



Injector Upgrade: toward 4-rings simultaneous injection

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(based on the Multi-Energy Linac Scheme)

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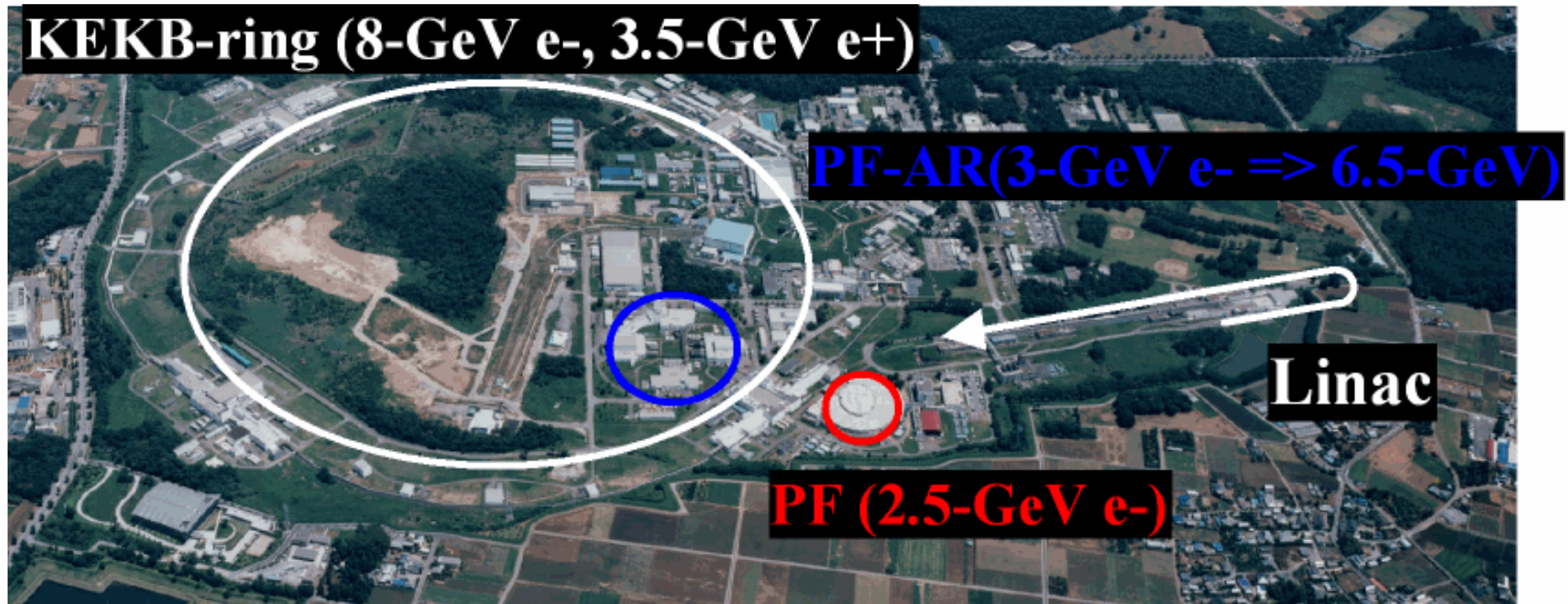
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- 1. Introduction -

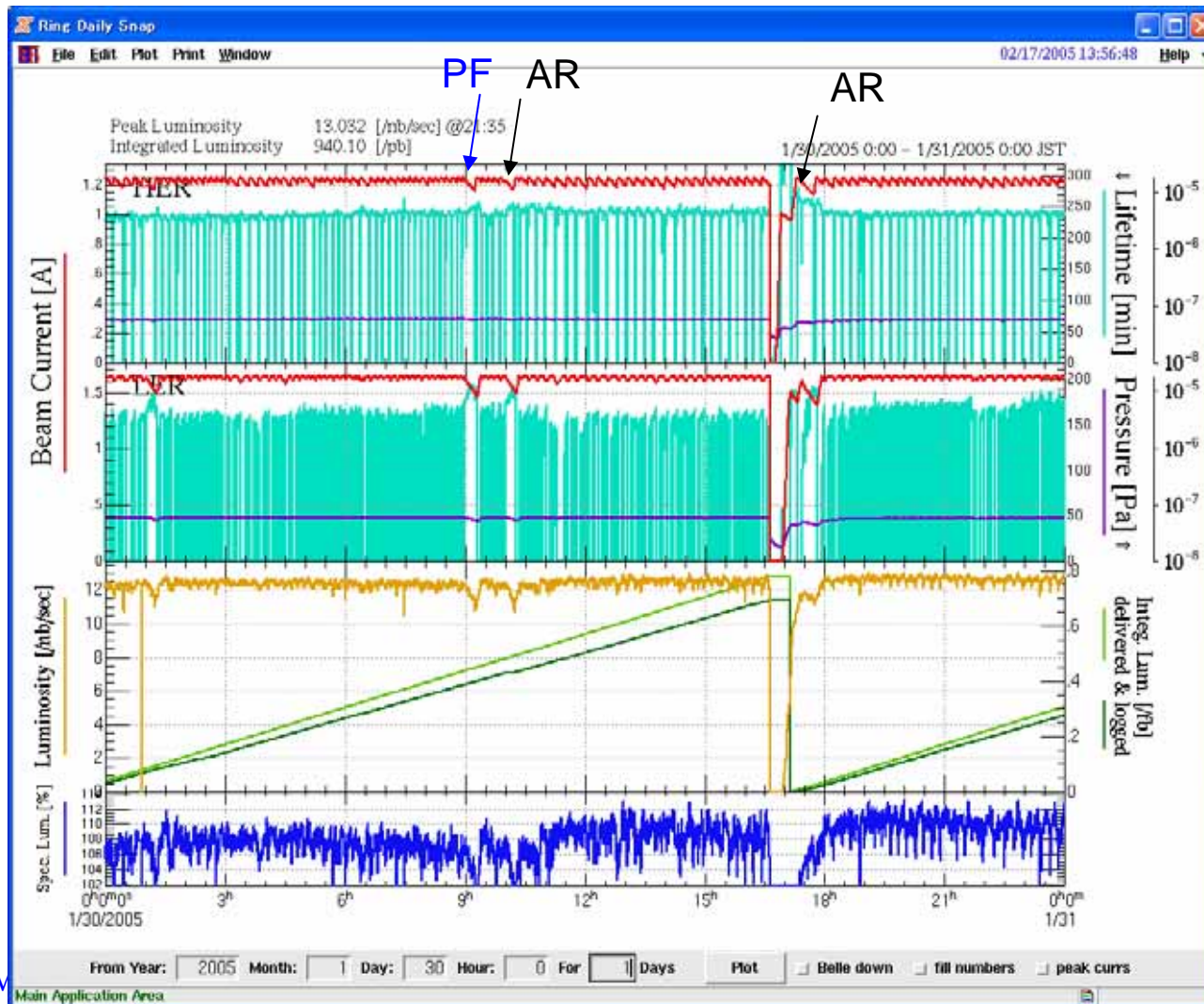
= KEKB Injector Linac =

- 600-m long linac with 180-deg. ARC section.
- Used for KEKB e-/ e+, PF, PF-AR injector.



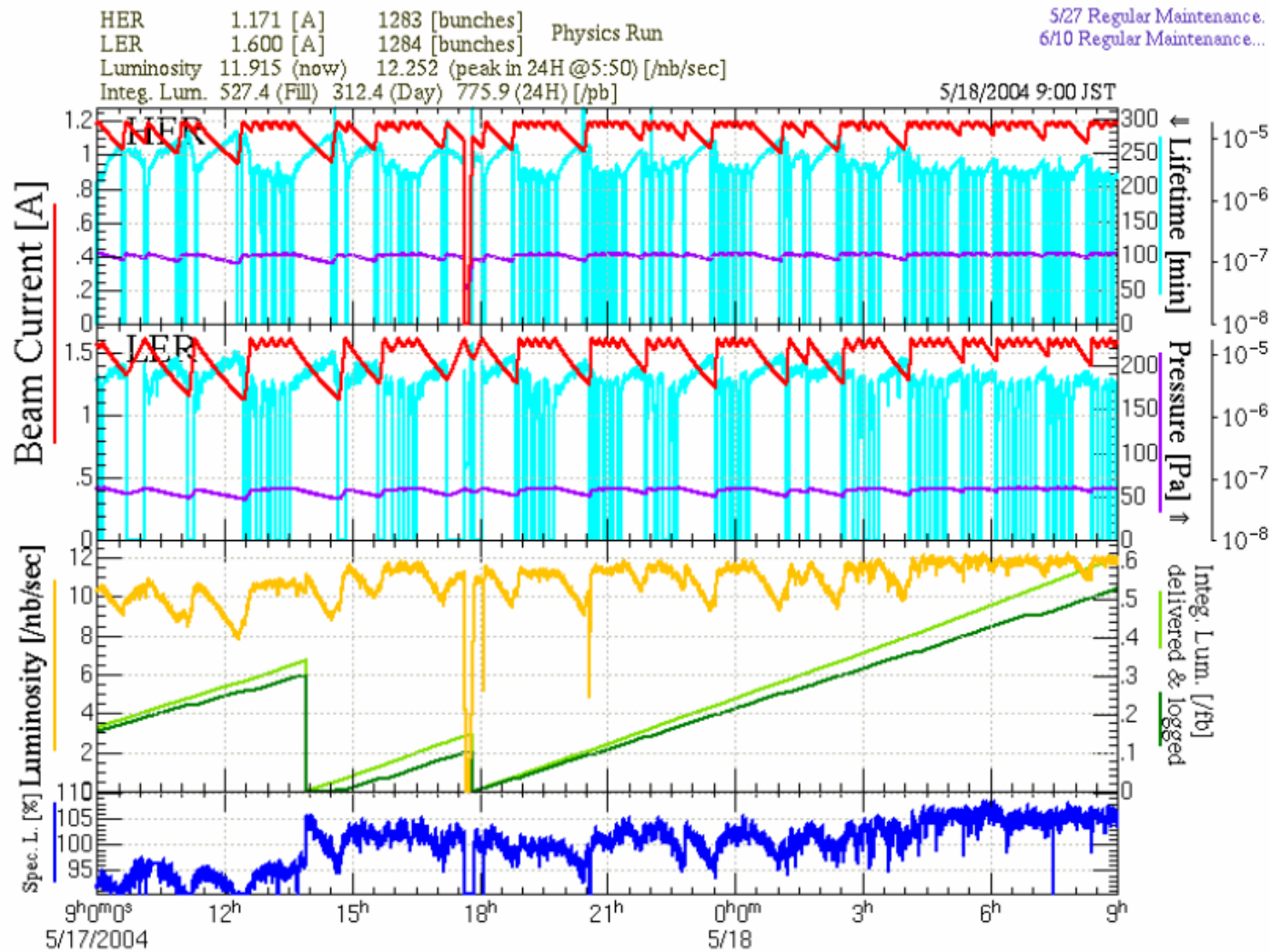
- 1. Introduction - = Typical KEKB Operation =

- KEKB-ring is operated under **Continuous Injection Mode**.
- PF (PF-AR) need once (twice) injection a day.



- 1. Introduction -

- Machine Study (PF, PF-AR) interrupts KEKB continuous injection.



- 1. Introduction -

= Issue of Current Beam Injection Mode =

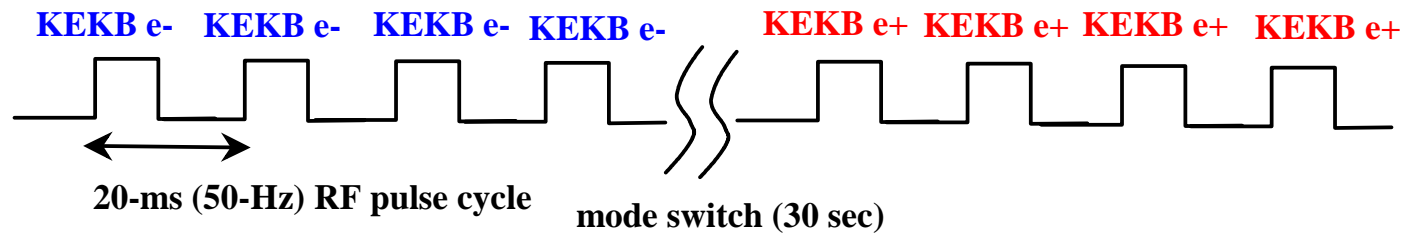
- One linac is used as an injector for 4-rings (time sharing).
- Changing the beam mode (KEKB => PF, PF-AR) takes time (2 or 3 min.) because ECS needs the magnet standardization.
- Super-KEKB needs the simultaneous beam injection (e- and e+).
- In the present operation, PF (and PF-AR) machine study interrupt the KEKB continuous injection.
- PF-ring needs the Top-up injection mode in the future.
- PF-AR also needs Top-up (6.5-GeV e-) injection (if possible).

= PF-AR BT needs to replace many magnets and power supplies (Large cost)

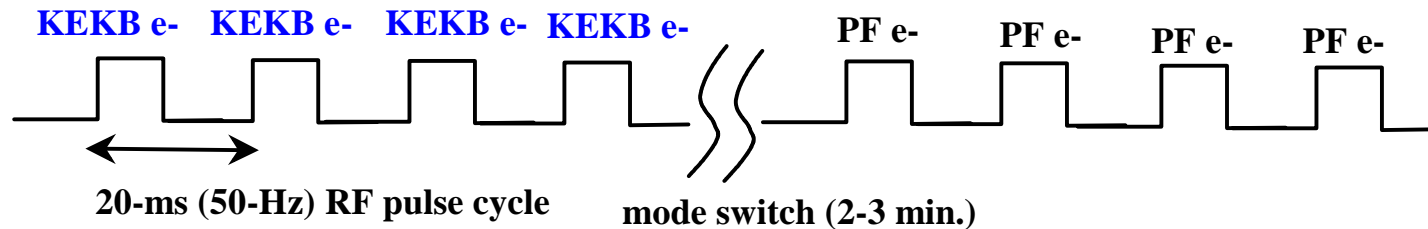
- **To solve the above problems, simultaneous injection scheme is strongly required. (beam mode switching in pulse-by-pulse).**

- 1. Introduction -

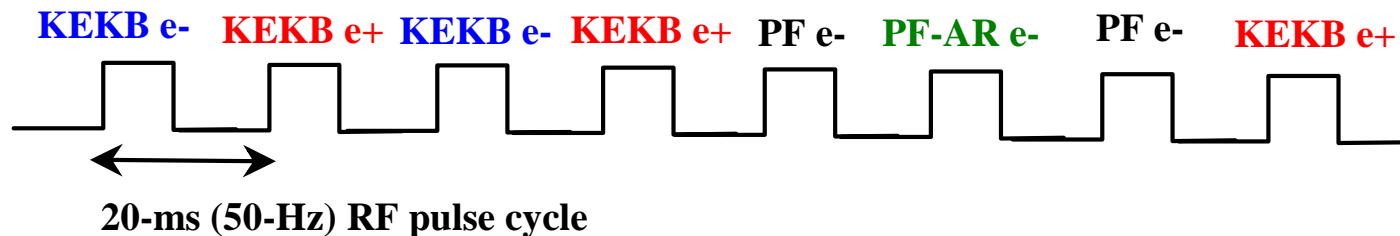
Current beam mode switch (KEKB e- \leftrightarrow e+)



Current beam mode switch (KEB e-/e+ \leftrightarrow PF/ PF-AR)



Simultaneous injection (Pulse-by-pulse beam mode switch)



- 2. Simultaneous Injection Scheme-

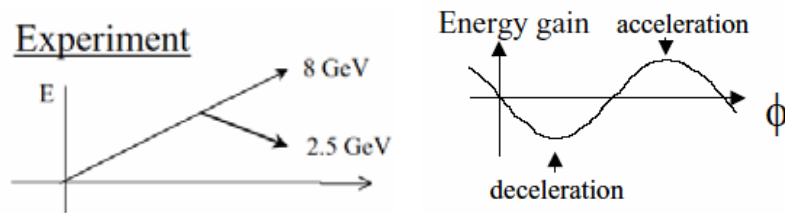
= Multi-Energy Linac Scheme =

- Fast change of the magnetic field is difficult by using current system.
- ***Use the common magnetic field (Quadrupole and Steering magnets)***
- Energy adjustment be done by changing klystron or sub-booster phase quickly.
 - Beam is accelerated up to ~5.3 GeV then decelerated to 2.5 GeV using deceleration phase (PF e-).
 - KEKB/PF/AR should use common electron Gun A1.

- 2. Simultaneous Injection Scheme-

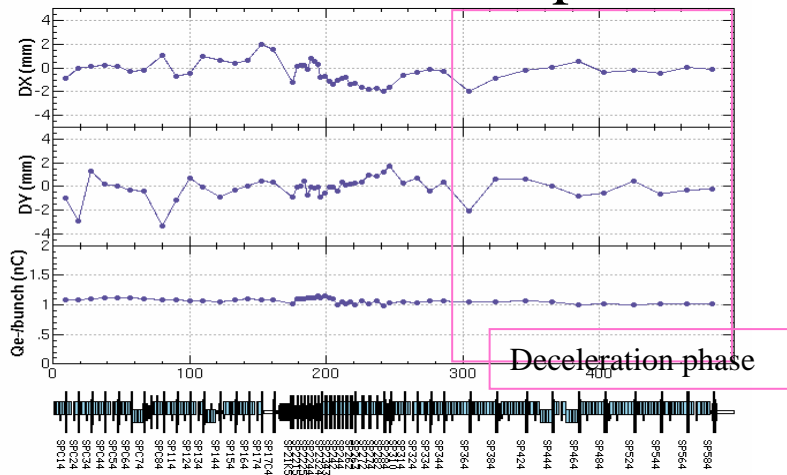
= Preliminary Machine Study for Multi-Energy Linac (1)

- Common magnet setting has been tested for "2.5-GeV" and 8-GeV e- beams.
- Optics difference comes from acceleration phase.

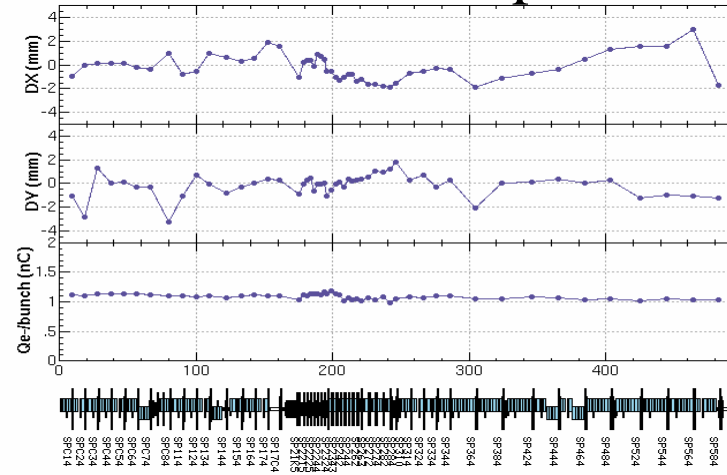


- Orbit correction satisfies both energies can be made.
- Normalized emittance of 8 GeV is similar to "2.5 GeV" e- optics.

"2.5 GeV" e⁻ optics



8 GeV e⁻ optics



Measurement of energy and emittance

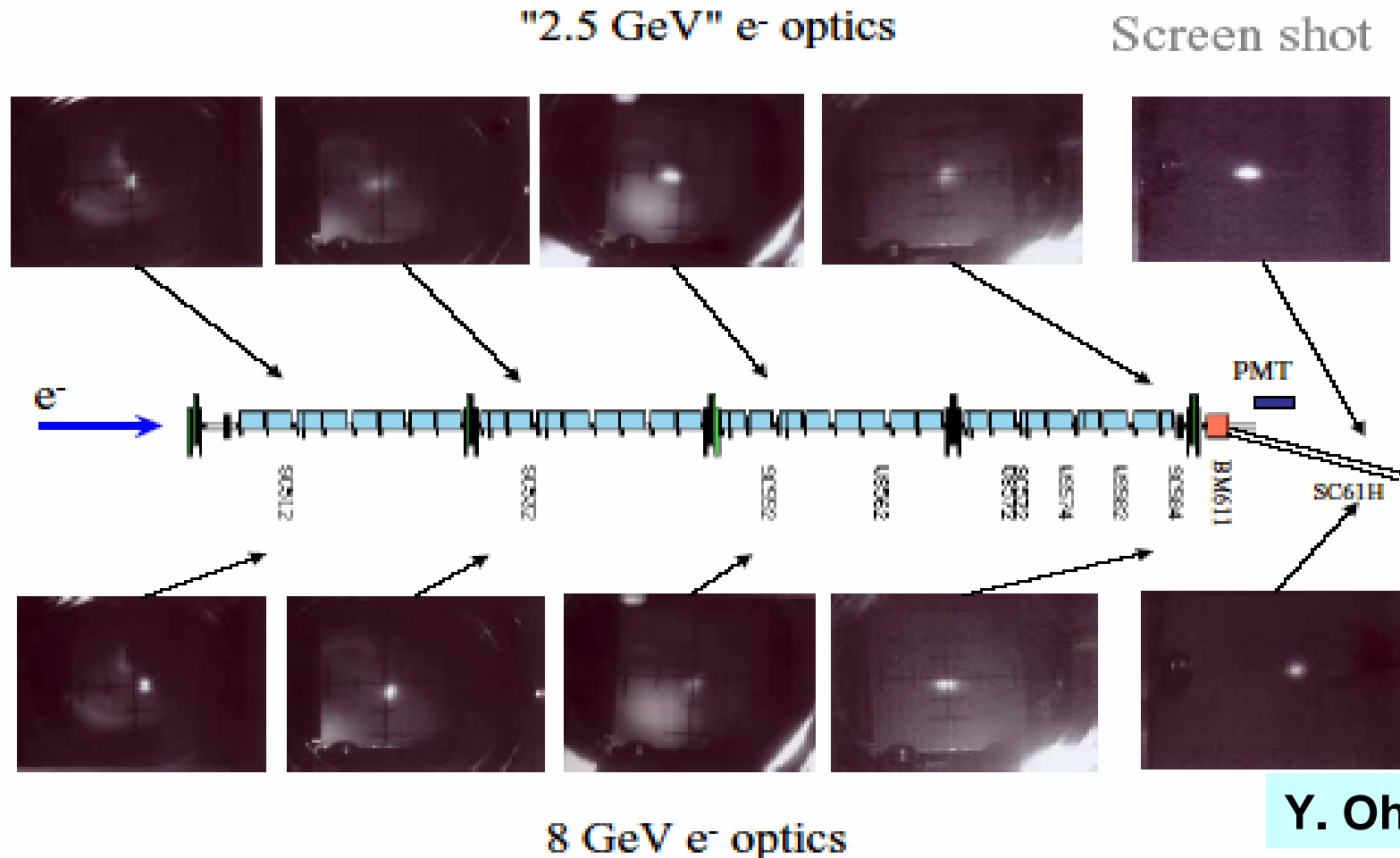
- Energy = 2.7 GeV (SC61H)
- $\gamma\epsilon_x = 3.6 \times 10^{-4}$ m
- $\gamma\epsilon_y = 6 \times 10^{-5}$ m

- Energy = 8 GeV (SC61H)
- $\gamma\epsilon_x = 2.5 \times 10^{-4}$ m
- $\gamma\epsilon_y = 4 \times 10^{-5}$ m

Y. Ohnishi

- 2. Simultaneous Injection Scheme-

= Preliminary Machine Study for Multi-Energy Linac (2) =



- *Multi-Energy Linac is feasible for practical operation.*
- *Need more Machine Study.*

- 3. Upgrade Plan-

= Upgrade Overview =

- Upgrade work consists of three phases:
 - Phase-I: Construction of New PF-BT line in this summer FY05 (bypass ECS)
Save time for switching beam mode (KEKB \leftrightarrow PF)
 - Phase-II: Simultaneous Injection (KEKB e-, PF e-)
 - Phase-III: Simultaneous Injection (KEKB e-/ e+, PF e-, PF-AR e-)
- To save costs, spares should be used (magnet, monitor, ...) as many as possible.
- Phase-III schedule depends on budget allocation.
- It should be carried out as soon as possible.

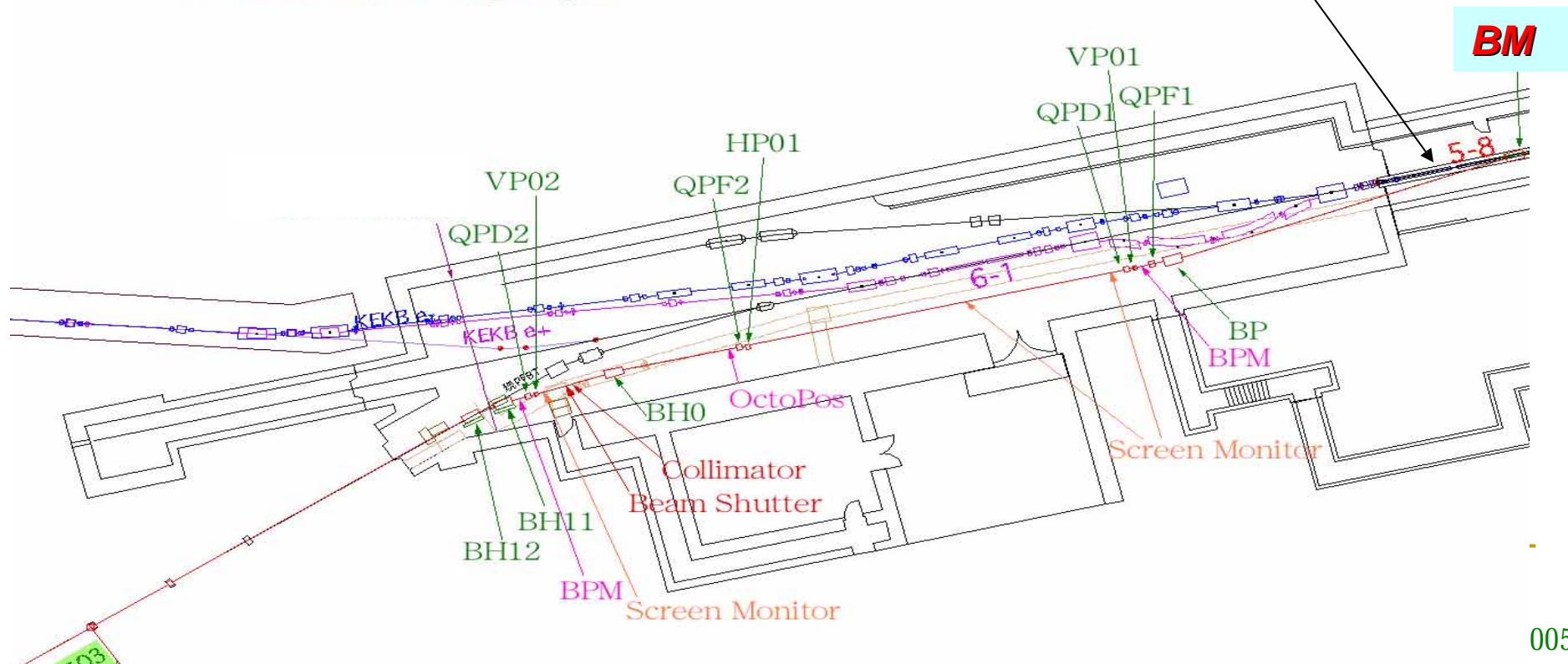
- 3.1 Phase-I (Upgrade Plan)

= Phase-I New PF-BT Layout =

- 5-8 accelerating unit will be removed. In order to compensate the energy margin, C-7 section uses SLED system.
- DC Bend will be installed in this summer. It will be replaced by pulse bend in FY05 winter /or FY06 summer.

B* ... Bending magnet
QP* ... Q-magnet
HP* ... Horizontal steering magnet
VP* ... Vertical steering magnet

Remove 58 accelerating unit



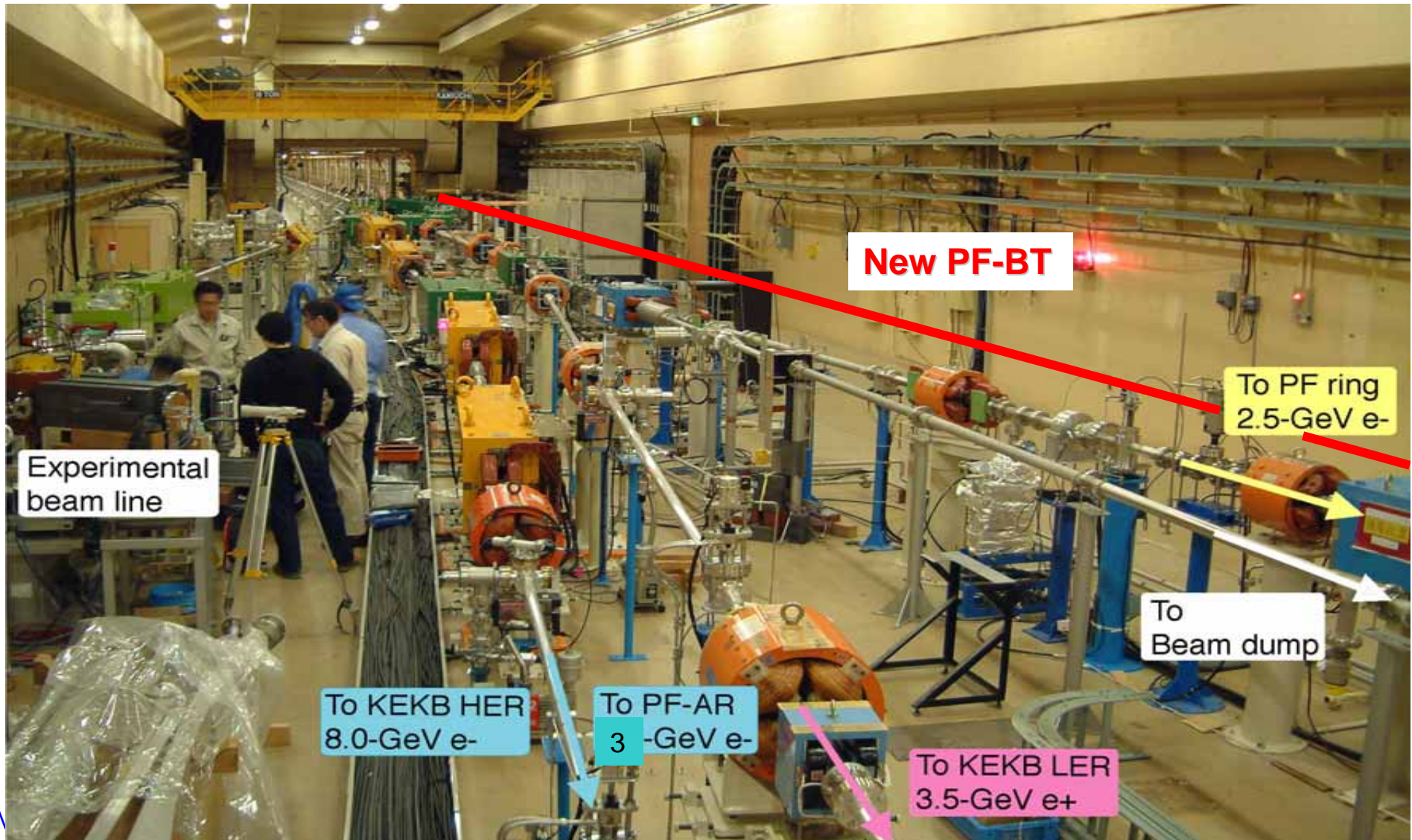
- 3.1 Phase-I (Upgrade Plan)

5-8 unit wave guide is a obstacle for new PF-BT.



- 3.1 Phase-I (Upgrade Plan)

Photograph of 3-SY



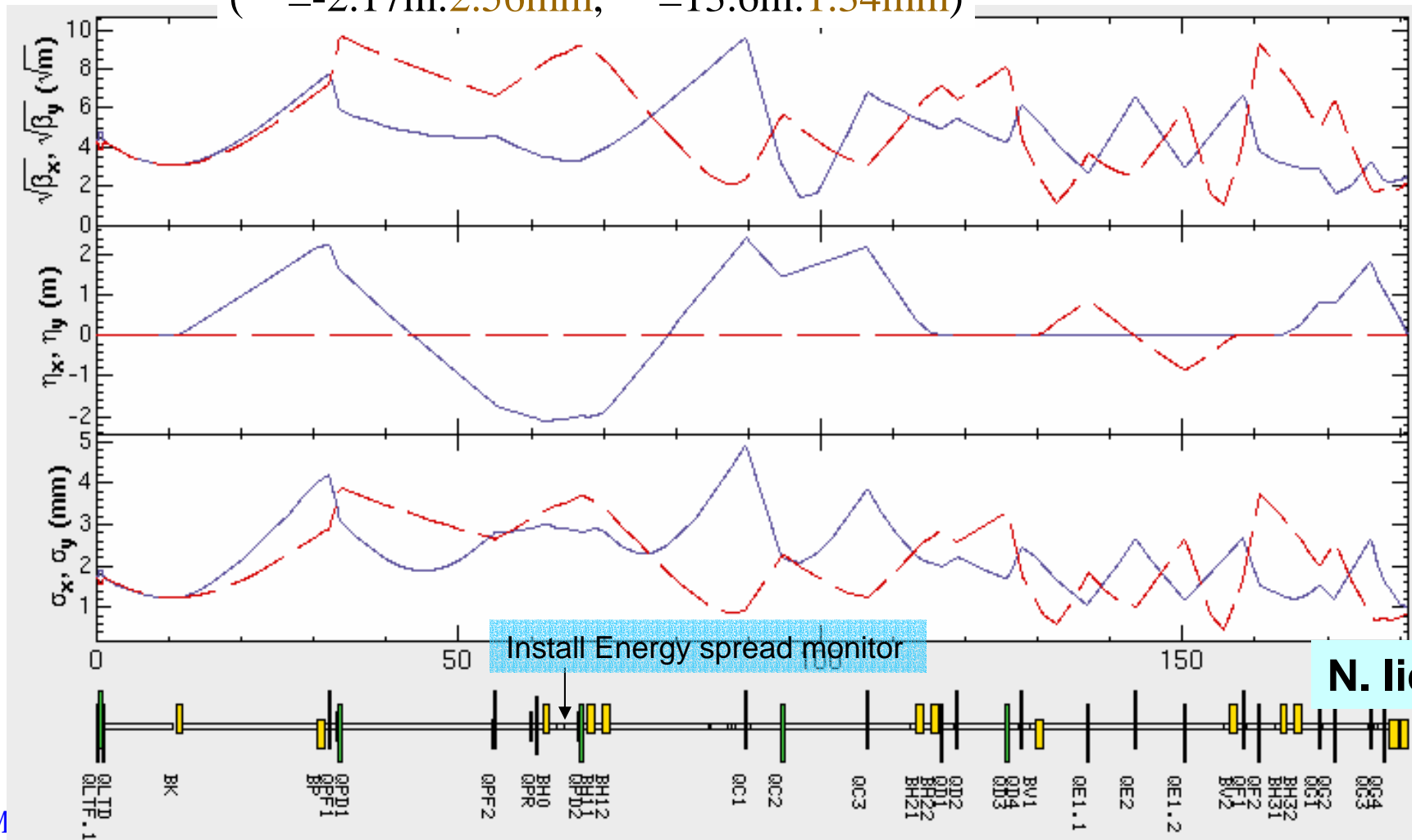
- 3.1 Phase-I (Upgrade Plan)

Phase-I New PF-BT Optics = —

$dP/P=0.125\%$ (1 σ), $\sigma = 1.6e-7m$

($\sigma_x = -2.17m:2.56mm$, $\sigma_y = 13.6m:1.34mm$)

1.91times



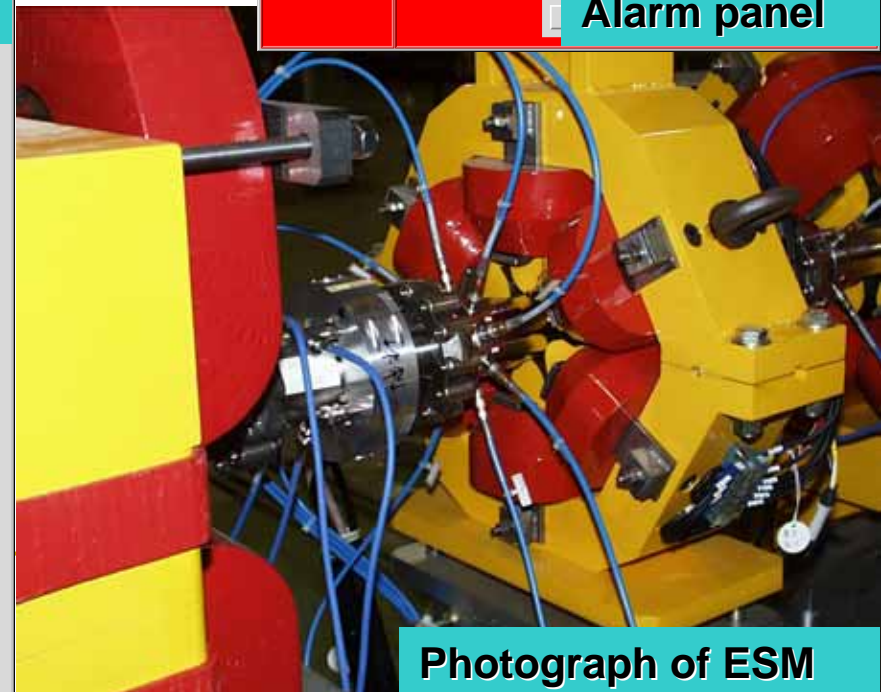
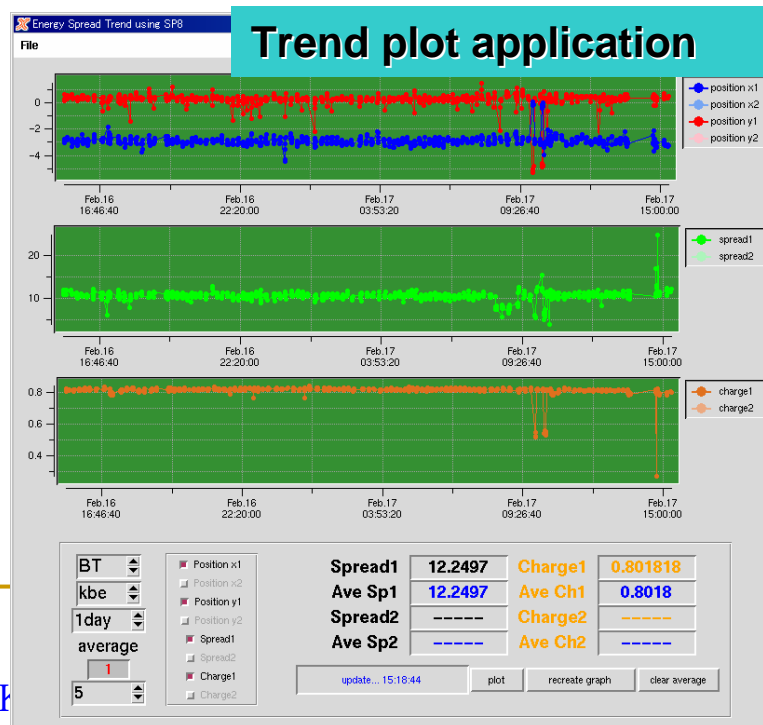
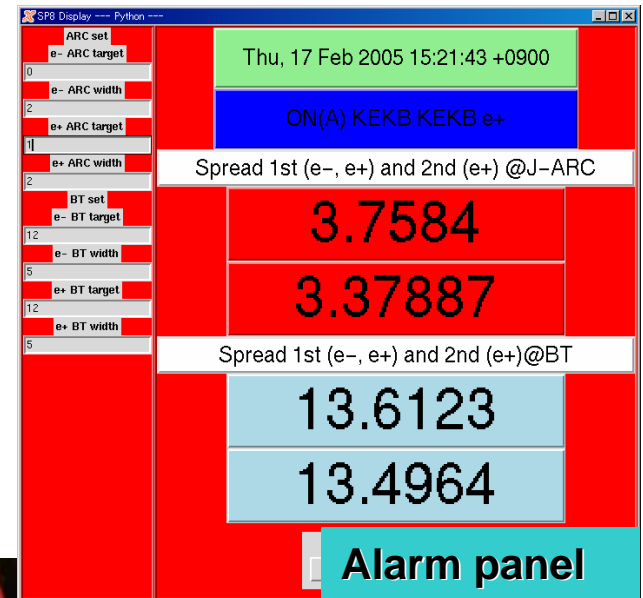
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- 3.1 Phase-I (Upgrade Plan)

= Energy-Spread Monitor (ESM) =

- Three ESMs have been installed, and it works well in daily operation J-ARC, KEKB BT (e-, e+)
- Same type of ESM will be installed in NEW PF-BT.
- Energy-spread Feedback will be carried out.

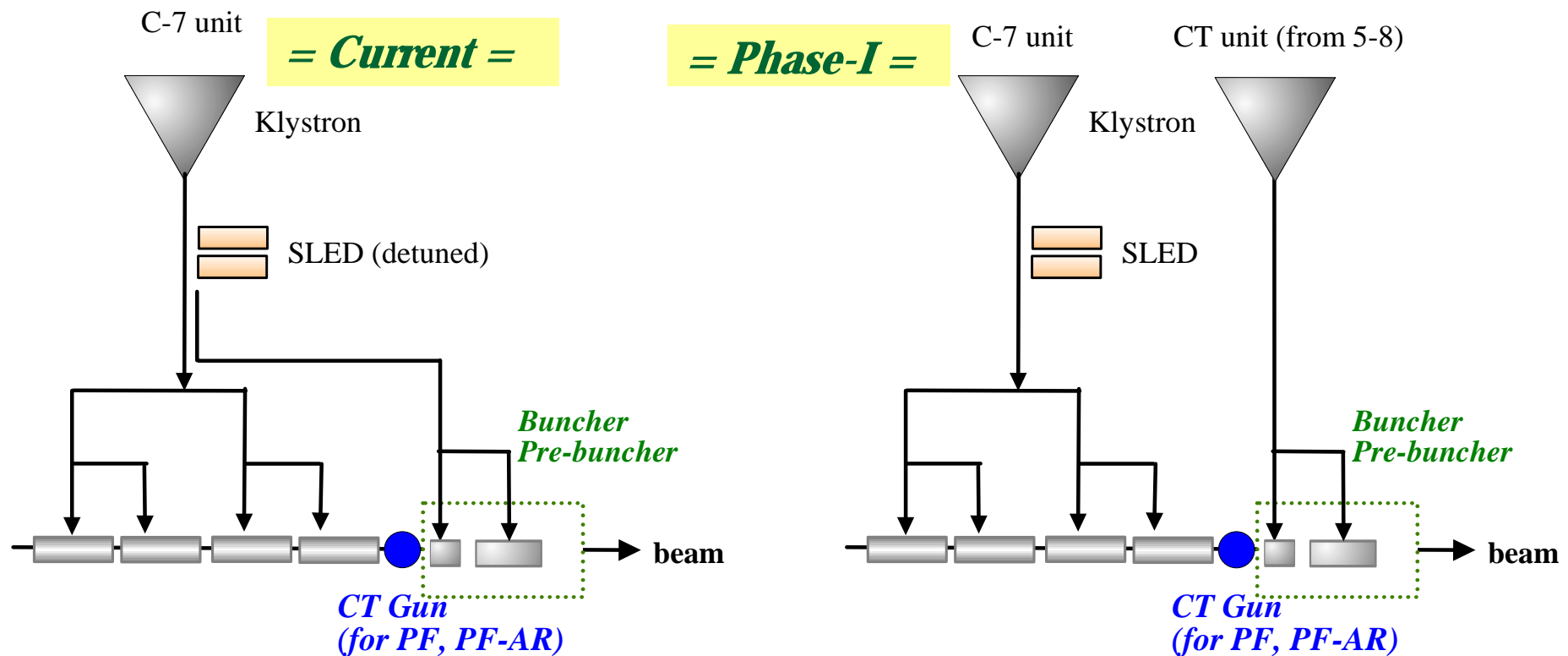


- 3.1 Phase-I (Upgrade Plan)

= Compensation for 5-8 unit energy gain (160-MeV) =

- Use C-7 unit SLED.
- 4-4 unit (C-band unit) will complete.

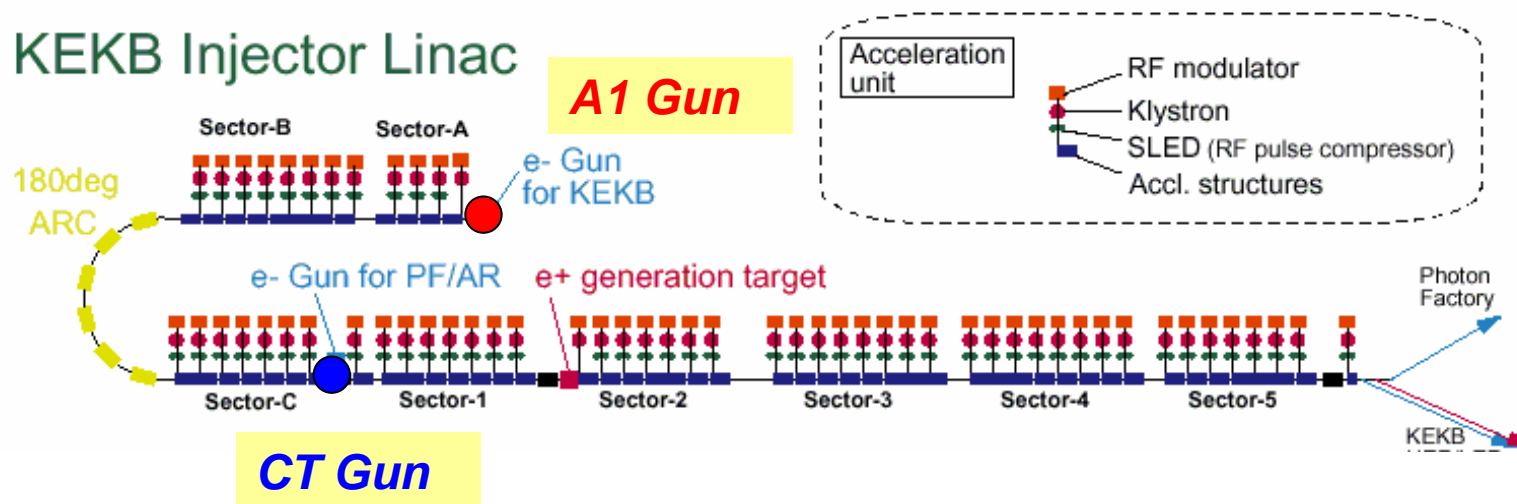
(1 acc. structure => 4 acc. structures with SKIP)



- 3.2 Phase-II (Upgrade Plan)

- KEKB and PF uses common electron Gun (A1) -

- KEKB and PF will be operated by common Gun (A1).
- Use common magnetic field (Quadrupole, Steering).
- Change only the klystron phase.



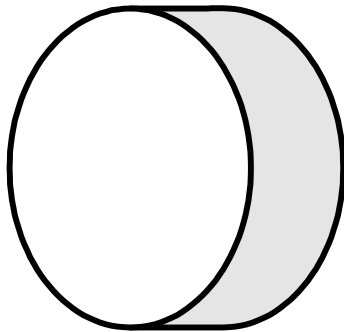
- 3.3 Phase-III(Upgrade Plan)

= KEKB e-/ e+, PF, PF-AR =

- Use common magnetic field (Multi-Energy Linac Scheme)
- Use e+ target with a hole.
- For fast switch (e-/ e+ mode) :
Change the e- beam orbit (Use fast steering magnet.)
- In this summer, e+ target replaced by crystalline tungsten with a hole)

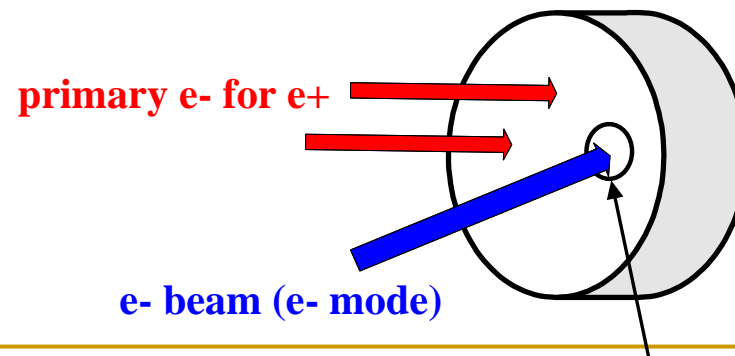
Current e+ target

(amorphous tungsten)



e+ target for phase-III

(crystalline tungsten with hole)

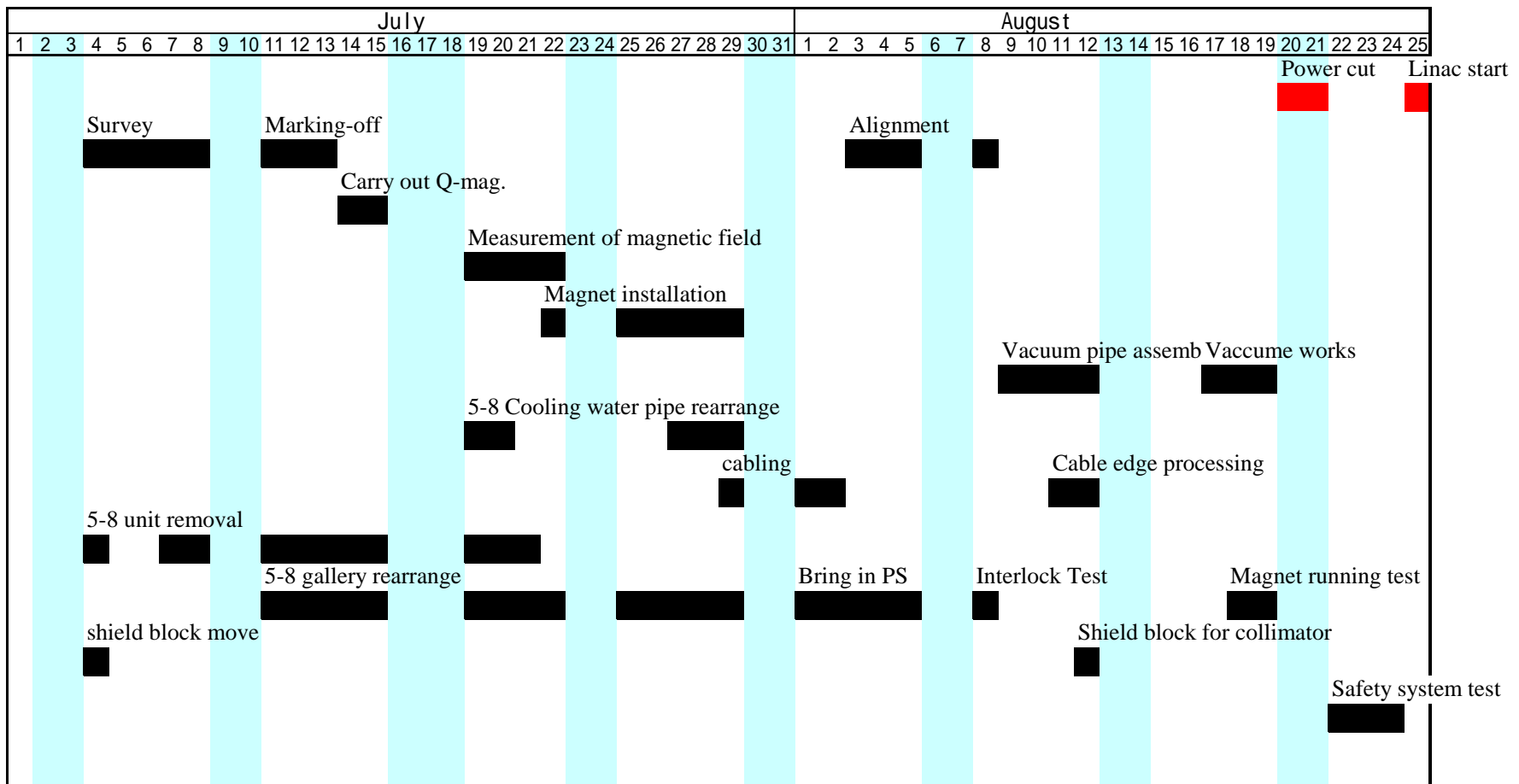


Hole for e- bypass

- 4. Budget and Construction Schedule

= Construction Schedule for Phase-I (this summer) =

- **Schedule is very tight (only 8 weeks).**
- **Other works during summer maintenance:**
 - **C-Band accelerating structures(x3)**
 - **Replacement of e+ target (amorphous tungsten => crystalline tungsten)**



- 4. Budget and Construction Schedule

= Budget =

	[US\$ million]
Phase-I	1.18
Phase-II	0.11
Phase-III	?

- Phase-II:

Grid purser and timing system (use A1 Gun for PF e- beam).

- Phase-III:

Beam monitor DAQ system for pulse-by-pulse measurement.

We will start R&D soon.

(fast waveform digitizer based on c-PCI)

Need fast phase shifter.

5. Summary

- KEKB injector linac upgrade project will start in this summer (FY05, Phase-I) toward the simultaneous injection (KEKB e-/ e+, PF e-, PF-AR e-; Phase-III).
- Use “Multi-Energy Linac scheme”:
 - Common magnetic field and fast change of klystron phase.
 - Machine study result shows feasibility. (Need more Study)
- Remaining issue (PF-AR Top-up injection):
 - Difficult to realize PF-AR Top-up (6.5-GeV) w/o large budget.
 - (Current PF-AR BT can transport beam 3.1-GeV max.)
 - Make a decision to PF-AR injection scenario .
(give up PF-AR Top-up?)