



Injector linac status

Kazuro Furukawa

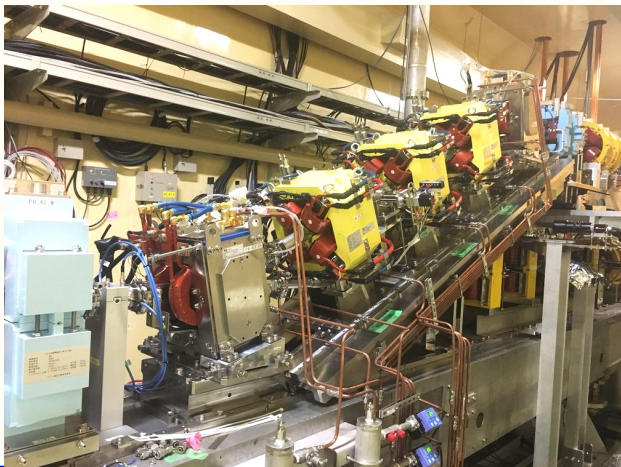
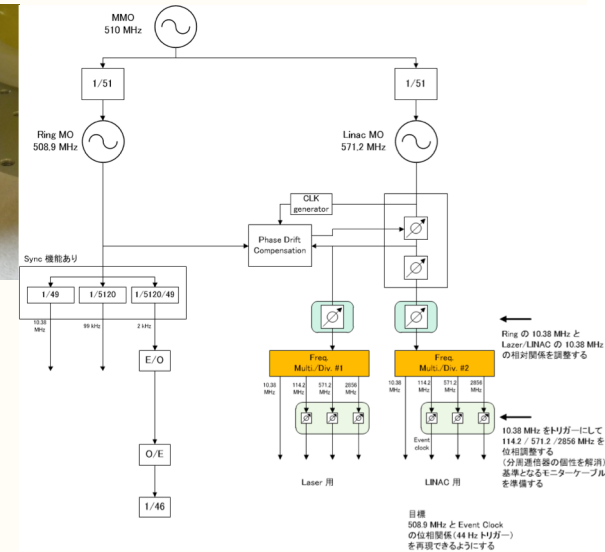
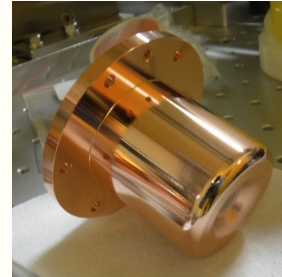
for Injector Linac Groups

<<http://www-linac.kek.jp/linac-paper/general/>>

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Improvements during summer shutdown

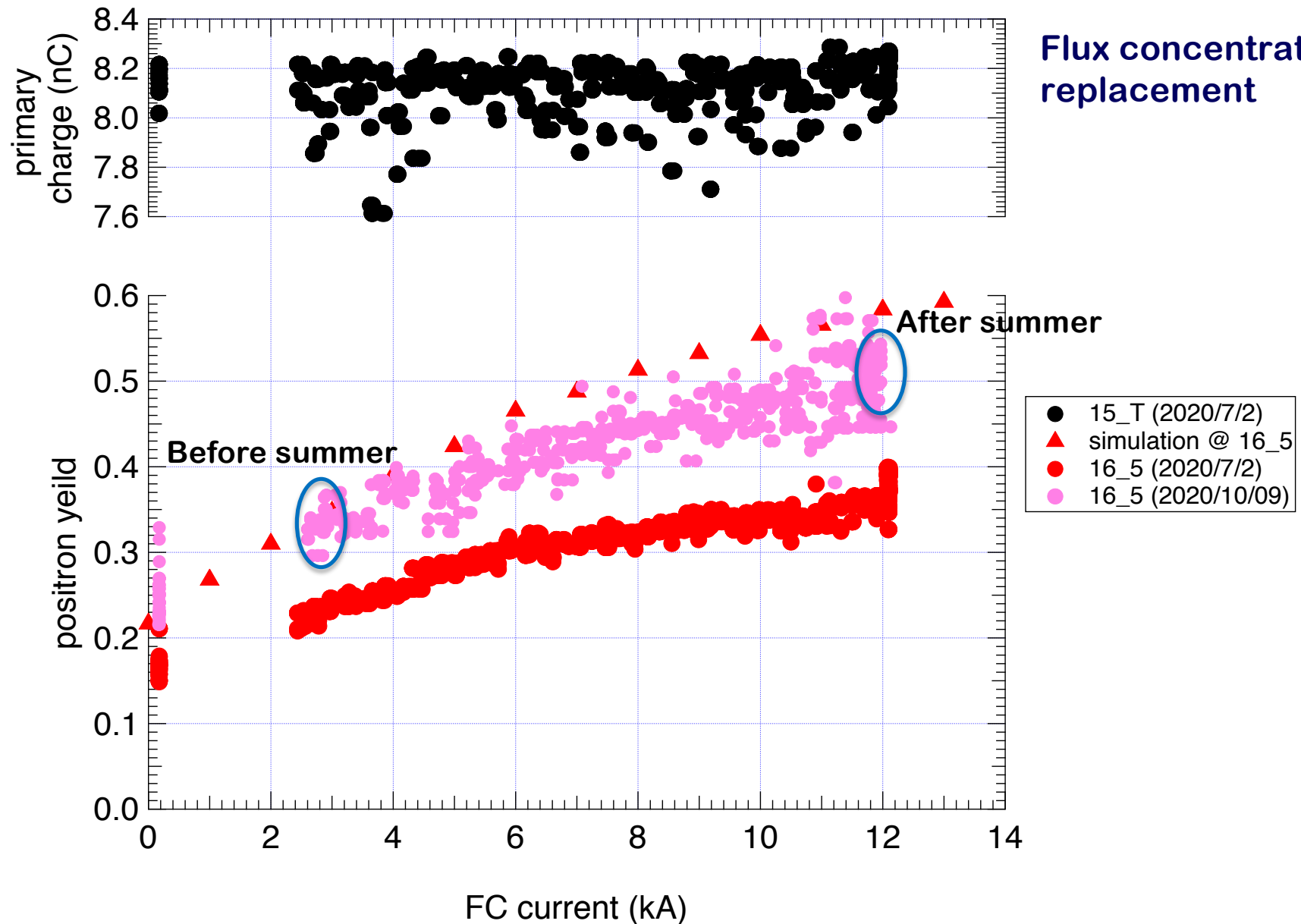
- ◆ Installation of diffractive optical element (DOE, laser profile shaping), laser position stabilization feedback, cathode, etc. for true 50 Hz, cleaning and stabilization
- ◆ Improvement to master oscillator with more detectors and phase shifters
- ◆ Upgrade the merger beamline of two guns with 2 pulsed bends, 3 quads, 2 bpms and a chamber for true 50 Hz
- ◆ Installation of 4 steering magnets and 4 bpms inside of positron capturing section
- ◆ Replacement of flux-concentrator and nominal operational field (12 kA)
- ◆ And many other improvements



Injector linac status

Positron yield

Y. Enomoto

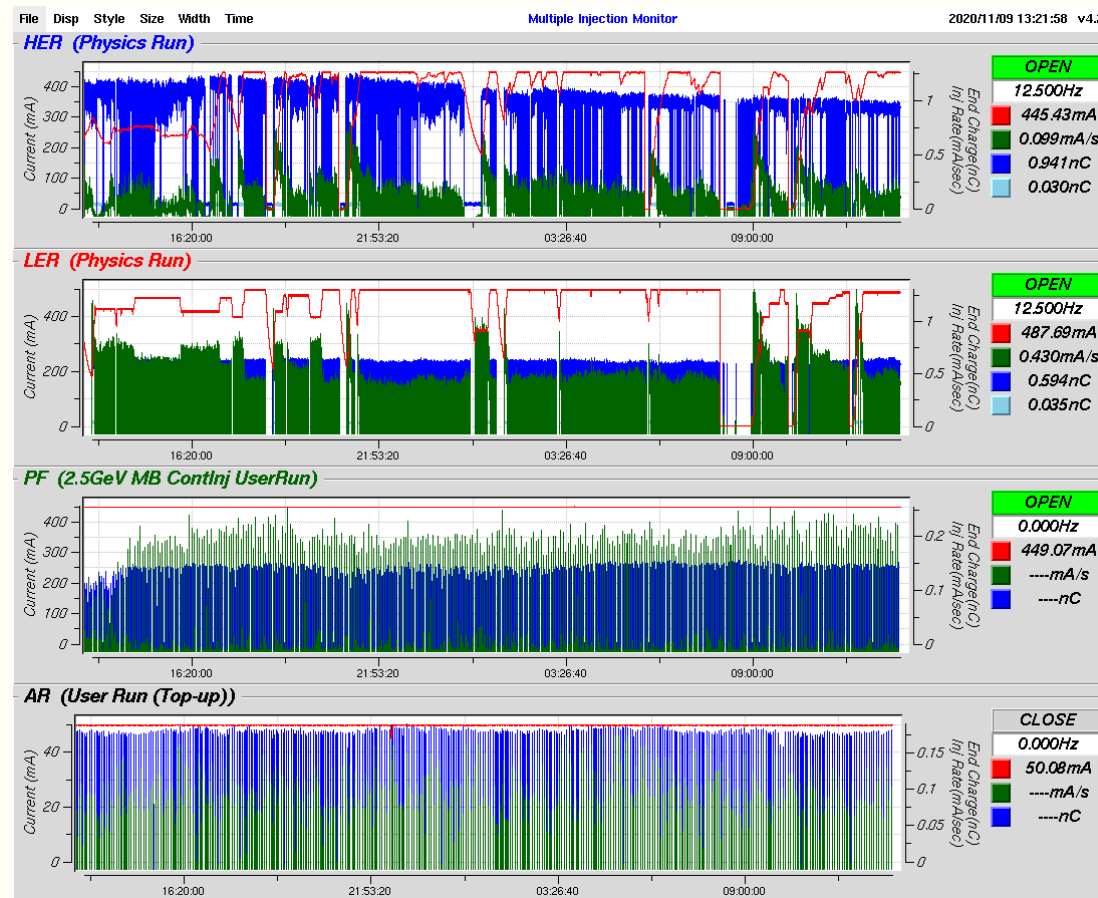




Improvements during summer shutdown

- ◆ Replacement of thermionic gun cathode
- ◆ Replacement of RF gun cathode (Ir7Ce2), removing heating system
- ◆ Installation of diffractive optical element (DOE, laser profile shaping), Laser position stabilization feedback
- ◆ Upgrade of event timing controls for continuous laser cleaning
- ◆ Preparation for secondary RF gun
- ◆ Replacement of high power klystron (KL_B4)
- ◆ Replacement of klystron solenoid power supply (2)
- ◆ Replacement of thyatron (KL_A1_B, A2, 15, 16, 17, DS, DN)
- ◆ Installation of noise elimination measure (all 60 units)
- ◆ Replacement of inverter power supply (KL_17, DS)
- ◆ Improvement to master oscillator with more detectors and phase shifters
- ◆ Replacement of driver klystron with solid-state amplifier (SB_B)
- ◆ Installation of independent amplifier (KL_C8)
- ◆ Pulse-to-pulse amplitude controls at SHB
- ◆ Replacement of flux-concentrator and nominal operational field (12 kA)
- ◆ Installation of 4 pulsed steering magnets and 4 bpms inside of positron capturing section
- ◆ Replacement of charging circuit for all pulsed magnet power supplies
- ◆ Replacement of old cables for high power magnet power supplies
- ◆ Upgrade merger beamline after two guns with 2 pulsed bends, 3 quads, 2 bpms and a new chamber

Injector linac operation



◆ HER

◆ LER

◆ PF ring

◆ PF-AR

- ◆ Injector linac could not allocate machine study time this season up to last week, that was devoted to bt beam study and radiation safety.
- ◆ Injector linac had limited chance to tune injector beams as we shared startup time for light sources, who cancelled most of beam time before summer.
- ◆ This week, several study items are being performed.



Investigations and improvements in this week

◆ Discrete vertical orbit

- ✧ Discrete orbits observed with light-source injections, that didn't affect the injection much (?)
- ✧ Caused by the combination of magnetic aftereffect and hysteresis of the new pulsed bending magnet to merge two guns, and by the beam pattern (found on Nov.18)
- ✧ Would tune the beam pattern in this season
 - ✧ Further tuning measures during winter shutdown

◆ 7-minute orbit variation

- ✧ Orbit and charge variation even with laser stabilization, that annoyed the injection tuning.
- ✧ Caused by one of the chillers for a optical table (found on Nov.19)
- ✧ Would stop it for the moment, while laser position stabilization should cover this
 - ✧ Further investigation in this week

◆ Emittance break-up at the latter part of the beam transport

- ✧ Emittance blow-up several times while the beam goes through BT
- ✧ Precise tuning of the beam with new beam monitors like OTR beam profile, etc
- ✧ Trying to understand step by step from beam experiments and simulations

◆ Many other items like dispersion corrections, device calibrations, backup device preparation, operation software improvements, etc.

Examples at the end of linac

Y. Seimiya

Before Summer

After Summer

After summer

* 7-minute instability

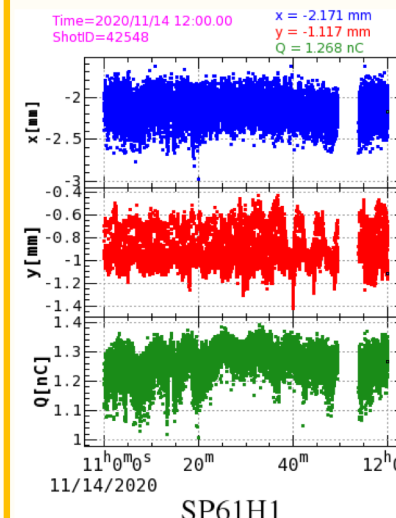
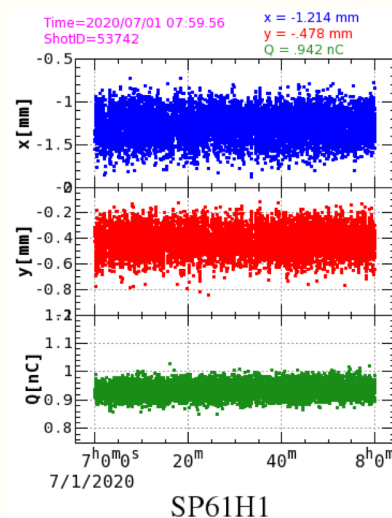
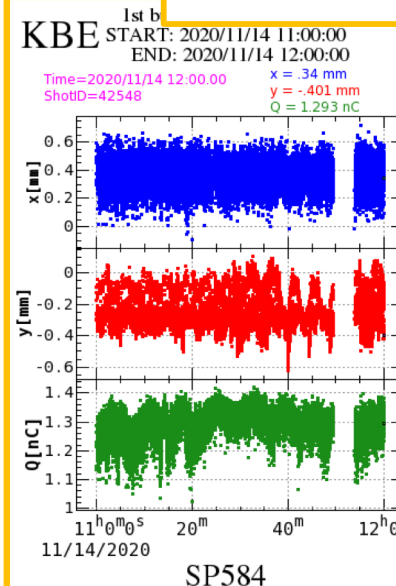
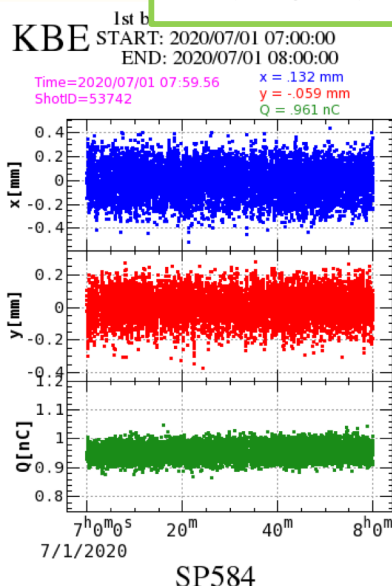
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Chiller for a table

* Discrete vertical orbit

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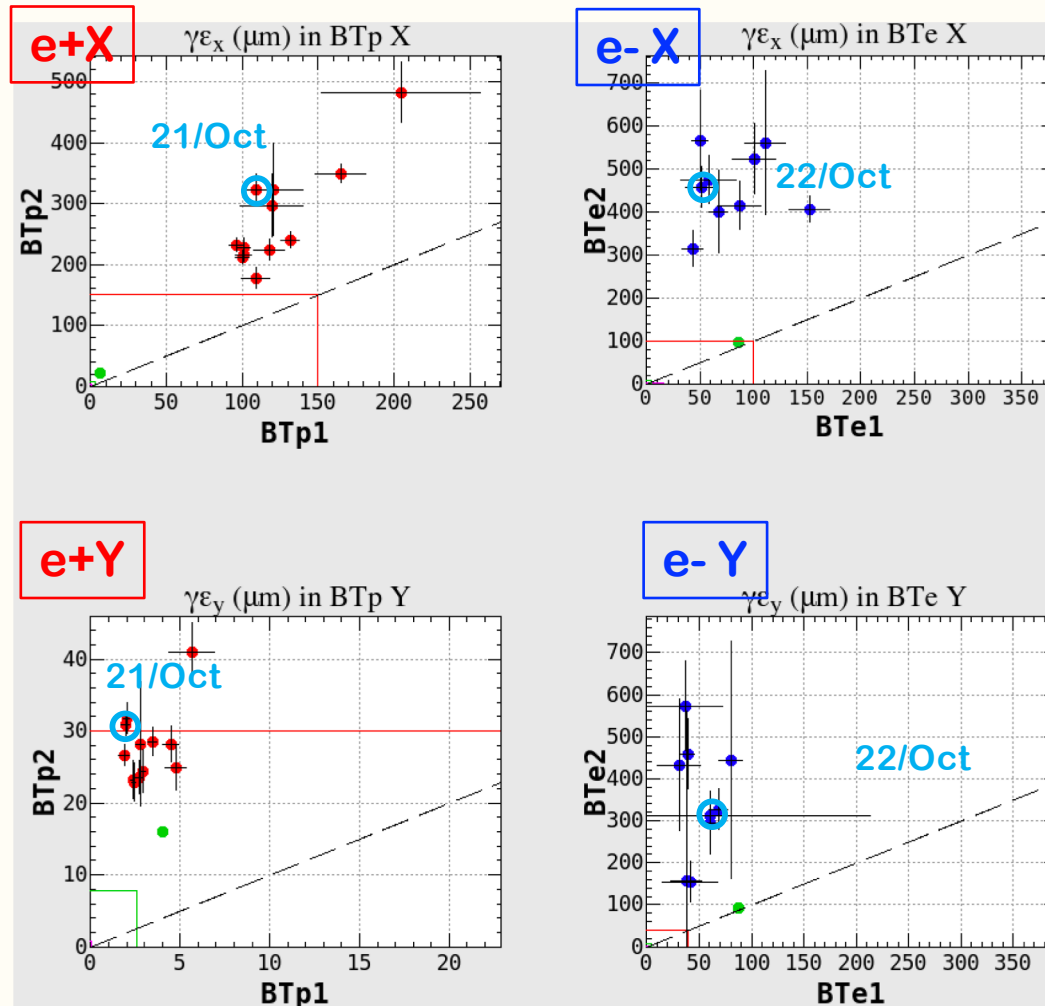
New pulsed bend





Emittance break-up in BT

N. Iida



- Measured by WS
- Emittance due to Jitter
- Emittance due to BPM res.
- Emittance due to σ_δ (invisibly small)

- Same emittance line of BT2 as BT1
- Required emittance from LER/HER

- The horizontal orbit jitter in the e+ is negligibly small.
- The other jitter emittances at BT1 is comparable as measured emittance.
- **But in BT2, all measured emittances are larger than the jitter emittances.**



	早朝	日中 LINAC mode	準夜 BT dump mode
11/18 (水)		2値化問題(パターンを変える。)(夏井)	~18:00 OTR, BT2 QuadScreen
11/19 (木)	QuadBPM(BTp) OctoPos(SY3)e- data taking	7分変動の調査(吉田) KBP DS Study(三浦)	~できるまで BT Study
11/20 (金)	KBP DC4 response 8:00~9:00e-放射線測定 25Hz Jarc dispersion(吉田)	Jarc dispersion(清宮) 3-5 sector 軌道FB(清宮)	~できるまで BT Study
11/21 (土)	TBD	KBE beam Cleaning	~18:00 Conditioning KBP DS Study(三浦) 1H MOFB Offの影響を見る
11/22 (日)	KBE beam Conditioning	KBE beam Conditioning	KBE beam Conditioning
11/23 (月)	KBE beam 1 st laser	KBE beam 1 st +2 nd laser	KBE beam
11/24 (火)	KBE beam	HER injection LER injection	

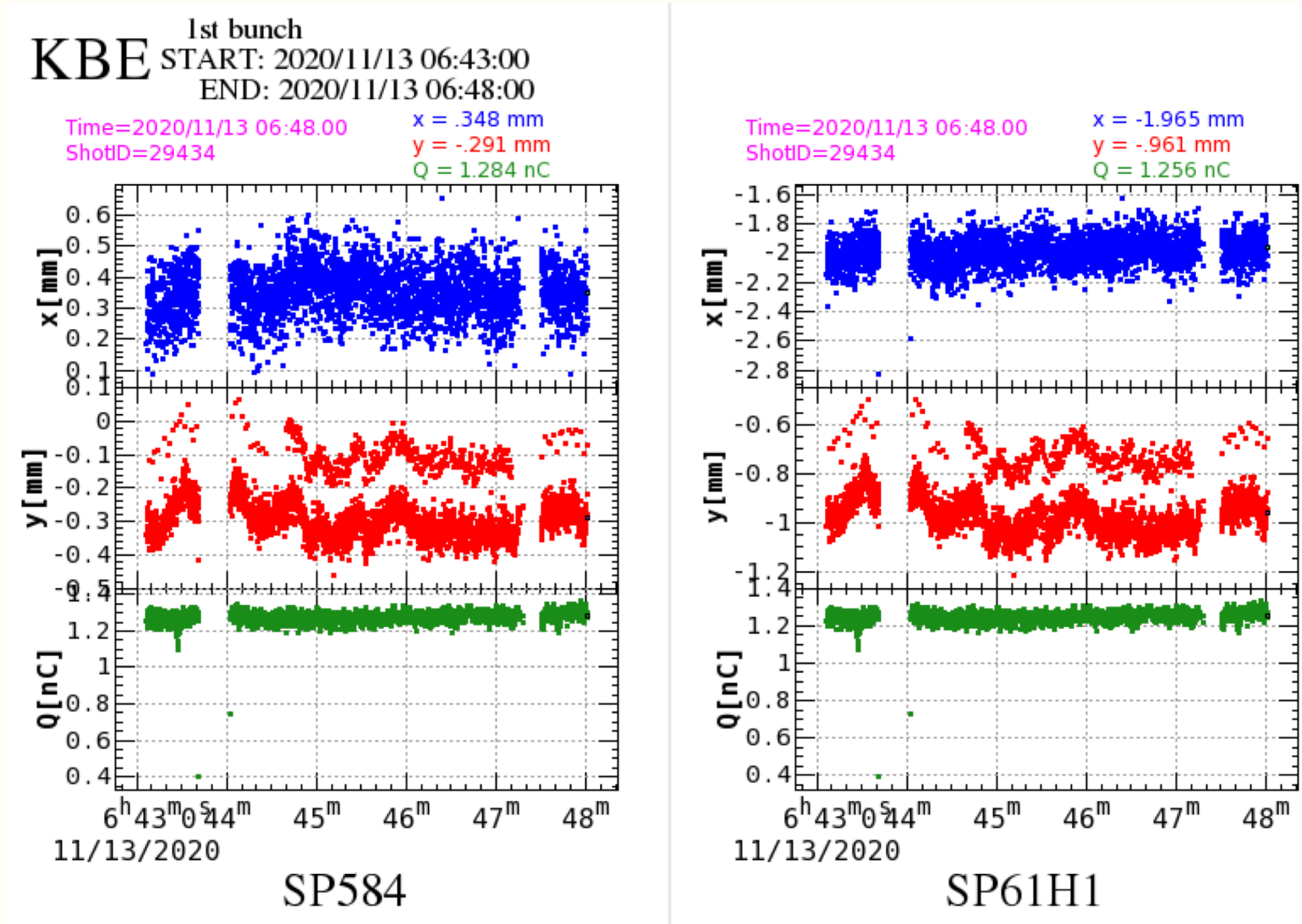


- ◆ Many improvements during summer shutdown and additional items in this week
- ◆ Injection stabilization is still one of the major challenges for now
- ◆ Further stabilization expected with existent hardware to help investigation at the beam transport line
- ◆ Then, pursue several more steps to final designed beams

Thank you



e- beam V-orbit binarization at LINAC end





Higher energy injection and collision

◆ Mitigation of accelerator structure failures

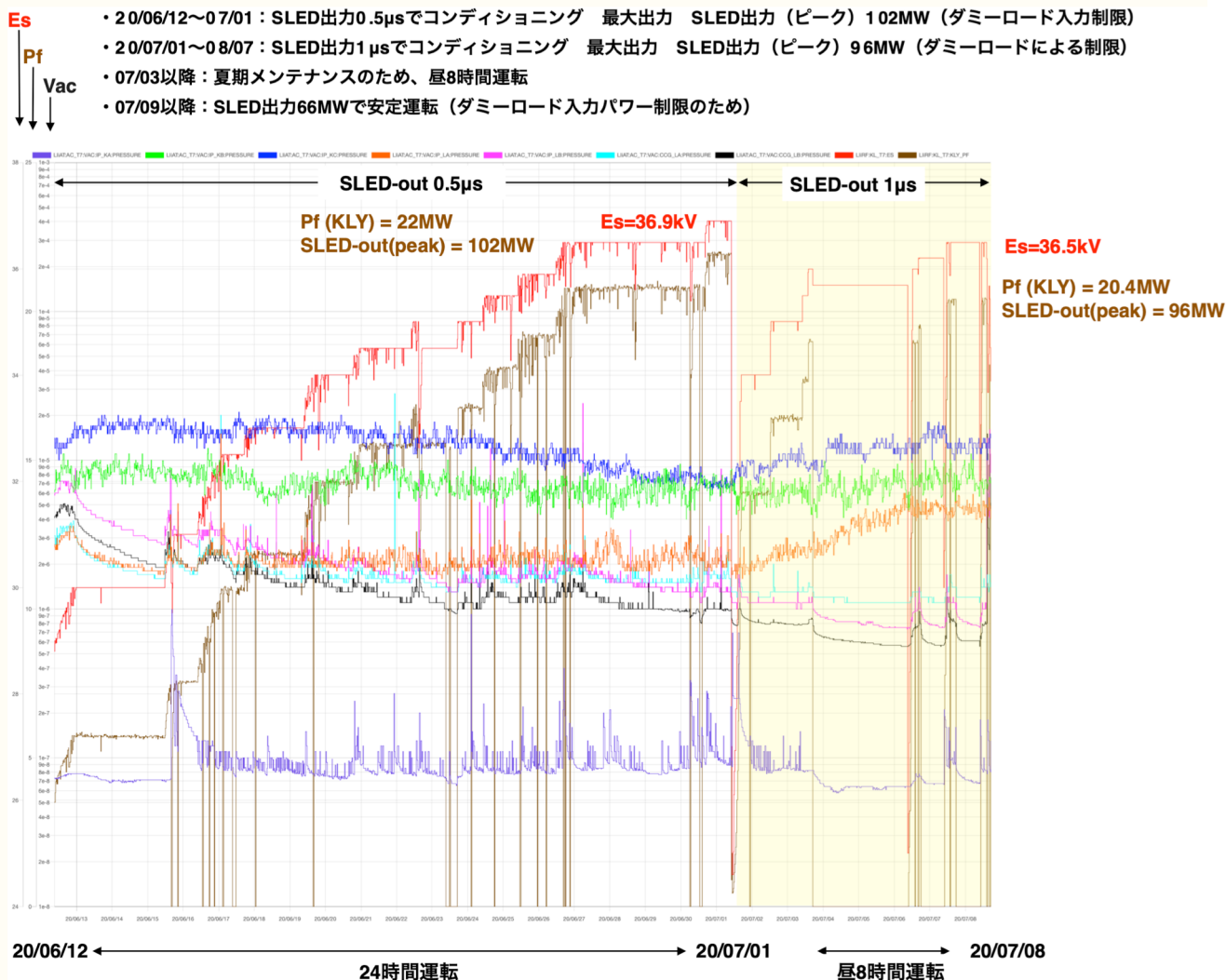
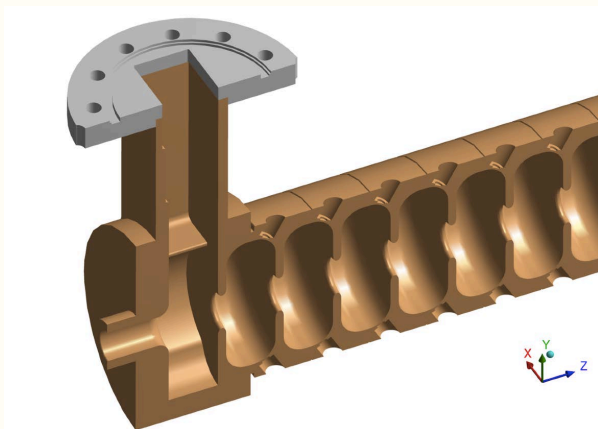
- ❖ Originally designed for 8 MeV/m, but used at 20 MeV/m
- ❖ Degradation that lead to high field emission rate and discharges
- ❖ Water leaks
- ❖ Not only Y(6S) but even Y(4S) could be suffered

◆ 4-year plan to fabricate and install new accelerator structures

FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
New S-band structure				
Completed ! R & D	Completed ! Fabrication of four structures	High-power test & installation		
		Material procurement for 12 structures	Fabrication of 12 structures	
			Conditioning	Installation
RF source addition				
			Device procurement	Installation
Pulse compressor				
		R & D	Fabrication	Installation
		prototype high-power test		

New accelerator structures

- ◆ First batch acceptance of structures (4)
- ◆ Now being high-power-conditioned
- ◆ It exceeded our expectations





Energy

◆ Recent effort to optimize parameters

❖ 10.753 + 0.023/2 GeV could be possible with backups

✧ e+ : 4.071 GeV, e- : 7.124 GeV

✧ with 2 nC/bunch

◆ After structure upgrade in 2023 winter

❖ 6S : 11.020 GeV could be reached with backups

✧ e+ : 4.165 GeV, e- : 7.289 GeV

✧ with 2-3 nC/bunch

◆ BT limit

✧ e+ : 4.290 GeV, e- : 8.465 GeV (both coil heating limit)

◆ MR

❖ No discussion yet, while included in the design

❖ Easier with Belle II solenoid scaled

❖ Otherwise, ...



Linac Beam Parameters for KEKB/SuperKEKB

Stage	KEKB (final)		Phase-I (achieved)		Phase-II (achieved)		Phase-III (interim)		Phase-III (final)	
Beam	e+	e-	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	4.0 GeV	7.0 GeV
Stored current	1.6 A	1.1 A	1.0 A	1.0 A	-	-	1.8 A	1.3 A	3.6 A	2.6 A
Life time (min.)	150	200	100	100	-	-	-	-	6	6
	primary e- 10		primary e- 8						primary e- 10	
Bunch charge (nC)	→1	1	→0.4	1	0.5	1	2	2	→4	4
Norm. Emittance	1400	310	1000	130	200/40	150	150/30	100/40	<u>100/15</u>	<u>40/20</u>
($\gamma\beta\epsilon$) (mrad)					(Hor./Ver.)		(Hor./Ver.)	(Hor./Ver.)	(Hor./Ver.)	(Hor./Ver.)
Energy spread	0.13%	0.13%	0.50%	0.50%	0.16%	0.10%	0.16%	0.10%	<u>0.16%</u>	<u>0.07%</u>
Bunch / Pulse	2	2	2	2	2	2	2	2	2	2
Repetition rate	50 Hz		25 Hz		25 Hz		50 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)	

◆ Final parameters will be updated



24th KEKB accelerator review

✧ Remotely on July 15th and 20th

◆ General recommendations on injector

❖ Pursue **aggressive linac/injector improvements** ...

◆ Injector recommendations

❖ Improvements in

✧ Positron capturing section, positron yield

✧ Photocathode for RF gun, electron bunch charge

✧ BT2 for obstacles, beam instrumentations, beam optics

❖ Mostly in line with planned improvements during summer



MEXT roadmap and injector

◆ MEXT Roadmap 2020

✧ HER 2.6 A x LER 3.6 A (original plan before 2020)

- ◆ 4 nC/bunch, 2 bunch/pulse, 50 Hz, 50% efficiency
could have supported 6 minute lifetime in HER/LER

❖➔ HER 2.0 A x LER 2.8 A

- ✧ The same condition supports lifetime down to 240 seconds
- ✧ although beam quality has to be maintained