



素粒子原子核研究所
Institute of Particle and Nuclear Studies

Tokai
Tsukuba
Wako

IPNS Perspective
Annual ILC Detector Meeting
March 9, 2022
Naohito SAITO



素粒子原子核研究所
Institute of Particle and Nuclear Studies

IPNS Organization FY2021-



Deputy Dir: Kazunori HANAGAKI

Deputy Dir: Shoji UNO

Director: Naohito SAITO

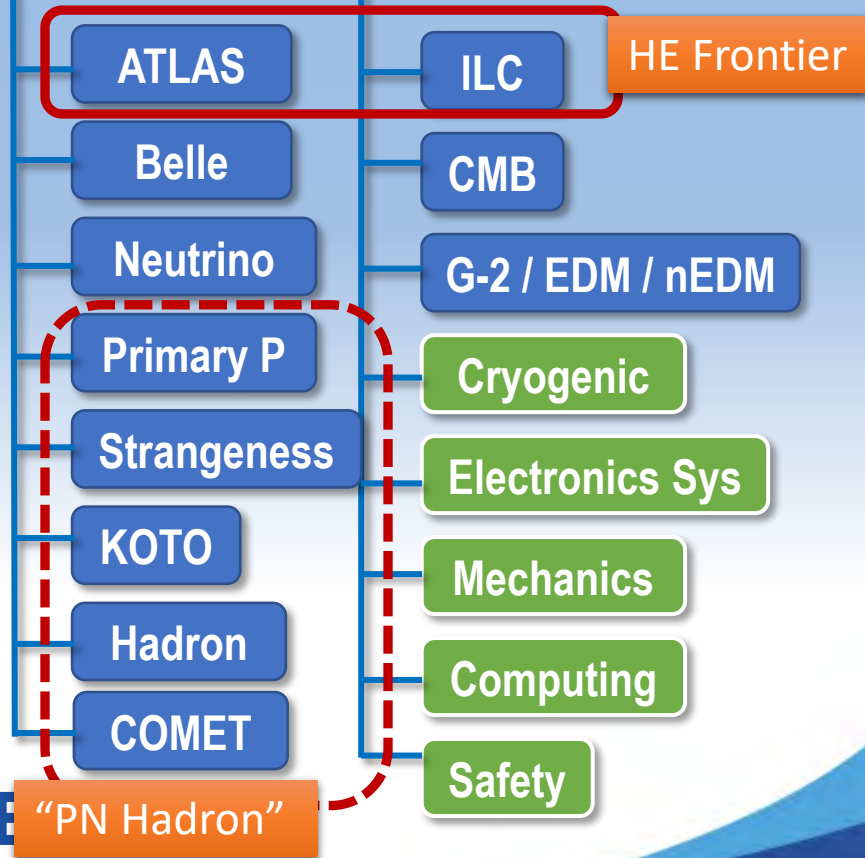
Deputy Dir: Takeshi KOMATSUBARA



Theory Center
Director
Shoji HASHIMOTO



Wako Nuclear Science Center @ RIKEN
Director
Michiharu WADA





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HANAGAKI

KOMATSUBARA



Theory Center
Director
Shoji HASHIMOTO



Wako Nuclear Science Center @ RIKEN
Director
Michiharu WADA

Detector R&D Center
Director
TBN

HEF (ATLAS+ILC)

Belle

Neutrino

Hadron
(Primary BL
+Strangeness+
KOTO+High-p
+COMET)

CMB

G-2 / EDM / nEDM

Cryogenic

Electronics Sys

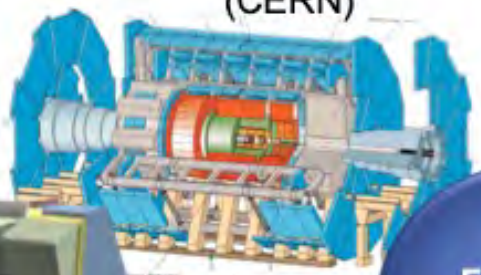
Mechanics

Computing

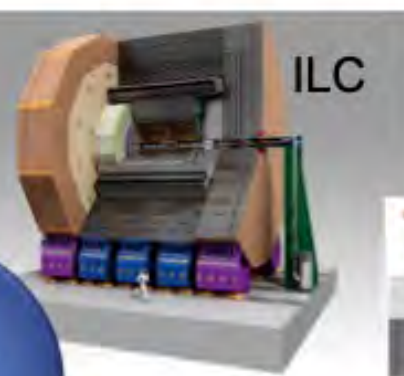
Safety



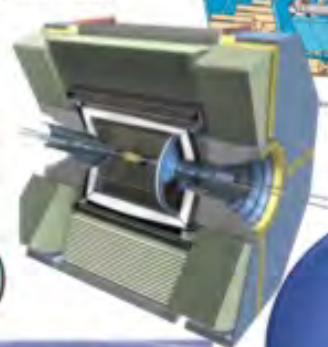
ATLAS
(CERN)



ILC



Belle-II
(KEKB)



COMET
(J-PARC)



Energy
Frontier



KISS
(RIKEN)

Flavor
Physics

Hadron
and
Nuclear
Physics

Hadron hall
(J-PARC)

Physics
at IPNS/KEK



SKS,
Hyperball-J



T2K
(J-PARC)

g-2/EDM
(J-PARC)



Astro-
particle
Physics

Theory

KOTO
(J-PARC)



UCN
(TRIUMF)



POLARBEAR-2
(Atacama)

LiteBIRD
(Space)



Technical Development Groups

Electronics System

Cryogenics

Mechanical Engineering

19/3/2021

Origin of Matter and Universe explored with accelerators

Evolution of Universe and Matter

J-PARC Hadron

SuperKEKB / Belle II

Elucidation of the environment of the birth of various matter and elements and understanding of the role of strong interactions

Merger of ultra-dense objects, neutron stars could be a background of the formation of various elements; Nuclear force under such an extreme condition should be understood.



Neutron Star or Blackhole

SuperKEKB / Belle II

J-PARC ν / K / μ

LHC / ATLAS

ILC

Explorations of new physics indispensable for the matter-dominant universe

To elucidate the origin of the matter-dominant universe, a new physics beyond the SM is essential. In addition to searches for new phenomena in unprecedented high energies as in LHC and ILC experiments, we need to shape the new physics through flavor physics at SuperKEKB and J-PARC.



Matter vs Anti-matter

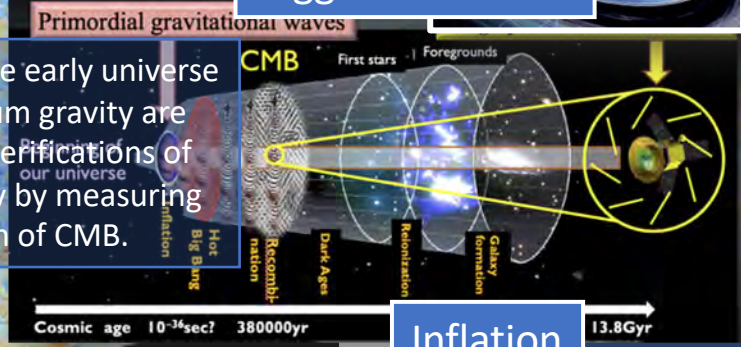
CMB / LiteBIRD

What happened before the Big bang? How the space-time and matter emerged?

Mysteries of the early universe and the quantum gravity are revealed thru verifications of inflation theory by measuring the polarization of CMB.



Higgs Mechanism



Inflation

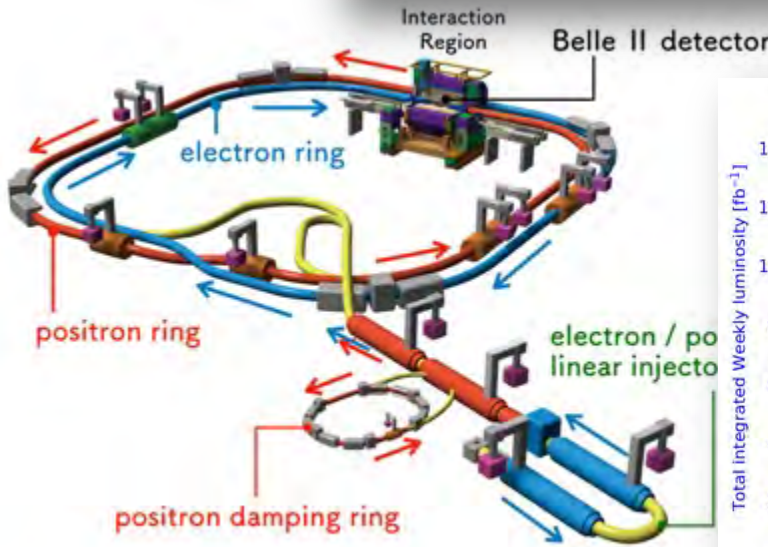


SuperKEKB/Belle II (and Belle)

Exploration of New Physics with the World Highest Luminosity

- SuperKEKB achieved $3.81 \times 10^{34} \text{ cm}^{-2}/\text{s}$ in 2021!

~ KEKB x 1.8
~ PEP-II x 3.2

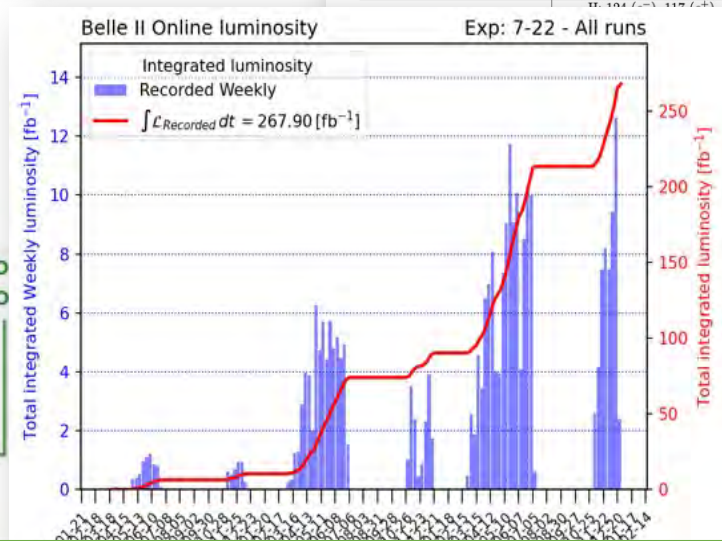


High-Energy Collider Parameters: e^+e^- Colliders (III)

PDG needs to be updated

Table 32.3: Updated in M... (contact E. Pianori, LBNL). The table shows the parameter values achieved. Design parameters for SuperKEKB may be found in our 2018 edition (Phys. Rev. **D98**, 030001 (2018)) Quantities are, where appropriate, r.m.s.; unless noted otherwise, energies refer to beam energy; H and V indicate horizontal and vertical directions; s.c. stands for superconducting.

	KEKB (KEK)	PEP-II (SLAC)	SuperKEKB (KEK)
Physics start date	1999	1999	2018
Physics end date	2010	2008	—
Maximum beam energy (GeV)	e^- : 8.33 (8.0 nominal) e^+ : 3.64 (3.5 nominal)	e^- : 7–12 (9.0 nominal) e^+ : 2.5–4 (3.1 nominal)	e^- : 7 e^+ : 4
Delivered integrated luminosity per exp. (fb^{-1})	1040	557	10.57
Luminosity ($10^{30} \text{ cm}^{-2}\text{s}^{-1}$)	21083	12069 (design: 3000)	1.88×10^4
Time between collisions (μs)	0.00590 or 0.00786	0.0042	0.0065
Full crossing angle (μrad)	$\pm 11000^*$	0	± 41500
Energy spread (units 10^{-3})	0.7	e^-/e^+ : 0.61/0.77	e^-/e^+ : 0.64/0.81
Bunch length (cm)	0.65	e^-/e^+ : 1.1/1.0	e^-/e^+ : 0.5/0.6
		157	e^- : 16.6 (H), 0.25 (V)
		4.7	e^+ : 12.6 (H), 0.25 (V)
		± 0.2	e^- : $+1.20/-1.28$, e^+ : $+0.78/-0.73$
		± 300 mrad cone	($+300/-500$) mrad cone
		continuous	continuous
		continuous	continuous
		e^-/e^+ : 9.0/3.1 (nominal)	e^-/e^+ : 7/4
		e^- : 48 (H), 1.8 (V)	e^- : 4.7 (H), 0.061 (V)



Belle + Belle II

Total # of papers 663
Citations 34,355
as of 2022-Feb-22

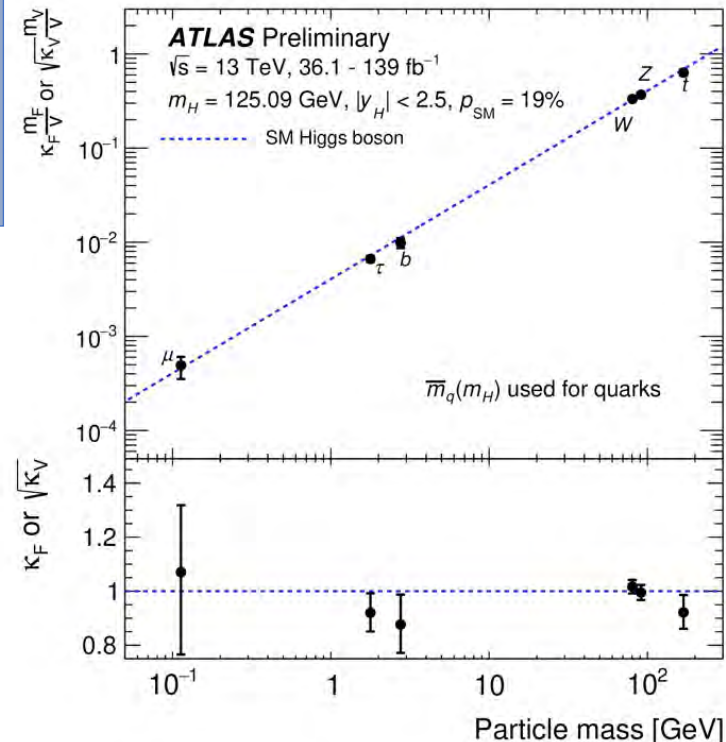
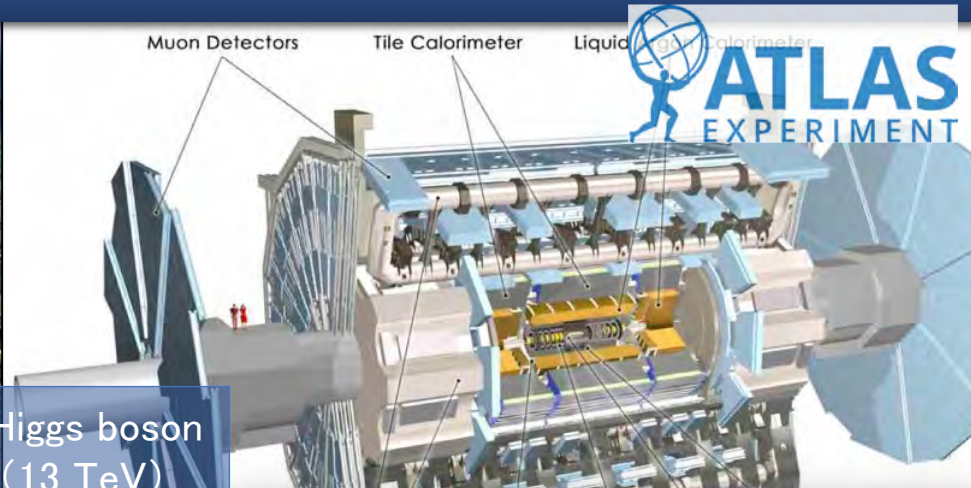
Still a factor of 15 improvement needed to achieve the design Luminosity

High Energy Frontier Group

Exploration of New Physics with Unprecedented High Energy



2012 : Discovery of the Higgs boson
 2015~2018 : Run 2 experiment (13 TeV)
 → >1,000 papers published!
 2022~2025 : Run 3 experiment (13.6 TeV)
 2025~ : Upgrade for HL-LHC
 2027~ : HL-LHC (14 TeV)



Total # of papers 1,166
 Citations 79,829
 as of 2022-Feb-22



New Small Wheel Muon Chamber Ready for Run 3 (2022 -)

Neutrino Facility and T2K, then Hyper-K

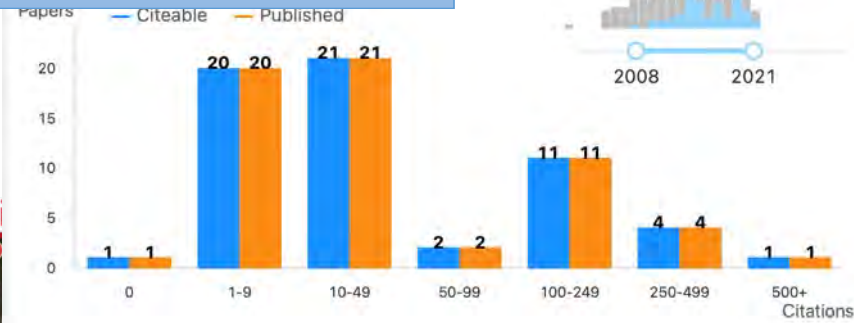
Establishing CPV in the lepton sector and discoveries beyond the SM

Super-Kamiokande



T2K publication
 Total # of papers 60
 Citations 5,275

Date of paper



Indication of Electron Neutrino Appearance from an Accelerator-produced Off-axis Muon Neutrino Beam

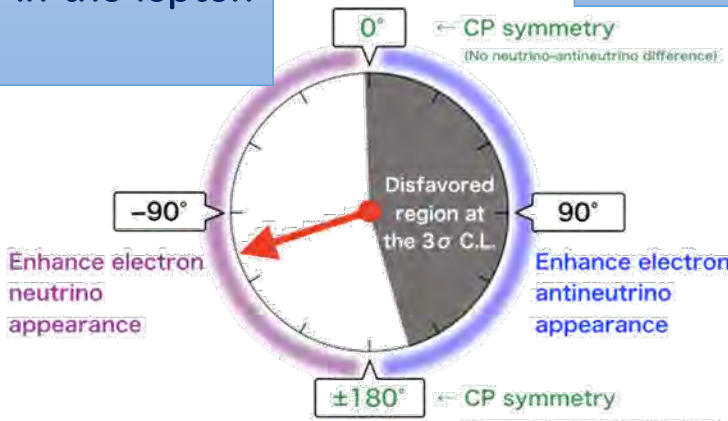
T2K Collaboration • K. Abe (Tokyo U., ICRR) et al. (Jun, 2011)
 Published in: *Phys.Rev.Lett.* 107 (2011) 041801 • e-Pr

pdf links DOI cite

1,668 citations

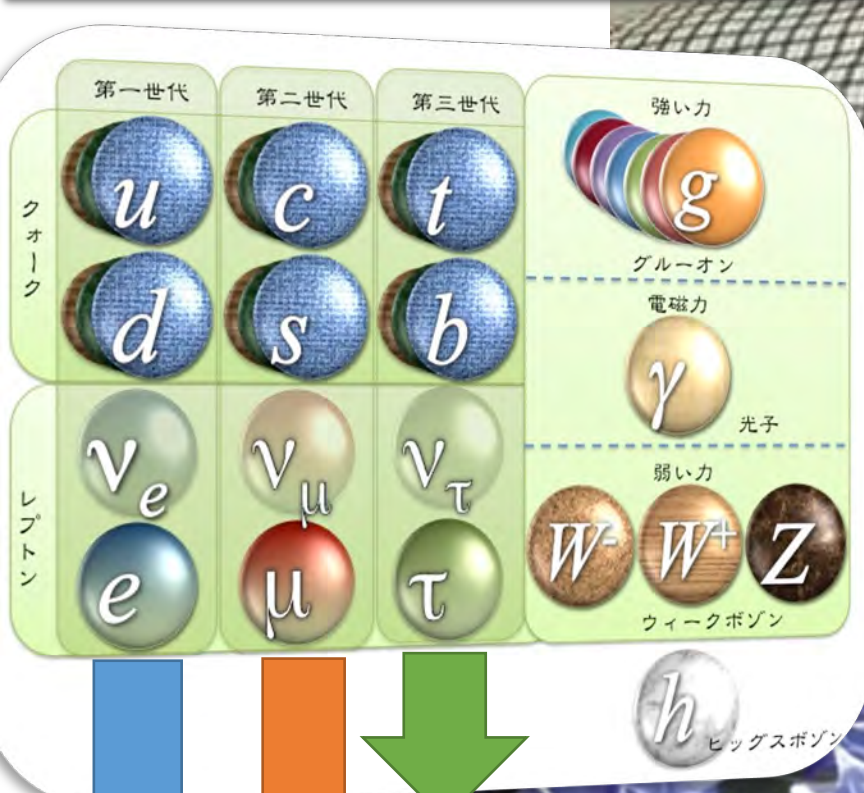
Establish CPV with T2K-II and Hyper-K

T2K:
 Discovery of Electron neutrino appearance
 Intriguing hint of CPV in the lepton sector



2022-2026: T2K-II
 2027 - HyperK

Unbearable Incompleteness of the SM



Explored with SuperKEKB/Belle II

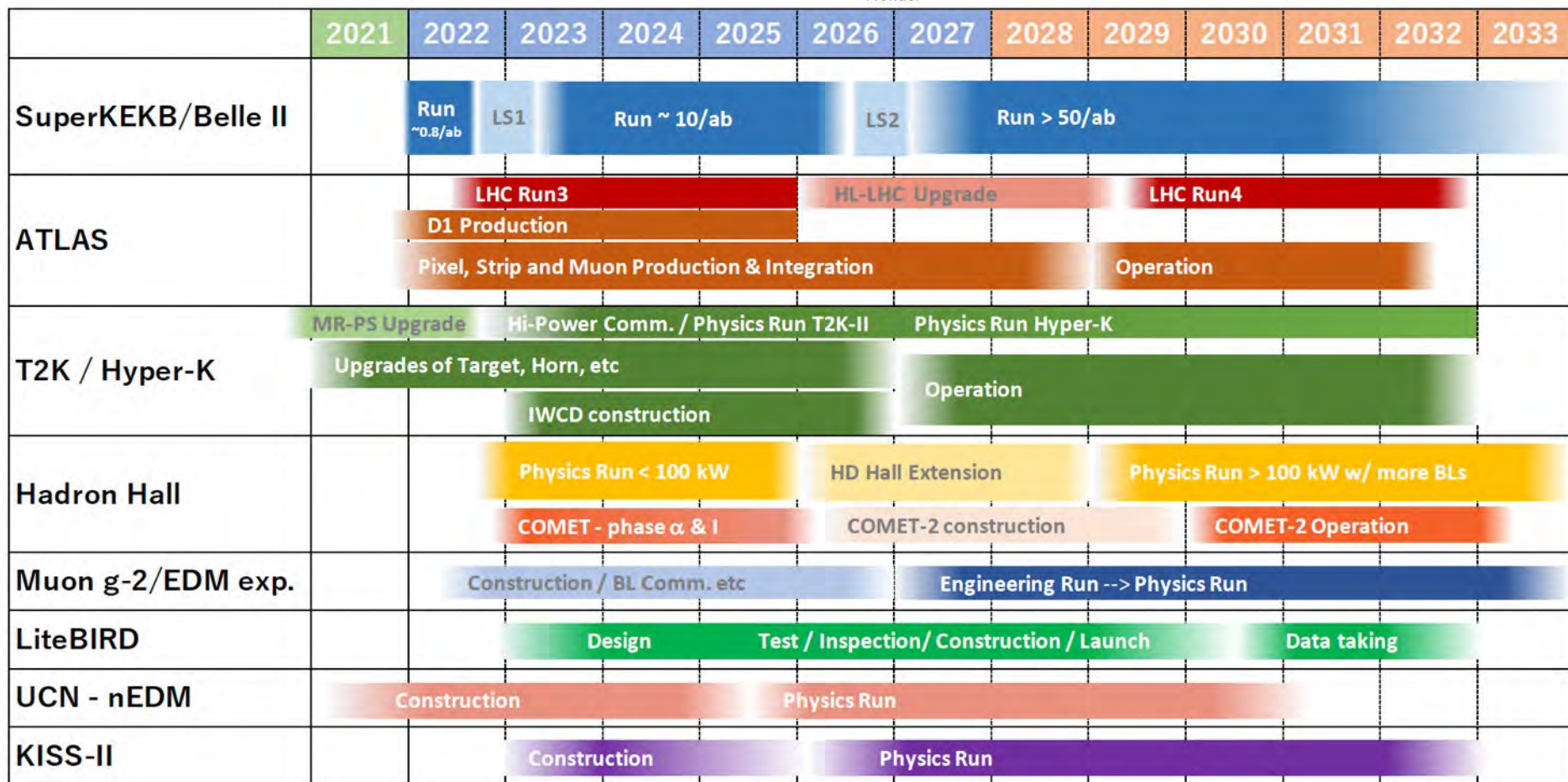
Explored with J-PARC

Our Stable World

- Why three generations?
- Why anti-particle disappeared?
- Why particle masses distribute this way?
- Baryon number, lepton number, flavors conserve?
- What is dark matter, dark energy?
- Do we understand the gravity?
- Super symmetry exists?

The Timeline (ver 2022.01.26)

- Intended schedule by IPNS, so far
- ILC will be mentioned after the conclusion by an external panel under MEXT, then follow-up discussion by community

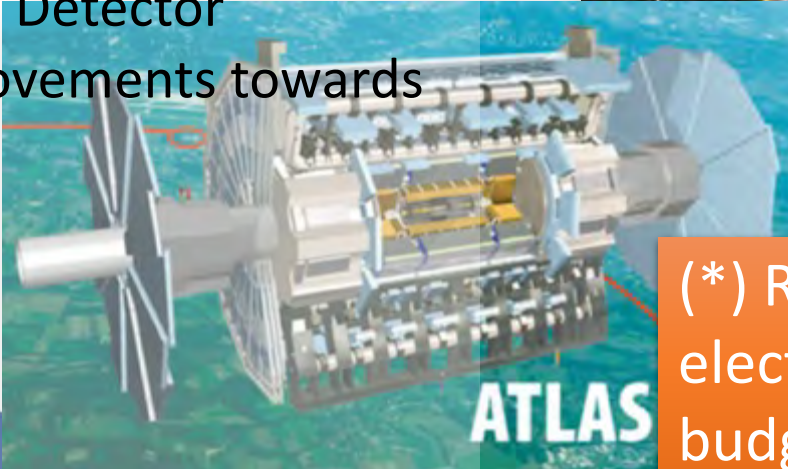


Gov't Budget for JFY2022

MEXT: Large-Scale Scientific Frontier Promotion Projects

Approved at the Lower House

- SuperKEKB/Belle II
 - Operation for 4.8 month (*)
 - Hardware improvements
 - Injector, Ring, and Detector
- J-PARC
 - 4.5 cycles(*) of MR Operation
 - Improvements towards 0.75 MW
- Hyper-K (J-PARC side)
 - Intermediate Detector
 - Facility improvements towards 1.3 MW
- HL-LHC
 - D1 magnet
 - Detector



(*) Run length based on the electricity bill at the time of budget request; June, 2021

Operation Challenges

- Balance between the beam time and facility improvements, especially in J-PARC experiments and SuperKEKB/Belle II.
- Securing the beam time even with sky-rocketing oil price, thus electricity bill.
- Gathering enough resources even under current travel and transportation restrictions
- Creating new ideas thru close *and remote* communications

Mehr Licht !



World Premiere Institute Launched@KEK

- International Center for **Q**uantum-field Measurement Systems for Studies of the **U**niverse and **P**articles (**QUP**)
- Director = Prof. Masashi HAZUMI (IPNS)
- Inaugurated on December 16 (KEK special colloquium was held)
- It is a top-down, new independent organization in KEK, but it strongly cooperates with IPNS to bring a breakthrough to the field!



Slides by Prof. HAZUMI shown at IPNS-SC are available below (only in Japanese)



KEK50年



QUP brings "new eyes" to humanity.

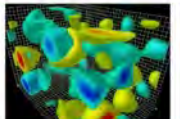
QUP
KEK



"The only real voyage of discovery consists not in seeking new landscapes, but in having new eyes."
Marcel Proust

Quantum-field
measurement systems

Quantum fields



= the backbone of reality
from particles to cosmos



2/24

A slide by Prof. HAZUMI

Summary

- We are working to enhance “ILC related” activities to be ready for the high-energy frontier project to come.
- One of the actions we have taken is forming High Energy Frontier (HEF) group by merging ATLAS and ILC R&D groups in IPNS some months ago.
- We are in a process to define the core activities around the ongoing experiments, *e.g.* ATLAS and Belle II.
- We appreciate your patience and cooperation!

- And we are happy to have a discussion on how we can further enhance the HEF activities in Japan and in connection with global communities!



Let's Share More Excitements!

