KEK, High Energy Accelerator
Research Organization

Particle Physics Program in Japan

July 25, 2022
Snowmass Meeting in Seattle

M.Yamauchi
KEK

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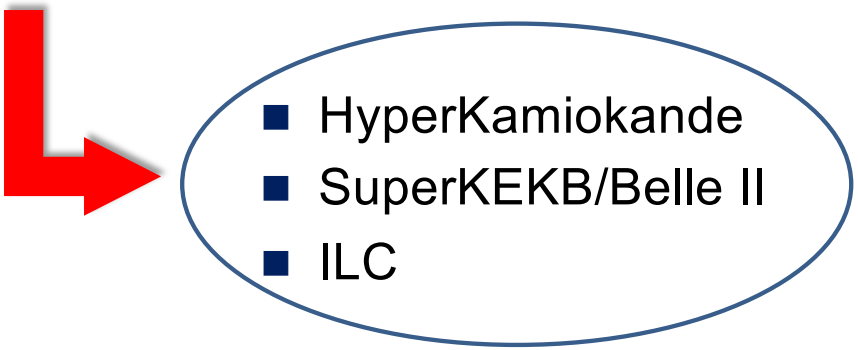
Outline

- Neutrino program: T2K and beyond
- The μ program at J-PARC
- SuperKEKB and Belle II
- ILC: Efforts to realize it
- LiteBIRD, astro-particle physics at KEK
- Application of superconducting RF technology to industry
- Summary and Conclusions



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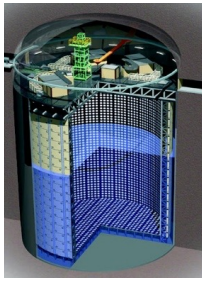
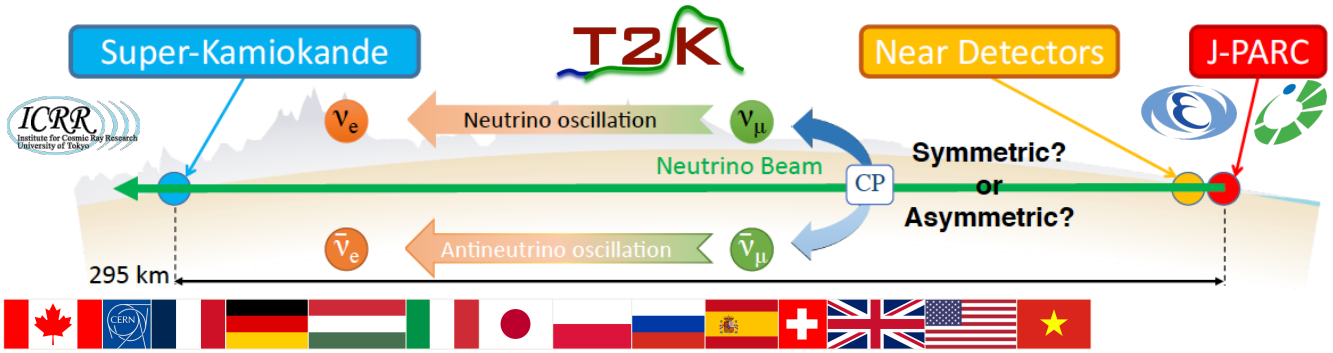
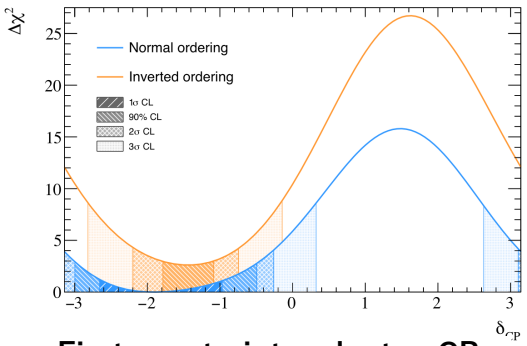
T2K: Long baseline neutrino oscillation experiment

Search for ***lepton CP violation***

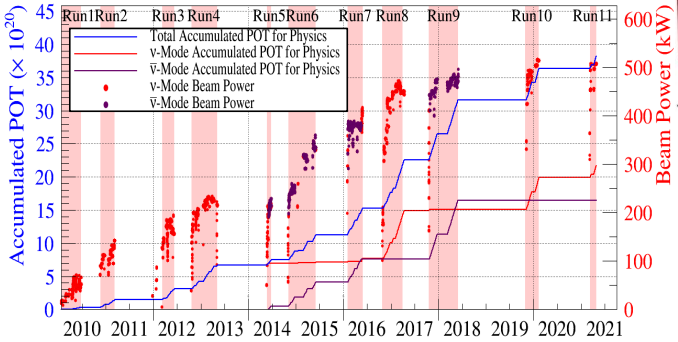


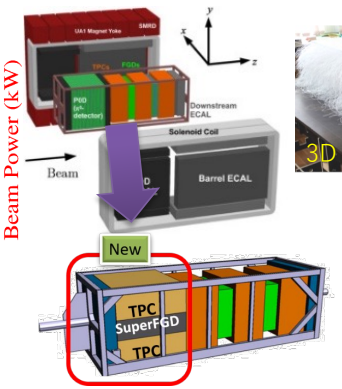


~470 members, 74 Institutes, 13 countries



First constraint on lepton CP asymmetry has been obtained.





High power neutrino beam; ~520kW (achieved)

→ **Intensity upgrade up to 1.3MW**
& Near-detector upgrade are on going.

Precise measurement with doubled data by ~2026 is expected.

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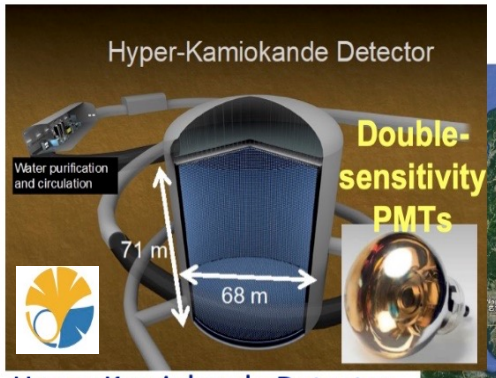
Hyper-Kamiokande (HK) by U. Tokyo and KEK

- Project
  - 190kt-FV Hyper-Kamiokande Detector (UT)
  - Upgrade of J-PARC to 1.3MW (KEK)
- Physics goals
  - CPV in neutrino sector
  - Search for proton decay
  - Atm-nu, solar-nu and supernova nu
- International project hosted by U.Tokyo & KEK
- **Funding approved and construction started in**
  - Preparation of cavern excavation, production of PMTs started
  - J-PARC upgrade on-going
- Aiming to start operation in 2027.



Hyper-Kamiokande Detector

High power proton beam
J-PARC and near detectors


Delivered PMT for HK

Access tunnel excavated

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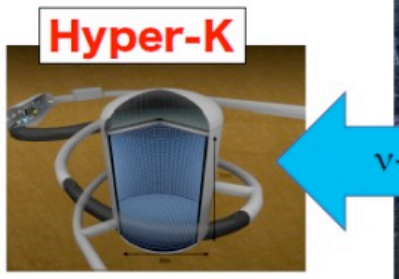
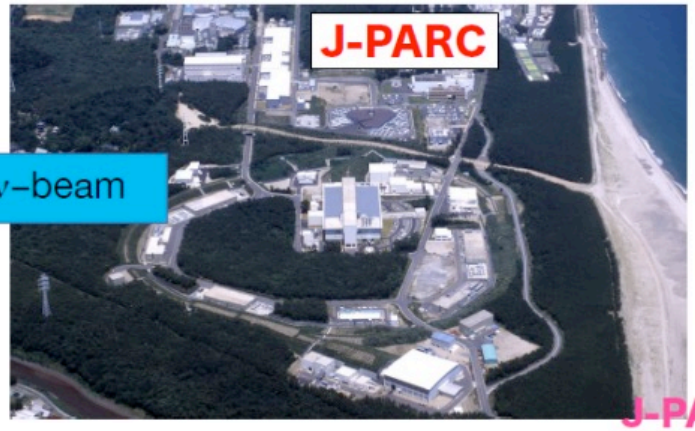
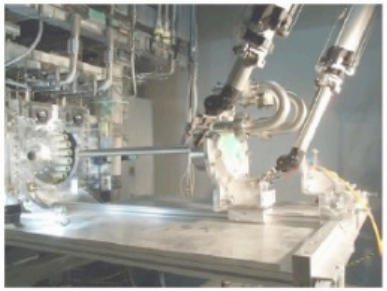
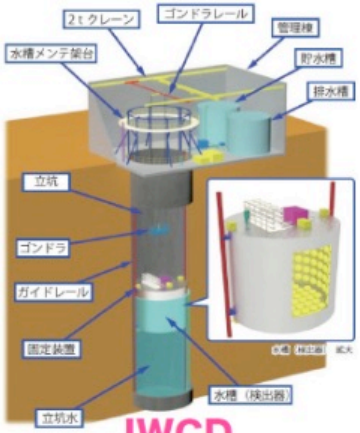
KEK's role in HyperKamiokande program



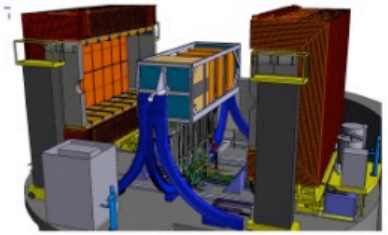


Neutrino beamline





IWCD



ND280

J-PARC Accelerator

- **J-PARC Accelerator/Beamline upgrade**
  - Beam power = 0.5 MW → 1.3 MW (x2.6)
- **J-PARC Near Neutrino detector upgrade**
  - ND280 upgrade, Intermediate Water Cherenkov Detector (IWCD)

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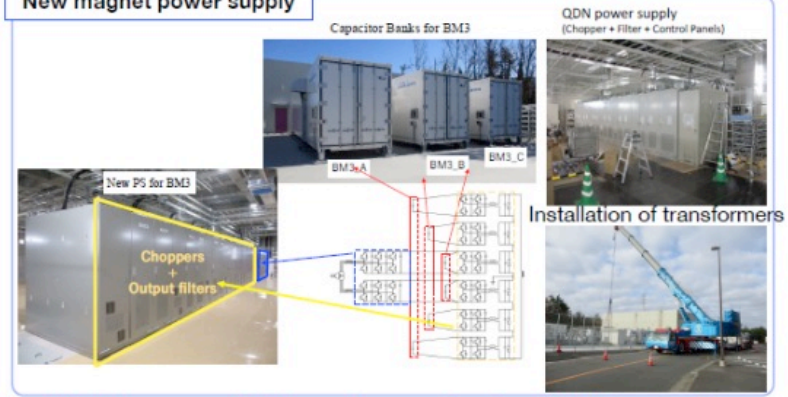
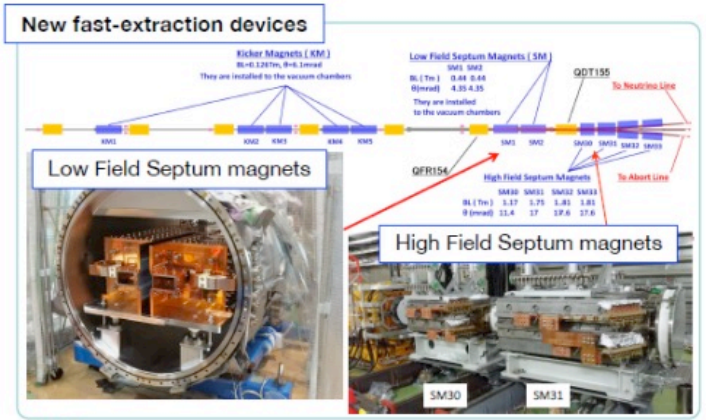
J-PARC upgrade for HyperKamiokande

New magnet power supply



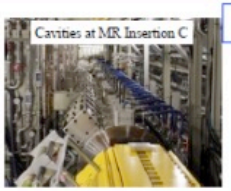
New fast-extraction devices



Installation completed and operation test of 1.3 s cycle succeeded
→ Now in service

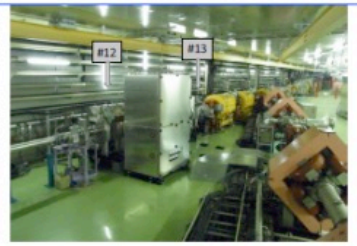
RF system upgrade

	Present	2022	2026
MR Cycle	2.48 s	1.32 s	1.16 s
Fundamental Cavities	7	9	11
2nd Harmonic Cavities	2	2	2
Accelerating Voltage	300 kV	510 kV	600 kV
2nd Harmonic Voltage	110 kV	110 kV	110 kV

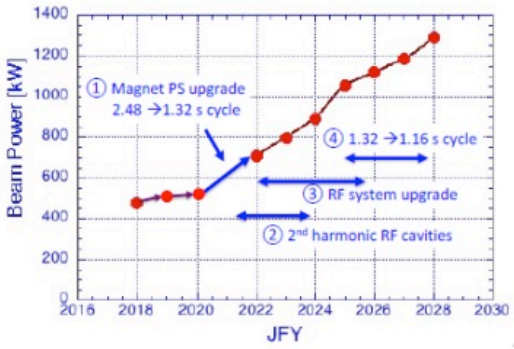


Ins A: 2 2nd harmonic cavities
Ins C: 11 fundamental cavities

New 2nd harmonic cavities installed



- Beam commissioning in June/July 2022
- Beam operation from Fall 2022 (>750kW)



- New 2nd harmonic RF system JFY2021~2023
- Additional 2 fundamental RF cavities (9→11) JFY2022~2025
- Anode PS upgrade (15→19 units) JFY2022~2025

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Neutrino beamline upgrade

Horn PS upgrade for 320 kA operation → 10% more ν flux

- New PS, transformers, and striplines installed

Horn2 cooling improvement (US)

- New horn2 produced in US and to be installed in August

Target upgrade (UK)

- Target He cooling system upgrade and 1.3 MW-capable target prototyping

DAQ upgrade for faster-cycle and safer operation (US)

- New electronics development / GPS upgrade

Primary beamline and beam monitor upgrade (Canada, UK, Vietnam)

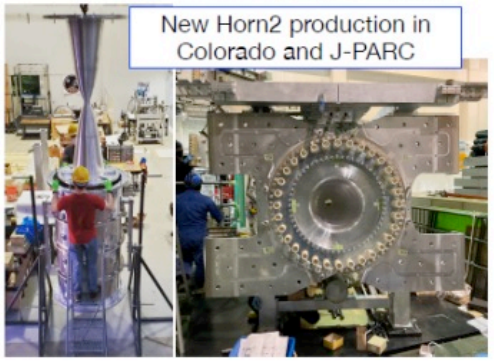
- Installation of new bending magnet
- Development of high radiation-tolerant monitors

Radio-active Water Disposal Capacity Upgrade

- Construction of new tanks (2x253m^3) completed in February 2022

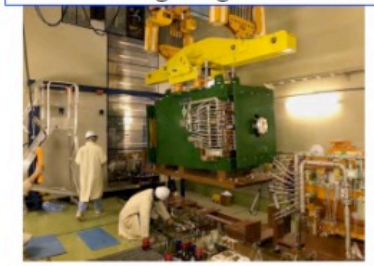
3rd PS and new capacitors installed

New Horn2 production in Colorado and J-PARC



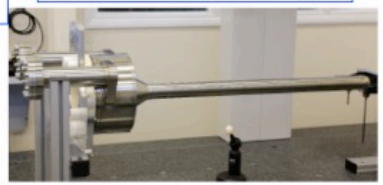
New dilution tank construction

New bending magnet installed



New interlock electronics for beam position calculation

1.3 MW target prototype



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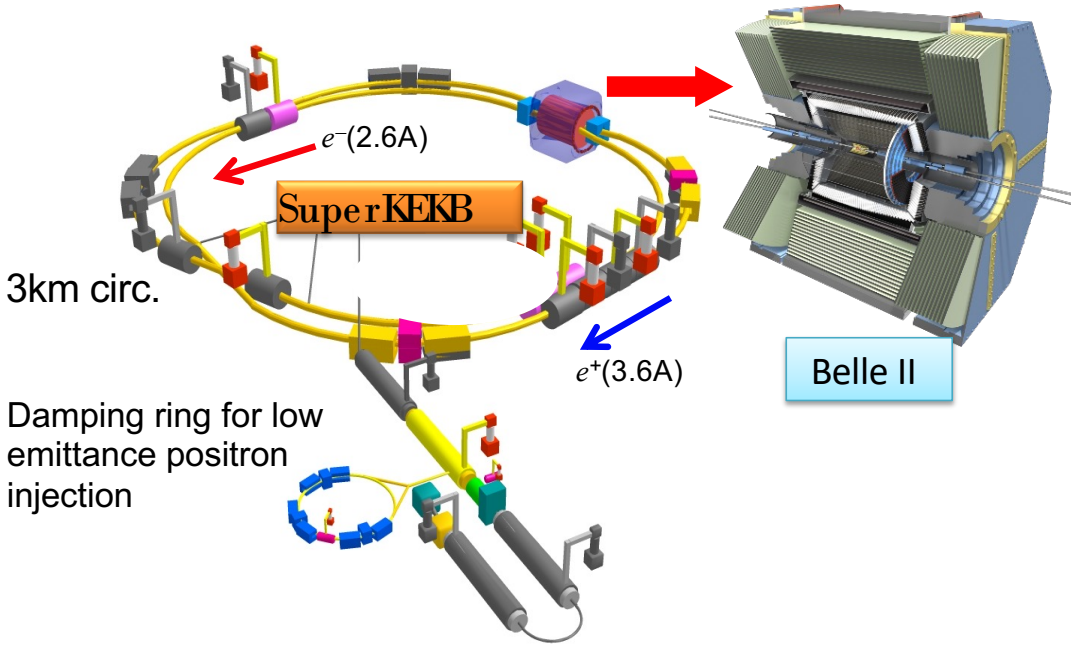
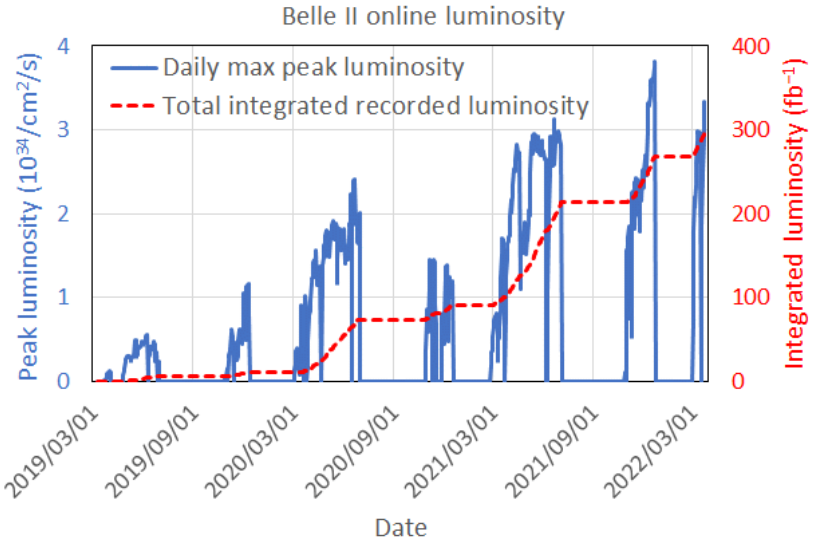
SuperKEKB and Belle II





L_{peak}=4.7x10^{34}/cm^2/s

$\int L\,dt$ = 475fb^{-1}
Belle II

- Asymmetric e^+e^- collider at $\Upsilon(4s)$ with target L=6x10^{35}/cm^2/s
- ~10^{11} B, D and τ measured with vertex reconstruction and PID
- Physics run started March 2019.
- Belle II collaboration consists of 1100 physicists from 26 countries.

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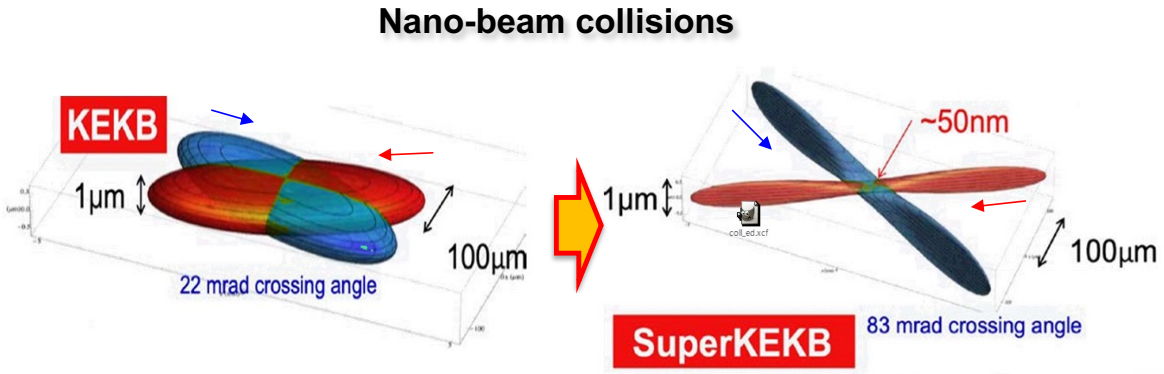
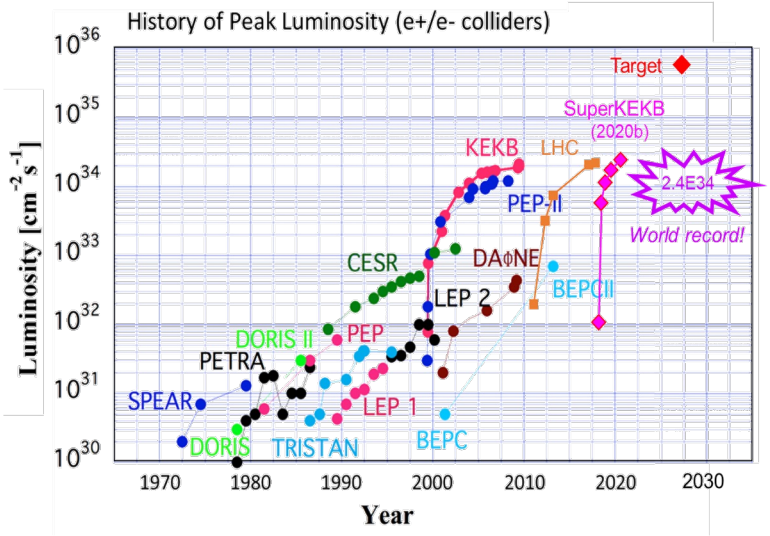
Luminosity strategy at SuperKEKB





Machine improvement in July 2022 – September 2023

- Replacing the beam collimators with the one that are highly resistant to the beam and less likely to cause beam instability
- Improved radiation shield to Belle II detector
- Increasing the diameter of the beam pipe at the injection point
- Improving pulse-by-pulse beam control of the injection linac

→ L ~ 2.4 x 10^{35}/cm^2/s will be achieved after careful machine tuning.

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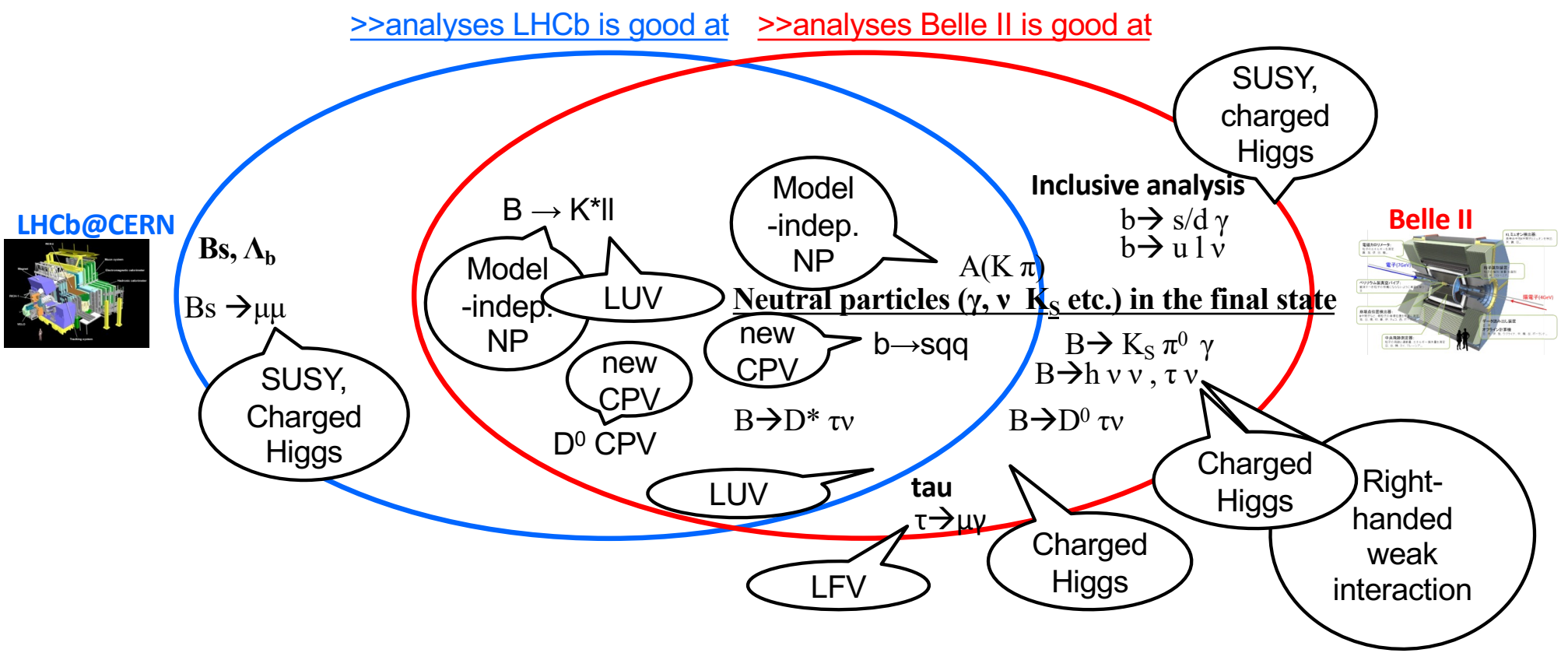
Physics at Belle II



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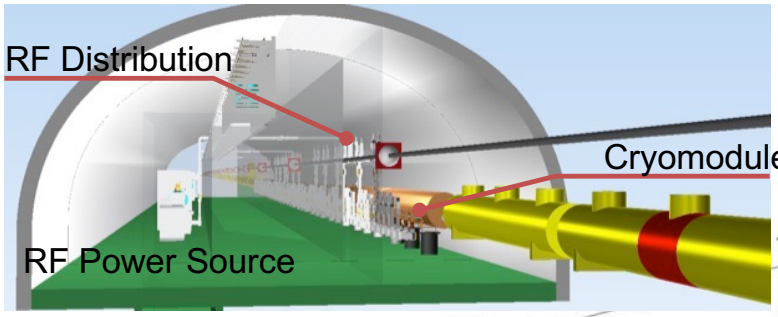
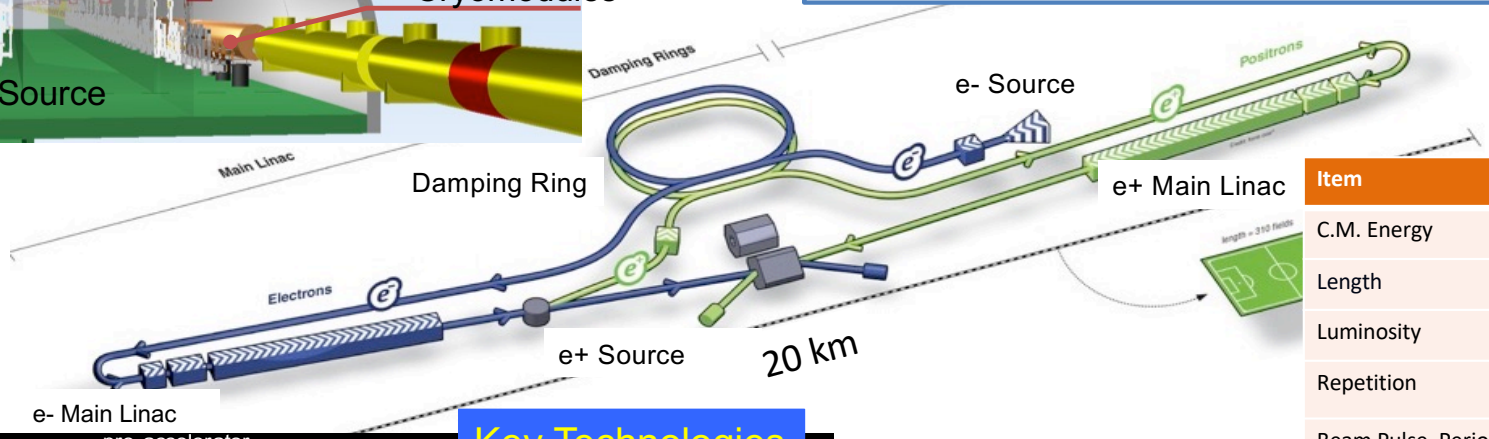
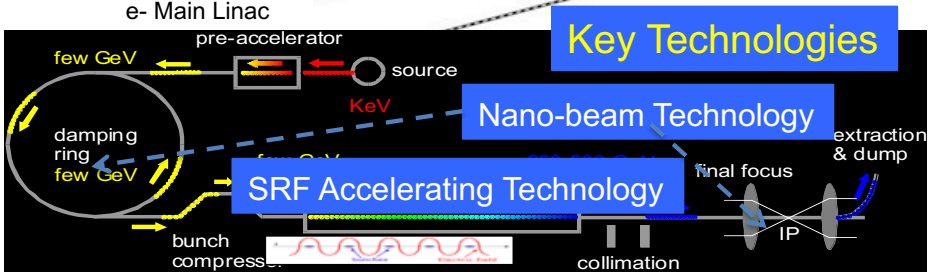
International Linear Collider



ILC has been developed by the international HEP community and supported by European strategy, US P5, etc. Its design has been conducted by the initiative of ICFA.





Item	Parameters
C.M. Energy	250GeV
Length	20km
Luminosity	1.8 x10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	**5.9** nm
SRF Cavity G. Q_0	**31.5** MV/m Q_0 = 1x10 ^{10}

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ILC Promotion Scheme in Japan

Five-party meeting (Mar. 2021 -)

- ILC Federation of Diet Members
- MEXT
- Physicists
- Industrial sector
- Candidate site

Productive discussions of possible solutions to the problems to realize ILC by all the stakeholders

ILC-Japan (May 2021 -)

- Spokesperson: Shoji Asai (U. Tokyo)
- Executive board
- Taskforces
- Working groups

Organize activities of the Japanese physics community to realize the ILC.

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- Outcome of the meeting so far
  - It was agreed that the physics community will report on the progress made over the past three years.
  - It was recommended to MEXT to hold a meeting of experts to evaluate this report and the Pre-lab proposal by the IDT.
  - It was also at this meeting that MEXT was recommended to exchange views with the governments of US and European countries.

- Activities of ILC-Japan
  - We focused on providing good input to the ILC Advisory Panel at MEXT.
  - ILC communications
  - Activities to deepen the understanding of ILC by scientists in other fields

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Recent history of ILC

- The ICFA established the IDT in August 2020 to realize the ILC in multiple-stages, and in June 2021 the IDT published the report on overall design of the Pre-lab and 18 work packages to be implemented there. At the same time, the Japanese physics community submitted a report to MEXT on the progress of the ILC over the past three years.

- MEXT set up an ILC Advisory Panel to evaluate these reports, and published a recommendation in February 2022.

  - The panel recognizes the academic significance of particle physics research and the importance of the research field, including that of a Higgs factory, and understands the value of international collaborative research. However, the panel found that it is still premature to proceed into the ILC Pre-lab phase, which is coupled with an expression of interest to host the ILC by Japan as desired by the research community proposing the project.

  - The panel recommends that the development of the key technology for the next-generation accelerator such as ILC should continue by further strengthening the international collaboration among institutes and laboratories, shelving the question of hosting the ILC.

  - For realizing a very large project such as the ILC, cultivating a framework where the related countries can exchange information on their situations and discuss required steps would be important.

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Plan in the next years

- Create a new international collaborative framework to implement the most urgent work packages.
  - We believe that it is highly likely that the budget for this will be approved in Japan in JFY2023.
  - Detailed R&D plan is being elaborated in the IDT-WG2.
  - We are about to start discussions with related laboratories to exchange MOU's between the laboratories.

- An International Expert Panel will be set up by IDT to deepen discussions in two or three stages, and then, hold meetings to explain the progress to the representatives of the relevant governments. With this as a starting point, we will encourage intergovernmental discussions on the ILC.
  - At least one meeting attended by the government representatives will be held by the end of this year.

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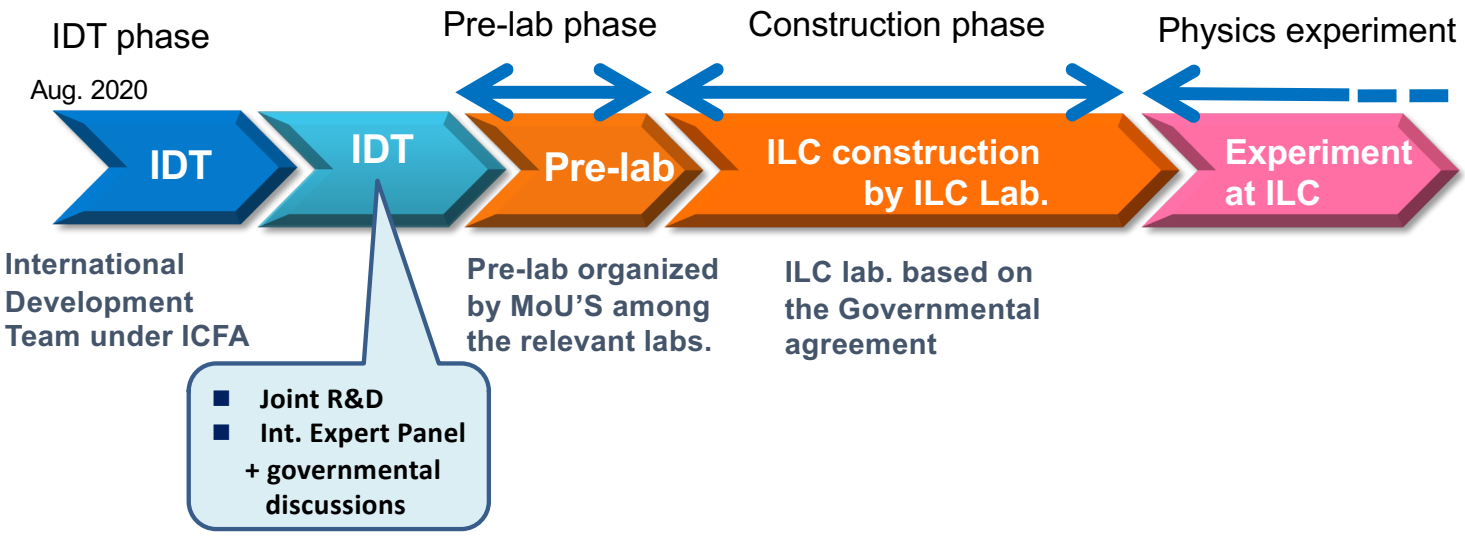
Longer term scenario of ILC



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Summary and Conclusions

- Particle physics program at KEK
  - Long baseline neutrino program at J-PARC/SuperKamiokande
  - Flavor physics at J-PARC: K_L and μ
  - High precision measurements of B, D and τ decays with SuperKEKB/Belle II
  - >100 Japanese physicists are involved in ATLAS. KEK takes a role of supporting them.

- KEK is also working on next step in (astro-)particle physics.
  - Upgrade of J-PARC MR for HyperKamiokande
  - Contribution to HL-LHC and the ATLAS upgrade
  - LiteBIRD to test cosmic inflation and quantum gravity

- We are committed to play a leading role in realizing ILC.
  - Create a new international collaborative framework to implement the most urgent work packages in advance.
  - An International Expert Panel will be set up by IDT to deepen discussions in two or three stages, and then, hold meetings to explain the progress to the representatives of the relevant governments.