



SuperKEKB Electron Positron Injector LINAC Upgrade towards Higher Charge and Lower Emittance



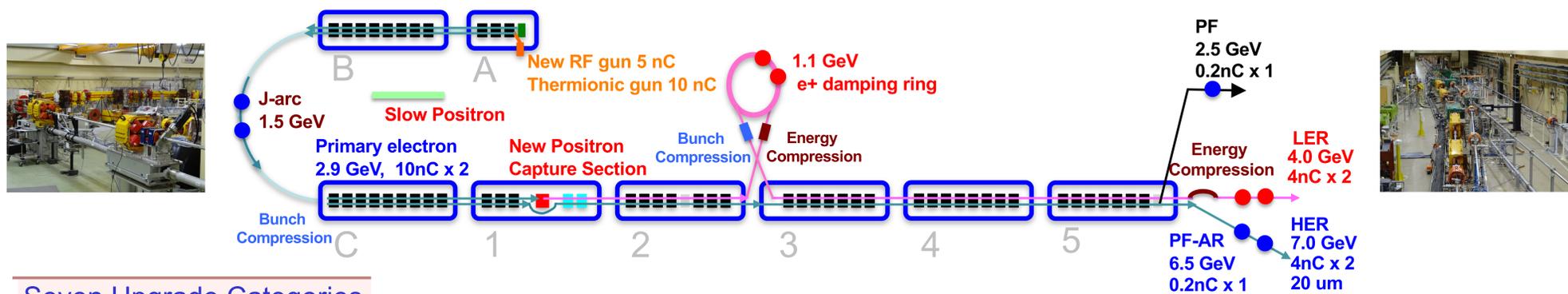
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KEK electron positron injector linac has established simultaneous top-up injections in 2019 for 5 rings of SuperKEKB DR, LER, HER, PF ring and PF-AR as a base of the both elementary particle physics and photon science experiments even under a quite short beam lifetime. It improved the injection stabilities while the SuperKEKB broke the world record of the collision luminosity of the previous project KEKB. As the collision performance improves,

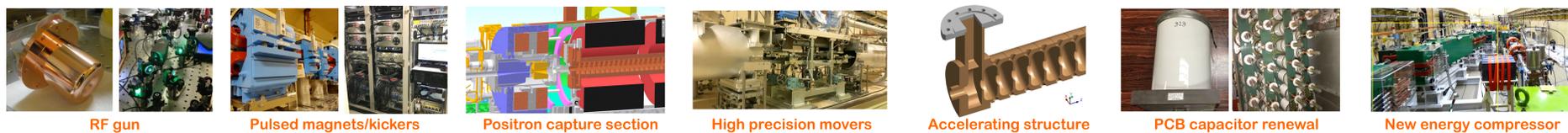
the beam-beam effect makes the dynamic aperture shrink, and the beam lifetime reduces further. Thus, it became inevitable for the injector to be upgraded in order to resolve the contradictory improvements of higher charge and lower emittance of injection beams regarding beam wakefield till 2025. The upgrade plan is described including pulsed magnets, an energy compression system, accelerating structures, girders, and positron generator.

KEK e⁻ / e⁺ injector LINAC is being upgraded further in seven categories for higher beam charge and lower beam emittance in order to achieve the final goal of SuperKEKB

Present Injector LINAC

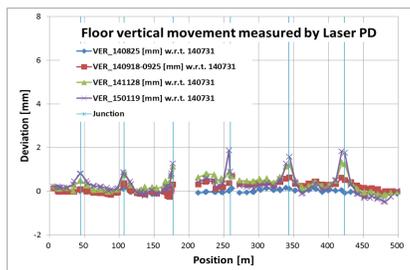


Seven Upgrade Categories

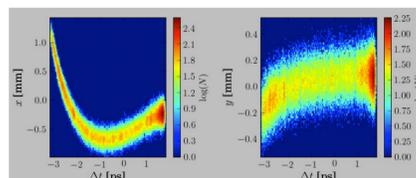


Transverse and Longitudinal Emittance Mitigation

◆ As the beam orbit deviation by 0.1mm may cause wakefield effect in the structures, pulsed magnets and movable girders are prepared.



Seasonal alignment deviation.



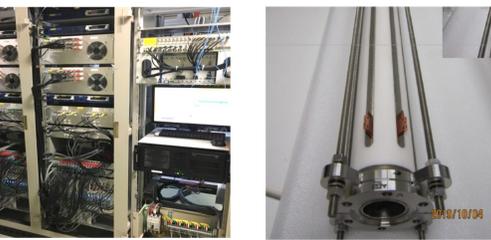
Possible beam shape distortion

by pulsed magnets/kickers



by movable girders

Girders for magnets and structures up to 1000 kg can be moved by a micron.



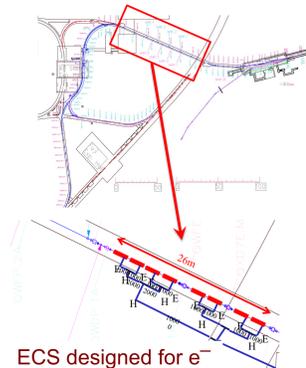
Required Beam Performance

Stage	KEKB (final)	Phase-I (achieved)	Phase-II (achieved)	Phase-III (interim)	Phase-III (final)
Beam Energy	3.5 GeV	8.0 GeV	4.0 GeV	7.0 GeV	4.0 GeV
Stored current	1.6 A	1.1 A	1.0 A	1.0 A	1.3 A
Life time (min.)	150	200	100	100	6
Bunch charge (nC)	-1	1	-0.4	1	-4
Norm. Emittance (μmrad)	1400	310	1000	130	150/30
Energy spread	0.13%	0.13%	0.50%	0.50%	0.16%
Bunch / Pulse	2	2	2	2	2
Repetition rate	50 Hz	25 Hz	25 Hz	25 Hz	50 Hz
Simultaneous top-up injection (PPM)	3 rings (LER, HER, PF)	No top-up	Partially	4+1 rings (LER, HER, DR, PF, PF-AR)	4+1 rings (LER, HER, DR, PF, PF-AR)

by energy compression system



Existent energy compression (ECS) for e⁺



ECS designed for e⁻



Electron/positron machine complex at KEK



700 Capacitors in power modulators with low-level PCB (30-40-year old) have to be replaced for legal compliance

Aged Device Renewals

230 S-band structures (many 40-year old)
19 have discharge issues
6 had cooling water leakages



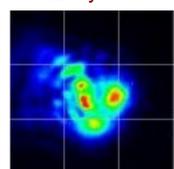
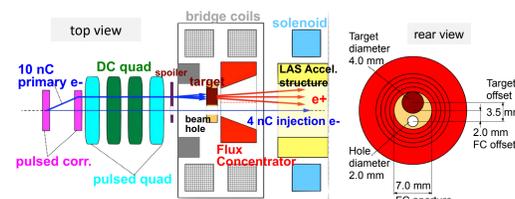
Electron and positron source improvements



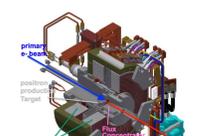
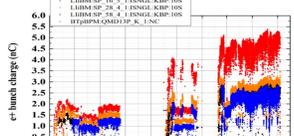
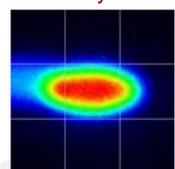
RF cavity



Ir-Ce alloy cathode



Laser shaping by DOE



Summary

- ◆ KEK injector LINAC will be upgraded progressively in order to support a higher collision rate in SuperKEKB collider rings.
- ◆ The upgrade is designed in seven categories for transverse and longitudinal emittance optimization, electron and positron source enhancement, and aged device renewals.

