Injector linac status

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for Injector Linac Group

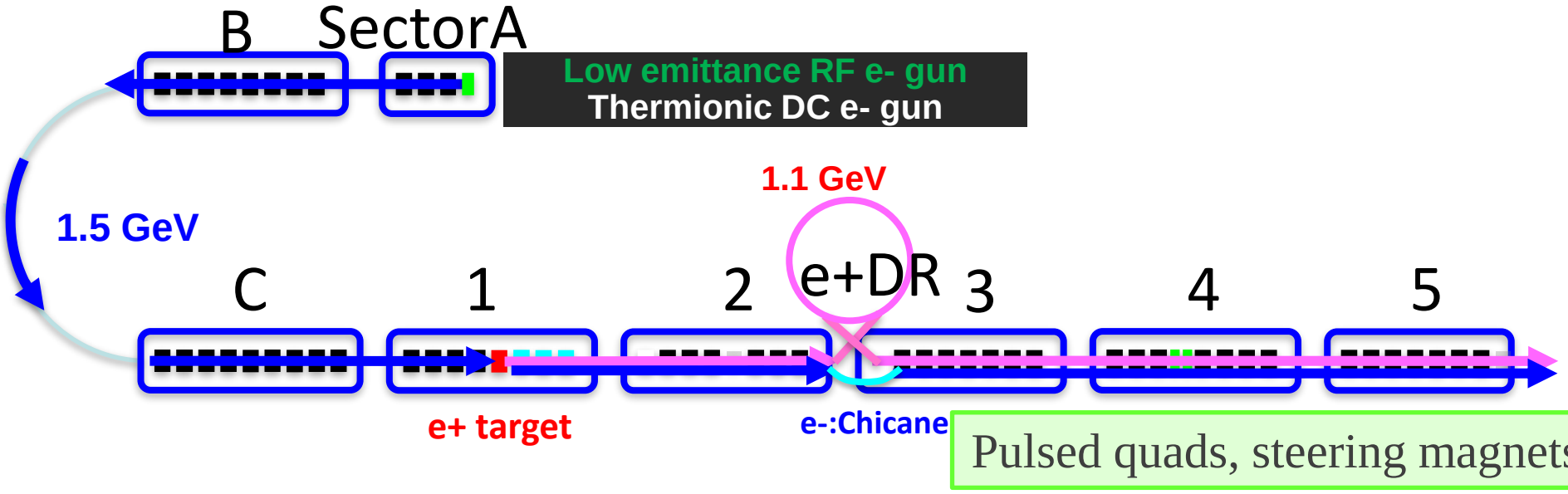
B2GM, 2021/2/8

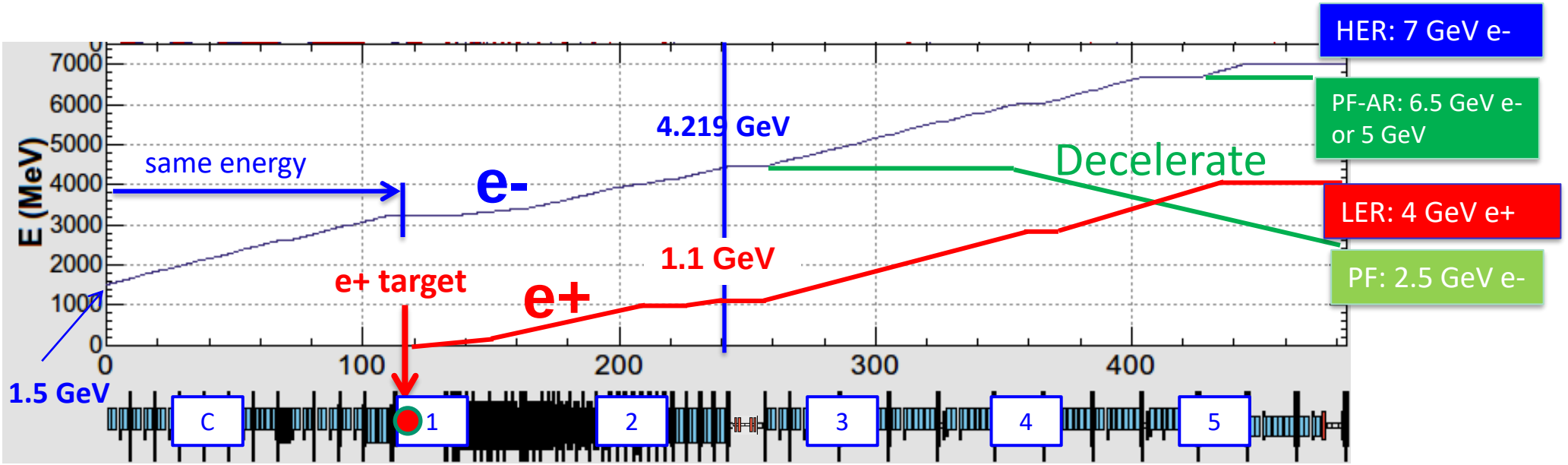
Contents

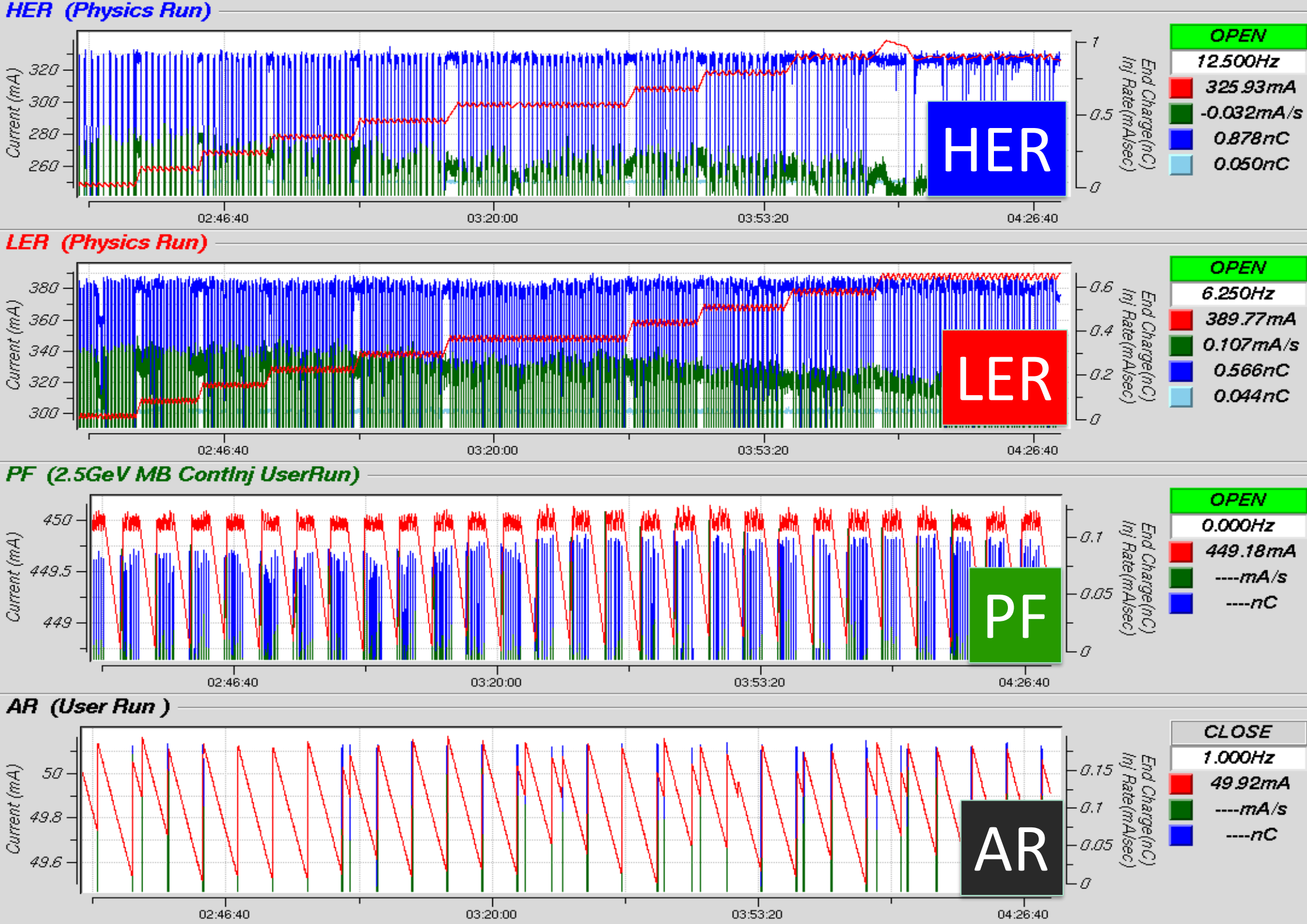
- Operation overview
- Recent progress
- New accelerating structure
- Summary

Injector: Simultaneous top-up to five rings

- Photocathode RF gun for HER injection
- Thermionic gun for LER (via DR), PF, PF-AR

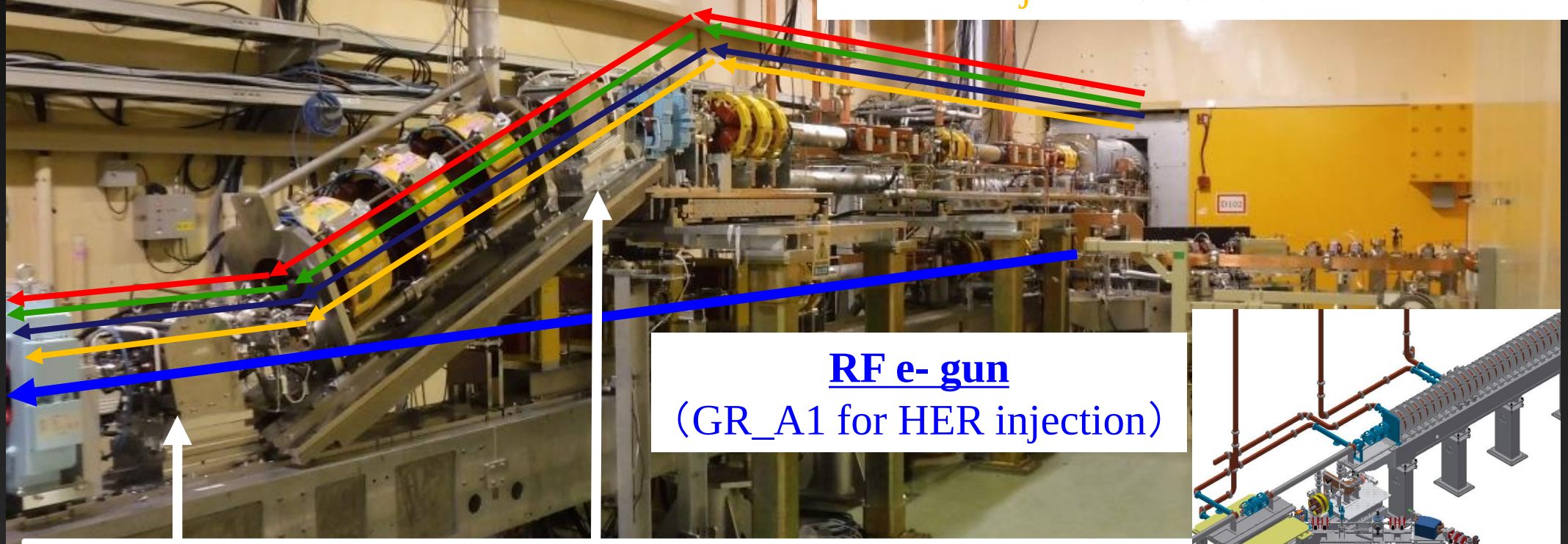





HER (Physics Run)
Current (mA)
320
300
280
260
02:46:40
03:20:00
03:53:20
04:26:40
End Charge(nC)
Inj Rate(mA/sec)
1
0.5
0
HER
OPEN
12.500Hz
325.93mA
-0.032mA/s
0.878nC
0.050nC
LER (Physics Run)
Current (mA)
380
360
340
320
300
02:46:40
03:20:00
03:53:20
04:26:40
End Charge(nC)
Inj Rate(mA/sec)
0.6
0.4
0.2
0
LER
OPEN
6.250Hz
389.77mA
0.107mA/s
0.566nC
0.044nC
PF (2.5GeV MB ContInj UserRun)
Current (mA)
450
449.5
449
02:46:40
03:20:00
03:53:20
04:26:40
End Charge(nC)
Inj Rate(mA/sec)
0.1
0.05
0
PF
OPEN
0.000Hz
449.18mA
----mA/s
----nC
AR (User Run)
Current (mA)
50
49.8
49.6
02:46:40
03:20:00
03:53:20
04:26:40
End Charge(nC)
Inj Rate(mA/sec)
0.15
0.1
0.05
0
AR
CLOSE
1.000Hz
49.92mA
----mA/s
----nC

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

Thermionic DC e- gun (GU_AT)
w/ 2 subharmonic bunchers and 2 bunchers
- e+ production e-: 10 nC (for LER injection)
- e- study/HER injection: 1 nC
- PF injection: 0.3 nC
- PF-AR injection: 0.3 nC



RF e- gun
（GR_A1 for HER injection）

Beam repetition of thermal gun limit: 25 Hz => 50 Hz
(LER + PF + PF-AR)
- Pulsed bends, chamber, DC quads were replaced. Two BPMs were newly installed in merger line for precise beam tuning. (magnet coil and chamber heating issues have been resolved.)

e- beam (rf gun) improvement

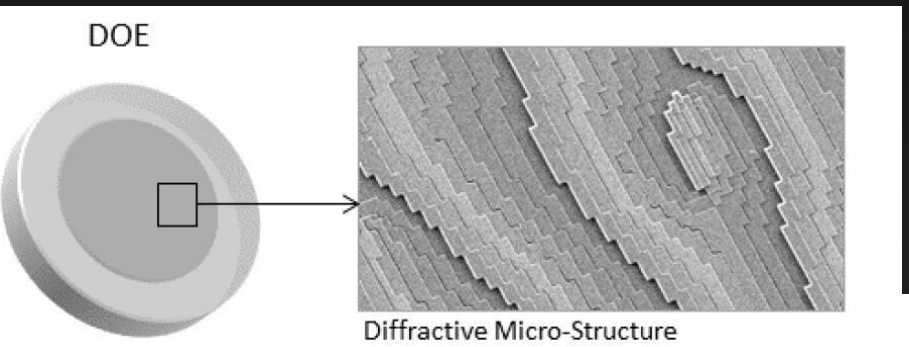
- Summer shutdown in 2020
  - Cathode (Ir_7Ce_2)
  - Cathode type: Backside electron irradiation heating cathode => original type
  - DOE in 1st laser line for reshaping transverse laser profile
  - Laser position feedback has been implemented.
  - Inter pulse laser cleaning has been implemented.

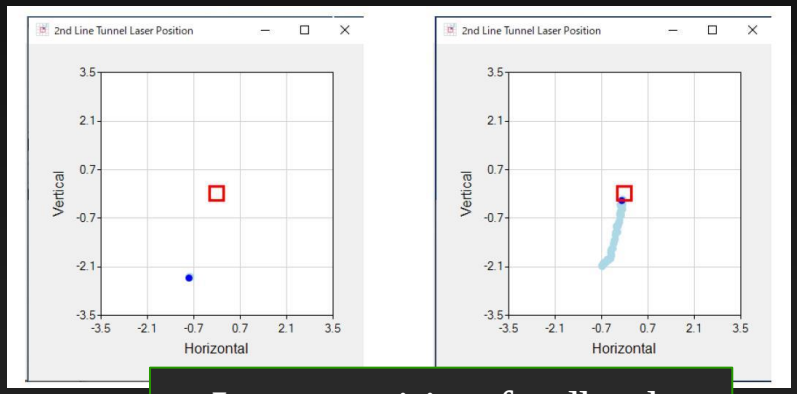
Reshaping of rf gun laser w/ DOE

- **D**iffractive **O**ptical **E**lement (DOE): Laser beam **homogenizer**

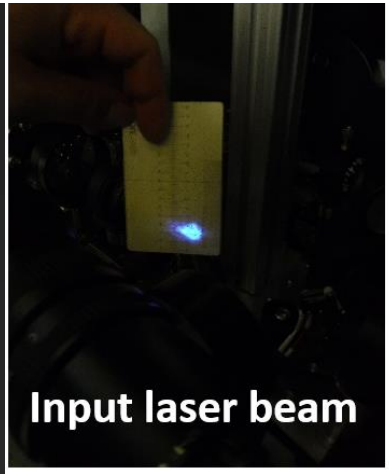
(DOE for UV laser is a world first.)

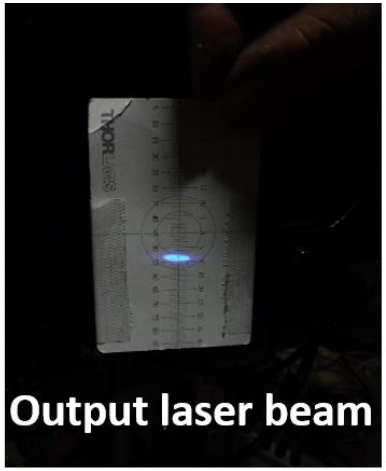
- Inside vacuum chamber (sensitive to dust). Laser power loss ~ 15%
- For 1st laser line only. 2nd laser line has not enough space.

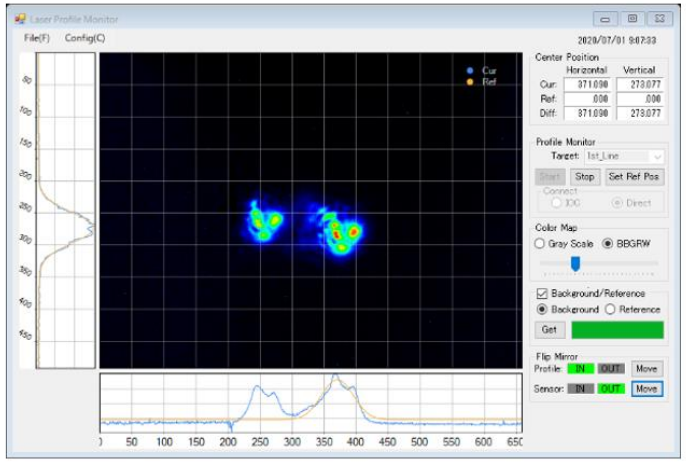


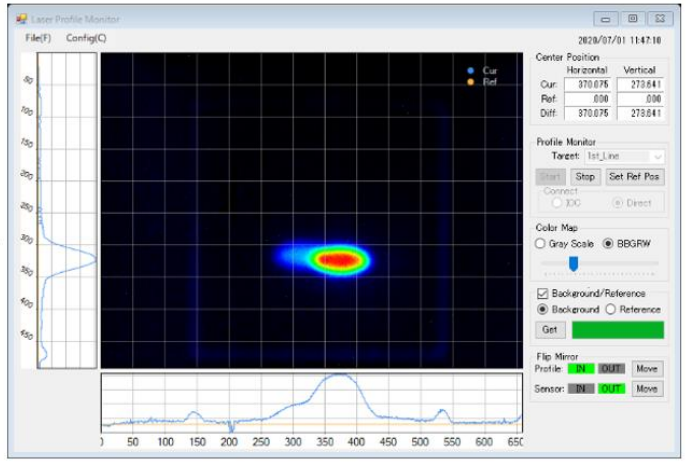


Laser position feedback



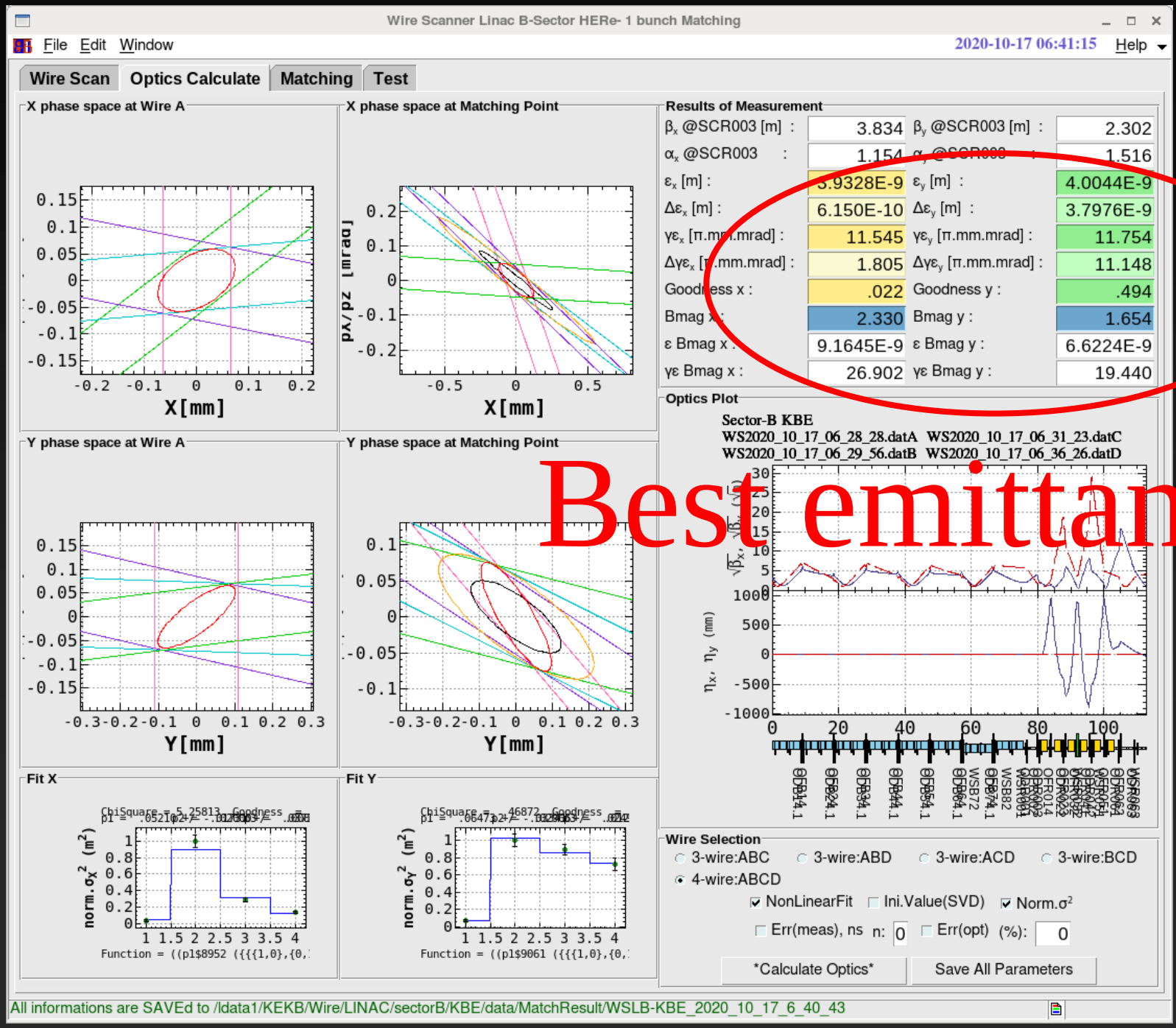






R. Zhang

Wire scanner (B-sector) @ 2 nC

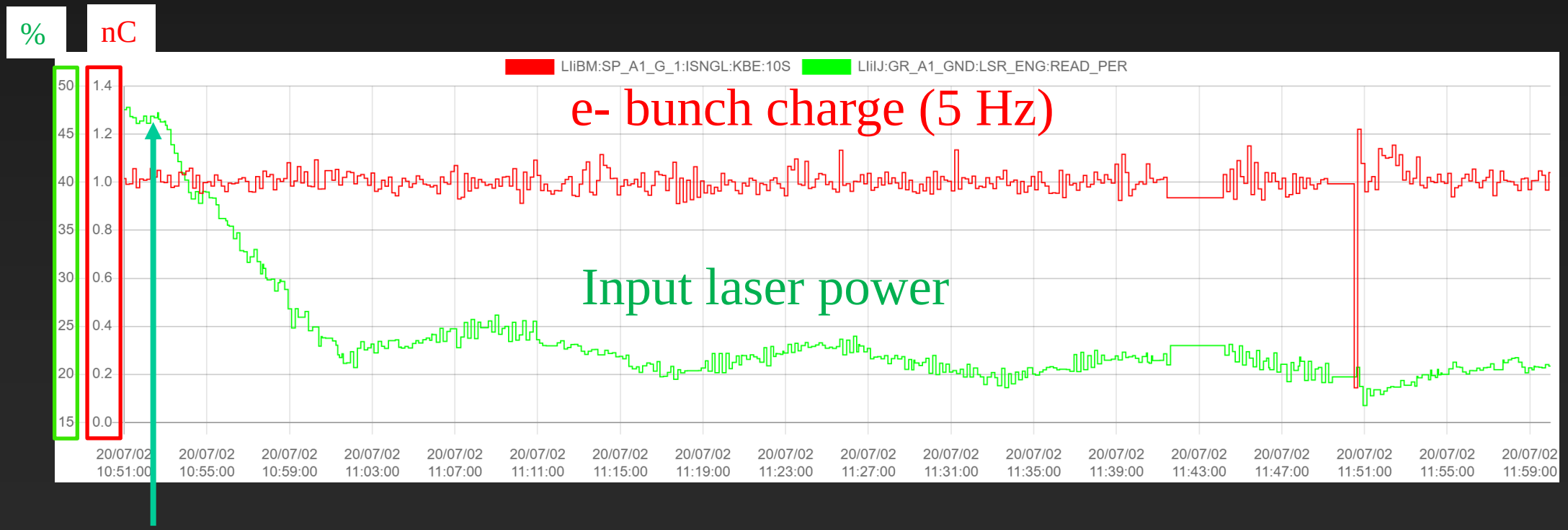


Best emittance

M. Yoshida

Inter pulse laser cleaning

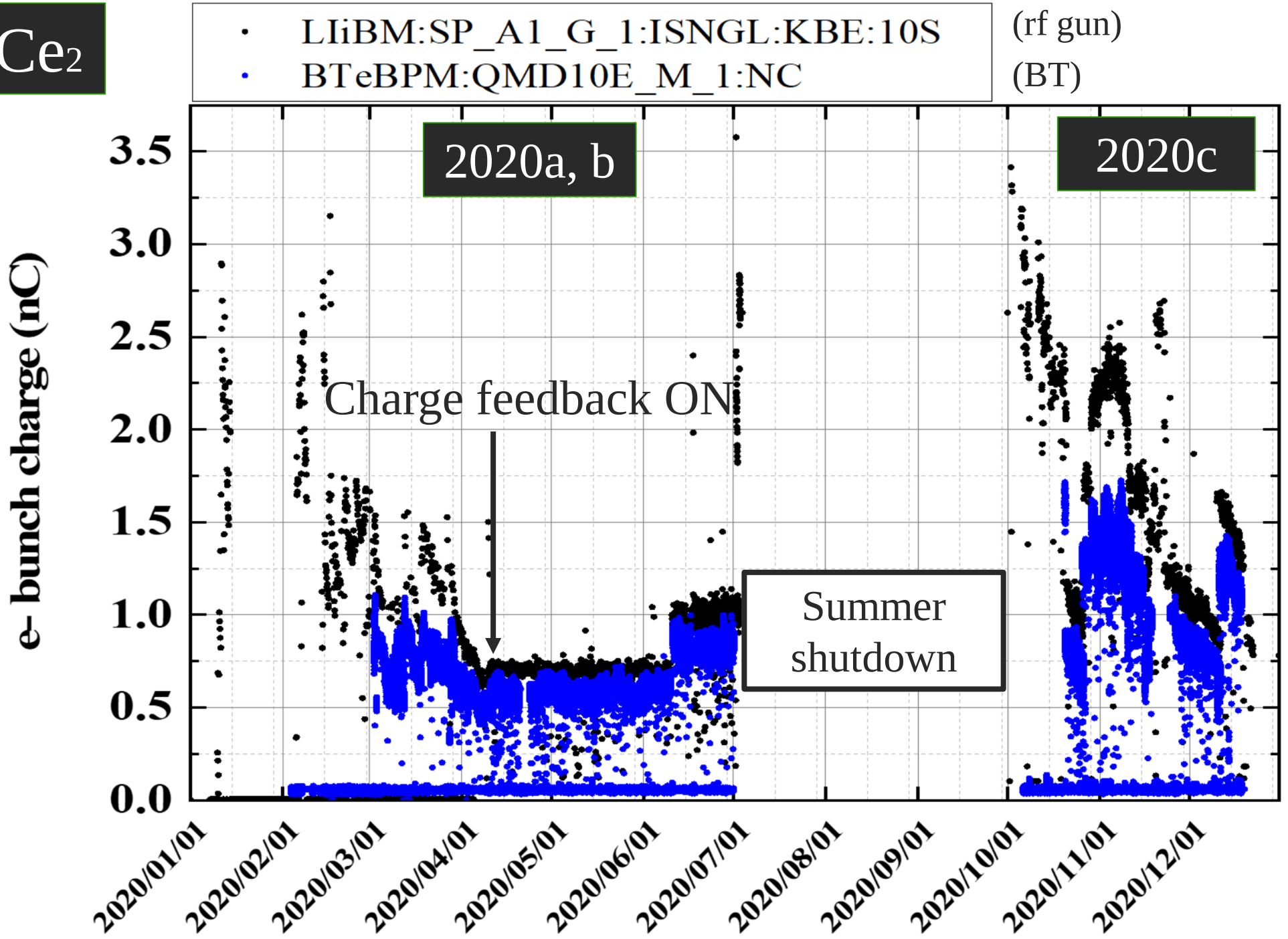
- Laser cleaning works fine for recovering Qe.
- Usually, it takes 30 min. ~ 1 hour. (every two weeks).
- Fast switching scheme between beam on (rf on) and laser cleaning (rf off) was tested (Jul. 2nd, 2020).
- In summer shutdown of 2020, this scheme was implemented for operation software.



Laser cleaning on (5 Hz)

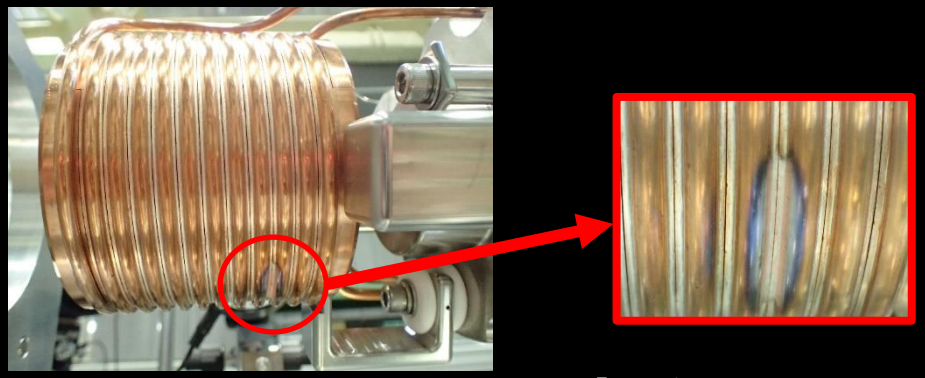
e- bunch charge (2020a, b, c)

Ir7Ce2



e+ beam improvement

- Flux concentrator (FC)
  - After large discharge in phase2, not possible to apply high voltage.



  - 2019/1 ～ 2020/6: 2.5 kA operation (design operation current: 12 kA)
  - New FC was developed w/ Cu alloy (NC50: Cu-Si-Ni) instead of oxygen free copper. It has worked fine in 2020c w/o any significant trouble.

- DC solenoid section in Sector1 (positron capture section)
  - DC steering magnets (x4) and BPMs (x4) have been installed for improving the beam loss in DC solenoid section.
  - Solenoid field is increased to design value.

FC assembly, base summary

	Phase 1	Phase 2	Phase 3	2019 autumn	2020 spring	2020 autumn	2021 winter～	delivery	removal	Present status（2020/6）	remark
Assembly 1								Before 2015	2017/3	Tunnel	
Assembly 2								2016/3		Beam line	
Assembly 3								2017/11		Test bench	
FC base 1								before 2015			Trial product
FC base 2								before 2015			Trial product
FC base 3								before 2015	2017/3	Assembly 1	
FC base 4									2018/9	Tunnel	
FC base 5								2016/7	2020/9	Beam line for operation	
FC base 6								2017/11		Reserved	Hardening (Toyama)
FC base 7*								2019/10		Finished long term test	
FC base 8**								2020/5		Under test	Final version modified
FC base 9**								2021/3		Under design	Final version spare

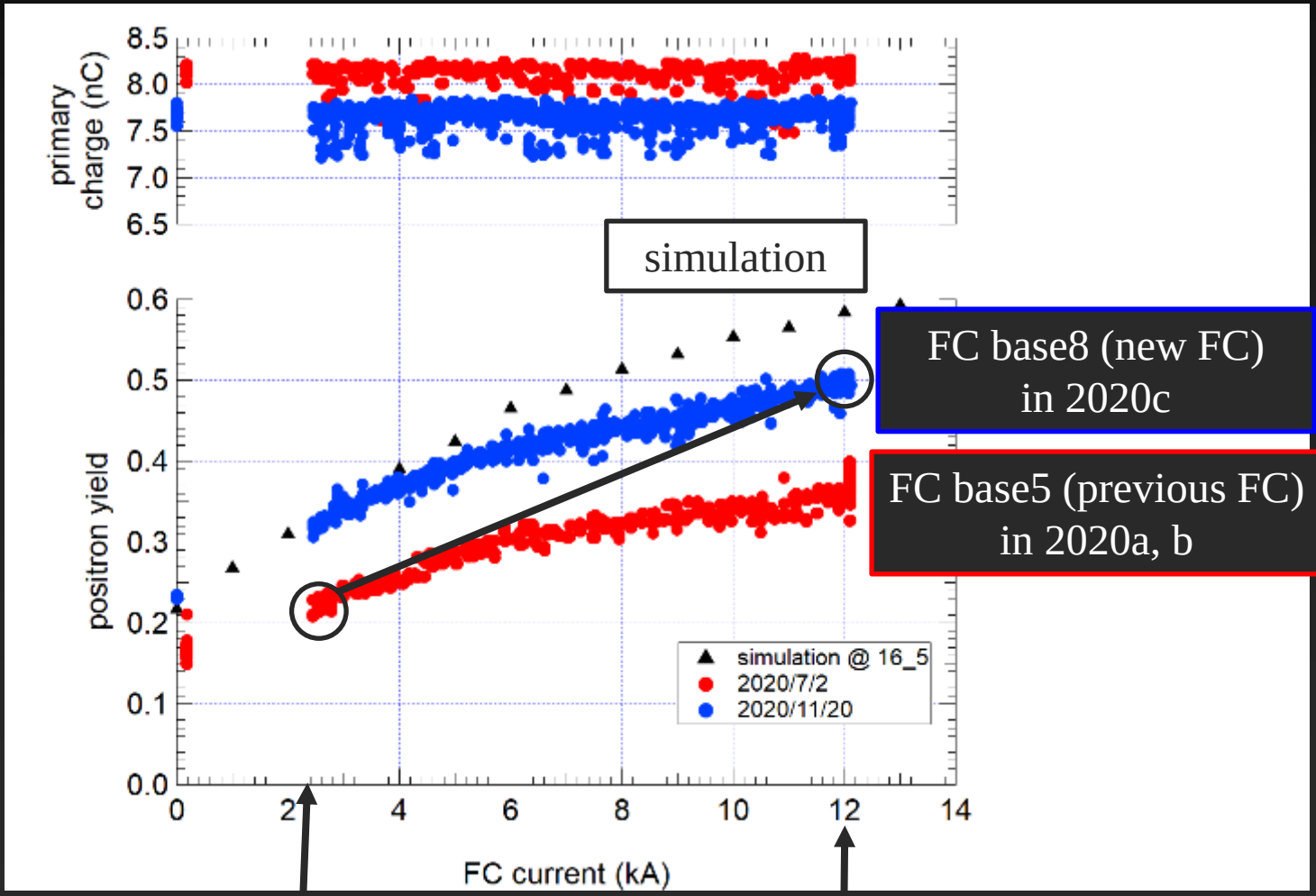
- *Base 7, 8, 9 (head : Cu → NC50, return yoke : SS400 → permendur)
- **Base 8, 9 Shape optimization (insulation, leakage magnetic field)

red : operation
blue : spare
black : test bench

Y. Enomoto

Positron yield improvement

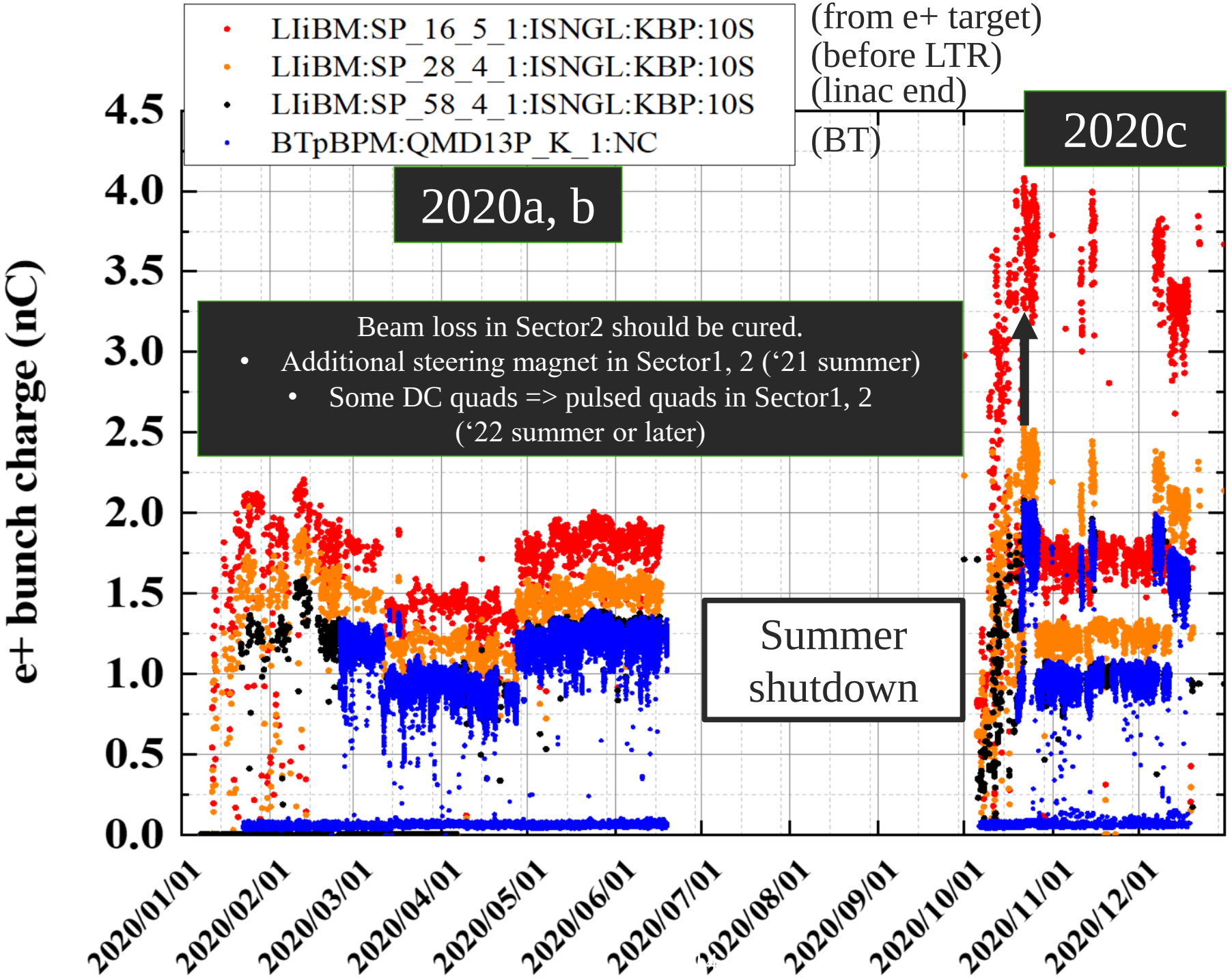
- Positron yield has been increased w/ new FC.
- Stable operation w/ design current (12 kA)



- New FC (design current)
- Steering magnets in solenoid section mitigate beam loss in DC solenoid section.
- DC solenoid current can be set at design value.

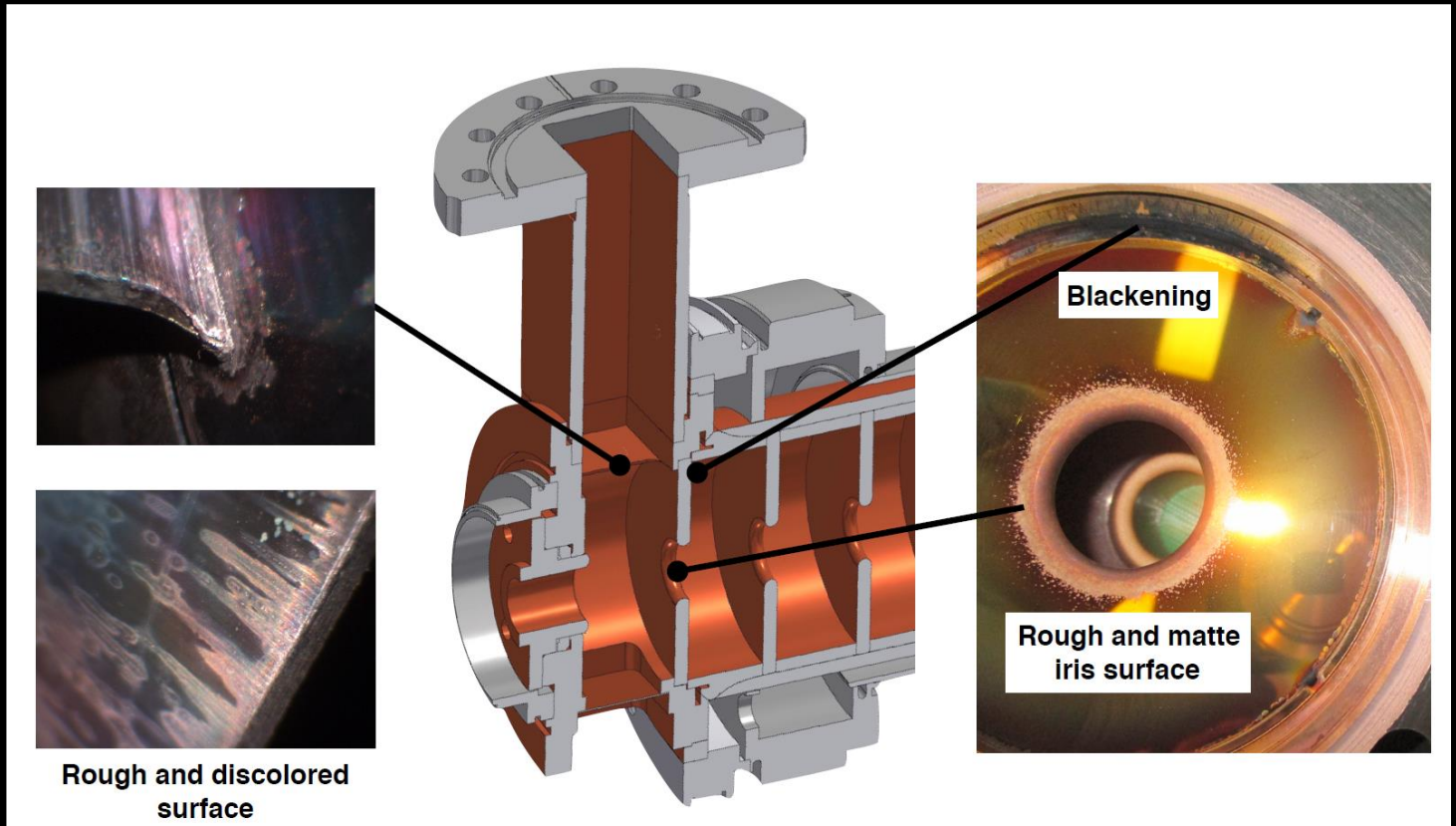
Y. Enomoto

e+ bunch charge history (2020a, b, c)



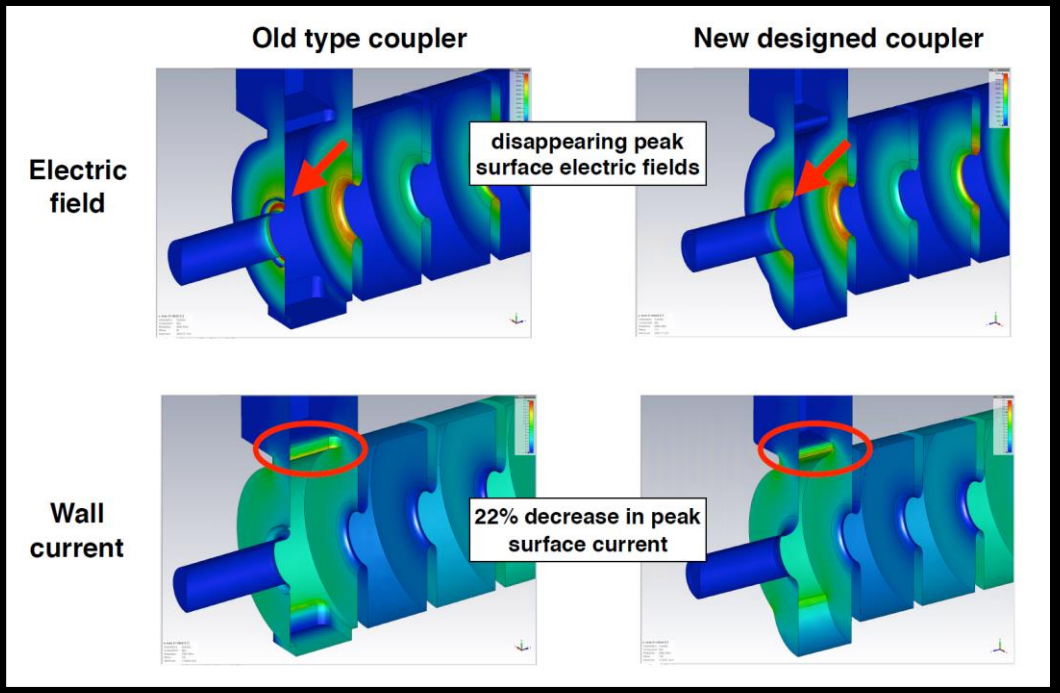
New accelerating structure (1)

- Old accelerating structures (fabricated 35 years ago) are deteriorated. (damaged coupler, water leakage). Designed for 8 MV/m (PF injector), now used at 20 MV/m since KEKB project.
- No good spare (Spares also suffer from power reflection and excessive field emission)
- Toward Y(6s), damaged structure should be replaced.



New accelerating structure (2)

- New structure has been developed. (improved coupler design)
- Unit energy gain is improved to 180 MeV from 160 MeV.
- In this winter (Jan.), one unit (Sector4) was replaced by new one. It works fine.
  - Three units will be installed in Jan. 2023 (FY2022).



H. Ego, B2GM, June 2019

- 10.75 GeV operation in 2021c
  (e+ : 4.071 GeV, e- : 7.124 GeV)
  - Linac: possible w/ 2 nC/bunch
  - BT: possible
    - e+ 4.290 GeV, e- 8.465 GeV (both coil heating limit)

Summary

- Simultaneous top up operation
- New vertical pulsed bends and chambers in SectorA can work up to 50 Hz. Before 2020c, it was limited up to 25 Hz (coil/chamber heating issue is fixed).
- e- beam
  - DOE, laser position feedback work fine.
  - 2 nC operation. Best emittance ~ 11 um @ SectorB
  - Inter pulse laser cleaning scheme was implemented.
- e+ beam
  - New FC works well
  - DC steering and BPM in solenoid section (Sector1)
- New accelerating structure (1 unit, 4 structures) in operation