

The Belle II Experiment: Status and Prospects

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on behalf of the Belle II collaboration

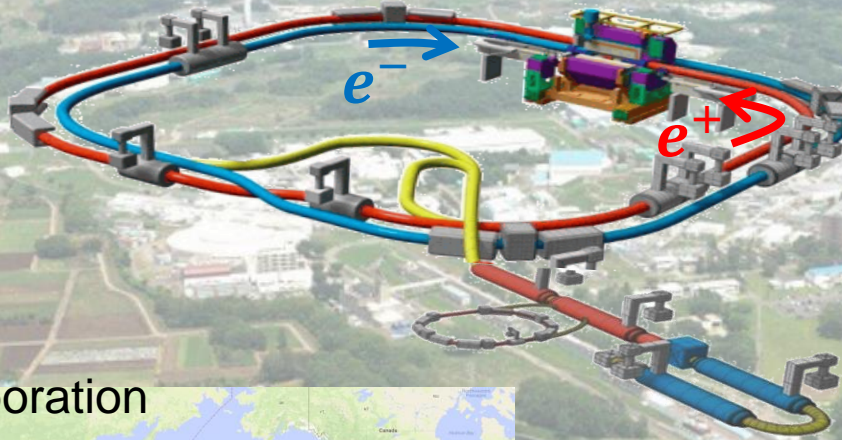


Belle II at SuperKEKB

Plan to collect **50 ab⁻¹** of collisions at and near $\Upsilon(4S)$
 Successor to Belle at KEKB (1.05 ab⁻¹)

At $\Upsilon(4S)$, $E_{CM} = 10.58$ GeV
 7 GeV e^- (HER; High Energy Ring)
 4 GeV e^+ (LER; Low Energy Ring)

Belle II detector



Nano beam scheme

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

5.9 \rightarrow 0.3 mm
 KEKB SuperKEKB

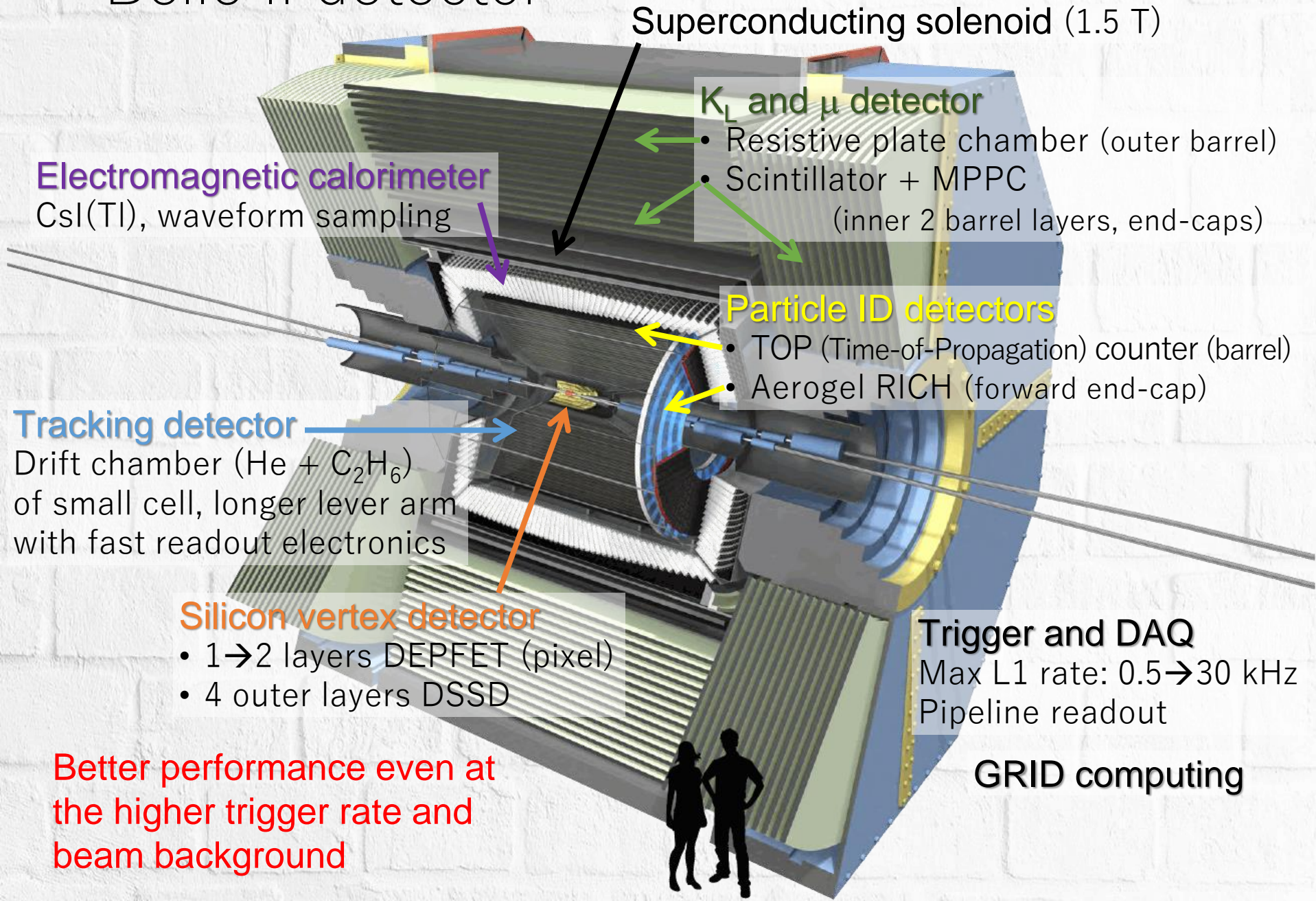
Physics motivations

- New physics search in B , B_s , D , τ decays
- Direct search for light new particles
- Precise measurement of Standard Model
- Hadron physics

Belle II collaboration

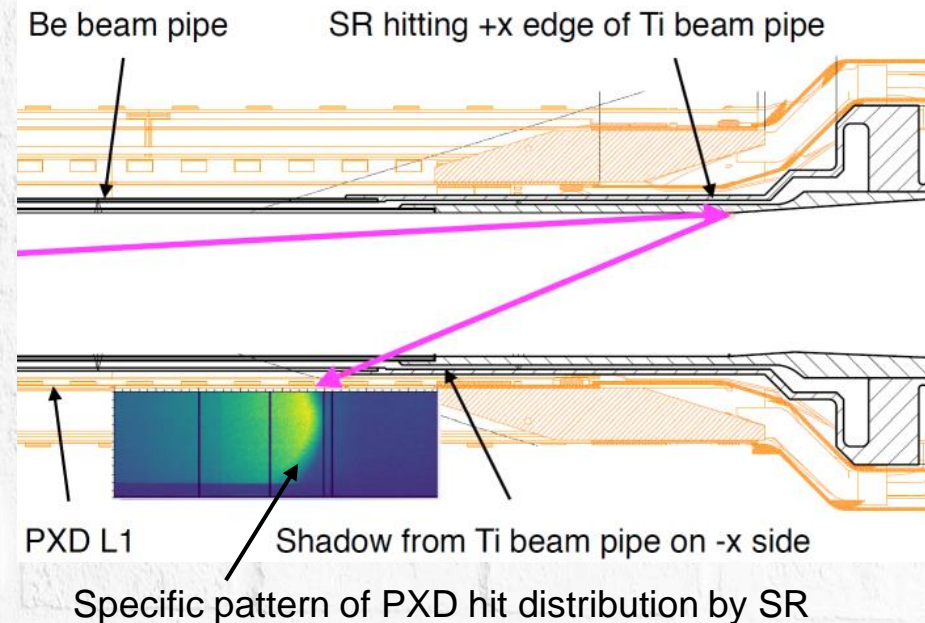
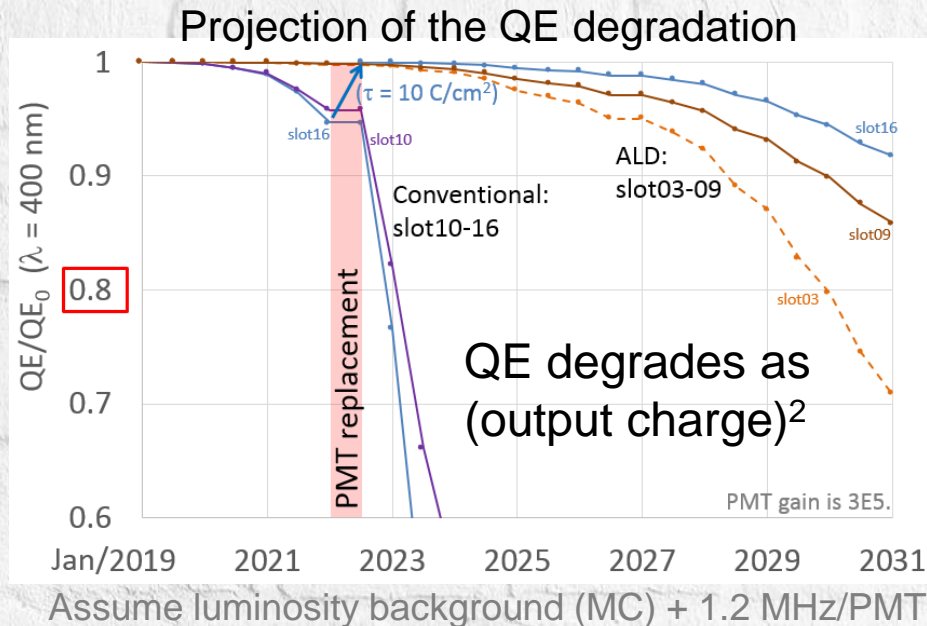


Belle II detector



Major detector issues in the operation

- Detector lifetime (in particular TOP counter)
 - To keep the MCP-PMT QE within an acceptable level ($QE/QE_0 > 80\%$) until 50 ab^{-1} , the Touschek and beam gas backgrounds, which increase with $(\text{beam current})^2$, have to be kept constant by collimators, beam tuning, additional shielding, ...
 - TOP PMT hit rate could limit the luminosity.
- Permanent damage on PXD and SVD by accidental huge beam loss.
- Synchrotron radiation from HER beam on PXD
 - Should be carefully monitored not to irradiate PXD unnecessarily.



Operation status in 2020

- SuperKEKB/Belle II was operated under Covid-19 pandemic while minimizing risk of infection:
 - Minimize person-to-person contact and avoid 3C
 - Remote control room shifts and expert shifts
 - Travel restrictions (~40 Belle II colleagues on-site)
 - Online meetings
 - Hygiene (face mask, alcohol disinfection, ventilation, ...)

Closed space
Crowded places
Close-contact settings

KEK campus

Beam background

(SpeakApp)

HV ctrl

(RocketChat)

Belle II Exp Hall

Sub-system experts

Accelerator ctrl room

Another bldg

Ctrl room

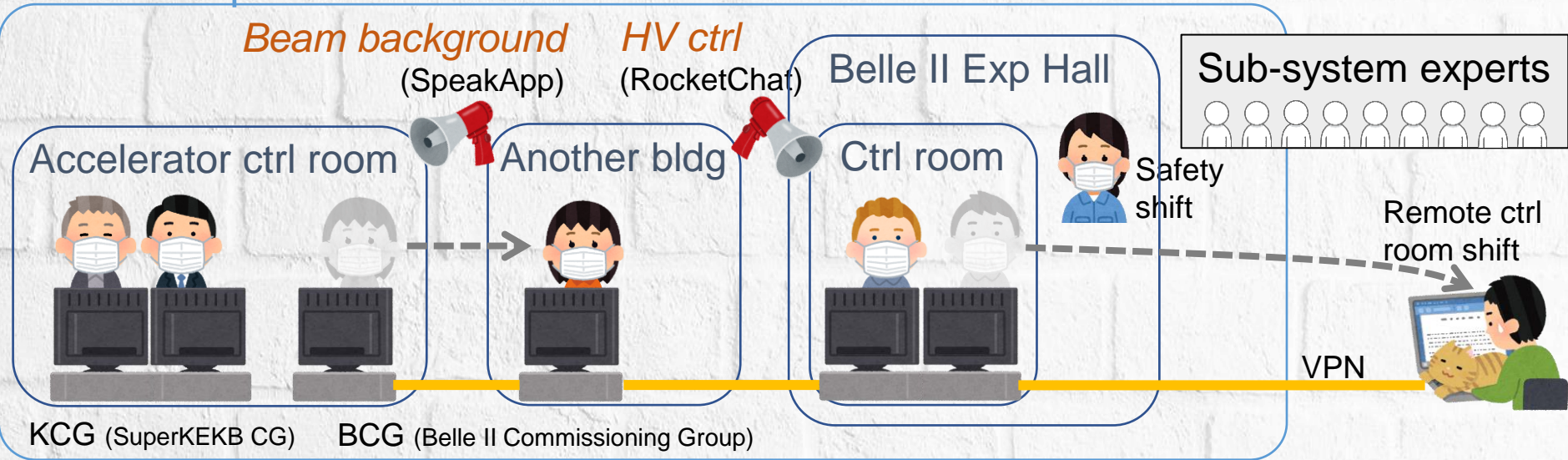
Safety shift

Remote ctrl room shift

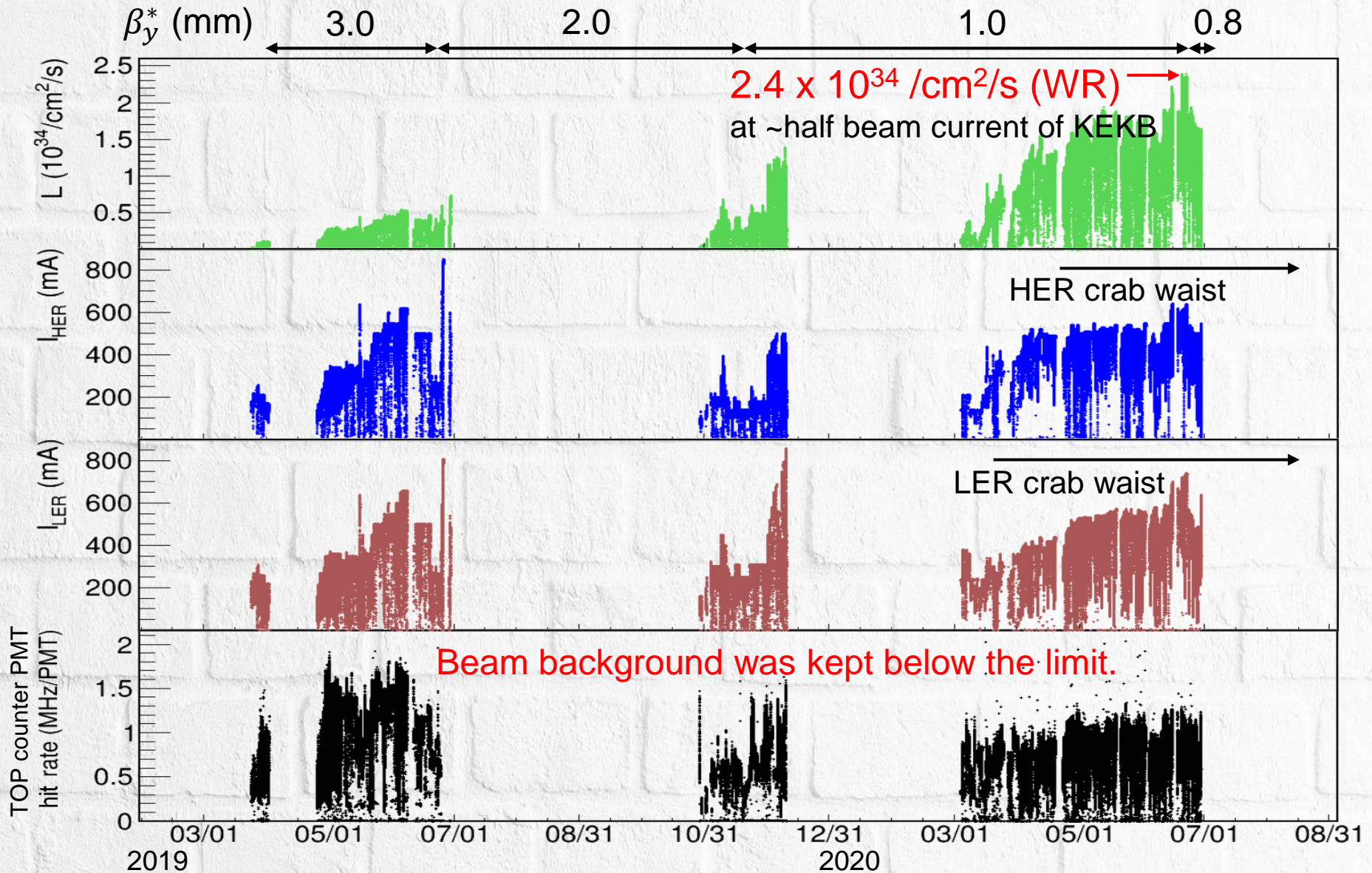
VPN

KCG (SuperKEKB CG)

BCG (Belle II Commissioning Group)



Accelerator operation summary → Talk by Y. Ohnishi

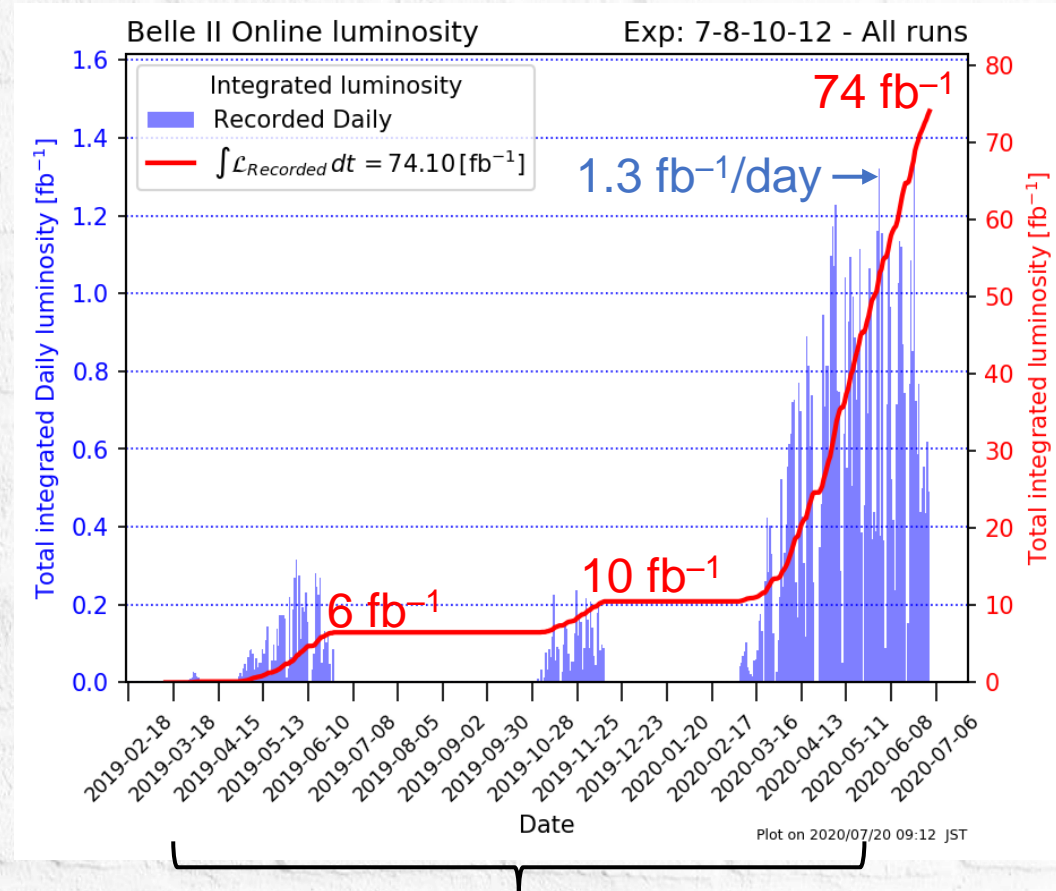
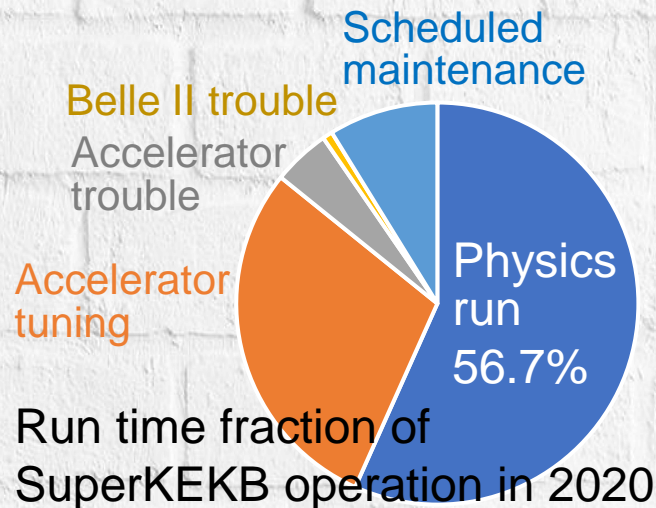


Try to squeeze β_y^* down to 0.6 mm in this coming autumn run.

Integrated luminosity

Belle II data taking efficiency has been improved to 84%.

- ✓ Less DAQ errors and more prompt recovery from the errors by experts' consistent effort
- ✓ Error analysis and monitor by ELK (Elasticsearch Logstash Kibana)
- ✓ More experienced shifters
- ✓ Controlled injection veto dead time (avg. 4.9%) as a result of injection background studies



ICHEP2020 dataset
34.6(3.2) fb⁻¹ on-(off-)resonance

Data analyses to be shown in ICHEP2020

Performance assessment for the flavor physics program

- B^0 lifetime → Talk by C. Praz
- B flavor tagger → Talk by N. Rout
- Reconstruction of (semi-)leptonic B decays with FEI → Talk by M. Milesi
- Search for $B \rightarrow K\ell\ell, X_s\ell\ell$
→ Talk by Y. Sato
- D^0 lifetime, D, D_s, Λ_c reconstructions
→ Talk by G. Casarosa

Outset of flavor physics measurements

(Need more statistics for publication)

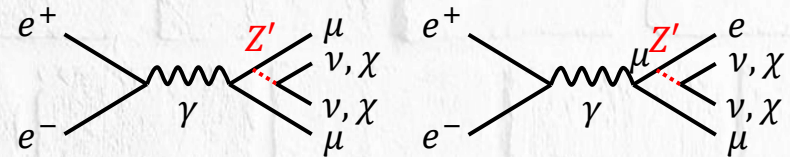
- $\mathcal{B}(\bar{B}^0 \rightarrow D^{*+}\ell^-\bar{\nu})$, V_{ub} and V_{cb}
→ Talk by R. Cheaib; poster by S. Grandeth
- \mathcal{B} and A_{CP} of charmless B decays
→ Talk by E. Ganiev
- f_L in $B \rightarrow \phi K^*$ → Talk by N. Rout
- τ -lepton mass → Talk by K. Inami

Dark sector

with the data taken in 2018

→ Talk by E. Graziani

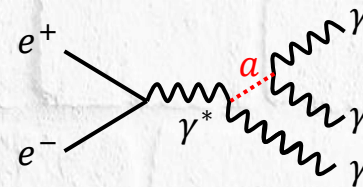
- Z' or LFV Z' to invisible



0.276 fb⁻¹; PRL 124 (2020) 141801

1st Belle II physics paper

- Axion Like Particle



0.445 fb⁻¹; Being submitted to PRL

2nd Belle II physics paper

Physics publication prospects in near future

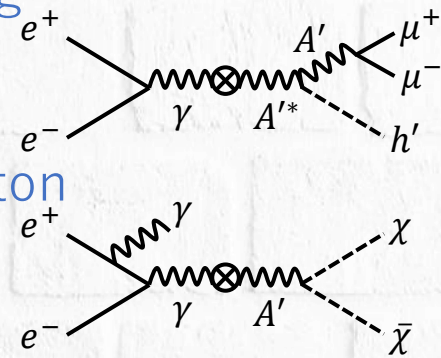
- 140-240 fb⁻¹ until Mar 2021 (depending on the operation budget)

Flavor physics

- $|V_{cb}|$ from hadronic q^2 moments
 - Inclusive $|V_{ub}|$ from lepton endpoint
 - Inclusive and FEI tagged $b \rightarrow sy$
 - Inclusive $B^+ \rightarrow K^+ \nu \nu$
 - B^0 lifetime and mixing
 - 1st combined Belle + Belle II analysis on BPGGSZ ϕ_3
 - D^0, D^+, D_s, Λ_c lifetimes
 - $B \rightarrow \Lambda_c + \text{invisible}$
 - τ -lepton mass measurement
 - $\tau \rightarrow \ell + \text{invisible}(\alpha)$ search
- Talk by F. Tenchini

Dark sector

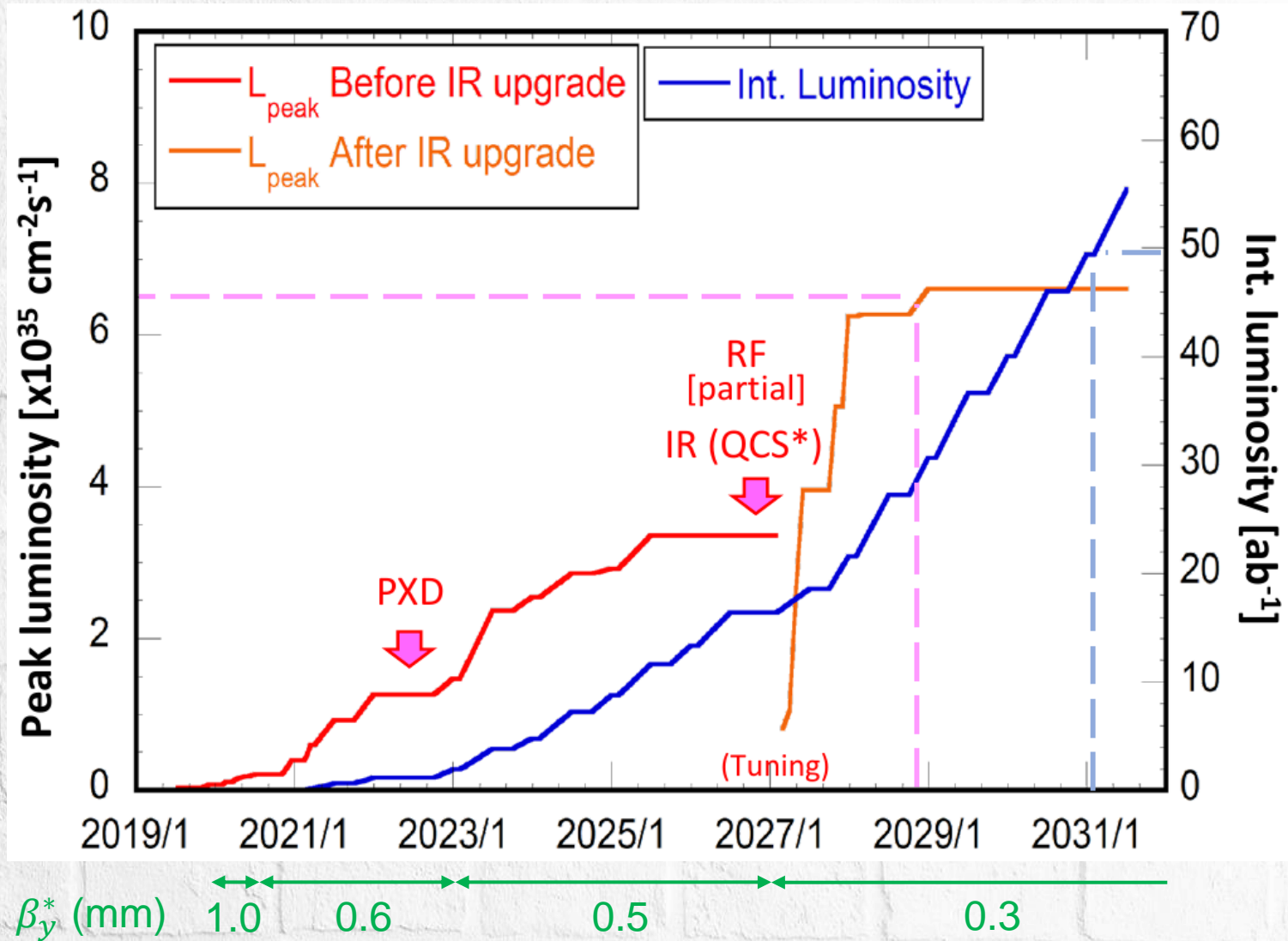
- Dark higgstrahlung
- Invisible dark photon
- Visible dark photon
- Z' or LFV Z' to invisible update
- $Z' \rightarrow \mu\mu$
- Inelastic dark matter
- Dark scalar
- ...



- $\sim 1 \text{ ab}^{-1}$ before long shutdown in 2022 to surpass BaBar and Belle
- Belle II will join in with the hunting for New Physics in earnest.

Projection toward 50 ab^{-1}

- Recently updated based on the past results.



Summary

- Belle II plans to collect 50 ab^{-1} to extensively search for New Physics in the flavor and dark sectors as well as to provide better understanding of the Standard Model and hadron physics.
- Accelerator and detector operation is in good shape: **the world record of the peak luminosity $2.4 \times 10^{34} \text{ /cm}^2\text{/s}$ (KEKB record: $2.1 \times 10^{34} \text{ /cm}^2\text{/s}$) was achieved with the acceptable beam background level.**
- **Collected 74 fb^{-1} , and 1st physics paper on dark sector was published,** to be followed soon by other results on dark sector and flavor physics.
- **In a few years, Belle II will join in with the hunting for New Physics in earnest.**