MOPMS029

The BPM DAQ System Upgrade for SuperKEKB Injector Linac

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Issues for 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)

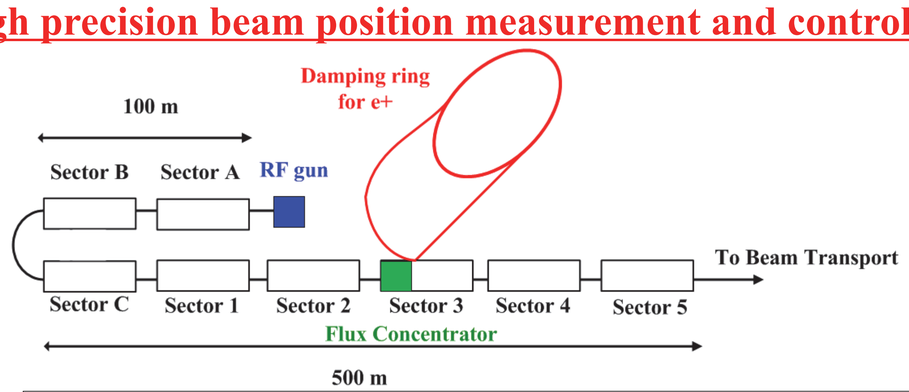

FIG. 1: Schematic drawing of SuperKEKB Linac. Colored parts will be newly installed.

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.

Low Emittance transport w/o damping ring

- Misalignment of accelerating structure and quadruple magnet cause the emittance growth.
- Assuming KEK injector linac configuration (#C～#5 sector), 5 nC charge and initial emittance of 10 mm·mrad, the acc. structure misalignment of 0.5 with standard deviation cause the emittance growth (168 mm·mrad at maximum) as shown in FIG. 2.
- However, the fine control of beam offset and angle can cure the emittance deterioration as shown FIG. 3.

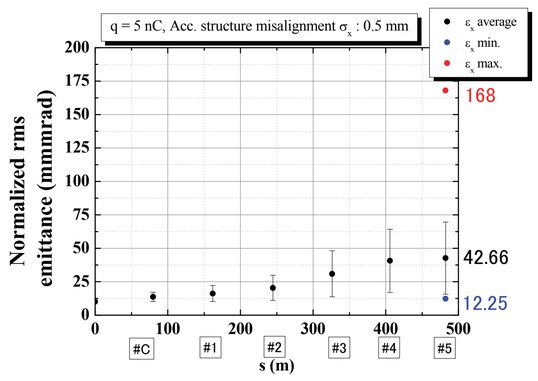

FIG. 2: Simulation result of emittance growth caused by the accelerating structure misalignment.

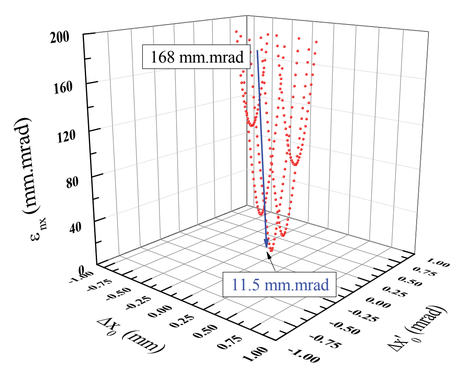

FIG. 3: Simulation result of emittance growth suppression by the fine control of beam orbit

Current BPM DAQ System

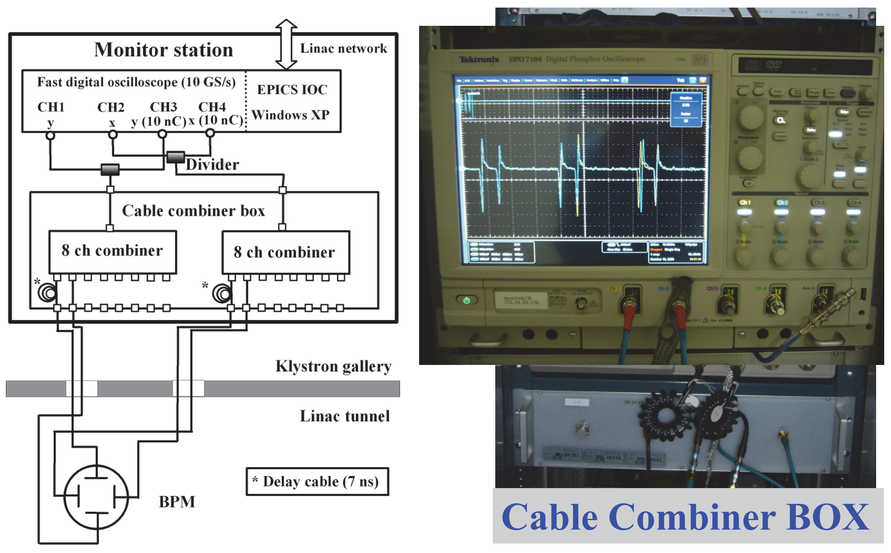

FIG. 4: Schematic drawing and photograph of current BPM DAQ system. Twenty-four DAQ systems handle with 94 BPMs.

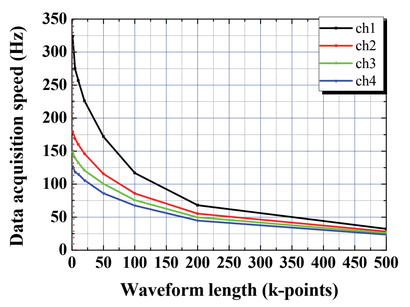

FIG. 5: Data acquisition performance of current DAQ system. In our application, we need waveform length of 2-k points at 2 channel simultaneous acquisition.

Table 2: Precision of current BPM DAQ system measured by 3BPM method.

Bunch charge (nC)	Precision (μm)
0.1	66.3
1	106.5
7	50.5

Requirement for New BPM DAQ System

- Woks as an EPICS IOC
- Fast data acquisition up to 50 Hz
- Simultaneous measurement of 2 bunch beam with 96 ns interval
- Acquisition for wide range of charge intensity: 0.1 nC ~ 10 nC

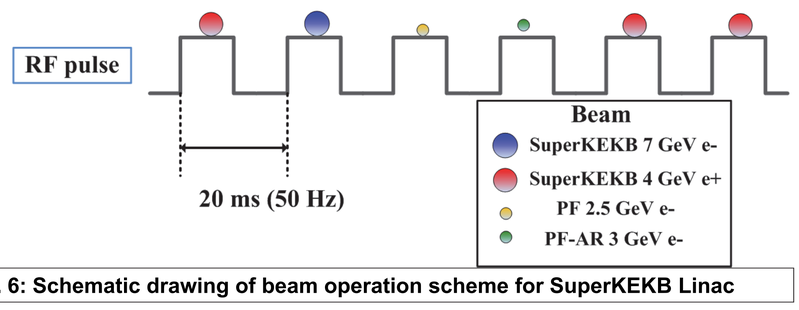

FIG. 6: Schematic drawing of beam operation scheme for SuperKEKB Linac

Performance Evaluation of New DAQ System

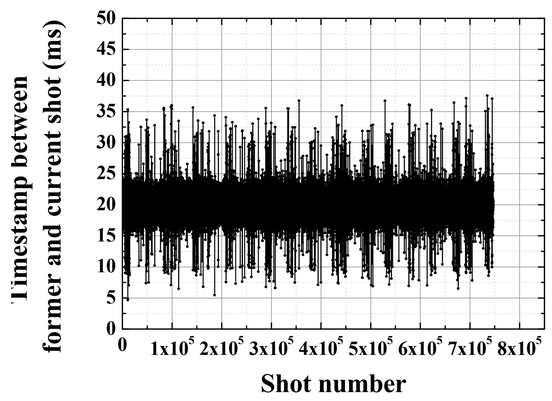

FIG. 8: Result of data acquisition defect by using test pulse of 50 Hz while four hours of continuous test. All beam pulse could be measured up to 50 Hz (corresponding to 20 ms) since all timestamp differences are less than 40 ms.

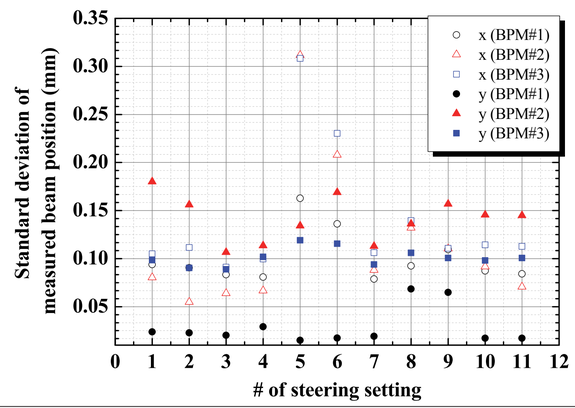

FIG. 9: Precision of position measurement by using 0.1 nC beam and eleven different steering settings. These results include the beam position fluctuation. The result of y (BPM#1) at steering setting #5 shows the standard deviation with 15 μm. The measurement precision of LIBERA could be less than 15 μm when the effect of beam fluctuation effect is subtracted from this result.

Candidate for New DAQ System

- LIBERA Brilliance Single pass (i-tech)

- Widely used for recent accelerator facilities.
- 120 MSa/s ADC with 16-bits of resolution, SAW filter
- Attenuator control range: 0 dB ~ 31 dB
- Implementation of the fast attenuator control function is going on for our specific needs.

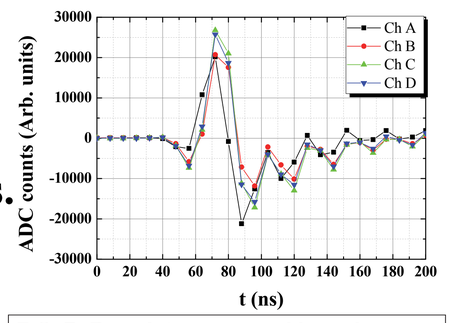

FIG. 7: Raw data measured by using electron beam of 0.1 nC at KEK linac.

Summary and future plan

- Toward SuperKEKB injector upgrade, a new BPM DAQ system is under evaluation (LIBERA).
- We are aiming at achieving the measurement precision less than 10 μm.
- Result of beam test shows that the measurement precision could be less than about 15 μm.
- Other DAQ schemes are now under consideration.

- In the near future, beam test by 3BPM scheme will be carried out for accurate evaluation.
- Functionality of fast attenuator control will be also tested.