


## Development of the Energy Frontier and International Human Resources toward a Unified Understanding of Interaction

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	Project Information	Project Number : 24K23939 Project Period (FY) : 2024-2030 Keywords : Energy Frontier Exp., Superconducting Technology, Detector R&Ds for Particle Physics

### Purpose and Significance of the Research

This research aims to unveil the Higgs mechanism, a major mystery in modern particle physics, and detect signs of supersymmetry to explore phenomena beyond the Standard Model. The ultimate goal is to establish a unified theory of physics, valid at energy scales above  $10^{15}$  GeV, such as a Grand Unified Theory unifying electromagnetic, weak, and strong interactions (Figure 1). Despite the discovery of the Higgs boson, its full nature remains unclear, including the origins of fermion generations and the shape of the Higgs potential. Unlike the gauge principle, the Higgs field is incorporated into theory "by hand", prompting speculation about other Higgs bosons or supersymmetry behind it. Understanding the Higgs field will be a key challenge in particle physics over the next decades. This research develops talent to lead international projects, advances detector technologies, and positions Japan to spearhead future energy frontier experiments like the Higgs factory (Figure 2). Three research domains are prioritized:

**Physics:** Utilize high-statistics data and AI to enhance precision and discover new physics by comparing measurements with precise theoretical predictions.

**Superconducting Magnet:** Revive aluminum-stabilized NbTi wire production, apply stabilization techniques to new materials like ReBCO, evaluate radiation resistance, and develop magnets exceeding 10 T.

**Detector:** Develop radiation-resistant MAPS through TCAD simulations, evaluate prototypes via irradiation tests, and explore integrating advanced FPGA-based trigger technologies.

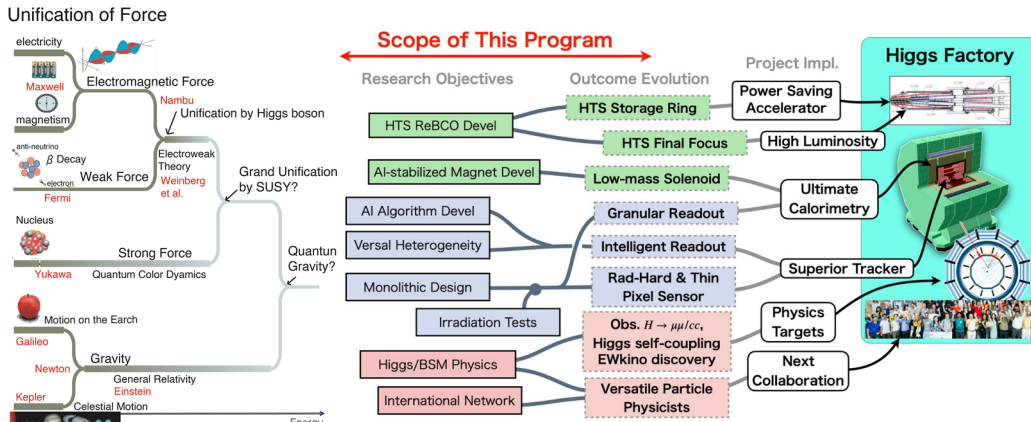
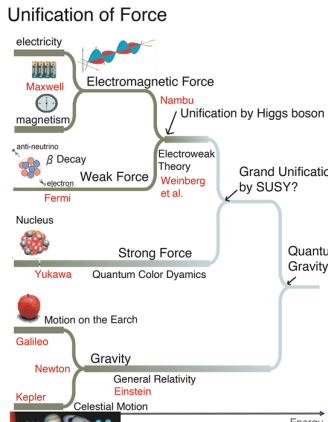


Fig.2 Research roadmap towards Higgs Factory conducted by this program.

Fig.1 Path towards unification of fundamental forces.



### Organization of the Project Team

Energy frontier experiments require international collaboration due to their scale, but intense competition for leadership arises. To maintain Japan's presence, long-term research plans and talent development are vital. This project focuses on unraveling the mysteries of the Higgs potential and searching for supersymmetry, led by LHC experts. By involving young and international researchers in next-generation detector technologies, Japan aims to lead post-HL-LHC energy frontier efforts. Key domains — "physics," "superconducting magnets," and "detectors" — will foster the next generation of researchers through interdisciplinary collaboration. Leveraging international networks, this program will nurture globally capable researchers to lead future projects like the Higgs factory.

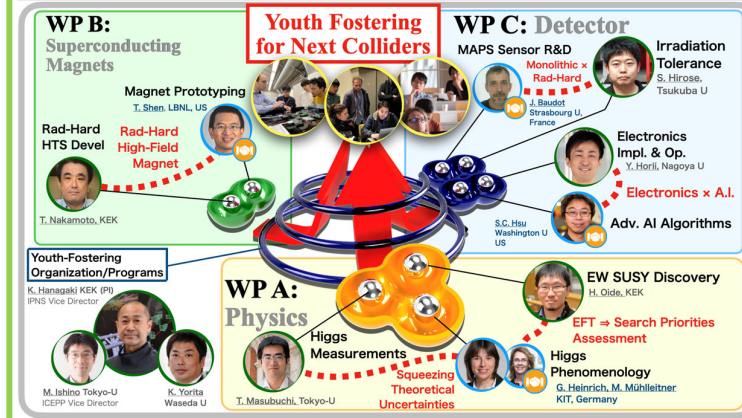


Fig.3 Organization of this research program

### Plan for Fostering Early-career Researchers

The fostering plan focuses on two main pillars to nurture future leaders in the field:

- 1. Training researchers to tackle cutting-edge technologies** international schools and programs encouraging young scientists to pursue innovative new technologies.
- 2. Developing particle physics researchers** with hands-on experience ranging from manufacturing to project construction and new experiment operations, equipping them to lead multinational teams.

This program provides a long-term, stepwise career guide for students and young researchers to advance Japan's leadership in particle physics. Additionally, a third global development axis a program to foster international leaders for next-generation experiments like the Higgs factory. This includes interdisciplinary initiatives that transcend fields, enhance scientific literacy, and cultivate broad talent with global competence.

The program will produce highly skilled leaders who can internationally spearhead particle physics.

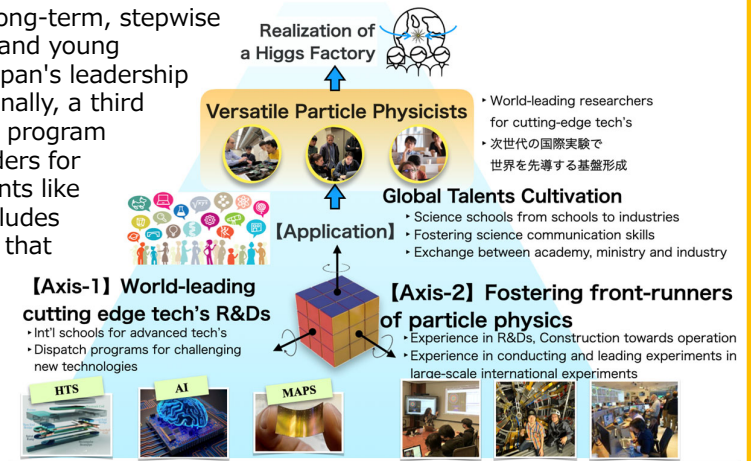


Fig.4 Young researchers fostering plan in this program.