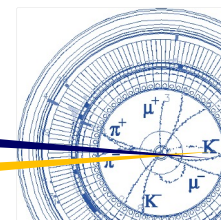


# The SuperKEKB Has Broken the World Record of the Luminosity



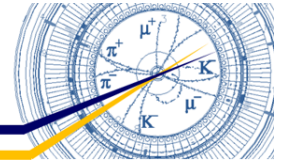
Yoshihiro Funakoshi (yoshihiro.funakoshi@kek.jp)  
On behalf of SuperKEKB Commissioning Group



Inter-University Research Institute Corporation **High Energy Accelerator Research Organization (KEK)**  
大学共同利用機関法人 **高エネルギー加速器研究機構 (KEK)**

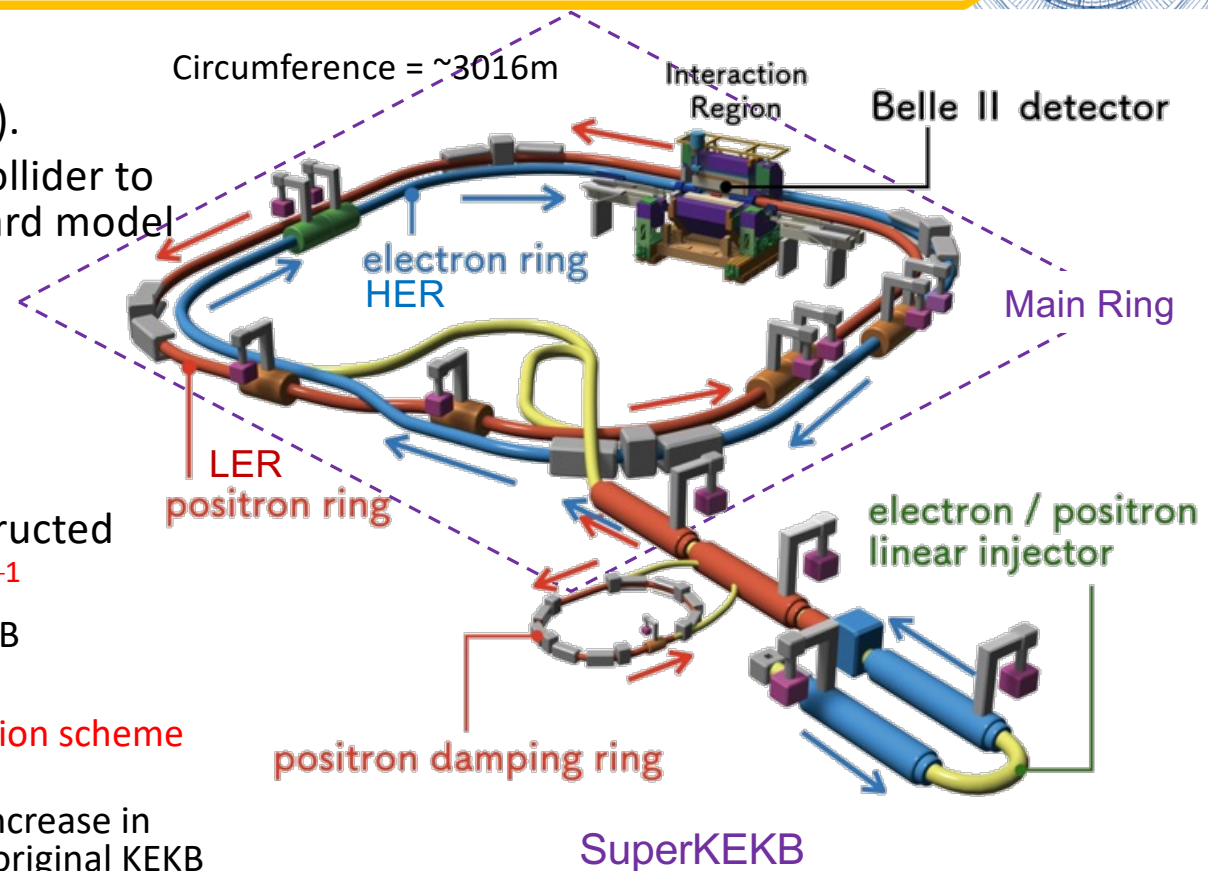


# SuperKEKB

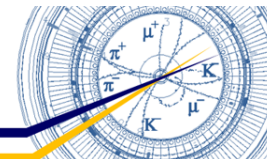


- SuperKEKB;

- An upgrade of KEKB B-factory (KEKB).
- High-luminosity **electron-positron** collider to seek out new physics beyond standard model
- Main ring (MR) is composed of
  - Low Energy Ring (LER);  
4.0 GeV Positron, 3.6 A(design)
  - High Energy Ring (HER);  
7.0 GeV electron, 2.6 A(design)
- Positron damping ring: newly constructed
- Design Luminosity :  $8.0 \times 10^{35} \text{ cm}^{-2} \cdot \text{s}^{-1}$ 
  - ✓ 40 times maximum luminosity of KEKB
  - ✓ **Twice beam current** of KEKB ( $\times 2$ )
  - ✓ Squeezing  $\beta y^*$  with **nano-beam collision scheme** ( $\times 20$ )
  - ✓ Over a period of 10 years, a 50-fold increase in integrated luminosity relative to the original KEKB is expected.



# SuperKEKB project history



- Phase1 operation (2016.Feb. ~ June);
  - Vacuum scrubbing, low emittance beam tuning, and background study for Belle II detector installation
  - w/o final focusing system (QCS) and Belle II detector
- Phase2 operation (2018.Mar. ~ July);
  - Damping ring for positron was introduced.
  - Pilot run of SuperKEKB and Belle II w/o pixel vertex detector (PXD)
  - Demonstration of nano-beam collision scheme
  - Study on background larger than at KEKB due to much lower beta functions at IP.

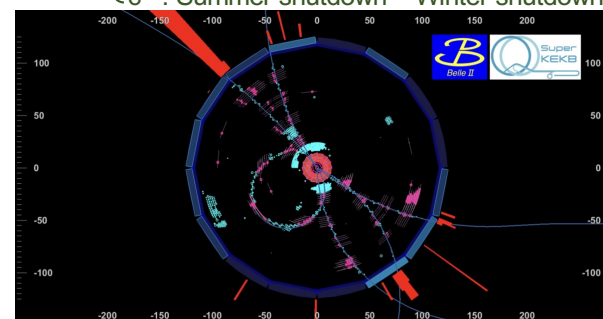
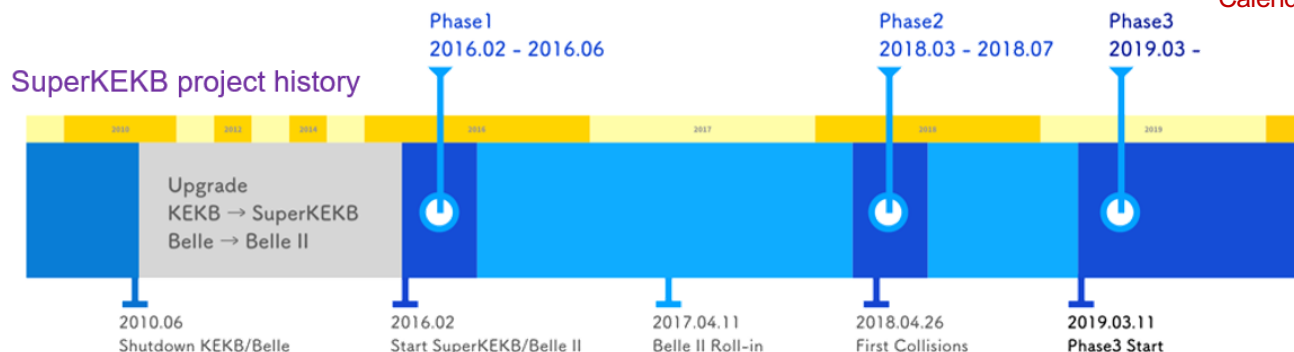
- Phase3 operation (2019.March~);
  - Physics run with fully instrumented detector.
    - Top-up injection in both rings
  - Phase3 2019ab (2019.3~7)
    - “Status of Early SuperKEKB Phase-3 Commissioning” by A.Morita (WEYYPLM1) @ IPAC’19 (2019.5.22)
  - Phase3 2019c (2019.10~12)
  - Phase3 2020ab (2020.2~)
    - “Highlight from SuperKEKB Beam Commissioning” by K. Shibata @ IPAC2020 (2020 May)

## ✓ New nomenclature of each run of Phase3

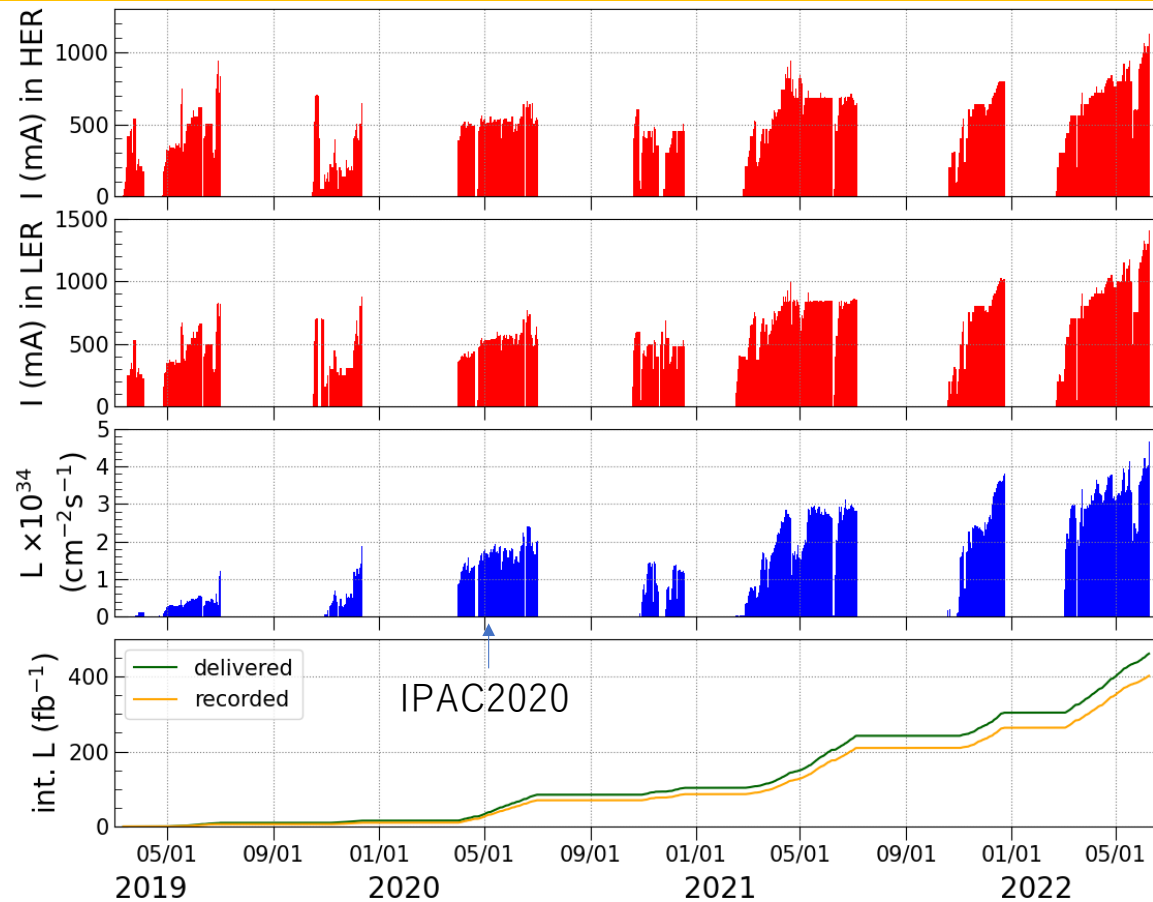
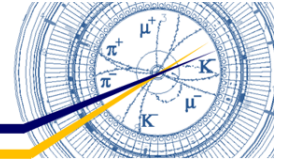
“Phase3 YYYYxx”

Calendar year

- a : Winter shutdown - March
- b : April - Summer shutdown
- ab : Winter shutdown – Summer shutdown
- c : Summer shutdown – Winter shutdown

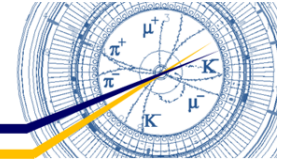


# History of beam operation





# Comparison of machine parameters



IPAC2020  
K. Shibata

IPAC2022  
at present

|   | KEKB achieved |        | SuperKEKB 2020 May 1 <sup>st</sup> |        | SuperKEKB 2022 June 8 <sup>th</sup> |                                 | SuperKEKB design |        |
|---|---------------|--------|------------------------------------|--------|-------------------------------------|---------------------------------|------------------|--------|
|   | LER           | HER    | LER                                | HER    | LER                                 | HER                             | LER              | HER    |
| $I_{\text{beam}}$ [A]                               | 1.637         | 1.188  | 0.438                              | 0.517  | 1.321                               | 1.099                           | 3.6              | 2.6    |
| # of bunches  | 1585          |        | 783                                |        | 2249                                |                                 | 2500             |        |
| $I_{\text{bunch}}$ [mA]                             | 1.033         | 0.7495 | 0.5593                             | 0.6603 | 0.5873                              | 0.4887                          | 1.440            | 1.040  |
| $\beta y^*$ [mm]                                    | 5.9           | 5.9    | 1.0                                | 1.0    | 1.0                                 | 1.0                             | 0.27             | 0.30   |
| $\xi y$   | 0.129         | 0.090  | 0.0236                             | 0.0219 | 0.0407<br>(0.0565) <sup>a</sup>     | 0.0279<br>(0.0434) <sup>a</sup> | 0.0881           | 0.0807 |
| Luminosity [ $10^{34}\text{cm}^{-2}\text{s}^{-1}$ ] | 2.11          |        | 1.57                               |        | 4.65                                |                                 | 80               |        |
| Integrated Luminosity [ $\text{ab}^{-1}$ ]          | 1.04          |        | 0.03                               |        | 0.40                                |                                 | 50               |        |

a) High bunch current collision study



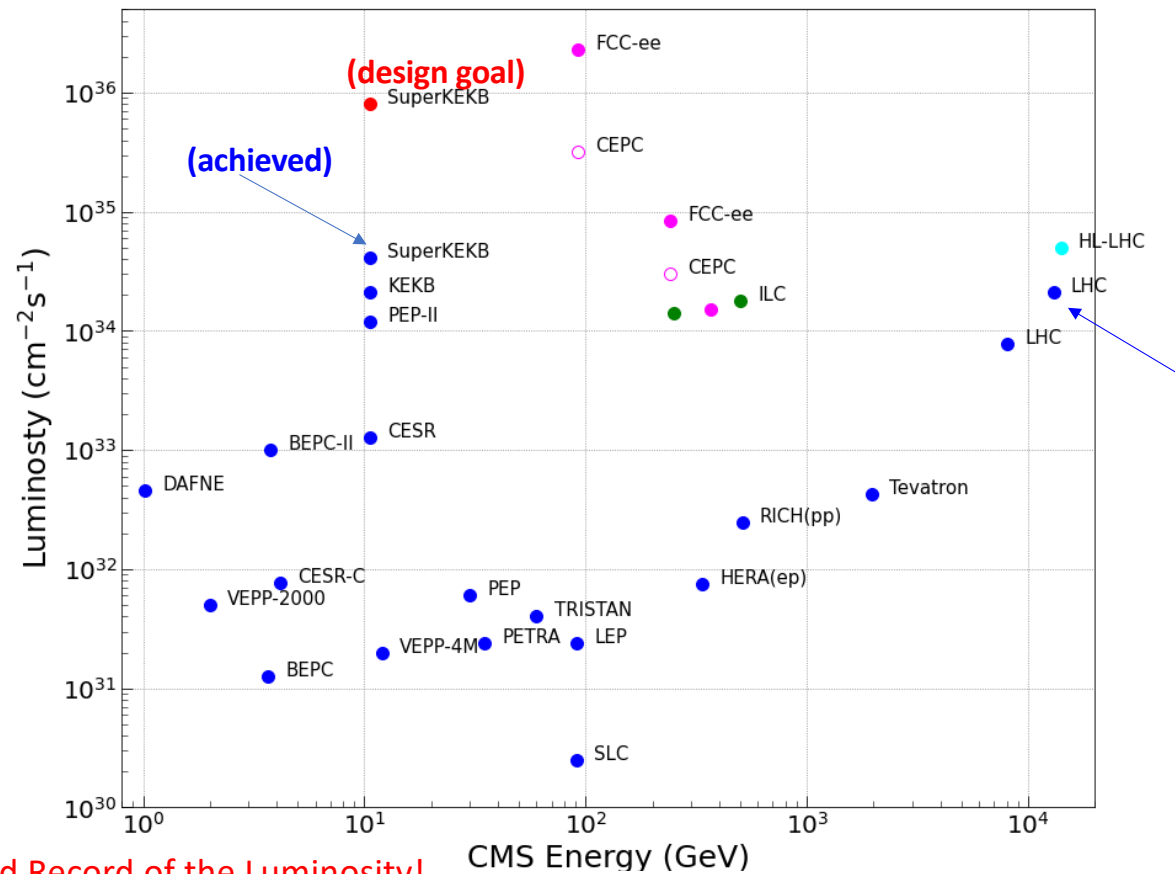
2022/June/12th

IPAC2022 SuperKEKB Y. Funakoshi

5



# Comparison of Luminosity



The SuperKEKB Has Broken the World Record of the Luminosity!



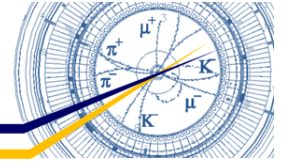
2022/June/12th

IPAC2022 SuperKEKB Y. Funakoshi

6



# Machine Parameters of SuperKEKB



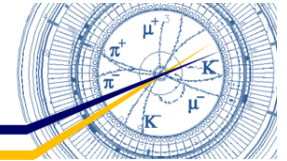
|  | LER           | HER           |  |
|--|---------------|---------------|--|
| Beam Energy  | 4.0           | 7.0           | GeV                                      |
| Circumference                                      | 3016          |               | m  |
| Crossing angle                                     | 83            |               | mrad                                     |
| Crab waist ratio                                   | 80            | 40            | %  |
| Beam current @Maximum Luminosity                   | 1.321         | 1.099         | A  |
| Number of bunches                                  | 2249          |               |  |
| Bunch current @Maximum Luminosity                  | 0.5873        | 0.4887        | mA                                       |
| Total RF voltage $V_c$                             | 9.12          | 14.2          | MV                                       |
| Synchrotron tune $\nu_s$                           | -0.0233       | -0.0258       |  |
| Bunch length $\sigma_z$                            | 5.69          | 6.03          | mm                                       |
| Momentum compaction $\alpha_c$                     | 2.98E-4       | 4.54E-4       |  |
| Betatron tune $\nu_x / \nu_y$                      | 44.524/46.592 | 45.532/43.575 |  |
| Beta function at IP $\beta_x^* / \beta_y^*$        | 80/1          | 60/1          | mm                                       |
| Measured vertical beam size (XRM) @IP $\sigma_y^*$ | 0.224         | 0.224         | $\mu\text{m}$                            |
| Vertical beam-beam parameters $\xi_y$              | 0.0407        | 0.0279        |  |
| Beam lifetime                                      | 8             | 24            | min.                                     |
| Luminosity (Belle 2 Csl)                           | 4.65          |               | $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ |

← Touschek dominant





# Luminosity improvement [1/4] Crab waist

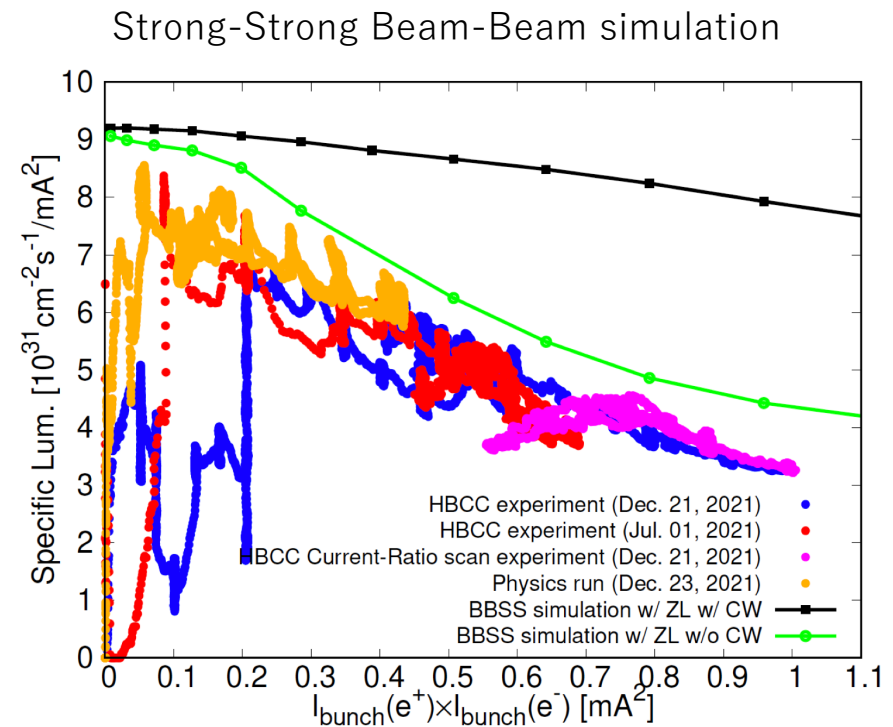
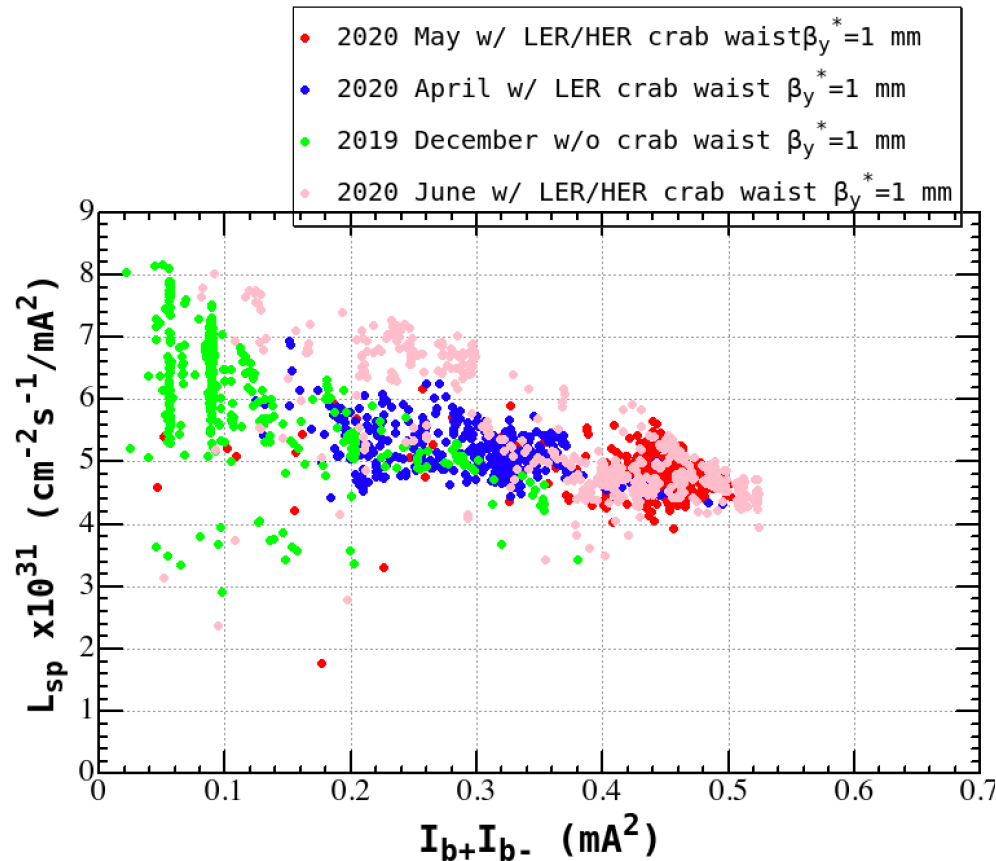
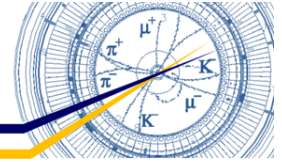


- Introduction of crab waist at SuperKEKB
  - Motivations
    - The beam-beam performance was poor in spite of all of knob tunings for improving it. It was limited by beam-beam resonances which can be suppressed by crab waist.
  - Method
    - FCC-ee type scheme: use of imbalance sextupoles in the vertical local chromaticity correction section.
  - Time table
    - 2020 March 16<sup>th</sup> : LER crab waist (40%)
    - 2020 March 24<sup>th</sup> : LER crab waist (60%)
    - 2020 April 24<sup>th</sup> : HER crab waist (40%)
    - 2020 June 1<sup>st</sup> : LER crab waist (80%)



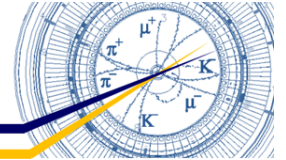


# Specific luminosity w/ and w/o crab waist





# Summary of crab waist scheme

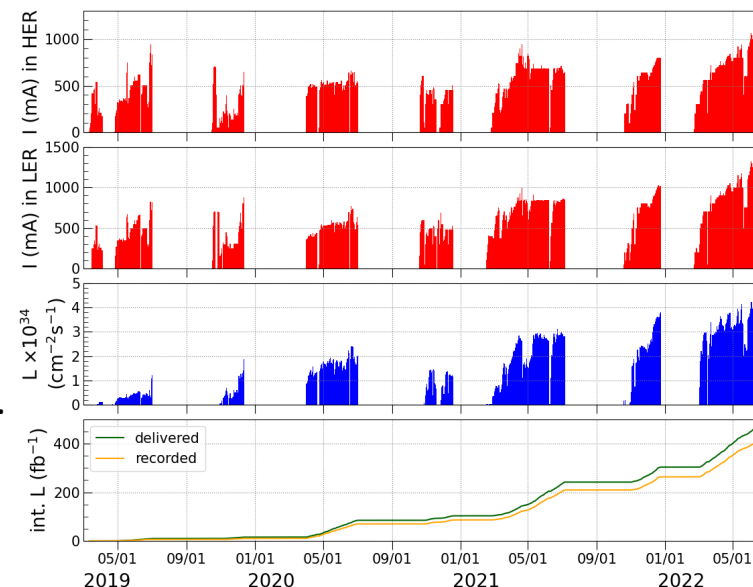


- Benefits of use of crab waist scheme
  - Suppression of beam-beam blowup
    - Specific luminosity was improved.
  - Increase of the bunch currents of both beams
    - Without crab waist, beam injections was limited due to beam blowup.
- Beam lifetime issue
  - Dynamic aperture shrinks w/ crab waist and the lifetime decrease w/ crab waist was expected.
    - But in  $\beta y^* = 1\text{mm}$  case, no lifetime decrease was observed in LER and HER.
      - The narrow physical apertures at collimators determine the lifetime.
    - In the case of lower  $\beta y^*$ , simulations showed the lifetime w/ crab waist will set a strong limit.

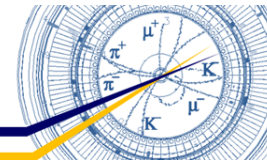


## Luminosity improvement [2/4] Higher beam currents

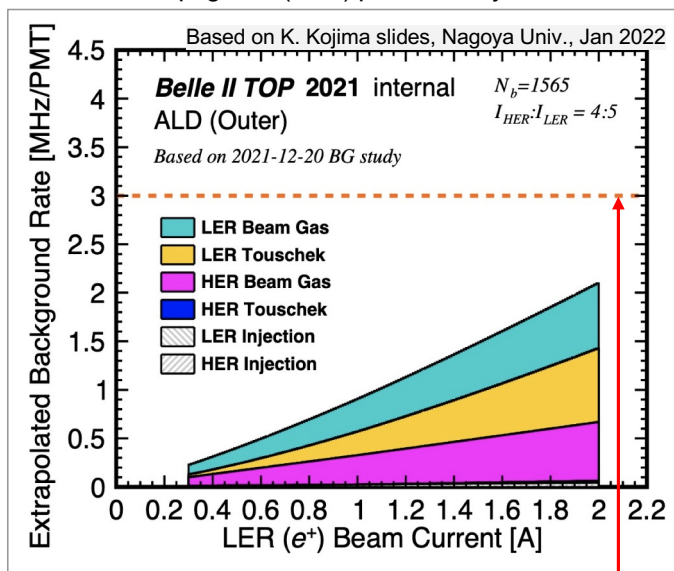
- We have been increasing beam currents with fighting with obstacles
  - Obstacles
    - **Hardware damages due to fast beam losses**
      - Frequency hardware troubles on collimators (and Belle II sub-detectors) happened when the bunch current in LER is larger than 0.7 mA. The recent increase in beam currents was achieved by increasing the number of bunches while respecting the limit from bunch current limit ( $\sim 0.7$  mA/bunch). (to be addressed later)
    - Detector beam background
    - Beam aborts
    - Beam instability
    - Beam injection



# Current background level in Belle II



One of the most vulnerable sub-detectors is the Time of Propagation (TOP) particle ID system



Current background limit for the TOP PMT rate

- Current background rates in Belle II are acceptable and well below limits
- Belle II did not limit beam currents in 2021 and 2022
  - It will limit SuperKEKB beam currents eventually, without further background mitigation
- To reach the design luminosity an upgrade of crucial detector components is foreseen (e.g. TOP short lifetime conventional PMTs)

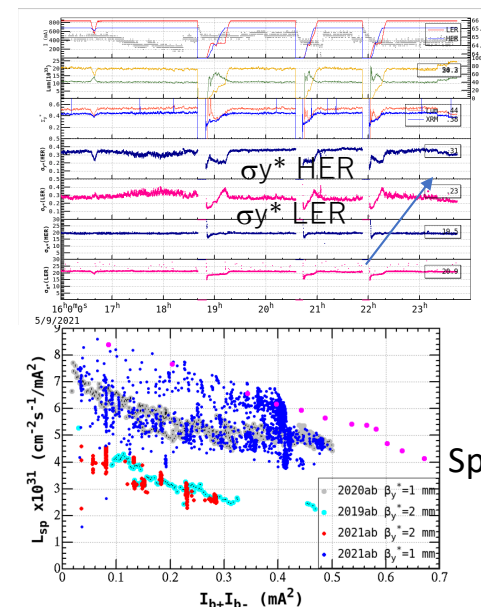
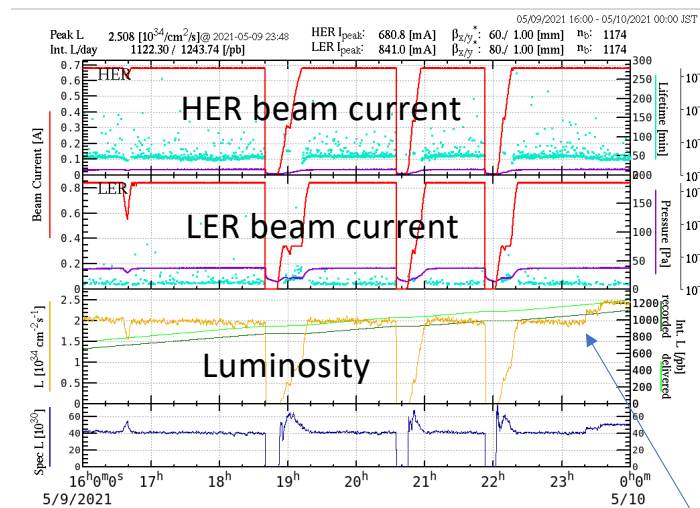
In view of replacement of a vulnerable part of PMTs in LS1 (Long Shutdown 1), the BG limit of TOP PMT was raised to 5 MHz in 2022.

Beam Gas BG in LER is expected to be lowered in the process of vacuum scrubbing. We also expect that BG will be lowered by IR radiation shield reinforcement done in LS1. On the other hand, luminosity related BG will increase with a higher luminosity.



# Luminosity improvement [3/4] Bunch-by-bunch feedback gain

- In May 2021, the luminosity increased by lowering gain of the bunch-by-bunch feedback system in HER.
- Noise mixed in FB system affected the luminosity.
  - The noise was caused by a troubled module. Since the noise frequency was near the betatron tune, its effect was large.

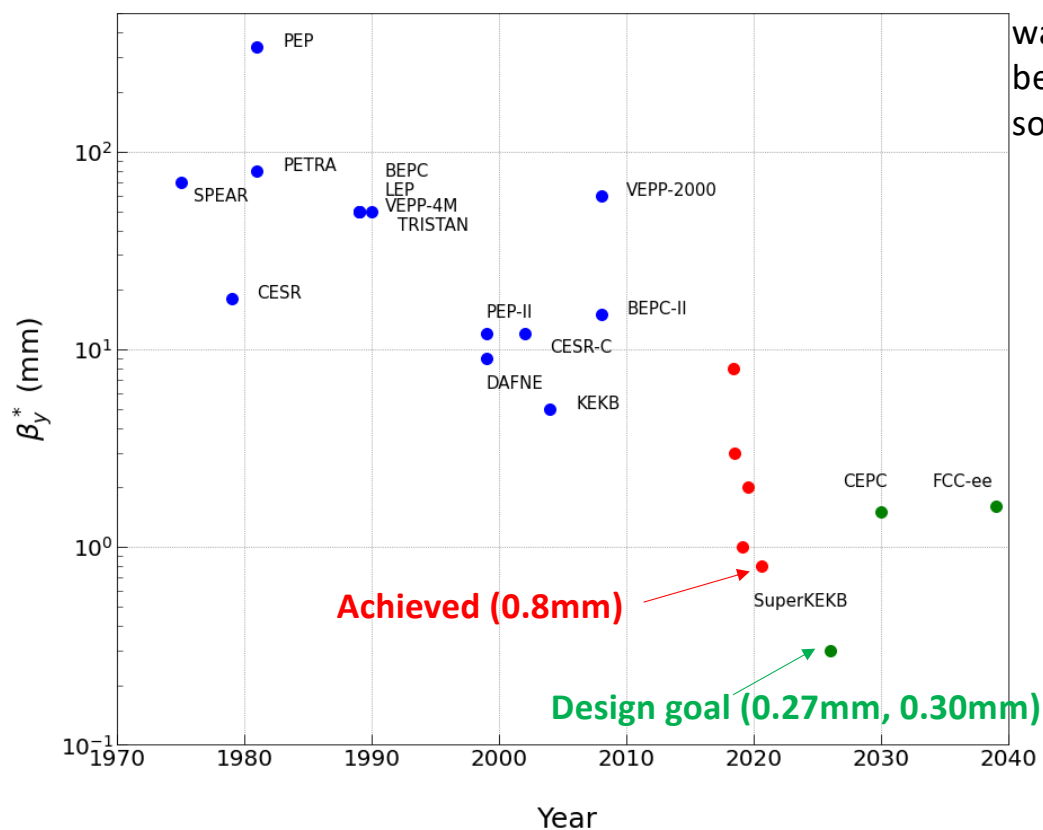
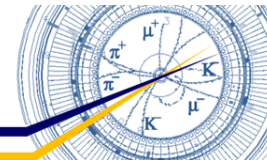


The luminosity increased by lowering HER vertical FB gain by 4dB + 4dB.

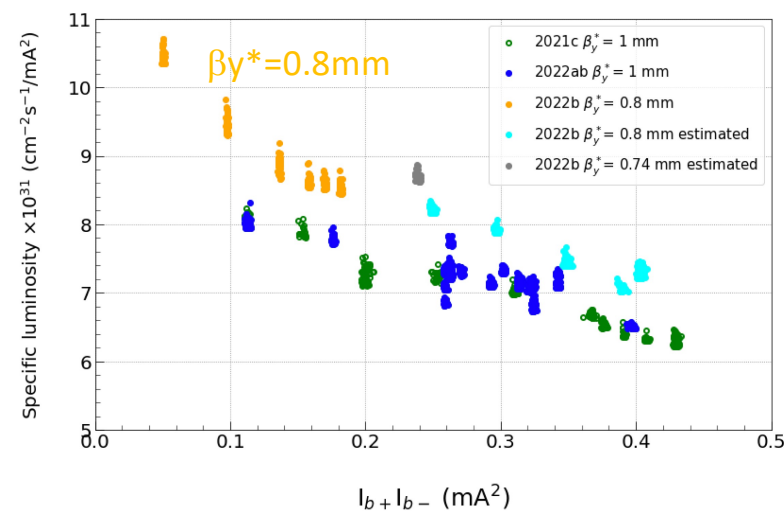
The increase in the luminosity was ~25%

IPAC2022 SuperKEKB Y. Funakoshi

# Luminosity improvement [4/4] $\beta_y^*$



In 2022b run, we tried  $\beta_y^*=0.8\text{mm}$ . The specific luminosity was higher than  $\beta_y^*=1\text{mm}$  case. We could not store higher beam currents due to poor injection efficiency. We will re-try soon.

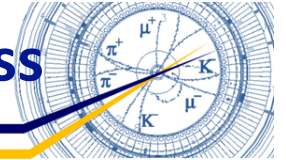


In the data in cyan and blue, estimated values of  $\beta_y^*$  in HER were less than 1mm(setting value) due to horizontal orbit change in SLY depending on total beam current.

SLY: Sextupoles at local chromaticity correction



# Performance limiting issues [1/4] Fast & large beam loss

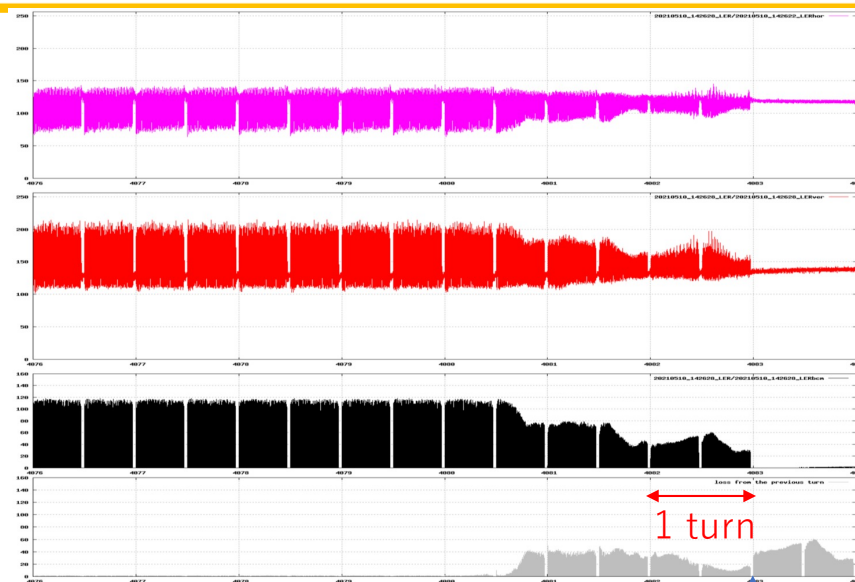
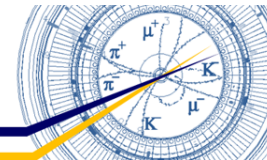


- Observations
  - Fast and large beam loss ( $< 3$  turns) (particularly in LER)
  - The loss causes damage of collimators and Belle II inner sensors, and QCS quench
  - Empirical rule: Bunch current must not exceed 0.7mA.
- Obstacle to machine operation
  - We have been conservative in increasing beam currents (particularly bunch currents).
  - This issue determines the speed of increasing beam currents and then slows down increase of luminosity.
- Mechanism of fast & large beam loss
  - Still not understood well
    - A hypothesis was proposed by T. Abe.
    - A microparticle heated by the beam-induced field causes a macroscopic vacuum arc.
    - We will continue to study this hypothesis
  - A joint Belle2-SuperKEKB team has been working to identify the original places of fast beam losses. Recent progress shows collimators near the injection region are the most possible candidates.  
(<https://kds.kek.jp/event/41394/contributions/209334/attachments/154298/195935/16aA561-03.pdf>)
  - Investigations are ongoing to fully understand this issue and countermeasures are being sought.





# Typical large beam loss events (LER)



Bunch oscillation recorder (BOR)  
Horizontal oscillation

Bunch oscillation recorder (BOR)  
Vertical oscillation

**BOR amplitude**  
= **oscillation amplitude** × **bunch current**

Bunch current monitor (BCM)

Amount of beam loss (from BCM)

Beam was aborted here by beam abort system based on information from beam loss monitors.

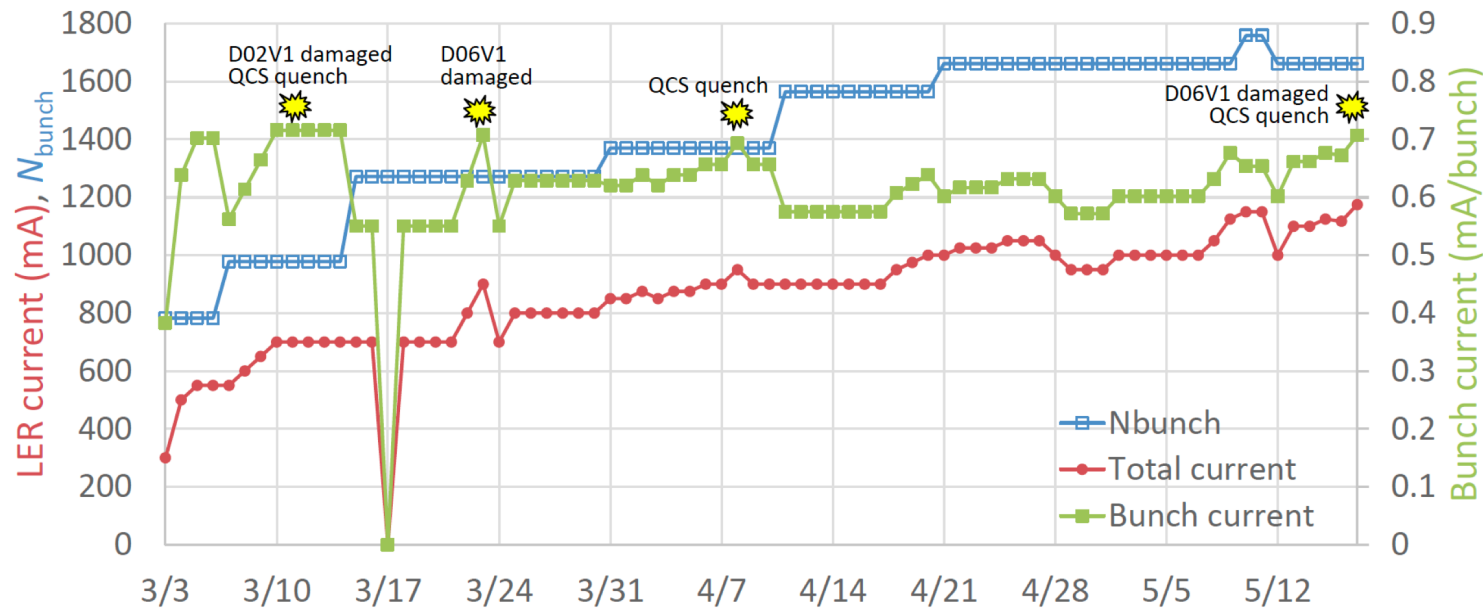
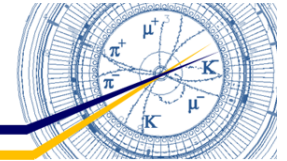
- Very fast beam loss: within 3 turns
- No bunch (dipole) oscillations were observed before beam loss.
  - In some cases, beam oscillation in the previous turn of beam loss was observed.
- No beam size blowup is observed before beam loss.







# History of large beam loss events 2022



K. Matsuoka

The three big accidents of LER beam loss in 2022 happened at  $I_b > \sim 0.7 \text{ mA/bunch}$  within a day after increasing the beam current at the three different  $N_{\text{bunch}}$  -> **Empirical rule: red must not exceed 0.7mA/bunch.**

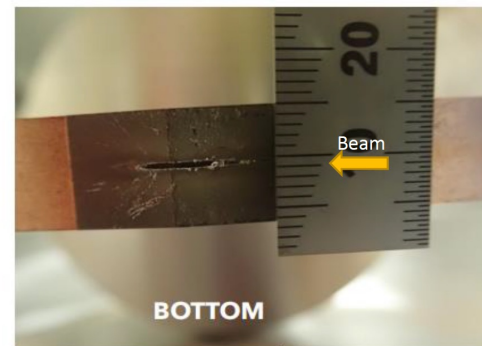
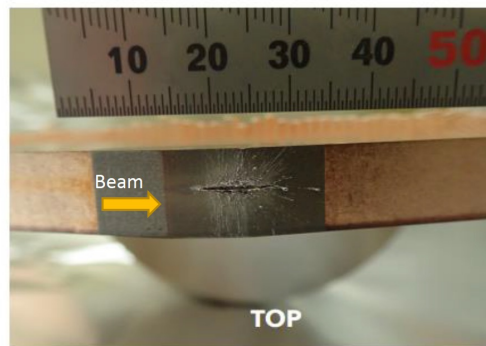
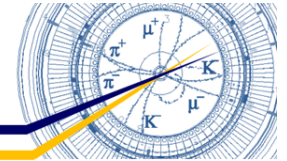
In the case of a small number of bunches ( $N_{\text{bunch}} = 793, 61, 31$ ), we haven't observed the large beam loss with a higher bunch currents.

Occasionally, large beam loss in LER happened with bunch currents lower than 0.7 mA but the total current was high (For example, on June 3<sup>rd</sup>,  $I_b = \sim 0.62 \text{ mA/bunch}$  with a high total current (1325mA)).





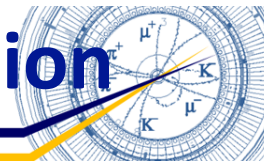
## Severe damage on LER vertical collimator



- After a huge beam loss event on June 6<sup>th</sup> in 2021, LER BG increase significantly.
- D02V1 collimator jaws were severely damaged (deep scar on the bottom jaw).
- Typically, collimator replacement work and the baking runs take 3~4 days.



# Performance limiting issues [2/4] Beam injection



- SuperKEKB injection scheme

K. Furukawa et al, Poster, THPOST011

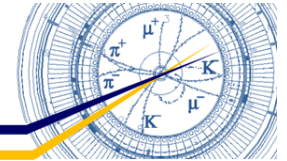
- Injector Linac provides e+ and e- beams. (e+: thermionic gun, DR, e-: RF gun)
- Synchronization between injector and rings allows 1-bunch or 2-bunch injection per pulse.
- Top-up injection is achieved for e+ and e- beams at 50Hz at maximum(sum of e- and e+).

- Beam current limitation

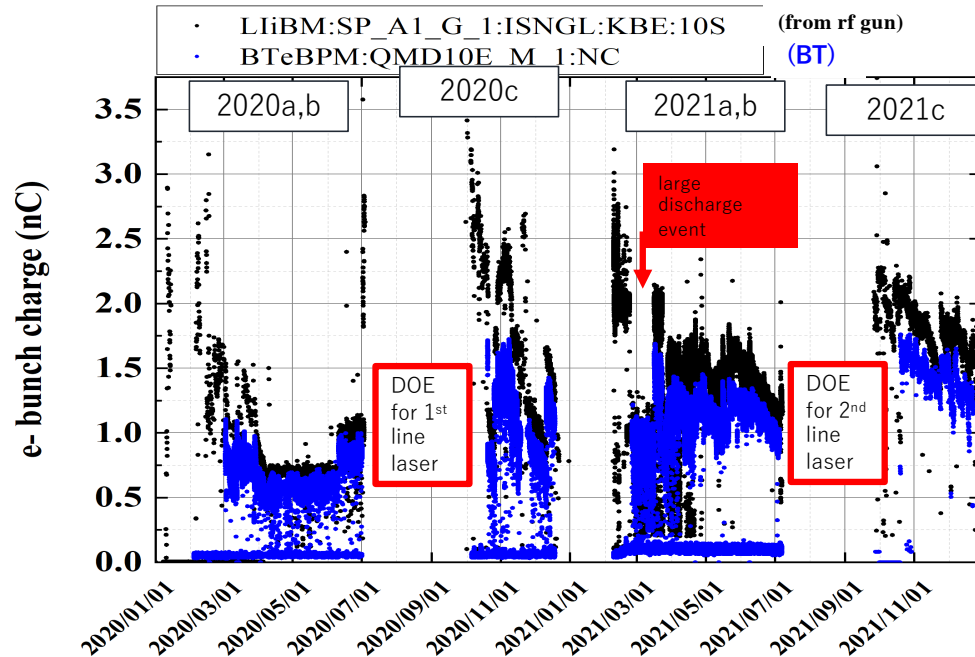
- The maximum stored beam currents in the rings are determined by the balance between the charge sent from Linac and the charge loss due to beam lifetime.
  - Increasing linac charge is important.
- The shorter beam lifetime at smaller  $\beta y^*$  (dynamic aperture) requires a more powerful injection. Conversely, injection sets a limit on the achievable  $\beta y^*$ .
  - Machine operation with the optics of  $\beta y^* = 0.8\text{mm}$  is being tried in this run.
- The injection efficiency is also a very important issue.
  - Depends on  $\beta y^*$ , bunch currents, machine tuning, collimator setting...
  - Typical values of injection efficiency with  $\beta y^* = 1\text{mm}$ : ~50%(LER), ~40%(HER)
  - Emittance preservation in Linac and BT is important.



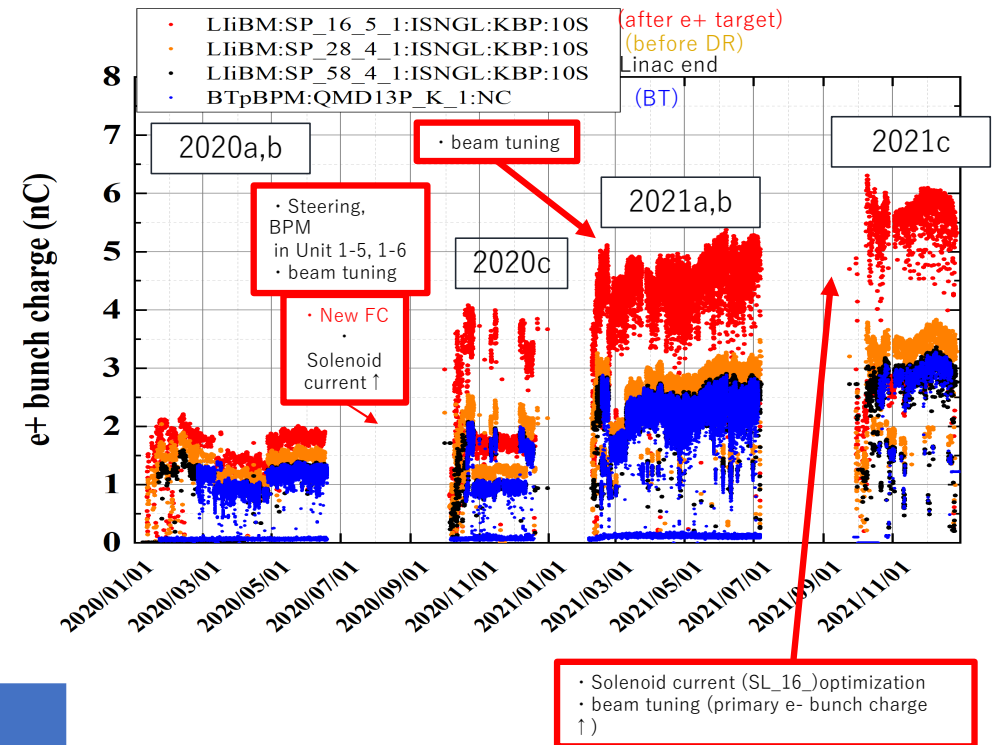
# Linac bunch charge history



## Electron



## Positron



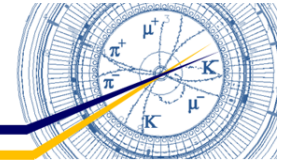
### Target (design) values

|                     | e+ | e- |
|---------------------|----|----|
| Charge / bunch [nC] | 4  | 4  |





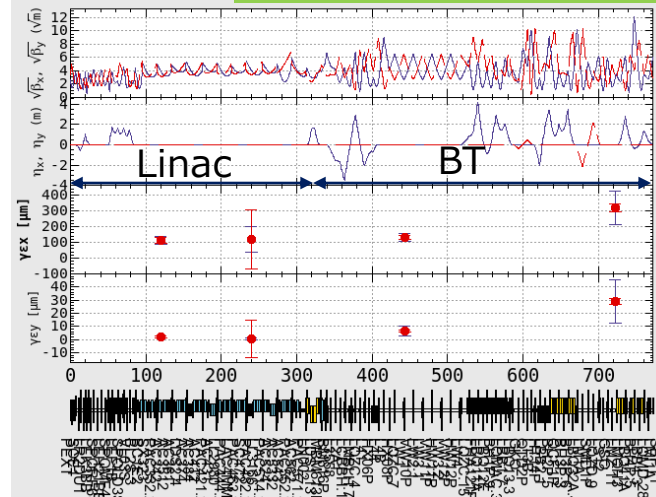
# Linac, BT Emittance measurement using wire scanners (2021c)



From: Year: 2021 Month: 10 Day: 1 Hour: 0 Min.: 0 sec: 0  
 To: Year: 2022 Month: 1 Day: 1 Hour: 0 Min.: 0 sec: 0  
 Nsigma cut: 1.5

Positron

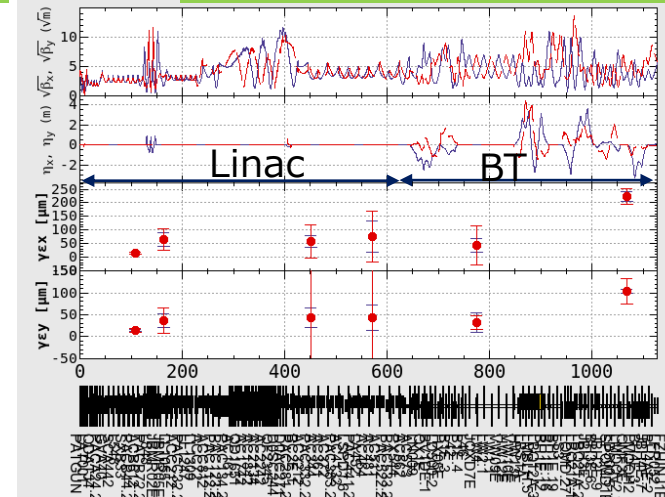
Error bars:  
 Blue: RMS of multiple measurements  
 Red: average of error of individual measurement



From: Year: 2021 Month: 10 Day: 1 Hour: 0 Min.: 0 sec: 0  
 To: Year: 2022 Month: 1 Day: 1 Hour: 0 Min.: 0 sec: 0  
 Nsigma cut: 1.5

Electron

Error bars:  
 Blue: RMS of multiple measurements  
 red: average of error of individual measurement



| Target (design) values                       | e+     | e-    |
|--|--------|-------|
| Normalized emittance (H/V) [ $\mu\text{m}$ ] | 100/15 | 40/20 |

For better injection efficiency, suppression of emittance growth in BT lines is important.

The emittance growth is bunch charge dependent and may be caused by CSR effect.



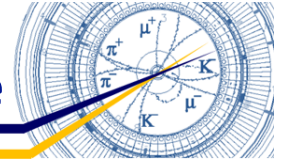
2022/June/12th

IPAC2022 SuperKEKB Y. Funakoshi

21



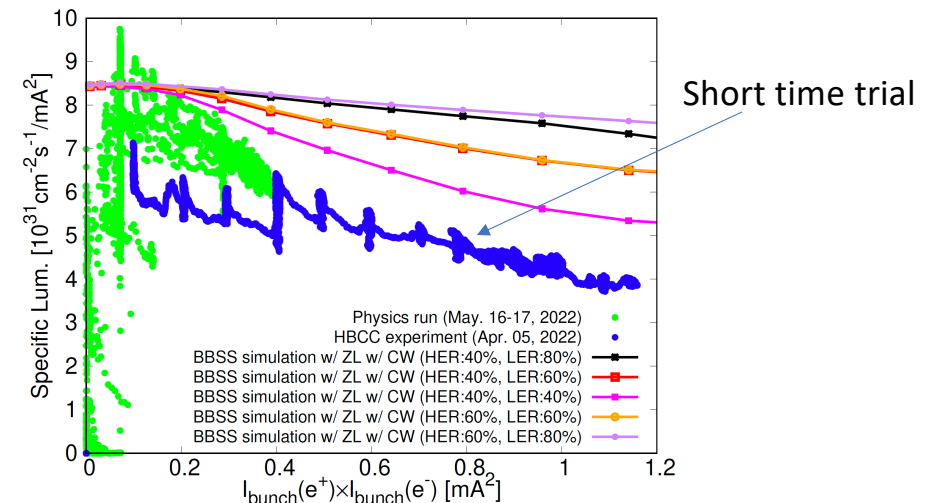
# Performance limiting issues [3/4] Beam-beam performance



- Observed luminosity performance is much lower than simulations with BBSS (Beam-Beam Strong-Strong). This has been and will be a challenge at SuperKEKB. **D. Zhou, et al, Poster, WEPOPT064**
- Candidates of causes
  - Machine imperfections: Non-zero linear and chromatic coupling (**M. Masuzawa, Contributed Oral, TUOZSP2**) and dispersions at IP, beam-current dependent optics distortion due to orbit change at QCS\* and SLY\*, etc.
  - Imperfect crab waist scheme; Interplay of beam-beam interaction and beam coupling impedance.
  - Beam oscillation excited by injection kickers at LER causes luminosity loss by ~10%.

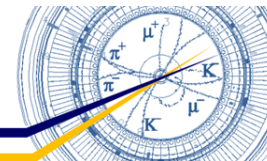
Operation parameter set for BBSS simulation

|                         | 2022.04.05 |                  | Comments                       |
|-------------------------|------------|------------------|--------------------------------|
|                         | HER        | LER              |                                |
| $I_{\text{bunch}}$ (mA) | $I_e$      | $1.25 \cdot I_e$ |                                |
| # bunch                 | 393        |                  | Assumed value                  |
| $\epsilon_x$ (nm)       | 4.6        | 4.0              | w/ IBS                         |
| $\epsilon_y$ (pm)       | 35         | 30               | Estimated from XRM data        |
| $\beta_x$ (mm)          | 60         | 80               | Calculated from lattice        |
| $\beta_y$ (mm)          | 1          | 1                | Calculated from lattice        |
| $\sigma_{z0}$ (mm)      | 5.05       | 4.60             | Natural bunch length (w/o MWI) |
| $\nu_x$                 | 45.532     | 44.524           | Measured tune of pilot bunch   |
| $\nu_y$                 | 43.572     | 46.589           | Measured tune of pilot bunch   |
| $\nu_s$                 | 0.0272     | 0.0233           | Calculated from lattice        |
| Crab waist              | 40%        | 80%              | Lattice design                 |

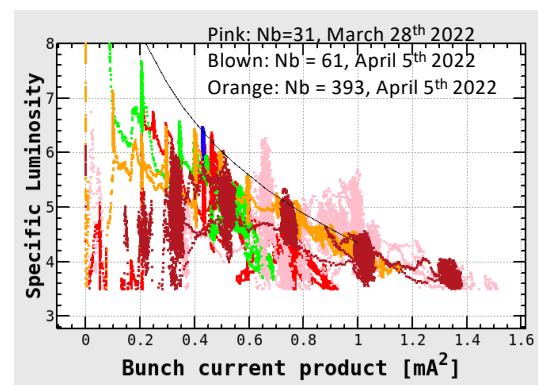
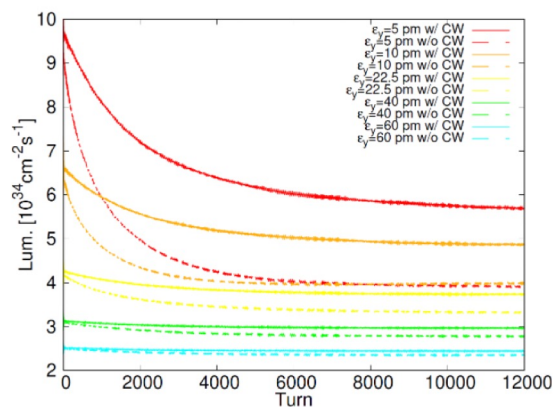




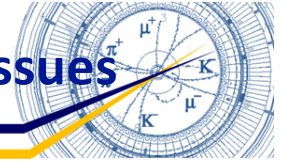
# Beam-beam issues [contn'd]



- Ways to better beam-beam performance
  - Beam-beam simulations predict better beam-beam performance with
    - Smaller vertical emittance in single beam (matter of optics corrections)
    - Higher crab waist ratio in HER (strength)
  - Identification of causes of discrepancy between simulations and experiments
  - Better working points
- Beam-beam parameters
  - Achieved values in physics runs:  $\xi_y(\text{LER}) = 0.0392$ ,  $\xi_y(\text{HER}) = 0.0269$
  - Achieved values in high bunch collision study:  $\xi_y(\text{LER}) = 0.0565$ ,  $\xi_y(\text{HER}) = 0.0434$
  - By increasing bunch currents in physics run, higher  $\xi_y$  and then a higher luminosity is expected.



# Performance limiting issues [4/4] Impedance related issues



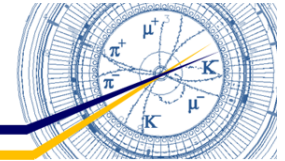
- Single bunch effect
  - LER TMCI (Transverse Mode Coupling Instability)
    - The apertures of vertical collimators scale as  $\beta y^*$ , TMCI will set a limit on the bunch current. Extensive machine studies have been done on this issue.
      - With the use of 2 vertical collimators and taking into account the impedance from the high- $\beta$  region around final focus quadrupoles, the TMCI threshold will be lower than the design bunch current of 1.44mA when  $\beta y^* < 0.6\text{mm}$ .
      - By introducing a nonlinear collimator (NLC), we can use more vertical collimators and meanwhile reduce Belle II BG.
  - Single bunch beam blowup in LER (-1 mode instability)
    - Beam blowup has been observed with a threshold  $\sim 0.8\text{mA/bunch}$ , .
    - This blowup has been intensively studied. The interplay of the feedback system and vertical impedance was identified to be the main source of beam blowup. Fine-tuning of FB system helped suppress the blowup.
- Multi-bunch (coupled bunch) instability
  - Low-frequency resistive wall (RW) impedance gives the fastest growth time (1.6ms@600mA in HER, 3.6ms@600mA in LER). This instability has been well suppressed by the bunch-by-bunch feedback system so far.
  - The longitudinal coupled bunch instability caused by fundamental mode impedance of RF cavities has been well suppressed by -1 mode dumpers in both rings.
- Electron clouds
  - In the current beam condition (4 or 6 ns bunch spacing,  $< 0.7\text{ mA/bunch}$ ), no significant beam size blowup due to the electron clouds effect has been observed in LER.



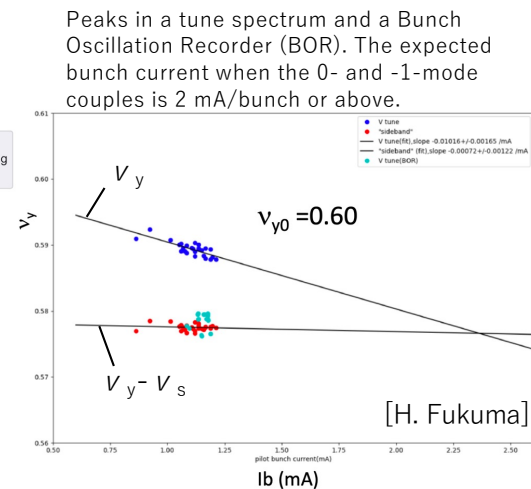
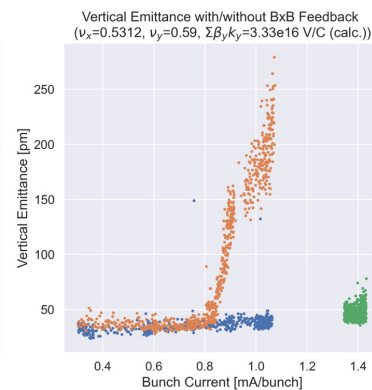
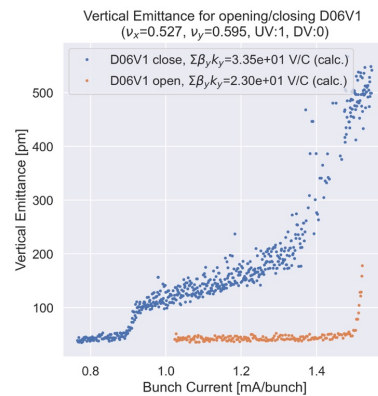




# Study on TMCI and -1 mode blowup



- We've observed vertical beam-size blow-ups around 0.8 mA/bunch in LER with single-beam operations, and this value is about 50% or more lower than an expected TMCI threshold.
  - When the beam-size blow-ups have been observed, a peak corresponding to  $\nu_y - \nu_s$  appears (so we call this "-1 mode instability").
  - The impedance in vertical collimators contributes to this instability, and opening apertures of them can increase the threshold.
  - The vertical bunch-by-bunch feedback system with a standard setting enhances this instability, and its tunings can suppress the instability.
  - The mechanism of the -1 mode instability is under investigation ([S. Terui et al., Poster, WEPOTK050](#)), but we've found two ways to deal with this instability.
    1. Tuning of the vertical bunch-by-bunch feedback
    2. Reducing the impedance in the vertical direction by opening vertical collimators
- ✓ The second point is one of motivations to introduce the nonlinear collimator.



T. Ishibashi



2022/June/12th

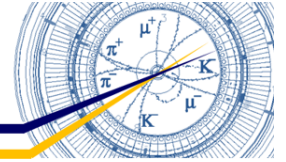
IPAC2022 SuperKEKB Y. Funakoshi

25





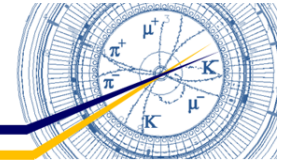
# Upgrade plan



- Long Shutdown 1 (LS1): July 2022 – September 2023
  - Belle II: additional VXD detector installation, TOP counter PMTs replacement
  - SuperKEKB: Upgrade works in this opportunity
- Medium term plan for increasing luminosity
  - We will aim at the luminosity of  $1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$  within 1 or 2 years after LS1 with  $\beta y^* = 0.8\text{mm}$ .
  - The operation with  $\beta y^* = 0.6\text{mm}$  will also be tried.
- Long term plan for luminosity upgrade
  - To squeeze  $\beta y^*$  down to design values (0.27mm in LER and 0.30mm in HER), further upgrade works will be required, including an extensive IR upgrade to improve beam lifetime. We have a plan to do those upgrade works in Long Shutdown 2 (LS2) in around 2027. The upgrade plan is being studied.



# Major upgrade items during LS1



## IR radiation shield modification

- For BG reduction
  - New heavy metal shields around IP bellows
  - Additional concrete & polyethylene shields around Belle II
  - Material change from W to SUS of QCS cryostat front plate

## Non-linear collimator (LER)

- For impedance and BG reduction
  - New collimation scheme less likely to cause TMCI
  - Removal of 50 wiggler magnets
  - Installation of 2 skew sextupole and 5 quadrupole magnets
  - Installation of new vertical collimator with wider aperture

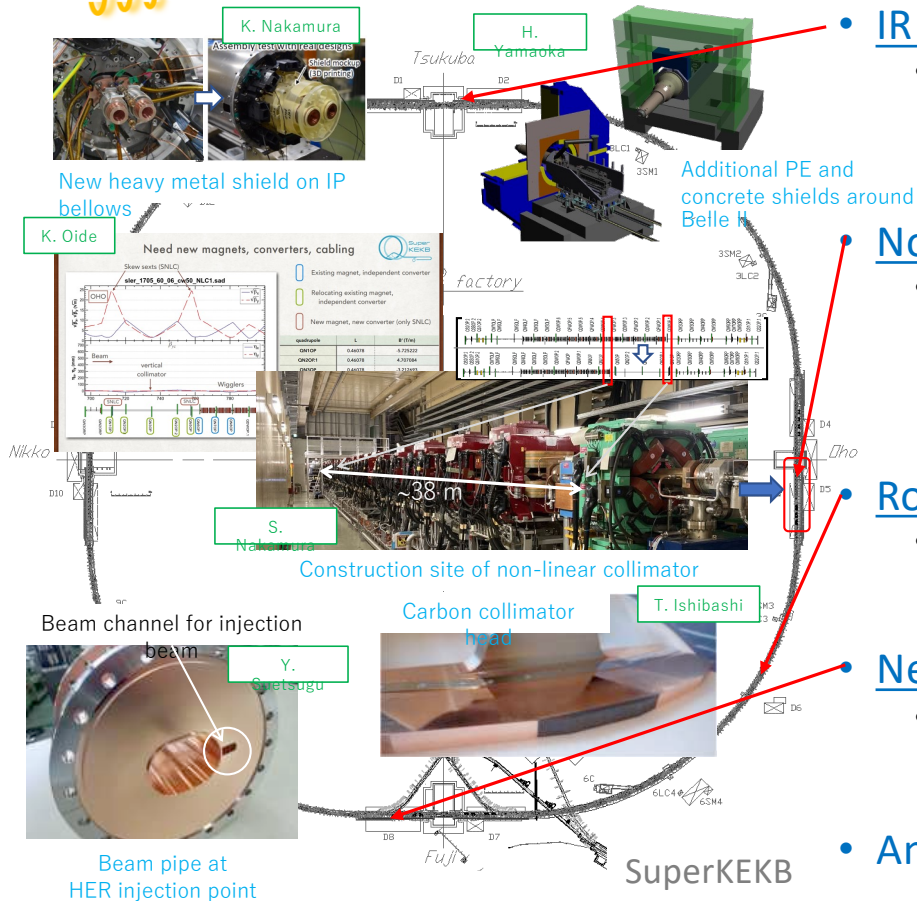
## Robust collimator head (LER)

- As countermeasure against kicker-pulser misfiring and resulting destruction of collimator
  - Replacement with carbon head of horizontal collimator D06H3

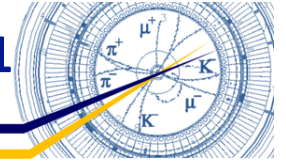
## New beam pipes with wider aperture at HER injection point

- For improvement of injection efficiency
  - New beam pipes with wider aperture
  - New BPM for precise measurement of injected beam

And so on...



## Example of parameters for $L = 1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$



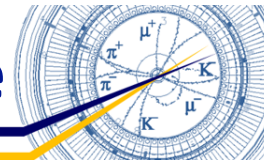
|                    | LER   | HER    |
|--------------------|---|--------|
| # of bunches       | 2345+1  |        |
| Luminosity         | $1.0 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$ |        |
| $I_{\text{total}}$ | 2.35 A  | 1.64 A |
| $I_{\text{bunch}}$ | 1.0mA   | 0.7mA  |
| $\beta y^*$        | 0.8mm   | 0.8mm  |

- This parameter list was made based on a high bunch current collision study.
  - We will need higher bunch currents.
- We will aim to achieve the parameter list.
- In the process of aiming at the parameter set, we will need to study various issues and aim at the luminosity with solving issues found and with modifying the parameter set.





# International Task force for SuperKEKB upgrade



## Mission

- Bring ideas and exchange notes to solve various problems we face as a luminosity frontier machine, to achieve SuperKEKB design luminosity.
  - Short term
    - Working together on a to-do list with priority for LS1 to achieve luminosity of the order of  $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$  without any large-scale modification of accelerator components.
  - Longer-term
    - Searching for ideas to achieve the design luminosity.

## Four working groups (sub-groups) organized

- Optics
- Beam-beam
- TMCI
- Linac

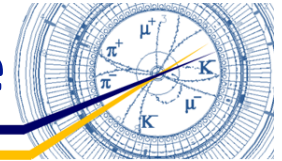
## History

- Started with the Initial members recommended by ARC members
- The first kick-off meeting was held in July, 2021
- More people joined us.
- There have been 6 ITF general meetings many more sub-group meetings held so far.
- ITF working in close collaboration with KEKB commissioning team.





# International Task force for SuperKEKB upgrade



## Examples of activities

- Lattice translation and repository for SuperKEKB; Optics optimization and simulations with independent codes.
- Dynamic aperture optimization, new optics design.
- Beam-beam simulation, impedance calculation, instability theories.
- Deep discussions on the simulation results and new ideas.
- Proposed many machine study items and discussion on the results.

You are welcome to join us!

International Task Force members

2021/7/27

### International members

|                      |          |
|----------------------|----------|
| Maria Enrica Biagini | INFN     |
| Georg Hoffstaetter   | Cornell  |
| Evgeny Levichev      | BNP      |
| Mark Palmer          | BNL      |
| Yunhai Cai           | SLAC     |
| Rogelio Tomas        | CERN     |
| Pantaleo Raimondi    | ESRF     |
| Katsunobu Oide       | CERN/KEK |

### KEK ACCL members

|                      |        |
|----------------------|--------|
| Mika Maszawa (Chair) | SKEKB  |
| Yukiyoshi Ohnishi    | SKEKB  |
| Akio Morita          | SKEKB  |
| Hiroshi Sugimoto     | SKEKB  |
| Renjun Yang          | SKEKB  |
| Haruyo Koiso         | SKEKB  |
| Yoshihiro Funakoshi  | SKEKB  |
| Tsukasa Miyajima     | SKEKB  |
| Kazuhito Ohmi        | SKEKB  |
| Demin Zhou           | SKEKB  |
| Kentaro Harada       | KEK-PF |

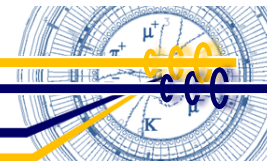
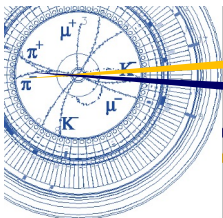
### Belle II members

|                   |          |
|-------------------|----------|
| Hirofumi Nakayama | Belle II |
| Francesco Forti   | Belle II |

### BPO members

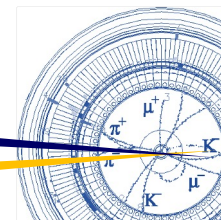
|                   |       |                 |          |
|-------------------|-------|-----------------|----------|
| Masanori Yamauchi | KEK   |                 |          |
| Tadashi Koseki    | ACCL  | Naohito Saito   | IPNS     |
| Makoto Tobiyama   | SKEKB | Shoji Uno       | Belle II |
| Hiroyasu Ego      | SKEKB | Yutaka Ushiroda | Belle II |
| Kyo Shibata       | SKEKB | Toru Iijima     | Belle II |
| Mika Masuzawa     | SKEKB | Kodai Matsuoka  | Belle II |





We will continue to make every efforts to improve SuperKEKB performance toward design goal.

Fin.



Thank you for your attention.

