Operation status and upgrade plan of the KEK-LINAC

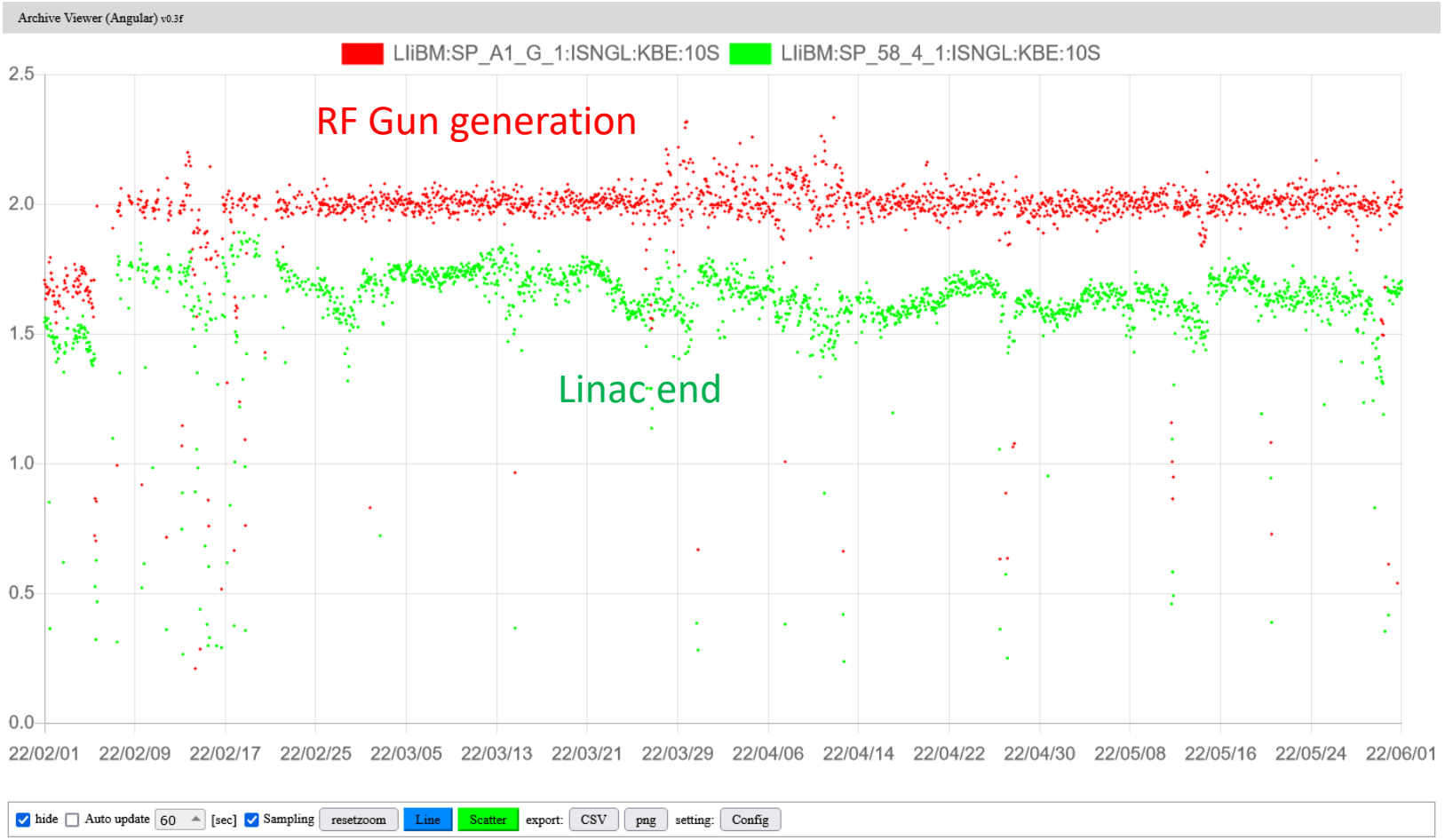
Takuya Natsui

Beam status

	2022ab		Final goal	
Beam	e+	e-	e+	e-
Energy	4.0 GeV	7.0 GeV	4.0 GeV	7.0 GeV
Bunch charge 1st , 2nd [nC]	3.5 , 3.0	1.8 , 1.5	4.0, 4.0	4.0, 4.0
Normalized emmittance [mm-mrad]	120, 5 (Hor. , Ver.)	40-20, 40-20 (Hor. , Ver.)	100, 15 (Hor. , Ver.)	40, 20 (Hor. , Ver.)
Simultaneous top-up injection	4+1 rings (LER, HER, DR, PF, PF-AR)		4+1 rings (LER, HER, DR, PF, PF-AR)	

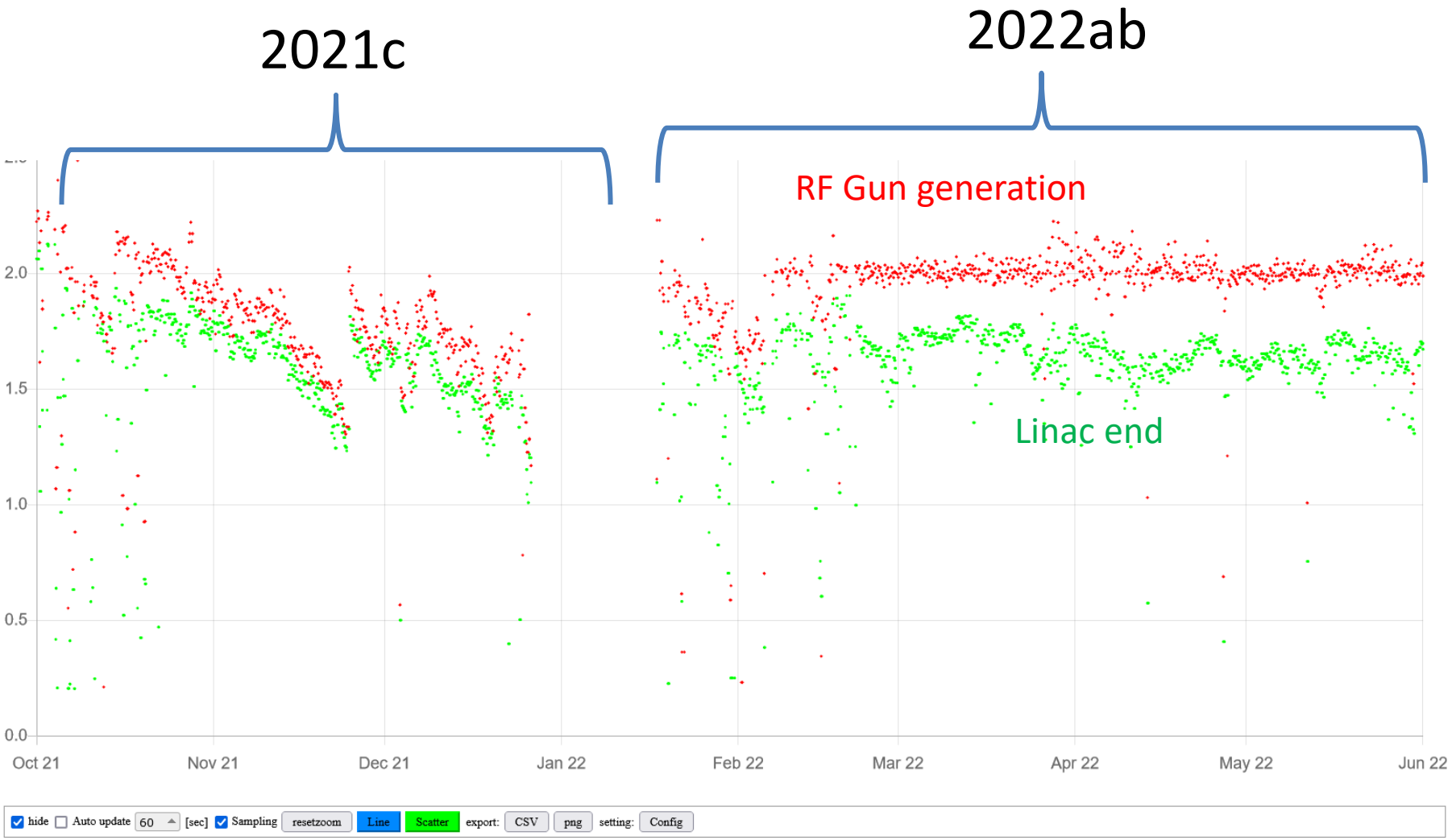
Electron beam charge history of 2022ab

Four months history



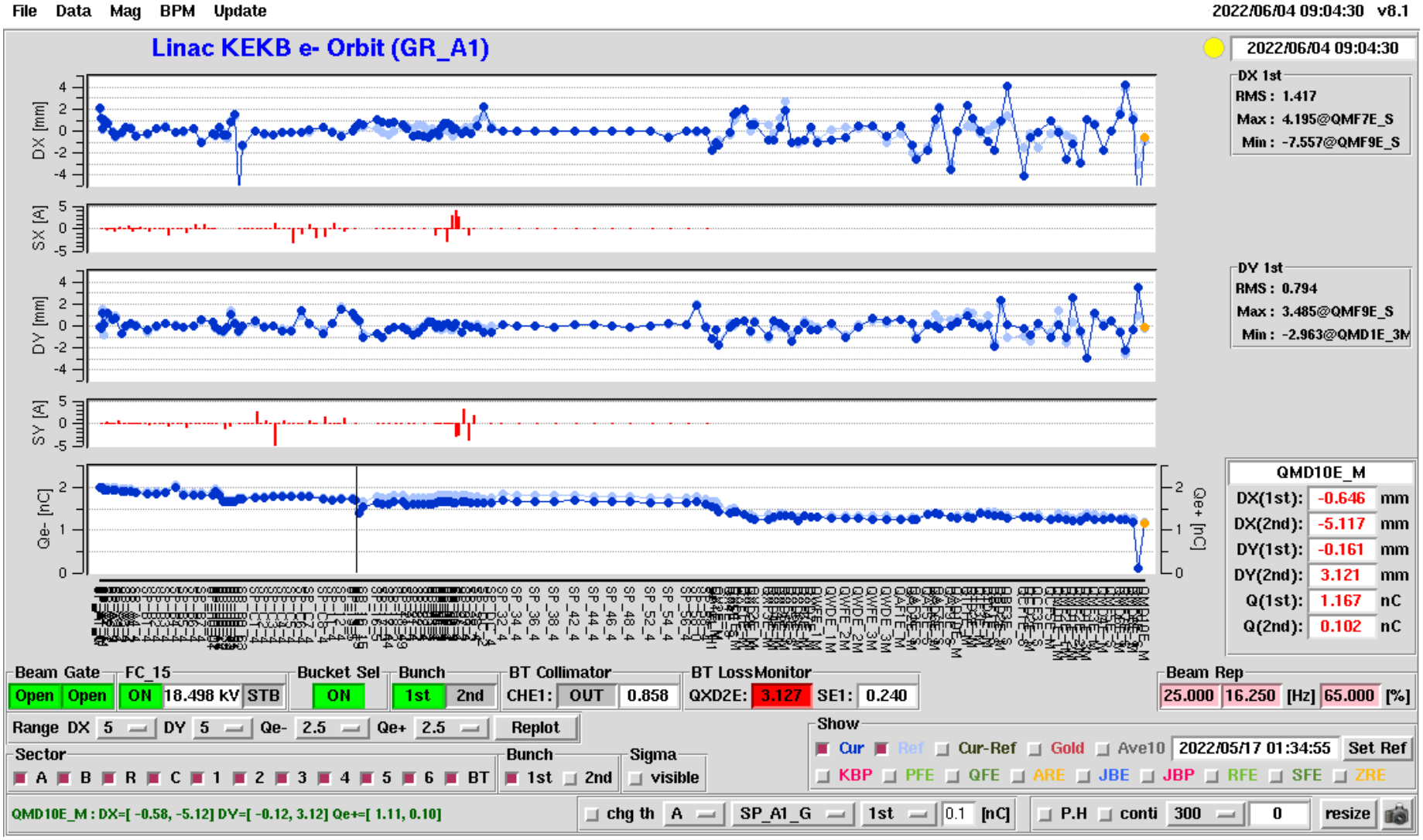
Stable beam charge due to charge feedback using laser power adjustment

Charge stabilization of KBE beam

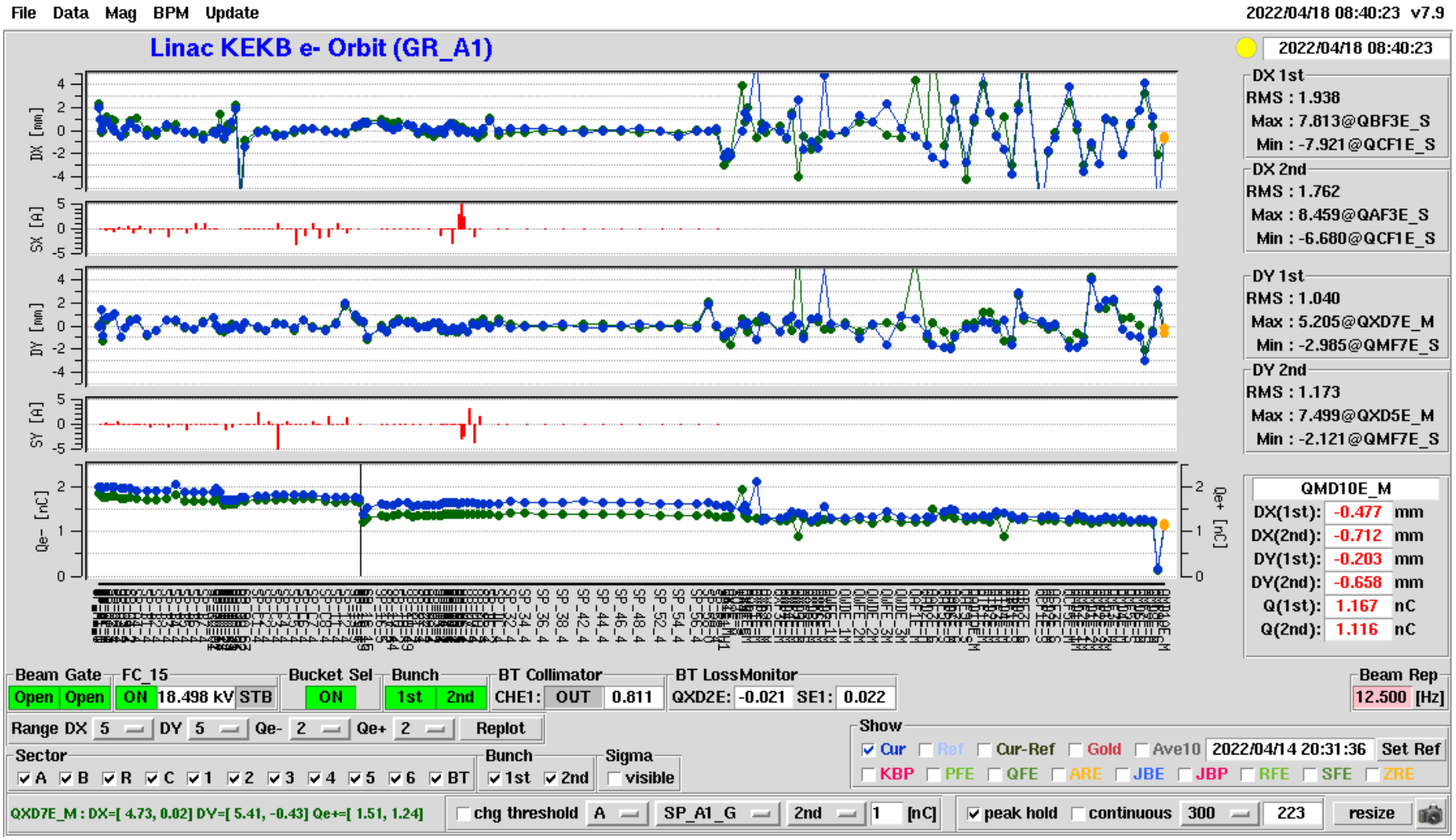


The bunch charge stability was significantly improved compared to the previous period.

Electron beam orbit in Linac and BT



2 bunch operation of KBE



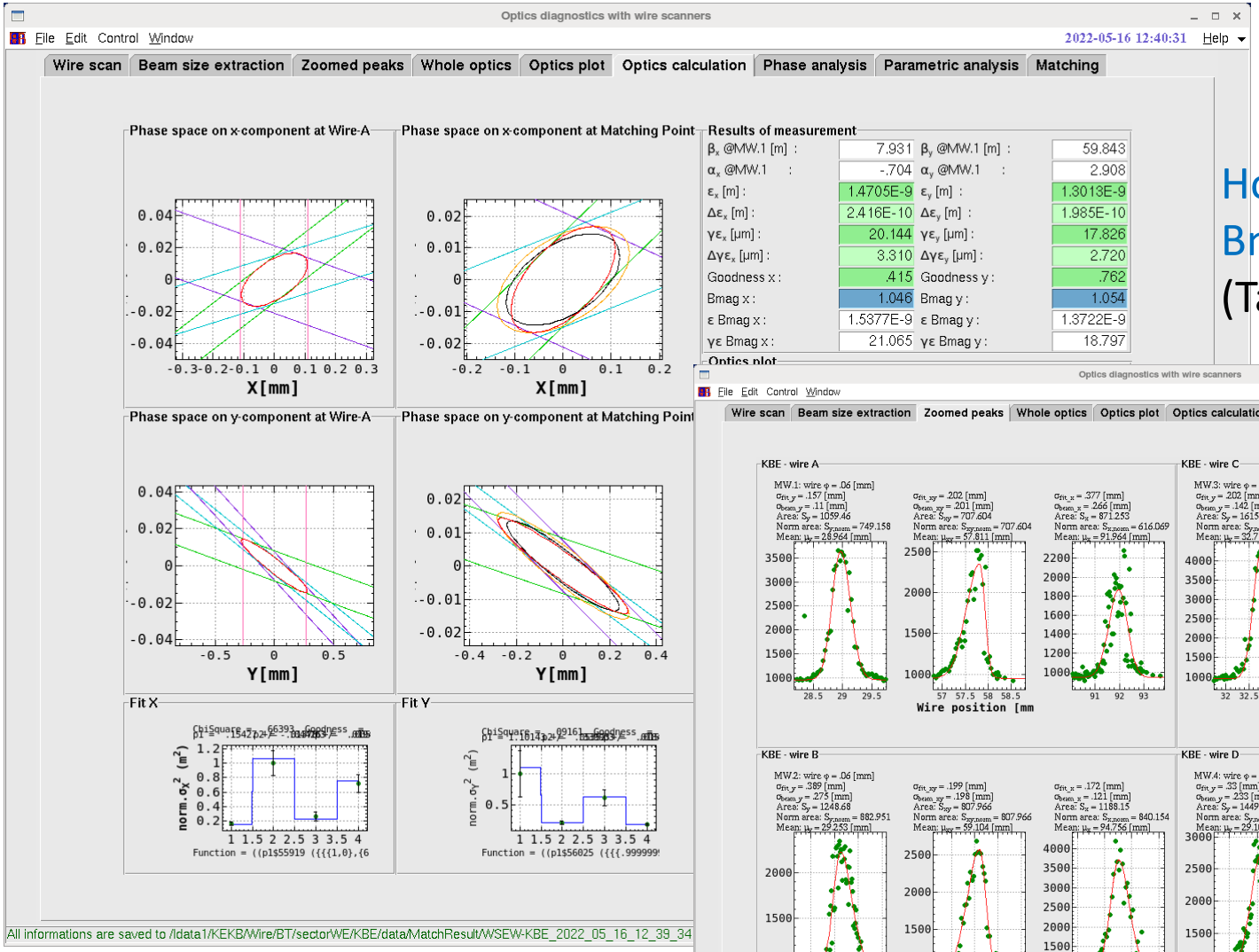
Sometimes we try to 2 bunch operation.

But injection rate is not so good. We use 1 bunch operation in usual.

Beam orbit seems good. But emittance value is not so good, maybe.

Electron emittance measurement.

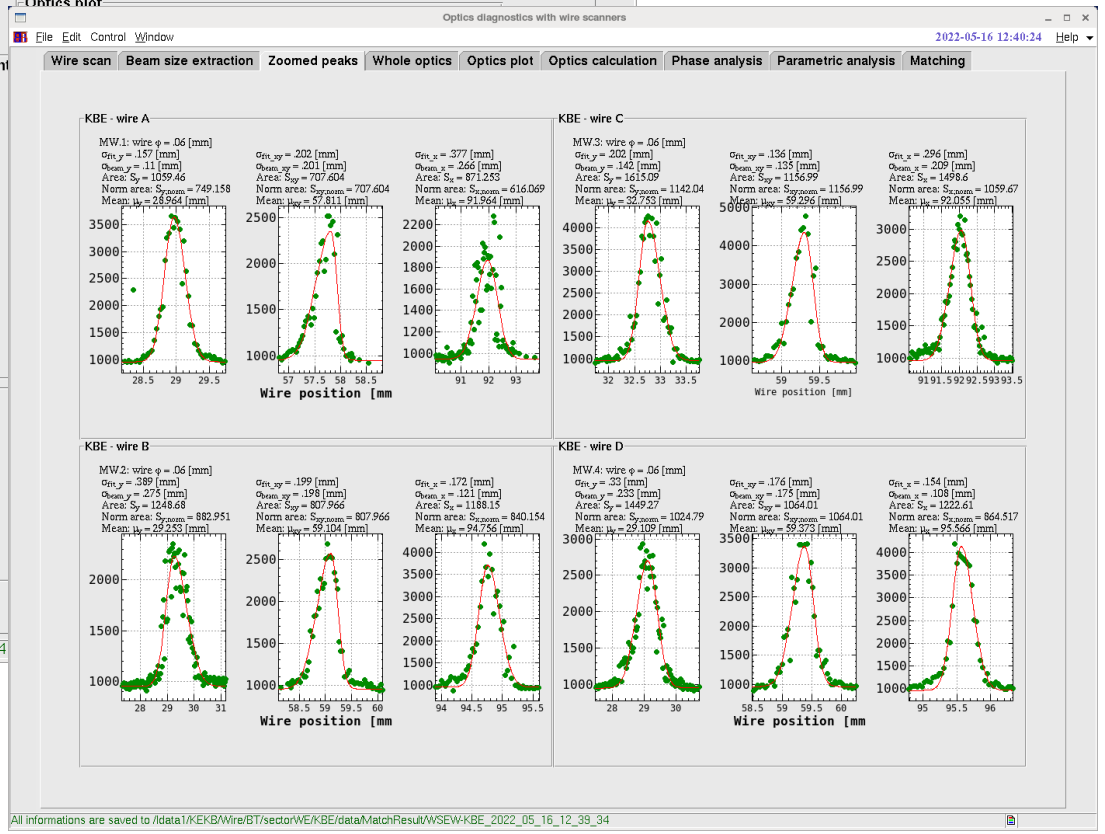
Sometimes we achive a very good condition. The next task is to maintain this condition.



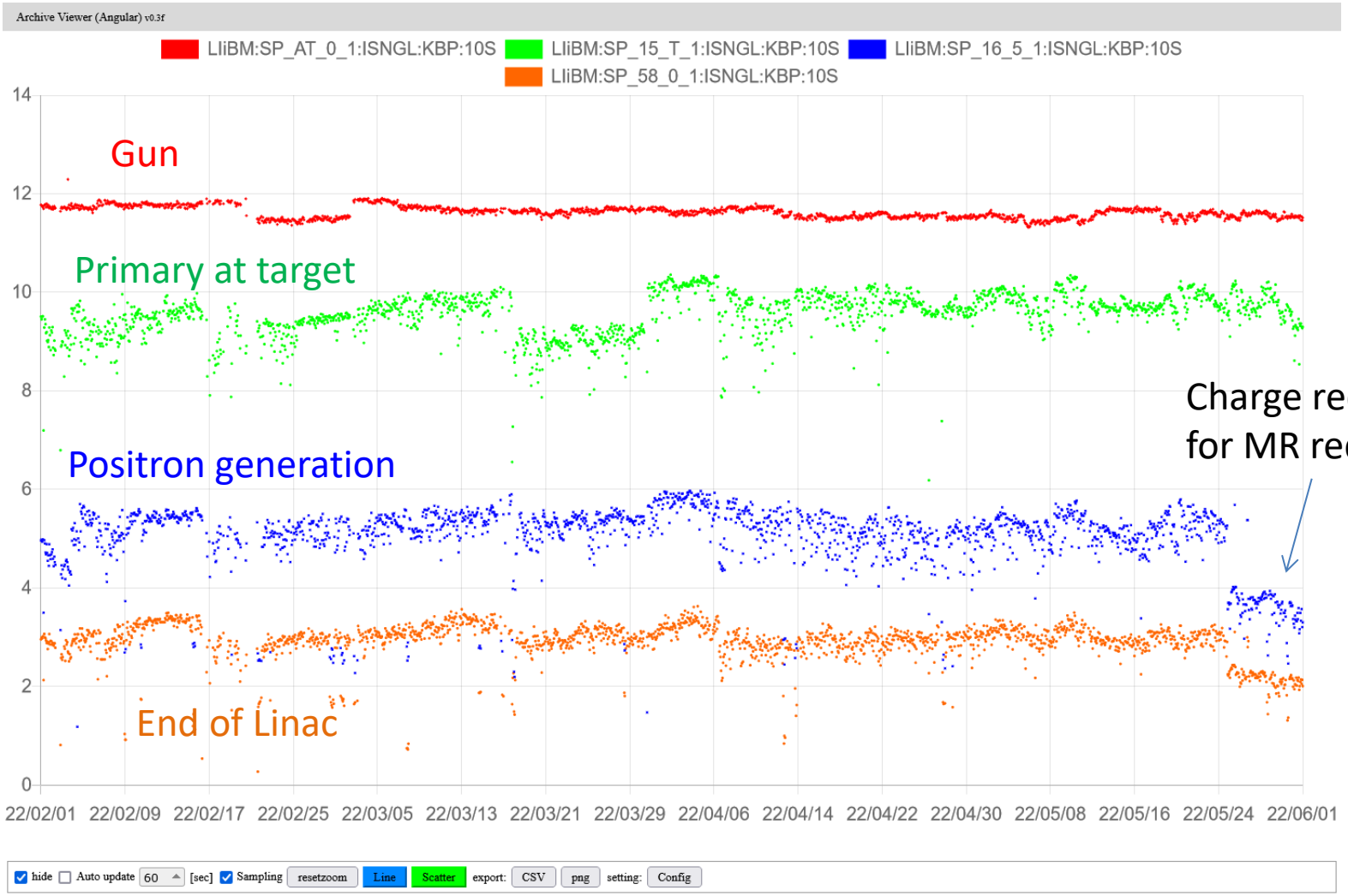
Hor. 20.1, Var. 17.8

Bmag is Good

(Target value : 40, 20)

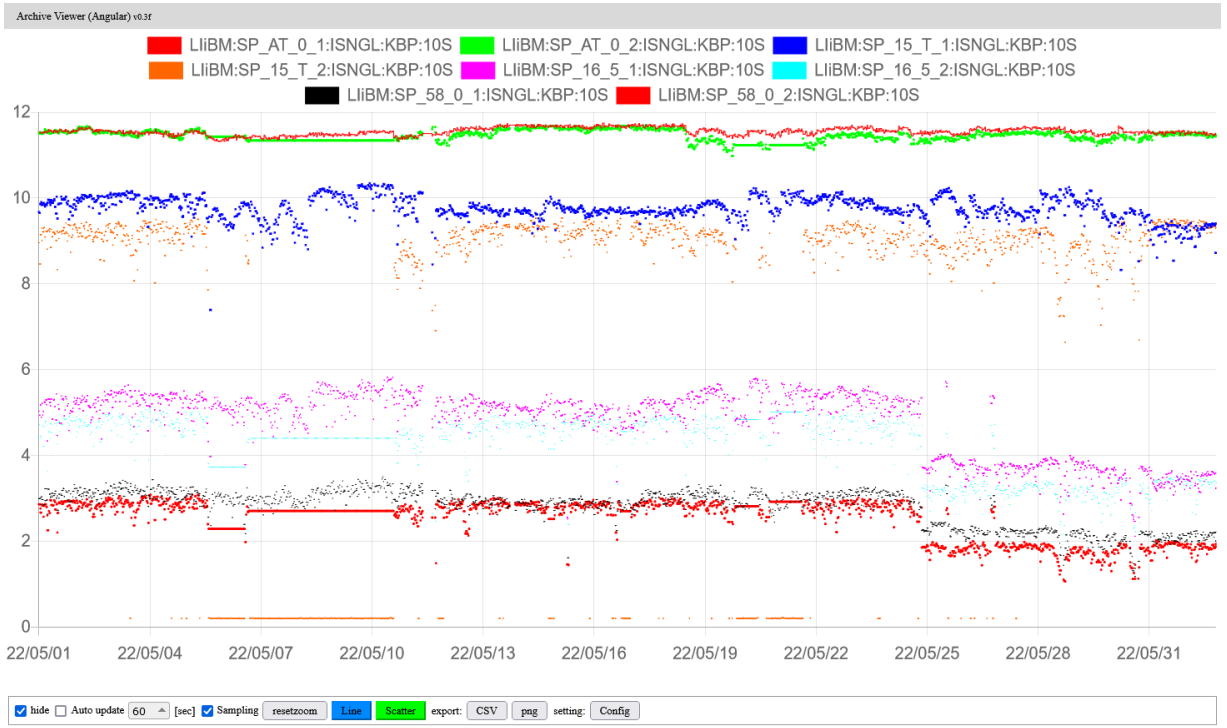


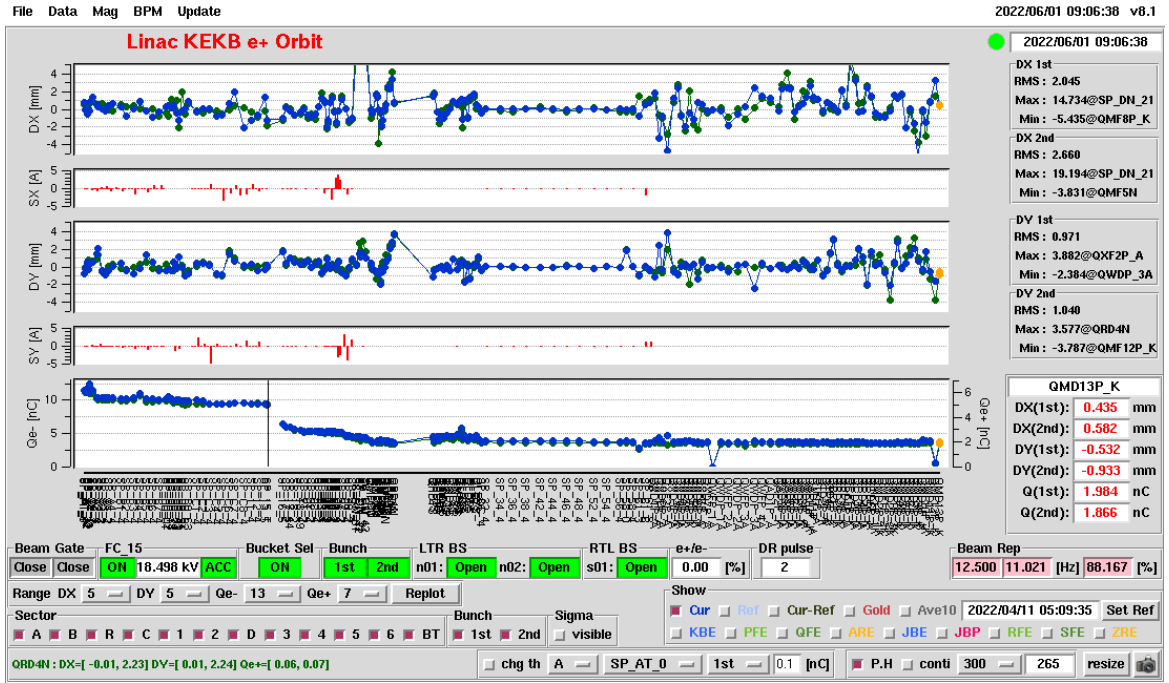
Positron beam charge history of 2022ab



Maximum beam charge is 3.5 nC

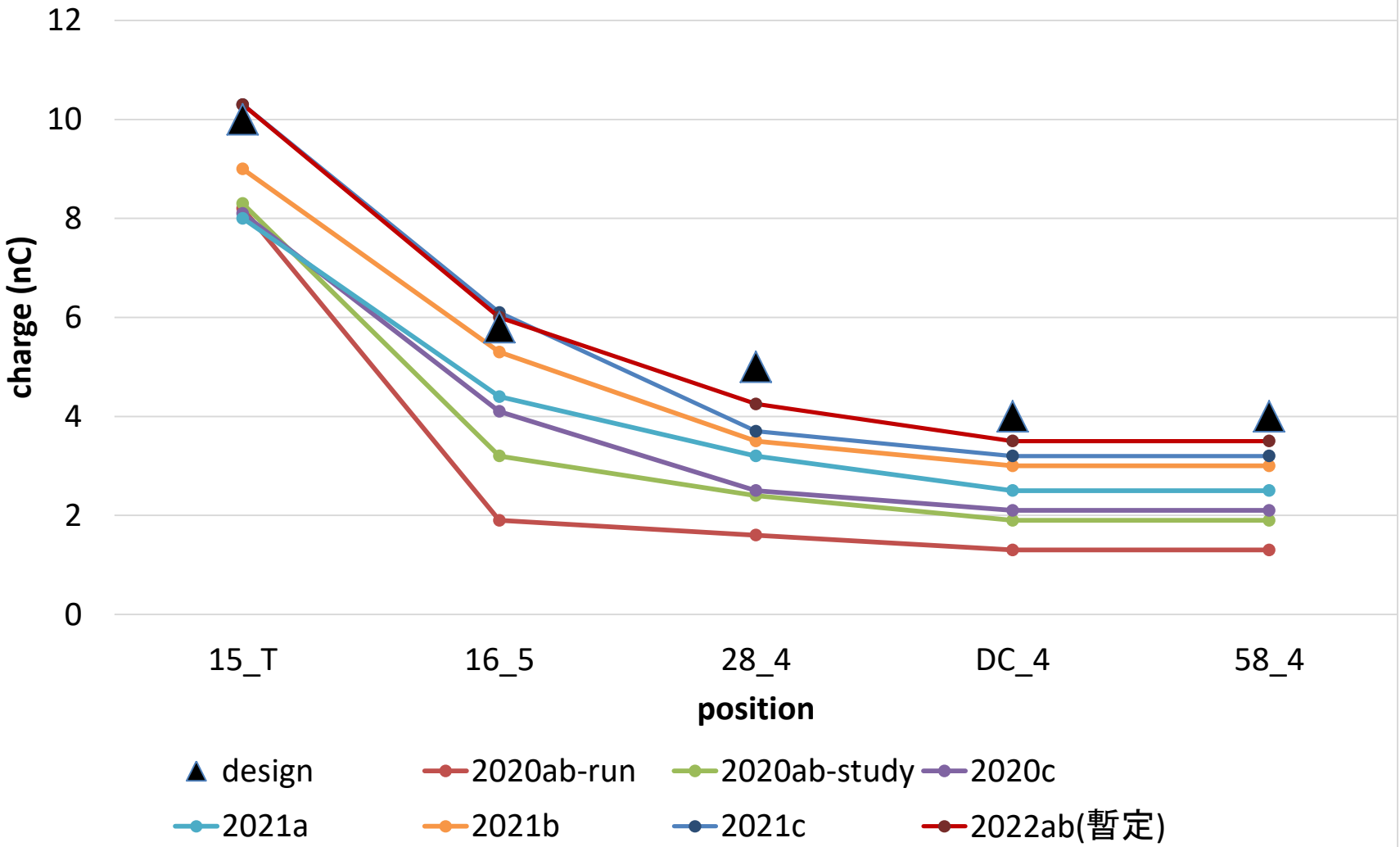
Two bunches operation history of KBP





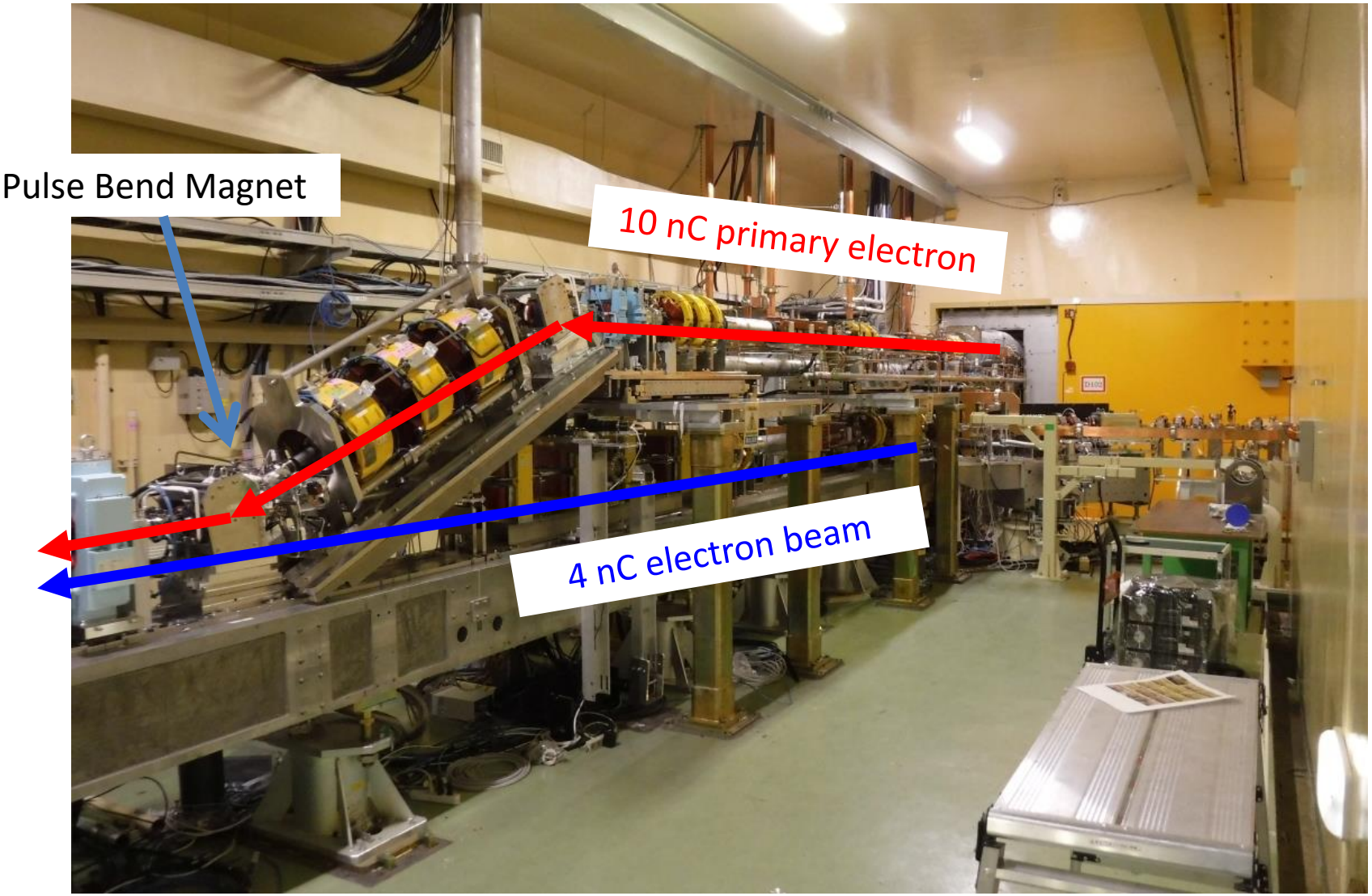
We succeeded to the two bunches operation for KBP.
2nd bunch charge is almost same as 1st bunch charge.
We can maintain a stable two bunches injection.

Long term charge history of KBP beam



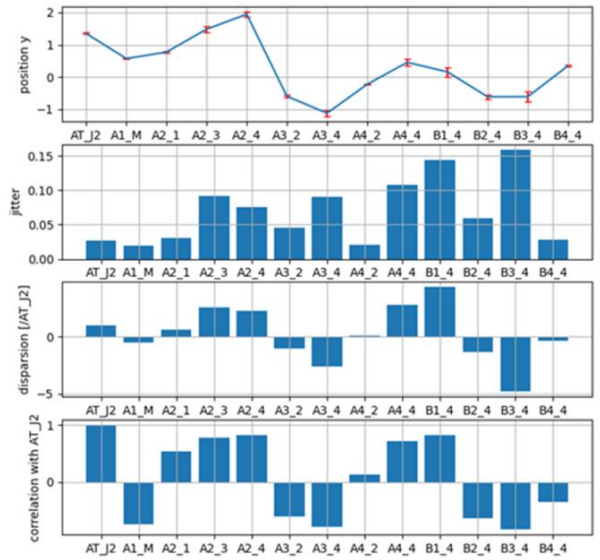
Injector line

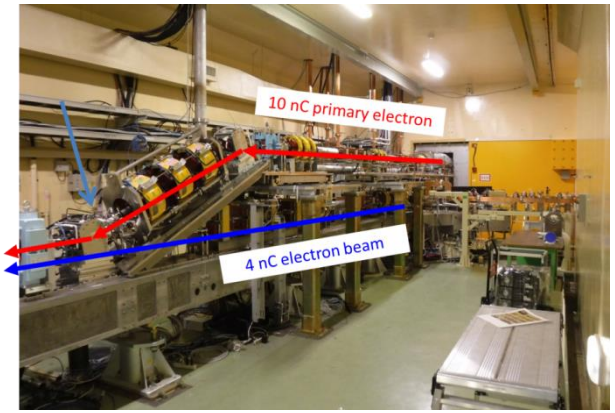
We have two lines in injector sector for positron and electron beam.



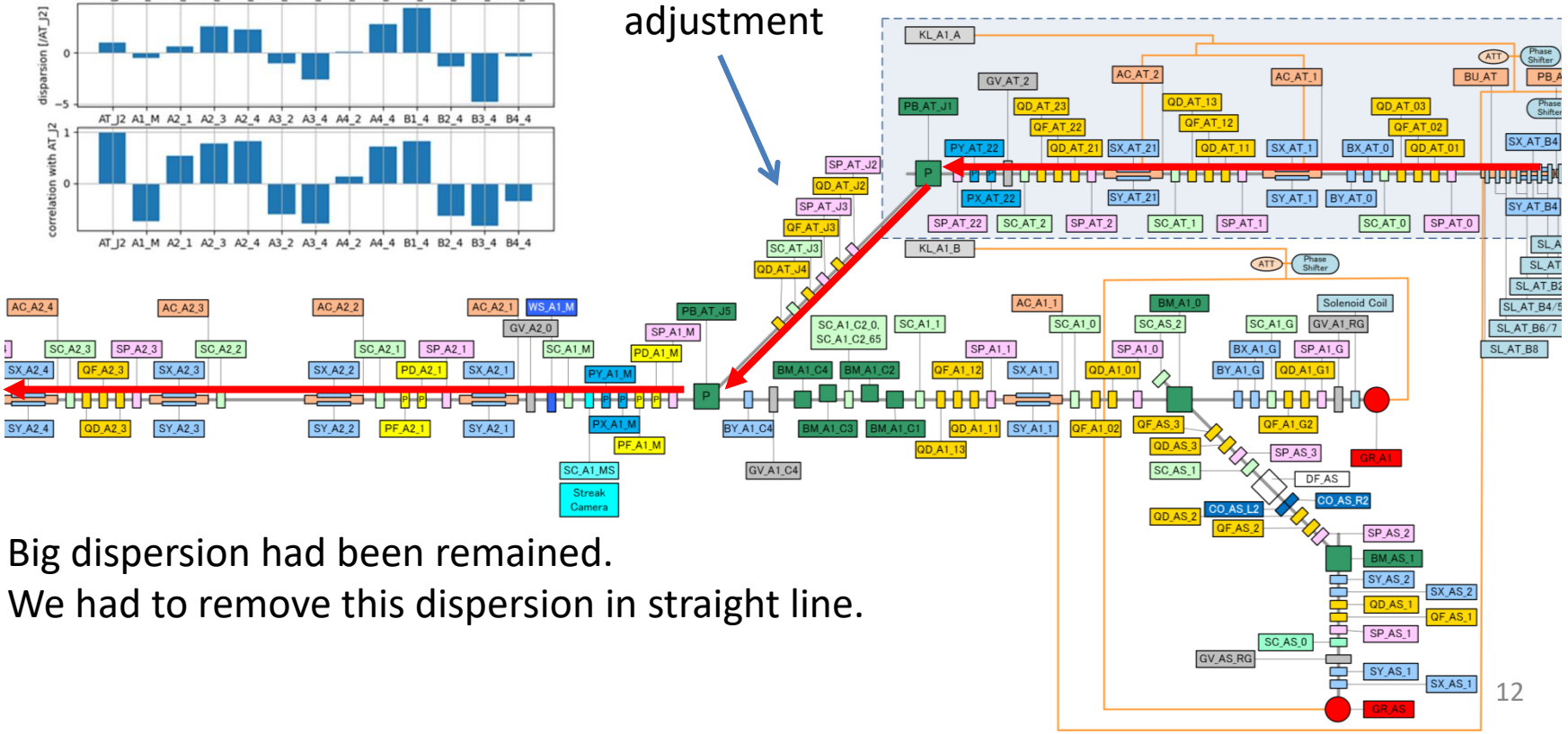
Improvement of 24 deg slope line for KBP beam

Leal time dispersion measurement panel



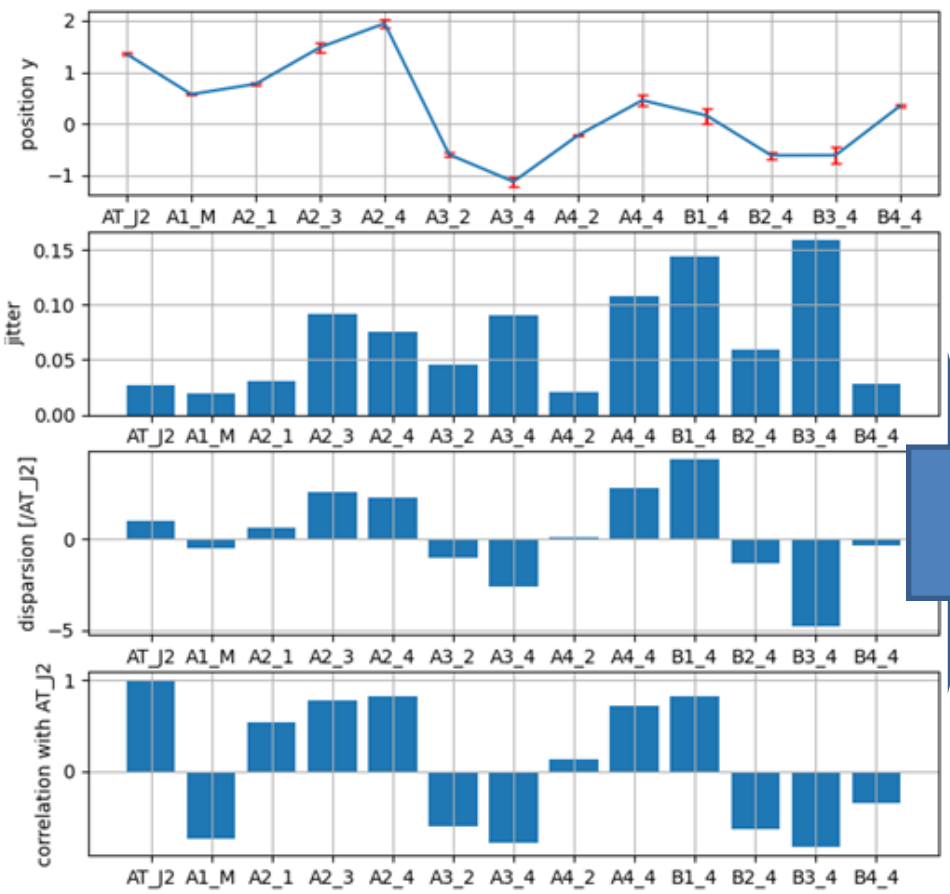


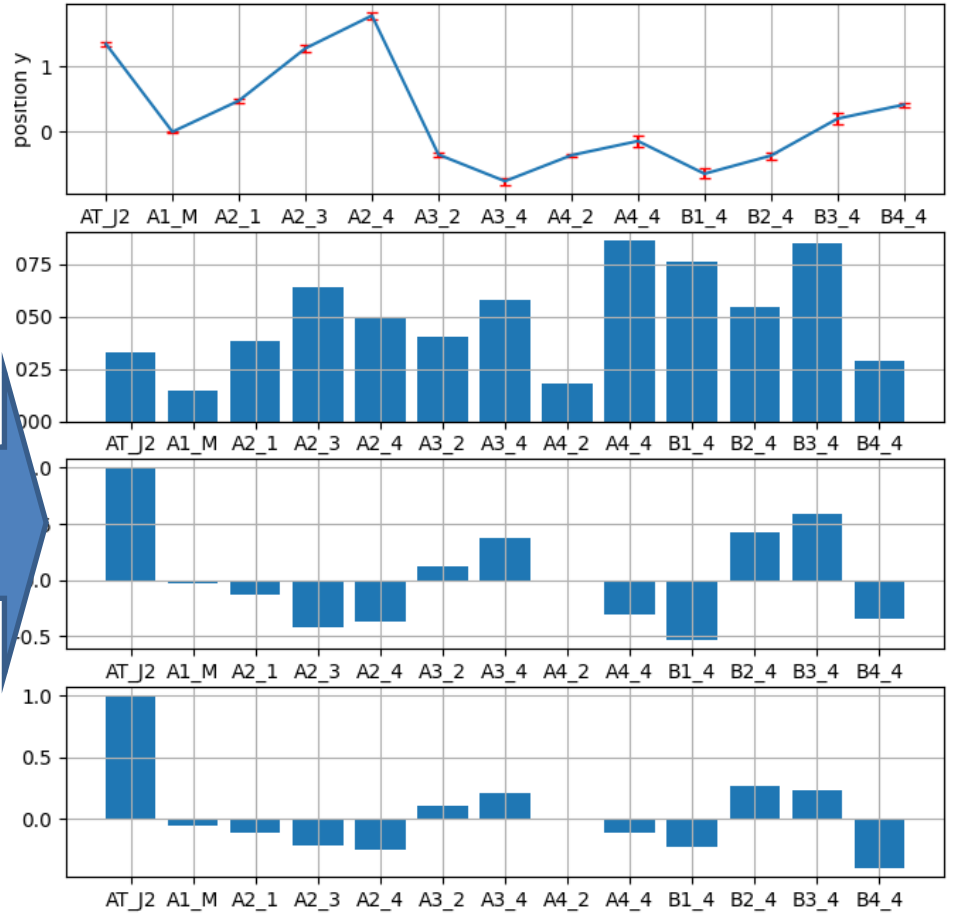
Magnet adjustment



Big dispersion had been remained.
We had to remove this dispersion in straight line.

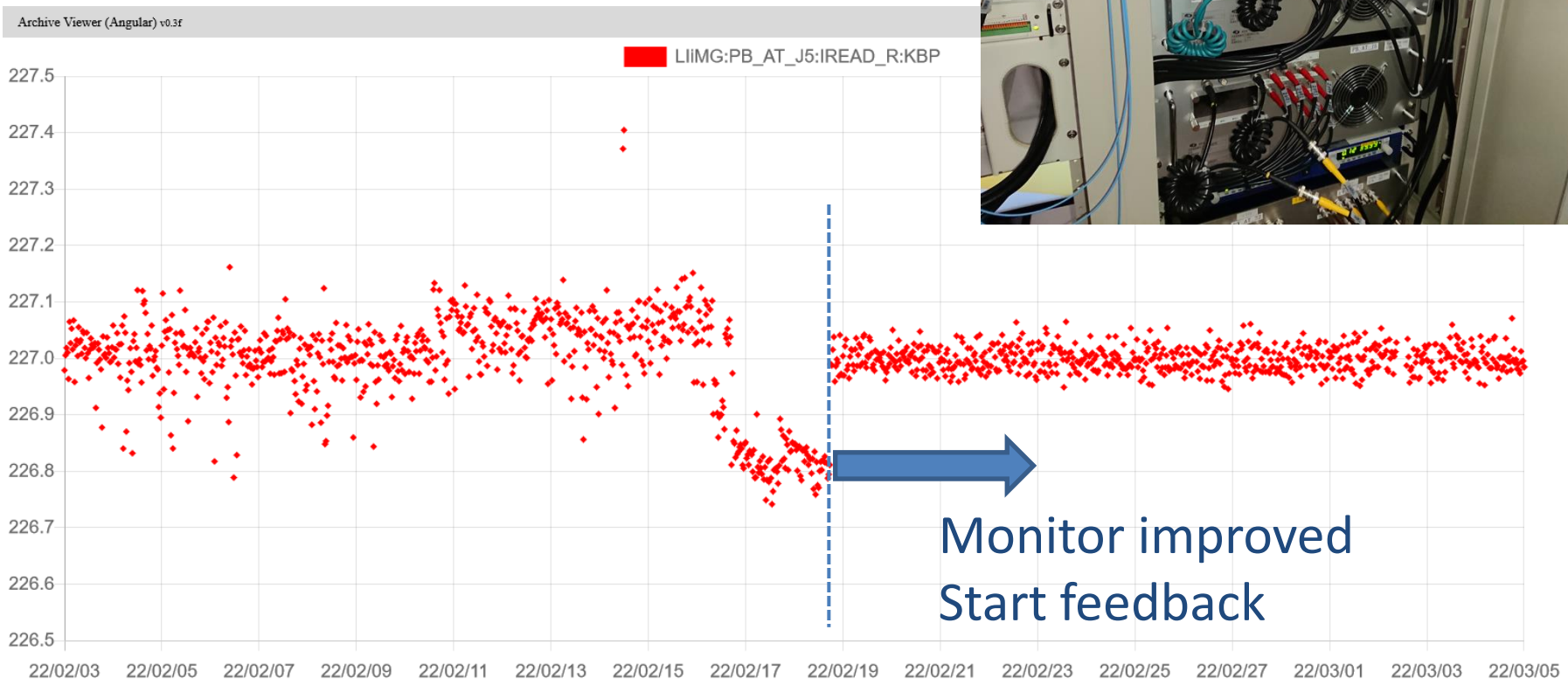
Adjust magnets (PB_J1, J5, Q mag J2, J3, J4)
We found a better magnet condition





Pulse bend magnet current (AT_J1, J5) improvement

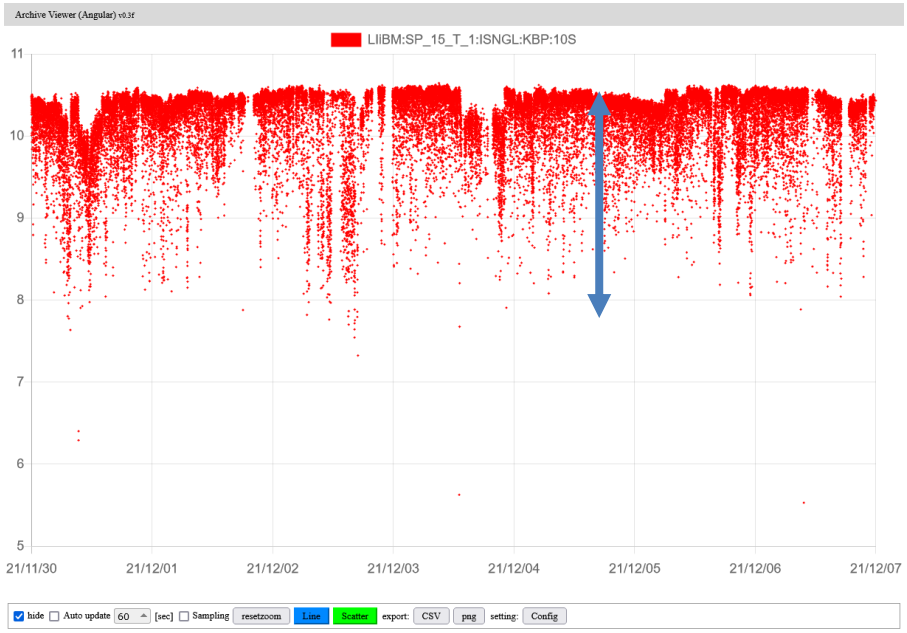
Noise reduction at control signal and monitor



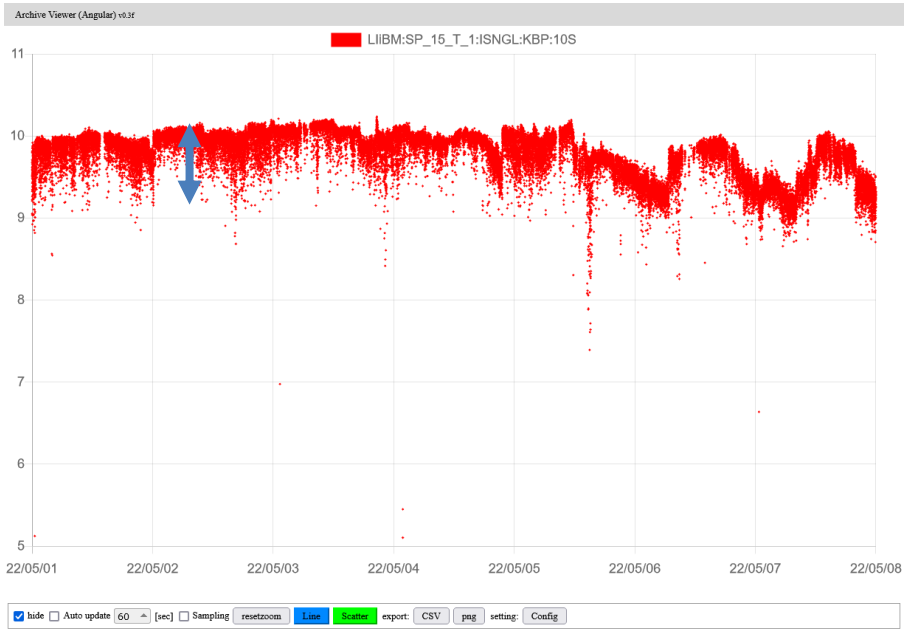
Stable pulse magnet operation was realized in 2022ab

Improvement of beam fluctuation of KBP

2021c

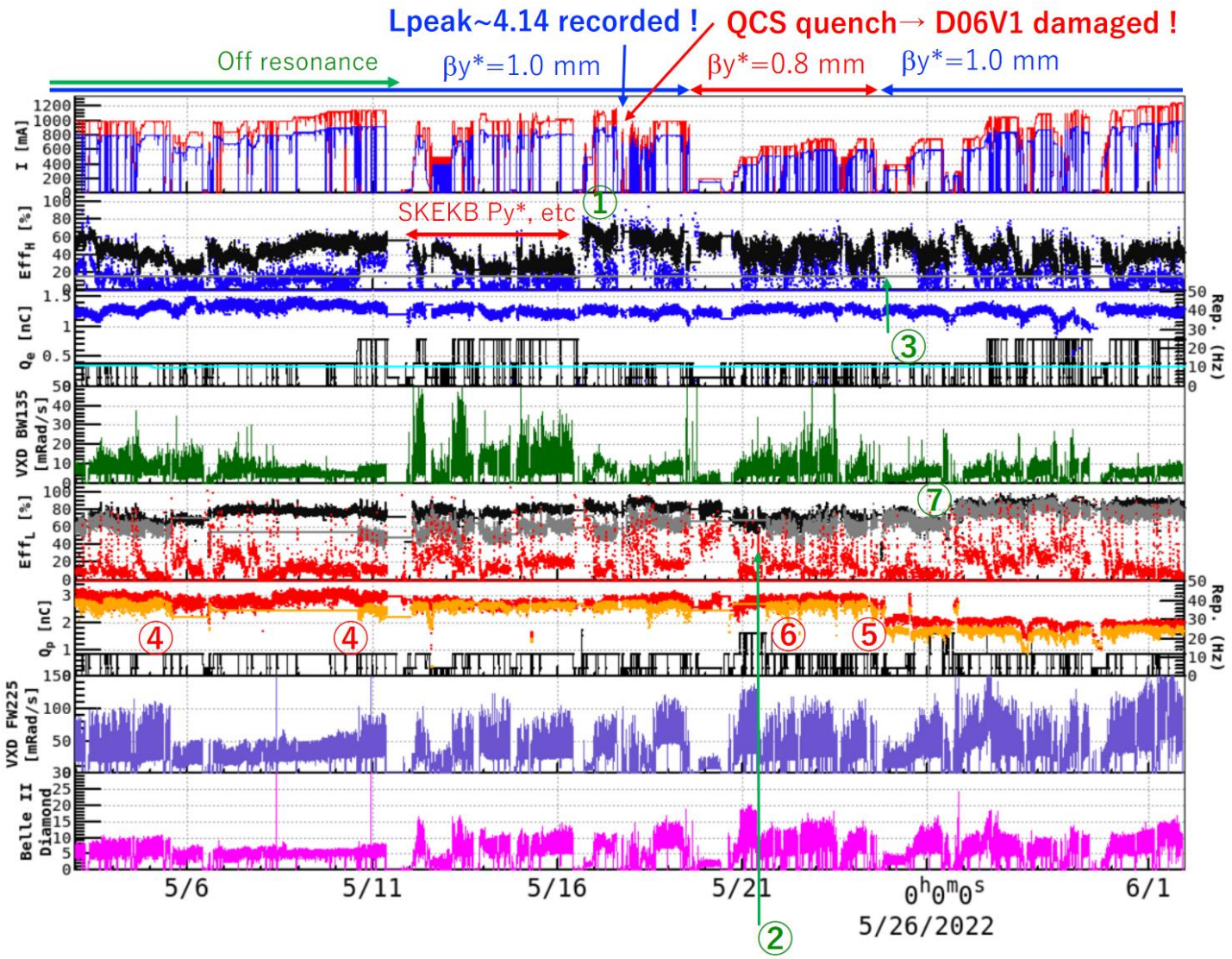


2022b



Small beam charge fluctuation at target.

Injection summary



① The horizontal orbits at SLY* in the KEKB rings affects to the injection.

② Installed a fast strip line kicker for LER 2nd bunch.

③ Continuous operation of HER Septum 25Hz started.

④ 2 bunch injection given up to avoid frequent aborts, is recovered by lengthening CLAWS VETO.

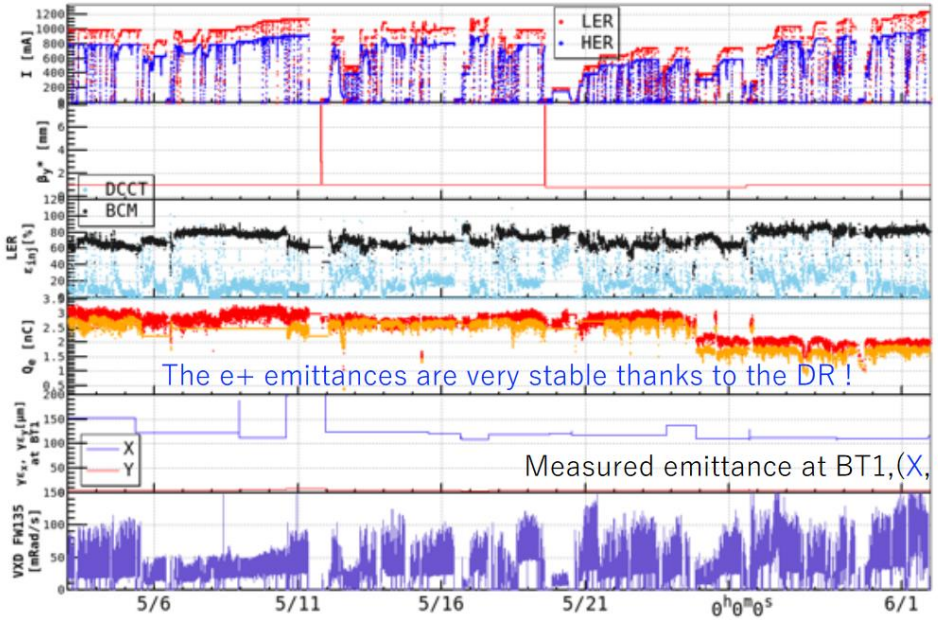
⑤ e+ charge is reduced for avoiding CLAWS aborts.

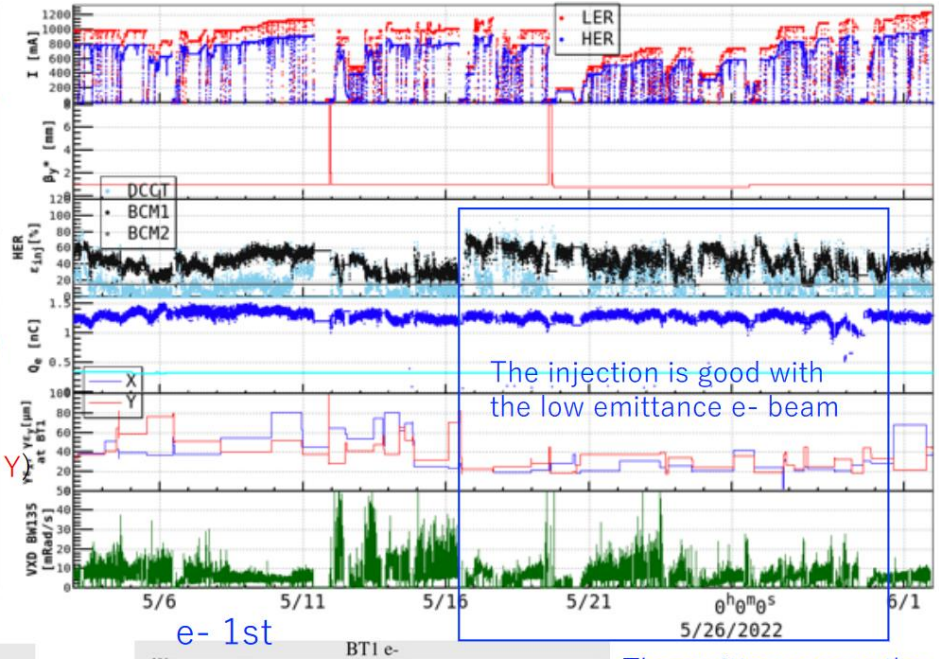
⑥ 25Hz injection was given up for the high VXD.

⑦ D06V1 tuning

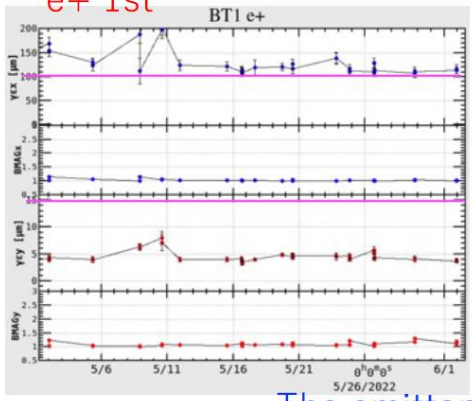
N.Iida

Measured emittances of the injection beam

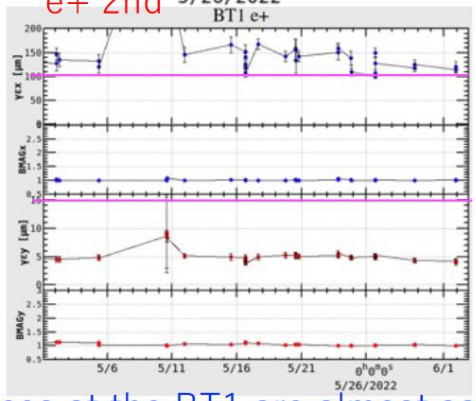




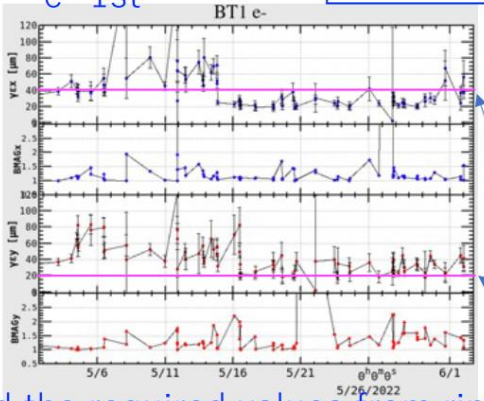
e+ 1st



e+ 2nd



e- 1st



The emittances are the lowest level !
It thanks to the tuning with BT dump mode by LINAC operators when aborts happened .

Request values
from SuperKEKB

10

The emittances at the BT1 are almost satisfied the required values from rings.

N.Iida

Still remain a emittance brow up in BT. We have to study the brow up problem.

Linac Upgrade 2022-2026

- Pulse magnet
- Girder Mover
- PCB capacitor replace
- electron ECS

Upgrade budget

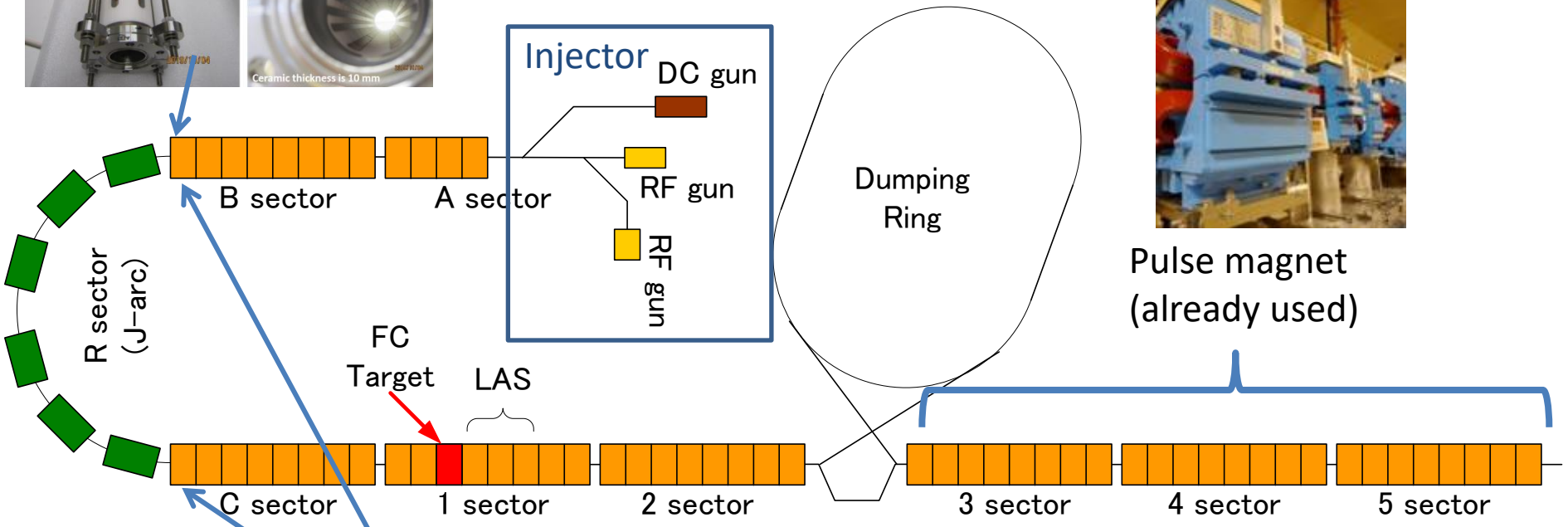
- RF gun
- Positron target and capture
- Acceleration structure

Normal budget

Pulse magnet upgrade

Fast kicker

Pulse magnet
(already used)



New large pulse
Q magnet and
fast kicker

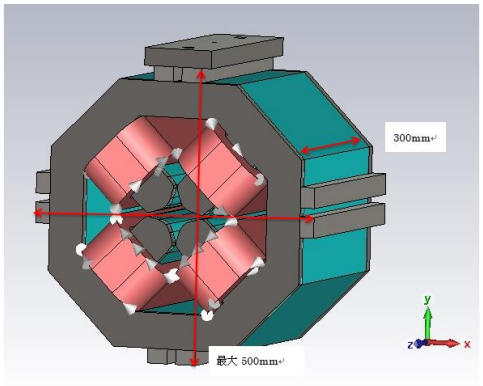
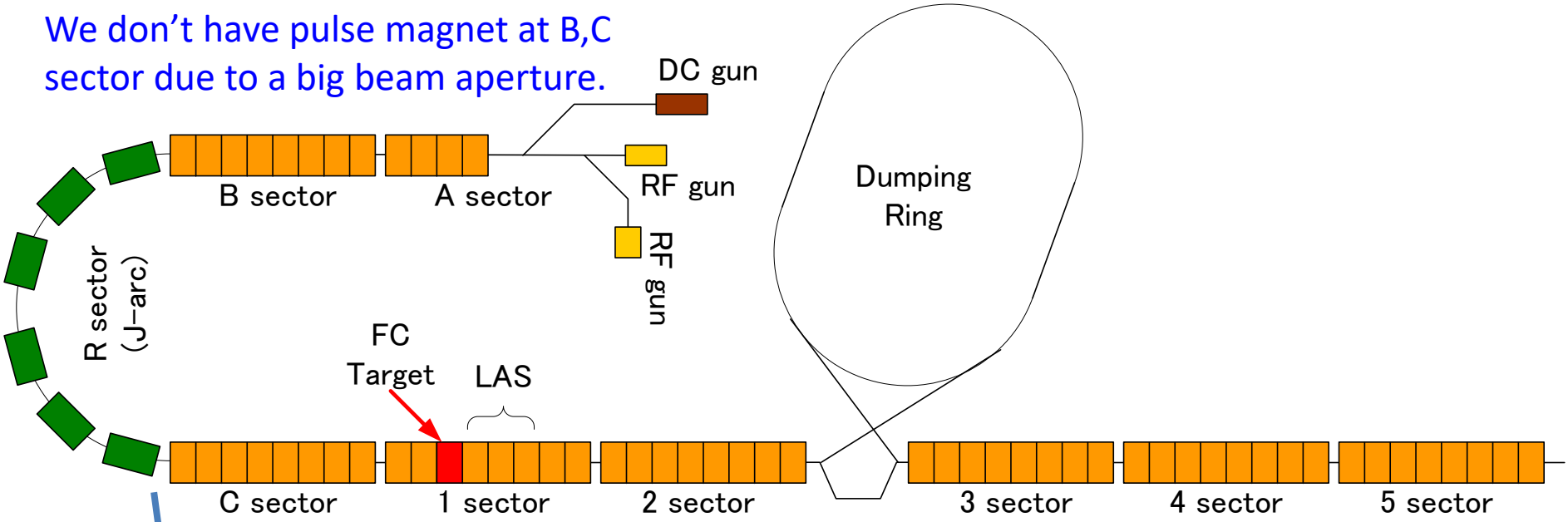
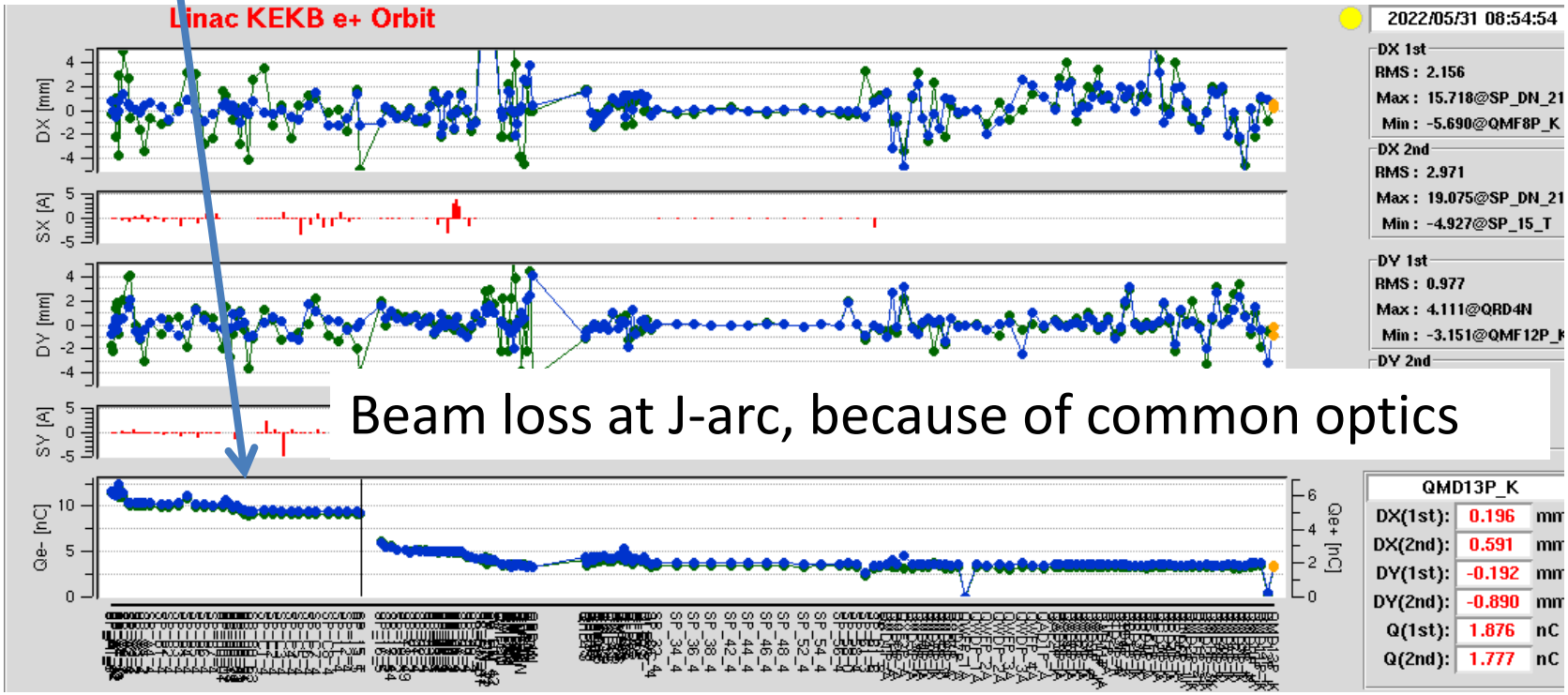


図1　外観形状案（参考図）パルス四極電磁石

We already use a pulse magnet in 3-5 sector.
But we need additional pulse magnet at J-arc for matching with both beam of KBP and KBE

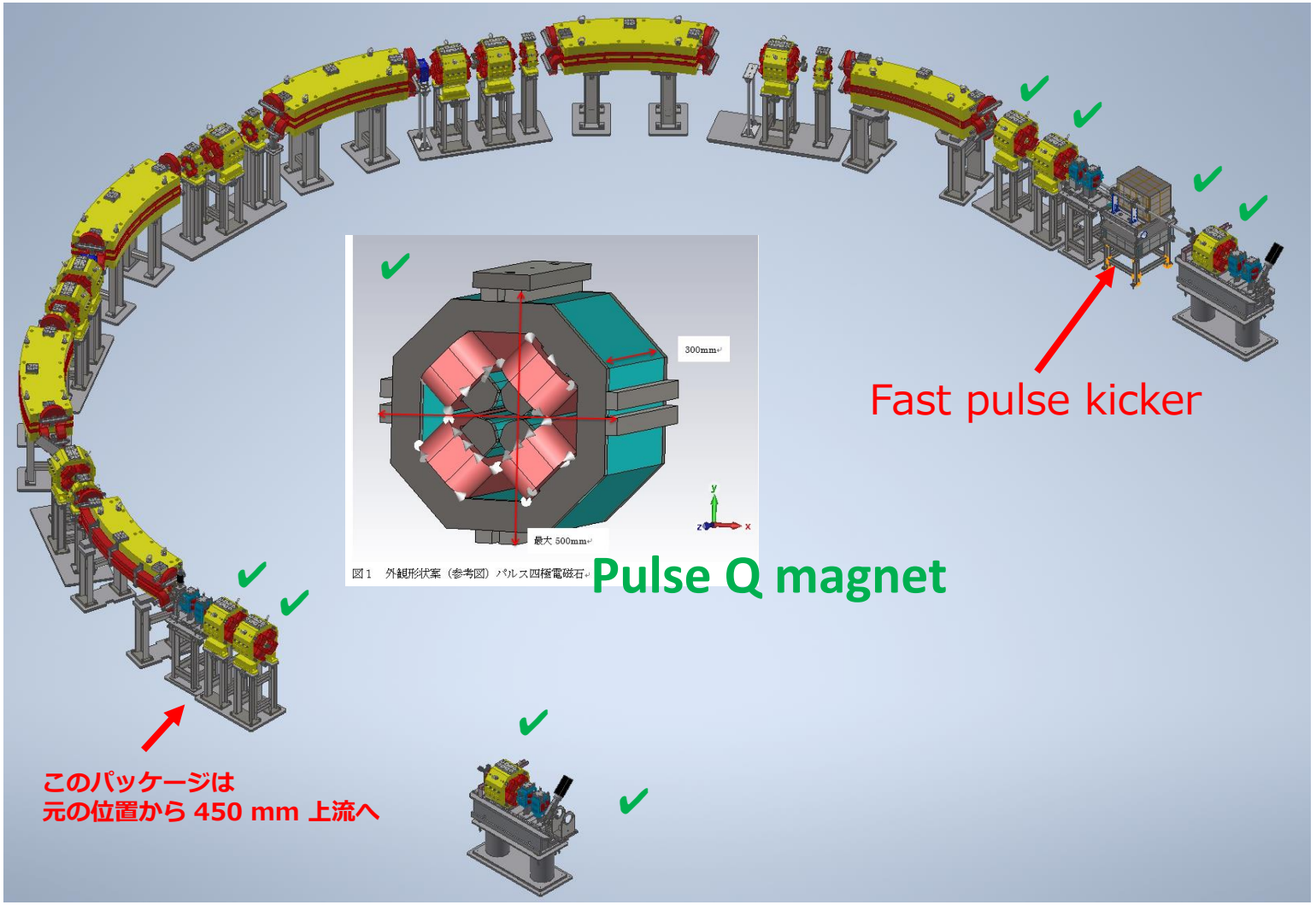
We don’t have pulse magnet at B,C sector due to a big beam aperture.





Beam loss at J-arc, because of common optics

8 large pulse magnets will be installed at entrance and exit of J-arc



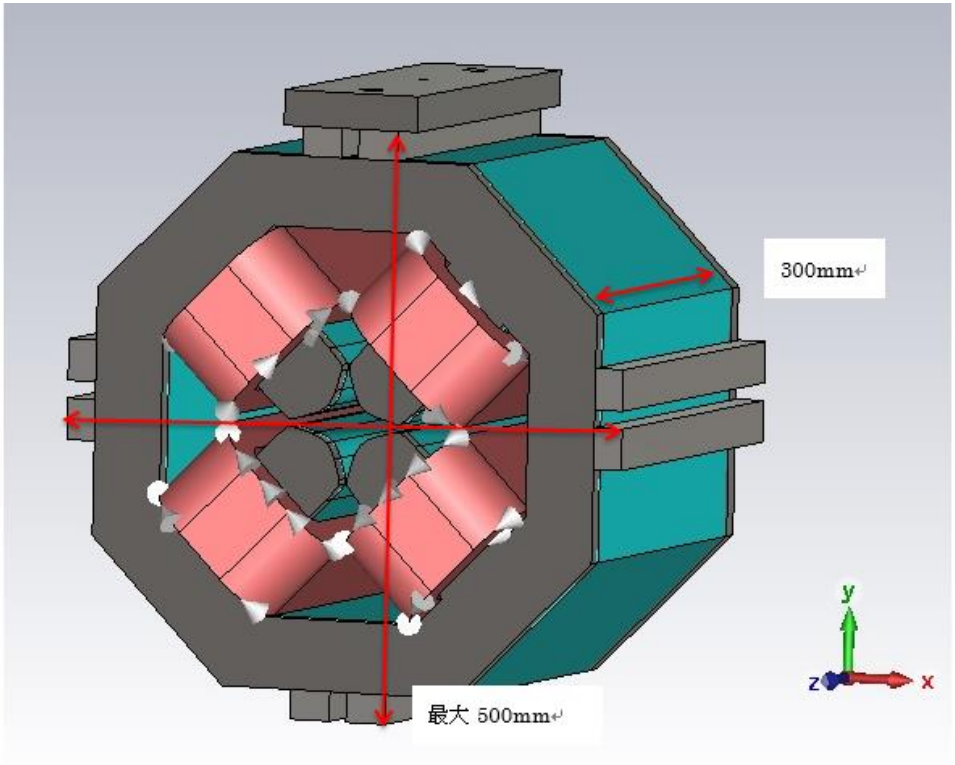


図１　外観形状案（参考図）パルス四極電磁石

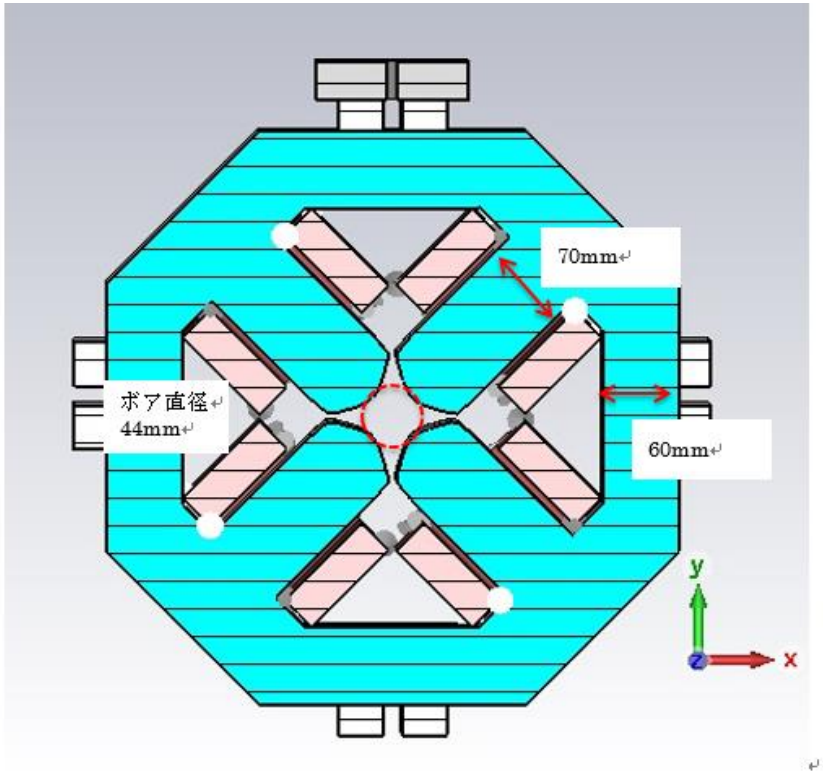
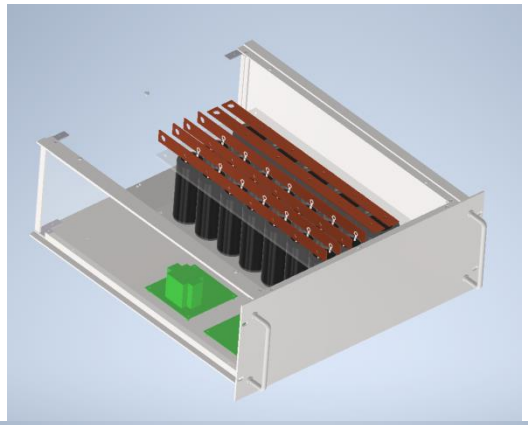


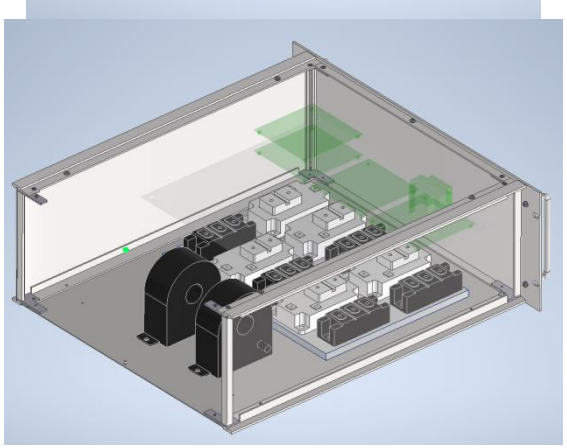
図２　断面形状（参考図）パルス四極電磁石

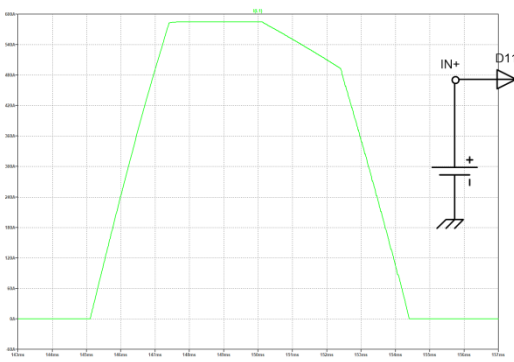
New pulse Q magnet has large aperture for positron primary

New pulse magnet driver is also developing.

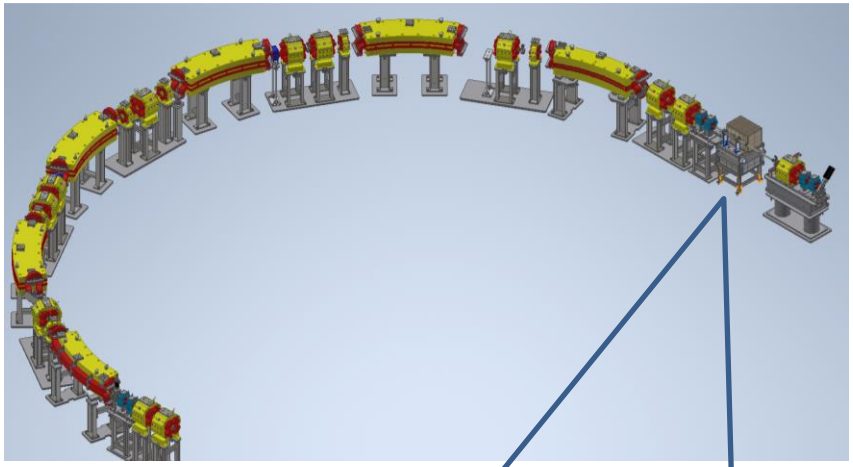
	3-5 sector type	New driver
Max Voltage [V]	230	400
Max Current [A]	330	600
Magnet inductance [mH]	1	1.5
Control method	I_D-V_{GE} analog control	PWM

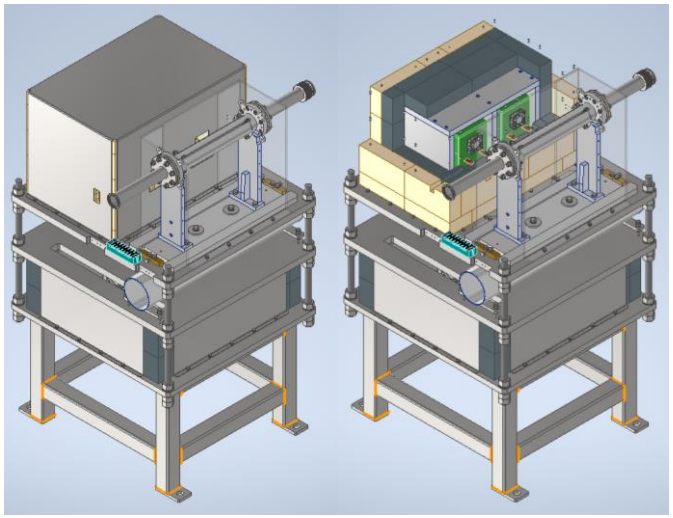






Fast kicker for 2nd bunch

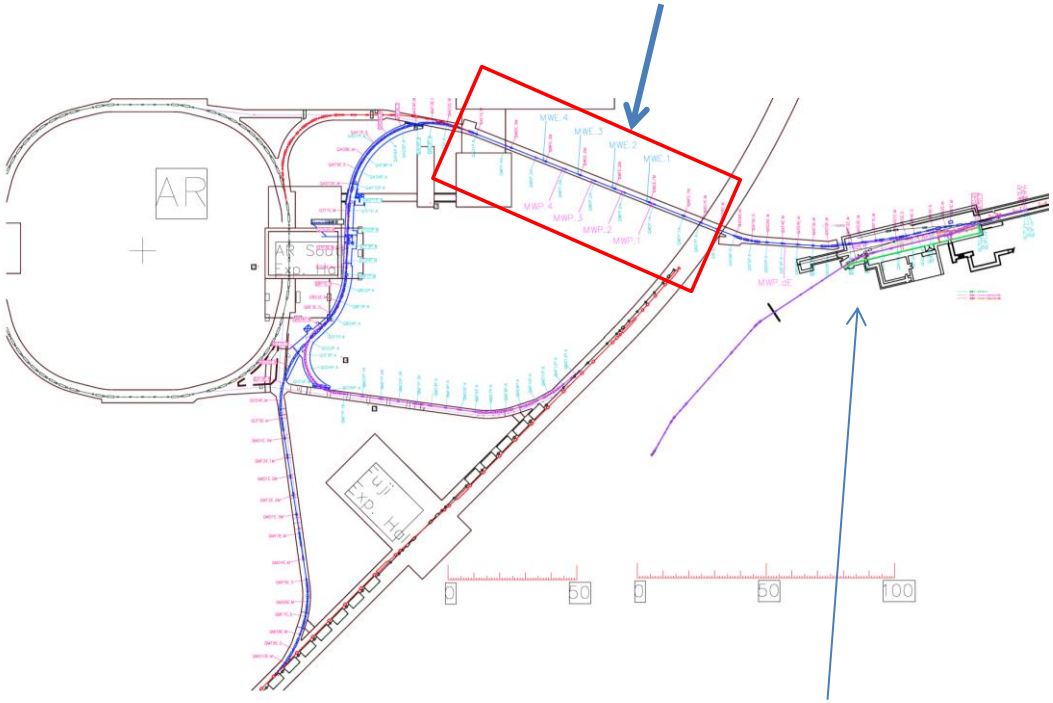




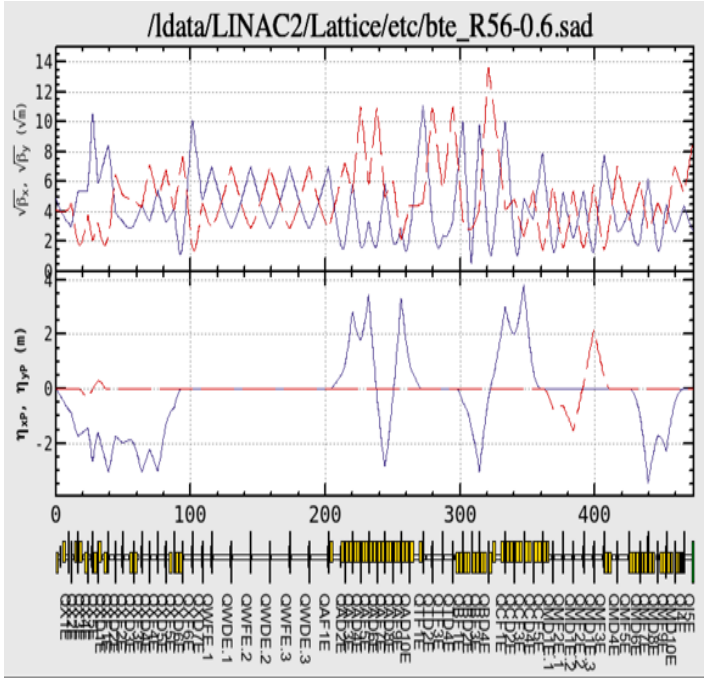
Fast kicker affects to only 2nd bunch.
Pulse raising time must be under 96 ns.

Energy Compression System (ECS) for KBE

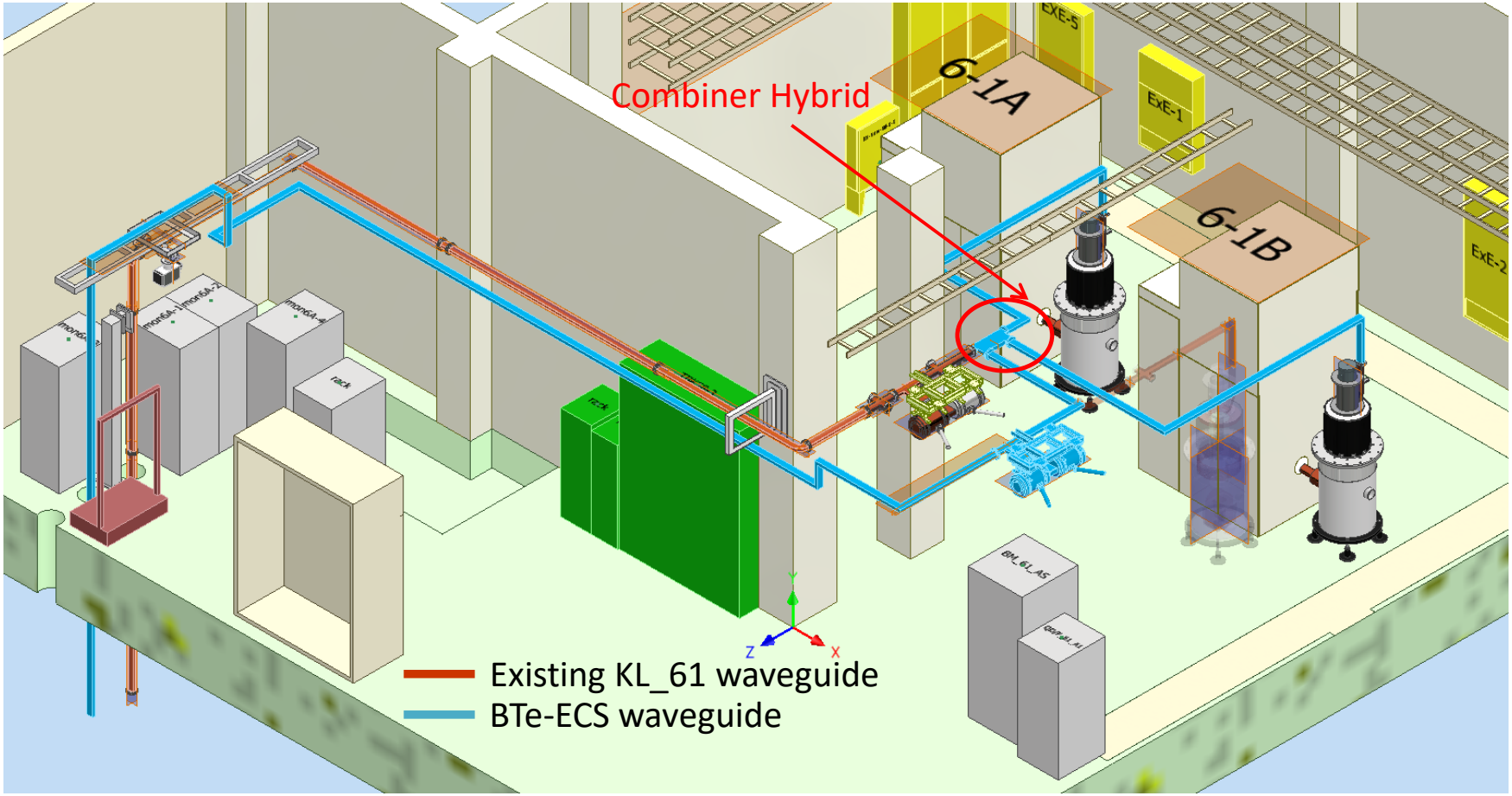
Install accelerating structure in BTe



We make R56 in Arc0 of BTe



We will add a klystron in end of linac for electron ECS.
Now we are ready to install a new klystron and modulator.



PFN capacitor replace for PCB countermeasures

PCB : Poly Chlorinated Biphenyl

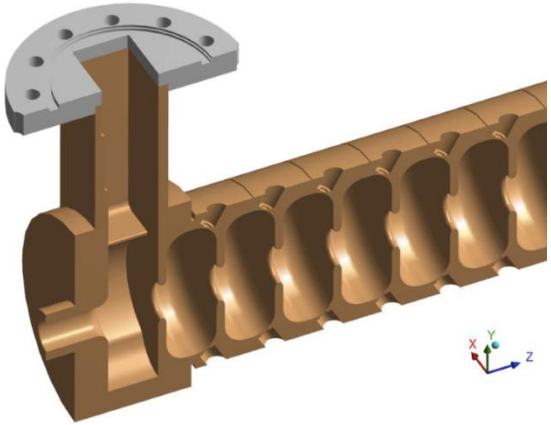
- 40 capacitors in one klystron modulator
  - 2 series, 20 ladder PFN
- We have to replace about 600 capacitors

- This upgrade does not contribute to performance improvement.

PFN

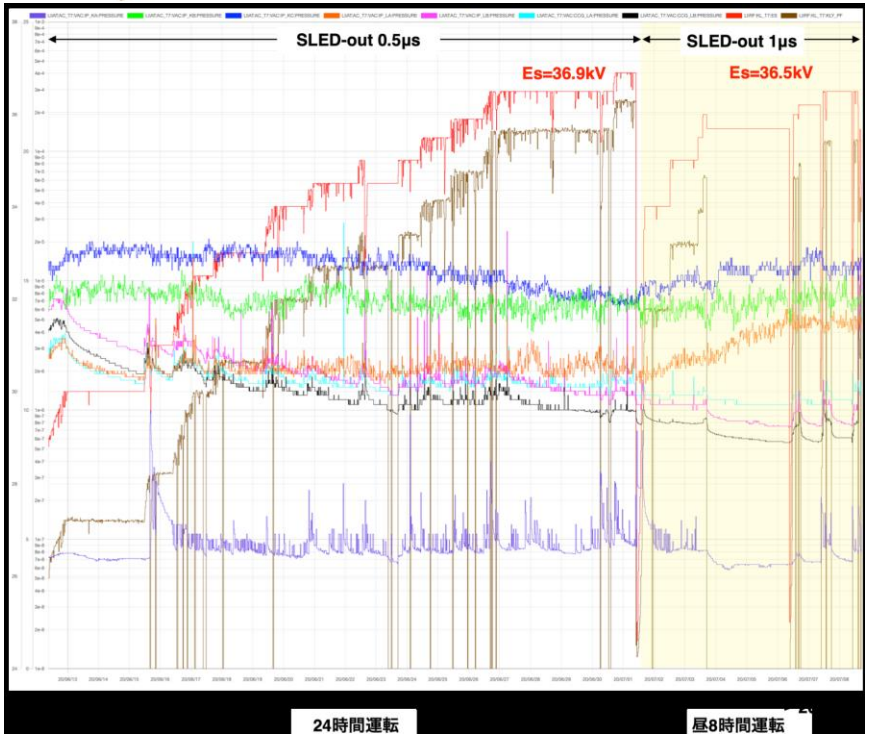
- Voltage : 47kV
- Capacitance : 0.0155μF

New acceleration structure

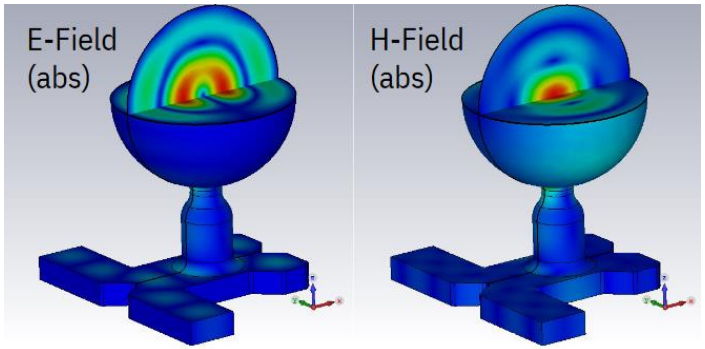


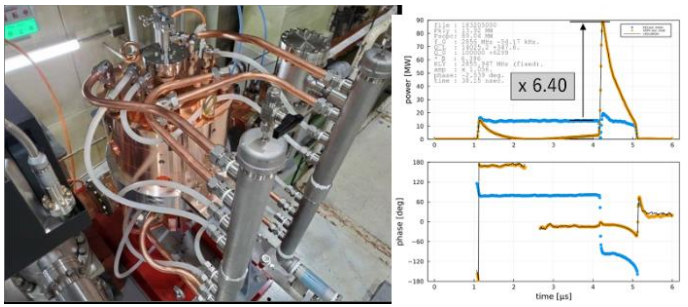
The old acceleration tube must be replaced.

New structures have higher accelerating gradient and lower surface electric field.
We will replace to a new accelerating structure to reach a collision at the higher energy resonance of (6S).



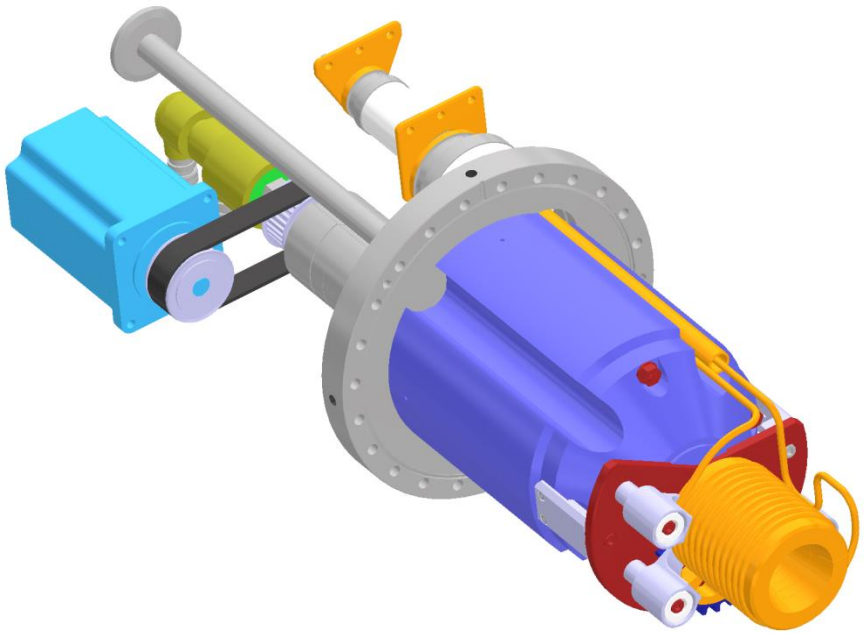
New accelerating structure is high quality



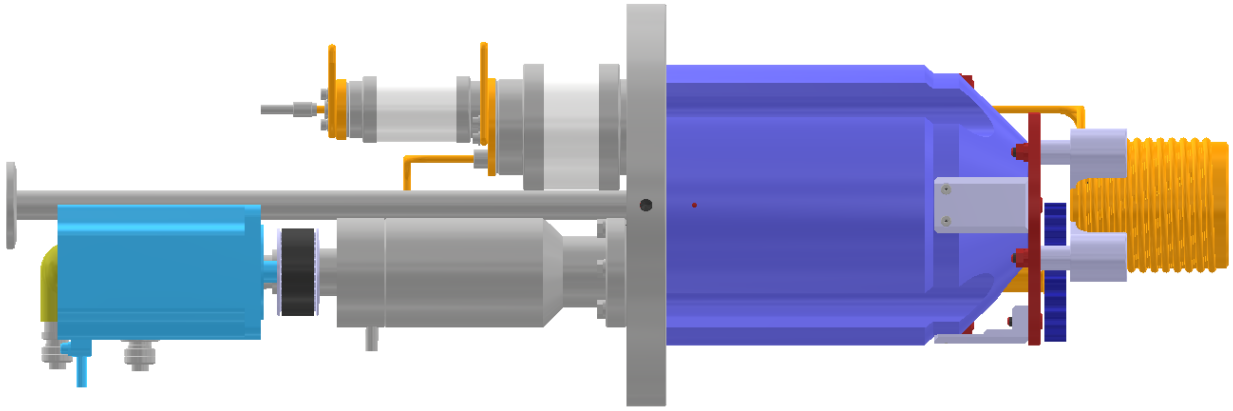


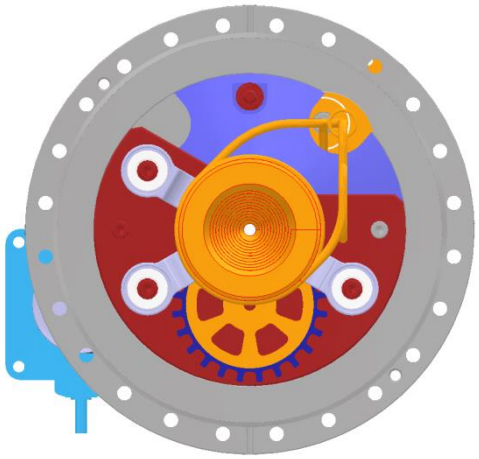
New pulse compression system also developed.

New positron rotation target and FC

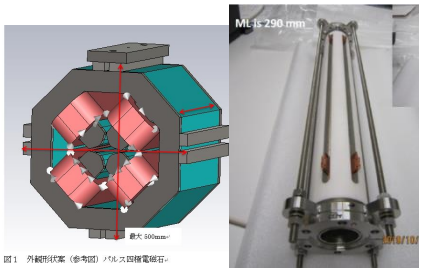


Rotation target is very nice system for not only positron beam but also electron beam. That why, both beam orbit will be on the axis and big aperture for electron beam.





7 items of injector upgrades by 2026

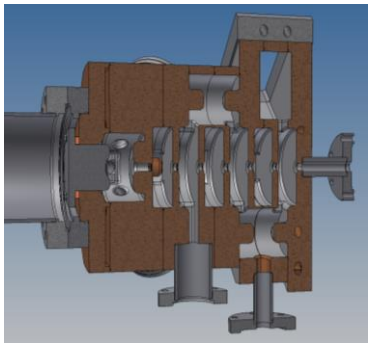


Pulse magnet

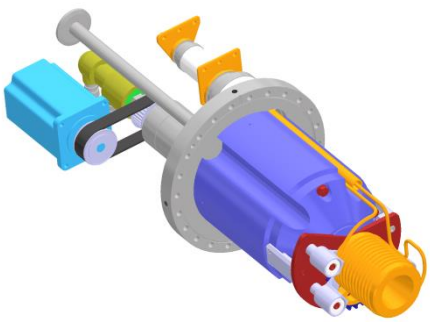
Girder Mover

PCB

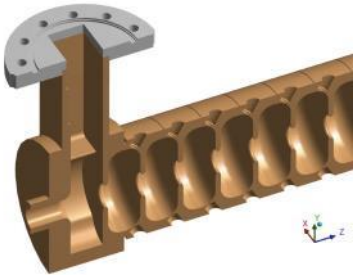
ECS



RF gun



Positron



Accelerating structure

Summary

Electron beam

- Beam charge is very stable.
- Emittance is almost satisfied a required value.

Next challenges

- 2 bunches operation.
- How to maintain good emittance.
- Increase beam charge, over 2.0 nC.
- Avoid emittance brow up at BT.

Positron beam

- Beam charge is almost reach the target value.
- 2 bunch operation is succeeded.
- Emittance is almost satisfied a required value.

Next challenges

- Increase beam charge to 4.0 nC
- Stable operation.
- Avoid emittance brow up at BT.

Linac upgrade is on going.