KEK Activities

1. Beam Halo Monitor (Mitsuhashi)
2. Crab Cavity (Morita)
3. SuperKEKB Commissioning (Suetsugu,Tobiyama)

CERN-KEK meeting
November 11, 2019

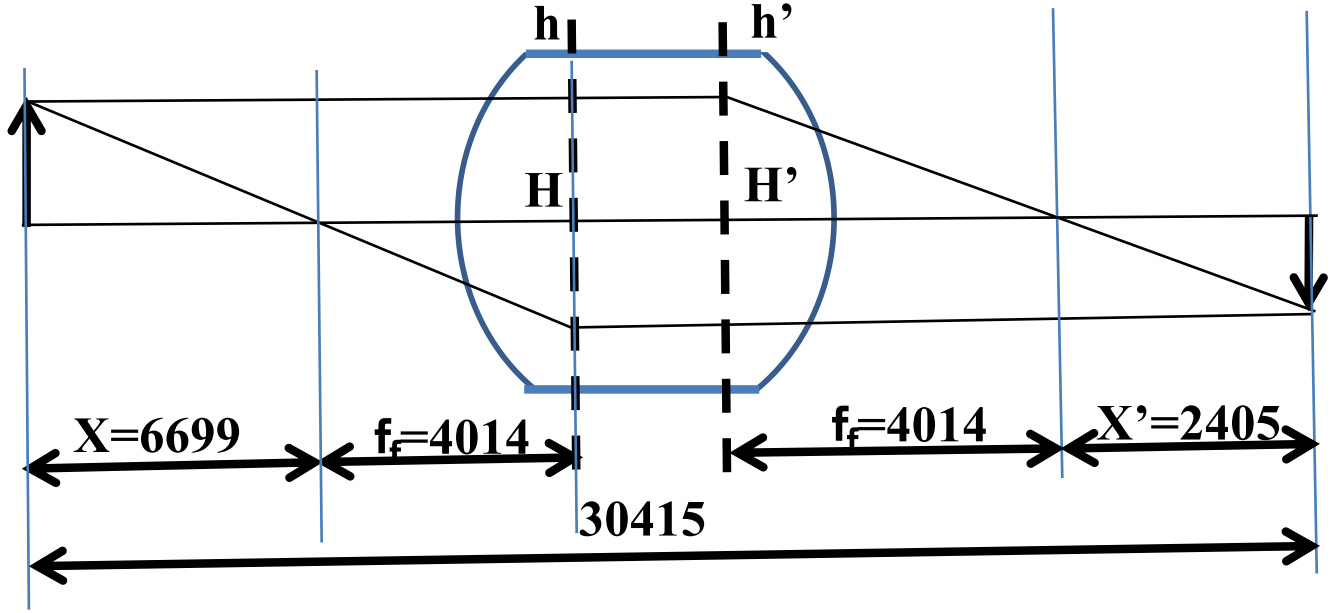
Accelerator Laboratory
Seiya Yamaguchi

HL LHC collaboration
Status of coronagraph

1. Objective design for HL LHC coronagraph
2. Objective design for SuperKEKB

Design of Coronagraph objective for HL LHC

Conceptual design of objective for HL LHC
Relation between source point and beam image



Distance between beam and beam image :28,405 mm

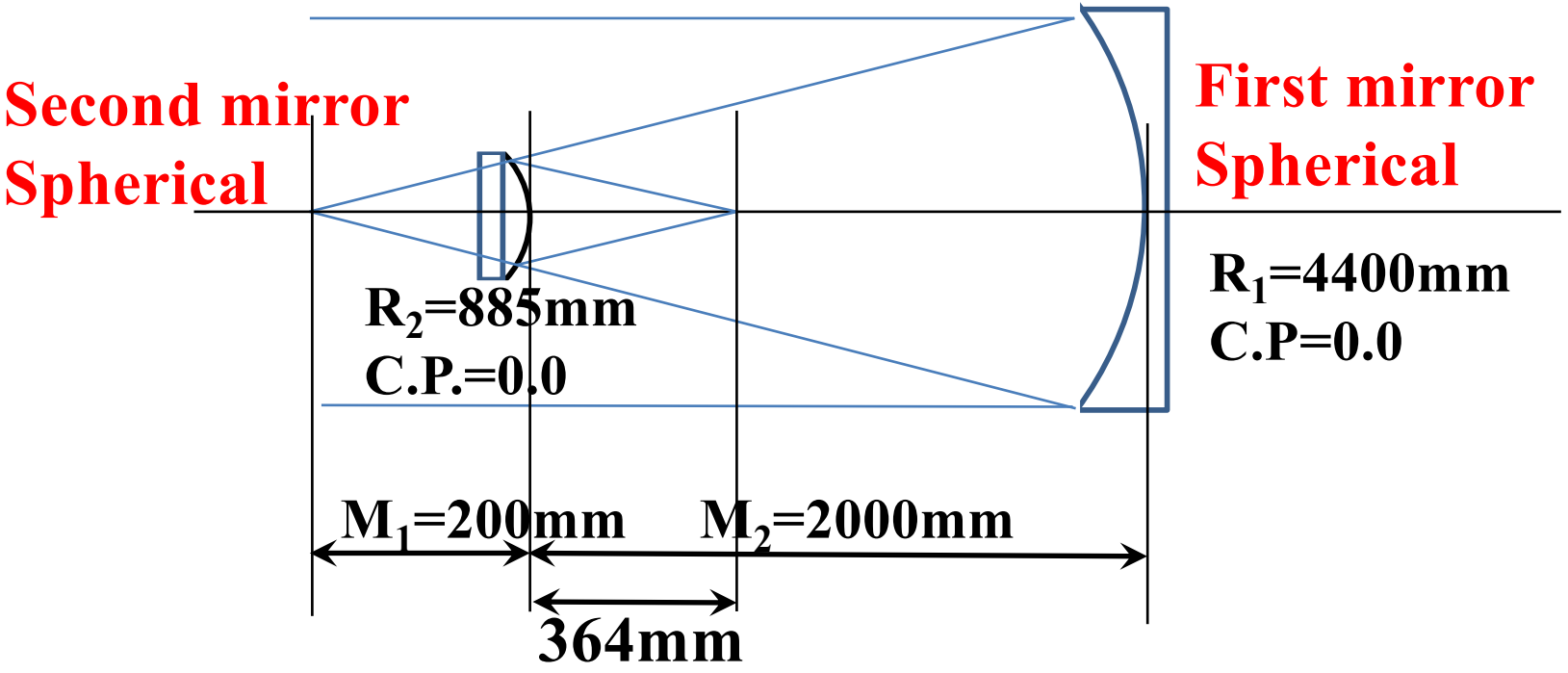
Focal length = 4,014 mm

Magnification=0.599(=4014/6699)

Distance between H and H' is 13283mm

Ex. 300 μm beam -> 180 μm beam image

Optical design of Cassegren objective in HL-LHC

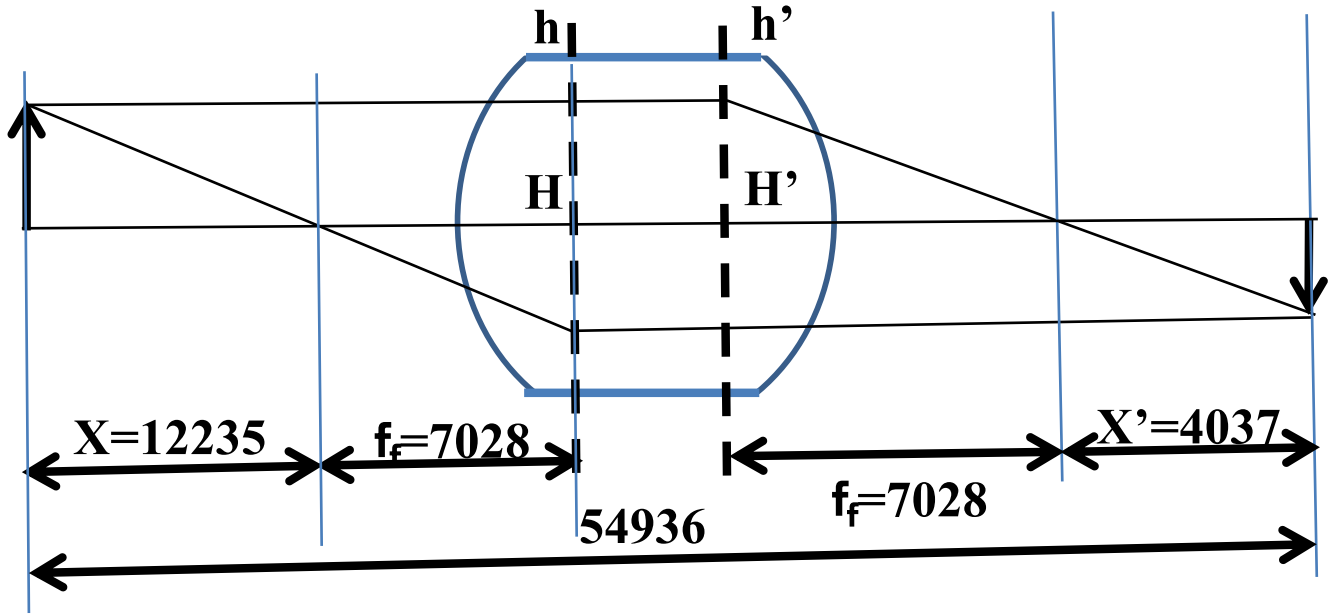


Cassegrain focal length=4014mm

Cassegrain extension ratio=1.82

Final design of Coronagraph objective for SuperKEKB

Conceptual design of objective for SuperKEKB
Relation between source point and beam image



Distance between beam and beam image :54,936 mm

Focal length = 7,028 mm

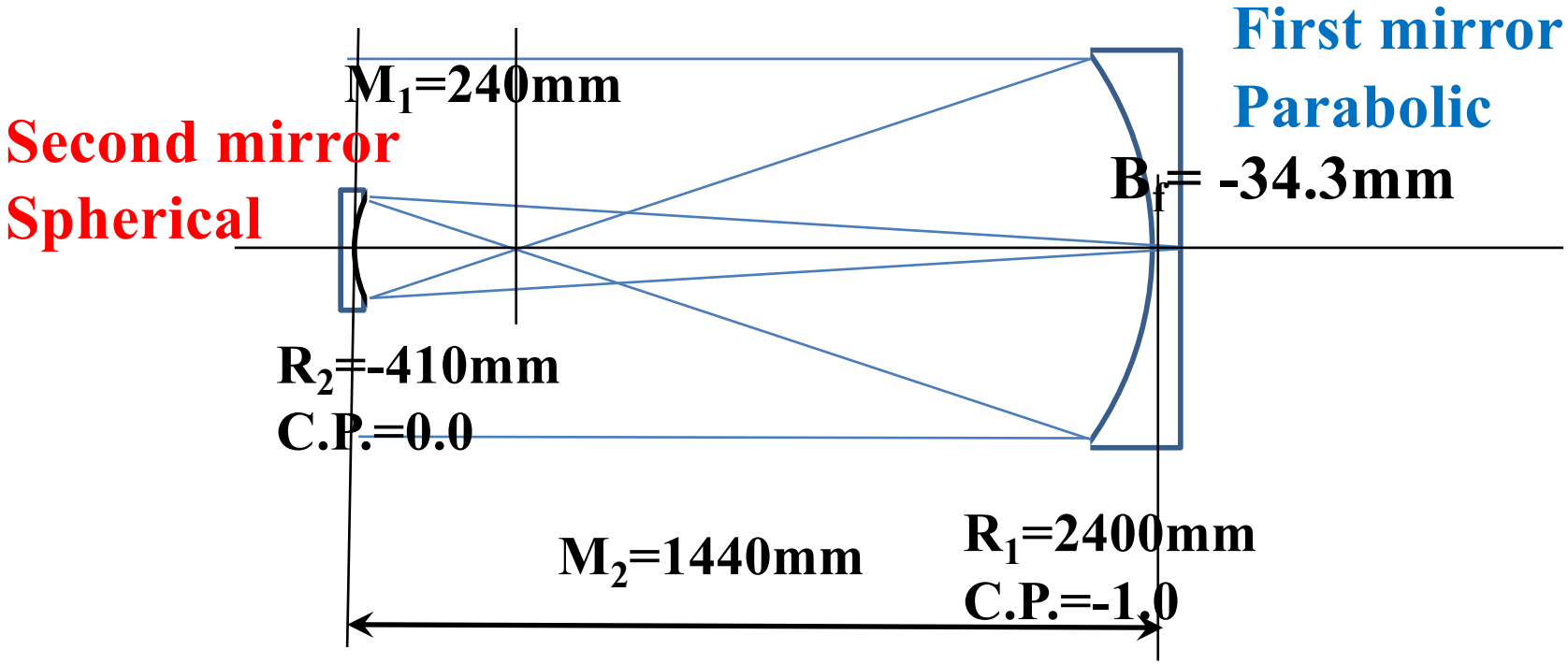
Magnification=0.574 (=7028/12235)

Distance between H and H' is 24608mm

Ex. 100 μm beam -> 50 μm beam image

Beam size is so small in SuperKEKB, that chromaticity correction is important.

Optical Design of Gregory system for SuperKEKB



$$f = M\frac{R_1}{2} = 7028\text{mm}$$

Gregorian extension ratio=7.02

Status

1. **Objective for HL LHC coronagraph**
   - Optical design : finished
   - requesting quotation
2. **Objective for SuperKEKB**
   - Optical design : finished
   - First mirror optical testing : Finished
   - Second mirror : will be finished end of November
   - Optical testing with SR : end of this Year

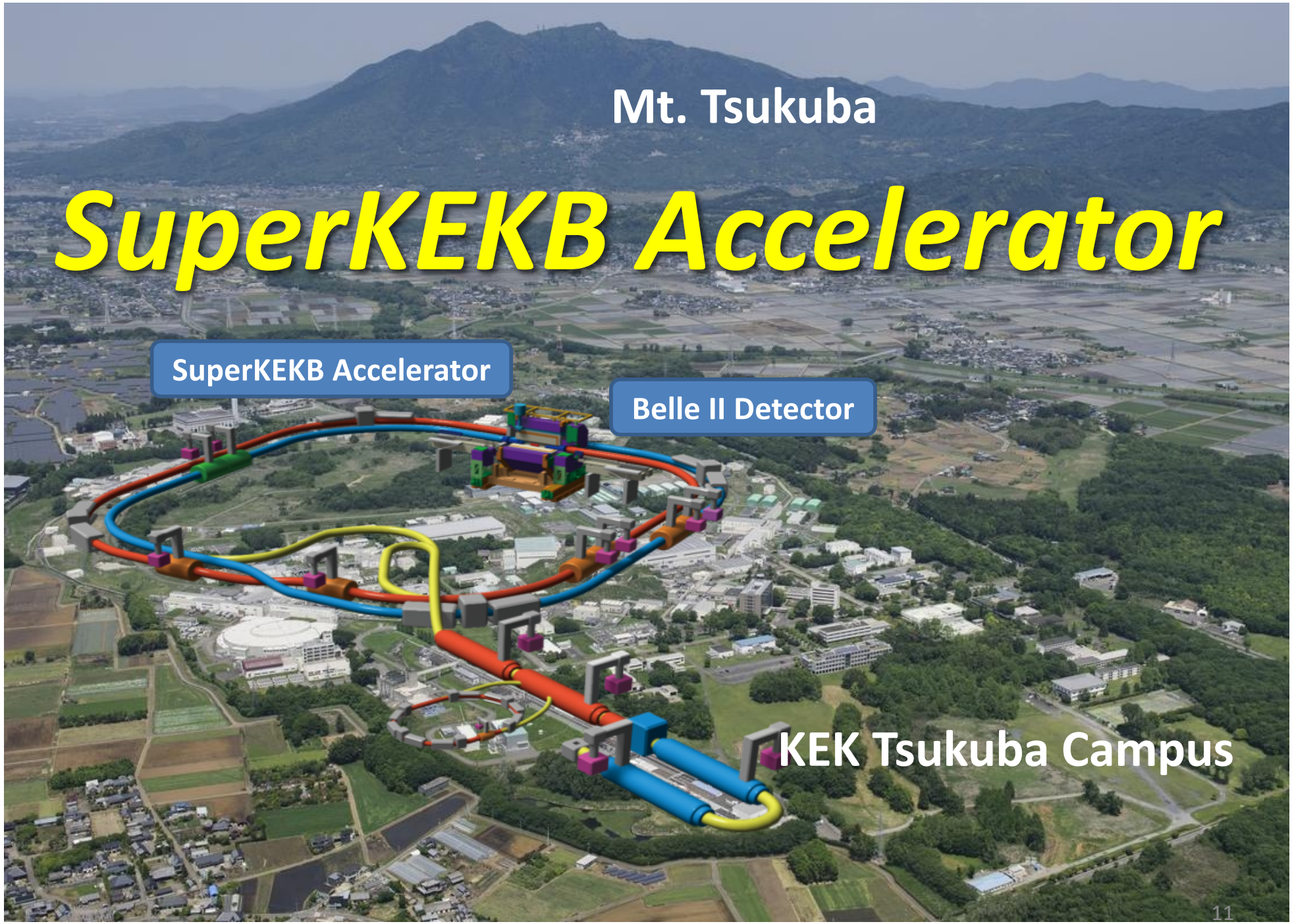
Vertical EP R&D for LHC crab cavity at KEK

- The first vertical EP was successfully applied for the LHC model crab cavity in 2017
  - Average polishing of 30 microns was obtained.
  - Unfortunately performance of the crab cavity was limited by heating of its beam pipe flange
  - It is not clear that the VEP can improve its performance or not

Model crab cavity

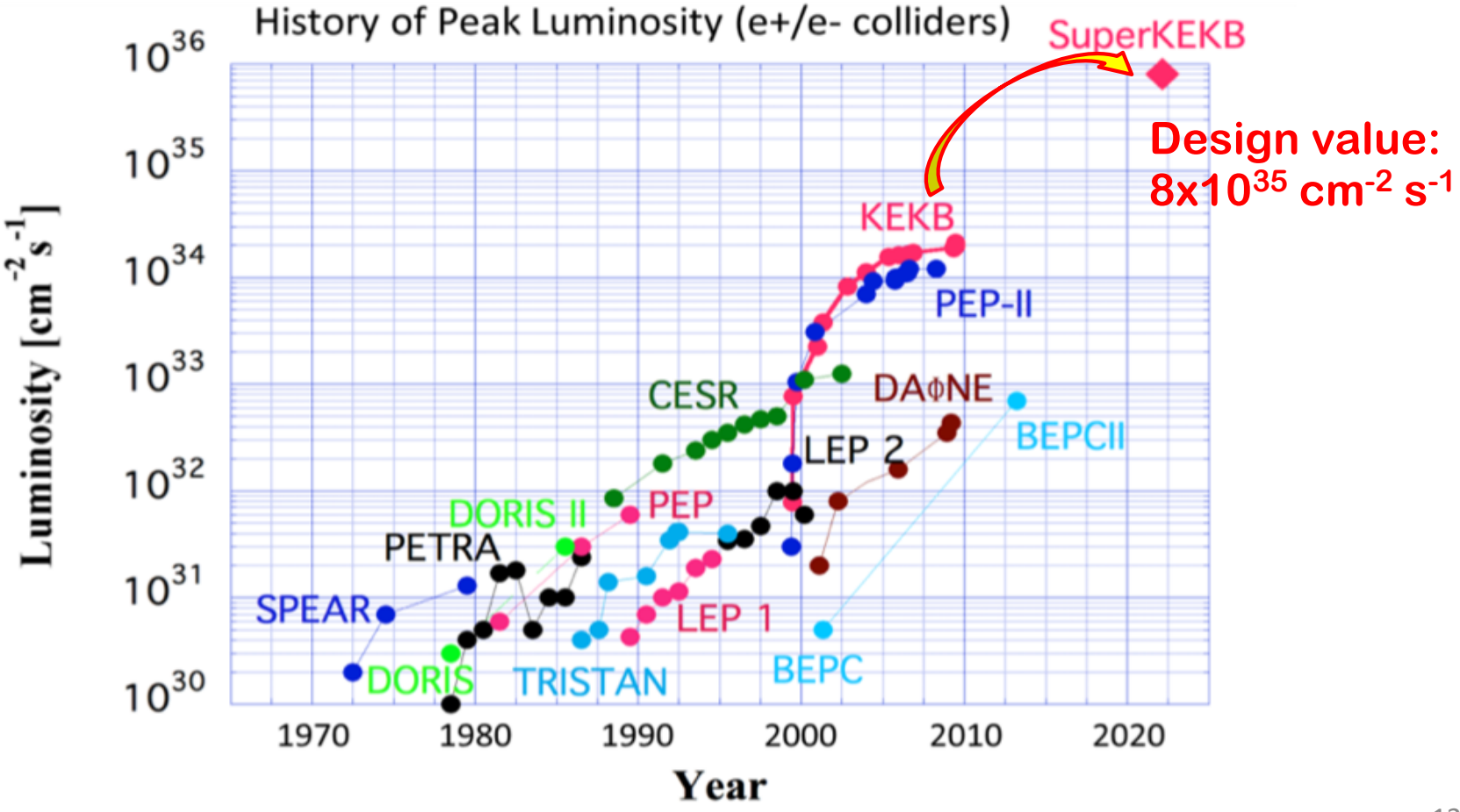
Vertical EP at KEK in 2017

- KEK will continue vertical EP R&D to examine effectiveness of EP for LHC crab cavities
- "Research and Development of high field superconducting RF crab cavities for High Luminosity LHC (HL-LHC)" was extended to April 2021
  - CERN will provide the LHC crab cavity designed for SPS beam test
- "Center for Applied Superconducting Accelerator " will support this R&D
  - Support items are;
  - High pressure rinsing after VEP
  - Clean room for assembly
  - Vacuum pump system
- With those supports we will perform vertical EP and cold tests next year

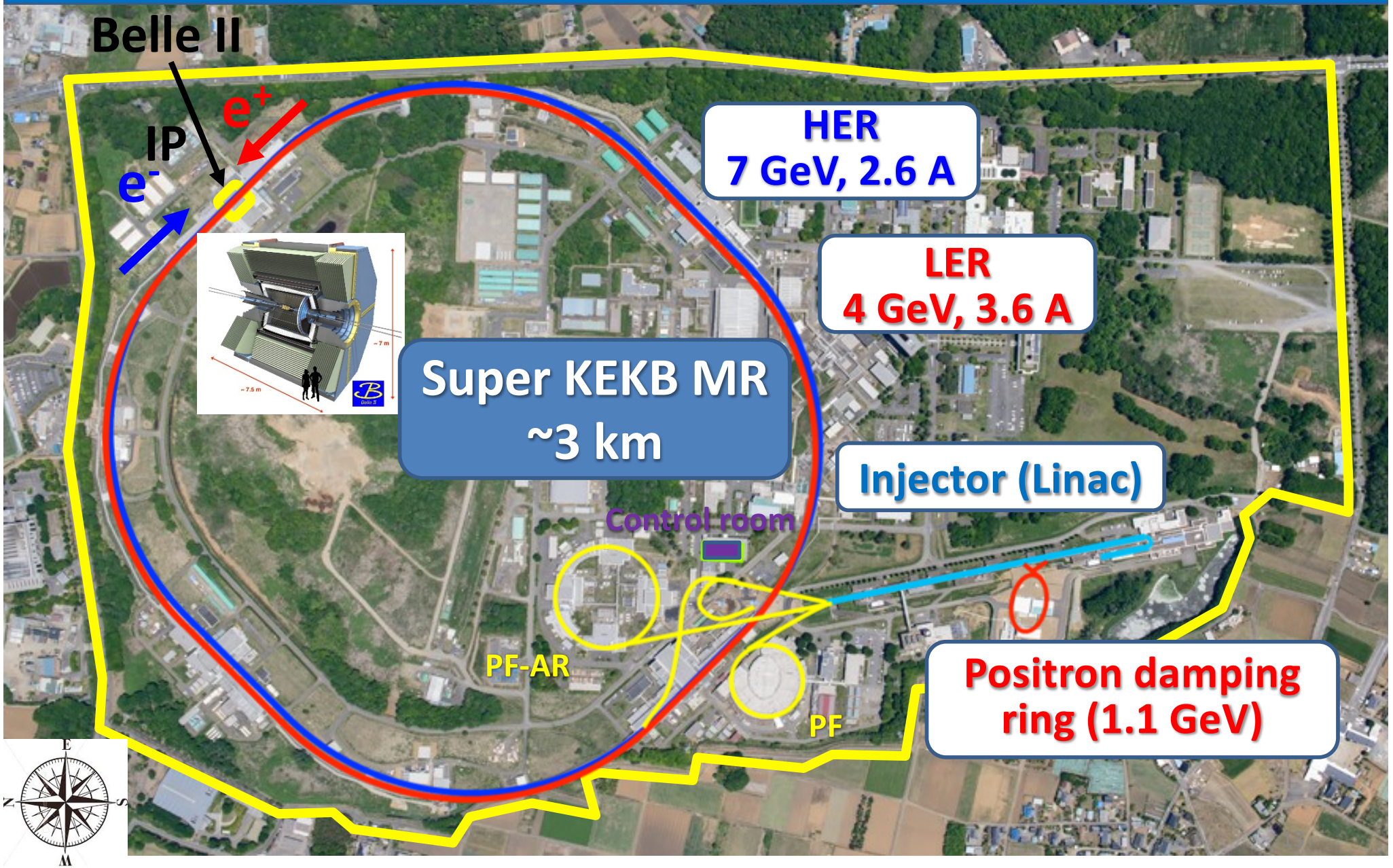

Mt. Tsukuba
SuperKEKB Accelerator
SuperKEKB Accelerator
Belle II Detector
KEK Tsukuba Campus

Feature

Aim the world-highest luminosity (a measure of collision frequency) by using a novel "nano-beam scheme" collision.



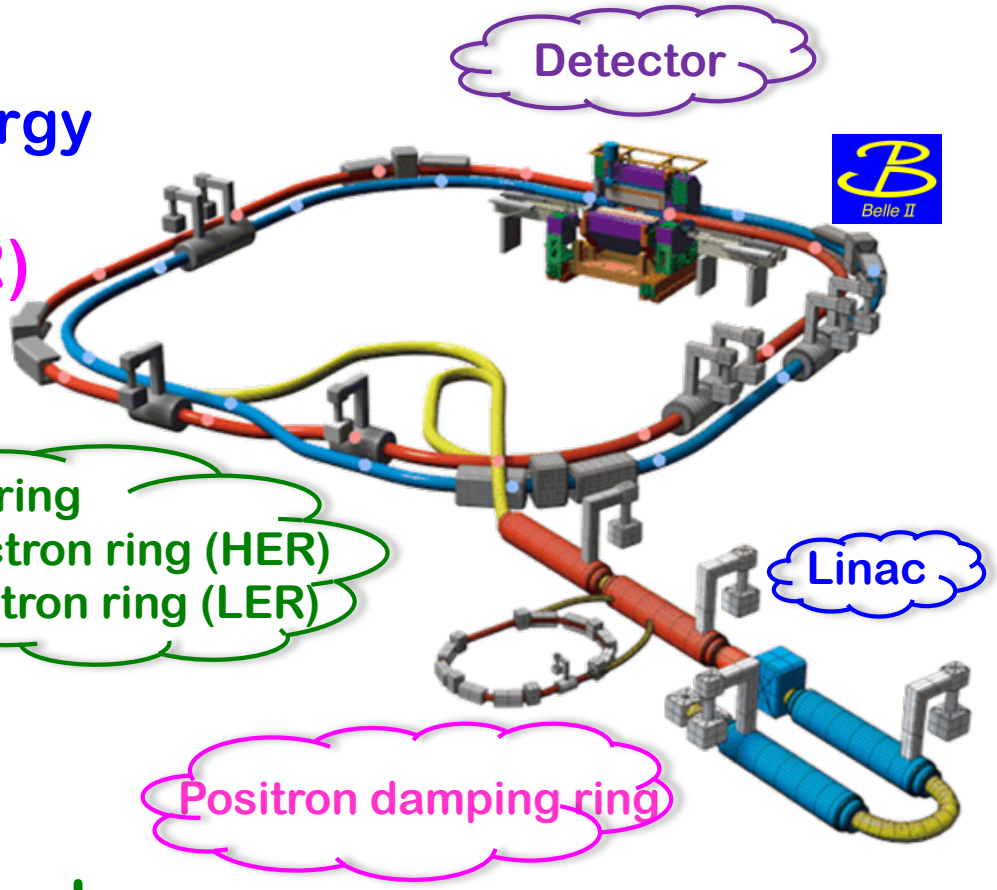
Layout


Belle II
IP
e+
e-
HER
7 GeV, 2.6 A
LER
4 GeV, 3.6 A
Super KEKB MR
~3 km
Injector (Linac)
Control room
PF-AR
PF
Positron damping
ring (1.1 GeV)

Configuration

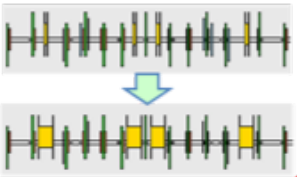
- Injector (Linac)
  - Length～700 m
  - Generate e^- and e^+
  - Accelerate to the final energy
- Positron damping ring (DR)
  - Circumference ～136m
  - 1.1 GeV positron
- Main ring (MR)
  - Circumference～3016 m
  - 7 GeV electron ring (HER)
  - 4 GeV positron ring (LER)
  - The largest e^- - e^+ collider in Japan

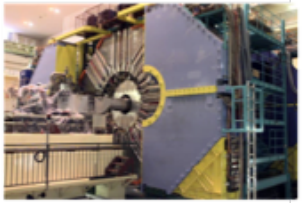
- Belle II Particle detector



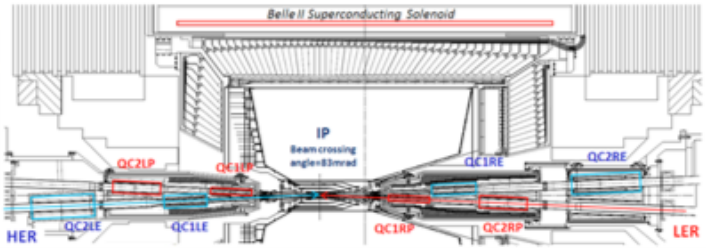
Upgrade from KEKB

Redesign the lattice to squeeze emittance (replace short dipoles with longer ones, increase wiggler cycles)

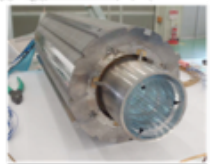




Upgrade Belle II detector



New superconducting final focusing magnets near the IP



e^+ 3.6A

e^- 2.6A

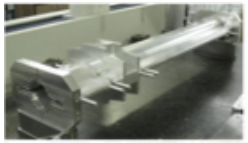
SuperKEKB

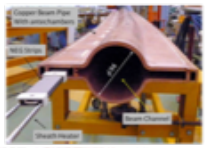
- Nano-Beam scheme
  extremely small β_y^*
  low emittance
- Beam current double

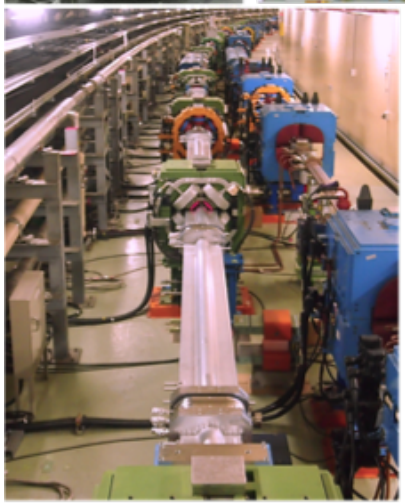
$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

40 times higher luminosity
2.1×10^{34} --> 8×10^{35} $cm^{-2}s^{-1}$

Upgrading (LER) and new (HER) wiggler sections







Replace beam pipes with TiN-coated beam pipes with antechambers

- Low emittance RF electron gun
- Upgrade positron capture section

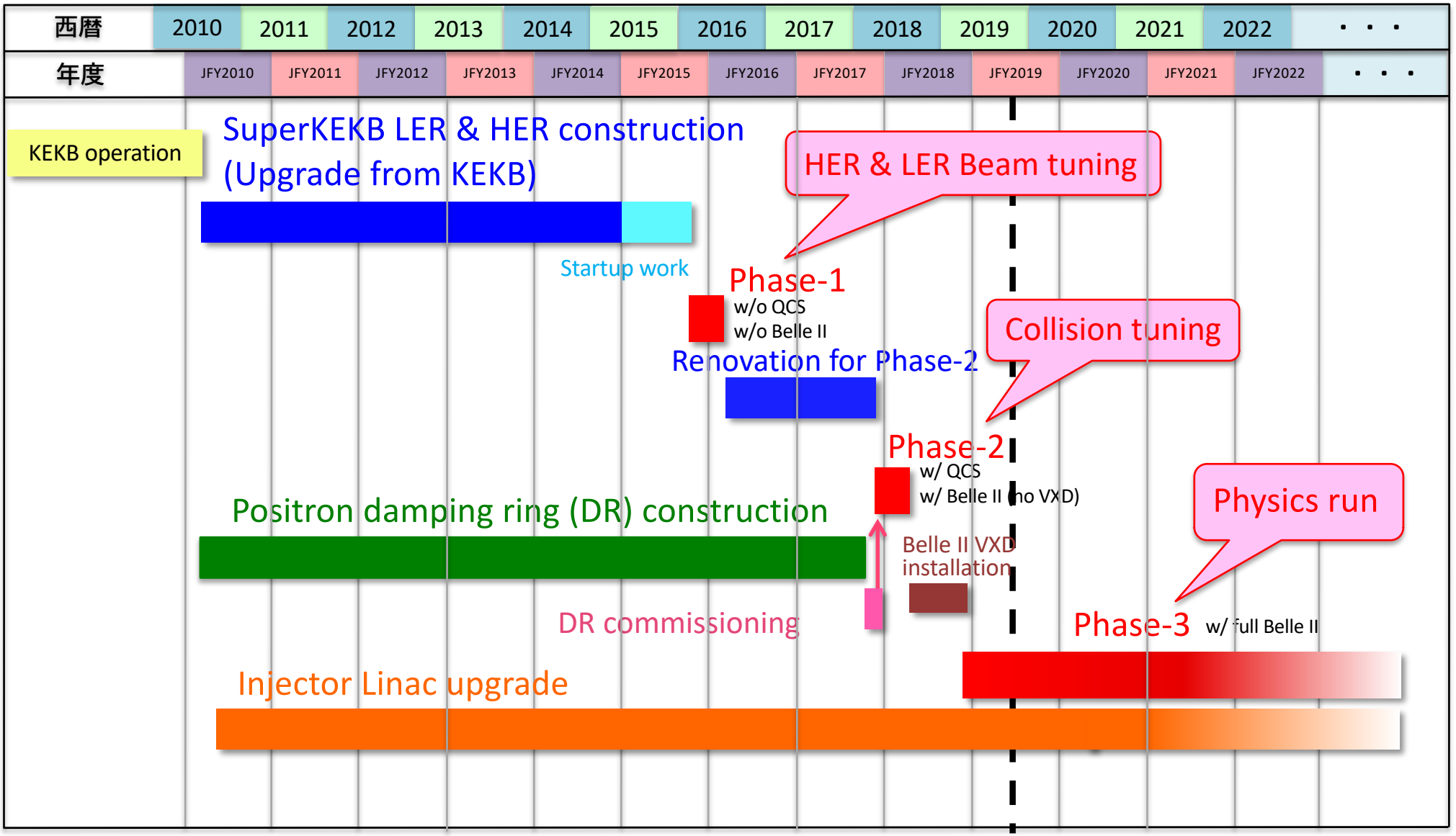
Injector Linac upgrade

New e+ Damping Ring

Reinforce RF systems for higher beam currents

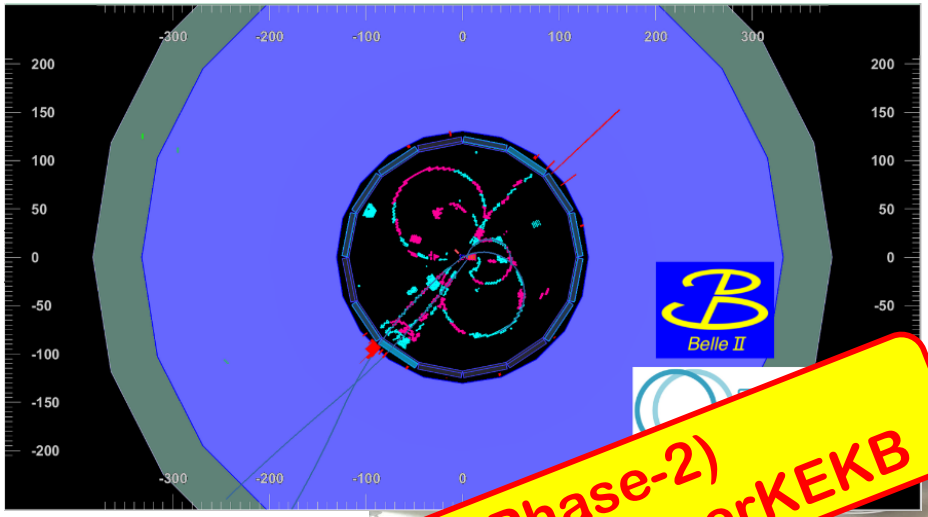
K. Akai

Timeline

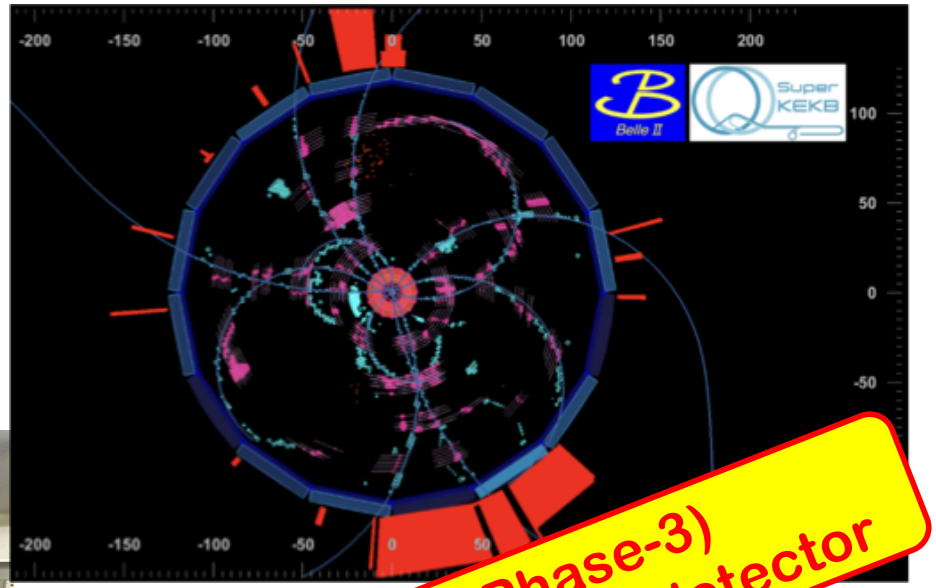


Based on K. Akai, Mar. 14, 2018 @KEKB review

Milestones

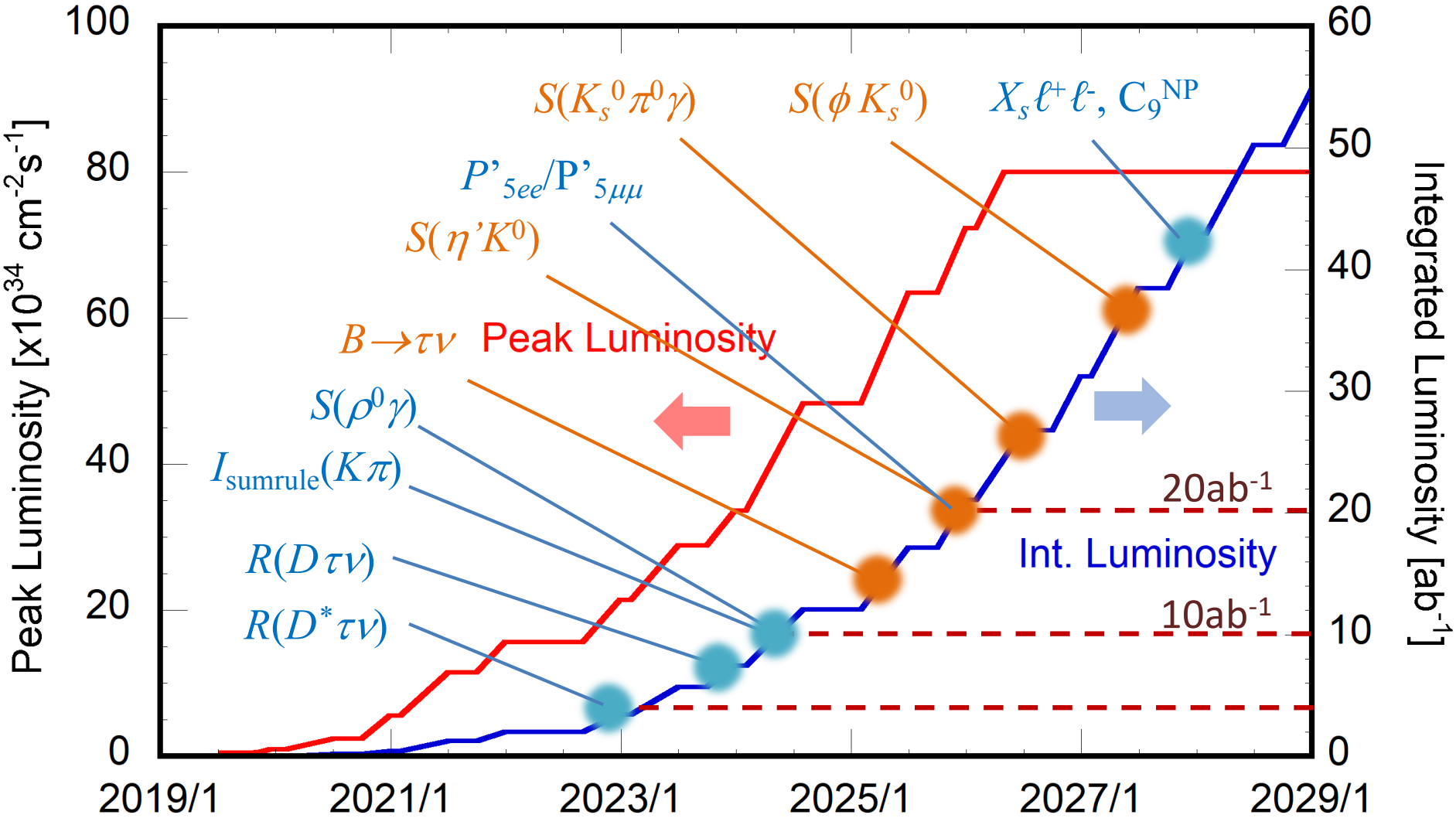


2018/04/26 (Phase-2)
First collision event at SuperKEKB



2019/03/25 (Phase-3)
First B-B event with full detector

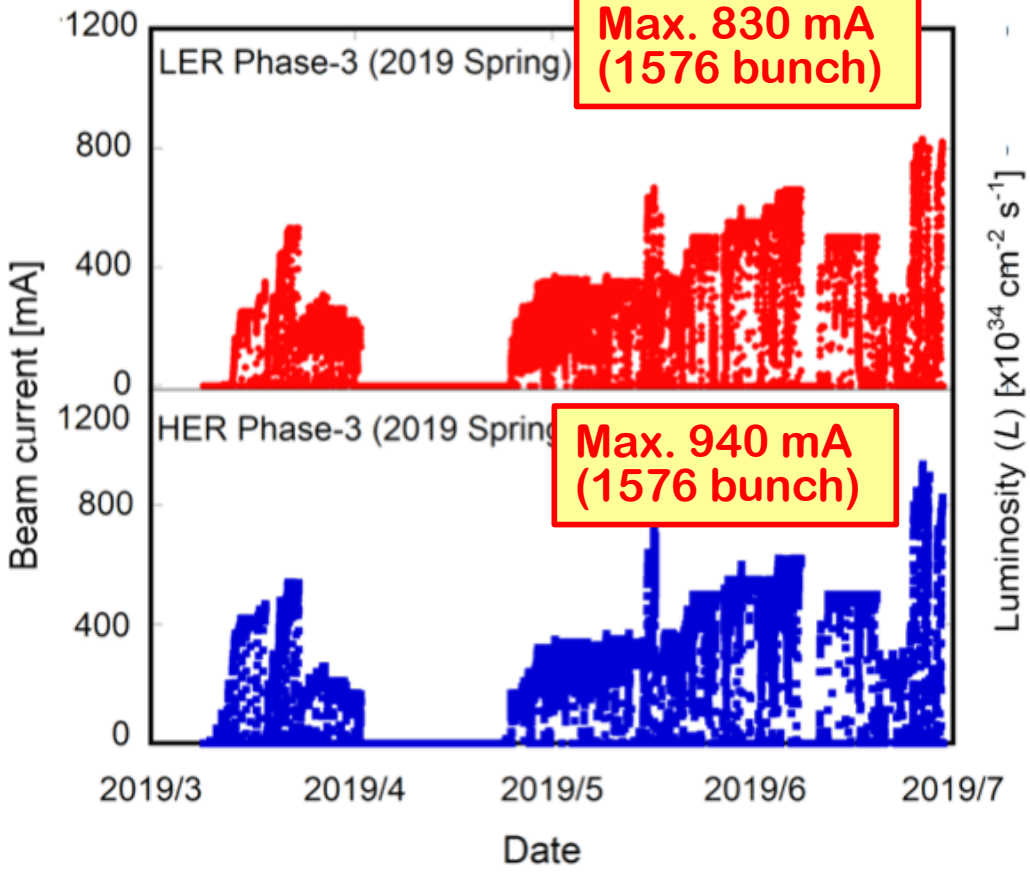
Luminosity projection and expected physics



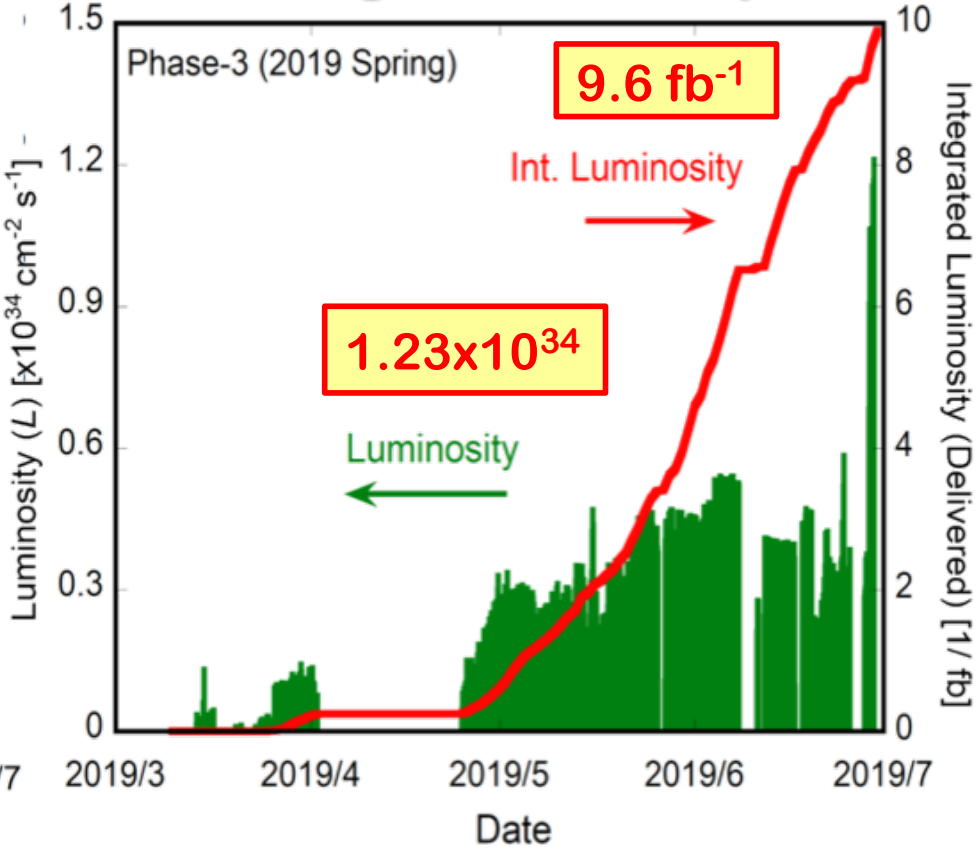
Latest results

Results in Phase-3 2019b Spring run (2019/3/11~2019/7/1)

Beam currents

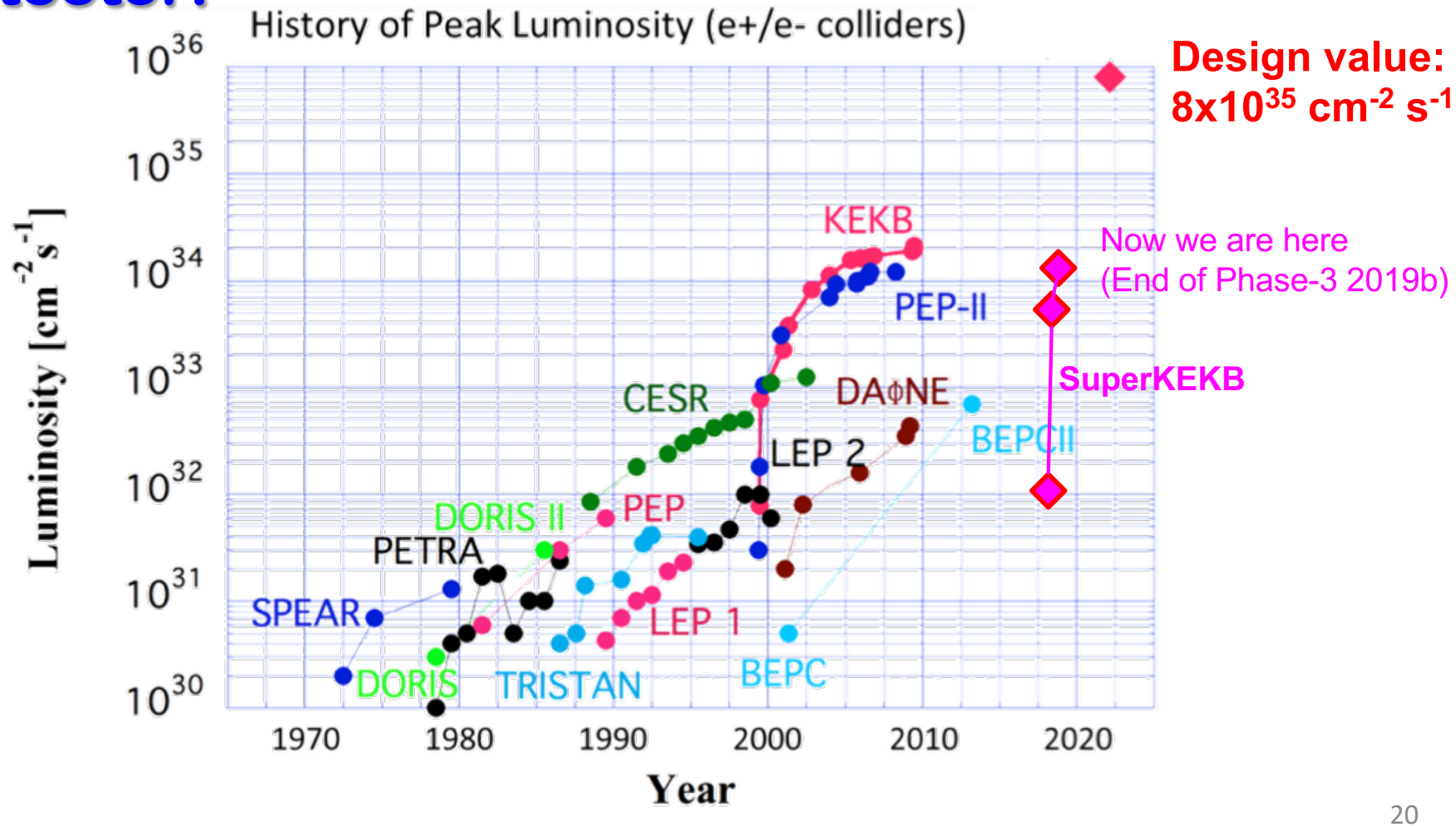


Peak luminosity and integrated luminosity



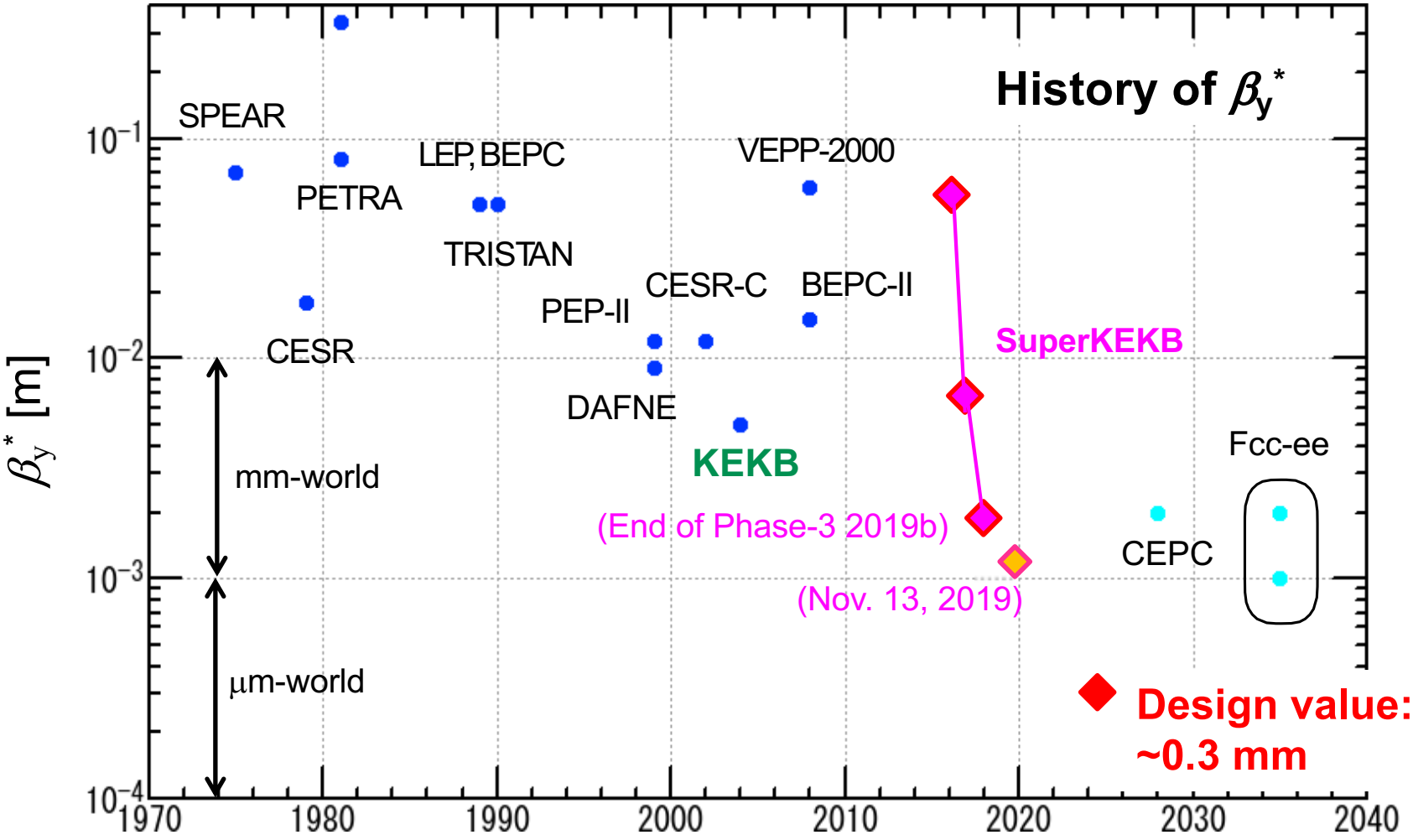
Present status

We are now struggling every day to increase luminosity and deliver more data to Belle II detector.



Present status

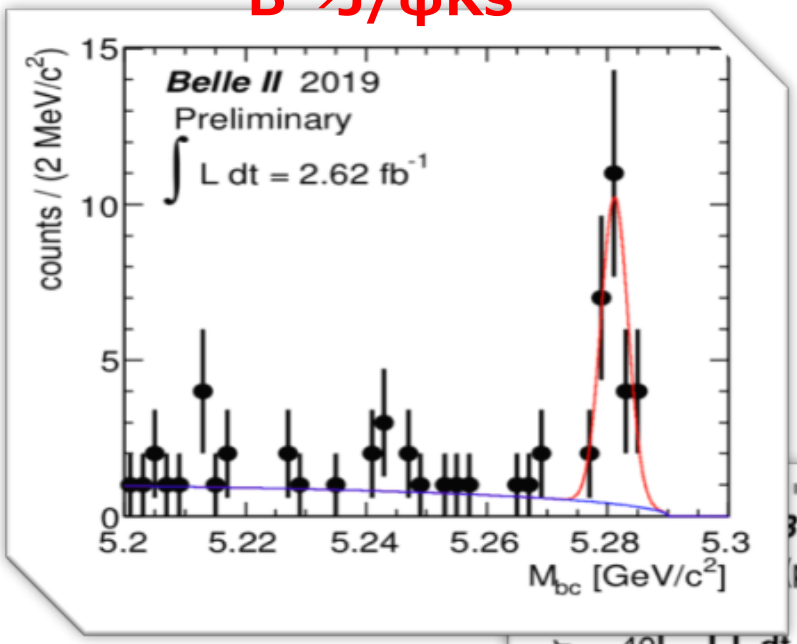
Now operating with the world's smallest β_y^* of 1.2 mm, lower than the bunch length of ~6 mm.



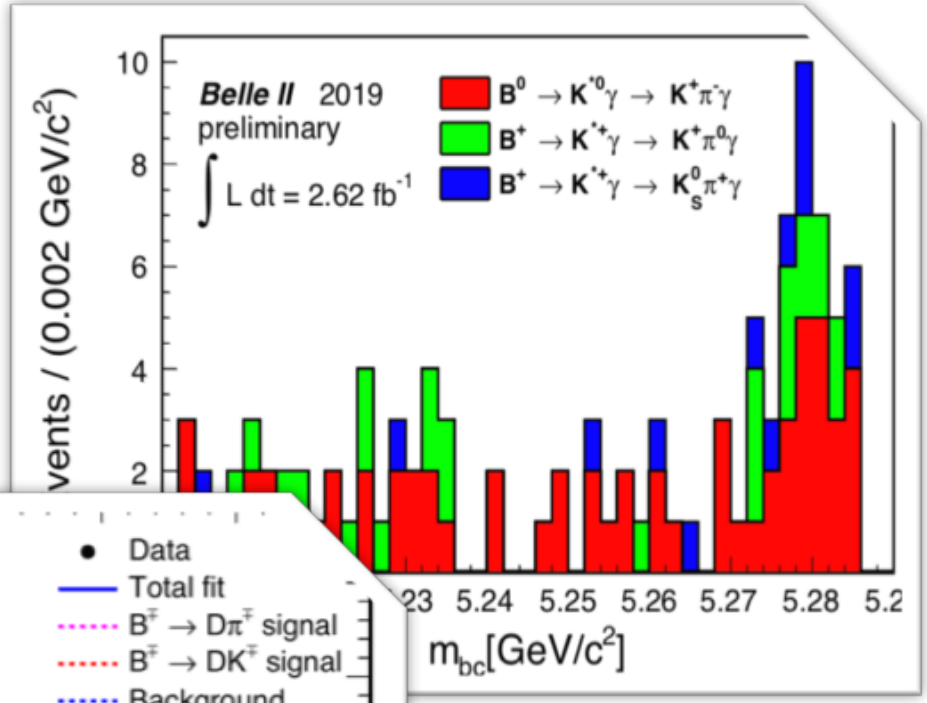
Latest results

Data analysis is also on going.

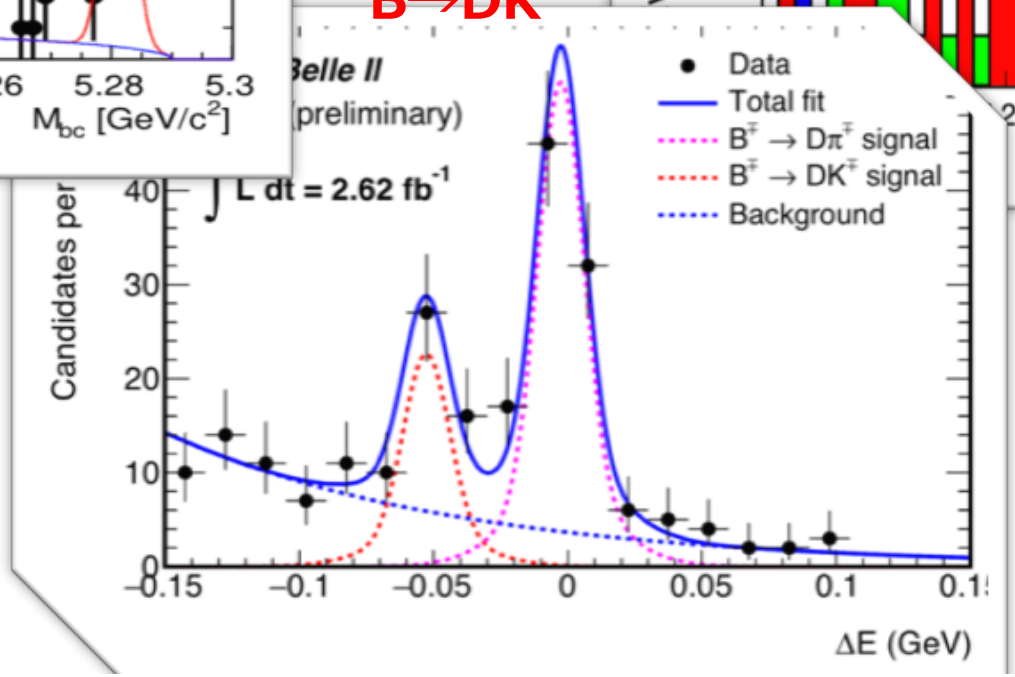
B→J/ψKs



B→K*γ



B→DK



International collaboration on SuperKEKB accelerator commissioning and developments

- **R&D for high luminosity colliders [MNPP-01]**
  - LAL: Fast luminosity monitor (LumiBelle2)
  - CERN: Beam Commissioning
    - Salim Ogur, Dima El Khechen, Marian Luckhof, Andreas Wegscheider, Jacqueline Keintzel, Frank Zimmerman, Renjin Yang, Adam Koval..
  - IHEP Beijing: Beam commissioning
- **US-Japan collaboration in HEP**
  - SLAC/Stanford:
    - IP feedback, Beam background, Collimators, HOM suppression, BxB feedback, X-ray monitor
  - University of Hawaii
    - X-ray monitor
  - Wayne State University : LABM
  - BNL, FNAL: Superconducting final Quads

Thank you for your attention.