

# Opening remark

Joint Workshop of the  
Nagoya B-I units “Heavy  
Flavor & Dark Matter”.

Toru Iijima,  
KMI, Nagoya University / KEK





# World Research Unit for Heavy Flavor Particle Physics (“WPI-next”)

SuperKEKB/Belle II II



Toru Iijima

- B, Tau Physics
- Exotic hadrons



Theory

Junji Hisano  
Flavor Physics  
Dark Matter



LHC-ATLAS



Makoto Tomoto

- Top physics
- Higgs



Peter Krizan  
(Ljubljana)

Boost Nagoya's activities for collider experiments/phenomenology, and leadership.

- T. Iijima: Belle II spokesman (2019.6~)
- A. Gaz: Belle II convener for TCPV analyses
- P. Krizan: Belle II technical coordinator (and former spokes)
- Y. Nakahama: ATLAS trigger coordinators
- M. Tomoto, J. Hisano, T. Iijima: leaders of grant-in-aid projects

- TOP detector, Computing at Belle II
- Trigger R&D and operation at ATLAS

Received a “S” rating  
in the final evaluation



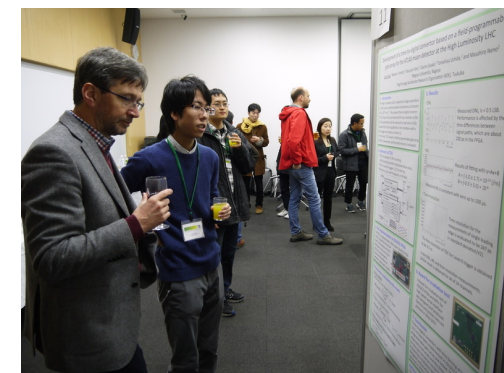
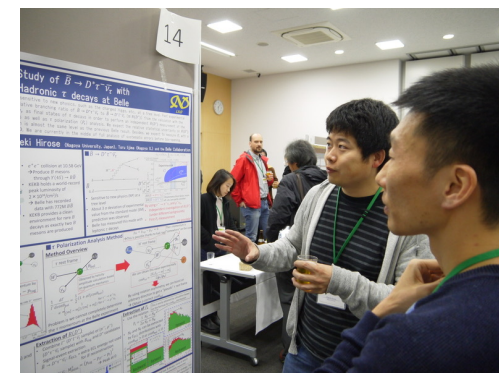
# 国際会議・研究会の開催

## 国際会議、研究会

- Flavor Physics & CP Violation (FPCP2015), 2015. 5. 25-29 (約142名)
- Muon Trigger Workshop in Kyoto, 2016.1.12-1.14 (38名、外国人11名)
- Symposium "Interplay between LHC and Flavor Physics", 2016. 3. 14 -15 (47名、外国人9名)
- Mini-workshop on  $D^{(*)}\tau$  and related topics, 2017. 3. 27-28 (42名、外国人27名)
- 3rd Workshop for the HL-LHC muon trigger upgrade, 2017. 6. 12 -14 (20名、外国人6名)
- AC2I ATLAS meeting with Adelaide/Freiburg/Nagoya, 2018.2.12-2.15, Adelaide
- Mini-workshop "Hints for New Physics in Heavy Flavors", 2018. 11. 15-17 (45名、外国人17名)



FPCP2015





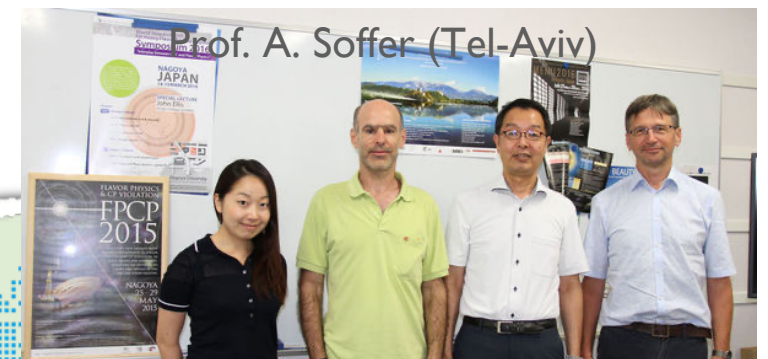
# 国際ネットワークの構築

## ● 海外研究機関とのネットワーク構築

- ヨゼフ・ステファン研、リュブリアナ大学（スロベニア）
- アデレード大学（オーストラリア）
- エジンバラ大学（イギリス）
- テル・アビブ大学（イスラエル）
- パドヴァ大学（イタリア）
- ミシガン大学、ハワイ大学（アメリカ）
- オルセー線形加速器研（フランス）



IJS-KMI, MoU ceremony, 2014



NU research, 2016/11/18



- 外国人招聘研究者（2014～）：47名
- 外国人研究者受入：1名＋1名（今年度）
- 大学院留学生（2014～）：3名，長期受入：1名（アデレード大）

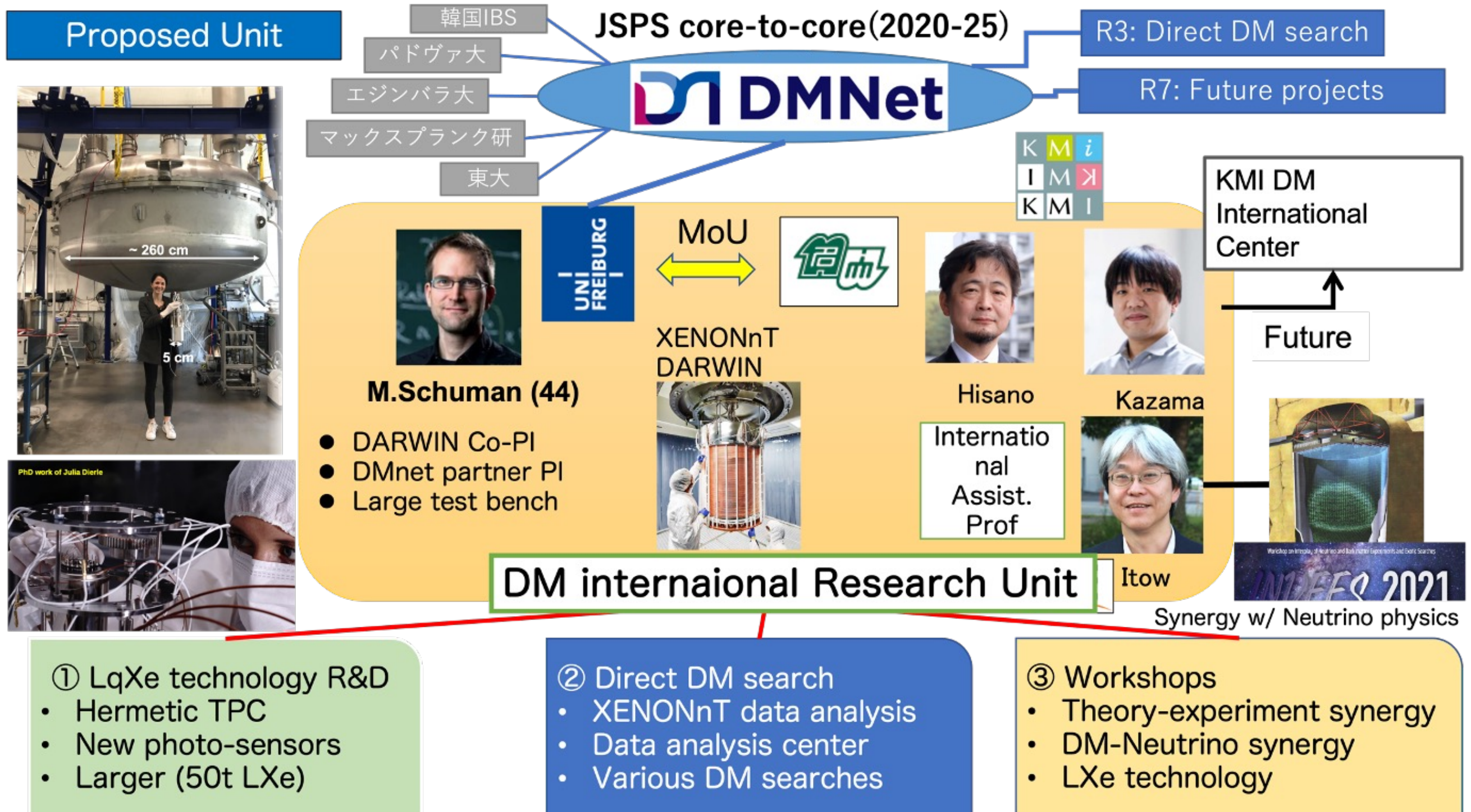


KMI Film



# International research unit for innovative dark matter search

Itow-san et al.





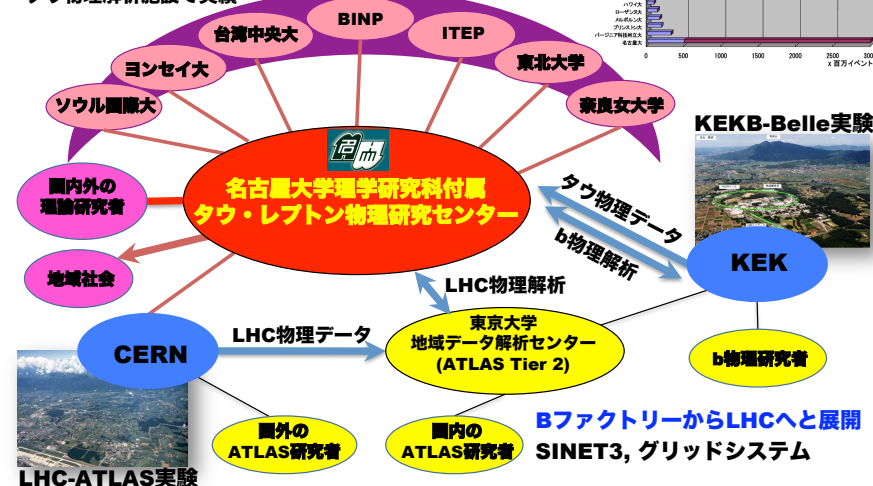
# Flavor Physics International Research Center

## Tau-Lepton Physics Research Center (Graduate School of Science)



研究者集団を組織 ... タウ・レプトン物理解析を中心とした先端研究・教育拠点  
物理探索の人的資源  
国際研究者ネットワークを強化

タウ・レプトン研究大学ネットワーク  
タウ物理解析施設で実績

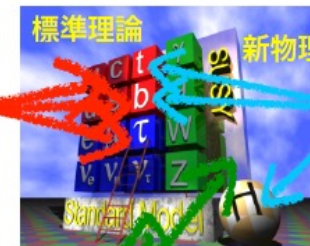


## World Research Unit for Heavy Flavor Particle Physics ("WPI-next")

SuperKEKB/Belle II II



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• B, Tau Physics  
• Exotic hadrons



Theory  
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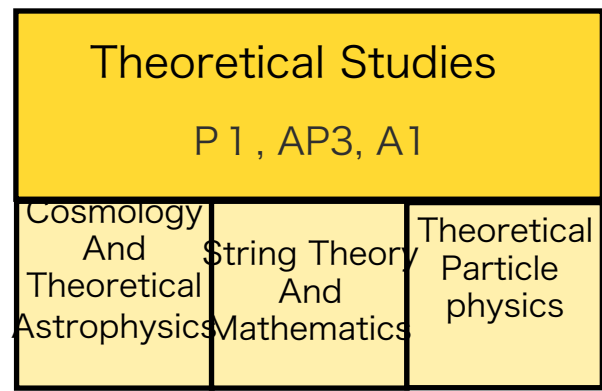
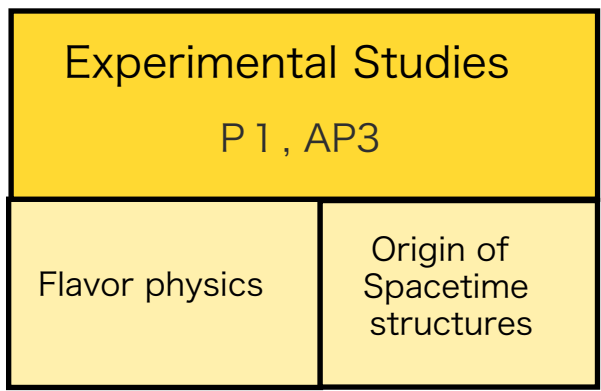
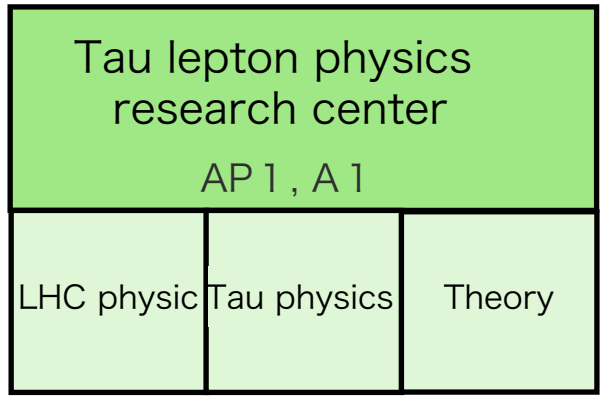


# New/Old organization chart

Old

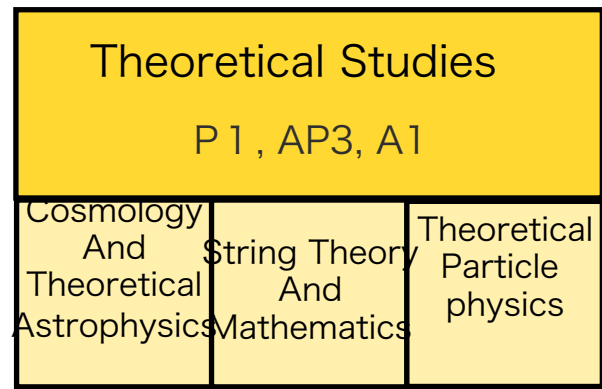
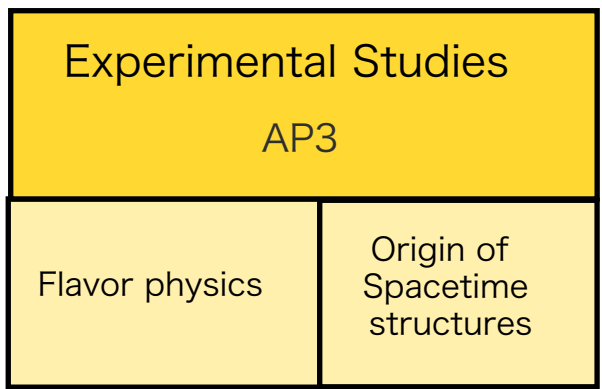
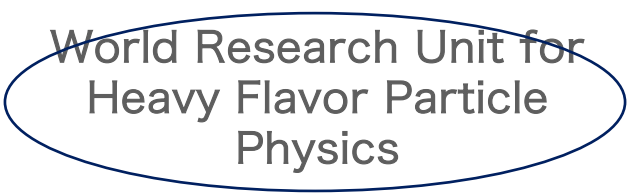
Graduate School of Science

Kobayashi-Maskawa Institute (KMI)



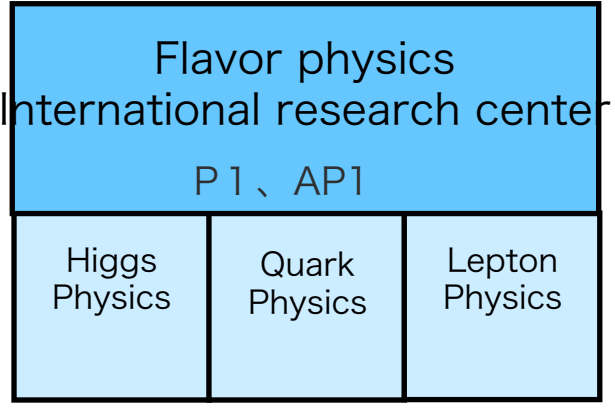
New

A1 (Graduate School of Science)



P1

AP1 (KMI)



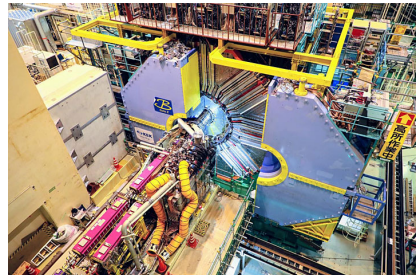


# Flavor physics international research center 8

Promoting international research and education on flavor physics, which is expected to make significant progress in the 2020s

**SuperKEKB/Belle II** 50 times more data

- Origins of Symmetry Breaking outside of the Kobayashi - Maskawa Theory
- Exploration of Symmetry Breaking in Tau leptons

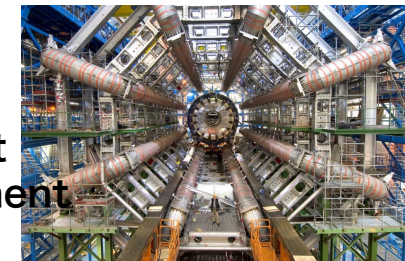


**New physics**

**LHC-ATLAS**

Run 3 → Higher luminosity

- Top, Higgs properties, symmetry breaking
- Direct search for new particles (e.g., second Higgs)



J-PARC

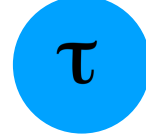
- Muon experiment
- Neutrino experiment



Charm quark



Bottom quark



Tau lepton



Muon



Neutrino



Top quark



Higgs

**Development of a state-of-the-art detector for international collaborative experiments**



New detector for collider experiment

Exchange of human resources through cross-appointment

**Cross-cutting research on big data analysis and machine learning**



Other flavor experiment

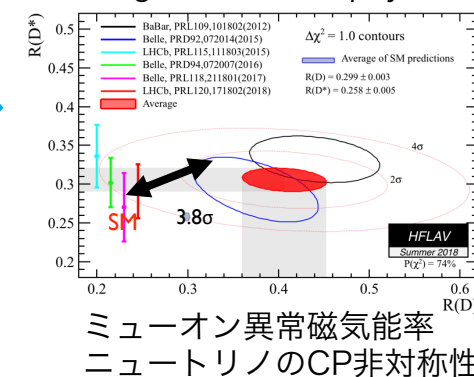


(KMI) Tau lepton data analysis

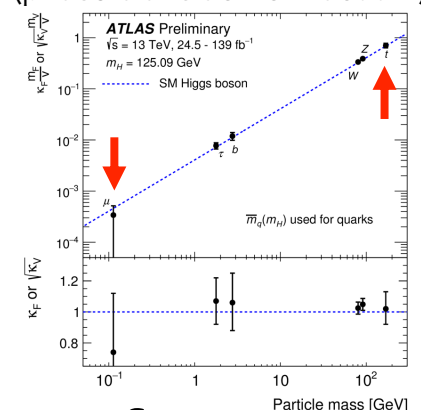
**Integrated analysis**

## Physics results

**New physics searches**  
Verification of B decay results showing hints of new physics



**Higgs mechanism**  
Revealing the origin of mass (phase transition of vacuum)



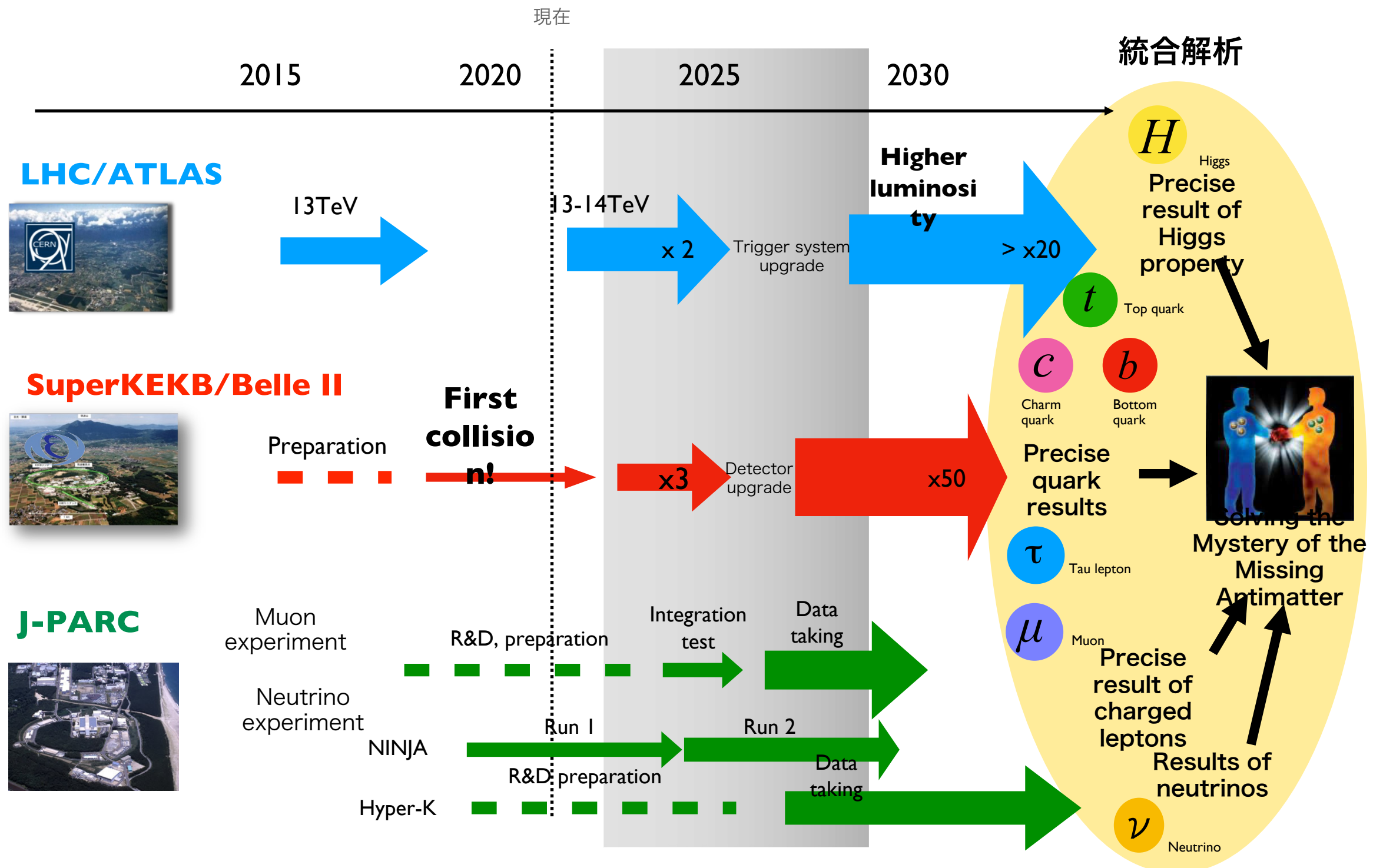
**Understanding of "Mystery of the Missing Antimatter"**

As a center for the promotion of international collaborative research at the university, the center will lead the development of cutting-edge detector and data analysis, and will promote research centered on the understanding of the mysteries of antimatter that have disappeared from its fusion research across various projects, and publish the results.



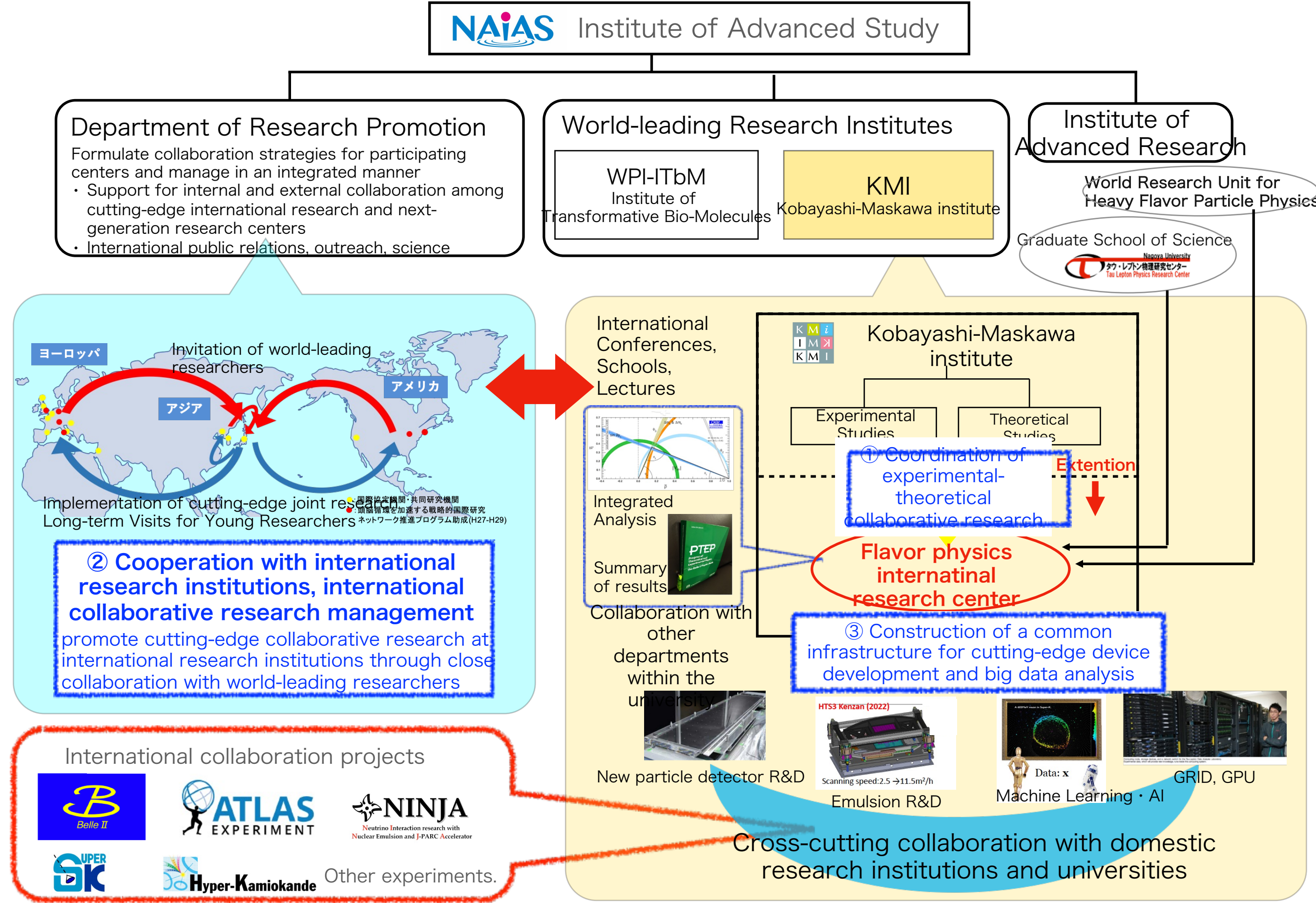
# Research plan

- Super B factory (SuperKEKB/Belle II) experiment: Accumulate 50 times more bottom, charm quark, and tau lepton data over the next 10 years
- LHC/ATLAS experiment: New top quark and higgs data in Run 3 (2022-2026) → High luminosity LHC
- Muon g-2/EDM experiment at J-PARC, Neutrino experiment (T2K→Hyper-K, NINJA etc.)



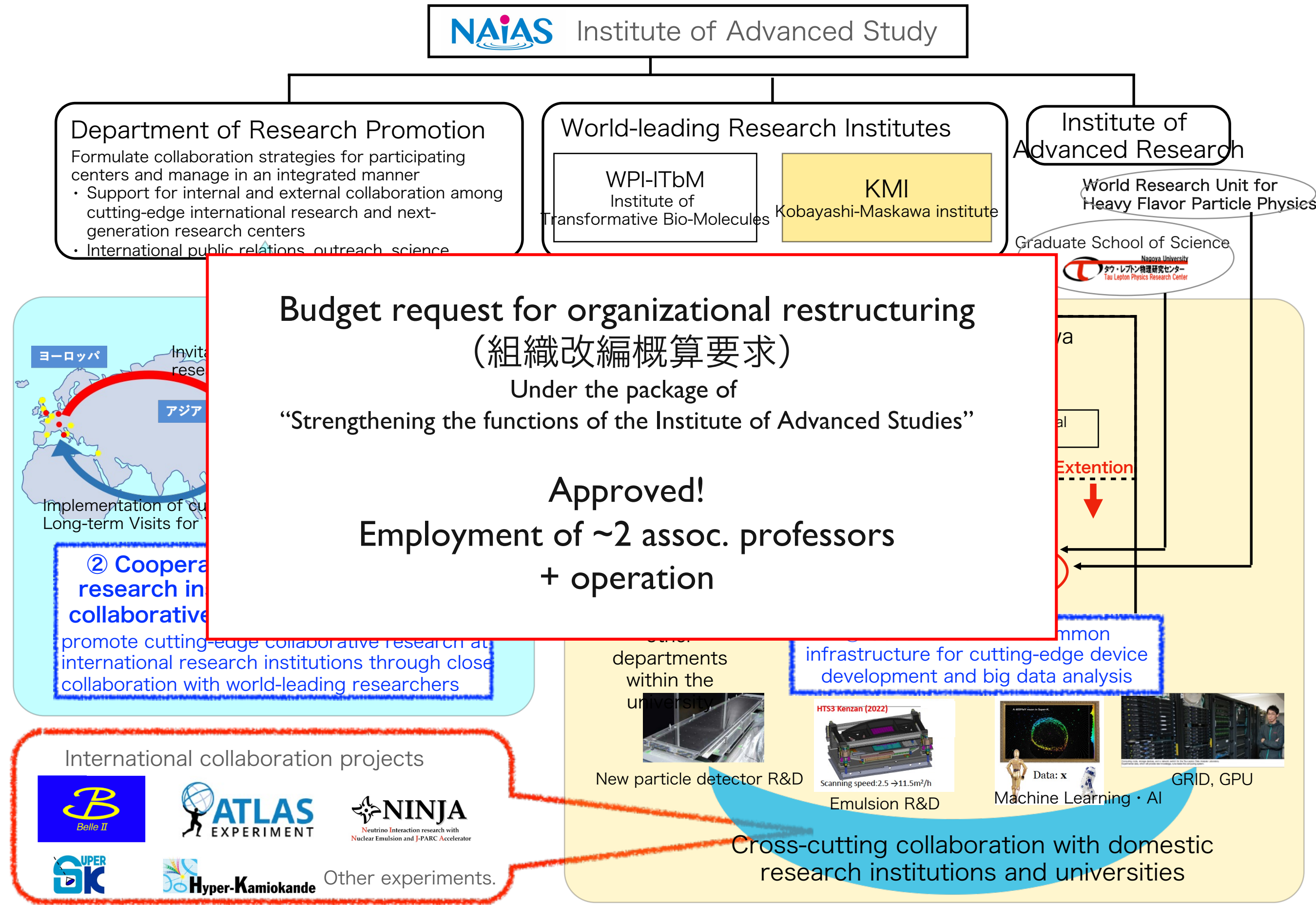


# Collaboration inside and outside the university 10





# Collaboration inside and outside the university 11





# International research exchange in the post Corona era

14

A good news!

We have succeeded in application to the  
New JSPS grant-in-aid program “International Leading Research”

This grant aims to enable research groups led by top-level researchers in our country to play a central role in the international network, thereby achieving research results of high scientific value internationally. With the participation of postdoctoral fellows and graduate students, the grant seeks to foster researchers who can play leading roles in the international research community in the future.

(7 years (extendable up to 10 years); up to 500 million yen)

[International Leading Research]

**Exploration of the particle physics frontier at the Super B-factory and cultivation of young researchers**

	Principal Investigator	Nagoya University, Kobayashi-Maskawa Institute, Professor <b>IJIMA Toru</b> Researcher Number : 80270396
	Project Information	Project Number : 22K21347 Project Period (FY) : 2022-2028 Keywords : particle physics, accelerator, particle detectors

**Purpose and Significance of the Research**

- “How did antimatters disappear from the Universe?” – Approaching the mystery with the world-leading accelerator experiment

Elementary particles have **antiparticles** with reversed charges. Equal amounts of particles and antiparticles should have been produced from the enormous energy of the Big Bang, 13.8 billion years ago. However, the current universe is composed of matter (particles), and antimatter (antiparticles) is not found. Why? We are conducting research to approach this mystery with the **Super B-Factory (SuperKEKB/Belle II)** experiment at the High Energy Accelerator Research Organization (KEK) in Tsukuba.

We pioneered this research by discovering the particle and antiparticle asymmetry (**CP violation**) in the decay of B mesons at the KEK B factory experiment in 2001 and verifying the **Kobayashi-Maskawa theory**. However, the found asymmetry is too small, and a **new theory beyond the Standard Model** is required to answer the mystery.

We are now conducting the Super B-Factory experiment, which has greatly enhanced performance, to explore new physics (launched in 2019). The SuperKEKB accelerator is renewing the world's highest collision performance (luminosity) with the “**Nano-beam collision**” scheme. The Belle II experiment aims at collecting a large data sample of **B meson and  $\tau$  lepton** decays, 50 times more than the previous KEKB/Belle experiment.

The purpose of this program is to ultimately improve the collision performance and potential of the experiment to find new physics by enhancing the cooperation of domestic and foreign researchers in Belle II, SuperKEKB, and theory working together. Our research will elucidate new physics and the mystery of the disappearing antimatter.

- The world-leading **Super B Factory Research**
- **SuperKEKB**: world highest luminosity
- **Theory**: flavor phenomenology including lattice QCD
- **Belle II**: world highest sensitivity

Aiming at the discovery of BSM!  
(BSM: Beyond the Standard Model)



High Energy Accelerator Research Organization(KEK)  
The world highest luminosity record  
 $4.7 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  (2022)

Fig.1 Particle physics research at the Super B-factory

**Organization of the Project Team**

- **World's leading international accelerator experiments hosted by Japan**

SuperKEKB/Belle II is one of the world's leading international accelerator projects, with more than 1,100 researchers from 27 countries and regions. KEK is responsible for the accelerator operation, whereas participating countries contribute to Belle II promotion (construction, operation, data analysis) with sub-detectors, funds, and computer resources. Toru Iijima is the Belle II spokesperson, and Japanese researchers are taking leading roles as the project manager, sub-detector, and data analysis group leaders.

- **Enhancing bidirectional research exchange with overseas research**

While the experiment is being conducted in Japan, the development of each sub-detector and data analysis are progressing worldwide. Our research program will create a flow from Japan to overseas and enhance two-way research exchange. The program is conducted by the PI (Toru Iijima) and 6 co-PIs. More than 10 young researchers and more than 10 graduate students will participate. From overseas, 18 researchers from 7 countries, including IJCLab, DESY, and CERN. Also, 18 researchers from Japanese research institutes collaborate to conduct research and to develop young researchers.




Fig.2 Belle II collaboration




Fig.3 Organization of this research

**Plan for Fostering Early-career Researchers**

- **Fostering international leaders bonding experiments and accelerators, and experiments and theories**

For the future development of particle physics, it is important to enhance collaboration among experiments, accelerators, and theories, and cultivate young researchers who share those expertise and have a wealth of international experience. We conduct the cultivation programs; (1) **Postdoctoral fellowship**: could be stationed at a foreign partner institute, (2) **Overseas internship**: dispatch young researchers and graduate students to overseas partners (2 ~6 months), (3) **Domestic internship**: train graduate students to learn new subjects (~ 3 months), (4) **Research project**: proposed and carried out by young researchers and students. Our program will develop young researchers who will be able to play a leading role in future international joint projects.

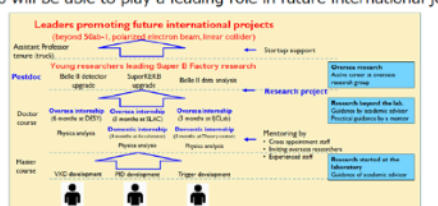


Fig.4 Cultivation program for leaders promoting future international projects

Homepage Address, etc. <https://belle2.org/>, <https://belle2.jp/>, <https://www.facebook.com/belle2collab/>

- In collaboration with SuperKEKB and their colleagues.
- One of 15 selected from >100 applications