

SuperKEKB/Belle II

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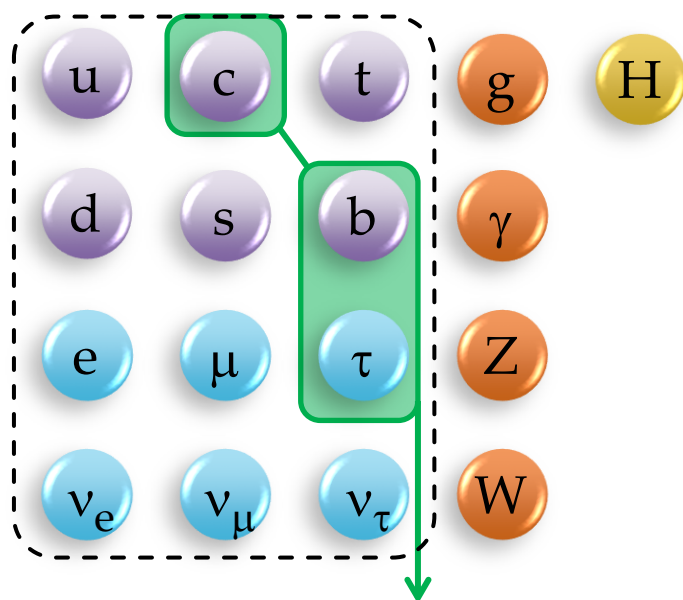
September 28, 2026

Physics at Belle II

Goal: Uncover BSM (Beyond the Standard Model) physics

Standard Model particles

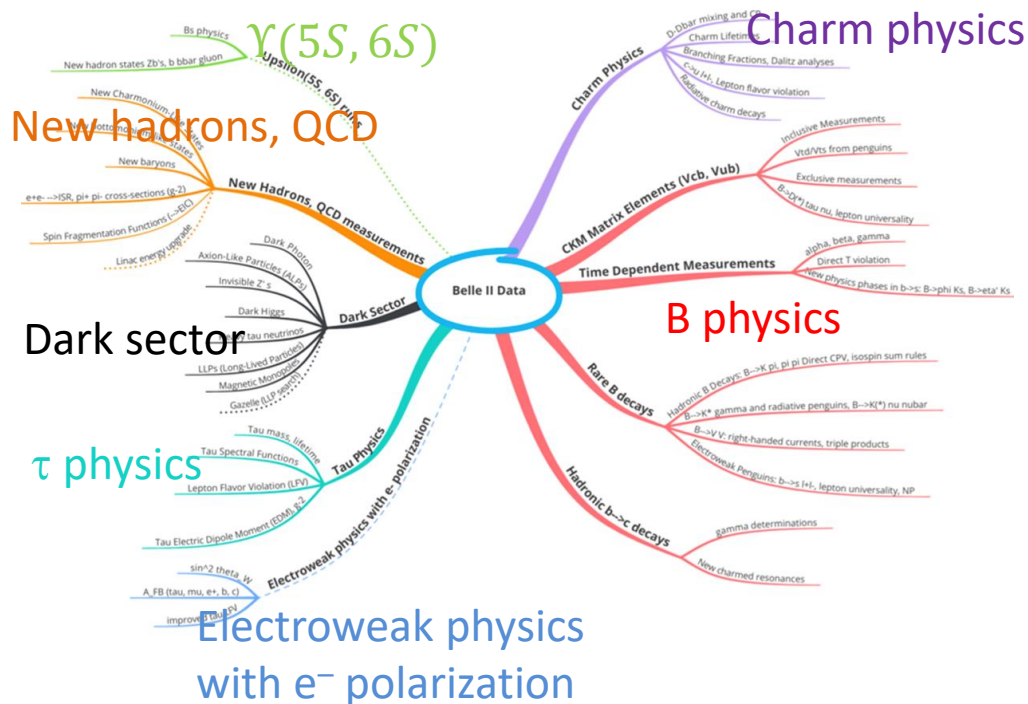
(Comprehensive search for BSM physics is important.)



(1) Large statistics

Billions of c , b , τ particles are produced in a clean environment at the SuperKEKB factory

(2) Broad physics programs



(3) High precision measurements

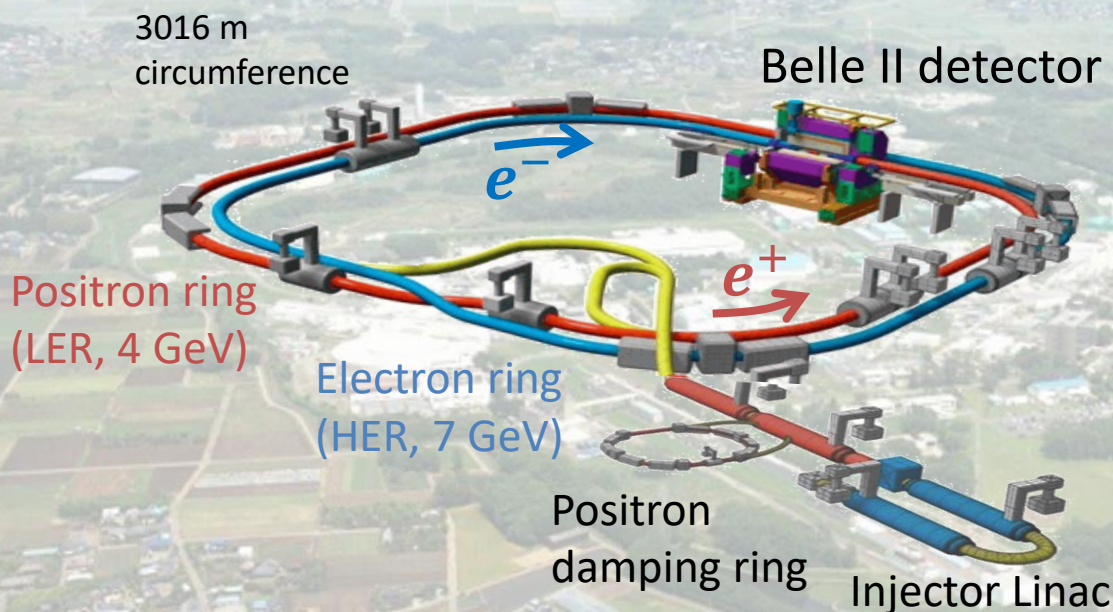
Access higher energy scales via quantum effects than are directly reachable at current or future colliders.

e.g. $\Lambda < \sim 1000$ TeV in B^0 mixing ($\mathcal{L} = \mathcal{L}_{\text{SM}} + \frac{1}{\Lambda^2} \mathcal{O}_{\Delta F=2}$)

[\[arXiv:1302.0661\]](https://arxiv.org/abs/1302.0661)

The SuperKEKB accelerator

- Asymmetric e^+e^- collider operating mainly at $\Upsilon(4S)$
- World's highest peak luminosity**
 $\mathcal{L} = 5.3 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ (= KEKB x 2.5 = PEP-II x 4.4)



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

Nano-beam scheme

- World's smallest vertical beam size at IP ($\sigma_y^* \approx 200 \text{ nm}$)

Powerful injector Linac

- Compensate for the short beam lifetime due to the narrow dynamic aperture of the main rings caused by the nano-beam collisions



The Belle II experiment

International collaboration with >1200 members
from 28 countries/regions



Superconducting solenoid (1.5 T)

Vertex Detector

2 layers DEPFET + 4 layers DSSD



Central Drift Chamber

He(50%):C₂H₆(50%), Small cells,
long lever arm, fast electronics

Particle Identification Detector

Time-of-Propagation (TOP) counter (barrel)
Prox. focusing Aerogel RICH (fwd)

Electromagnetic Calorimeter

CsI(Tl), waveform sampling (barrel)

K_L and Muon Detector (KLM)

Resistive Plate Counter (barrel outer layers)

Scintillator + WLSF + MPPC (end-caps, inner 2 barrel layers)

GRID computing



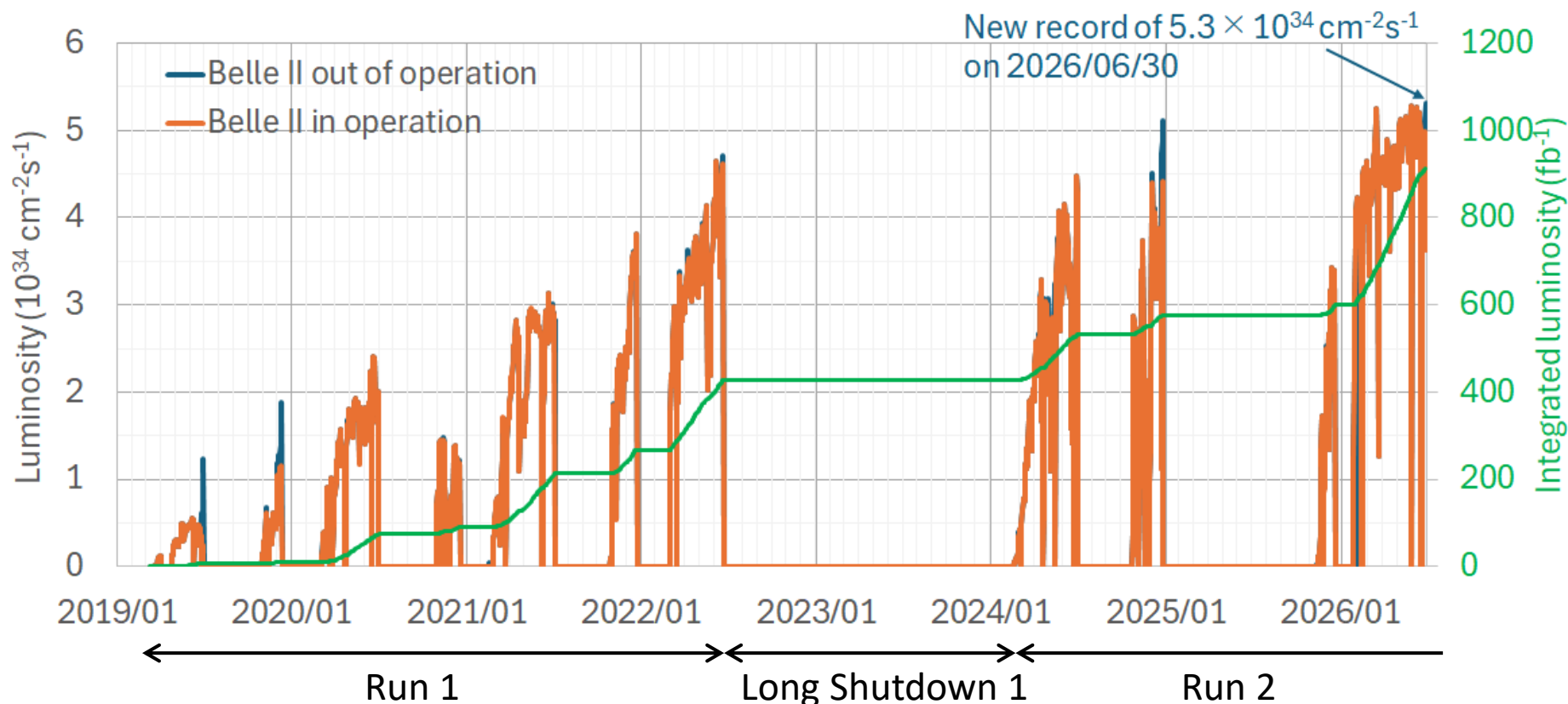
- Nearly hermetic spectrometer
- Capable of reconstructing neutrals (γ , π^0 , K^0 , η , etc) with high efficiencies
- Good lepton and hadron identification
- High trigger efficiency, including for low multiplicity events

- ✓ Well-known initial condition of e^+e^- collisions
- ✓ Excellent capability of reconstructing particle decays
(even with missing neutrinos or BSM particles)



**Enables unique and
complementary
physics programs**

Operation status



- Established stable operation at $5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$.
- Recorded 808 fb^{-1} at $\Upsilon(4S)$ ($>$ Belle), and 914 fb^{-1} in total.

A trinity of

SuperKEKB accelerator
(Large amount of data)

- World's highest luminosity with the nano-beam collision
- Demonstration of cutting-edge accelerator technology

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Belle II detector
(high performance)

- Precise measurements

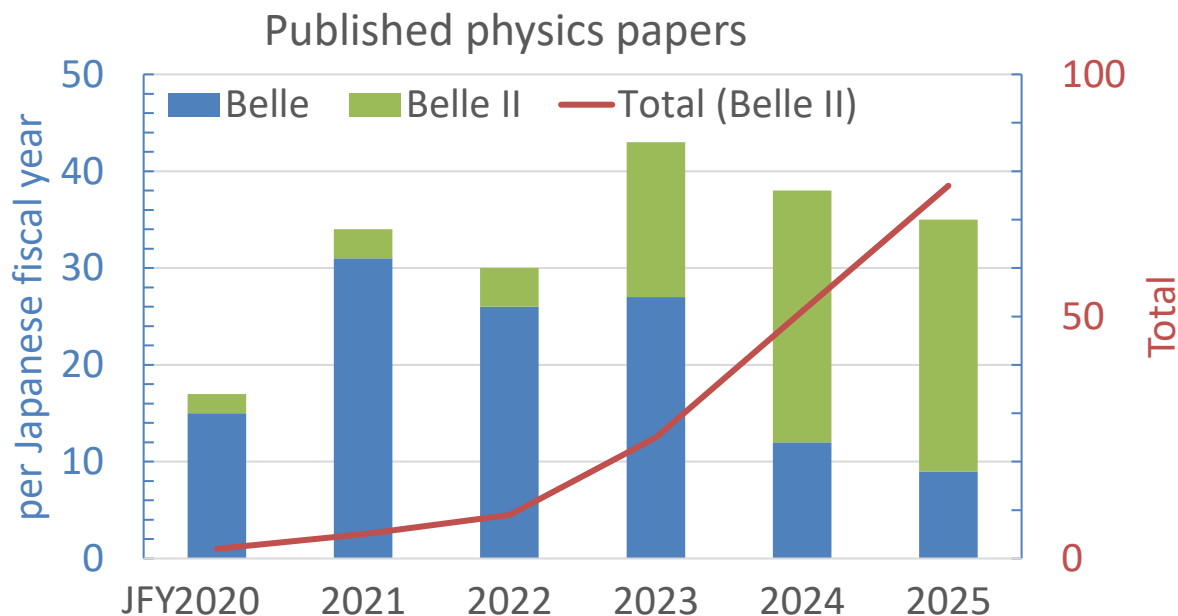
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Analysis technique
(high efficiency)

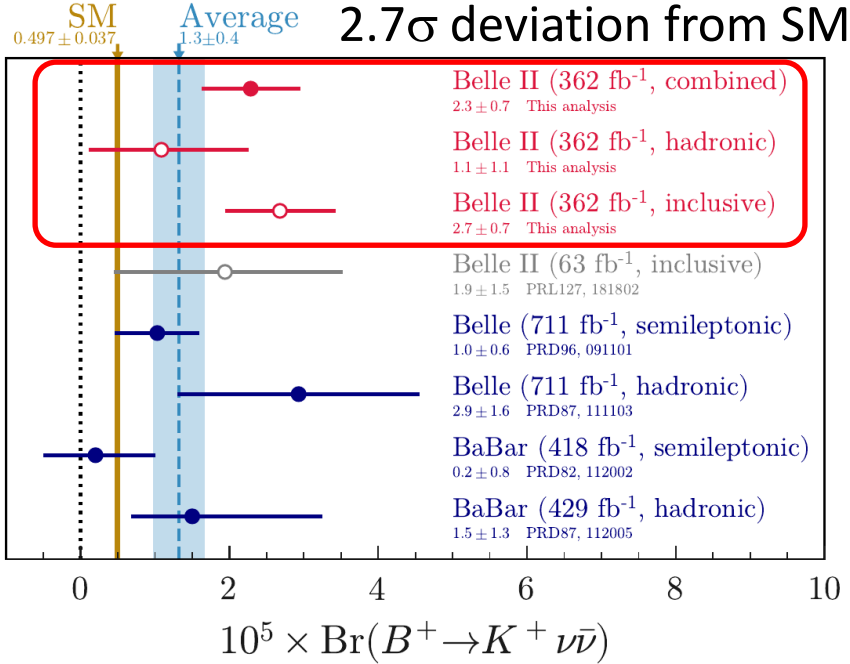
- New ideas
- Machine learning



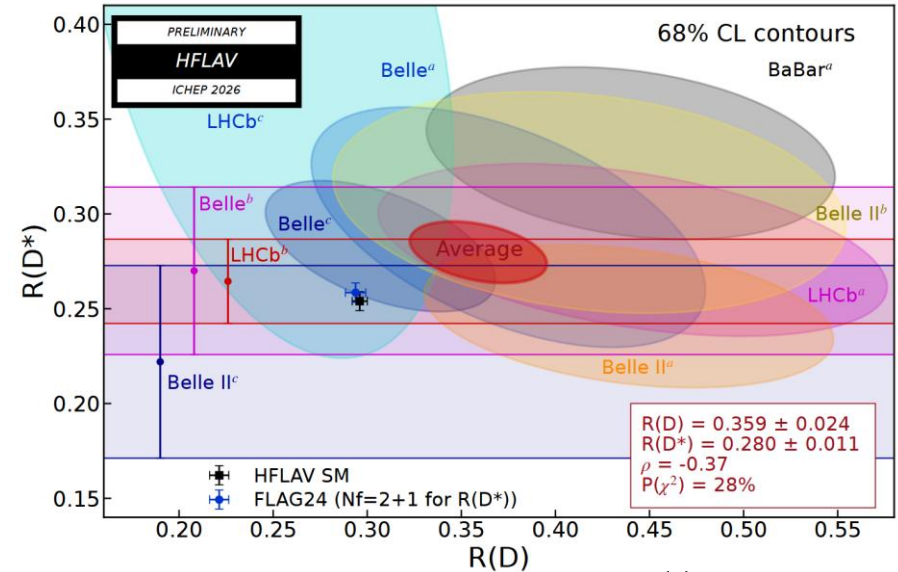
Producing world-leading physics results with the Run 1 data, which is only about half of the Belle data.



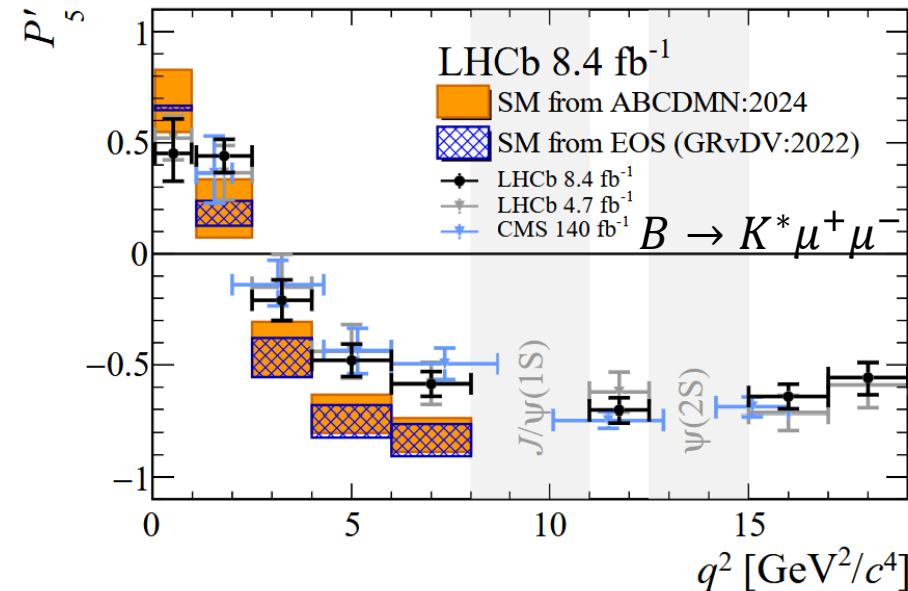
Hints of New Physics



3.7 σ deviation from SM

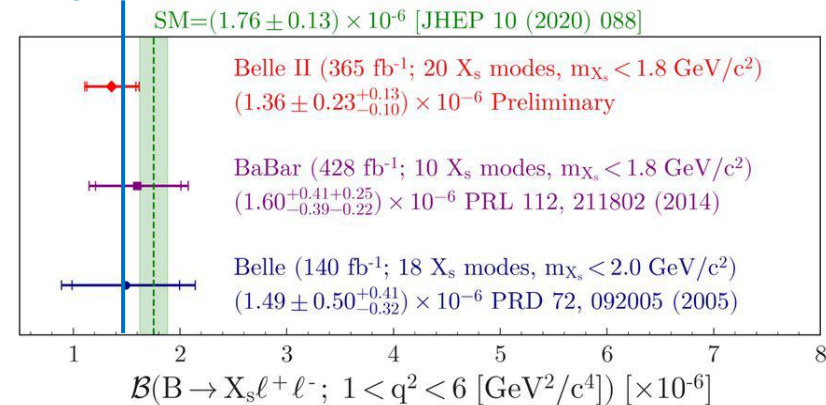


$$R(D^{(*)}) = \frac{\text{Br}(B \rightarrow D^{(*)} \tau \nu)}{\text{Br}(B \rightarrow D^{(*)} \ell \nu)}$$



Shift of $\text{Re}(C_9)$ from SM by -1 ($\sim 4\sigma$)
 ([arXiv:2605.18084](https://arxiv.org/abs/2605.18084)) New Physics or charm-loop?

$$C_9^{\text{NP}} = -1 \text{ (arXiv:2605.06567)}$$



Upgrade in the next long shutdown, starting in 2032

AI technology

SuperKEKB accelerator
(breaking through the limits)

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Belle II detector
(better performance)

×

Analysis technique
(further improve)

- Push up the luminosity
- Reduce the beam background
- Improve stability and reproducibility

- Enhance beam background tolerance
- Better vertex resolution
- Better efficiency for low p tracks

- New ideas
- Machine learning

【Objectives of the upgrade】

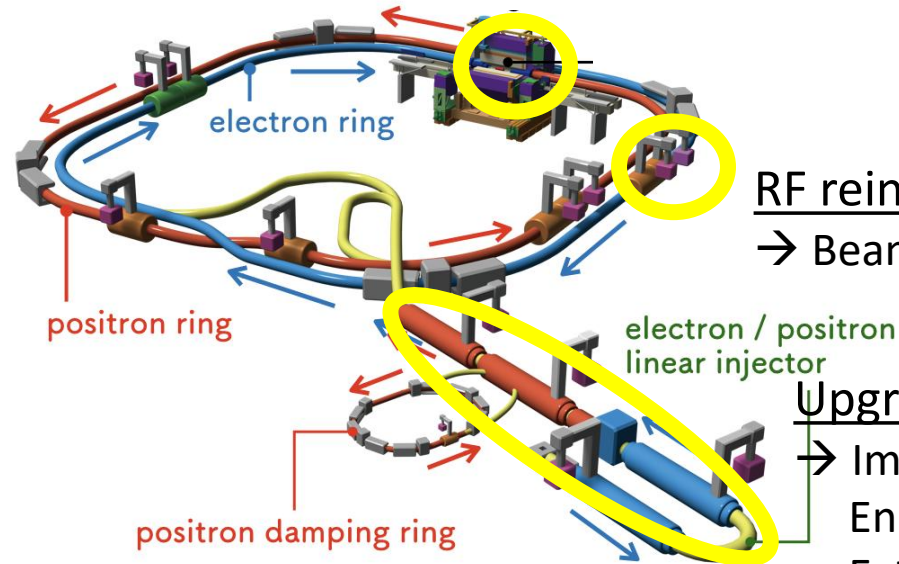
- Enhance Belle II's strengths
(photon, electron, π^0 , missing energy sensitivities)
- Open new unique windows of discovery

Technologies and experience developed for this upgrade will lead to next-generation collider experiments.

Accelerator upgrade

Upgrade of the final focusing system

→ Smaller beam size, longer beam lifetime

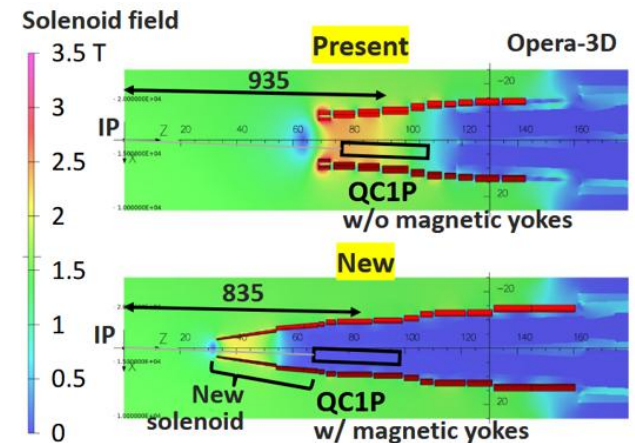


RF reinforcement for the electron ring

→ Beam current: 2.0 → 2.6 A

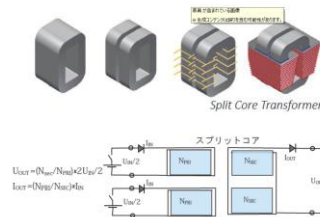
Upgrade of injector accelerator unit

→ Improved stability and reproducibility,
Enhanced injection beam power (under consideration)
Extended collision energy: 11.24 → up to 11.6 GeV

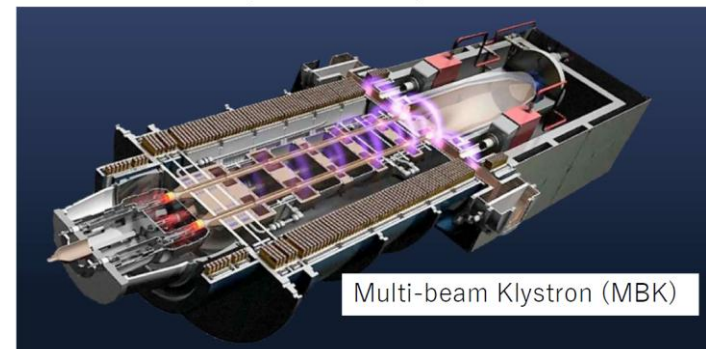


New modulator (Thyratron-free system)

Semiconductor type modulator using the split core transformer.
Stable output power jitter.



Thyratron-free system



Multi-beam Klystron (MBK)

Belle II detector upgrade

Upgrade to CMOS pixel detector (VTX)

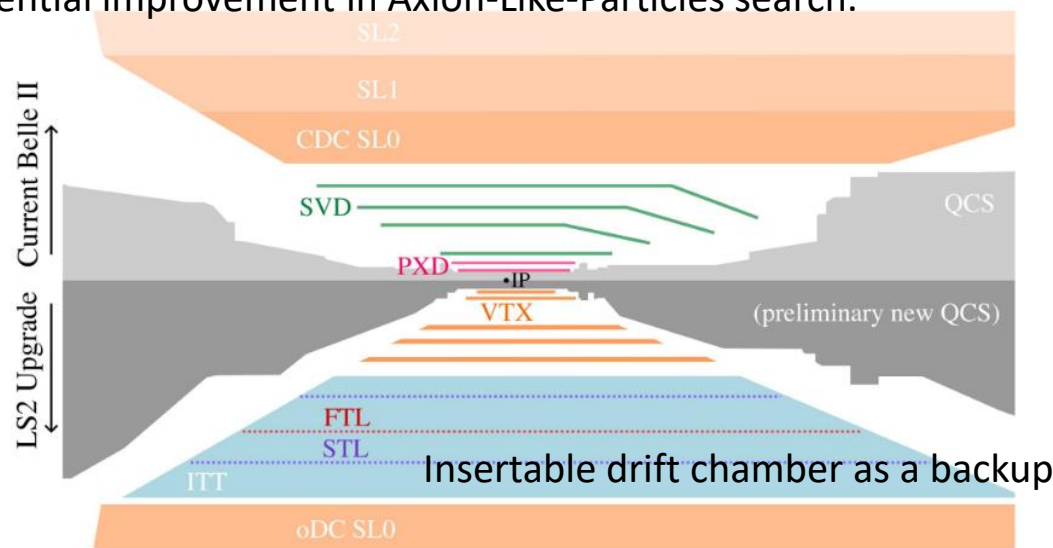
Upgrade to CMOS strip
+ LGAD timing layers
+ new drift chamber

Upgrade of front-end readout

AI-based trigger

Forward tagger

to tag two-photon events by detecting the scattered $e^{\pm}$.
Potential improvement in Axion-Like-Particles search.



Insertable drift chamber as a backup

Vertex Detector

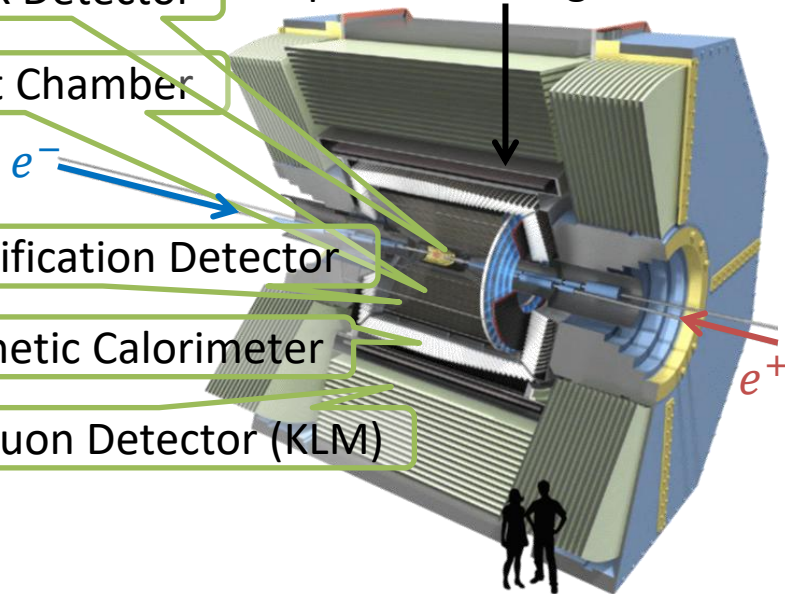
Central Drift Chamber

Particle Identification Detector

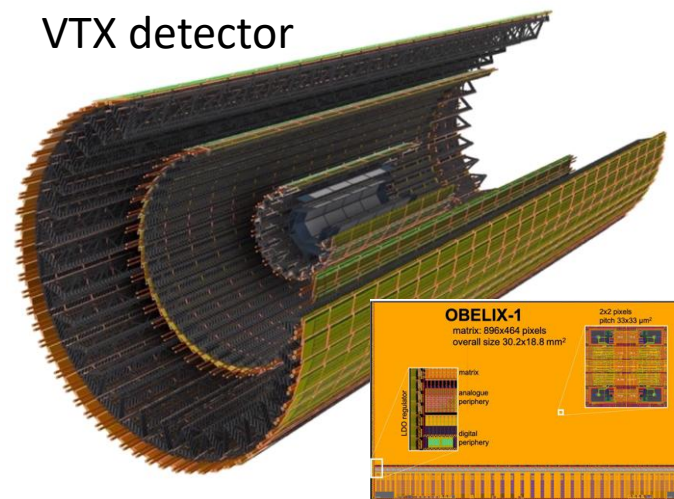
Electromagnetic Calorimeter

K_L and Muon Detector (KLM)

Superconducting solenoid



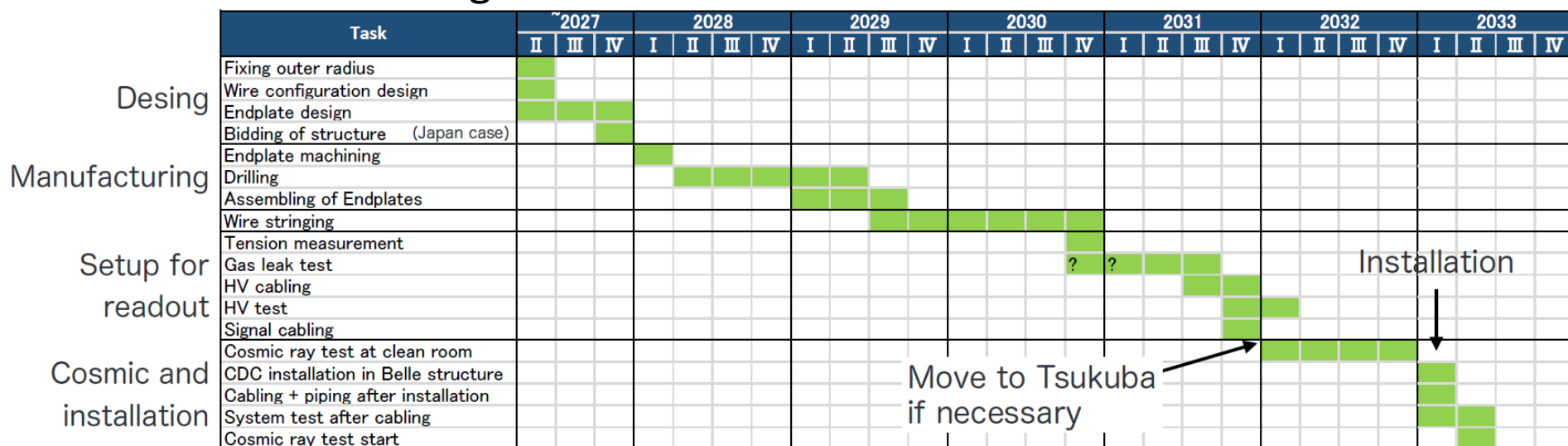
VTX detector



OBELIX prototype sensor

Upgrade of CDC (Central Drift Chamber)

- CDC is the “central” detector of Belle II but is most affected by the beam-induced background (Malter effect and wire ageing).
- We plan to replace the inner part of CDC with CMOS strip + LGAD timing layers and to build a new chamber (oDC) with possible countermeasures.
- A new oDC group was formed recently, but the available human resources are very limited. Contributions from Canada are essential. We would like to request a contribution from TRIUMF to the mechanical design.



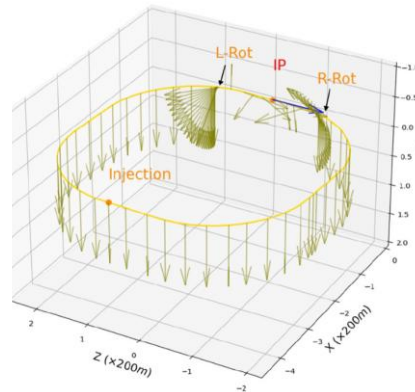
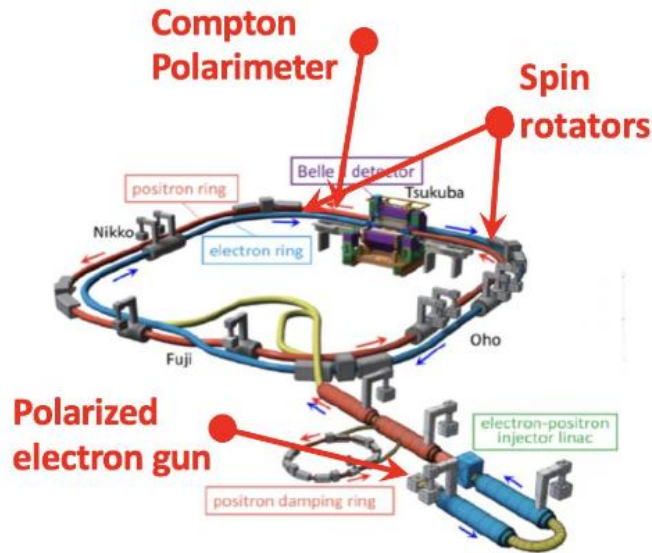
Chiral Belle

$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R} = \frac{4}{\sqrt{2}} \left(\frac{G_F s}{4\pi\alpha Q_f} \right) \langle g_A^e g_V^f \rangle \langle Pol \rangle$$

$$\propto T_3^f - 2Q_f \sin^2 \theta_W$$

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Polarized electron beam $\Rightarrow$ Precision neutral-current physics through left-right asymmetries.
Measuring τ g-2 (Pauli form factor) with 10^{-5} precision.



[Requirements]

- Extension of the SuperKEKB luminosity
- Polarized electron source
- Compact spin rotator magnets
- Compton polarimeter detector system

... KEK

... Hiroshima, KEK

} Canadian team

Universite Paris-Saclay

MoU was recently signed between KEK and UVic.

Summary

- Belle II is on track to produce physics results constantly.
- SuperKEKB keeps improving its performance.
- To extend the physics reach, SuperKEKB and Belle II plan major upgrades, starting installation in 2032.
- We would appreciate continued contributions and the close collaboration we have built up over the many years.
 - Details of the Canadian contributions to the upgrade project will be presented by T. Blake.
- We would like to request an additional contribution from TRIUMF to the upgrade project, oDC mechanical design.