

International Task Force (ITF)

Activity summary

Mika Masuzawa

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International Task Force (ITF) for SuperKEKB

Goal

Find a realistic way to achieve $10^{35}\text{cm}^{-2}\text{s}^{-1}$ after LS1 without major modification
Consider ideas to achieve $6 \times 10^{35}\text{cm}^{-2}\text{s}^{-1}$ with larger-scale modification at LS2

The kickoff meeting was held on July 28, 2021

Three working groups were originally organized.

- ① Optics (A. Morita/H. Koiso)
- ② Beam-beam (D. Zhou/K. Ohmi)
- ③ TMCI (M. Migliorati/T. Ishibashi)

- ④ LINAC (M. Satoh/S. Matsumoto) was organized later
- ⑤ SBL (H. Ikeda/H. Nakayama) was organized recently

ITF



Task force



- Members

- ARC members prepared a list of possible candidates in June, 2021
- Initial members have been identified. More members who have required expertise and strong interest are welcome.
- Should work in close collaboration with KEKB commissioning team.

Y. Suetsugu

International members	
Maria Enrica Biagini	INFN
Georg Hoffstaetter	Cornell
Evgeny Levichev	BINP
Mark Palmer	BNL
Yunhai Cai	SLAC
Rogelio Tomas	CERN
Pantaleo Raimondi	ESRF
Katsunobu Oide	The Univ .of Geneve

KEK accelerator members
Mika Masuzawa(Chair)
Yukiyoshi Ohnishi
Akio Morita
Hiroshi Sugimoto
Haruyo Koiso
Yoshihiro Funakoshi
Tsukaka Miyajima
Kazuhiro Ohmi
Demin Zhou
Kentaro Harada

Belle II members
Hirofumi Nakayama
Francesco Forti

ITF activities

We had 7 general meetings

Kickoff meeting

Mid-term review
by ARC

One year activity
report

	2021						2022											
	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
ITF general meeting	○ kick off		○	○		○		○ ARC			○		○					
ITF report								○										○
ARC review								○										○
SuperKEKB operation																		

Activity period
Coming one year



One year (or more) extension
New chair: Y. Ohnishi

Summary from each group

The activity report with

- comments from the reviewers
- responses from each group

Is uploaded here

<https://kds.kek.jp/event/44835/>
and distributed.

- Summary from each group

ITF activities

① Optics activities (A. Morita (KEK)/H. Koiso(KEK))

- Report on “Orbit drift at the SLY magnets (The sextupoles for local chromaticity correction and for creating CW) causes linear optics deformation.” by H. Sugimoto.
- Two schemes, suggested by ITF optics meetings, were tried for DA optimizations:
 - Yunhai Cai's sextupole parameter set was tried during 2021/12/20 swing shift.
→ (see next page).
 - Trial **simulation study** to insert IP phase weak sextupole to SuperKEKB LER, which was inspired by Pantaleo Raimondi talk, was performed.
→ No significant improvement of optimized Touschek lifetime is observed crab-waist single beam optics.

- Summary from each group

ITF activities

① Optics

Yunhai's LER sextupole setting

Reported 3rd sub-group meeting:

Conclusion

SLAC

- A model of the low energy ring is constructed using LEGO with good agreements both in linear optics and nonlinear dynamics.
- Currently, the momentum aperture is 0.9%, limited by the half integer resonance in the horizontal plane due to the tune selected for a good beam-beam performance and a positive linear chromaticity for control of TMCI.
- The momentum aperture can be enlarged to 1.4% using existing 54 pairs of sexupoles. The solution can be tested in the machine with intermediate steps.

11/16/2021

Yunhai Cai, SuperKEKB Optics Meeting

15

Yunhai's sextupole setting is tested at 2021/12/20 Swing shift.

Lifetime evaluations

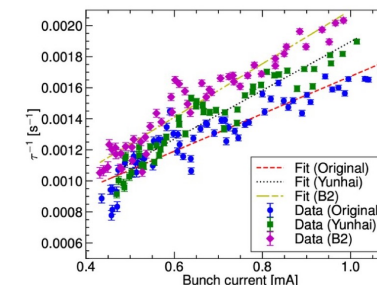
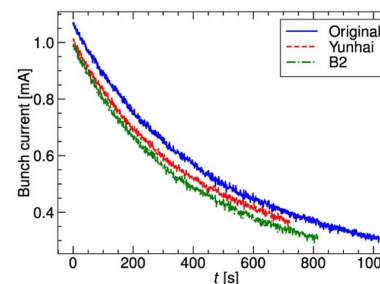
R. Yang

different sextupole settings in the LER

Assuming const. gas pressure and beam emittances during the measurements, the fitting out lifetimes (w/ bunch current of 1 mA) are

	$\langle \Delta\beta/\beta \rangle_x$ [%]	$\Delta\eta_y$ [mm]	ε_y [pm]	ξ_{xy}	IP knobs
original	4.2	4.5	~20	-1.24/3.58	≠0
Yunhai	5.3	3.7	~20	-1.24/3.66	0
B2	6.5	7.9	~20	0.1/1.9	0

	BGS [s]	Touscheck [s]
original	2138±227	829±48
Yunhai	3039±480	637±30
B2	2673±355	580±25



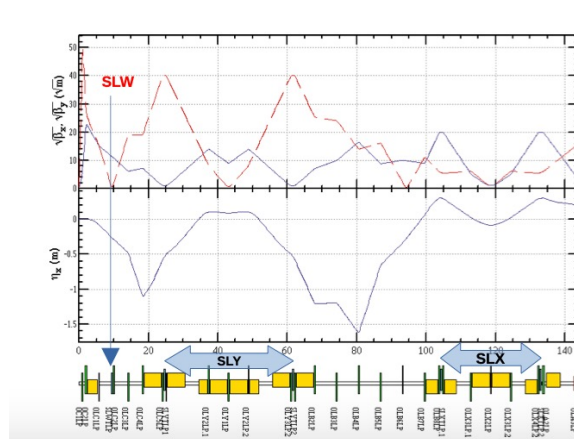
- Summary from each group

ITF activities

① Optics

LER Trial IR with IP phase sextupole

- Trail to insert weak sextupole(**SLW**) around β_y waist between QC2P and SLY imitating Pantaleo's idea.
 - In order to avoid xy-coupling effect around IR, IR unit is rebuilt from scratch using simple quadrupoles without solenoid.
 - Chicane structure similar with current SuperKEKB IR
 - Additional matching quadrupoles
 - Not fitted with current tunnel
 - SLW** is installed with $\Delta v_y(\text{IP-SLW}) = 0.5$, $\beta_y(\text{SLW}) < 10\text{m}$
 - $\Delta v_y(\text{QC1-SLY}) = 0.5$, $\Delta v_x(\text{IP-SLY}) \sim 0.48$ for crab-waist by using SLY
 - $\Delta v_x(\text{QC2-SLX}) = 1.0$
- Improvement of optimized Touschek lifetime by introducing **SLW** variables is not observed on crab-waist single beam optics.



CW K2 [m ⁻²]	τ w/o SLW	τ w SLW
0.0	931.6	916.0
0.2	620.9	619.4
0.4	461.8	469.5
0.8	341.3	331.4
1.2	266.0	258.4
1.6	206.3	201.3
2.0	179.8	172.2

$\beta_y^* = 0.3\text{mm}$
 $\kappa \sim 3\%$
 no-collision

A.Morita

- Summary from each group

ITF activities

There were 12 beam-beam meetings held.

② Beam-beam activities (D. Zhou (KEK)/K. Ohmi (KEK))

1) The critical issues investigated and key conclusions drawn from the ITF-BB sub-workgroup's activities and interactions with other ITF sub-workgroups

1.1) Crab waist: It is a must for the nano-beam collision scheme.

1.2) Interactions among beam-beam, lattice nonlinearity, and crab waist effects are show-stoppers with $y^* \sim 0.3\text{mm}$ but do not set a limit if $y^* > 0.6\text{mm}$.

1.3) Single-bunch impedance (longitudinal monopole, transverse monopole, dipole, and quadrupole terms) sets a limit on machine performances. The interaction between BxB feedback and vertical impedance in LER was affecting luminosity performance until April 2022. This problem was relaxed after BxB was fine-tuned but remains as a potential source of mild vertical emittance blowup.

1.4) Beam-beam simulation codes:

Strong-strong simulation codes are a must for reliable predictions of luminosity at SuperKEKB. Benchmarks among various codes presented good agreements in general. On the other hand, the effects of multiple beam dynamics (beam-beam, impedances, lattice imperfections, and BxB feedback) must be included. Efforts being made.

Beam-beam talk by D. Zhou after this talk.

- Summary from each group

ITF activities

There were 12 beam-beam meetings held.

② Beam-beam activities (From the summary report by D. Zhou)

2) Responses to the comments and recommendations from ARC members

2.1) “The high momentum compaction optics (when/once available) should be tried in operation before the shutdown.”

Machine tunings were focused on achieving a new record luminosity beyond $5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ before LS1. Machine tunings with high α is time-consuming and we had to give up trying this.

2.2) “Clarify the performance reach of the crab waist scheme, its operational range in usable strength and its impact on reachable specific luminosity and on dynamic aperture .”

Trying different crab waist ratio...

Because of the same reason, machine tunings by varying crab waist strengths were not tried before LS1.

- Beam-beam talk by D. Zhou after this talk.

- Summary from each group

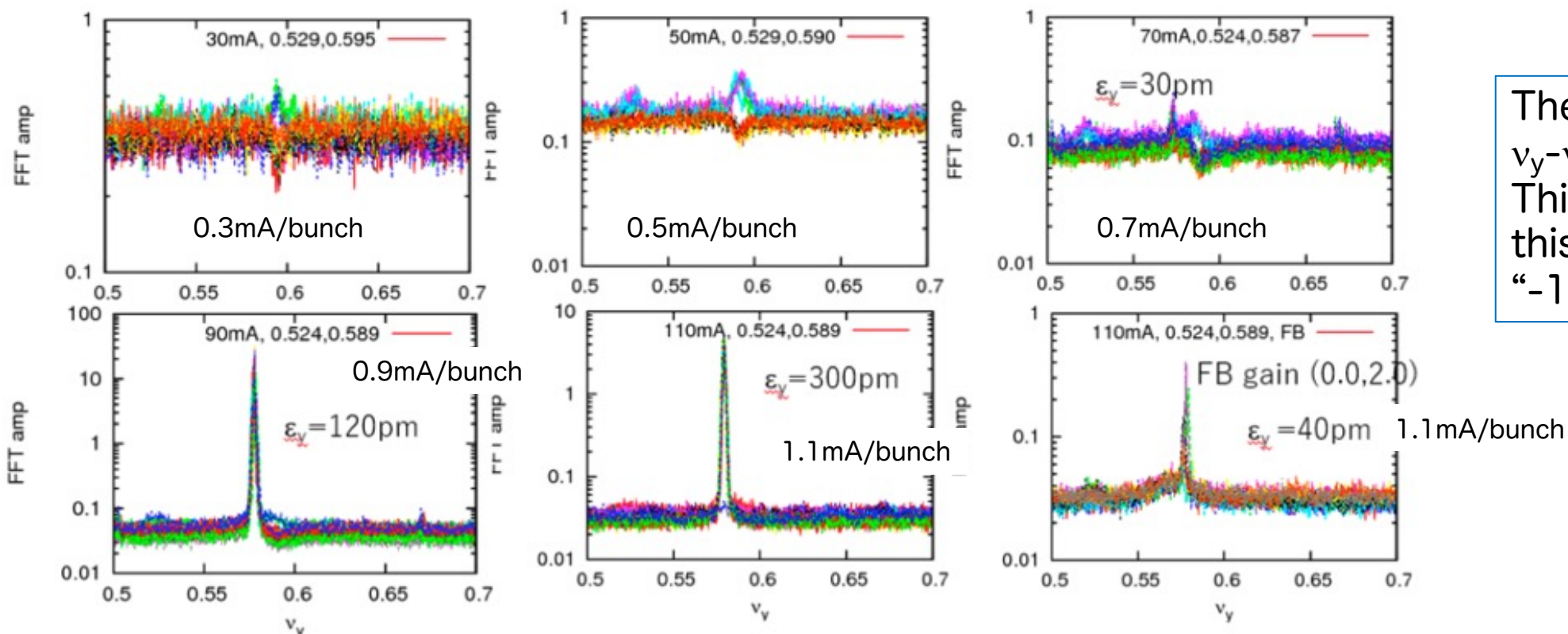
ITF activities

Ohmi-san's talk this morning

There were 7 TMCI meetings held by the end of April.

③ TMCI

- A TMCI-like single-bunch instability in the LER was identified as a “-1 mode instability”. The “-1 mode instability” causes a vertical blow-up with a bunch-current threshold of ~1 mA in LER. Fine-tuning the FB system helped suppress this instability.



The signal appears at $v_y - v_s$ (-1 mode). This is why we call this instability “-1 mode”

- Summary from each group

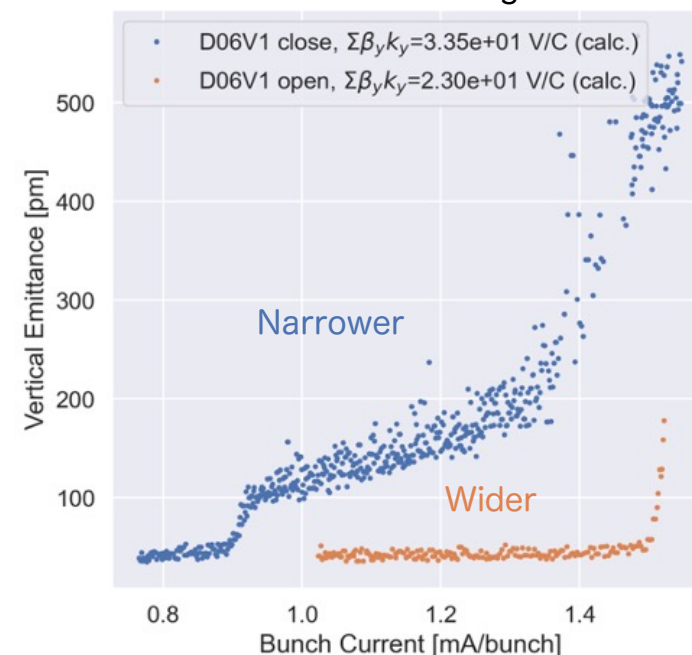
ITF activities

Ohmi-san's talk this morning

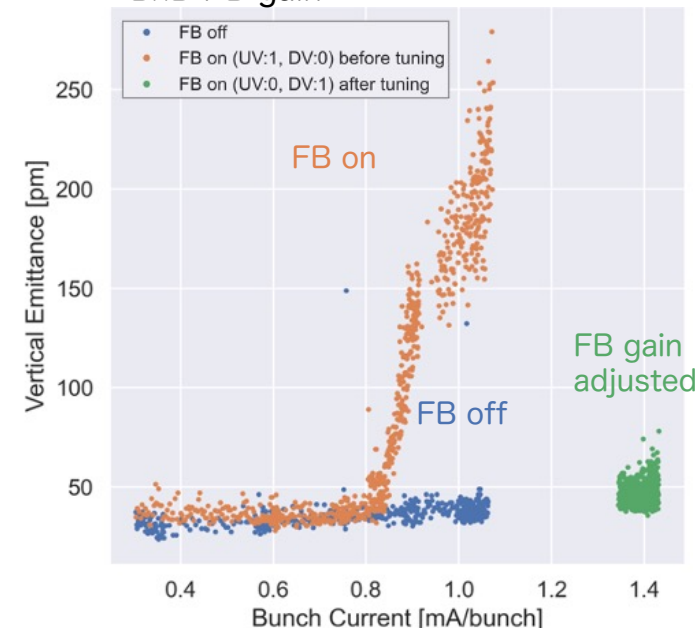
③ TMCI (M. Migliorati (Università di Roma)/T. Ishibashi (KEK))

- The TMCI sub-group investigated and studies the workaround and mechanism of the vertical beam size blowup at ~ 1 mA/bunch in LER, by machine studies and simulations.
- Remodeling of the impedance in LER and HER was carried out through the activities in this group.
- Observations are
 - beam size blowup is due to a single bunch effect.
 - 1 mode ($v_y - v_s$) signals are observed when the blowups occur.
 - the bunch current threshold increases by opening the aperture of the vertical collimator and decreasing the vertical impedance, and
 - BxB FB gain needs to be adjusted properly.

D06V1 collimator setting



BxB FB gain



ITF activities

③ TMCI (M. Migliorati (Università di Roma)/T. Ishibashi (KEK))

Workarounds for the instability suppression found through machine studies are:

- 1) Proper tuning of BxB FB gain
- 2) Higher vertical tune
- 3) Higher vertical chromaticity
- 4) Reducing vertical impedance

2) & 3) Injection efficiency drops...

4) A new collimation scheme “non-linear collimator scheme” to reduce the vertical impedance was proposed, and it is being installed now and will be completed during Long Shutdown 1 (LS1).

- Summary from each group

ITF activities

④ Linac (M. Satoh(KEK)/S. Matsumoto(KEK)), has not been active.

- The Injector linac sub-group was formed at the 2nd ITF general meeting on Sep. 2, after receiving a recommendation to increase the number of focused task-force groups to the other key areas.
- Unfortunately, there wasn't any members from overseas joining us who showed interest in joining the group in the first few months. And we could not gain momentum as an international team as we became busier with the daily commissioning of the linac for SuperKEKB/PF-AR/PF.
- We regret that there is not much to report as an ITF group this time.
- The injector linac activities, operation summary and the future plan were reported yesterday,
- Making a smaller, better-defined working groups may help activate international collaboration.

- Summary from each group

ITF activities

Ikeda-san's talk this morning

There were 2 SBL meetings held already.

- ⑤ Sudden Beam Loss (H. Ikeda (KEK)/H. Nakayama (KEK)), organized recently after the 2022b run.
- Sudden beam loss (SBL) is one of the obstacles for machine tuning and beam current increase.
- The SBL mechanism is not understood.
- SBL causes collimator (and other component) damages, QCS quenches, and large B.G. to Belle-II.
- The ITF SBL working group was launched at the ITF meeting held on July 22 this year.

Next

ITF activities

The first-round ITF activities end today.
It was not too easy to operate ITF while machine was running.

Y. Ohnishi is the new chairperson and re-organize working groups.

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ITF report								○										○
ARC review								○										○
SuperKEKB operation																		

➡ New ITF
During and after LS1

Thank you for your support

International members	
Maria Enrica Biagini	INFN
Georg Hoffstaetter	Cornell
Evgeny Levichev	BINP
Mark Palmer	BNL
Yunhai Cai	SLAC
Rogelio Tomas	CERN
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