Upgrade of BPM DAQ System for SuperKEKB Injector Linac

M. Satoh, F. Miyahara, T. Suwada, and K. Furukawa
Accelerator Laboratory, KEK, 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan
T. Kudou and S. Kusano
Mitsubishi Electric System & Service Co., Ltd, 2-8-8 Umezono, Tsukuba, Ibaraki 305-0045, Japan

THPPC033

SuperKEKB Injector Linac

- Simultaneous injection for 4 independent rings (SKB e-/e+, PF, and PF-AR) w/ different beam energies.
- Increase positron beam intensity:
  - 1 => 4 nC/bunch
- Increase electron beam intensity and Reduce electron beam emittance w/o Damping ring:
  - 1 nC => 5 nC
  - 100 mm·mrad => 20 mm·mrad
- High precision beam position measurement and control (≤ 10 μm)

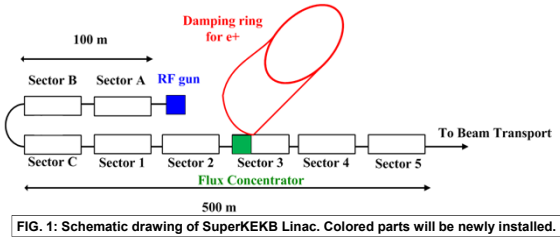

FIG. 1: Schematic drawing of SuperKEKB Linac. Colored parts will be newly installed.

TABLE 1: Main parameters of former KEKB and SuperKEKB.

Parameters	KEKB		SuperKEKB	
	e+	e-	e+	e-
Ring:				
Energy (GeV)	3.5	8	4	7
Stored current (mA)	1.6	1.2	3.6	2.6
Beam lifetime (min.)	150	200	10	10
Injector Linac:				
Bunch charge (nC)*	1 (10)	1	4 (10)	5
Emittance (μmrad)	2100	100	10	20
Energy spread (%)	0.125	0.05	0.07	0.08
Bunch length (mm)	2.6	1.3	0.7	1.3

(*) Numbers inside braces denote the charge of primary electron for positron production.

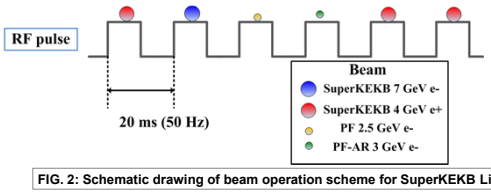

FIG. 2: Schematic drawing of beam operation scheme for SuperKEKB Linac.

Low Emittance Electron Beam Injection (w/o damping ring)

- Component misalignment (Accelerating structure, Q-Mag.) causes the serious emittance growth.
- Simulation was conducted for the 500-m-long straight line (5 nC, initial emittance 10 mm·mrad, Misalignment of accelerating structure: σ =0.5 mm).
  - Maximum emittance at end of linac (in 100 different seeds of misalignments) 168 mm·mrad (FIG. 2.)
- A precise initial beam offset and angle control can realize the emittance preservation 11.5 mm·mrad instead of 168 mm·mrad (FIG. 3.).
- Precise beam position measurement and control => Crucial issue

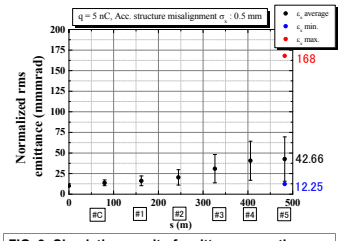

FIG. 3: Simulation result of emittance growth caused by the accelerating structure misalignment.

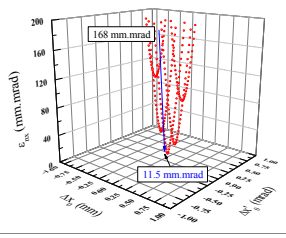

FIG. 4: Simulation result of emittance growth suppression by the fine control of beam orbit.

Evaluation of Long-term stability (variation of gain imbalance)

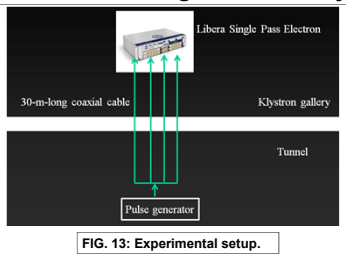

FIG. 13: Experimental setup.

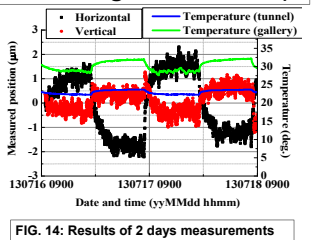

FIG. 14: Results of 2 days measurements (moving average over 5 minutes).

Current BPM DAQ System

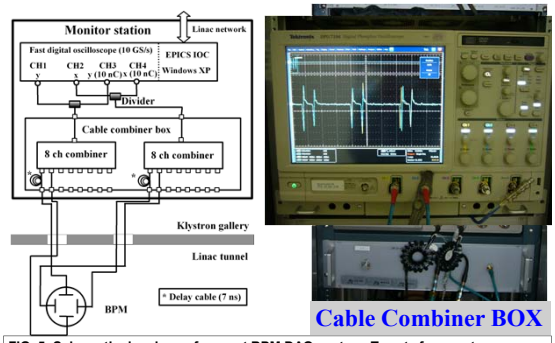

FIG. 5: Schematic drawings of current BPM DAQ system. Twenty four systems process 94 BPMs (WindowsXP-based digital oscilloscope).

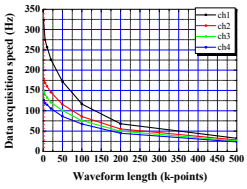

FIG. 6: Data acquisition speed of current DAQ system. For the real beam operation, one oscilloscope processes the waveform of 2000 data points and two channels at the same time up to 50 Hz.

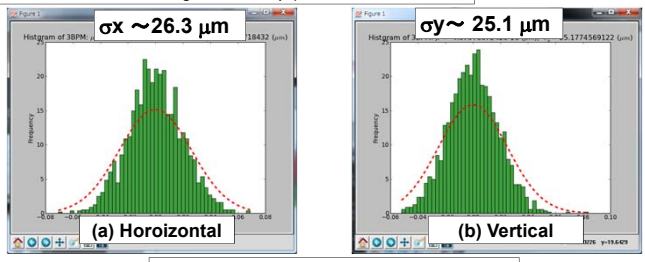

FIG. 7: 3-BPM result of current BPM DAQ system.

New System Candidates

- VME-based System (KEK Linac).
- LIBERA Single Pass Electron (i-tech).
  - 16 bit A/DC with 160 MSa/s.
  - SAW filter: fc = 522 MHz, Bandwidth = 24 MHz
  - Fast controllable attenuator : 0 dB ~ 31 dB.
  - Pulse-to-pulse (50 Hz, 20 ms interval) measurement.
  - EPICS IOC ready, Event receiver (MRF compatible) inside.

Performance Evaluation (3-BPM Measurment)

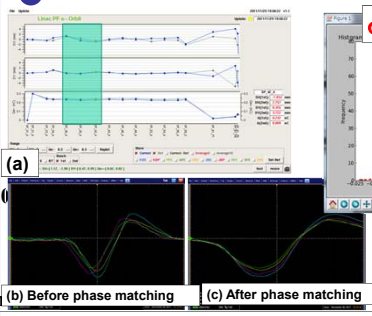

FIG. 8: Linac beam orbit along Linac (for PF injection w/ 0.3 nC). (a). Horizontal (upper), vertical (middle) beam orbits, and charge (bottom). For increasing measurement precision, signal phases from four strip-lines were precisely adjusted.

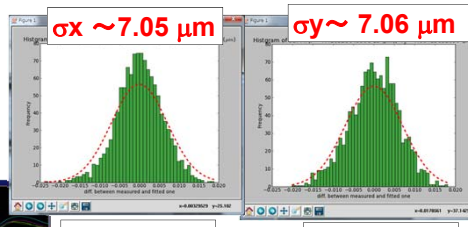

FIG. 9: Results of 3-BPM. Horizontal and vertical beam position measurement precisions are:

σx ~ 7.05 μm
σy ~ 7.06 μm

1st bunch impact on 2nd bunch measurement

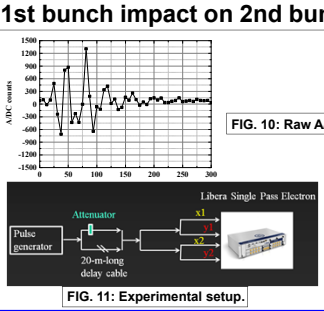

FIG. 10: Raw A/DC waveform.

FIG. 11: Experimental setup.

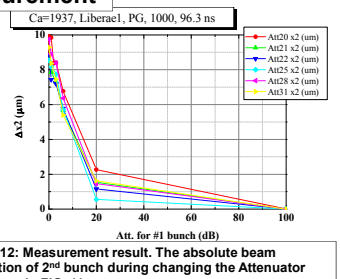

FIG. 12: Measurement result. The absolute beam position of 2nd bunch during changing the Attenuator settings in FIG. 11.

Summary and Future Plan

- Toward SuperKEKB Injector Linac Upgrade, we evaluate the performance of the New BPM DAQ System candidate (LIBERA Single Pass Electron)
- The result of 3-BPM measurement shows σx,y ~ 7 μm of measurement precision. (Our goal is less than 10 μm)
- Mass production and install will be conducted after evaluation of another candidate (VME-based module).