

The Belle II Experiment

Technology, physics, and people



Bianca Scavino (she/her)

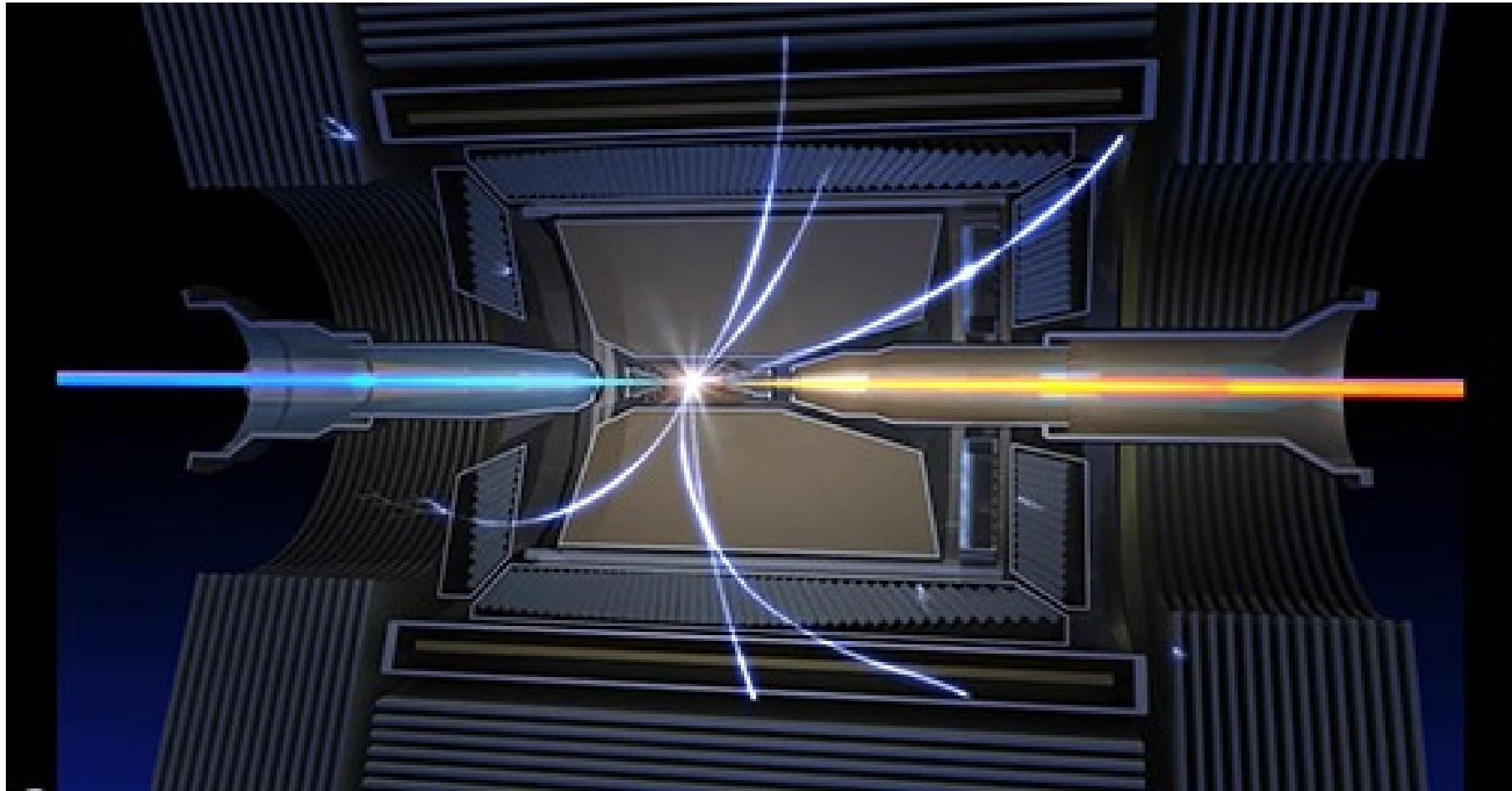
Uppsala Universitet

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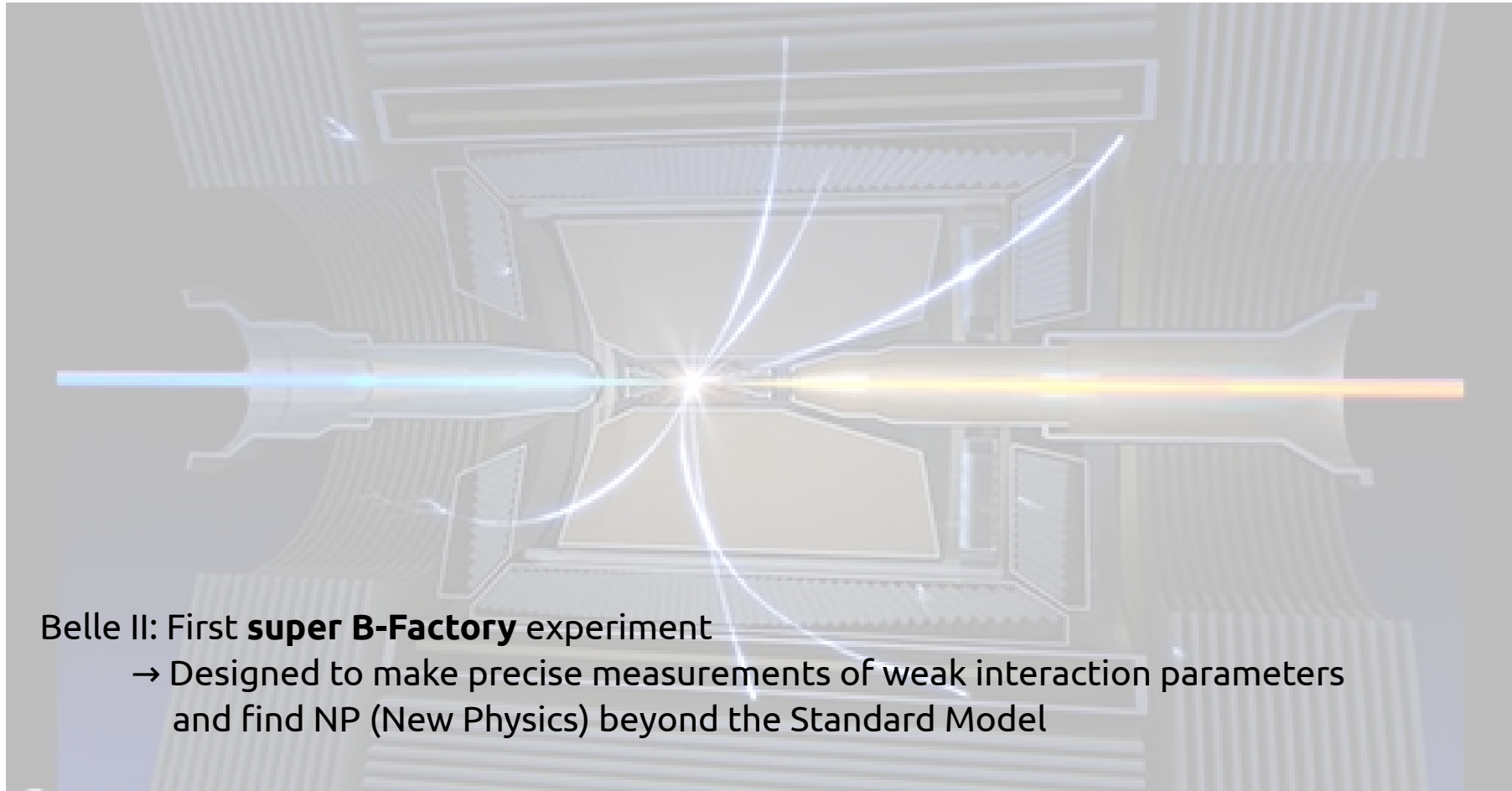
NorNDiP Conference

Copenhagen, May 24th, 2023

Belle II



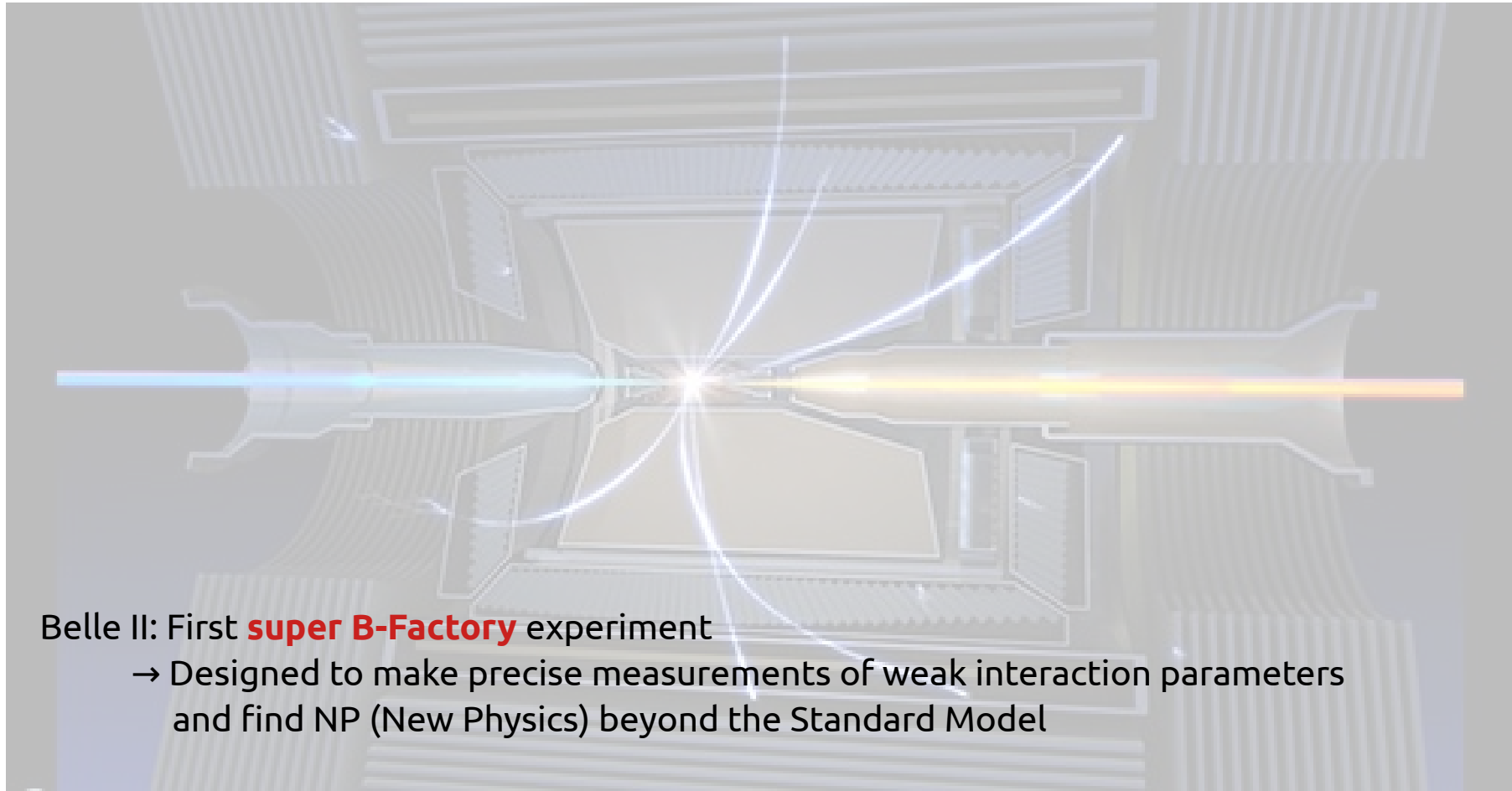
Belle II



Belle II: First **super B-Factory** experiment

→ Designed to make precise measurements of weak interaction parameters
and find NP (New Physics) beyond the Standard Model

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Belle II: super **B-Factory**

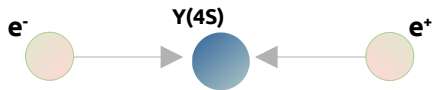
B-Factory: particle collider experiment designed to produce and detect a large number of B mesons so that their properties and behavior can be measured with small statistical and systematic uncertainties

$e^- e^+$ collisions \rightarrow direct production of $J^{PC}=1^-$ states



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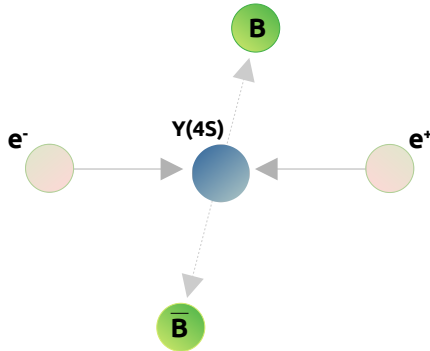
$e^- e^+$ collisions \rightarrow direct production of $J^{PC}=1^-$ states
 $\sqrt{s} = 10.58 \text{ GeV} (= m_{Y(4S)})$



$Y(4S)$: $b\bar{b}$ meson, $J^{PC} = 1^-$
 Γ : 20.5 MeV
 $m_{Y(4S)}$: 10.58 GeV
 \rightarrow right above the $B\bar{B}$ production threshold (10.56 GeV)

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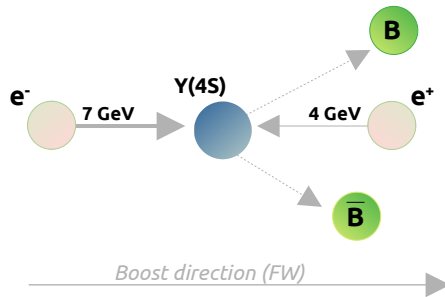
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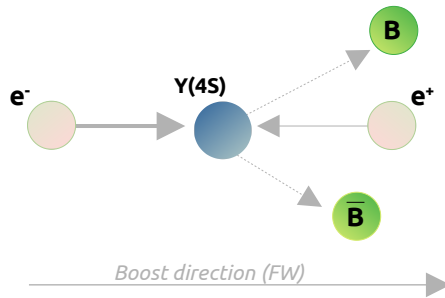
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Asymmetric collisions \rightarrow boosted collision products

(Other B-Factories)

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BaBar @ PEP-II (SLAC, California)
run period: 1999 - 2008

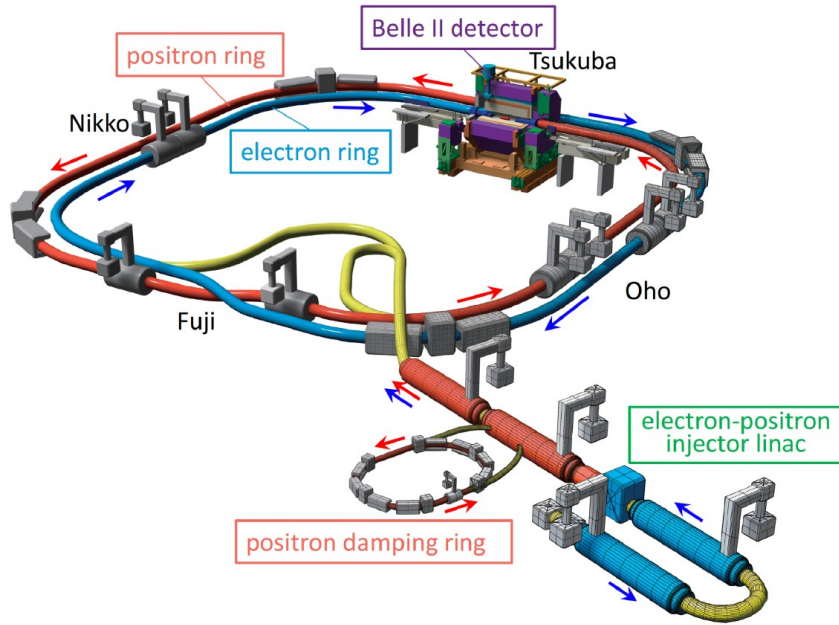


Belle @ KEKB (Tsukuba, Japan)
run period: 1999 - 2010

Belle II: Super B-Factory



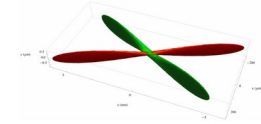
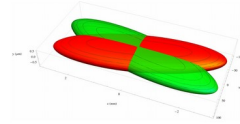
SuperKEKB: accelerator complex in which the Belle II experiment operates, located at KEK (High Energy Accelerator Research Organization) in Tsukuba, Japan



KEKB

SuperKEKB

Sketch of the Interaction region



$\int L dt$	1 ab ⁻¹	424 fb ⁻¹ {50 ab ⁻¹ }
$L_{\text{peak}} [\text{cm}^{-2} \text{s}^{-1}]$	2.1×10^{34}	4.7×10^{34} (WR) { 60×10^{34} }

{ x } : target values

Currently: LS1

Belle II: the detector

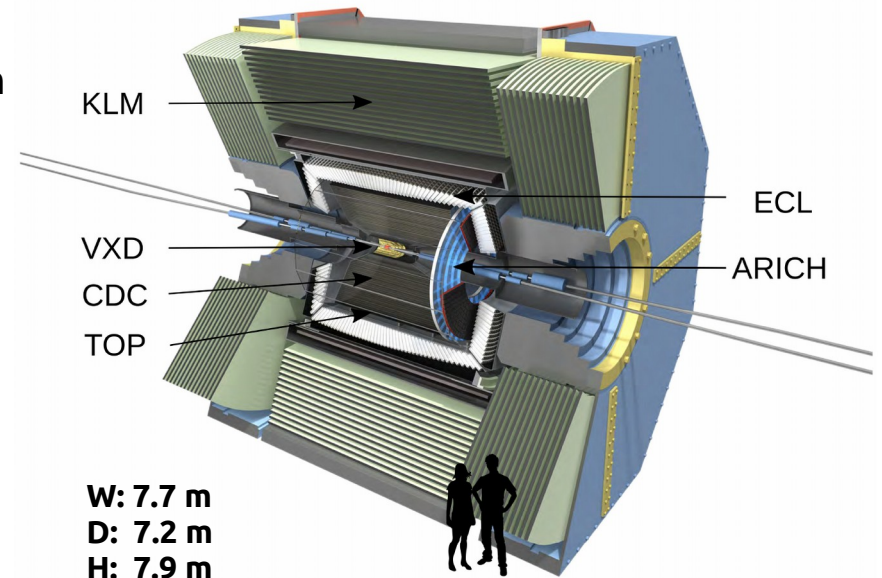
Belle II detector: 4 π spectrometer, optimal vertexing, tracking, PID & calorimetry capabilities

- Silicon detectors: tracking and vertexing
- Drift chamber: tracking and dE/dx measurements
- TOP and ARICH counters: PID
- CsI(Tl) crystals: e^\pm and γ calorimetry
- Iron/RPC layers: K_L and μ detection

Well known initial conditions, low background;

Excellent tracking, vertexing, PID;

Efficient reconstruction of neutrals, RS and ME



RS: recoiling systems
ME: missing energy

Belle II: physics potential

Belle II operates mainly at $\sqrt{s} = 10.58$ GeV:

$$- \sigma(e^+ e^- \rightarrow b\bar{b}) \sim 1.1 \text{ nb} \quad [L_{\text{peak}} = 2.7 \cdot 10^{34} \text{ cm}^{-2} \text{ s}^{-1} \rightarrow 30 \text{ } B\bar{B} / \text{s}]$$

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- $\sigma(e^+ e^- \rightarrow \tau\tau) \sim 0.9$ nb

- $\sigma(e^+ e^- \rightarrow c\bar{c}) \sim 1.3$ nb

→ *B* & τ & *c* factory

- $\sigma(e^+ e^- \rightarrow e^+ e^-) \sim 125/294$ nb (strongly depends on the acceptance angle)

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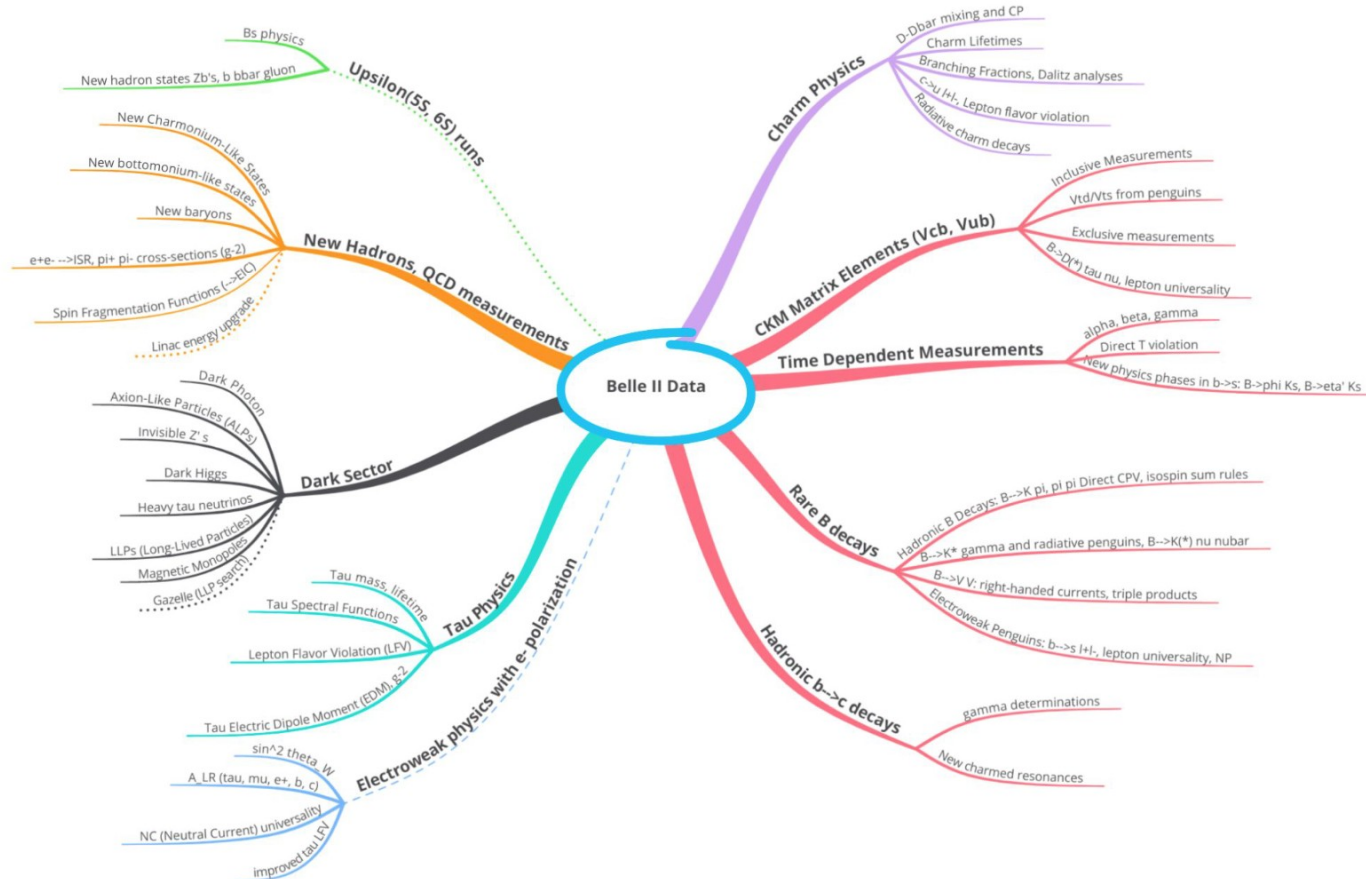
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It is possible to change the \sqrt{s} :

In 2019 unique energy scan sample collected at ~ 10.75 GeV

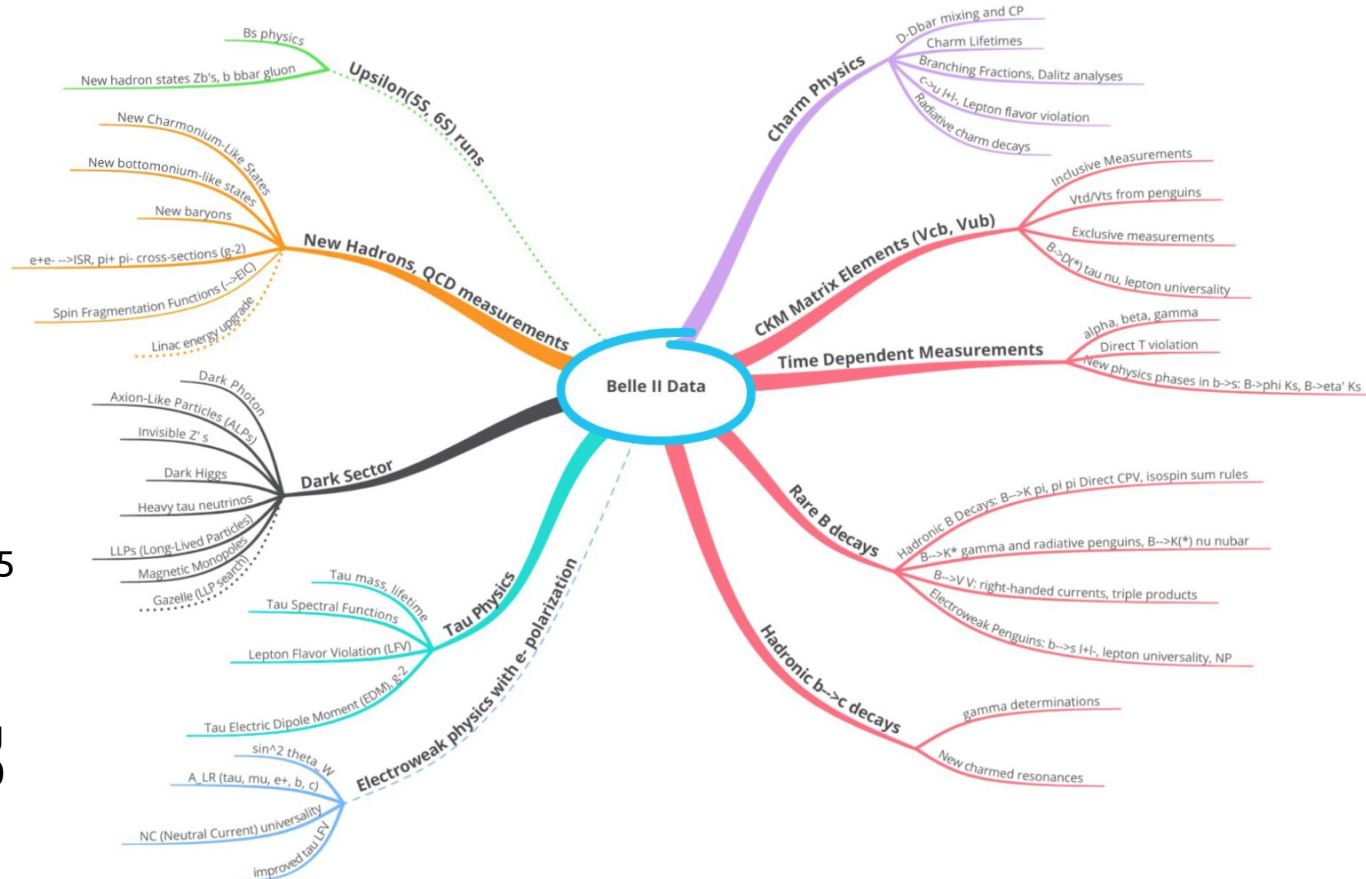
Belle II: physics program

[See: BIITIP, Snowmass Whitepaper]



Belle II: physics program

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See talks:
M. Laurenza
25/05 h.13:05

(partially)
K. Schönning
25/05, h.9:20



Belle II: physics results

[Full list: [INSPIRE HEP](#), [collaboration:Belle-II](#)]

Search for an Invisibly Decaying Z' Boson at Belle II in $e^+e^- \rightarrow \mu^+\mu^- (e^\pm\mu^\mp)$ Plus Missing Energy Final States

I. Adachi *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **124**, 141801 – Published 6 April 2020

Search for $B^+ \rightarrow K^+\nu\bar{\nu}$ Decays Using an Inclusive Method at Belle II

F. Abudinén *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **127**, 181802 – Published 27 October 2021

Search for Axionlike Particles Produced in e^+e^- Collisions at Belle II

F. Abudinén *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **125**, 161806 – Published 14 October 2020

Search for $B^+ \rightarrow K^+\nu\bar{\nu}$ Decays Using an Inclusive Tagging Method at Belle II

F. Abudinén *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **127**, 181802 – Published 27 October 2021

...and many more...

Search for Lepton-Flavor-Violating τ Decays to a Lepton and an Invisible Boson at Belle II

I. Adachi *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **130**, 181803 – Published 2 May 2023

Precise Measurement of the D^0 and D^+ Lifetimes at Belle II

F. Abudinén *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **127**, 211801 – Published 19 November 2021

Measurement of the Λ_c^+ Lifetime

F. Abudinén *et al.* (The Belle II Collaboration)
Phys. Rev. Lett. **130**, 071802 – Published 16 February 2023

Search for a Dark Photon and an Invisible Dark Higgs Boson in $\mu^+\mu^-$ and Missing Energy Final States with the Belle II Experiment

F. Abudinén *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **130**, 071804 – Published 17 February 2023

The Belle II Collaboration

Continents: 4

Countries: 27

Institutions: 123

Members: 1196

[Last update:
22/05/2023]



The Belle II Collaboration: (few) numbers



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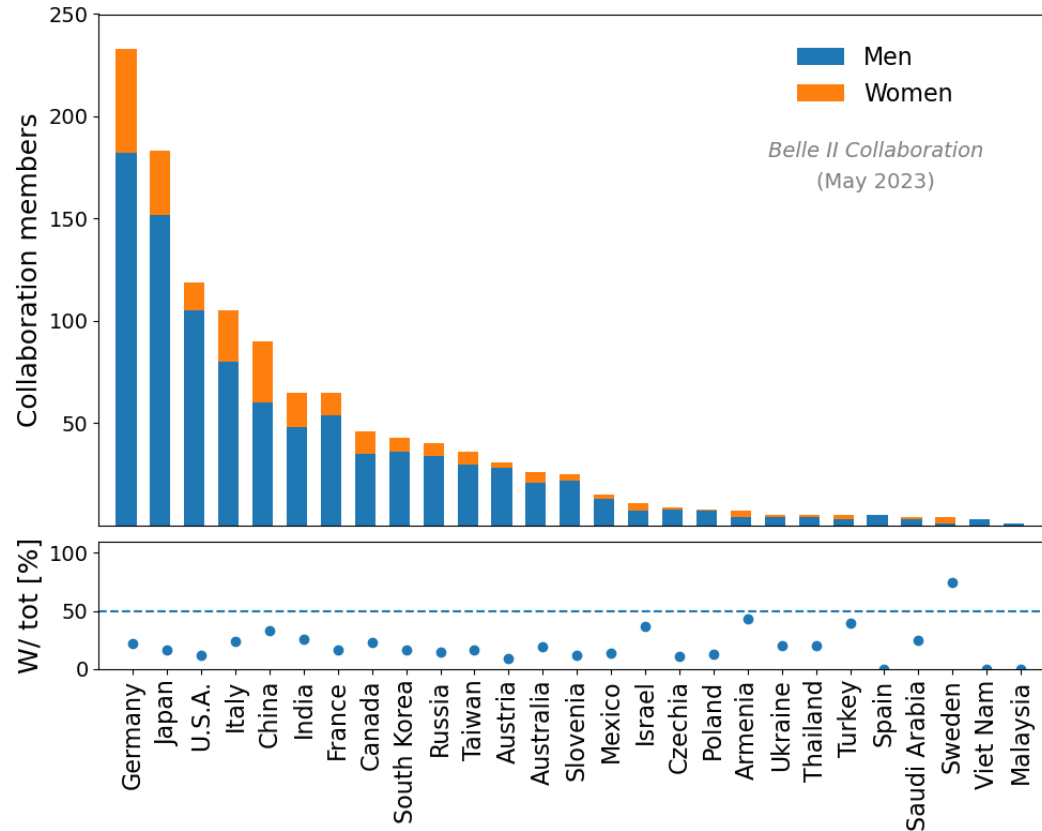
Members: 1196

M: 950

W: 239

O: 3

(NS: 4)



Women represent:

- **2011**: 12.2% of 467 members

- **2020**: 17.1% of 1078 members

- **2023**: 20.0% of 1196 members

[Last update:
22/05/2023]

The Belle II Collaboration: **social media**

@belle2collab: Belle II is active on Facebook, Twitter, and Instagram

Use social media to raise awareness of events including:

- International Women's Day
- International Day of Women and Girls in Science
- International Day for the Elimination of Racial Discrimination
- International Day of LGBTQ+ People in Science Technology Engineering and Mathematics
- Colo(u)r Blind Awareness Day



Twitter: <https://twitter.com/belle2collab>
Facebook: <https://www.facebook.com/belle2collab>
Instagram: <https://instagram.com/belle2collab>

The Belle II Collaboration: **diversity officers**

October 2018: Belle II created the positions of two diversity officers

The diversity officers exist to:

- Promote an inclusive environment within the collaboration
- Provide a safe and confidential point of contact for any collaborator to report any issues, particularly those related to discrimination, bullying, or harassment within the collaboration
- Ensure that persons from marginalized groups are appropriately considered for positions of responsibility in the collaboration and are supported in their careers
- Encourage and publicize the collaboration's events and efforts promoting equity

The Belle II Collaboration: initiatives at KEK laboratory

KEK laboratory: very receptive and dedicated to the issues that are coming to light

The Belle II secretariat worked to make childcare easier to find

KEK is working on improving bathroom accessibility

- A gender neutral, accessible bathroom has been made available in the experiment control room (previously only a male toilet was conveniently available)
- Has recently improved the dormitory bathroom provision for women

Colo(u)r blind friendly screens in our Control Room

TOP GUI (Normal):



TOP GUI (Red-Weak/Protanomaly):



TOP GUI (Green-Weak/Deutanomaly):



TOP GUI (Blue-Weak/Tritanomaly):



Summary

The Belle II experiment is living an exciting phase

Belle II has now on tape a sample equivalent to that of BaBar, half of Belle

Despite the limited statistics, we already published results better than earlier measurements, as well as some unique results

The Belle II Collaboration is a living and dynamic community, very international

A common effort is ongoing to raising awareness within the collaboration on the subject of diversity and inclusion

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“Towards equality, for higher luminosity”



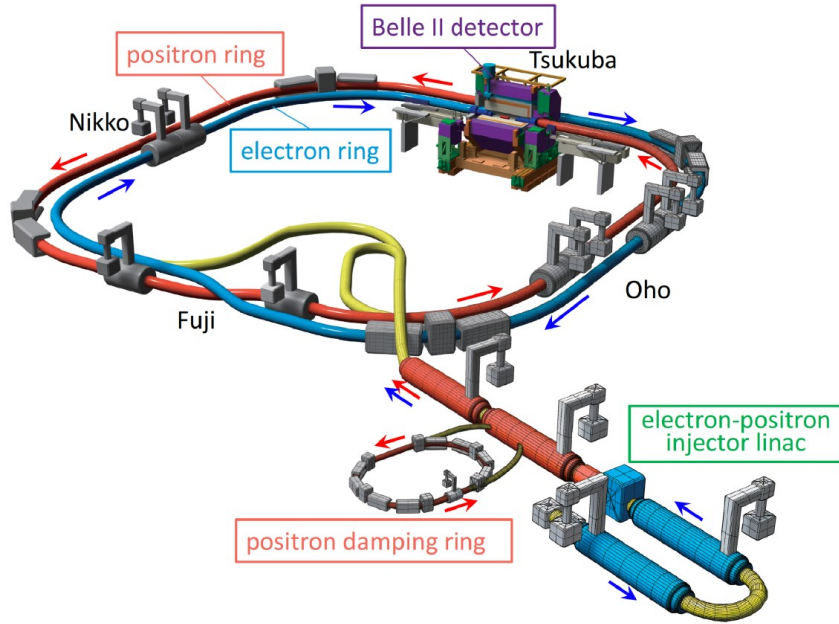
BACKUP



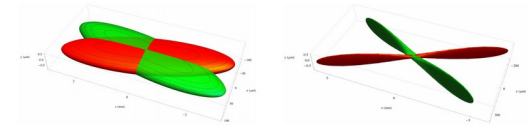
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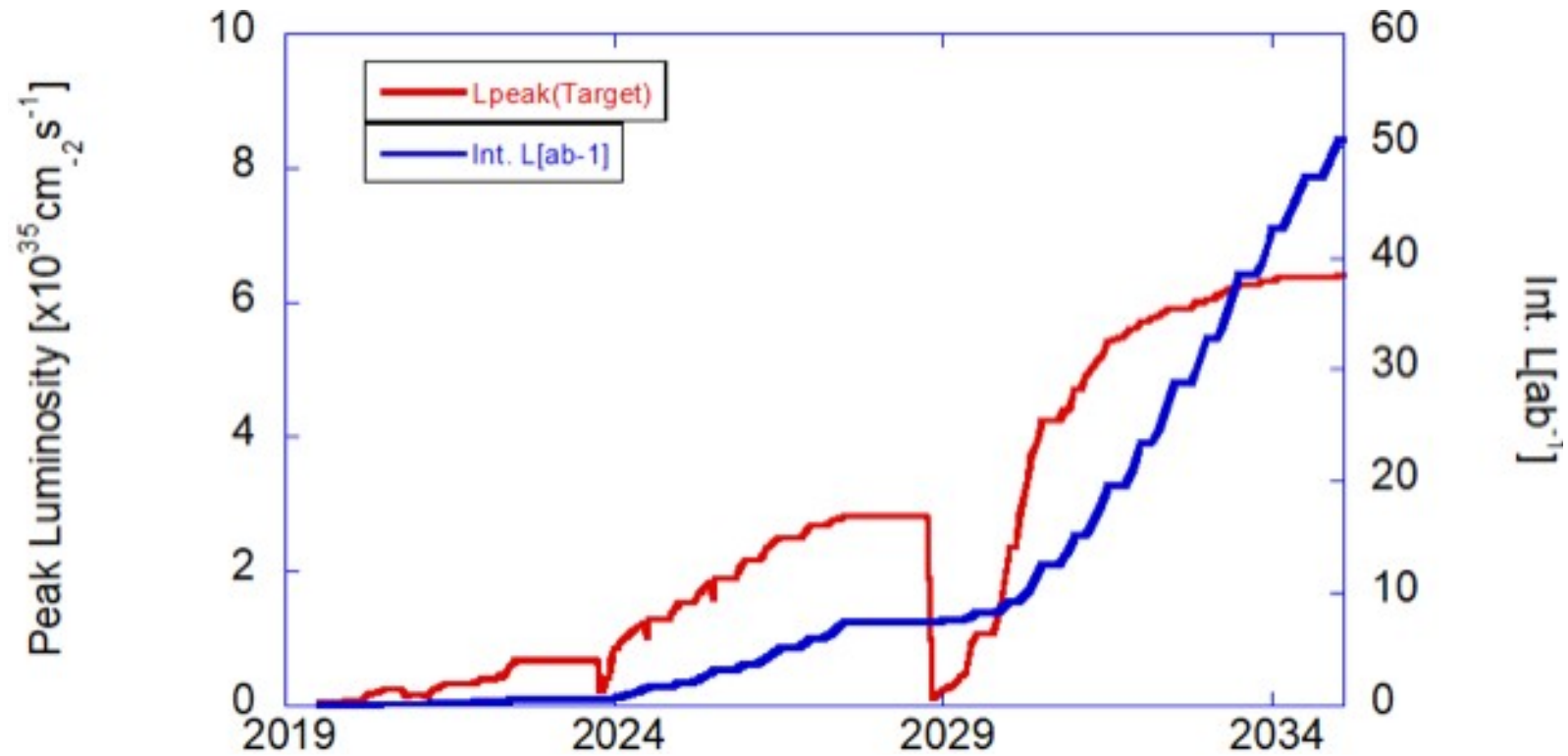


Sketch of the Interaction region



	KEKB LER (e ⁺) / HER (e ⁻)	SuperKEKB LER (e ⁺) / HER (e ⁻)
E [GeV]	3.5 / 8.0	4.0 / 7.0
2 ϕ [mrad]	22	83
ξ_x	0.127 / 0.102	0.0028 / 0.0012
ξ_y	0.129 / 0.090	0.088 / 0.081
β_y^*	5.9 / 5.9	0.27 / 0.30
I [A]	1.64 / 1.19	3.60 / 2.60
σ_x^* [μm]	147 / 170	10.1 / 10.7
σ_y^* [nm]	940 / 940	48 / 62
\mathcal{L} [$10^{35} \text{ cm}^{-2} \text{ s}^{-1}$]	0.211	8
$\int \mathcal{L} dt [\text{ab}^{-1}]$	1	50

Belle II: luminosity projection



Belle II: luminosity collected

