Injector Linac Status

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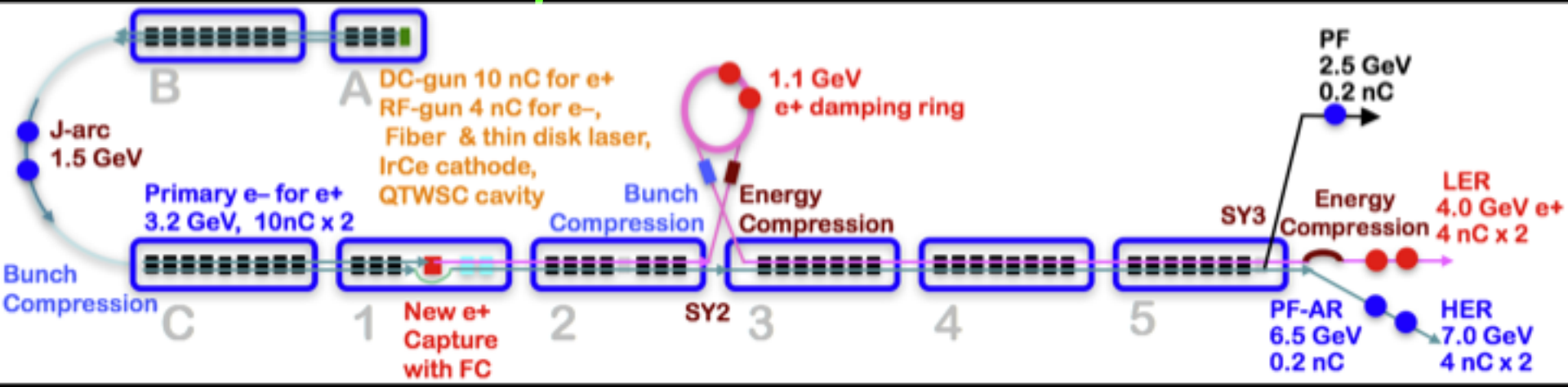
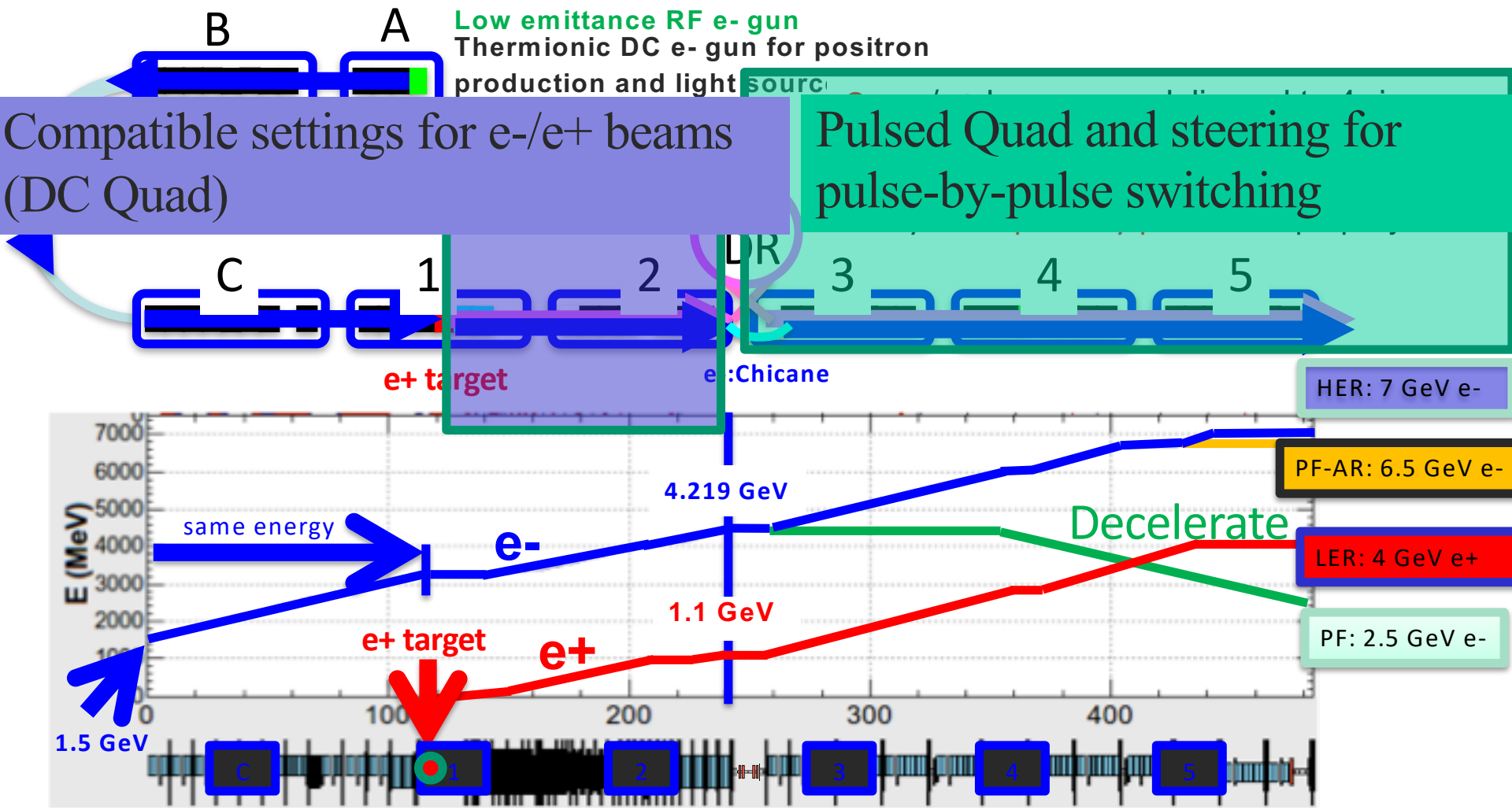
Injector overview



- Injector for light sources (PF, PF-AR)3 times daily injection and SuperKEKB
- up to 25 Hz beam repetition rate in Phase II (to save electricity)
  - 50 Hz operation in Phase III
- Thermionic e- gun for light source injection and 10 nC beam generation (e+ production)
- Photocathode rf gun for low emittance e- beam
- Flux concentrator, LAS (large aperture S-band) structure, solenoids for e+ beam capture system
- DR (damping ring) for low emittance e+ beam

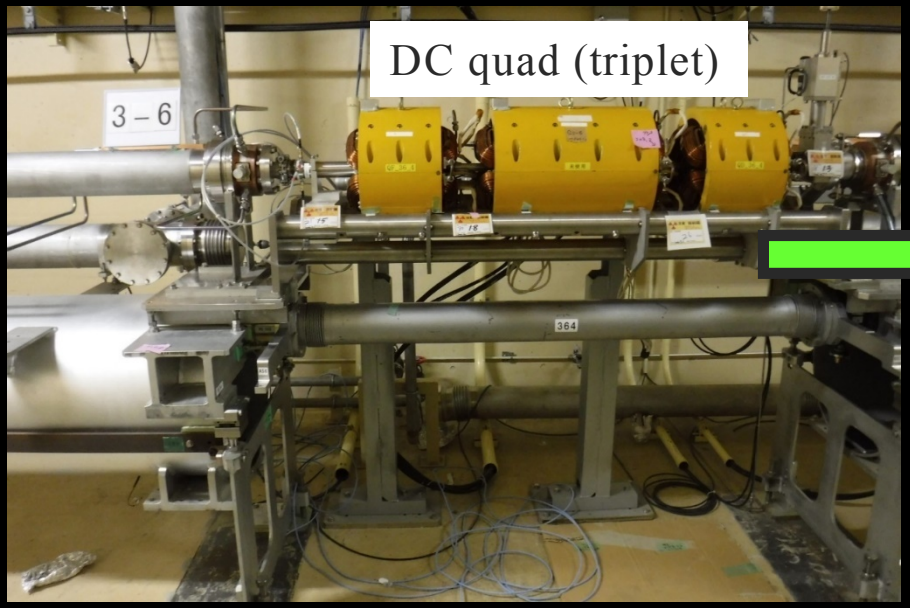
Energy profile for light source and SuperKEKB injection

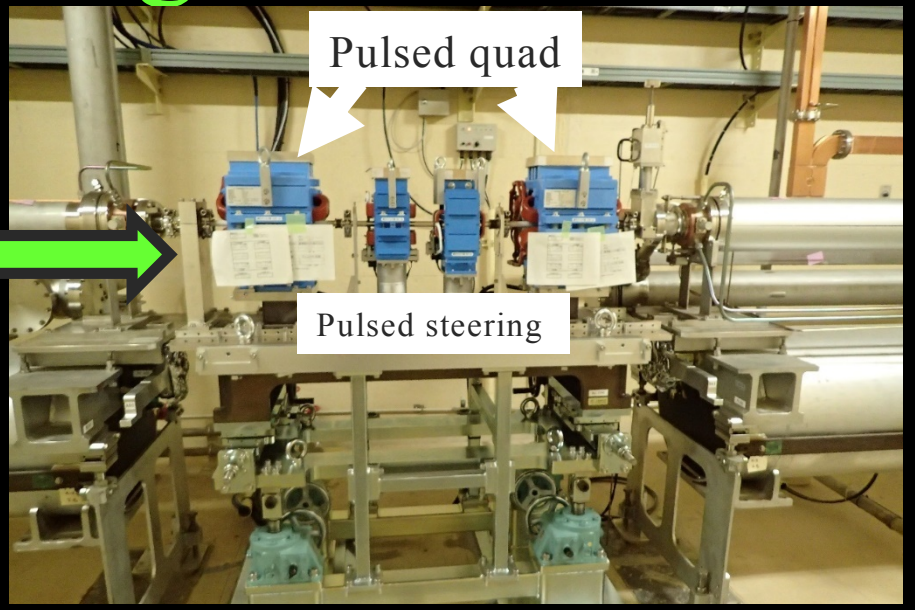


Progress in Phase II

- Monitors
  - High measurement precision readout (< 10 μm) and synchronized measurement for 100 beam position monitors (BPMs)
    - All data is stored together with shot id. Similar framework will be applied to pulsed magnet power supply and rf monitor data for the correlation analysis soon.
  - Wire scanner at SectorB, SectorC, Sector2, Sector3, and Sector5
  - Streak camera at Laser hut/SectorA, SectorC, and Sector3
  - RF phase/amplitude monitors for klystron, SLED, acc. structure
- Timing system for DR injection and extraction system
- Stable operation of pulsed quads and steering magnets
- Simultaneous beam injection via thermionic e- gun
- RF e- gun injection to HER (June 16th -)
- Beam energy stabilization

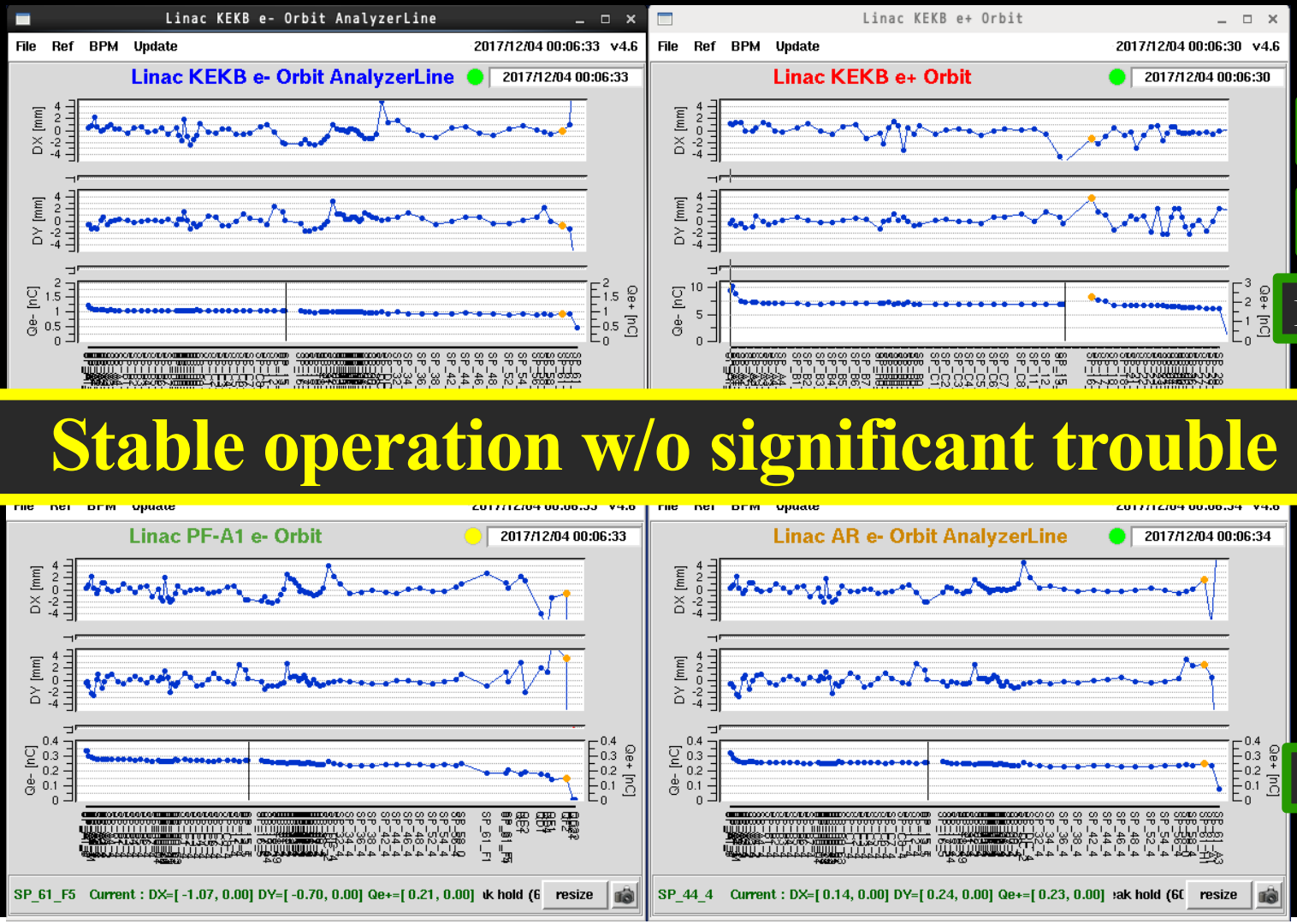
Pulsed magnet





- Pulsed quads (x28) (w/ ceramic duct) and steering magnets (x 36) on new girder (Sep. 2017 -) at Sector3 to Sector5
- Power supply stability ～ 0.01% (24 hours)
- PXI bus based local controller and cRIO
- Remote controllable mover will be ready in this summer.

Simultaneous beam operation w/ thermionic e- source



Hor. orbit

Ver. orbit

Bunch charge

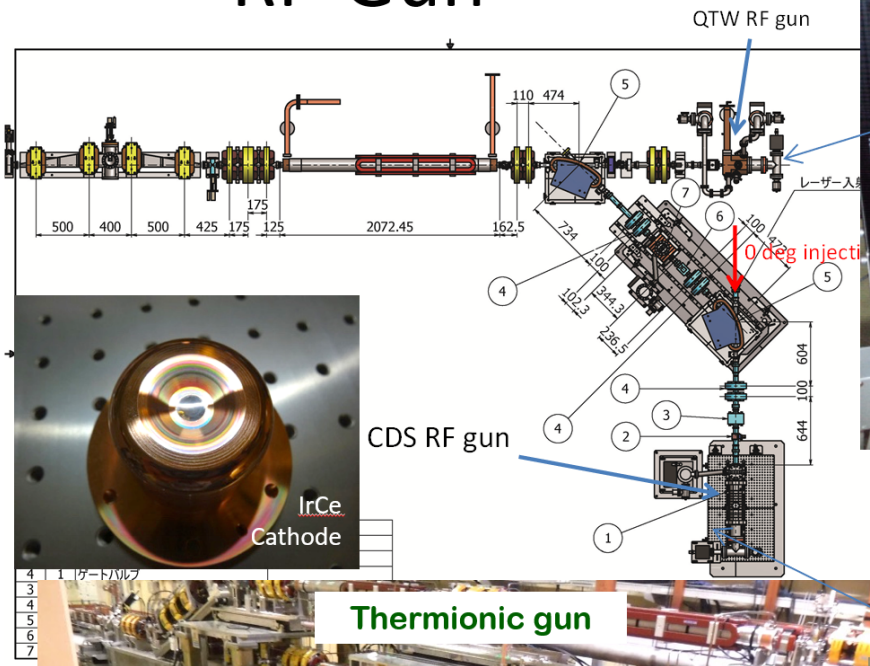
Stable operation w/o significant trouble

Hor. orbit

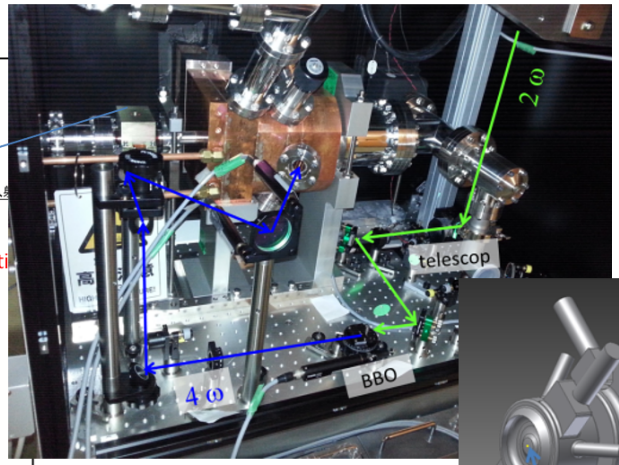
Ver. orbit

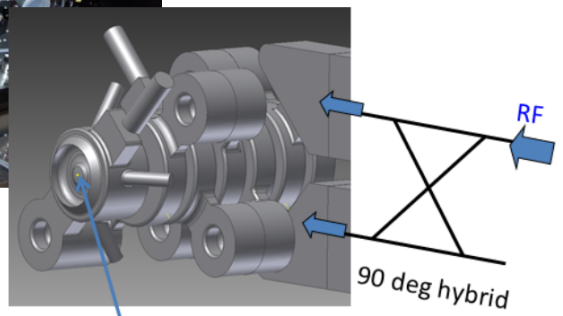
Bunch charge

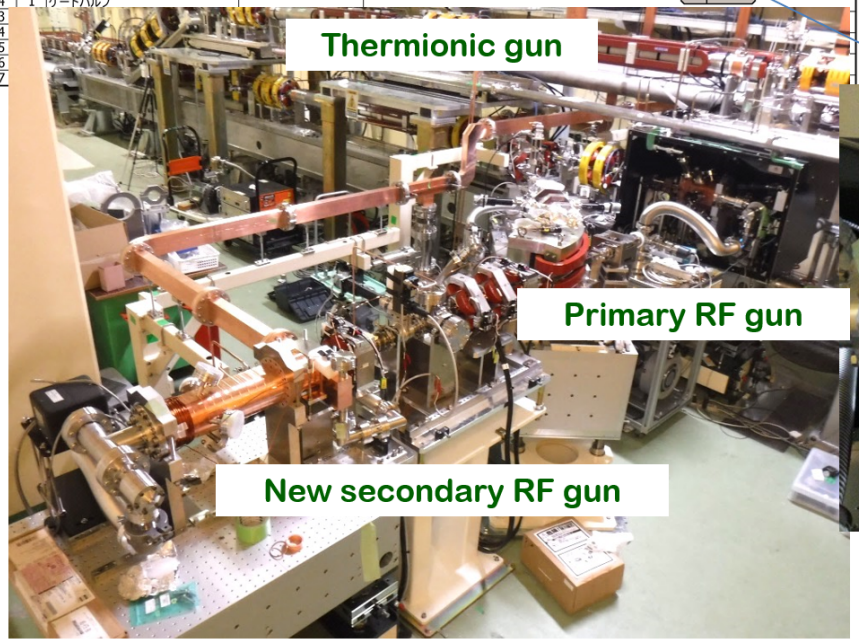
RF-Gun



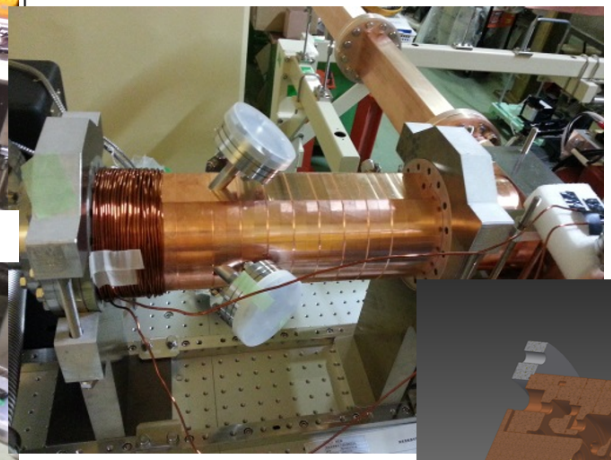
0-deg QTW RF gun

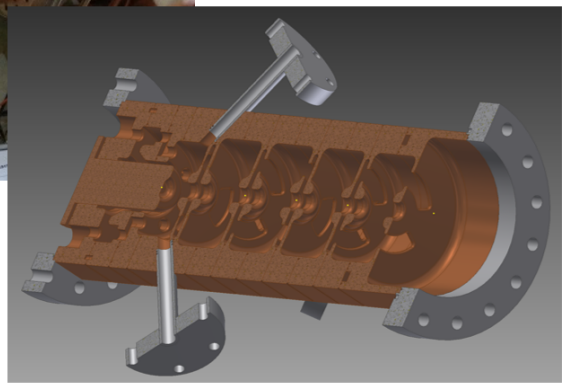




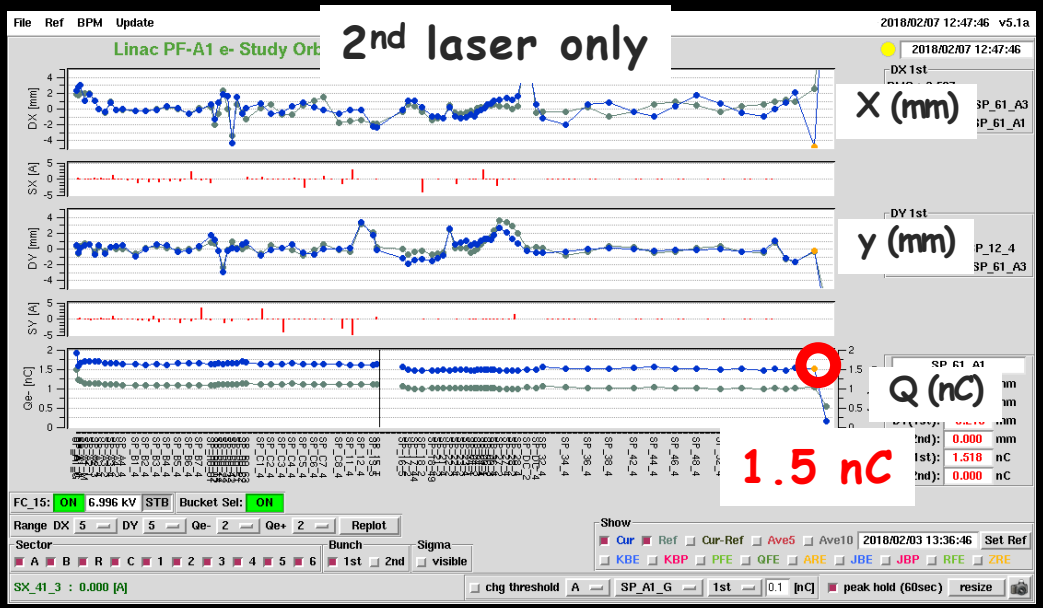


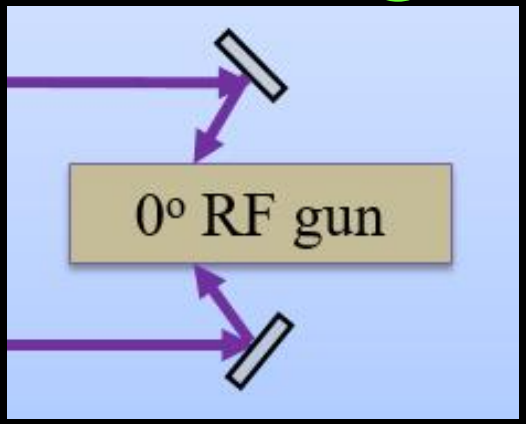
90-deg CDS RF gun



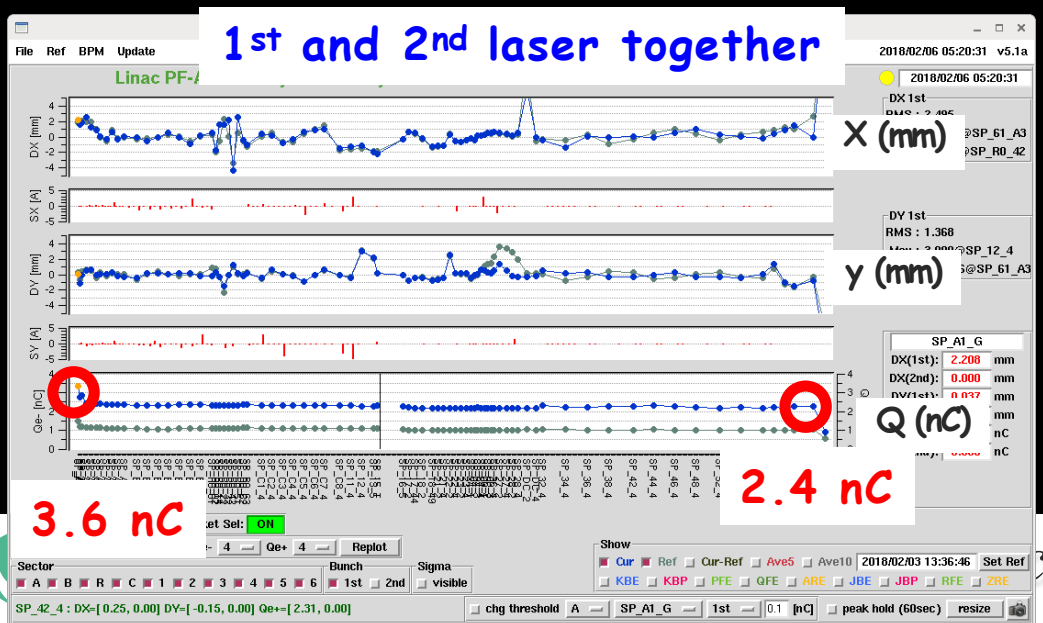


e- beam from photocathode rf gun

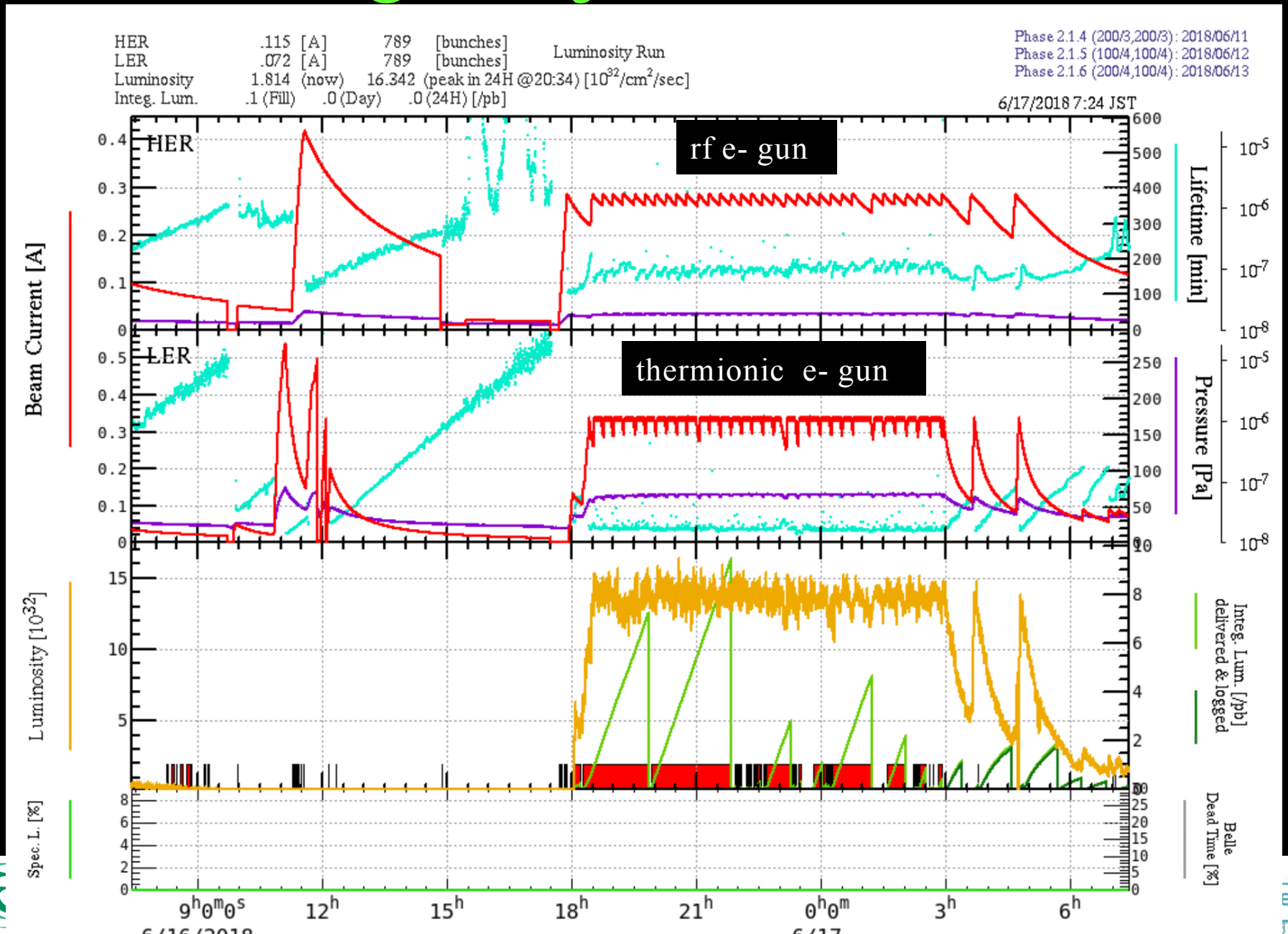




- Redundant Yb:Fiber + Nd:YAG Hybrid Laser System
- Three oscillators
- Bunch charge
  - 3.6 nC @ first BPM
  - 2.4 nC @ Linac end
    (Phase II requirement: 1 nC)



rf e- gun injection to HER



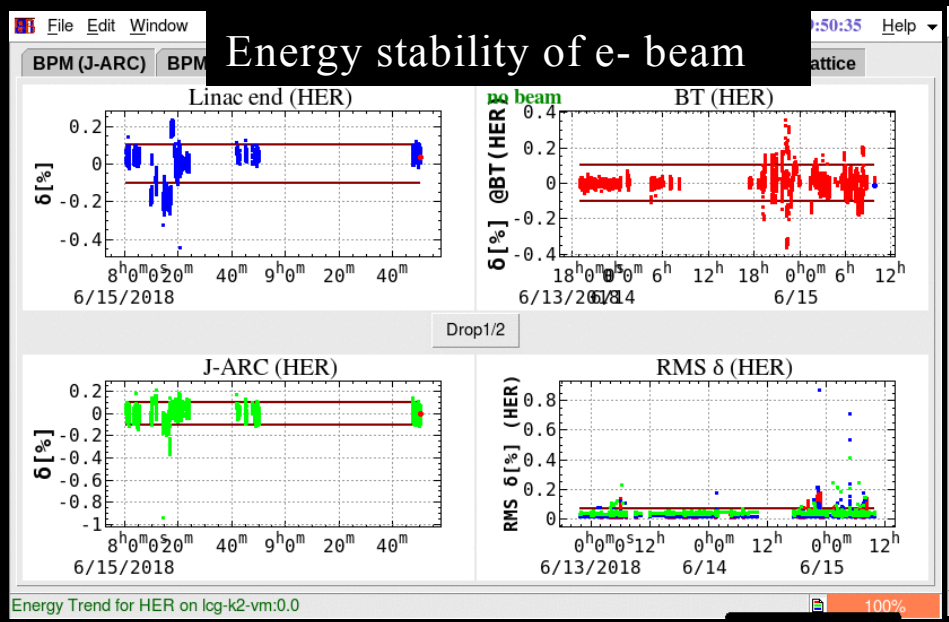
Emittance and bunch charge status

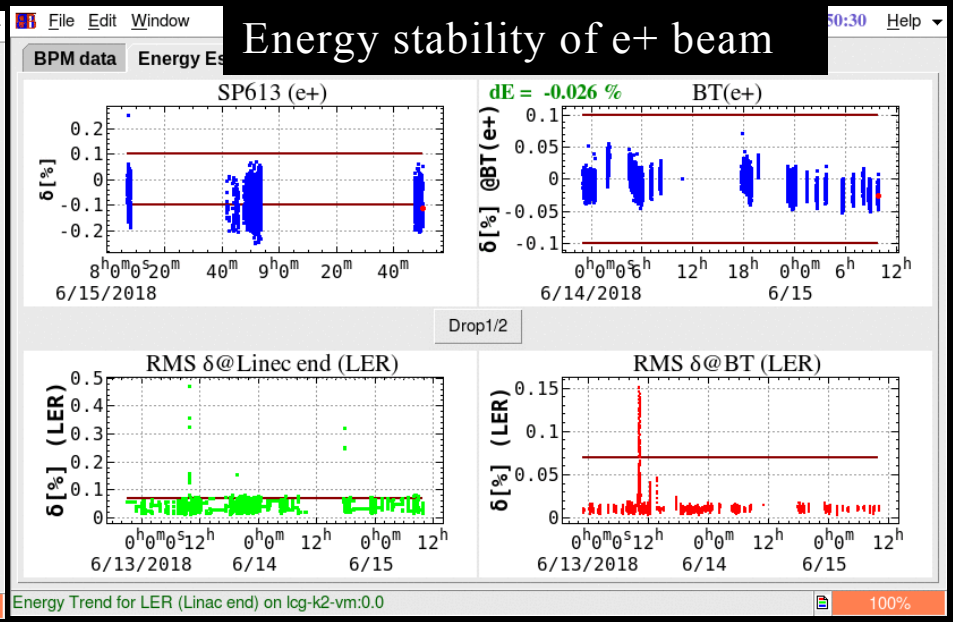
	LER injection e+ beam		HER injection e- beam	
	Goal	Current status	Goal	Current status
Normalized emittance (Hor./Ver.) (mm·mrad)	200/40 (w/ DR)	192 ± 22.4 / 2.01 ± 0.363 @ Sector3 185 ± 28.4 / 1.72 ± 0.704 @ Sector5	150/150	**rf e- gun** 23.411 ± 1.867/18.593 ± 9.372 @ SectorB 25.048 ± 18.128/37.960 ± 9.807 @ SectorC 49.258 ± 61.683/51.167 ± 38.077 @ Sector5 **Thermionic e- gun** e.g.) 250/100 @ Sector5
Bunch charge (nC)	0.5	1.4 (w/ flux concentrator) @ Sector5	1.0	1.0 (thermionic e- gun) @ Sector5 1.0 ~ 3.0 (rf e- gun) @ Sector5

- Phase II parameters are almost achieved.
- Horizontal emittance of e+ beam and e- emittance at BT are large.

Energy feedback,etc

- Energy feedback at J-ARC, Sector2, Sector5 for each beam operation mode (HER, LER, light source injection beam)
- Energy fluctuation at BT: < ± 0.1%
- When klystron down at Linac:
  - Beam gate close => waiting for recovery of klystron (8 s) => beam gate open

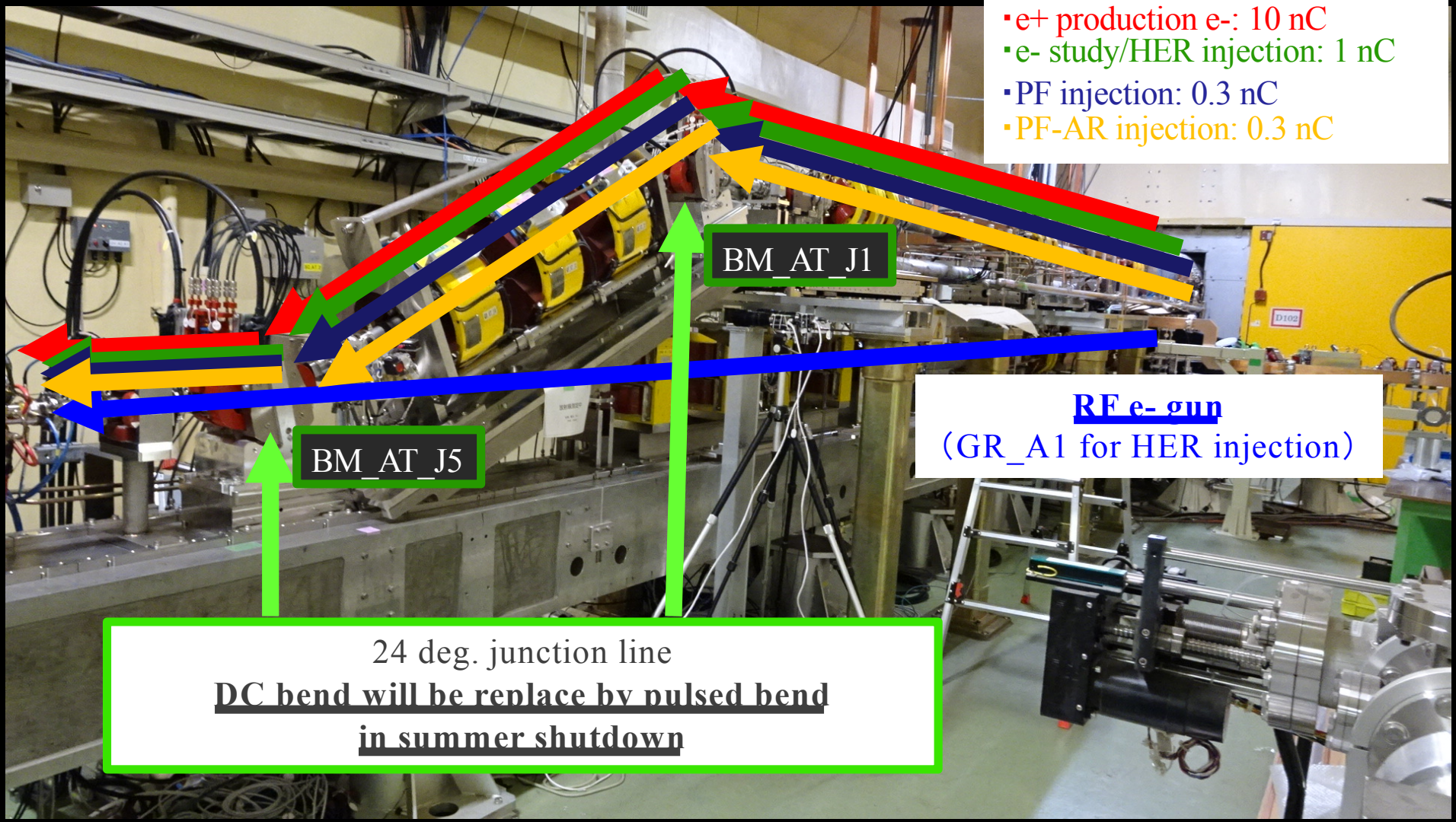




Towards Phase III

- Investigation of
  - e- beam emittance growth at BT.
  - large horizontal emittance of e+ beam
- Large misalignment at Sector2 (~ 2 mm)
  - will be fixed in this summer shutdown
- Simultaneous top up for HER, LER, PF, PF-AR by using rf e- gun and thermionic e- gun
  - Fast switching (50 Hz): rf e- gun and thermionic e- gun
- Beam position jitter issue

Pulse to pulse switching: rf e- gun/thermionic e- gun

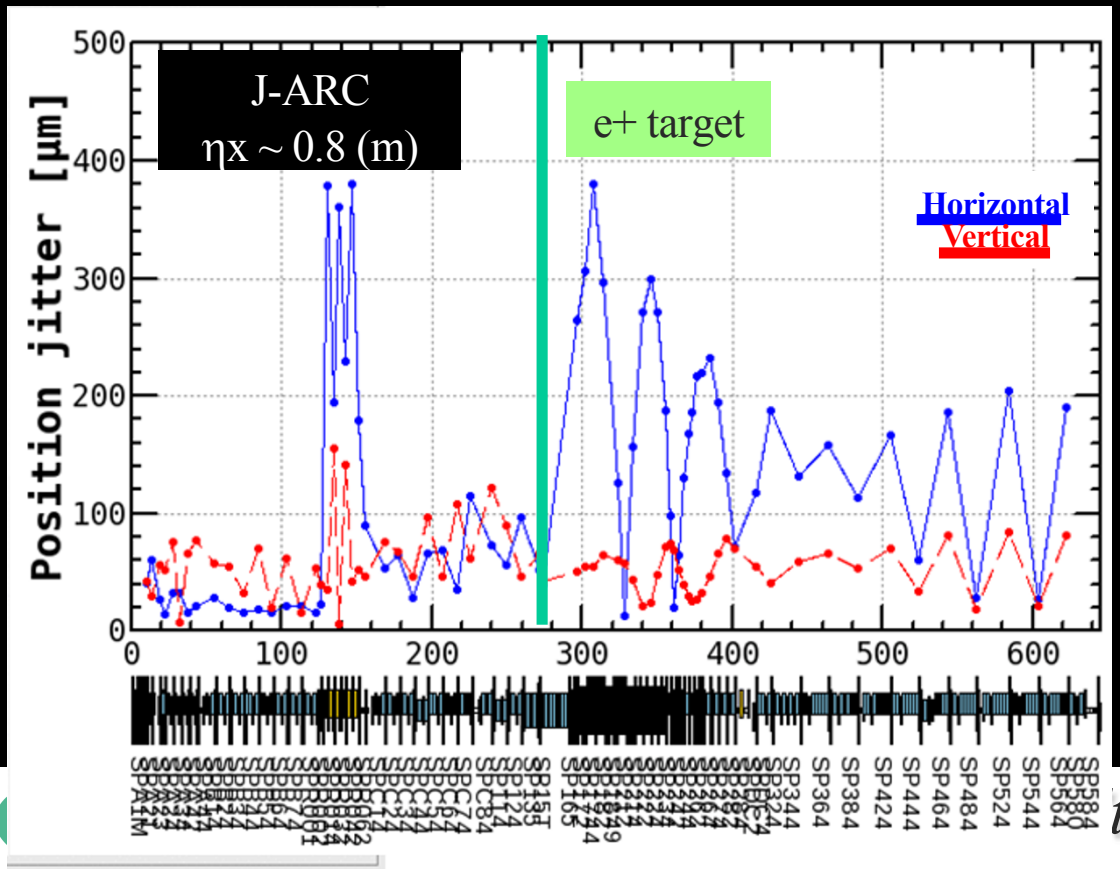


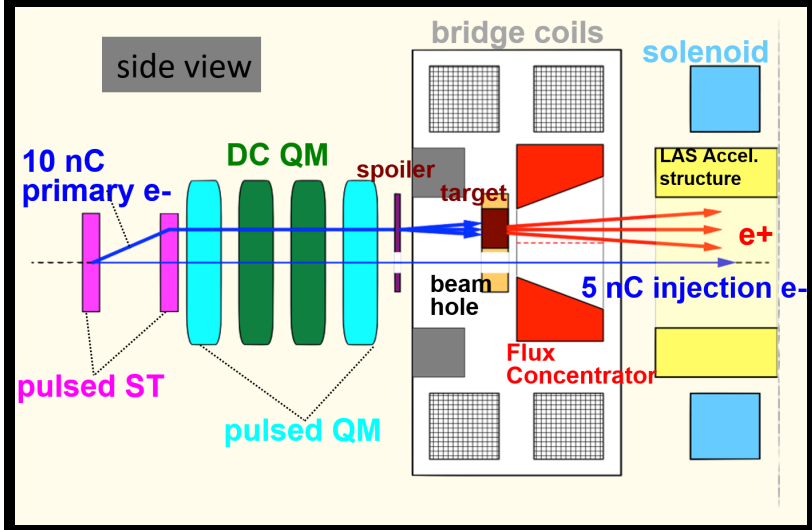
Required injector parameters

Stage	KEKB (final)		Phase-I		Phase-II		SuperKEKB (final)	
Beam	e+	e–	e+	e–	e+	e–	e+	e–
Energy	3.5 GeV	8.0 GeV	4.0 GeV	7.0 GeV	4.0 GeV	7.0 GeV	4.0 GeV	7.0 GeV
Stored current	1.6 A	1.1 A	1 A	1 A	–	–	3.6 A	2.6 A
Life time (min.)	150	200	100	100	–	–	6	6
Bunch charge (nC)	primary e- 10 → 1	1	primary e- 8 → 0.4	1	0.5	1	primary e- 10 → 4	4
Norm. Emittance ($\gamma\beta\varepsilon$) (μrad)	1400	310	1000	130	200/40 (Hor./Ver.)	150	100/15 (Hor./Ver.)	40/20 (Hor./Ver.)
Energy spread	0.125%	0.125 %	0.5%	0.5%	0.16%	0.1%	0.16%	0.07%
Bunch / Pulse	2	2	2	2	2	2	2	2
Repetition rate	50 Hz		25 Hz		25 Hz		50 Hz	
Simultaneous top-up injection	3 rings (LER, HER, PF)		No top-up		Eventually		4+1 rings (LER, HER, DR, PF, PF-AR)	

Beam position jitter issue

- e+ target w/ small beam hole for e- beam (ϕ2 mm)
- Small beam hole could cause the beam position jitter.
- Machine study plan:
  - Remove e+ target in this summer shut down and install test dummy target w/ small hole of various diameter.
  - e+ target will be back in winter shutdown for Phase III





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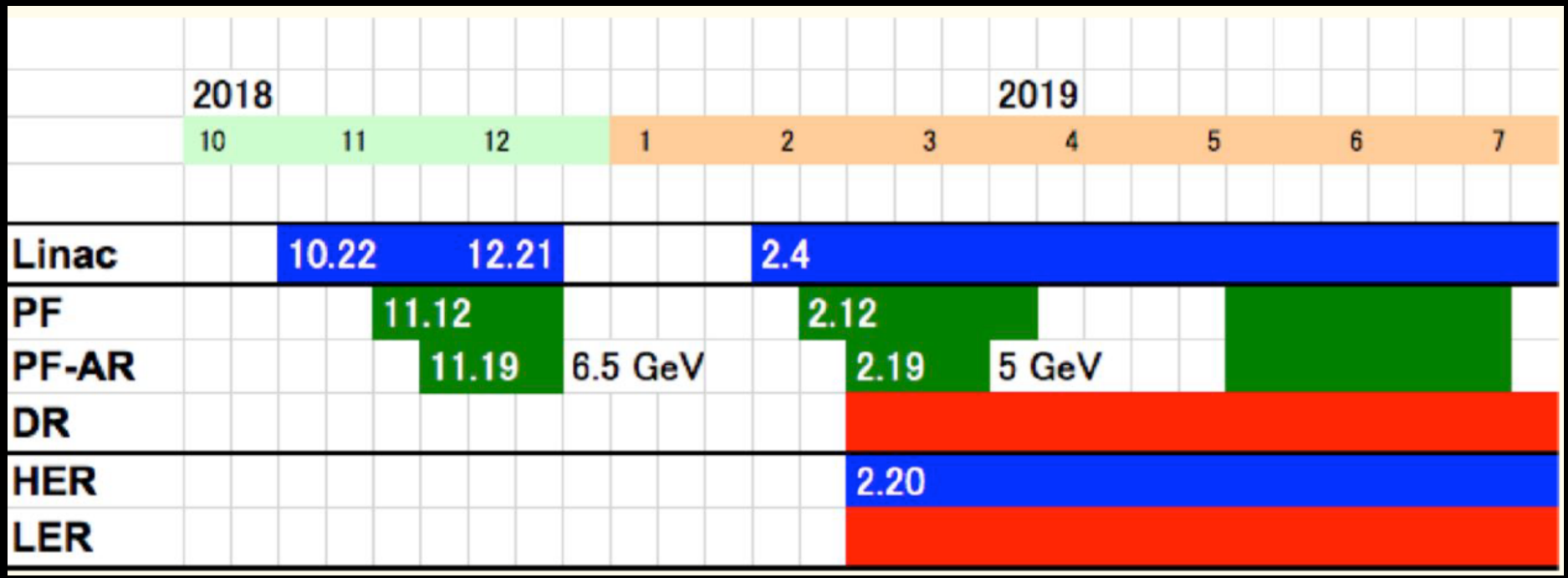
Schedule: Oct. 2018 -



- Pulsed bend (thermionic/rf gun merger line), some pulsed quads and steering installation in this summer shutdown
- Flux concentrator reinstallation during winter shutdown
- 50 Hz operation (will be tested in Dec. ‘18)

Summary

- Success of simultaneous injection to PF, PF-AR, HER, and LER from thermionic e- gun.
- Timing system for DR, pulsed quads and steering magnets work well.
- Success of HER injection via rf e- gun
- Required parameters for Phase II are almost achieved. e- emittance at BT and horizontal emittance of e+ after DR should be improved.
- Towards Phase III
  - Simultaneous top up injection with thermionic/RF e- gun
    - Pulsed bends and quads installation (in this summer shutdown)
  - High bunch charge and low emittance preservation
    - Beam line alignment (in this summer shutdown)
    - Beam jitter study w/o e+ target (in Oct. – Dec., 2018)
    - Beam orbit control study (in Oct. – Dec., 2018)