GENERAL INFORMATION & HIGHLIGHTS FROM THE 28TH (SUPER)KEKB ACCELERATOR REVIEW MEETING

Frank Zimmermann

201st FCC-ee Accelerator Design Meeting & 72nd FCCIS WP2.2 Meeting

Status FSR vol 2.

e+e- booster (tapering?), e+e- injector, hh in good shape

e+e- collider:
add orbit feedback, vibrations, tuning with IP signals, etc.
(proposal Xavier & Jack)

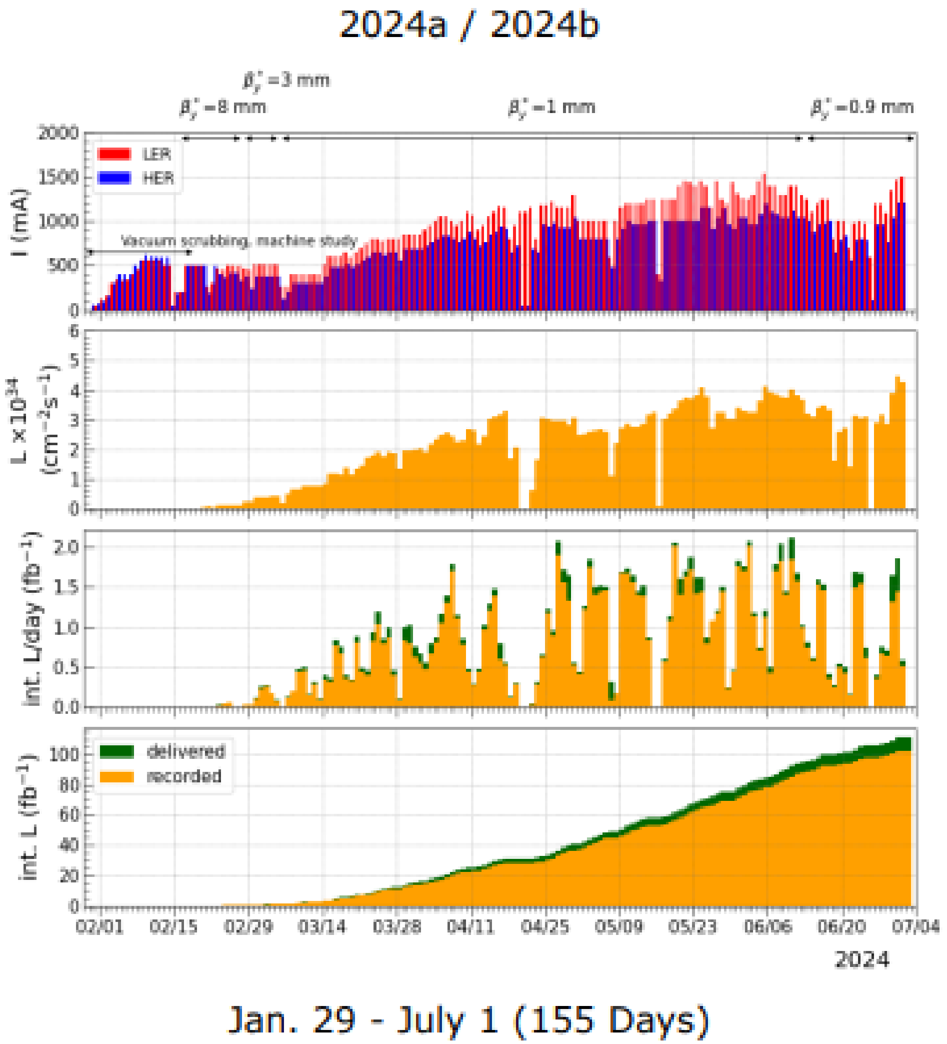
updates / addition in design section
(e-cloud & vacuum effects,..)

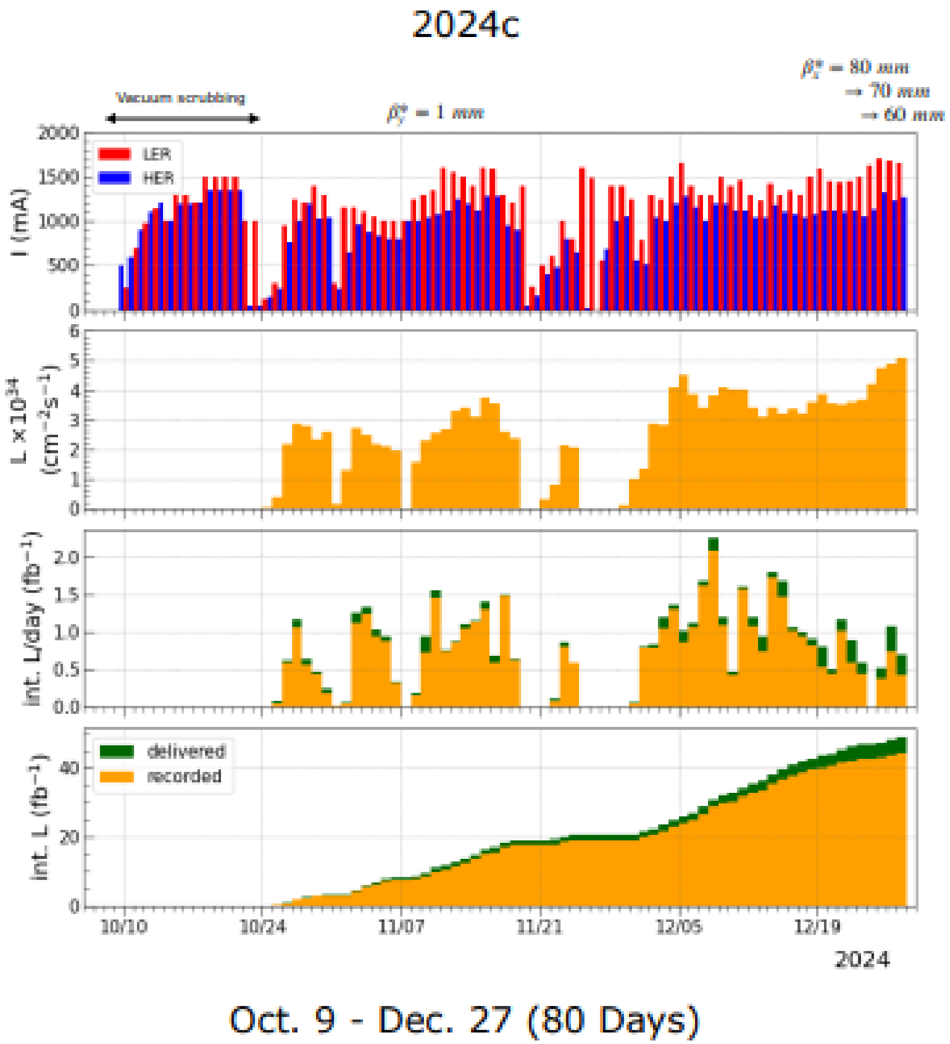
still empty parts operations section
(injection after abort, machine protection, availability, operation model)

(Super)KEKB review #28 | 14 -16 Jan 2025 | participants

Frank Zimmermann, Chair	CERN
Ralph Assmann	GSI
Vincent Baglin	CERN
Paolo Craievich	PSI
John Fox	Stanford University
Andrew Hutton	JLab (excused)
Heung-Sik Kang	POSTECH
Catia Milardi	INFN-LNF
Evgeny Perevedentsev	BINP (remote)
Qing Qin	ESRF
Bob Rimmer	JLab
John Seeman	SLAC
Michael Sullivan	SLAC
Tom Taylor	CERN (ret.)
Rogelio Tomas	CERN (remote)
Yuan Zhang``	IHEP
Tadashi Koseki	KEK, Director of Acc. Lab., Ex Officio Member
Kyo Shibata	KEK, Head of Acc. Division III, Ex Officio Member
Makoto Tobiyama	KEK, Head of Acc. Division IV, Ex Officio Member
Hiroyasu Ego	KEK, Head of Acc. Division V, Ex Officio Member

run 2024c





parameters, 2024 progress w.r.t. 2022 and SKB design

parameter	KEKB w Belle		SKB 2022b		SKB 27 December 2024		SKB design	
	LER	HER	LER	HER	LER	HER	LER	HER
E [GeV]	3.5	8	4	7	4	7	4	7
β_x^* [mm]	1200	1200	80	80	60	60	32	25
β_y^* [mm]	5.9	5.9	**1.0**	**1.0**	**1.0**	**1.0**	0.27	0.30
ε_x^* [nm]	18	24	**4.0**	**4.6**	**4.0**	**4.6**	3.2	4.6
ε_y^* [pm]	150	150	**~50**	**~50**	**~70**	**~70**	8.6	12.9
I [mA]	1640	1190	**1321**	**1099**	**1632**	**1259**	3600	2600
n_b	1584		2249		2346		2500	
I_b [mA]	1.04	0.75	0.587	0.489	0.696	0.537	1.44	1.04
ξ_y	0.098	0.059	**0.0407**	**0.0279**	**0.036**	**0.027**	0.069	0.060
L_{sp} [10^{30}cm^{-2}s^{-1}mA^{-2}]	17.1		**71.2**		58		214	
L [10^{34} cm^{-2}s^{-1}]	2.11		4.65		5.1		80	

parameters, record dec '24 and "near-term" targets

	December 27, 2024		Target at post-LS1 (1)		Target at post-LS1 (2)		Unit
Ring	LER	HER	LER	HER	LER	HER	
Emittance	4.0	4.6	4.0	4.6	4.0	4.6	nm
Beam Current	1632	1259	2080	1480	2750	2200	mA
Number of bunches	2346		2346		2346		
Bunch current	0.696	0.537	0.89	0.63	1.17	0.94	mA
Horizontal size σ_x^*	15.5	16.6	17.9	16.6	17.9	16.6	μm
Vertical cap sigma Σ_y^*	0.375		0.217		0.178		μm
Vertical size σ_y^*	0.265		0.154		0.126		μm
Betatron tunes ν_x / ν_y	44.525 / 46.589	45.531 / 43.599	44.525 / 46.589	45.532 / 43.573	44.525 / 46.589	45.532 / 43.573	
β_x^* / β_y^*	**60 / 1.0**	60 / **1.0**	80 / **0.8**	60 / **0.8**	80 / **0.6**	60 / **0.6**	mm
σ_z	4.6 (6.0*)	5.1 (6.1*)	4.6 (6.5*)	5.1 (6.4*)	4.6 (6.5*)	5.1 (6.4*)	mm
Piwinski angle	**12.3**	**12.7**	10.7	12.7	10.7	12.7	
Crab waist ratio	80	60	80	80	80	80	%
Beam-Beam ξ_y	0.036	0.027	0.0444	0.0356	0.0604	0.0431	
Specific luminosity	5.8×10^{31}		7.62×10^{31}		9.31×10^{31}		$cm^{-2}s^{-1}/mA^2$
Luminosity	**5.1×10^{34}**		1×10^{35}		2.4×10^{35}		$cm^{-2}s^{-1}$

* Bunch lengthening is considered by using streak camera measurements.

beam aborts

S. Ogasawara et al.

All Aborts

2024ab

155 Days (3696 Hours)

Abort ring	SBL	BeamLoss	Injection	RF	Mag	VA	EQ	Others	Manual	Uncategorized	TOTAL
TOTAL	162	588	1800	134	17	19	37	65	-	2	2824
Both(LER)	128	86	156	2	7	-	-	16	-	-	395
Both(HER)	19	143	1135	2	-	-	-	3	-	-	1302
Both	-	-	-	-	8	-	7	1	-	2	18
LER	15	234	199	75	1	4	5	24	-	-	557
HER	-	125	310	55	1	15	25	21	-	-	552

Beam abort per 79 min

2024c

80 Days (1896 Hours)

ring	SBL	BeamLoss	Injection	RF	Mag	VA	EQ	Tuning	Others	Manual	Uncategorized	TOTAL
TOTAL	114	352	423	63	4	13	9	440	17	-	9	1444
Both(LER)	80	53	31	2	1	-	-	76	6	-	-	249
Both(HER)	18	69	354	-	1	1	-	233	1	-	1	678
Both	-	-	-	-	1	5	2	-	-	-	4	12
LER	15	161	13	32	1	3	1	27	9	-	-	262
HER	1	69	25	29	-	4	6	104	1	-	4	243

Beam abort per 79 min

$I_{LER} > 60$ mA, $I_{HER} > 60$ mA

Abort ring	SBL	BeamLoss	Injection	RF	Mag	VA	EQ	Others	Manual	Uncategorized	TOTAL
TOTAL	139	470	205	84	8	11	30	22	-	1	970
Both(LER)	114	73	63	2	3	-	-	13	-	-	268
Both(HER)	18	131	114	2	-	-	-	1	-	-	266
Both	-	-	-	-	4	-	7	-	-	1	12
LER	7	183	6	49	-	3	3	3	-	-	254
HER	-	83	22	31	1	8	20	5	-	-	170

HER Injection was too many.

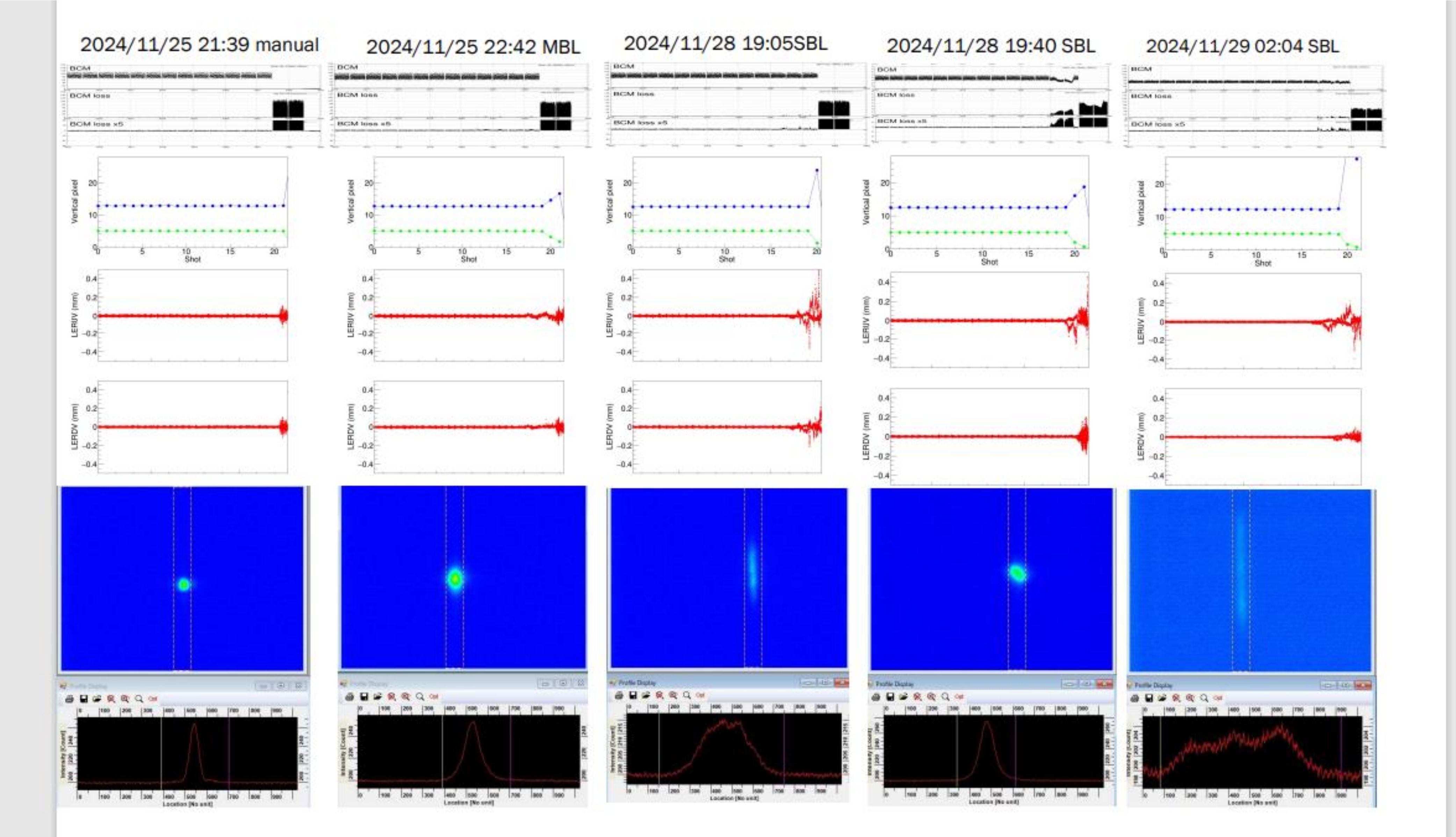
LER: #SBL/Beam Dose = 0.064 (1/Ah)
HER: #SBL/Beam Dose = 0.012 (1/Ah)

ring	SBL	BeamLoss	Injection	RF	Mag	VA	EQ	Tuning	Others	Manual	Uncategorized	TOTAL
TOTAL	102	310	76	45	3	7	9	1	15	-	8	576
Both(LER)	72	46	19	2	1	-	-	1	5	-	-	146
Both(HER)	18	64	52	-	1	1	-	-	1	-	1	138
Both	-	-	-	-	1	1	2	-	-	-	3	7
LER	12	146	1	20	-	2	1	-	8	-	-	190
HER	-	54	4	23	-	3	6	-	1	-	4	95

Aborts due to injection was much Reduced.

LER: #SBL/Beam Dose = 0.074 (1/Ah)
HER: #SBL/Beam Dose = 0.020 (1/Ah)

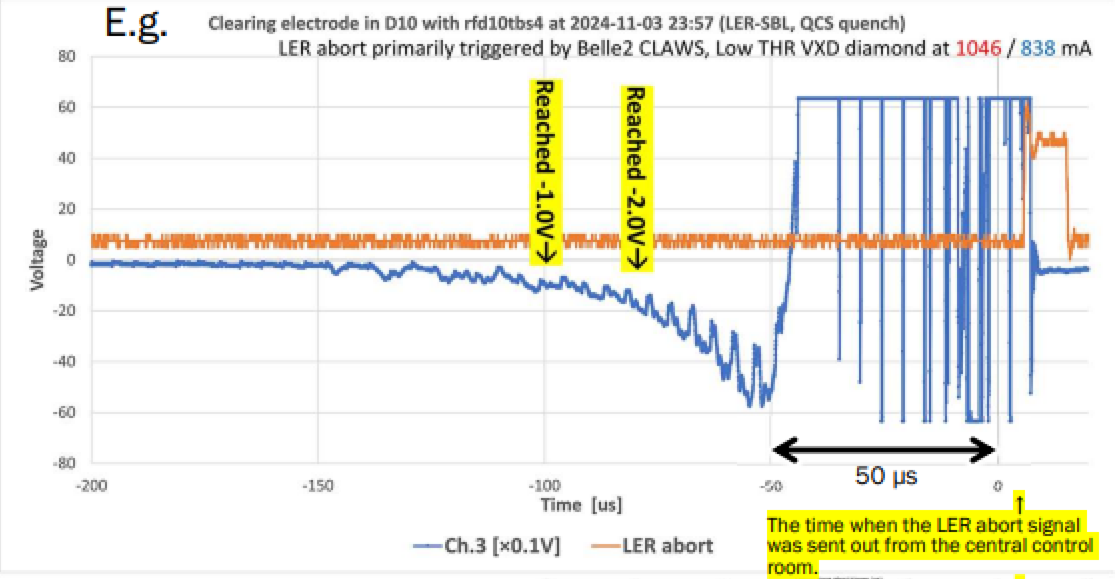
Sudden Beam Loss – vertical blow up seen

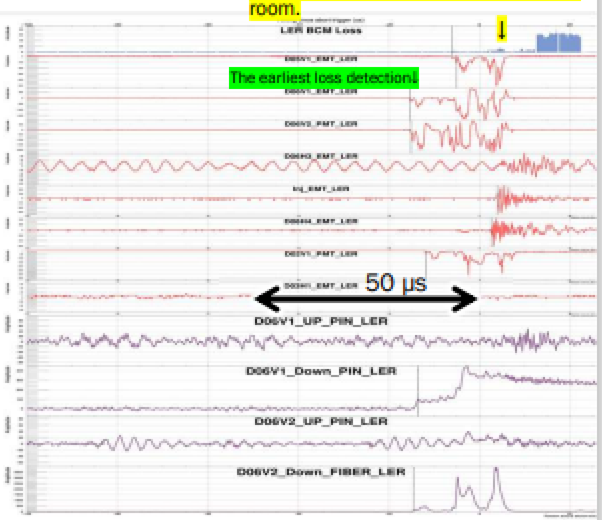


Sudden Beam Loss – signal on clearing electrodes

Discharge Signals from the Clearing Electrodes in D10 (@ SBL)

- We connected twelve of the clearing electrodes in D10 to the ground via 50Ω, then the voltages across the resistors were measured with oscilloscopes.
- At 38 LER aborts during 2024c, we detected significant voltages which should be a result of discharge at one of the clearing electrodes. 15 of the abovementioned 38 LER aborts were SBLs.
- Such voltages were never observed at more than one electrode simultaneously.
- The polarity of the detected voltages is negative and/or positive.
- Any LER abort with such abnormal voltage detection was accompanied by vacuum-pressure burst detected at the nearest gauge.
- In some events, the bunch-train structure was seen.
- In some events, the discharge signal appeared earlier than any beam-loss detection.
- We will try to simulate such events using CST.

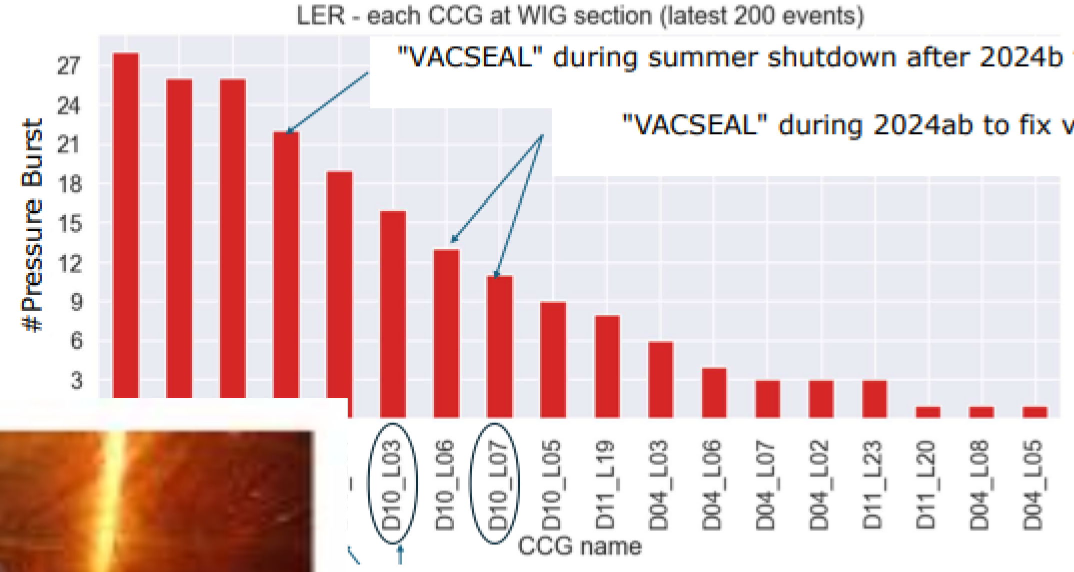


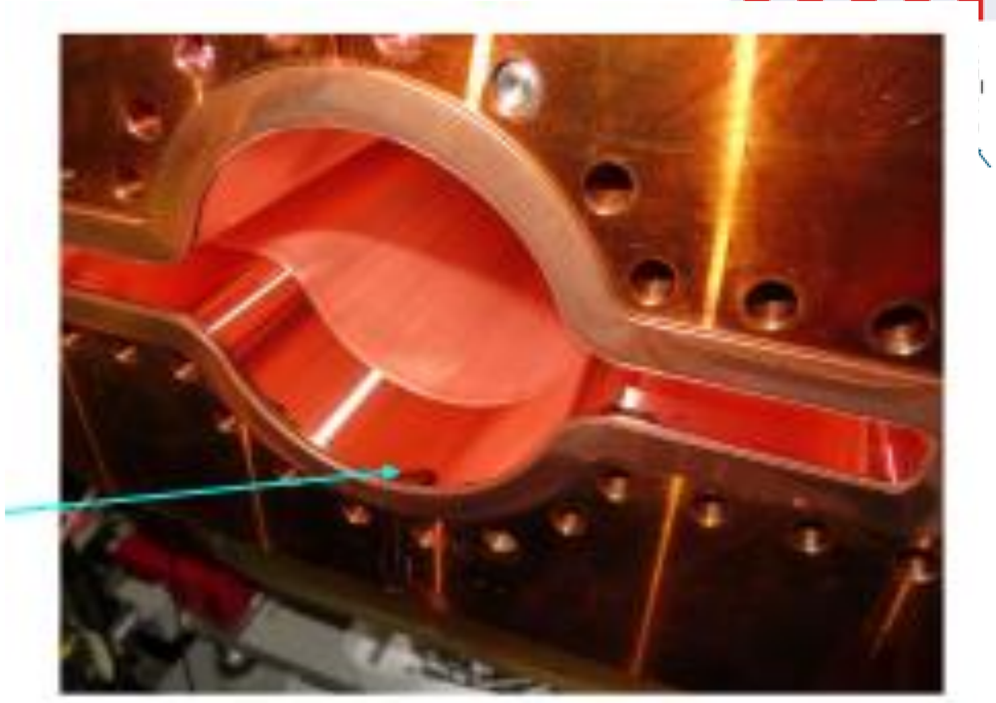


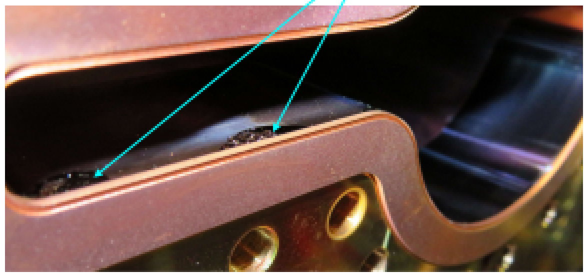
(T. Abe)

VacSeal in vacuum chamber

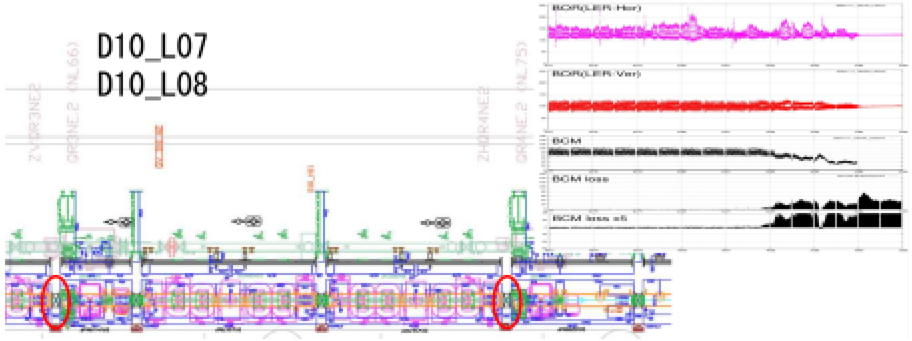
S. Terui et al.







SBL Event



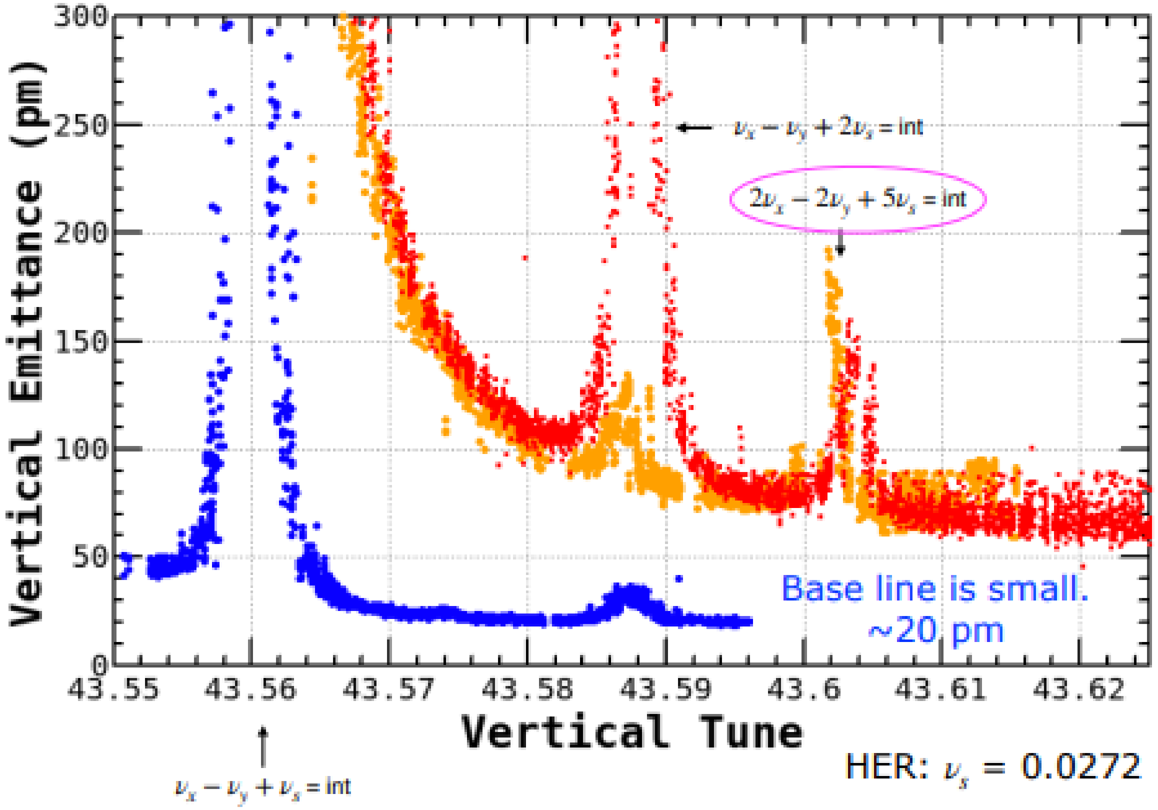
huge vertical emittance and vertical tune in HER

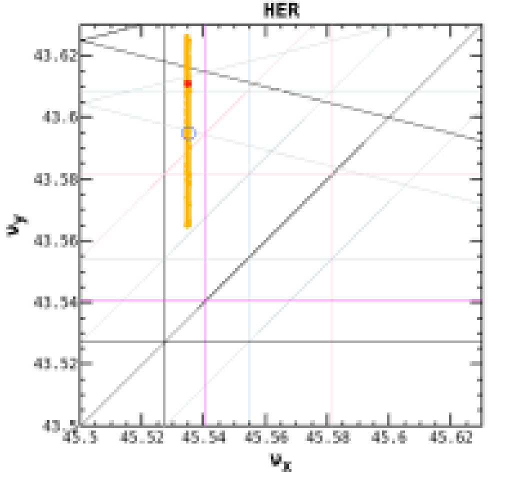
Vertical emittance in 2022ab and 2024ab is small, but large in 2024c.

2022 March 29 (2022a)

2024 Nov. 22 (2024c)

2024 Nov. 29 (2024c)
Another different optics correction





Base line is large.
~70 pm

HER: ν_s = 0.0272

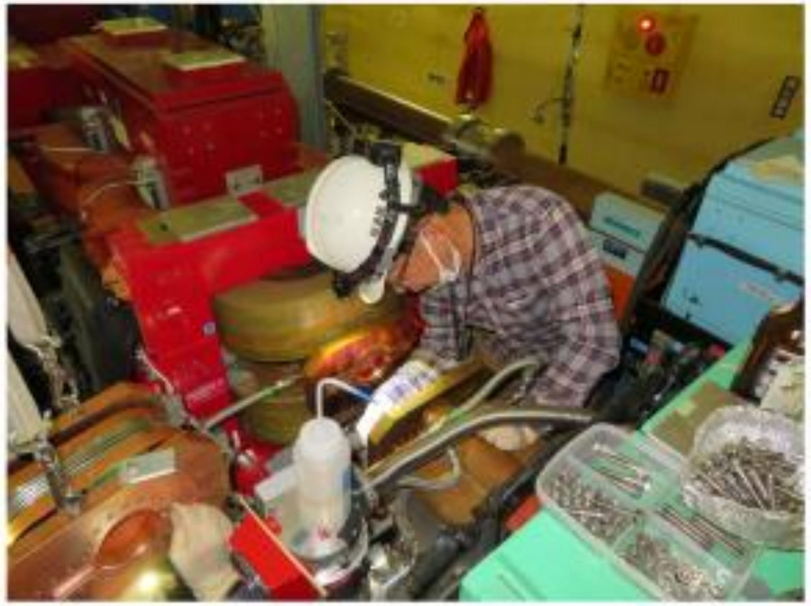
Higher order synchro-beta X-Y coupling resonance (9th)

started two weeks into the 2024c run; emittance could not be recovered

cleaning inside of flanges and vacuum chambers

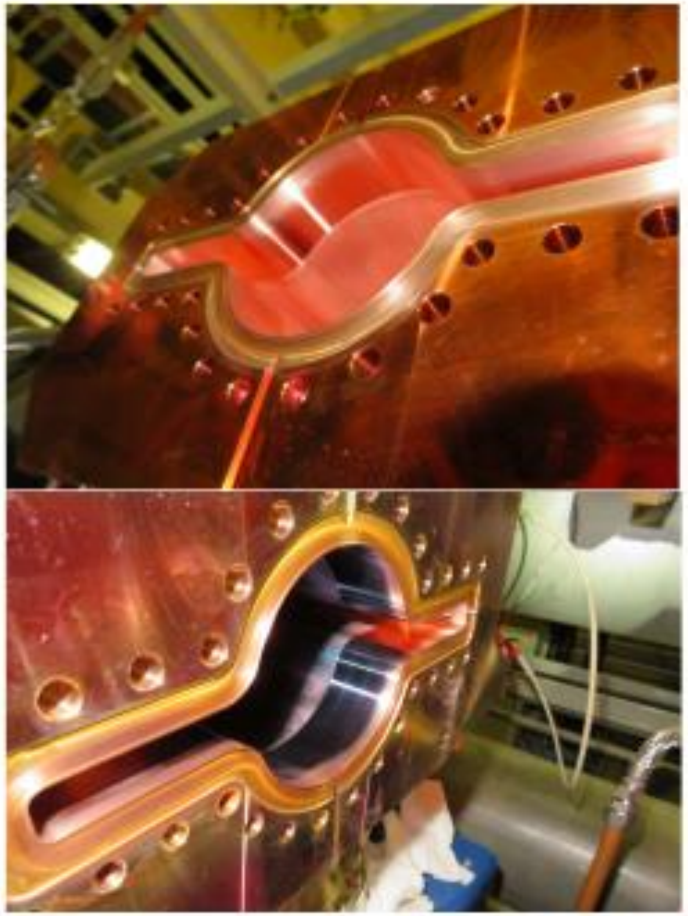
* Bellows Chamber at Nikko Wiggler Section Was Exchanged on November 6 2024

LER Wiggler Section



* Cleaning work at Nikko wiggler section on Nov. 26 2024

After removing VACSEAL (black color)

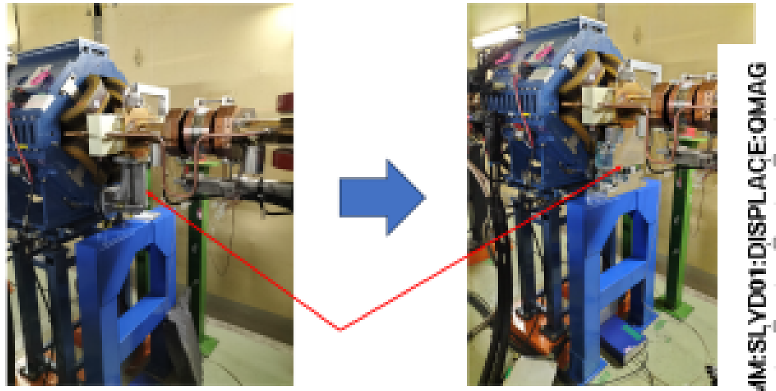


This reduces SBL related to the presssure burst at the pipe where VACSEAL removed.

Oct. 9 - Nov. 6 : #SBL/Beam Dose = 0.141 (1/Ah)
Nov. 6 - Dec. 27 : #SBL/Beam Dose = 0.043 (1/Ah)

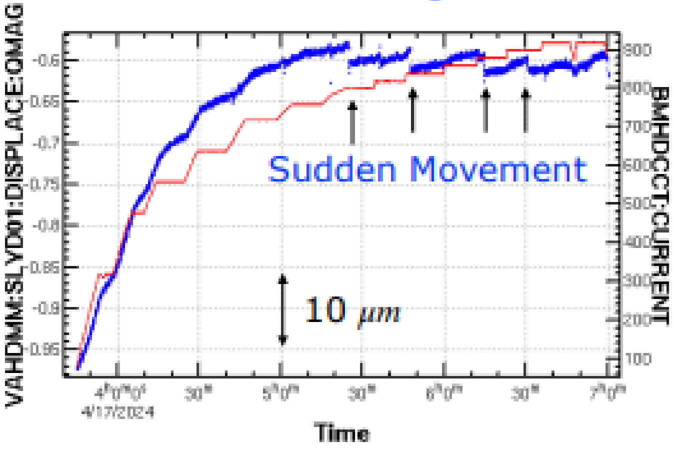
decoupling of BPMs from quadrupole

Before **HER** After

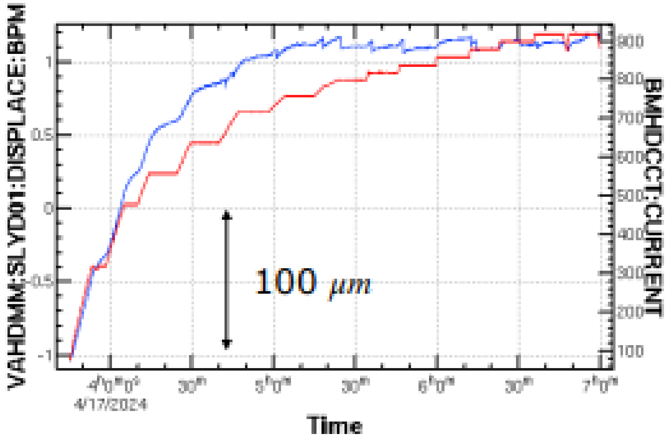


Red : Beam Current in HER

Movement of Quad



Movement of BPM Block



Remove BPM support from Quad

Work on April 17 2024

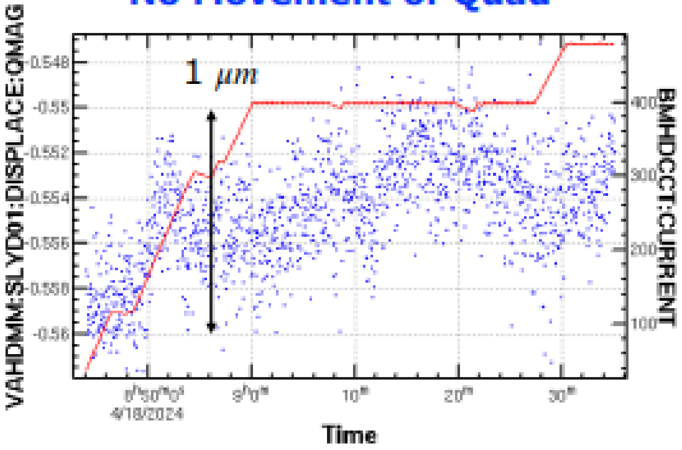
We don't observe Sudden Orbit Distortion after Isolation Work.

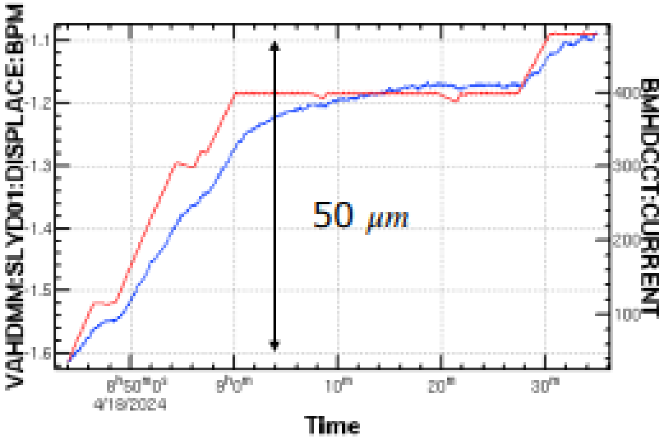
No unidentified beam abort occurs.

Horiontal orbit shift at sextupoles induces large beta-beat and tune shift.

After Modification 1 V = 100 μm

No Movement of Quad





ordered list of priority items, proposed by ARC review

0. Reconnect the BPMs which were isolated in 2024 to the adjacent quadrupoles, and stabilize the quadrupole position by mechanical means
1. Acquiring or producing vacuum clamshells to avoid use of VacSeal during the next run
2. Installing more BORs for SBL diagnostics around the LER, and at least one in the HER, in particular RFSoC with bunch-by-bunch capabilities
3. Additional laser-based (?) IR survey (misalignment/tilt of Belle-II detector w.r.t accelerator)
4. Further development of improved IR magnetic model
5. BT dipole magnet replacements (for LER)
6. Further realignment of both BT lines (since realignment of ARC1 e+ proved effective in reducing the emittance growth)
7. Improve and extend turn-by-turn BPM reading capability for both HER and LER
8. Routine recording of emittances or beam sizes measured by SR monitors
9. Installing two or more nonlinear magnets, such as octupoles, in each of the two BT lines, once the potential beneficial effect for injection efficiency is confirmed by simulations
10. Explore and, if deemed possible, implement a local water cooling at the heat source for some power supplies, to save energy and not only to rely on air conditioning