THPHA064

Control System Status of SuperKEKB Injector Linac

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SuperKEKB Injector Linac Overview

- High bunch charge (4 nC), low emittance (20 μm), small energy spread
- Simultaneous top-up injection for 5 independent rings

(SKB e-/e+, e+ damping ring PF, PF-AR) w/ different beam energies.

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

Table 1: Main Parameters of KEKB and SuperKEKB Injector Linac

Project	KEKB***		SuperKEKB*** (Phase I)		SuperKEKB**** (Phase II)		SuperKEKB**** (Phase III)	
Beam	e-	e+	e-	e+	e-	e+	e-	e+
Beam energy(GeV)	8	3.5	7	4	7	4	7	4
Stored current (A)	1.1	1.6	1	1	-	-	2.6	3.6
Beam lifetime (min.)	200	150	100	100	-	-	6	6
Bunch charge (nC)	1	1 (10*)	1	0.4 (8*)	1	0.5 (10*)	4	4 (10*)
Normalized vertical emittance (mm·mrad)	310	1400	300 / 130**	1200	150	40	20	15
Normalized horizontal emittance (mm·mrad)			160 / 200**	1000	150	200	40	100
Energy spread (%)	0.125	0.125	0.5	0.5	0.1	0.16	0.07	0.16
Bunch length (mm)	1.3	2.6	1.3	2.6	1.3	0.7	1.3	0.7
# of bunch	2		2		2			
Maximum beam repetition (Hz)	50		25		25 / 50			
Top up injection	3 rings (HER, LER, PF)		n/a		5 rings (HER, LER, DR, PF, PF-AR)			

*: Primary electron beam for positron production.
**: Results with the photocathode rf electron gun.
***: Achieved values.
****: Design values.

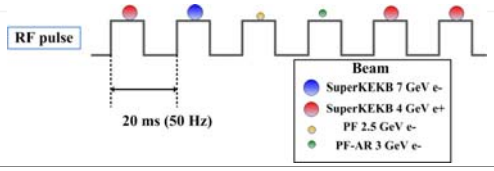
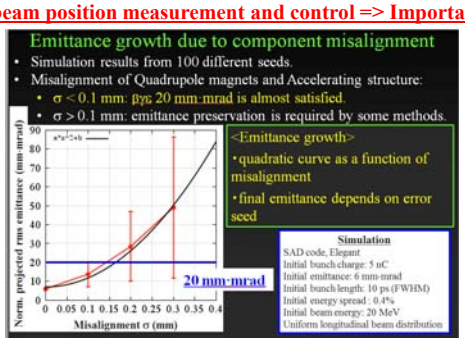


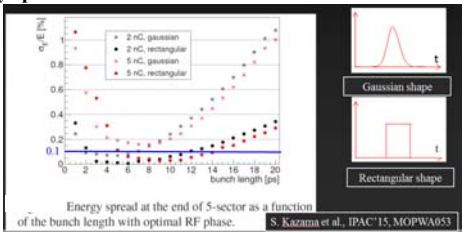
FIG. 2: Schematic drawing of simultaneous top-up injection operation scheme for SuperKEKB Linac.

Low Emittance Preservation for e- Beam (w/o damping ring)

- Component misalignment (Accelerating structure, Q-Mag.) causes the serious emittance growth.
- Simulation was carried out for the 500-m-long straight line (5 nC, initial emittance 10 mm·mrad w/ various misalignments of the accelerating structures and quadrupole magnets)
- Precise beam position measurement and control => Important issues



- The electron beam of short bunch length can mitigate the transverse wake field and eventually can avoid the significant emittance growth. However, it may cause the large energy spread if the longitudinal bunch shape is Gaussian. The rectangular like longitudinal bunch shape can keep the small energy spread beam.



Injector Linac Control System

- EPICS based Control System
  - Base R3.14.9, R3.14.12
- EPICS Channel Archiver, CSS Archiver, CSS Alarm
- Server machines (x17)
  - CentOS 5.10 (x86_64)
- HP blade BL460c G1/G8/G9, BL680c G5, 1U/2U server
- Storage: NetApp FAS3220, FAS2040, FAS2020
- Operation terminal machines (x10)
  - PC (Windows 7/CentOS 5.11, 6.8, 7.2 (x86_64))
- Tcl/Tk, SAD (Strategic Accelerator Design) => Python, SAD, MEDM, CSS
- SCM

Table : # of IOCs for each subsystem.

Group	# of IOCs (153)
Safety	2
Monitor	48
RF	57
Magnet	19
Vacuum	1
Operation	3
Timing	21
Temperature	2

Devices	Accelerator components (# of components)	# of controllers (385)
VME64x	Event-based timing system (MRF EVG-230, EVR-230RF)	25
PLC	Magnet (363)	59
	Vacuum (333)	26
	Klystron (5)	5
	Charge integration interlock	3
Network attached power supply	Magnet (105)	105
Linux-based PLC	Profile monitor (100)	30
Embedded Linux	Klystron (66)	66
Data logger (CHINO)	Temperature (690)	28
	Timing watchdog (15)	15
Oscilloscope	BPM (100)	23

FIG. 3: OPI GUI for each device control.

FIG. 4: Displaying example of archiver viewer. (Web application based on Adobe flush and amfphp)

FIG. 5: EPICS IOCs are running inside the vncserver.

FIG. 6: E-log system based on the web application.

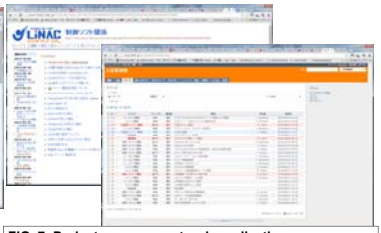
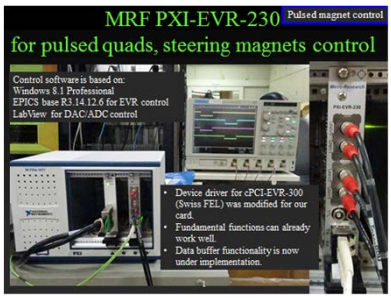
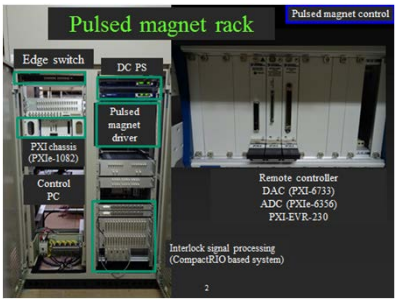


FIG. 7: Project management web application Redmine and PukiWiki are used for the injector linac control group.

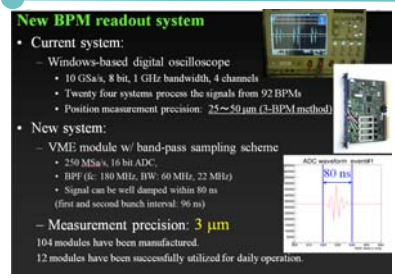
Event Based Timing Control System

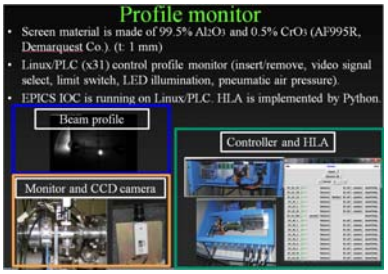
- MRF: VME EVG 230 x3, EVR-230RF x46, PXI EVR-230 x13
- VME 64x based. VxWorks 6.8.





Beam Monitor Control System





Summary and Future Plan

- SuperKEKB injector linac control system is based on the EPICS framework. We manage about 150 EPICS IOCs and about 50,000 PVs.
- The new BPM readout system based on a double width VME card w/ the precision of about 10 μm (1σ).
- The PXI based EVR 230 system is implemented for the pulsed steering and quadrupole magnet controls, now under test. It will be applied for the real beam operation in this October 10th.
- Project management tool Redmine and Git SCM are very effective for pushing the productivity of linac control group.