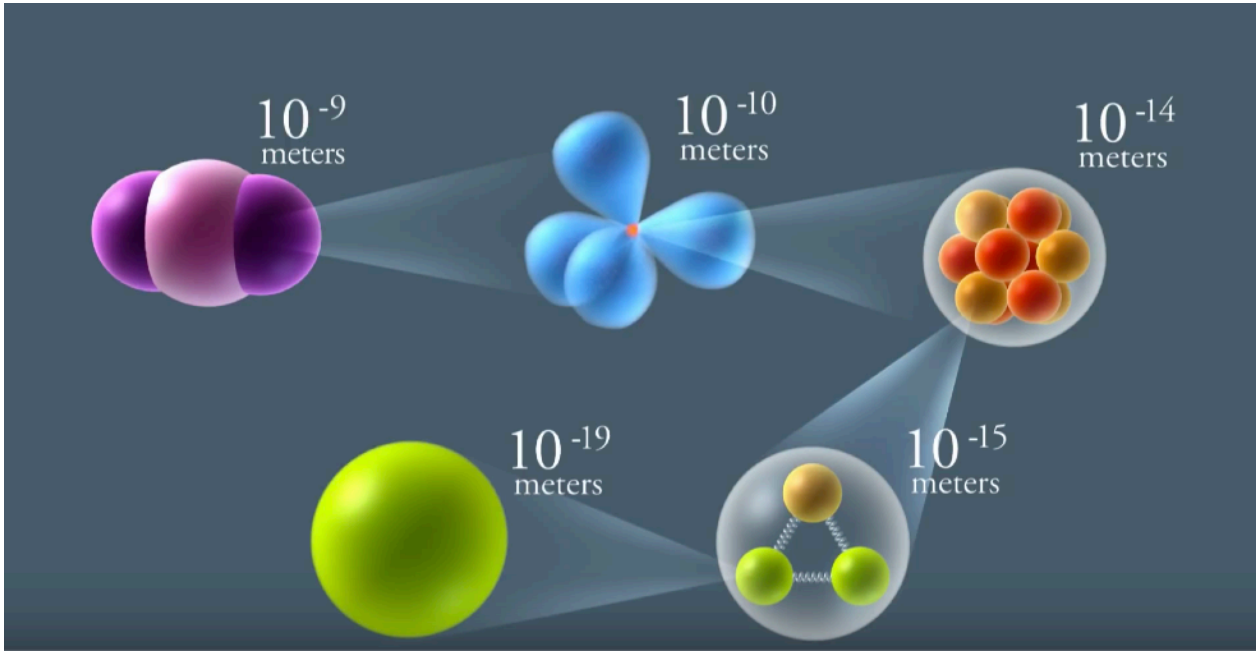
The 6th KMI International Symposium

Introduction to FlaP: Flavor Physics International Research Center

Toru Iijima / FlaP leader

March 5, 2025

The Standard Model of Particle Physics



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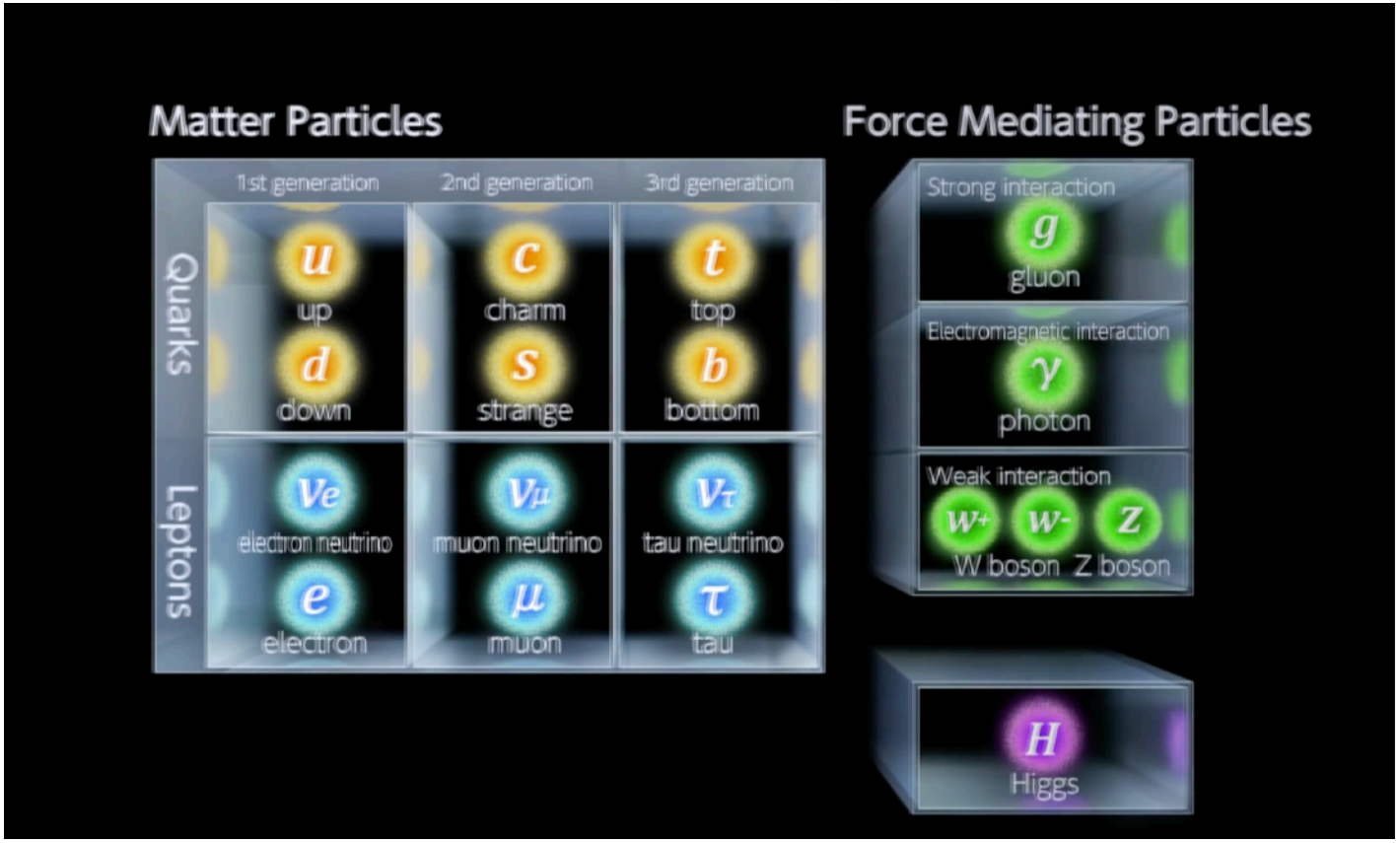

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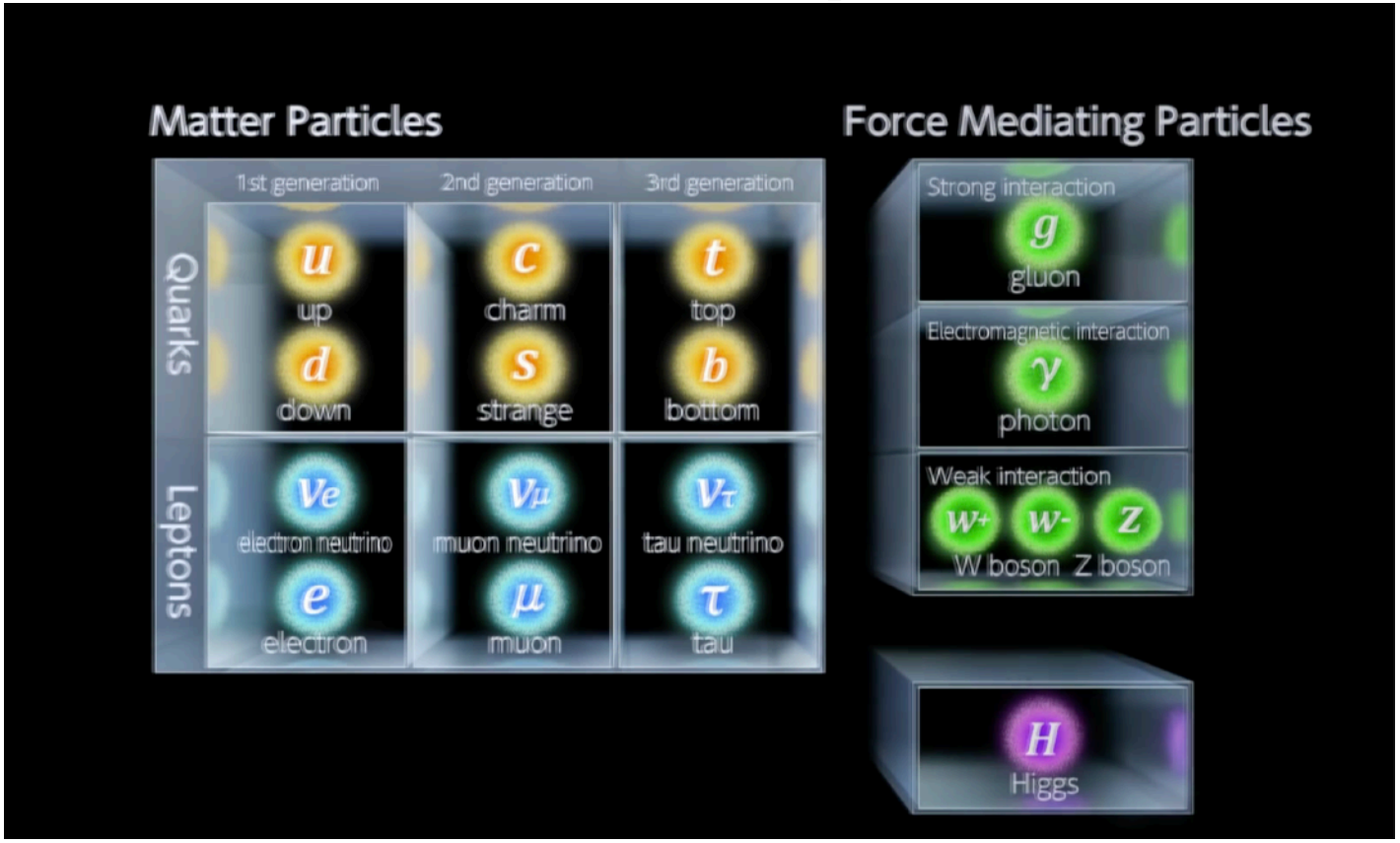


Flavor of particles?

Flavor Physics at Nagoya

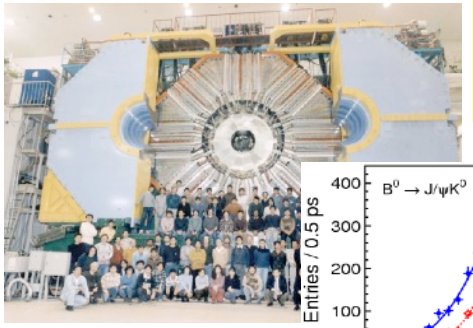
S. Sakata

T. Maskawa M. Kobayashi

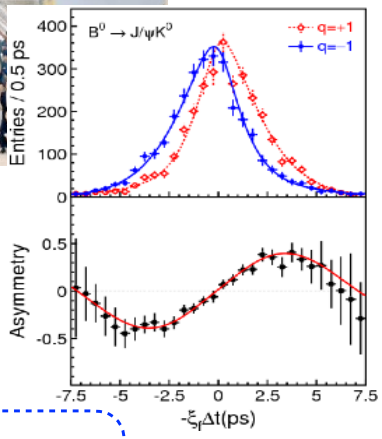
CKM

I. Sanda

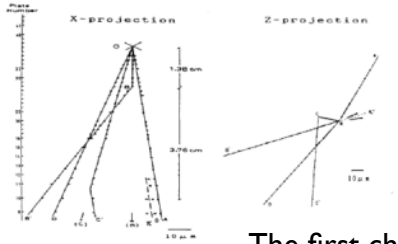
N. Cabibbo



BELLE



CKM2006 (Nagoya)

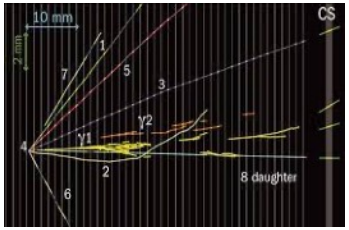


The first charm candidate observed in nuclear emulsion

PMNS

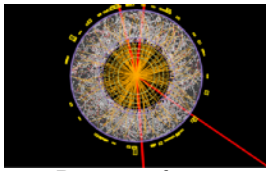
OPERA

The first tau neutrino appearance observed in nuclear emulsion

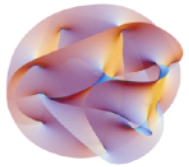


KMI

Kobayashi-Maskawa Institute
for the Origin of Particles and the Universe



Division for experimental studies



Division for theoretical studies

Nagoya University
タウ・レプトン物理研究センター
Tau Lepton Physics Research Center

Flavor Physics at Nagoya

S. Sakata

T. Maskawa M. Kobayashi

CKM

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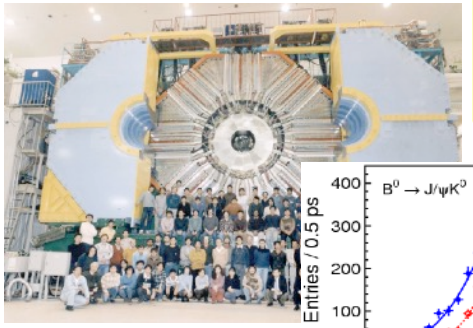

BELLE

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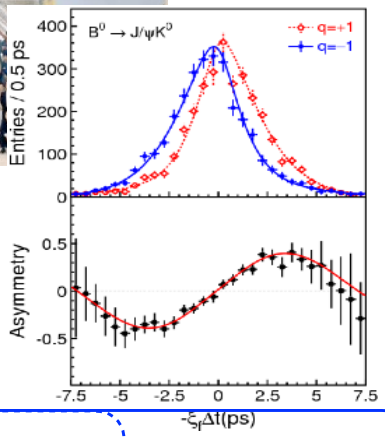

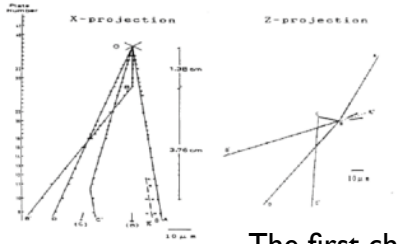

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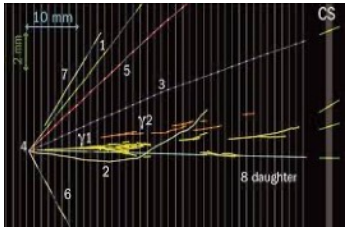

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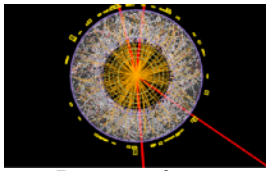
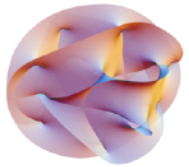
K M I

Kobayashi-Maskawa Institute for the Origin of Particles and the Universe



Division for experimental studies



Division for theoretical studies

FlaP
Flavor Physics International Research Center
フレーバー物理学国際研究センター

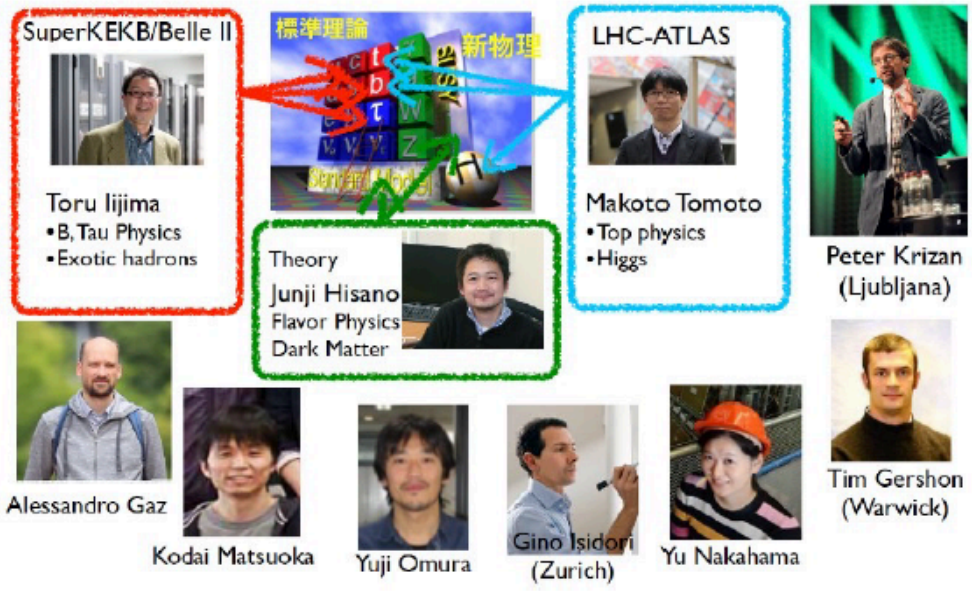
Research University Strengthening Promotion Project of MEXT (2014JFY-2022JFY)
Cutting-edge international research Unit

World Research Unit for Heavy Flavor Physics (Toru Iijima)

From 2014JFY to 2019JFY

重フレーバー素粒子物理学 国際研究ユニット

World Research Unit for Heavy Flavor Particle Physics



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

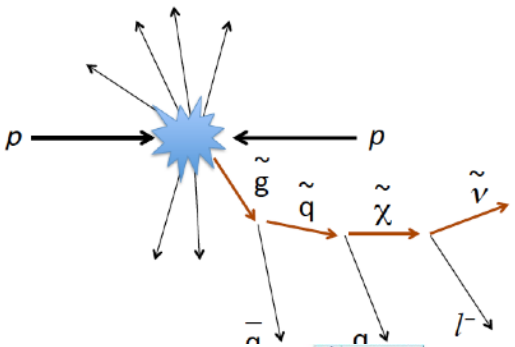
- T. Iijima: Belle II spokesman (2019.6~)
- A. Gaz: Belle II physics analysis coordinator
- P. Krizan: Belle II technical coordinator (and former spokes)
- K. Matsuoka: Belle II operation coordinator
- Y. Nakahama: ATLAS trigger coordinators
- M. Tomoto, J. Hisano, T. Iijima: leaders of grant-in-aid projects
- TOP detector, Computing at Belle II
- Trigger R&D and operation at ATLAS

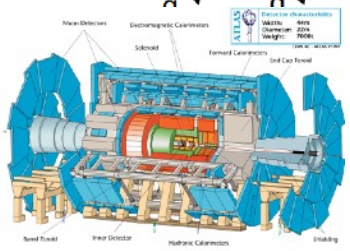
→ Flavor Physics International Research Center (FlaP, since 2023)

FlaP
Flavor Physics International Research Center
フレーバー物理学国際研究センター

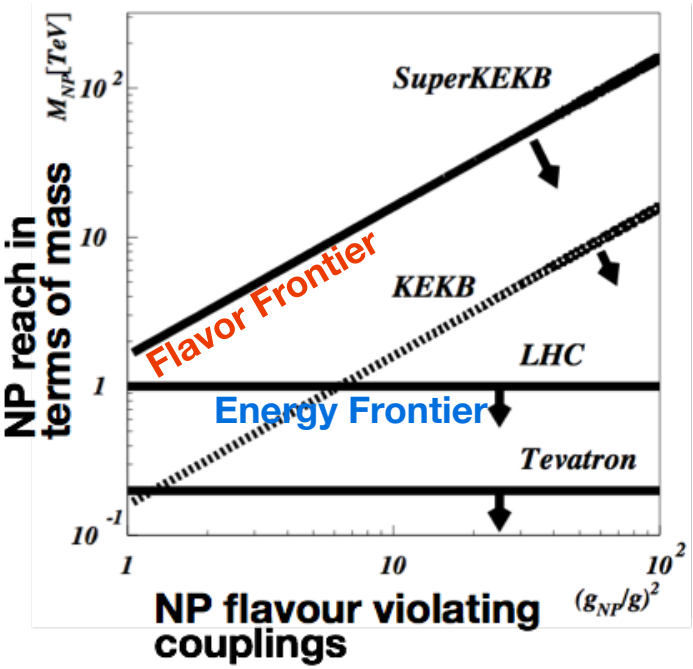
Two Ways to Find New Physics

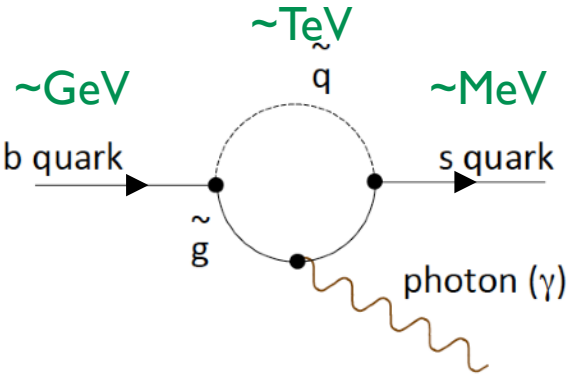
- **Energy Frontier :** produces and detects a new particle directly in collisions of extremely high energy beams.
- **Luminosity Frontier :** measures reactions of known particles very precisely, and finds deviations from the Standard Model predictions.

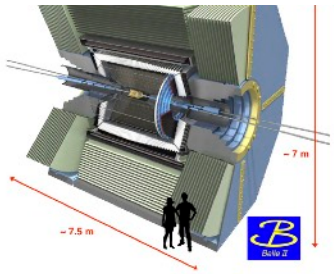




ATLAS







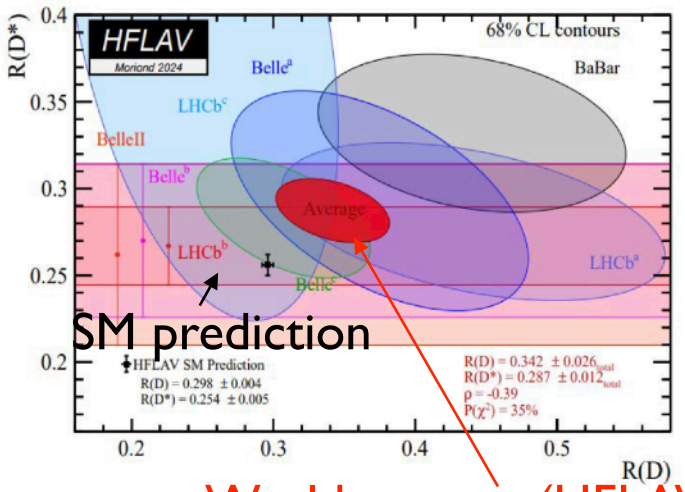
Belle II

Flavor Anomalies

Flavor physics experiments play important roles to search for NP.

“B anomalies”

$$R(D^{(*)}) = \frac{\mathcal{B}(\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau)}{\mathcal{B}(\bar{B} \to D^{(*)}\ell^-\bar{\nu}_\ell)} \quad (\ell = e, \mu)$$

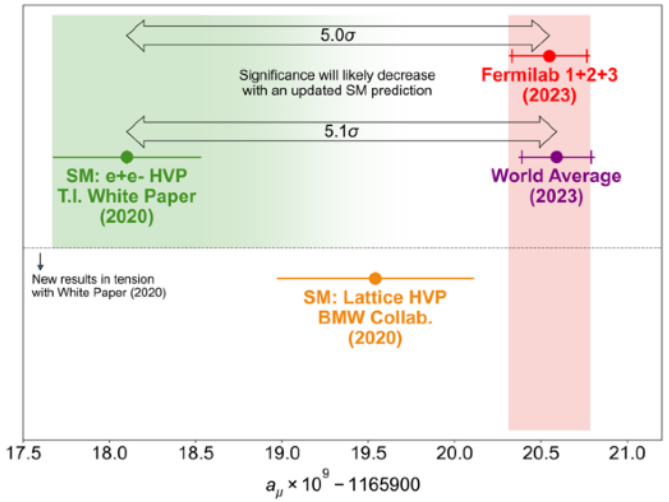


SM prediction

World average (HFLAV 2024)

>3σ deviation

“Muon g-2 anomaly”



Direct search & study of Higgs at the energy-frontier

Flavor physics international research center

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**

KEK

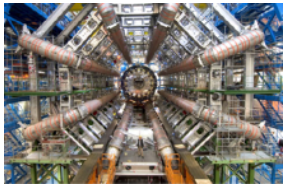
J-PARC

- **Muon experiment**
- **Neutrino experiment**

LHC-ATLAS

Run 3 → Higher luminosity

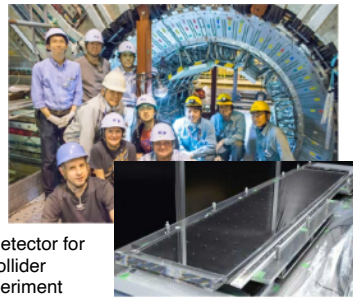
- **Top, Higgs properties, symmetry breaking**
- **Direct search for new particles (e.g., second Higgs)**



c Charm quark　b Bottom quark　τ Tau lepton　μ Muon　ν Neutrino　t Top quark　H Higgs

Exchange of human resources through cross-appointment

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



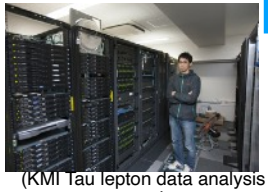
New detector for collider experiment

Cross-cutting research on big data analysis and machine learning

Belle II

ATLAS EXPERIMENT

Other flavor experiment

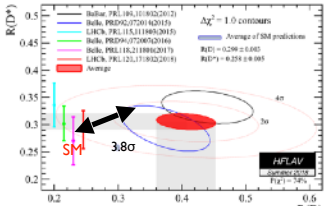


(KMI Tau lepton data analysis facility)

Integrated analysis

Physics results

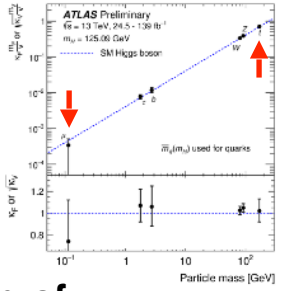
New physics searches
Verification of B decay results showing hints of new physics



ミューオン異常磁気能率

ニュートリノのCP非対称性

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

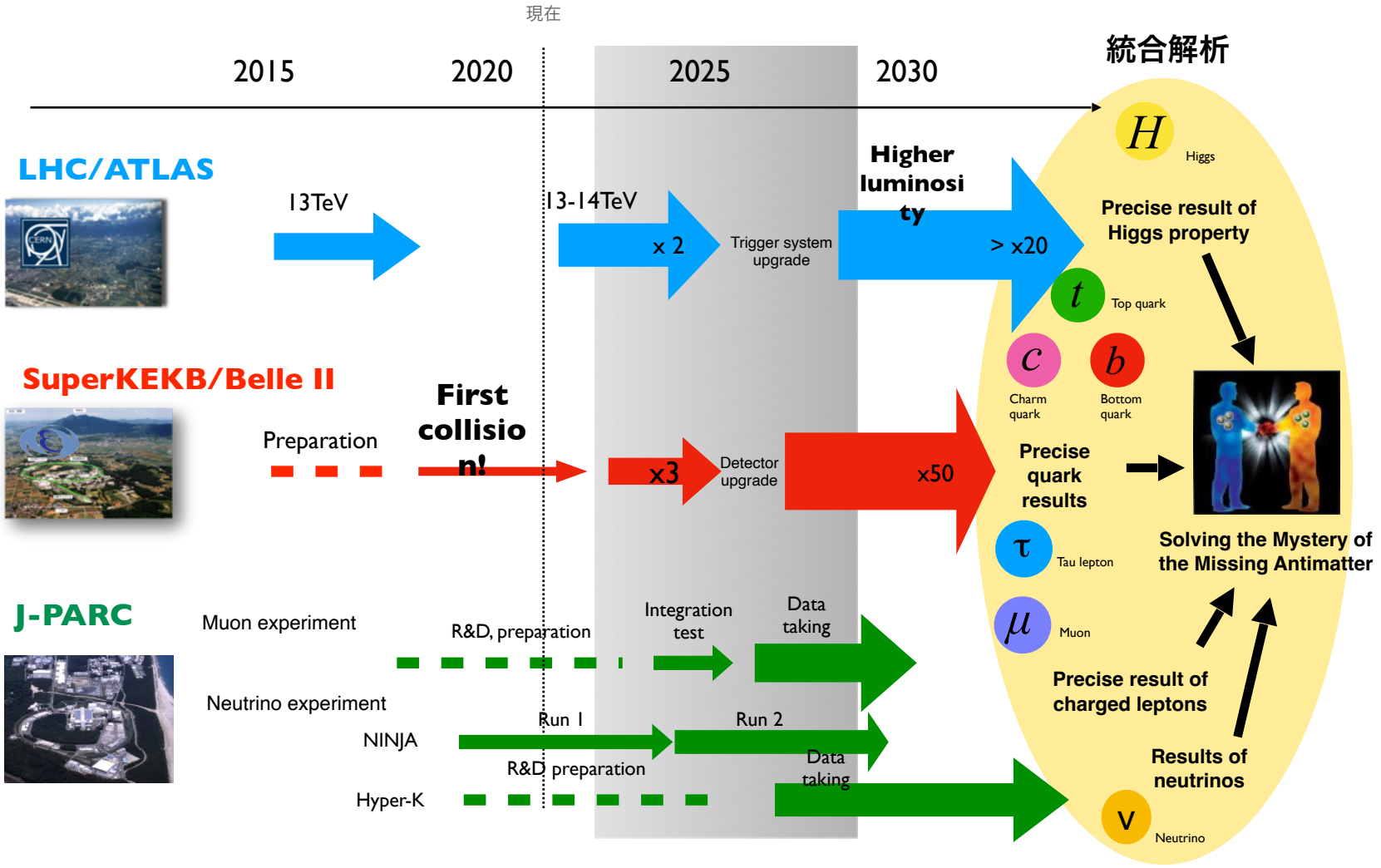


Understanding of "Mystery of the Missing Antimatter"

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, Neutorino experiment（T2K→Hyper-K, NINJA etc.）



FlaP Organization

Quark Physics

- Toru Iijima (Belle II, muon g-2)
- Masaaki Kitaguchi (neutron)
- Masayasu Harada (theory, hadron)
- Yasuhiro Yamaguchi (theory, hadron)

Lepton Physics

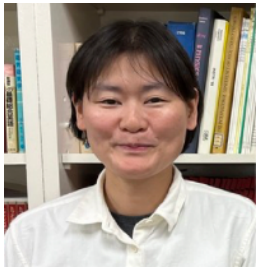
- Yoshitaka Itow (neutrino)
- Kenji Inami (Belle II, muon g-2)
- Kazuhiro Tobe (theory)
- Toshiyuki Nakano (neutrino)

Higgs Physics

- Masaharu Tanabashi (theory)
- Junji Hisano (theory)
- Yasuyuki Horii (ATLAS)

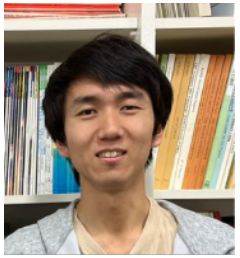
Designated Staff Members

Assist. prof.



Hikari Murakami (Belle II)

Petar Rados (Belle II)



Shota Izumiyama (ATLAS)

Associate. prof.

Kenji Mishima (neutron)

Kazuhito Suzuki (muon g-2)

Mark Hartz (neutrino)
cross-appointment w/ TRIUMF

Summary

- FlaP (Flavor Physics International Research Center) has been launched to boost further flavor physics.
- FlaP provides framework and resources
  - Physics studies
  - Detector R&D
  - International cooperation
- Funding from MEXT is available FY2023- 2026 and will hopefully be converted to a consecutive funding

Stay Tuned!