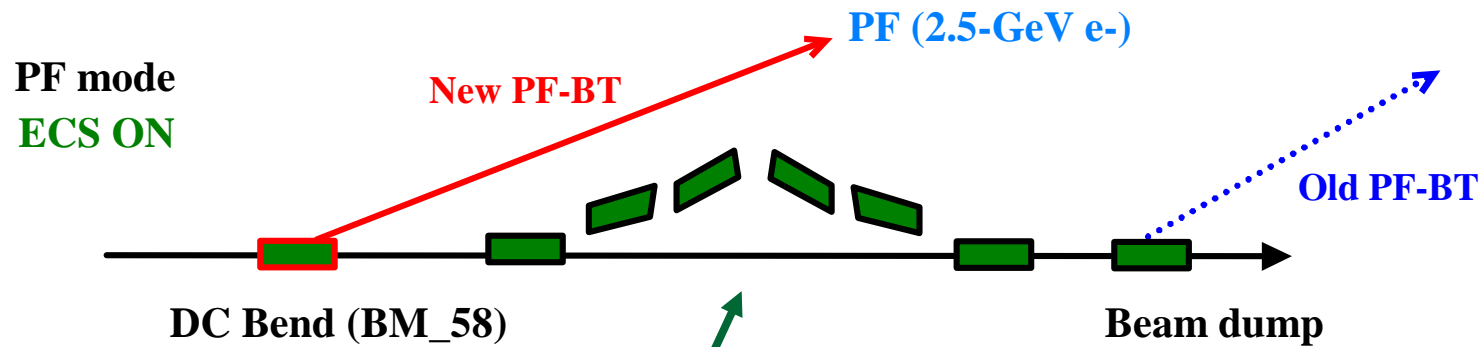# = Injector Upgrade Plan =

- ## Phase I, II, III

    - ### Phase-I (completed): Construction of New PF-BT line (bypass ECS)

    - Save time for switching beam mode between KEKB and PF
      5 min. 30 s => 2 min. 30 s
      (KEKB mode => PF mode => PF injection => KEKB mode)

=== Multi-Energy Linac Scheme ===

- Phase-II: Fast Beam-Mode Switch (KEKB e-, PF)

- Phase-III: Fast Beam-Mode Switch (KEKB e-/ e+, PF)

- (?): Fast Beam-Mode Switch (KEKB e-/ e+, PF. PF-AR)

Phase-I *[Completed, Summer 2005]*

- ECS is always ON. (KEKB e-/ e+ and PF modes)
- It shorten time for beam mode change. (KEKB⇔PF)

PF (2.5-GeV e-)

PF mode
ECS ON

New PF-BT

Old PF-BT

DC Bend (BM_58)

Beam dump

#3 Switchyard

ECS

Present PF-BT

Past PF-BT

= Injector Upgrade Plan =

- Phase I, II, III

  - Phase-I (completed): Construction of New PF-BT line (bypass ECS)

  - Save time for switching beam mode between KEKB and PF
    5 min. 30 s => 2 min. 30 s
    (KEKB mode => PF mode => PF injection => KEKB mode)

=== Multi-Energy Linac Scheme ===

- Phase-II: Fast Beam-Mode Switch (KEKB e-, PF)

- Phase-III: Fast Beam-Mode Switch (KEKB e-/ e+, PF)

- (?) : Fast Beam-Mode Switch (KEKB e-/ e+, PF, PF-AR)

= Fast Beam Mode Switch =

•Fast change of the magnetic field is difficult by using current system.

= Multi-Energy Linac Scheme =

•*Magnetic Field*

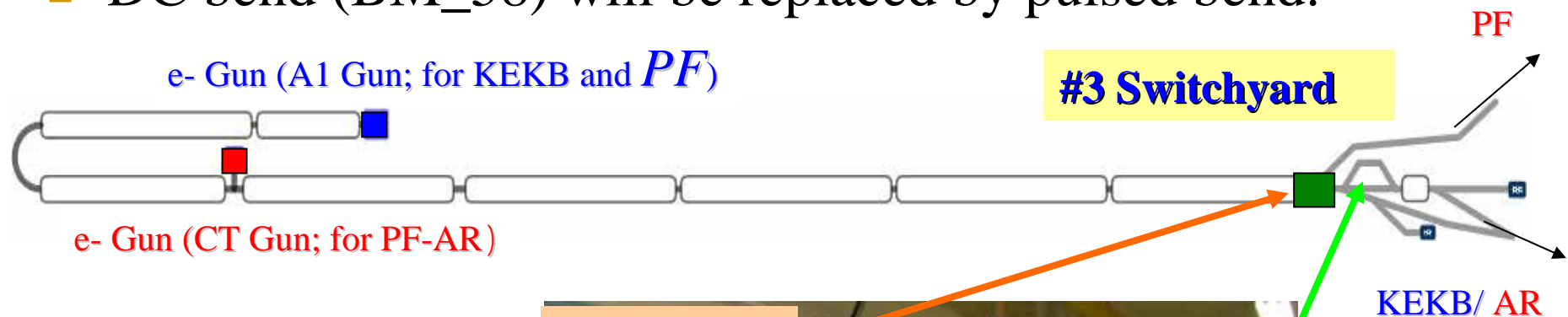➤•**Common Parameter (Quadrupole and Steering magnets)**

• *Energy Adjustment*

➤•**Change Sub-Booster Klystron Phase quickly.**

Low-Level RF Phase

Phase-II

= Fast Beam-Mode Switch (PF and KEKB e-) =

- Multi-Energy Linac Scheme
- PF injection will be performed by A1-Gun.
- DC bend (BM_58) will be replaced by pulsed bend.

PF

e- Gun (A1 Gun; for KEKB and *PF*)

#3 Switchyard

e- Gun (CT Gun; for PF-AR)

KEKB/ AR

DC Bend

ECS

= Pulsed Bend and Power Supply (Summer 2007) =

- Bend
  - Bending Angle   7-deg. (3-GeV)
  - Max. Field 1.2217-T
  - Gap   157 x 30 mm
- Ceramic chamber
  - Ti coating (1-μm)

- PS
  - Max. Current:
    - 32-kA (12.5-Hz),
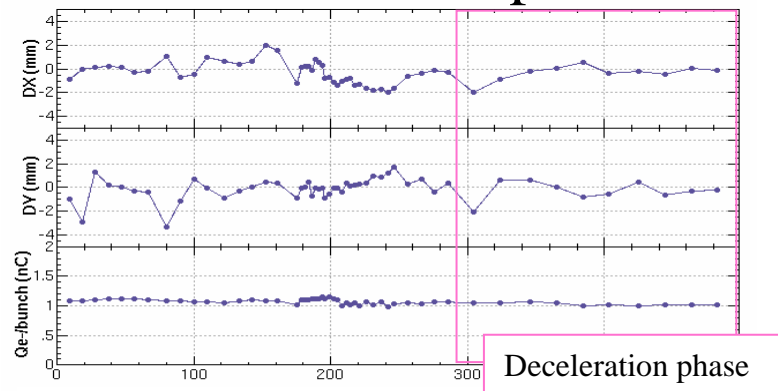   - 27-kA (25-Hz)
  - Pulse Width: 200-us
  - Stability: < 0.1%

M. Tawada, T. Mimashi, M. Kikuchi, et al.
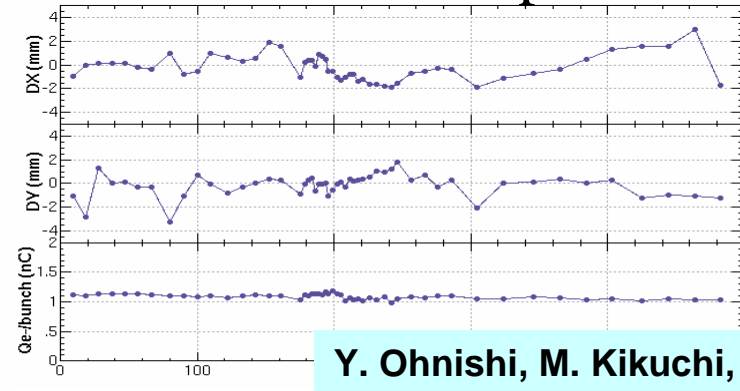
Phase-II   = Multi-Energy Linac Study =

- "2.5-GeV" "8-GeV" e- beam: accelerated by common magnet parameter

2.5-GeV e⁻ optics (for PF)

Deceleration phase

$\gamma\varepsilon_x = 3.6 \times 10^{-4}$ m, $\gamma\varepsilon_y = 6 \times 10^{-5}$ m

8-GeV e⁻ optics (for KEKB e-)

Y. Ohnishi, M. Kikuchi, N. Iida, et al.

$\gamma\varepsilon_x = 2.5 \times 10^{-4}$ m, $\gamma\varepsilon_y = 4 \times 10^{-5}$ m

= PF / KEKB e- Injection Rate =

- PF: 1.5 mA/s (25 Hz)

- KEKB e- : 4 mA/s (1-bunch/ 50 Hz)

- Noiselevel for Belle detector: No problem

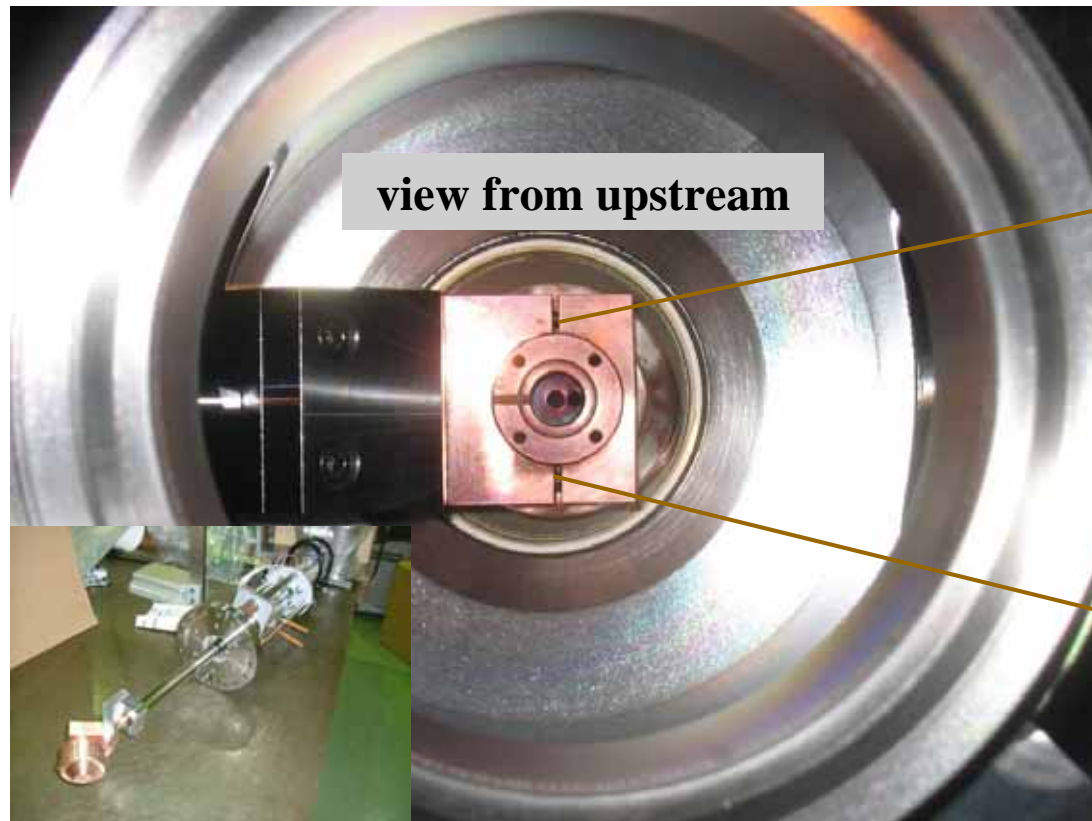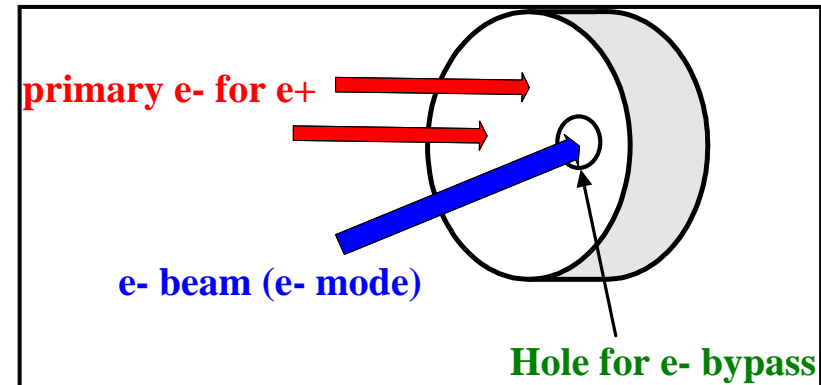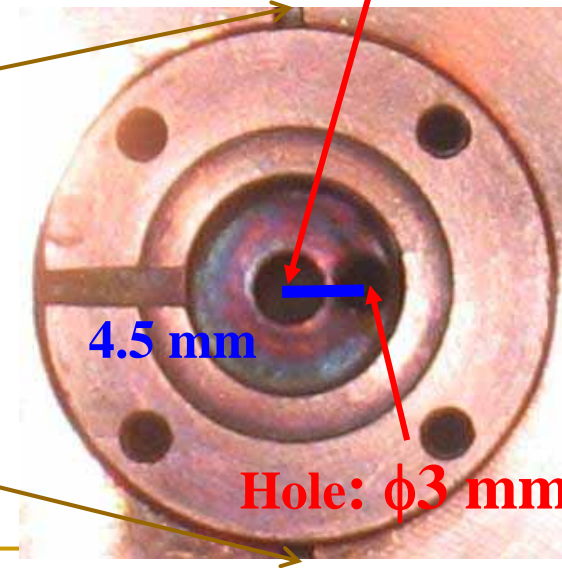PF Injection Study using Multi-Energy Linac Scheme

= Fast Beam-Mode Switch (PF, KEKB e-/ e+) =

For fast switch (e-/ e+ mode) :

- e+ target with a hole.
- Fast control of e- beam orbit by pulsed steering magnet.

primary e- for e+

e- beam (e- mode)

Hole for e- bypass

view from upstream

Crystal tungsten target :φ5 mm

4.5 mm

Hole: φ3 mm

Twelfth KEKB Accelerator Review Committee, Mar. 19-21, 2007

w/o e+ target

(normal operation)

X [mm]

Y [mm]

I [nC]

e+ target

w/ e+ target

M. SATOH/ KEK

T. Kamitani, Y. Ohnishi, et al.
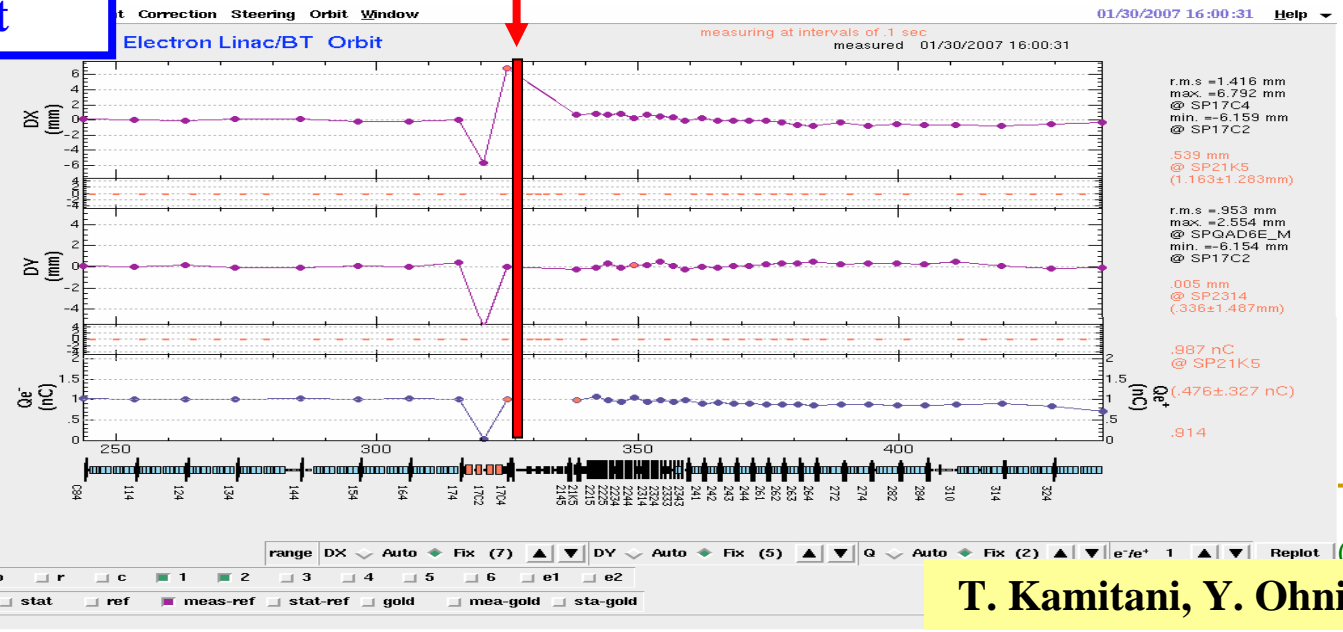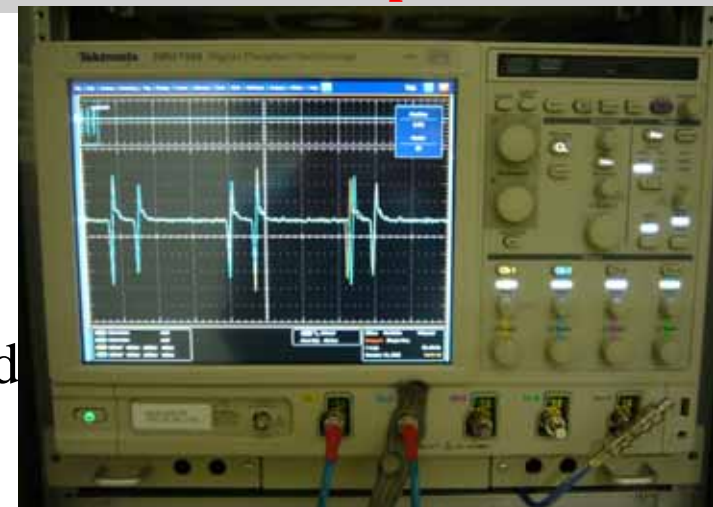
BPM-DAQ System Upgrade:

- BPM-DAQ System should be upgraded to measure beam position up to 50-Hz.

- Old System:
  - 5-GSa/s, 8-bit, 1-GHz Analogue BW
  - GPIB control
  - DAQ performance: 1-Hz

- New System:
  - 10-GSa/s, 8-bit, 1-GHz Analogue BW
  - 100-Mbps/ GbE Network
  - DAQ performance: Enough for 50-Hz
  - Thirteen systems have been installed.
  - Remaining old systems (8) will be replaced in this summer.

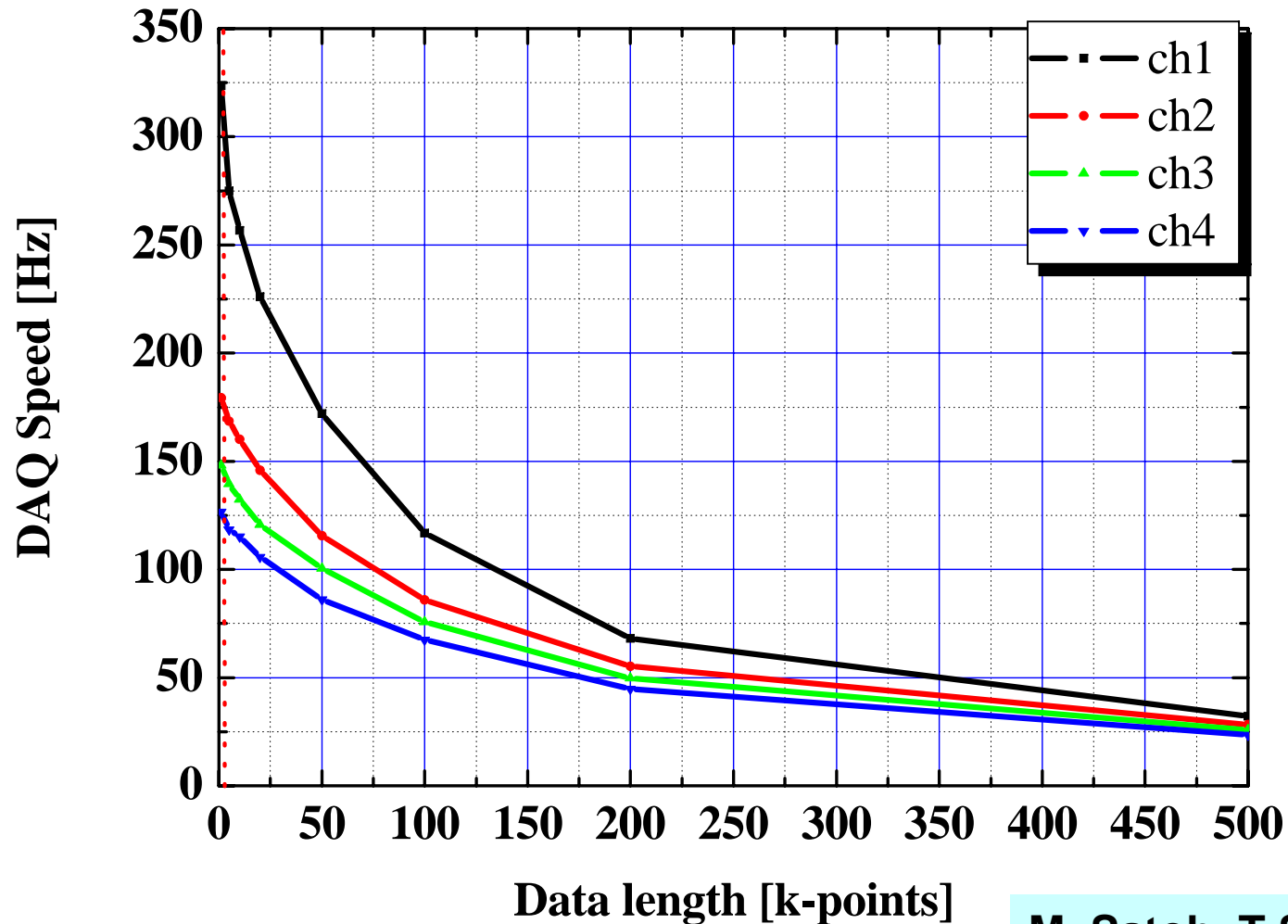**BPM DAQ system
(VME + Oscilloscope with GPIB)**

**New system
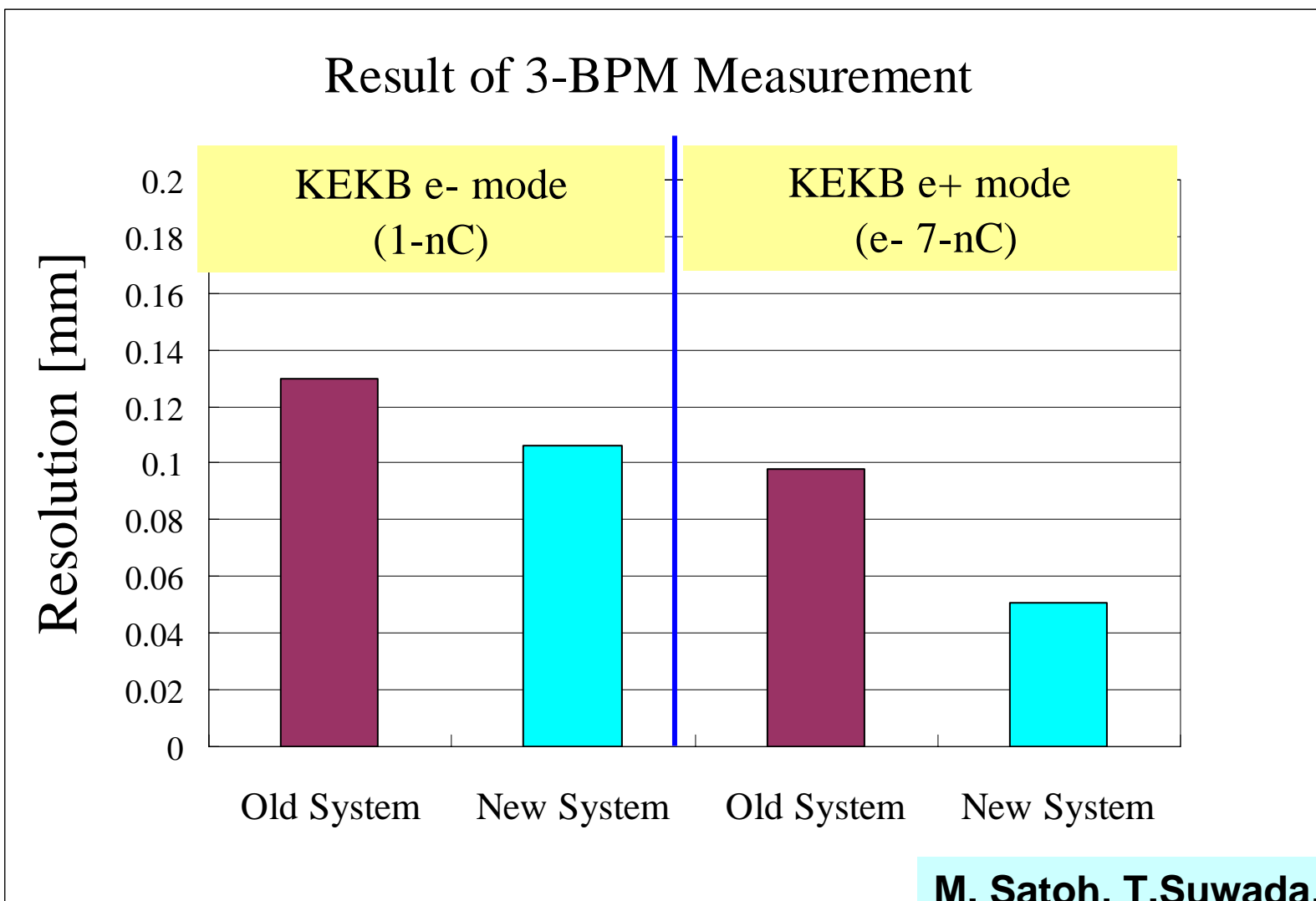(Fast Win. Based-Oscilloscope)**

= Repetitive DAQ Performance =
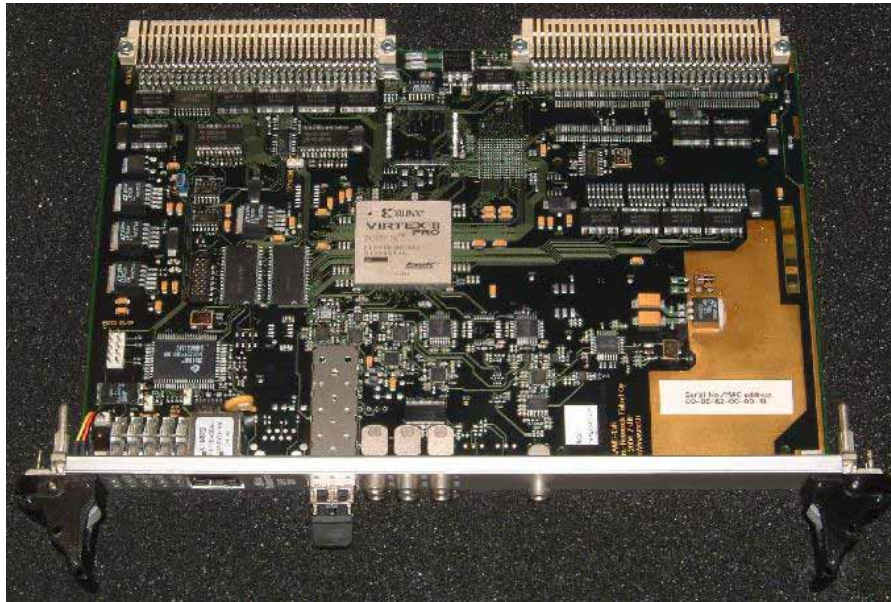# (Fast Digital Oscilloscope)

M. Satoh, T.Suwada, et al.
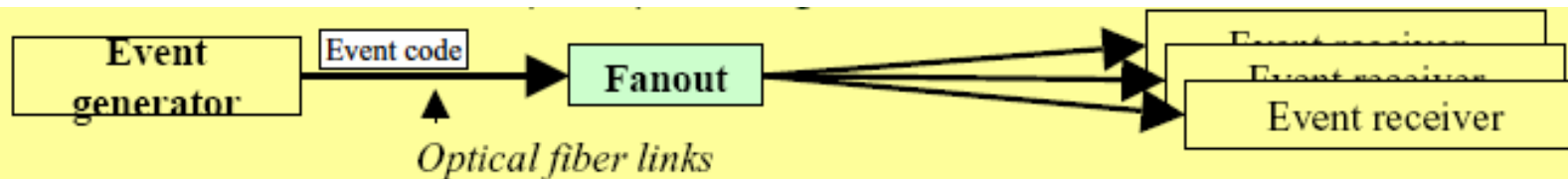
Result of 3-BPM Measurement

M. Satoh, T.Suwada, et al.

New Timing System (under test):

A. Kazakov, K. Furukawa, et al.

- Timing system should control the complicated operation mode.

  (after Phase-II/ III)

- Event generator (EG) and Receiver (ER) based on VME-64x is under test.

Event generator → Event code → Fanout → Event receiver / Event receiver / Event receiver

Optical fiber links

The stimulus to send an event can be:
- **pulse on a hardware input**
- **software event** (write to a register)
- an entry in an **event playback RAM** .

When an event code is received the receiver can:
- **output a pulse, of specified delay and width**
- **trigger a software action (process an EPICS record)**

Each event receiver can be programmed to respond in a different way to the same event code.

Scenario for PF-AR Injection:

- **PF-AR Top-up (6.5-GeV) needs large budget.**
  - Current PF-AR BT: 3.1-GeV max.
  - Some part of BT is common between PF-AR and KEKB e-.

- **One solution: Use KEKB e+ (3.5-GeV) beam for PF-AR injection. It also needs large budget.**
  - Need to replace some PS of bend (@AR-BT).
  - Need to replace Septum and Kicker PS
  - Need pulsed bend and PS
  - Cost estimation and design work will be done soon.

=== Schedule ===

FY	2005	2006	2007	2007	2008	200X ?
	Summer	Summer	Mar.	Summer	Summer	
Beam operation	Phase-I			**Phase-II TEST** **Phase-III TEST**	**PF Top-Up for user experiment** **(Phase-II/III)**	**Simultanious injection 4-rings**
Hardware	**New PF-BT construction**	**New BPM-DAQ**	**Pulsed Bend TEST** → **Pulsed Steering TEST (e+ target bump)** → **Pulsed sterrgin TEST (5-Sector)** → **New Timing System TEST** →	**New BPM-DAQ** **INSTALL** **INSTALL** **INSTALL** **INSTALL**		**AR-BT Upgrade?**
Software		**BPM Software for new DAQ**	**Software for New Timing System** **Operation Software Upgrade**	**TEST** → **TEST** →		

=== *Summary* ===

- KEKB injector linac upgrade project has started in the summer 2005 toward Fast Beam-Mode Switch.

  (KEKB e-/ e+, PF e-, PF-AR e-).

- Phase-I completed (New PF-BT line):

  - It can shorten time for beam mode switch (KEKB⇔PF)

- Phase-II, III

  - Use "Multi-Energy Linac scheme":
  - Use common magnetic field and fast change of rf phase.
  - Machine study result shows feasibility.
  - Machine study is going on.
  - Need to upgrade the operation software.

- After complete upgrade, the linac beam operation will become more effective.