SuperKEKB status report

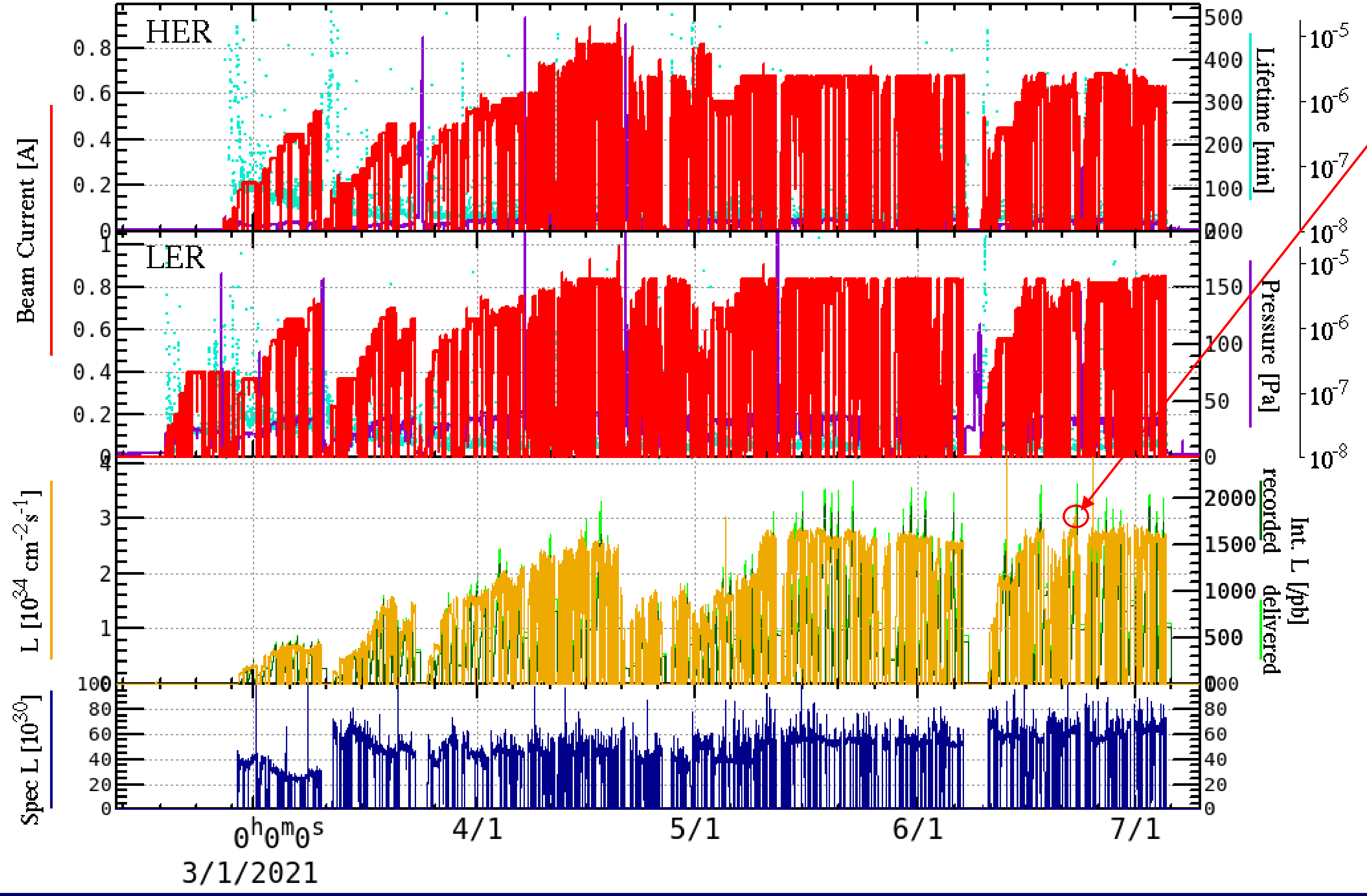
Kyo Shibata
(on behalf of SuperKEK Accelerator Group)

2021.10.18

40th B2GM Plenary Session

Overview of 2021ab run

2021ab run



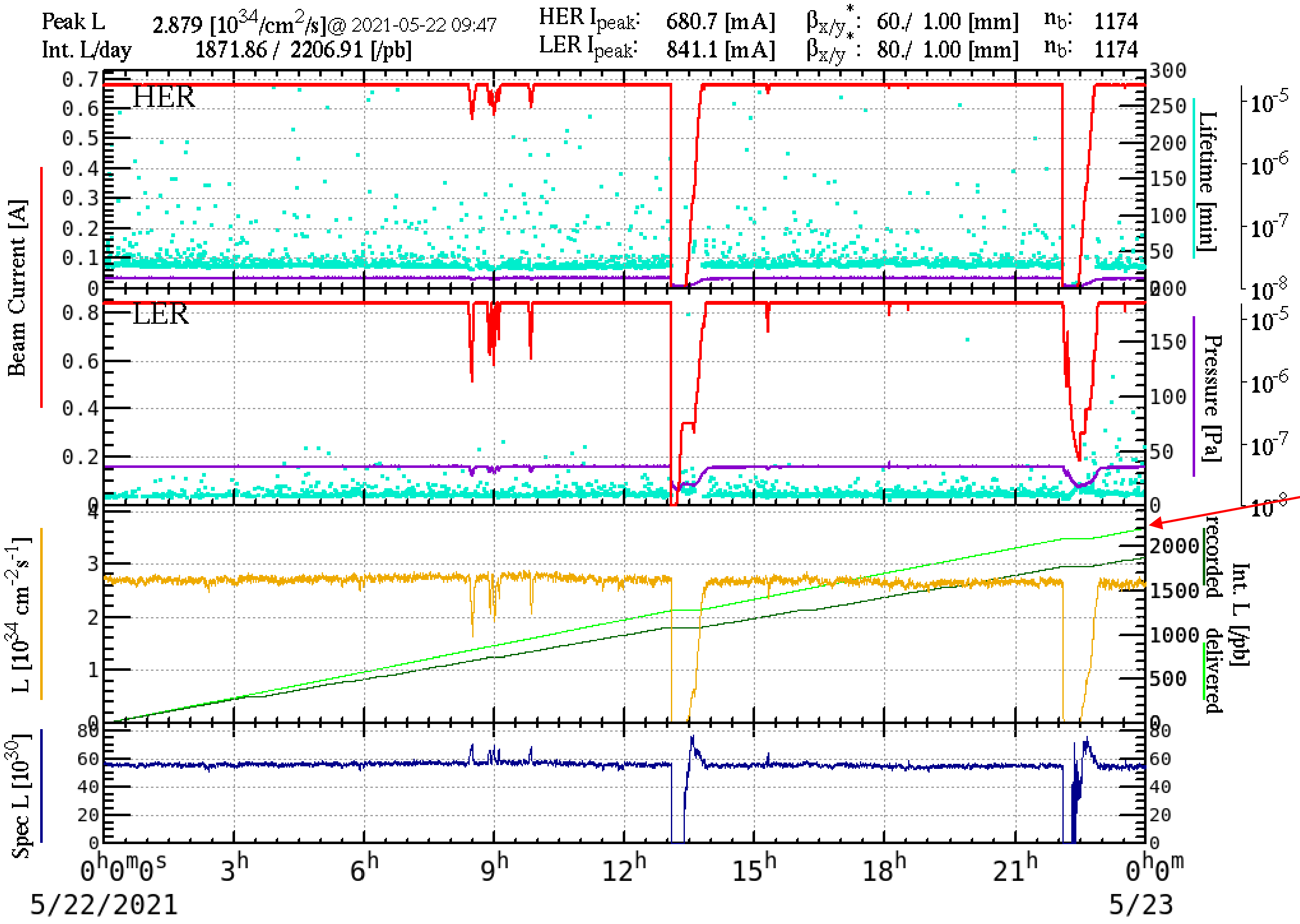
Luminosity record

Peak luminosity : 3.12×10^{34} cm^{-2}s^{-1}
(2021.6.22 18:30)

	int. L recorded	int. L delivered
Shift	747.2 pb^{-1} May 18 swing	797.6 pb^{-1} June 22 day
Day	1.964 fb^{-1} May 18	2.233 fb^{-1} May 22
7 days May 14 - 20	12.141 fb^{-1}	13.482 fb^{-1}
30 days May 18 - June 23	42.319 fb^{-1}	47.370 fb^{-1}
2021ab 140 days	123.2 fb^{-1}	138.6 fb^{-1}
total	213.5 fb^{-1}	

Y. Ohnishi (2021.09.01)
The 25th KEKB Accelerator Review Committee

Best day



Luminosity record

Peak luminosity : 3.12×10^{34} $cm^{-2}s^{-1}$

(2021.6.22 18:30)

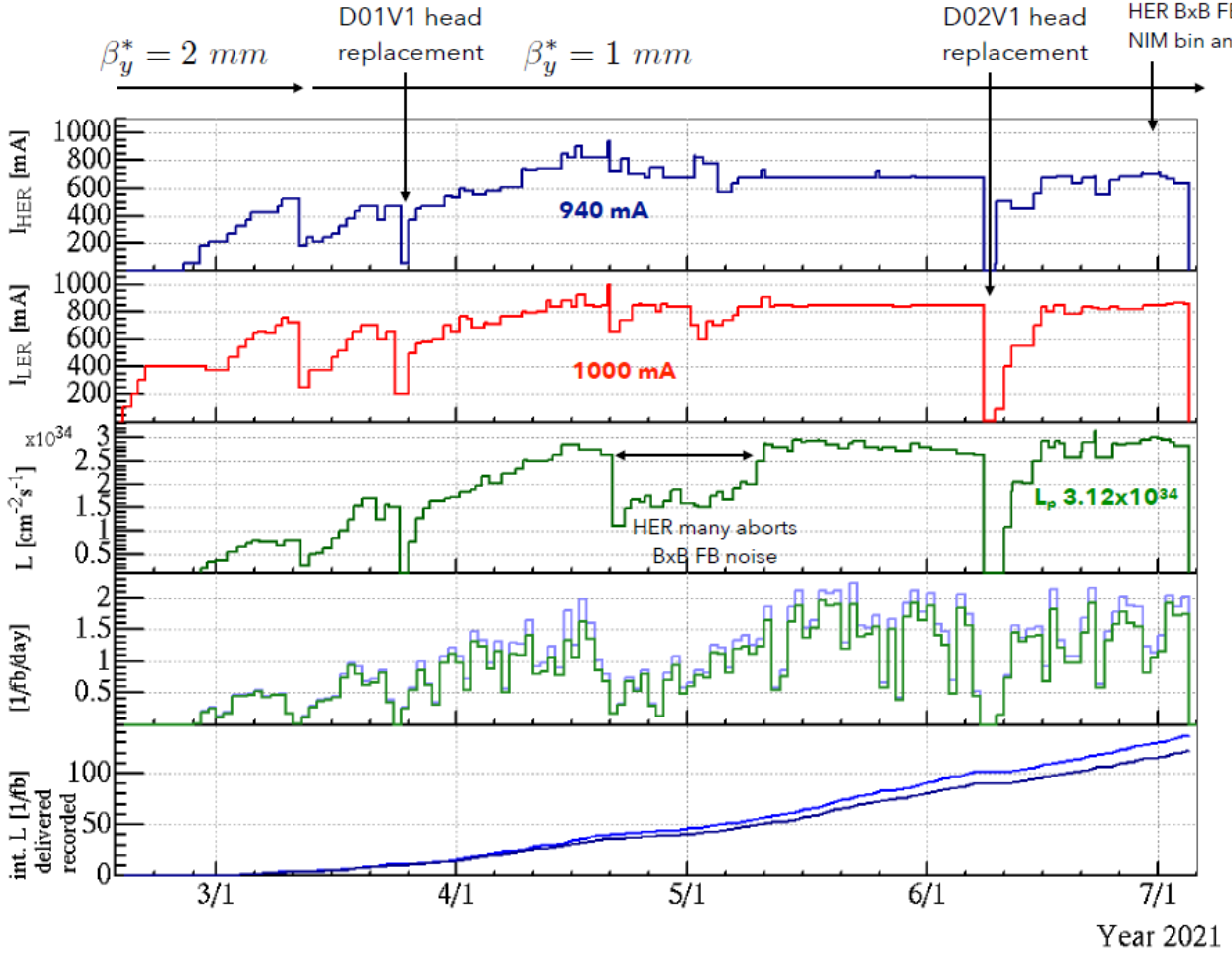
	int. L recorded	int. L delivered
Shift	747.2 pb^{-1} May 18 swing	797.6 pb^{-1} June 22 day
Day	1.964 fb^{-1} May 18	2.233 fb^{-1} May 22
7 days May 14 - 20	12.141 fb^{-1}	13.482 fb^{-1}
30 days May 18 - June 23	42.319 fb^{-1}	47.370 fb^{-1}
2021ab 140 days	123.2 fb^{-1}	138.6 fb^{-1}
total	213.5 fb^{-1}	

Y. Ohnishi (2021.09.01)
The 25th KEKB Accelerator Review Committee

Operation summary

Y. Ohnishi (2021.09.01)
The 25th KEKB Accelerator Review Committee

2021a/b Operation Summary



- The 2021a run started on 16th February and operated for 140 days (4 months and half).
- The first ten days were devoted to the vacuum scrubbing.
- We operated with β_y^* = 2 mm to check hardwares and to test high current operation safely.
- Calibrations of BPM and collimator head positions, etc. were also performed by using beams during the first two weeks.
- D01V1(HER) head was replaced. D01V1(HER) head was replaced. The top-jaw was for the LER collimator head and it was the short length in the HER. (March 23).
- We squeezed β_y^* down to 1 mm on 10th March. Beam currents increased with "baking run". 1000 mA / 940 mA w/o physics run
- HER many aborts from April 20 to May 3.
- D02V1(LER) head was replaced due damage (June 7).

5

Machine parameters

Machine Parameters (2020b and 2021b)

Y. Ohnishi (2021.09.01)
The 25th KEKB Accelerator Review Committee

	2020b : June 21, 2020		2021b : June 22, 2021		Unit
Ring	LER	HER	LER	HER	
Emittance	4.0	4.6	4.0	4.6	nm
Beam Current	712	607	790	687	mA
Number of bunches	978		1174		
Bunch current	0.728	0.621	0.673	0.585	mA
Lifetime	760	1270	540	1320	sec
Horizontal size σ_x^*	17.9	16.6	17.9	16.6	μm
Vertical cap sigma Σ_y^*	0.403		0.324		μm*1
Vertical size σ_y^*	0.285		0.229		μm*2
Betatron tunes ν_x / ν_y	45.523 / 43.581	44.531 / 41.577	44.524 / 46.596	45.532 / 43.581	
β_x^* / β_y^*	80 / 1.0	60 / 1.0	80 / 1.0	60 / 1.0	mm
Piwinski angle	10.7	12.7	10.7	12.7	
Crab Waist Ratio	80	40	80	40	%
Beam-Beam parameter ξ_y	0.039	0.026	0.046	0.030	
Specific luminosity	5.43×10^{31}		6.76×10^{31}		$cm^{-2}s^{-1}/mA^2$
Luminosity	2.40×10^{34}		3.12×10^{34}		$cm^{-2}s^{-1}$

*1) estimated by luminosity with assuming design bunch length
*2) divide *1 by √2

6

Specific luminosity (2021ab)

- Luminosity

$$L = \frac{N_+ N_- n_b f_0}{4\pi \sigma^*_{x,\mathrm{eff}} \sqrt{\varepsilon_y \beta^*_y}}$$

- Specific luminosity

$$L_{sp} = \frac{L}{I_{b+} I_{b-} n_b} \propto \frac{1}{\sqrt{\varepsilon_y \beta^*_y}}$$

σ^*_y

  - L_{sp} depends on $1/\sigma_y^*$.
  - L_{sp} doesn't depend on $I_{b+}I_{b-}$.

  - However, it was observed that L_{sp} decreases as $I_{b+}I_{b-}$ increases.

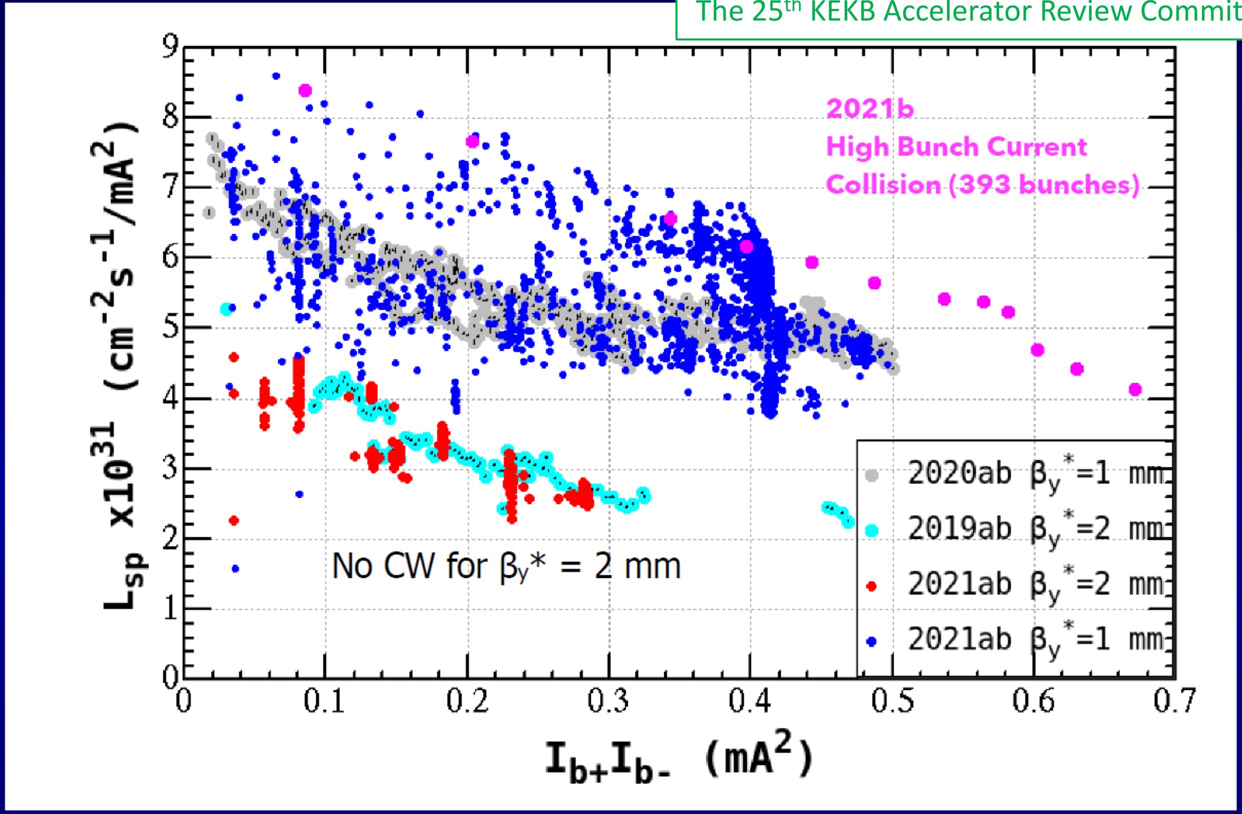
⇧

Beam blowup due to Beam-Beam effect at large $I_{b+}I_{b-}$.

Y. Ohnishi (2021.09.01)
The 25th KEKB Accelerator Review Committee

Definition of specific luminosity

$$L_{sp} = \frac{L}{n_b I_{b+} I_{b-}}$$



- Specific luminosity for β_y^* = 1 mm is improved compared to that of 2020ab.
- X-Y couplings at IP are improved by using local correctors with luminosity optimization.
- We also use chromatic X-Y coupling correctors.
- Bunch current product is achieved larger than 0.5 mA² with crab waist scheme.

Projection of specific luminosity in 2021ab

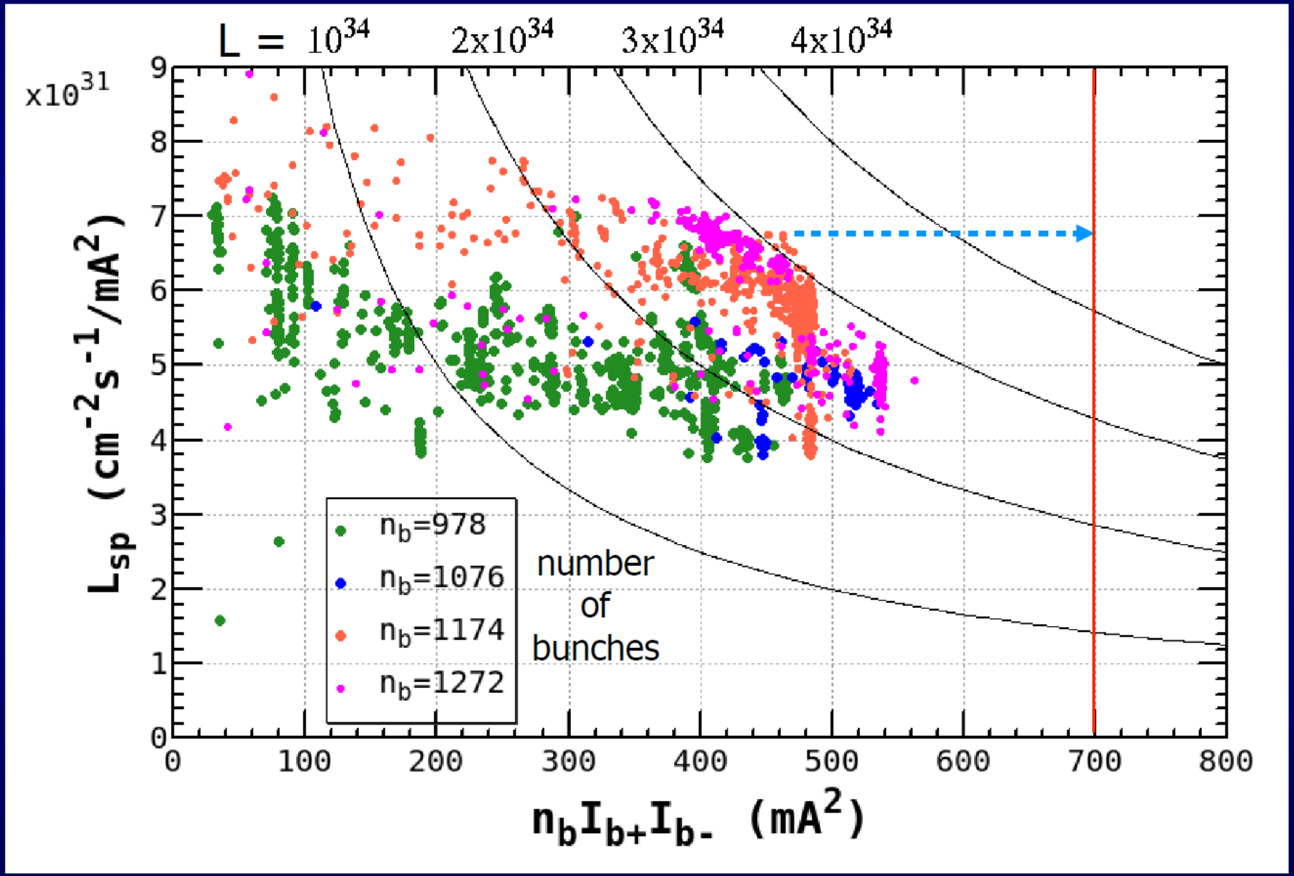
Projection of Specific Luminosity in 2021a/b

Y. Ohnishi (2021.09.01)
The 25th KEKB Accelerator Review Committee

Definition of specific luminosity $L_{sp} = \frac{L}{n_b I_{b+} I_{b-}}$

max of $n_b I_{b+} I_{b-}$ is 540 mA²
(840 mA/818 mA, n_b = 1272)

LER / HER : 1.1 A / 1.0 A
n_b = 1565
target of 2021b
700 mA²

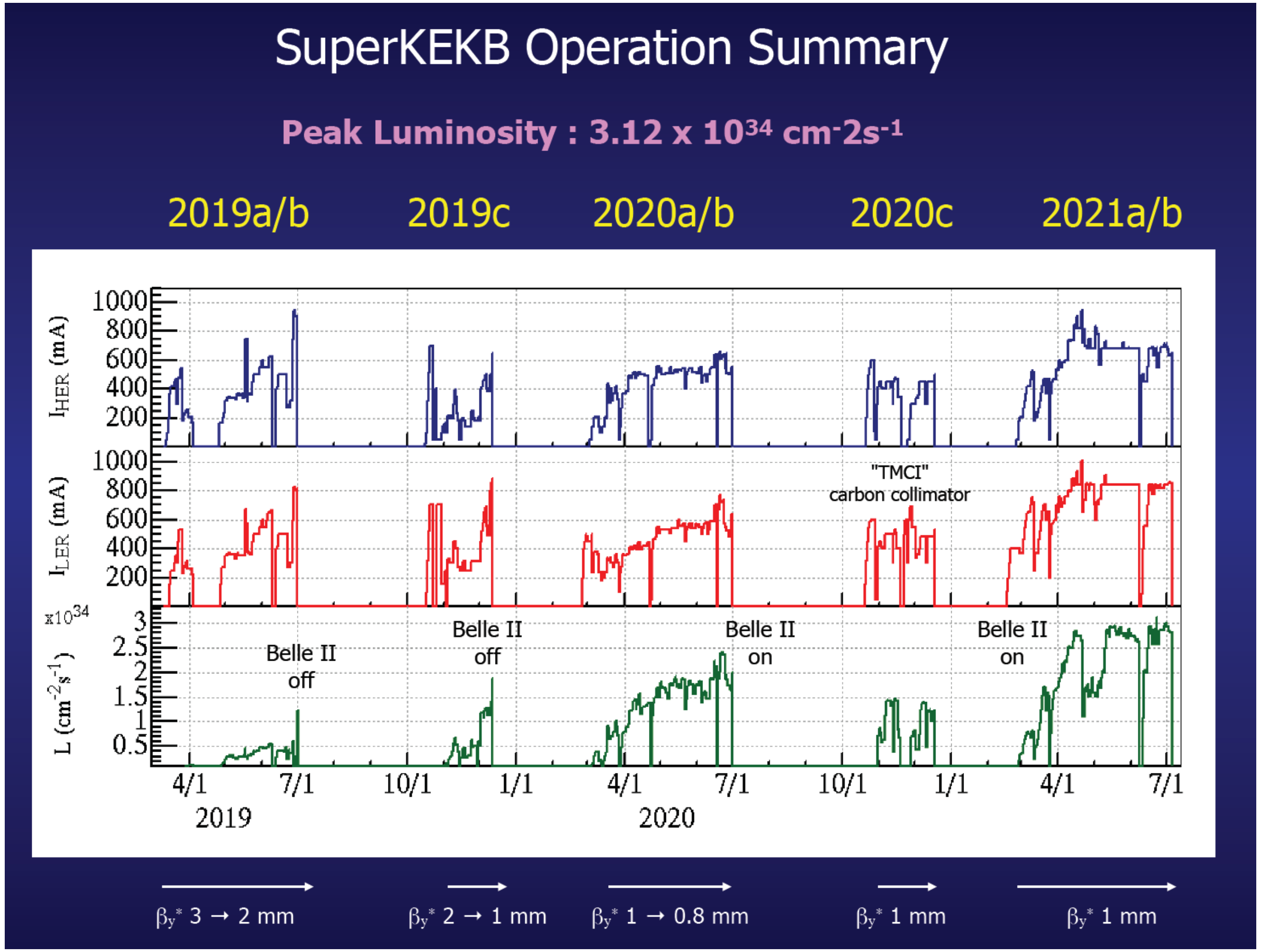


10

Difficulties in increasing beam currents

Y. Ohnishi (2021.09.01)
The 25th KEKB Accelerator Review Committee

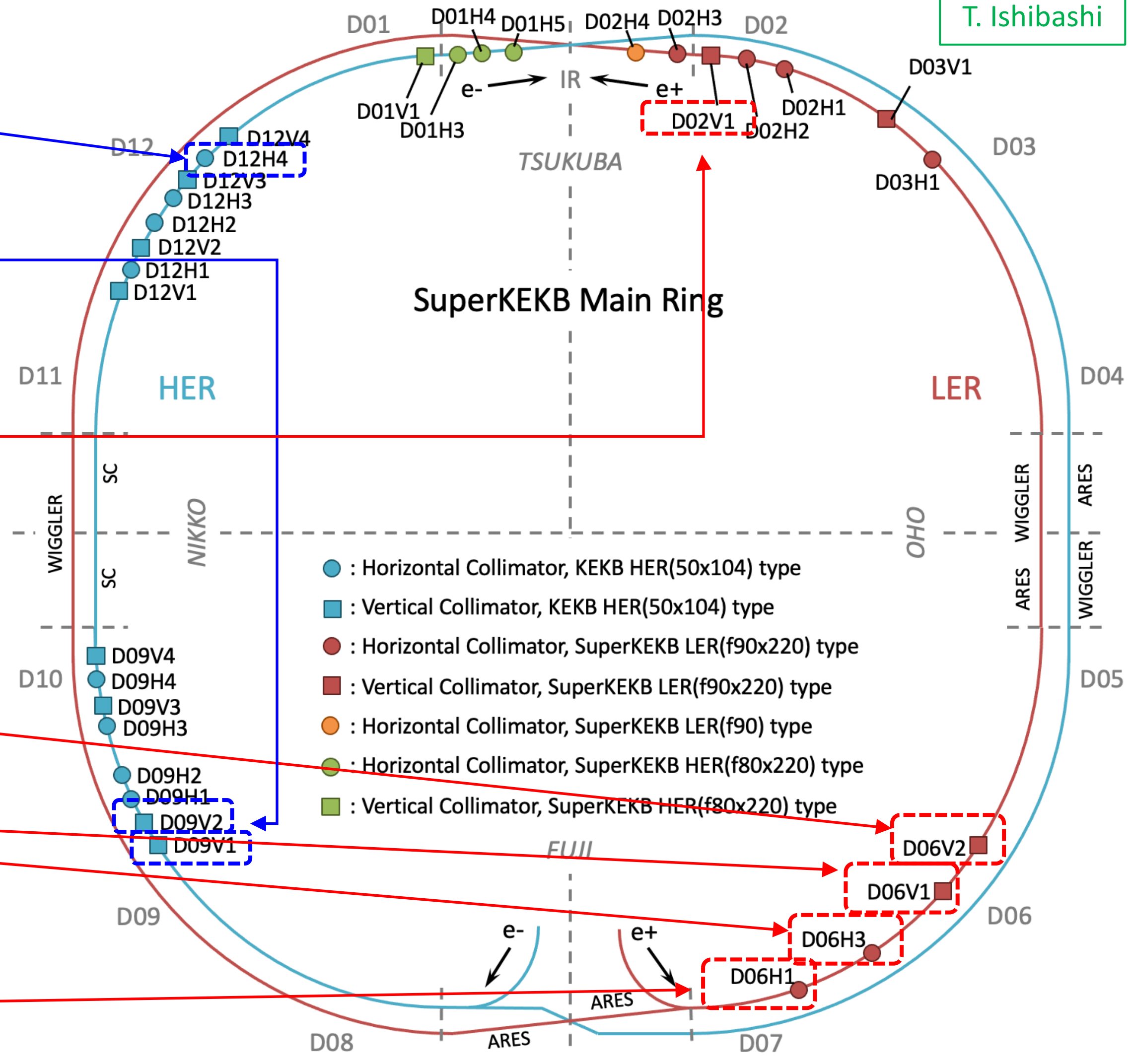
- It was hard to increase beam intensity.
  - Beam current
    $$L = \frac{N_+ N_- n_b f_0}{4\pi\sigma^*_{x,\mathrm{eff}}\sqrt{\varepsilon_y \beta^*_y}}$$ ≈ Beam current
    - ✓ Design values :
      (HER, LER) = (3.6 A, 2.6 A) @ 2500 bunches
    - ✓ Typical beam currents during 2021b :
      (HER, LER) = (~0.70 A, ~0.84 A)@ 1174 bunches
  - Reasons why the beam currents can not be increased
    - ✓ Short beam lifetime
      1. Narrow dynamic aperture (DA)
         - Beam-beam effect reduce DA.
         - Crab Waist (CW) collision scheme can suppress the reduction of beam lifetime.
         - It is necessary to optimize magnets for CW.
      2. Narrow physical aperture
         - It is necessary to narrow collimators to reduce the background noise in Belle 2.
    - ✓ Insufficient injector power
      - Injector power has not yet reached the design value.
    - ✓ Insufficient injection tuning？
      - Low injection efficiency especially in HER.
    - ✓ Unexplained sudden large beam losses
      - Operation with high currents increases the risk of damage to Belle2 and collimators.



Collimator works during summer shutdown

- HER
  - Upgrade of D12V4 driver unit
    - Not vacuum work. For precise jaw position control.
  - Damaged jaw replacement;
    - D09V2 : Replaced with new jaws
    - D09V1 : Replaced with new jaws
- LER
  - Relocation of D02V1
    - In order to match the betatron phase at D02V1 and QC1RP (superconducting final focusing magnet)
    - We will be able to open D02V1 wider and suppress TMCI.
  - Damaged jaw replacement;
    - D06V2 :Replaced with new hybrid-type jaws
      Robustness of hybrid-type jaws will be tested.
    - D06V1 :Replaced with new jaws
    - D06H3 : Damaged due to accidental kicker-pulser misfiring.
      Since we have no spare jaws, damaged jaws were replaced with healthy D06H1 jaws.
    - D06H1 :Replaced with short-stroke jaws.
      Minimum aperture is limited to ±14 mm.

T. Ishibashi

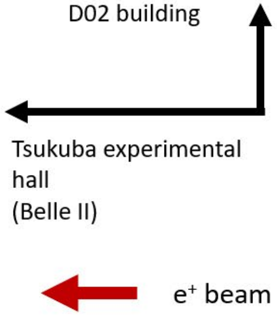


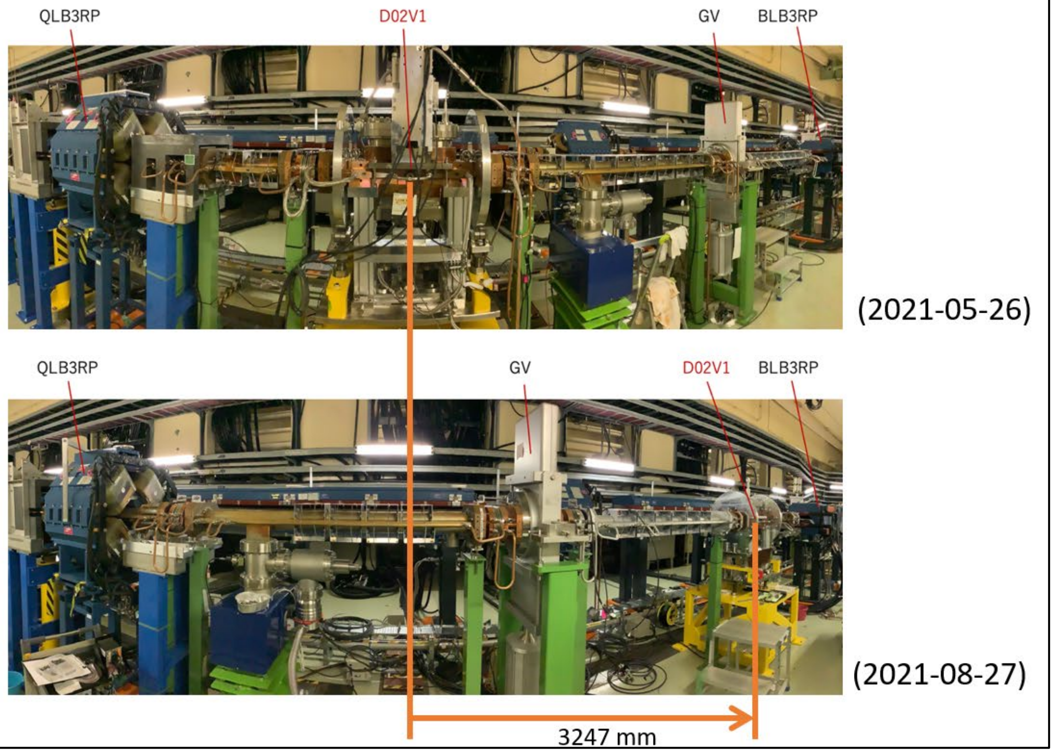
Relocation of LER D02V1 collimator

T. Ishibashi (2021.09.30)
MDI taskforce meeting

LER - Relocation work of D02V1

- Phase matching between D02V1 collimator and QC1RP in LER as much as possible by moving the collimator.
- We moved D02V1 3247 mm by the reconstruction of the existing components and baked it and the peripheral components.





- Expected effect;
  - Due to better phase matching with QC1RP, D02V1 relocation reduces IR backgrounds by ~20% and ~50% for Touschek and Coulomb components, respectively.
  - Physics run with wider collimator aperture will be possible.
  - TMCI bunch current limit will be relaxed.

⇩

  - Increasing beam intensity and luminosity

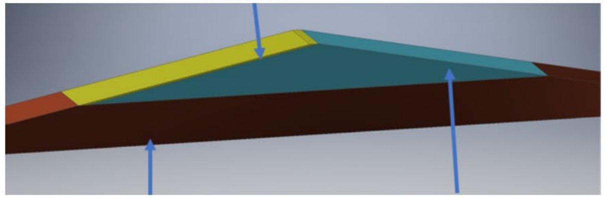
Robust hybrid-type collimator

- Robust hybrid-type jaws were installed into LER D06V2.
  - Conventional jaw material (High-Z)
    - Tantalum (Ta), Tungsten(W)
    - Short radiation length, short jaw length
    - Low impedance, large TMCI bunch current limit
    - Easily damaged
  - Low-Z collimator
    - Carbon (C)
    - High melting point
    - Long radiation length, long jaw length
    - High impedance, low TMCI bunch current limit
    - Hardly damaged
    - Limited beam current in 2020c
  - Robust Ta-C hybrid-type jaw
    - Adopting good points of both High-Z and Low-Z material
    - Thin Ta part can cut beam halo.
    - Carbon base is hardly damaged.
    - Low impedance, large TMCI bunch current limit

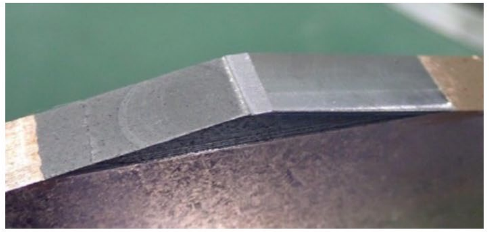
Plan – Replacement of the damaged jaws, installation of hybrid type jaws

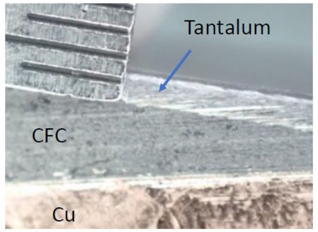
- We plan to replace the damaged jaws of D06V2 with hybrid type jaws, which has carbon and tantalum at the tip in order to improve the robustness regarding to the beam hit, for the test purpose.

Model



Actual





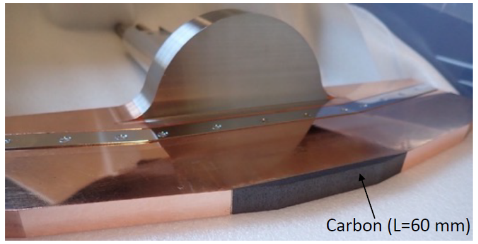
31

Issue – Low-Z collimator

- Materials with a short radiation length is very effective as a beam tail shield, however the beam loss is localized and the temperature of that exceeds the melting point.
- In order to protect the collimators for BG suppression from abnormal beams, we developed a collimator with carbon*.

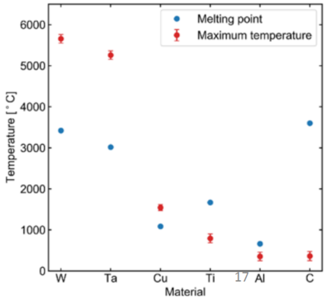
* Glass like carbon coated and impregnated C/C composite (GCX2002-U_GP2B, Toyo Tanso Co.,Ltd.).

  - Tested: bonding test, tensile test, impregnation/coating test for dust and outgassing reduction, RF absorbing test(2.45 GHz, 5.04 GHz), radiation degradation and so on
- Installed in a existing collimator (D06V1) during 2020 summer shutdown and worked for BG suppression during 2020c, however removed during 2021 winter shutdown because of the impedance problem.



Carbon jaw installed in D06V1.

Maximum temperatures within 1 RL and melti points (e+, 4 GeV. D: 0.5 mm, 50 mA, FLUKA).



17

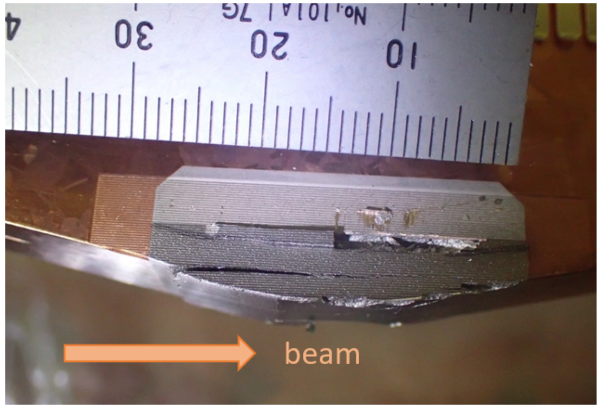
T. Ishibashi (2021.09.01)
The 25th KEKB Accelerator Review Committee

Injection kicker-pulser misfiring

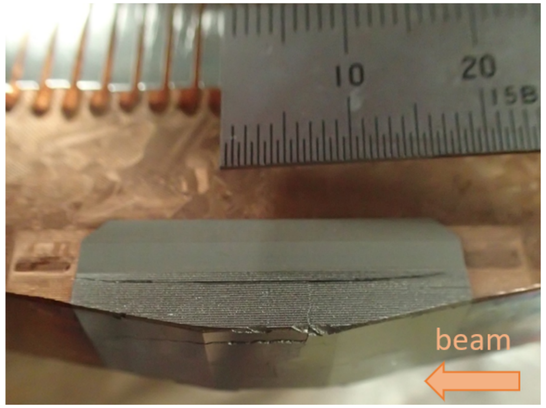
T. Ishibashi (2021.09.30)
MDI taskforce meeting

LER - Replacement work of D06H3

- D06H3 collimator has used for the protection from the accidental firing, and it was severely damaged.
- We replaced them with healthy ones during this summer shutdown.
  - We don't have the spare jaws for D06H3 collimator. Thus, we removed jaws of D06H1 and installed them into D06H3.
  - We installed new jaws into D06H1 instead, however the length of the jaws is short for this collimator. The minimum aperture of D06H1 is ±14 mm.
  - We're staring to manufacture the spare jaws made of tantalum, and it'll be delivered till the beginning of next Jan.
- For the countermeasure of the accidental firings, Mimashi-san has replaced all of the thyratrons with another ones, which have higher breakdown voltage, during this summer shutdown.



D06H3 IN (~700 μSv/h)



D06H3 OUT (~320 μSv/h)

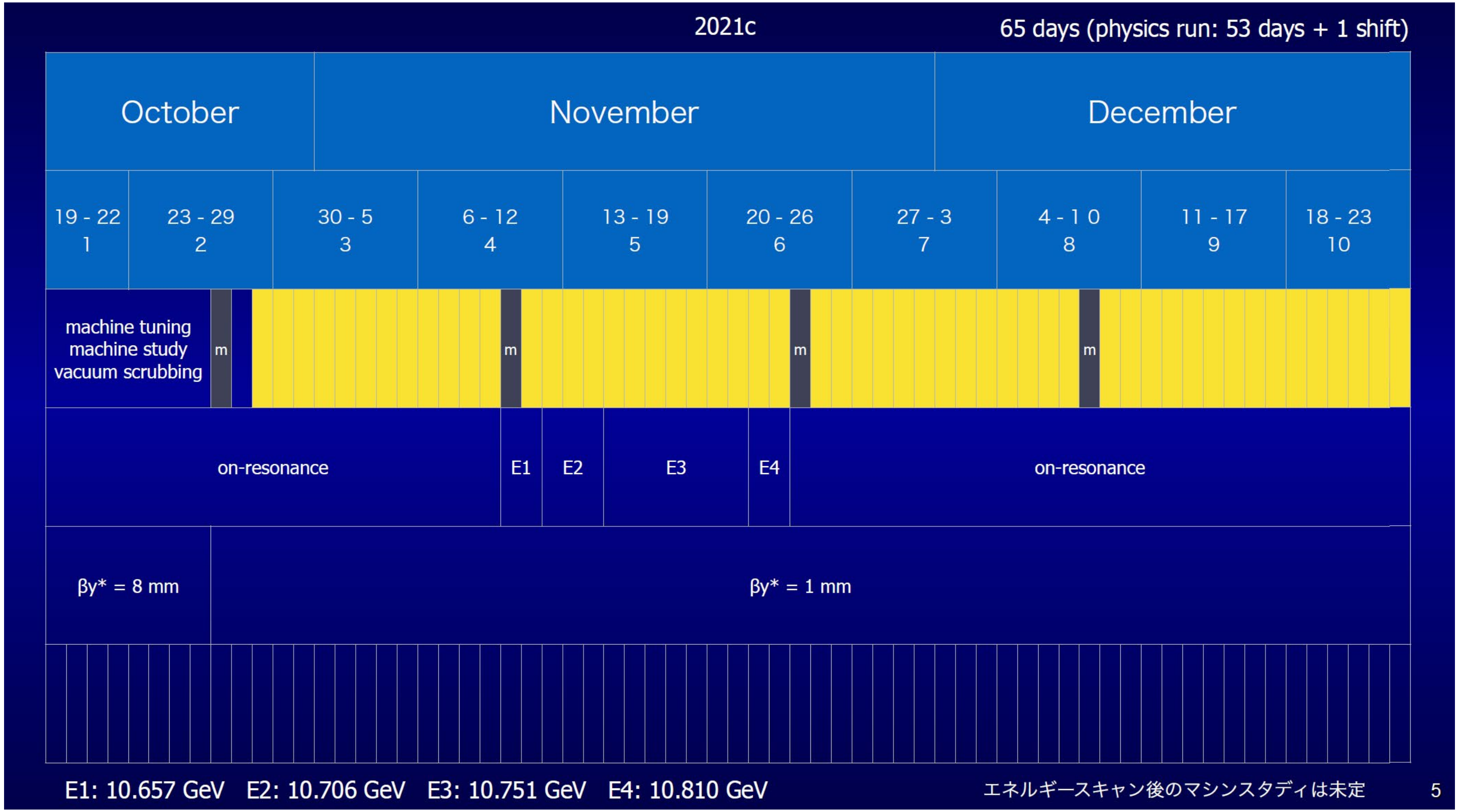
- Countermeasure;
  - Thyratrons for LER kickers were replaced with the equivalents of those for HER kickers.
  - So far, HER has not had kicker-pulser misfiring.

⇩

  - LER will also have no kicker-pulser misfiring in the future.

2021c operation plan

- First half;
  - Machine tuning & study:
    - HER beam injection
    - TMCI
    - Beam-beam effect
    - LER crab waist
  - On-resonance run
  - Energy scan:
    - 10.657 GeV
    - 10.706 GeV
    - 10.751 GeV
    - 10.810 GeV
  - β_y^* squeezing:
    - β_y^* = 1mm
- Second half;
  - On-resonance run with 1mm-β_y^*
  - Machine study plan is under consideration.



Y. Ohnishi (2021.10.8)
KCG meeting

2021c start-up schedule

Y. Ohnishi (2021.10.8)
KCG meeting

	October						
	16 (Sat)	17 (Sun)	18 (Mon)	19 (Tue)	20 (Wed)	21 (Thu)	22 (Fri)
C: Owl				Target of scrubbing LER: 50Ah HER: 20-30 Ah	LER vacuum scrubbing β_y^* = 8 mm	LER vacuum scrubbing HER vacuum scrubbing β_y^* = 8 mm	LER vacuum scrubbing HER vacuum scrubbing β_y^* = 8 mm
A: Day			Linac/BT/DR study	KCG meeting 9:00 - MR/BT patrol (1h)	HER starts HER β_y^* = 8 mm (or detuned optics) Find COD HER BCM	sextupole orbit optics correction	
				LER starts LER β_y^* = 8 mm (or detuned optics) Find COD LER BCM	HER optics correction HER BPM gain mapping HER abort check HER injection tuning	QKSLY calibration	Find collision bucket Beam-Beam scan (H)
B: Evening				LER optics correction LER BPM gain mapping LER abort check LER injection tuning	HER injection tuning HER QuadBPM	LER collimator tuning LER injection tuning	Beam-Beam scan (V)
				LER injection tuning LER QuadBPM		HER collimator tuning HER injection tuning	

24

2021c start-up schedule

Y. Ohnishi (2021.10.8)
KCG meeting

	October						
	23 (Sat)	24 (Sun)	25 (Mon)	26 (Tue)	27 (Wed)	28 (Thu)	29 (Fri)
C: Owl	LER vacuum scrubbing HER vacuum scrubbing β_y^* = 8 mm	LER vacuum scrubbing HER vacuum scrubbing β_y^* = 8 mm	LER vacuum scrubbing HER vacuum scrubbing β_y^* = 8 mm	LER vacuum scrubbing HER vacuum scrubbing β_y^* = 8 mm	LER vacuum scrubbing HER vacuum scrubbing β_y^* = 8 mm	LER vacuum scrubbing HER vacuum scrubbing	physics run 450 mA / 360 mA n_b = 783
A: Day	LER vacuum scrubbing HER vacuum scrubbing	LER vacuum scrubbing HER vacuum scrubbing	injection study	TMCI threshold with changing coll. aperture single bunch tune shift	maintenance	HER β_y^* = 8 → 3 → 2 → 1 mm CW 40 % HER optics correction	physics run 550 mA / 440 mA n_b = 783
			injection study	TMCI threshold with changing coll. aperture single bunch tune shift		HER injection tuning HER collimator tuning	
B: Evening	LER vacuum scrubbing HER vacuum scrubbing	LER vacuum scrubbing HER vacuum scrubbing	injection study	injection study	LER β_y^* = 8 → 3 → 2 → 1 mm CW 80 % LER BPM gain mapping LER optics correction	collision tuning Beam-Beam scan 300 mA / 300 mA	
			injection study	injection study	HER β_y^* = 8 mm HER BPM gain mapping LER injection tuning LER collimator tuning	collision tuning 450 mA / 360 mA n_b = 783	

3 shifts 25

Major challenges

Y. Suetsugu (2021.09.02)
The 25th KEKB Accelerator Review Committee

Challenges recognized in recent commissioning

- To improve the machine further to achieve the goal, however, various challenges as follows should be solved:

1) Severe beam-beam effect (vertical beam size blow-up)
   - Vertical beam size (vertical emittance) blow-up has been observed at high bunch currents.
   - Relaxed by the crab-waist collision scheme, but it still remains.
2) Shorter beam lifetime than expected in the design phase.
   - The maximum bunch currents are limited by the balance between the lifetime and the injection power.
   - The dynamic aperture is very small due to the beam-beam effect and crab-waist sextupoles, while the physical aperture is limited by the beam collimators.
3) Lower bunch-current limit due to TMCI than expected.
   - The cause is higher impedance of beam collimators, where the apertures are smaller than the design values to suppress high background to Belle II.
4) Low machine stability
   - Abnormal beam aborts, sometimes leading to the damage of collimators.
   - Operation efficiency during 2021ab, for example, was almost 0.5, lower than expected one, 0.65. (Main causes: machine tunings, machine troubles, maintenance, etc.).
5) Aging of hardware and facilities, and so on.

2021/9/2 4

- Upgrade to overcome these challenges are under consideration now.

+ 6) Low injection efficiency especially in HER.

International Task Force

- KEK has assembled a powerful International Task Force to address the challenges of the upgrade.
  - ITF has held three meetings so far;
    - July 28 : kick-off meeting.
    - Sep. 2 : Joint meeting with ARC meeting
    - Oct. 15 : third meeting
  - ITF has four subgroups at this point;
    - Beam-beam, optics, TMCI, Linac
- Deep discussions are actively conducted by each subgroup.
  - Beam-beam subgroup meeting;
    - Aug 24th, Sep. 28th, Oct. 28th
  - TMCI subgroup meeting;
    - Aug. 27th, Sep. 2nd, Oct. 1st
  - Optics subgroup meeting;
    - Sep. 22nd, Oct. 13th
  - Linac subgroup
    - Just starting its activity
    - Gathering the members

International Task Force (ITF) for SuperKEKB

From Y. Suetsugu's slides

Task force — KEK 2021

- Charges
  - Consider effective ideas to realize luminosity of ~6x10^{35} cm^{-2} s^{-1} as a result of an intermediate upgrade around 2026, which could include modifications of IR, final focus systems, injectors, but without changing the boundary to the Belle II detectors.
  - Find a realistic way before long shutdown 1 (LS1) scheduled to start Jul/2022 in order to achieve luminosity of the order of 10^{35} cm^{-2} s^{-1} without large modification of accelerator components.
  - Consider longer-term alternative idea to achieve ~6x10^{35} cm^{-2} s^{-1} or more, even by largely modifying the IR and the Belle II detector.

- Activity period
  - Coming one year, before the LS1
- Rough schedule
  - (Online) meeting per month basically.
  - Meetings are basically open, but may occasionally have closed sessions.
  - Special review by ARC per ~6 months.
  - Final report is to be submitted by the end of July, 2022.

	2021						2022						
	7	8	9	10	11	12	1	2	3	4	5	6	7
Meeting	○ Kick off	○		○	○	○		○	○		○	○	
Review by Arc			○				○			△ As needed			○ Report
Machine operation				←→	←→	←→		←→	←→	←→	←→	←→	←→

Mika Masuzawa (KEK) Sep.2, 2021

One of the important milestones

We are here now.

Final report (before LS1)

M. Masuzawa (2021.09.02)
The 25th KEKB Accelerator Review Committee

Recommendations from ARC

- The 25th KEKB Accelerator Review Committee (ARC) meeting
  - Meeting was held remotely on 1-2 September 2021.
    - Slides of the presentations and the report are available at https://superkekb.kek.jp/event/131/
- Most significant recommendations and more general recommendations;
  - Answers and reactions to ARC recommendations are under discussion now.

Recommendation	Answer/Reaction
✓ *Sufficient beam time should be allocated for beam studies (other than routine tuning) to better understand and characterize the machines and their limitations, and to develop solutions or mitigation measures. More beam diagnostics would be helpful. Planned, dedicated machine study periods would also enable remote participation by Task Force members and other foreign experts.*	Arranging longer study time and participation by foreign experts.
✓ *Check the RF gun timing and perform careful RF conditioning of the QTW RF gun to recover the RF pulse width and, possibly, to improve the 2nd bunch emittance.*	Timing check and careful conditioning of RF gun
✓ *Develop refined procedures including triggers so that Belle II can operate closer to the background limits of its sub-detectors.*	Under consideration
✓ *The six LER kickers should be rewired to use a common power supply, or three power supplies each of which feeds a pair of upstream and downstream magnets, to avoid problems related to thyratron misfiring and injection impact on circulating bunches.*	More stable thyratron
✓ *Localize, identify and eliminate the source of vertical coupling in the HER injection line.*	Experimental data analysis
✓ *Develop a safe plan for increasing beam intensity in documented phases/machine states, that are each formally verified for optimized performance, background and adequate machine protection.*	Making safe plan
✓ *Establish a realistic model of the transverse impedance including accurate collimator wake fields and correct weighting with local beta functions; assess TMCI threshold for this model.*	Under consideration
✓ *Measure the single-bunch tune shift created by each collimator as a function of its gap, compare with theoretical expectation and verify that collimator contributions to the impedance are correctly understood.*	Beam study in 2021c
✓ *Further develop and study the non-linear collimation scheme (including the removal of some wiggler sections) and quantify its implications on beam optics and beam dynamics.*	Under consideration
✓ *Carry out more comprehensive beam-beam simulations, incl. crab waist, impedance, lattice errors, etc., to guide the upgrade path.*	Discussion in ITF BB subgroup
✓ *Consider increasing the number of focused task-force groups to other key areas such as linac, injection, collimation and machine protection.*	Under consideration
✓ *Invite external international task-force members to share organization efforts for the ITF sub-task groups.*	Under consideration

Upgrade plan during LS1

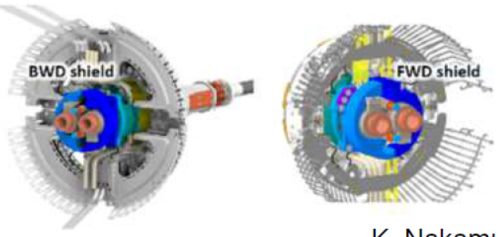
- Upgrade items during LS1.

Y. Suetsugu (2021.09.02)
The 25th KEKB Accelerator Review Committee

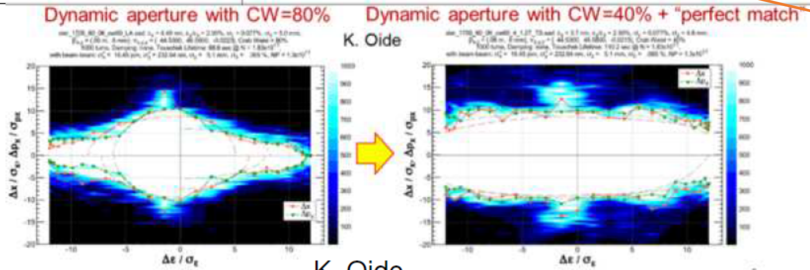
Planned countermeasures

- Possible countermeasures in LS1

Aim	Possible countermeasures	Expected improvement	Ready status	LS1 / LS2 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031~
Increase injection power (efficiency)	Large physical aperture at electron injection point (HER)	HER Injection rate x #?	Need further estimation, simulation, design of beam pipes	
Expand dynamic aperture	"Perfect matching"	**LER beam lifetime (Tousheck) x ~1.5.**	Need further simulation, design, manufacturing of magnets and pipes	
Expand physical aperture Suppress BG	QCS cryostat front panel modification and additional shield to IP bellows	Background, Physical aperture, **TMCI limit x ~1.2**	**Production is on going. Will be ready by 2022**.	
Expand physical aperture Suppress BG	Optimization of collimator location	**Background x ~1/2 (Storage beam)**	On going. Need further simulation.	
Relax TMCI limit	"Non-linear collimator"	**TMCI limit x~2 Background x ~1/2 (Storage beam)**	Need further simulation, design, manufacturing of magnets and pipes. **Production of PS has started.**	



K. Nakamura



K. Oide

2021/9/2 9

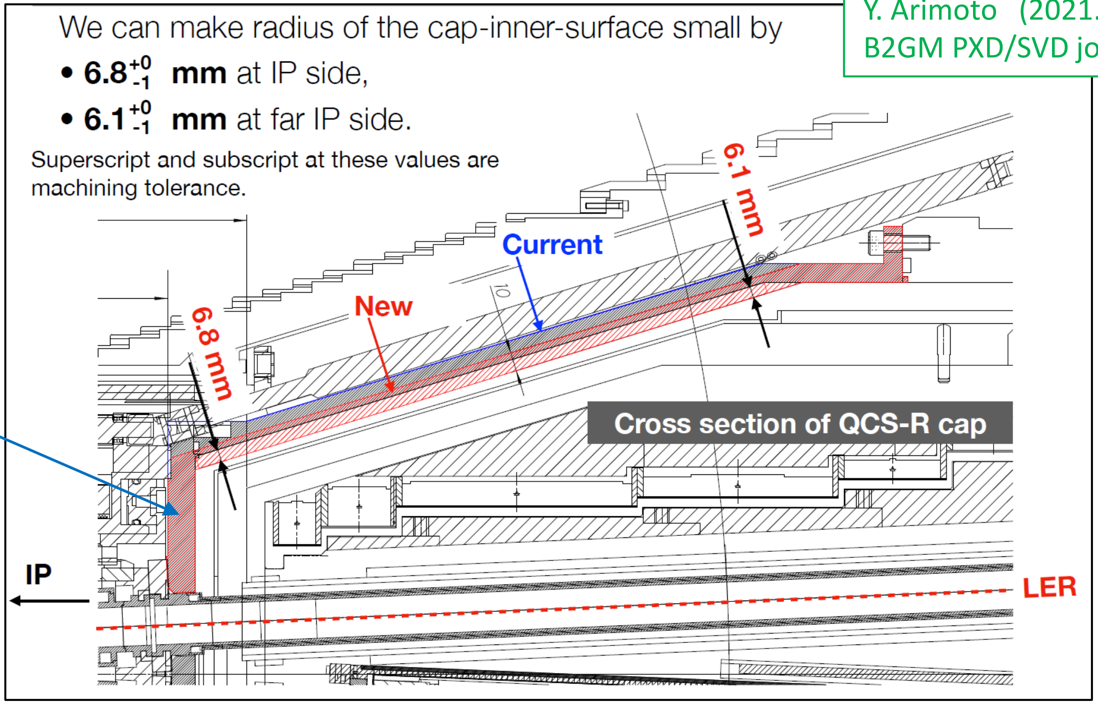
- LS1 (Long Shutdown1):
  - scheduled from July 2022 to May 2023.
  - can be delayed by 6 months or 1 year.
- What to be manufactured:
  - New beam pipes (HER)
  - It turned out that it may be possible to do this without hardware upgrade. (LER)
  - New front caps of QCS, radiation shields (IR)
  - Already done (LER)
  - New magnets, power sources, beam pipes (LER)

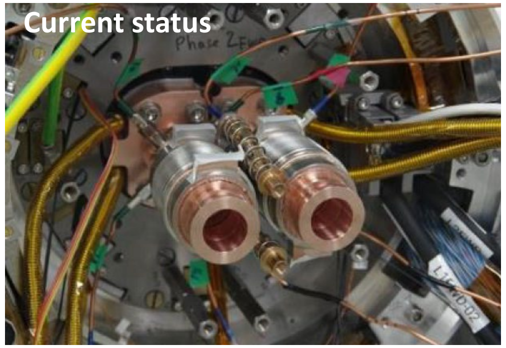
Background noise reduction (IR)

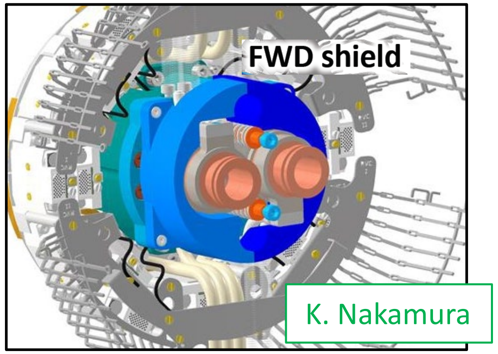
- Addition and modification of radiation shields at IR
  - Additional radiation shields around IP bellows pipes and Belle2 detector
  - Modification of front caps of QCSs
    - Front plate material will be changed from W to SUS to suppress the generation of radiation.
    - To make more space for the cables, new front cap of QCSR will be smaller than current one.

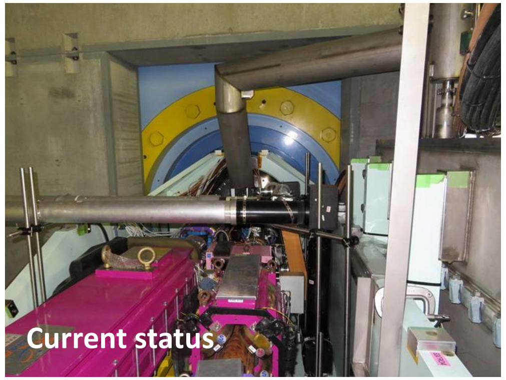
Y. Arimoto (2021.10.13)
B2GM PXD/SVD joint session

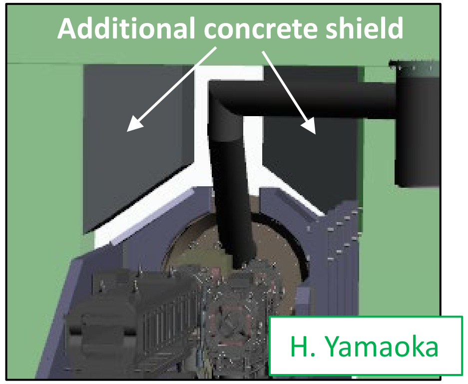
W → SUS

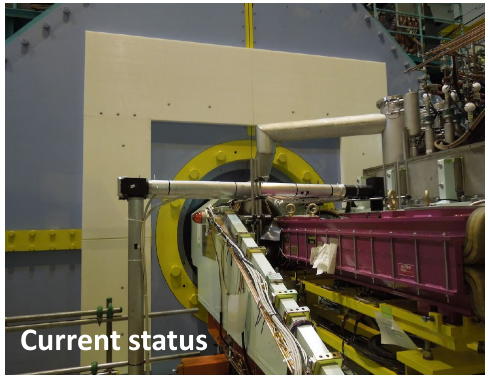


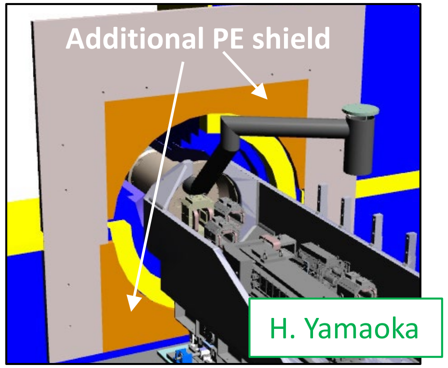








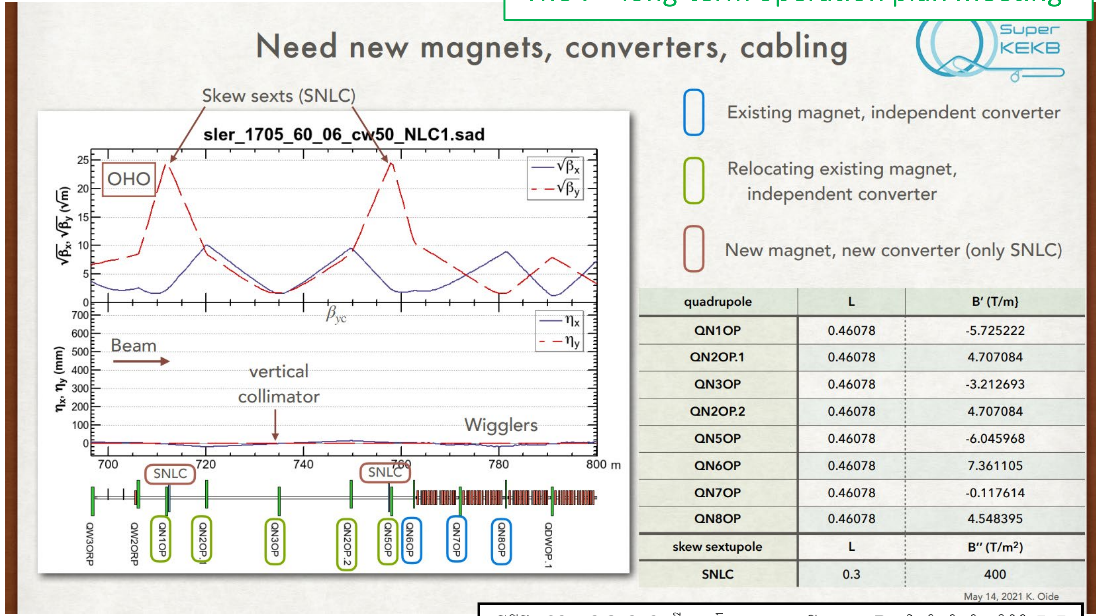




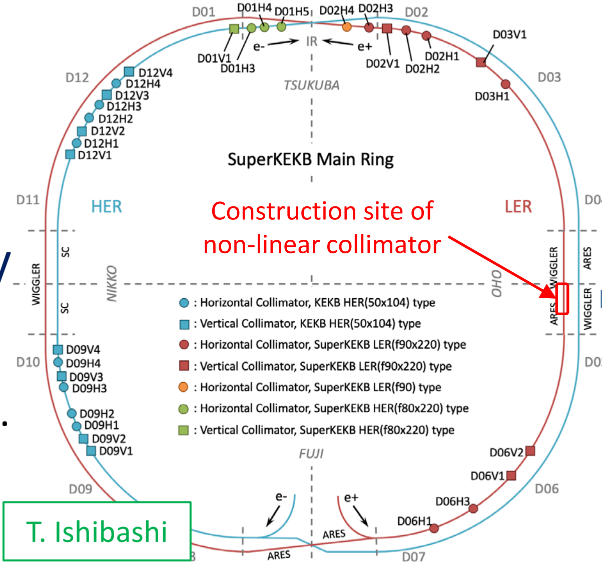
Relaxation of TMCI limit (LER)

- New non-linear collimation (NLC) scheme less likely to cause TMCI
  - Non-linear kick by skew sextupole magnet can make a vertical displacement at the collimator.
    - It is possible to open the collimator wider.
    - It is possible to place the collimator at larger beta-function.
    - ⇒ It is possible to relax TMCI bunch current limit.
  - NLC will be constructed at OHO straight section.
    - 50 wiggler magnets need to be removed.
    - 2 skew sextupole magnets and 5 quadrupole magnets need to be installed.
    - New magnet power sources and cabling works are required.
    - New collimator and beam pipes are also required.
  - Further development and study of NLC scheme is needed.
    - Consideration of the effect of the removal of some wiggler sections.
    - Quantification of its implications on beam optics and beam dynamics.

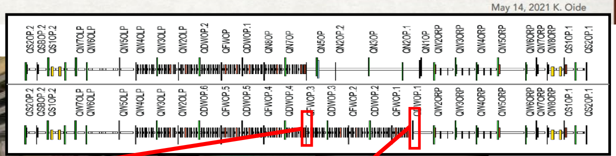
K. Oide (2021.05.14)
The 7th long-term operation plan meeting

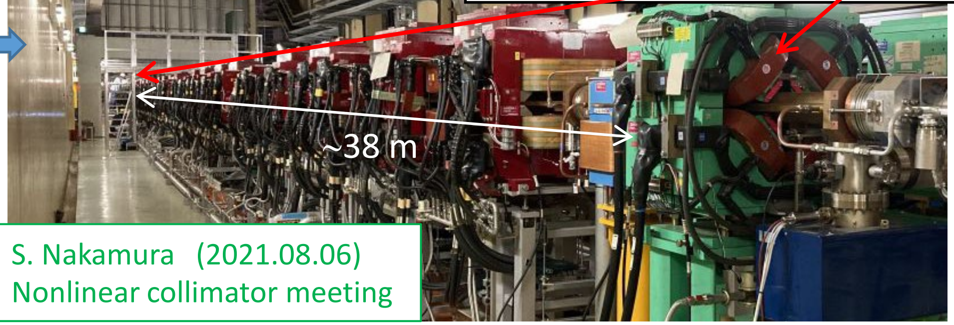


quadrupole	L	B' (T/m)
QN1OP	0.46078	-5.725222
QN2OP.1	0.46078	4.707084
QN3OP	0.46078	-3.212693
QN2OP.2	0.46078	4.707084
QN5OP	0.46078	-6.045968
QN6OP	0.46078	7.361105
QN7OP	0.46078	-0.117614
QN8OP	0.46078	4.548395
skew sextupole	L	B'' (T/m²)
SNLC	0.3	400



T. Ishibashi

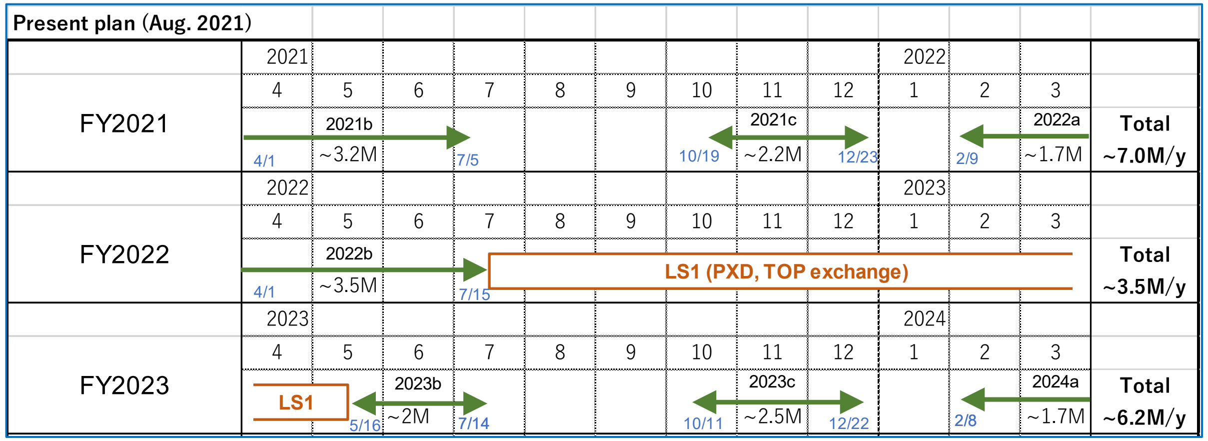




S. Nakamura (2021.08.06)
Nonlinear collimator meeting

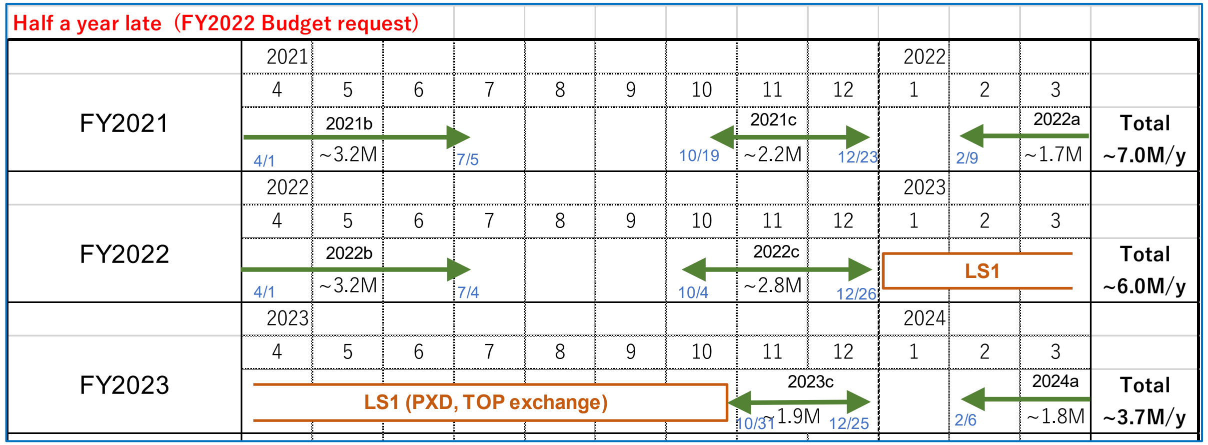
Three operation scenarios until JFY2024

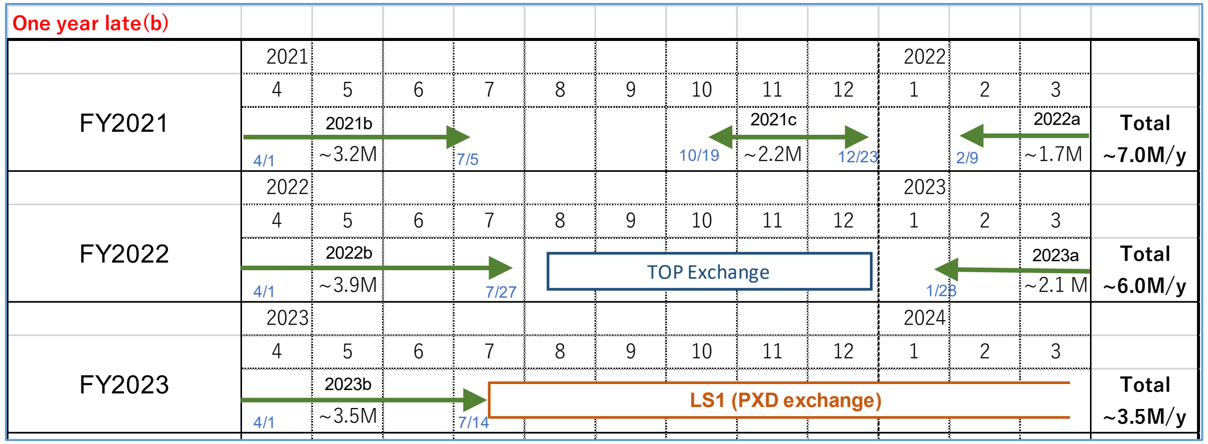
- Delaying LS1 due to COVID-19 is under consideration.
  - Three possible scenarios are being considered.
    - Present plan (start LS1 in July 2022), 6-months delay (start LS1 in January 2023), 1-year delay (start LS1 in July 2023)



Expected int. luminosity

Plan	Int. Lumi. Before LS1 [fb^{-1}]		Int. Lumi. until 2024b [fb^{-1}]	
	Target	Base	Target	Base
Present	~680	~680	~1260	~910
6-months delay	~850	~850	~1320	~940
1-year delay	~1160	~1160	~1200	~870





Summary

- 2021ab run;
  - Peak luminosity : 3.12×10^{34} $cm^{-2}s^{-1}$
    - β_y^* = 1mm, Beam current [mA]= 790 (LER)/687(HER), Number of bunches = 1174
  - Total integrated luminosity : 213.5 fb^{-1}
    - Maximum Daily integrated luminosity (delivered) = 2.233 fb^{-1}
  - Maximum beam current [mA]: 1000 (LER)/940 (HER) w/o physics run
- Collimator works during 2021 summer shutdown;
  - Jaw replacement
    - HER : D09V1, D09V2
    - LER : D06V1, D06V2 (hybrid-type jaws), D06H3, D06H1(short-stroke jaws)
  - LER D02V1 relocation
- 2021c run plan;
  - Energy scan : 10.657 GeV – 10.810 GeV
  - Machine tuning & study items
    - HER beam injection, TMCI, beam-beam effect, LER crab waist
  - β_y^* = 1 mm

Summary (cont'd)

- Challenges and countermeasures;
  - Major challenges recognized so far:
    - Vertical beam size blow-up, short beam lifetime, TMCI, low machine stability, aging of hardware and facilities, low injection efficiency (HER), etc.
    - Upgrade plans are under consideration to overcome the challenges.
  - KEK has assembled the International Task Force to address the challenges of the upgrade.
    - 4 subgroups : Optics, Beam-beam, TMCI, Linac
  - Answers and reactions to ARC recommendations are under discussion now.
- Major upgrade items that may be done during LS1;
  - Addition and modification of radiation shield at IR
  - Construction of Non-linear collimation section (LER)
- Operation plan until JFY2024;
  - Three possible scenarios:
    - Start LS1 in July 2022 (present plan)
    - Start LS1 in January 2023 (6-months delay)
    - Start LS1 in July 2023 (1-year delay)

Fin.

Thank you for your attention.

Backup

Assumptions for luminosity profile estimations -1

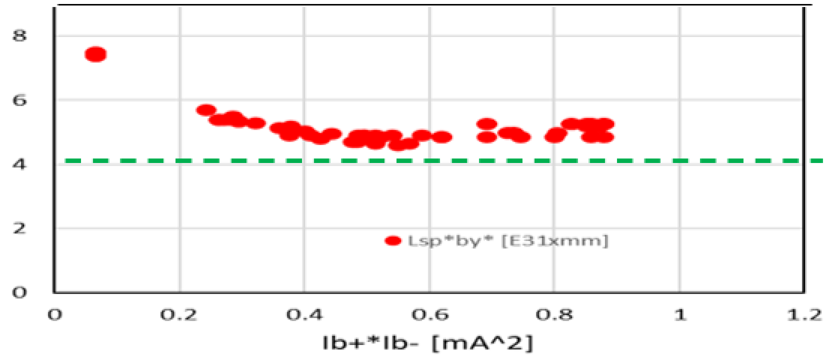
- Major assumptions

	Target profile*	Base profile
Profile until 2022b	Same profile as previous one	Modified from 2021c
Operation efficiency	~2021c: 0.65, 2022a~: 0.4	2021c~: 0.4
Bunch current	≤ 0.95 mA	≤ 0.9 mA
Total current	≤ 1.6 A	≤ 1.5A
Specific luminosity	Fig. (1) (see right)	Fig. (2) (see right)
Squeeze β_y^*	Squeeze to 0.8 mm at a proper timing after 2022c.	
After LS1	Need ~4 months' operation to fully recover the previous luminosity	

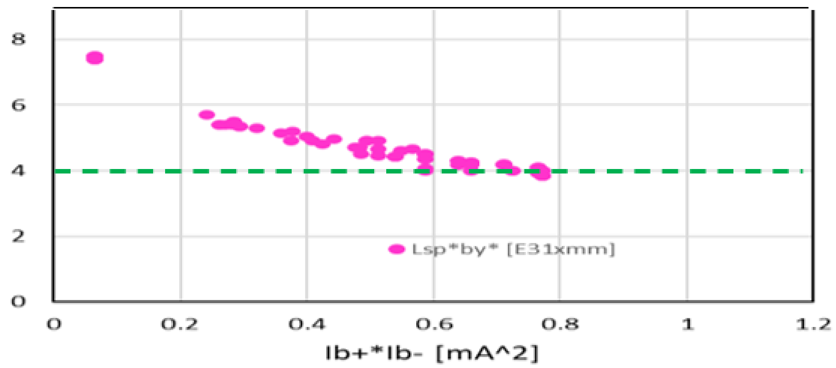
*The assumptions until 2022b basically follows those used for the previous profile presented in the last BPAC.

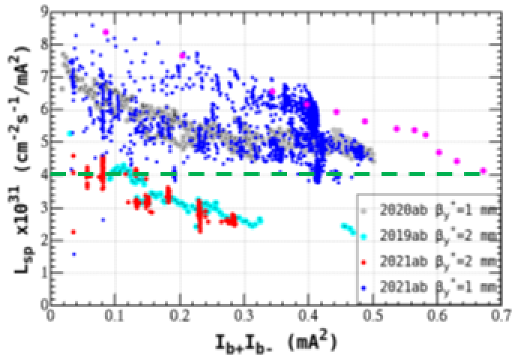
$L_{sp} x \beta_y^*$ [E31cm^{-2}s^{-1}/mA^2 mm]

(1)



(2)





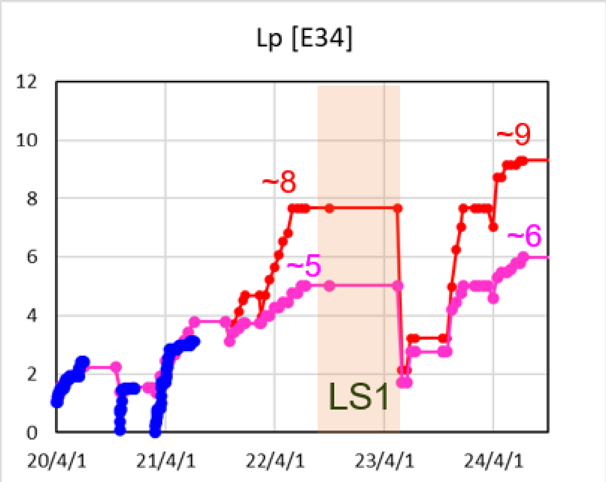
Y. Ohnishi

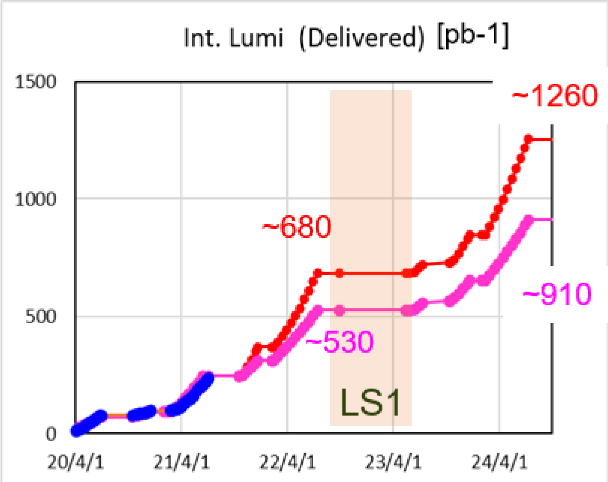
Luminosity profile for present plan

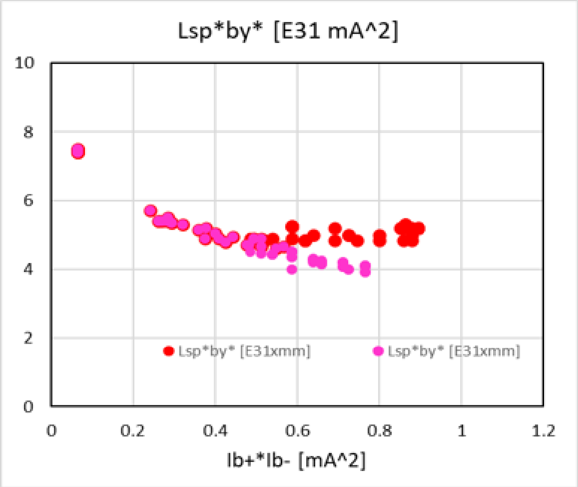
Present plan (Aug. 2021)

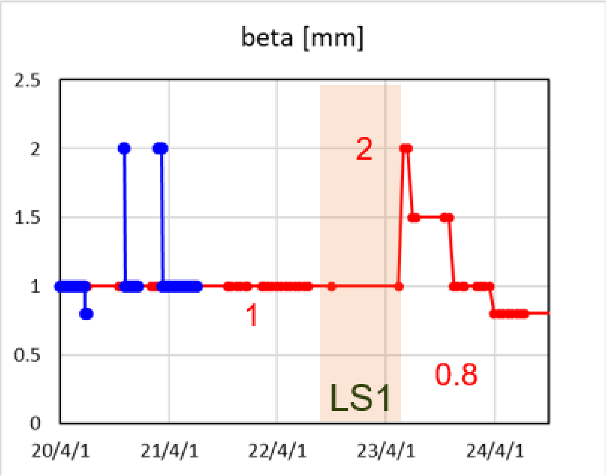
	4	5	6	7	8	9	10	11	12	1	2	3	
FY2021	2021									2022			
	4/1	2021b ~3.2M		7/5			10/19	2021c ~2.2M	12/23		2/9	2022a ~1.7M	Total ~7.0M/y
FY2022	2022									2023			
	4/1	2022b ~3.5M		7/15 LS1 (PXD, TOP exchange)									Total ~3.5M/y
FY2023	2023									2024			
	LS1	5/16	2023b ~2M	7/14			10/11	2023c ~2.5M	12/22		2/8	2024a ~1.7M	Total ~6.2M/y
FY2024	2024									2025			
	4/1	2024b ~3.4M		7/12			10/16	2024c ~2.3M	12/25		2/6	2025a ~1.8M	Total ~7.5M/y

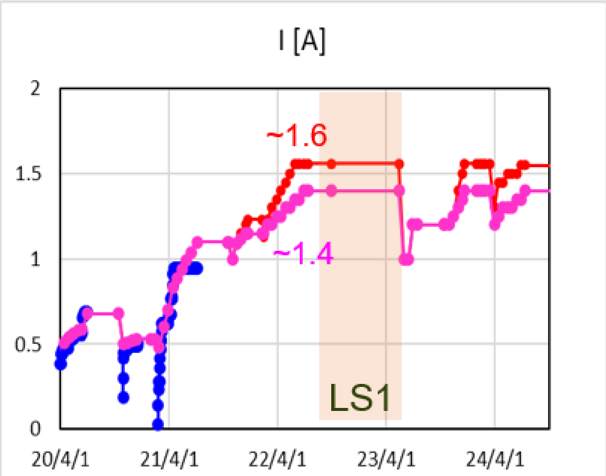
~2024b

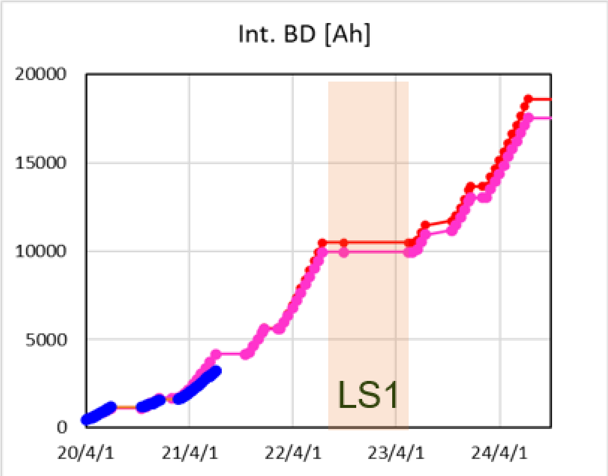












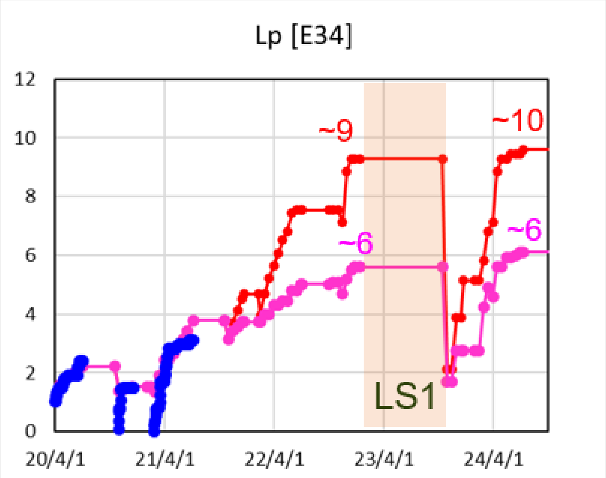
Note Blue dots: Results so far. I : Geometric mean of beam currents including those during baking runs.
Int. L: Delivered integrated luminosity. Reset in July 2021.

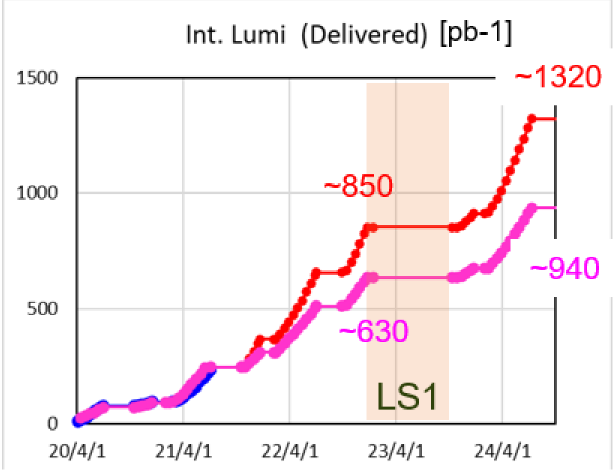
Luminosity profile for half a year delay plan

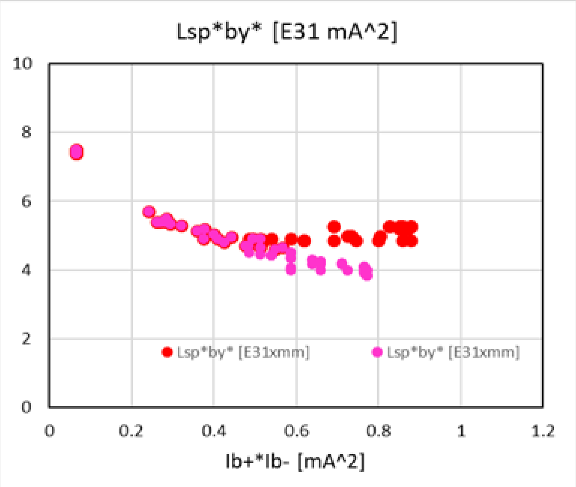
Half a year late (FY2022 Budget request)

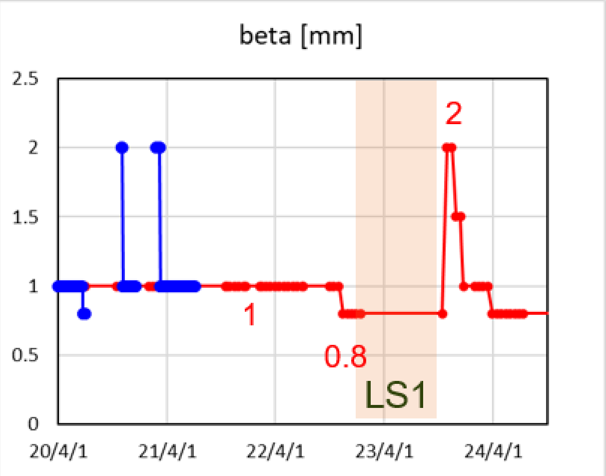
	4	5	6	7	8	9	10	11	12	1	2	3	
FY2021	2021									2022			
	4/1 →	2021b ~3.2M		→ 7/5			10/19 ←	2021c ~2.2M	→ 12/23		2/9 ←	2022a ~1.7M	Total ~7.0M/y
FY2022	2022									2023			
	4/1 →	2022b ~3.2M		→ 7/4			10/4 ←	2022c ~2.8M	→ 12/26	LS1			Total ~6.0M/y
FY2023	2023									2024			
	LS1 (PXD, TOP exchange)						10/31 ←	2023c ~1.9M	→ 12/25		2/6 ←	2024a ~1.8M	Total ~3.7M/y
FY2024	2024									2025			
	4/1 →	2024b ~3.4M		→ 7/12			10/16 ←	2024c ~2.3M	→ 12/25		2/6 ←	2025a ~1.8M	Total ~7.5M/y

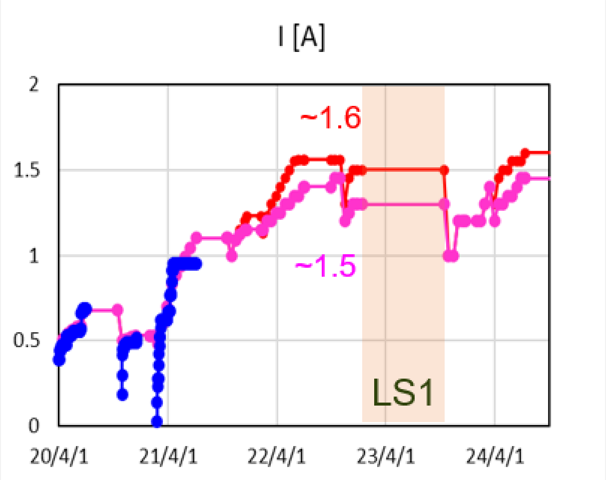
~2024b

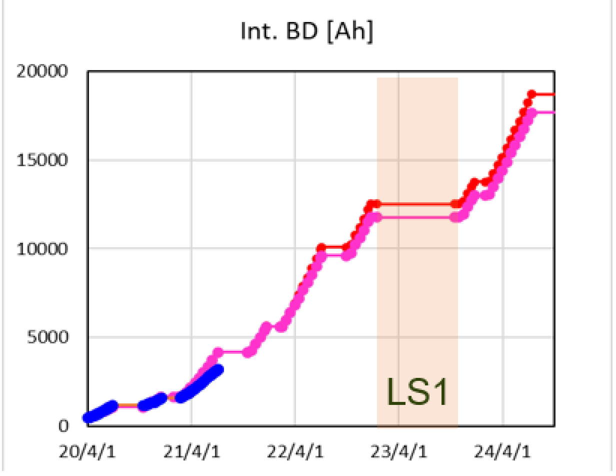






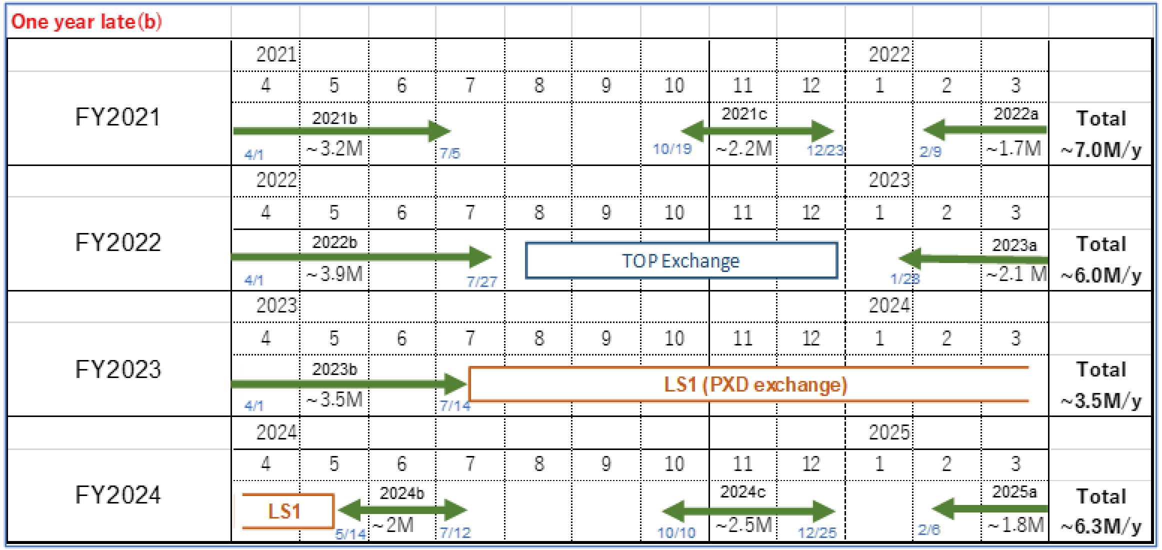




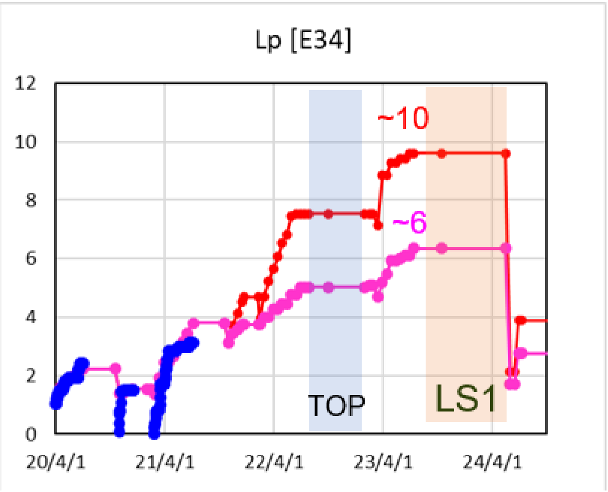


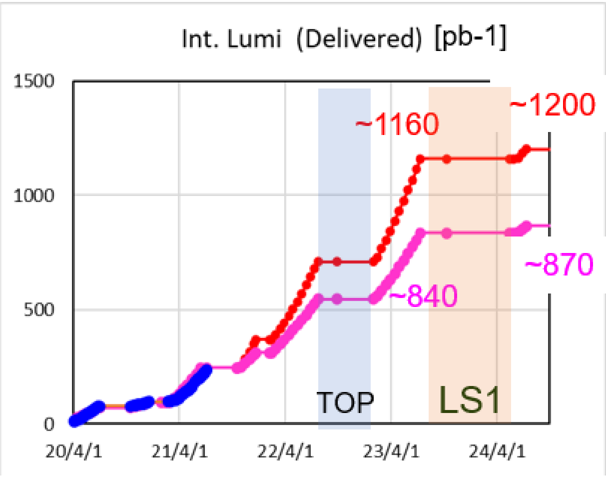
Note Blue dots: Results so far. I : Geometric mean of beam currents including those during baking runs.
Int. L: Delivered integrated luminosity. Reset in July 2021.

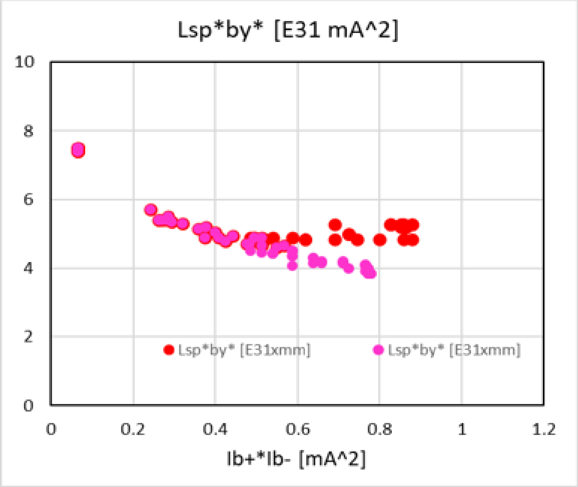
Luminosity profile for one year delay plan (b)

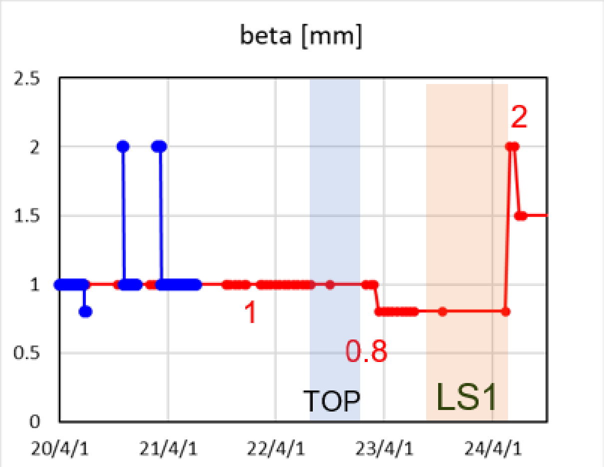


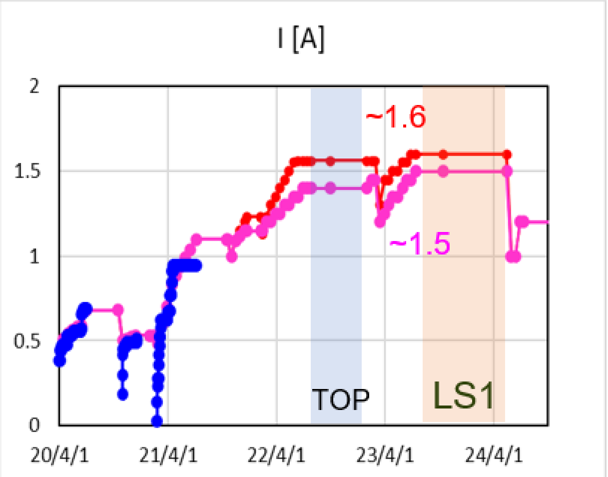
~2024b

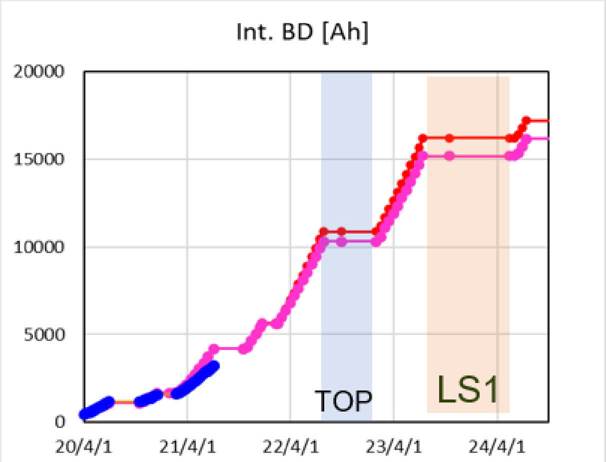






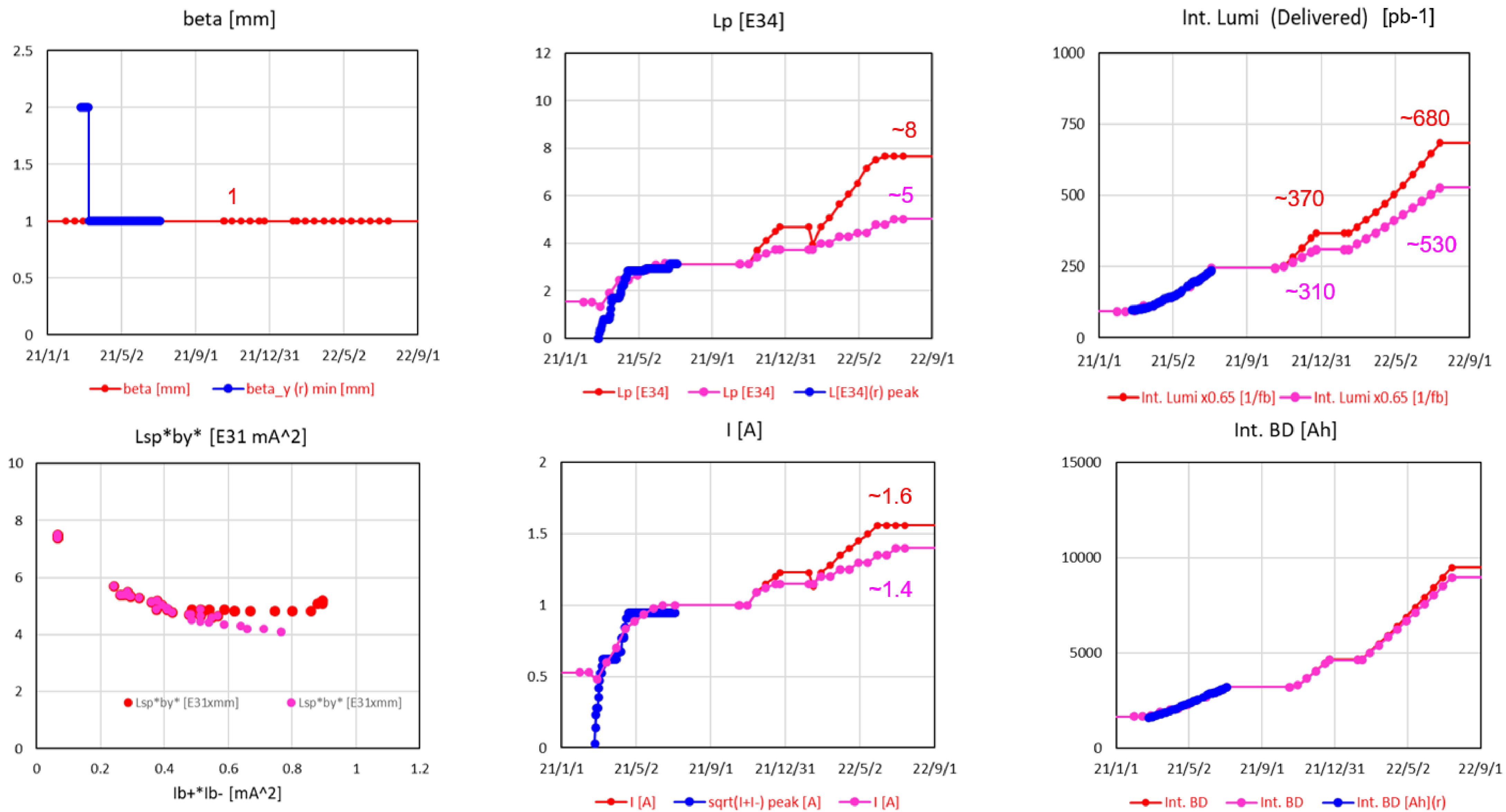






Note Blue dots: Results so far. I : Geometric mean of beam currents including those during baking runs.
Int. L: Delivered integrated luminosity. Reset in July 2021.

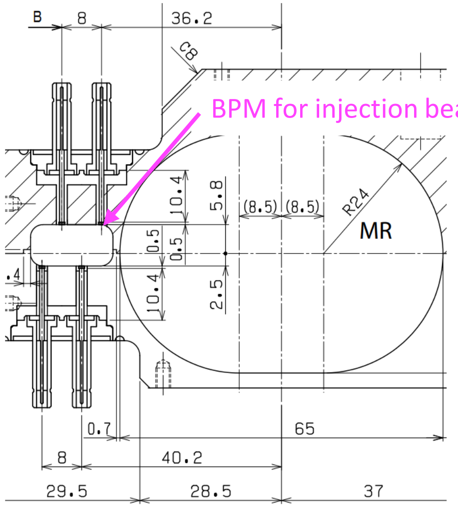
Luminosity profile until 2022/7



Note Blue dots: Results so far. I : Geometric mean of beam currents including those during baking runs.
Int. L: Delivered integrated luminosity. Reset in July 2021.

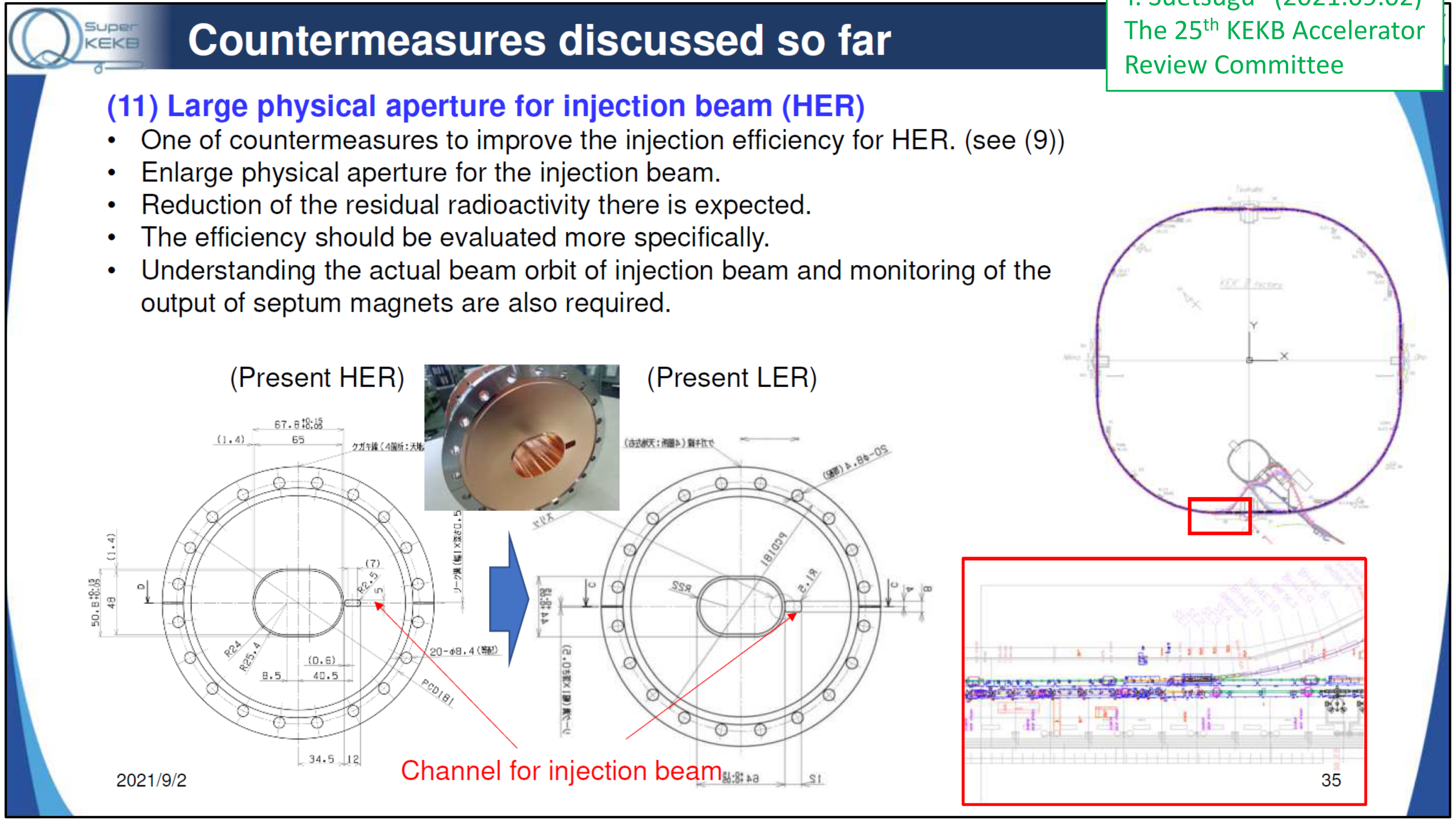
Improvement of injection efficiency (HER)

- Can we improve HER injection efficiency by enlargement of physical aperture for injection beam？
  - Beam Injection Task Force is considering the need to enlarge the aperture.
  - If necessary,
    - Three beam pipes will be replaced with new ones with large aperture.
    - Beam position monitor (BPM) for injection beam will be modified for more precise injection tuning.



G. Mitsuka

Y. Suetsugu (2021.09.02)
The 25th KEKB Accelerator Review Committee



Countermeasures discussed so far

(11) Large physical aperture for injection beam (HER)

- One of countermeasures to improve the injection efficiency for HER. (see (9))
- Enlarge physical aperture for the injection beam.
- Reduction of the residual radioactivity there is expected.
- The efficiency should be evaluated more specifically.
- Understanding the actual beam orbit of injection beam and monitoring of the output of septum magnets are also required.

(Present HER) (Present LER)

Channel for injection beam

2021/9/2 35