Outline of Selected Project

Host institution	High Energy Accelerator Research Organization (KEK)
Center name	International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles
Head of host institution	Masanori Yamauchi
Prospective Center director	Masashi Hazumi

<Project Summary>

Physics aims at an essential and unified understanding of the laws behind various physical phenomena ranging from particles to the universe. In physics, new research methods or means to establish the unification theory are highly evaluated, as clearly seen from the past research for which Nobel Prizes have been awarded. This center will return to the essence of physics and conduct interdisciplinary research on methodology by making maximum use of the research infrastructure resources of KEK, which is an international center of accelerators. In modern physics, a "quantum field" is the spacetime in which particles and quasiparticles are created and annihilated. Physicists have been exploring the fundamental equations governing quantum fields both theoretically and experimentally. "Quantum field measurement systems" in the name of this center is a new concept that has two meanings: one is to measure the quantum field, and the other is to measure "with" the quantum field (including various quasiparticles).This center focuses on quantum field measurement systems, which have been undergoing significant innovation in recent years. It aims to bring about innovative development through interdisciplinary research of particle physics, astrophysics, condensed matter physics, measurement science, and systems science. This means that humanity will gain new "eyes," so to speak. It will lead to applications in various academic fields beyond physics and their huge and high-level fusion. Furthermore, it will pave the way for implementation in the future society, as represented by smart cities.

<Remarks>

- The proposal has the possibility for making a major leap forward in scientific knowledge across many domains by a fusion of macro (cosmological), micro (sub-atomic) scale physics and systems science, and development of novel quantum measurement principles.
- The proposal embodies what is expected of a WPI center (path-breaking research, globalization etc…).
- The proposed director is a world-class researcher.

High Energy Accelerator Research Organization (KEK)

International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles (QUP)

Center Director
Masashi Hazumi

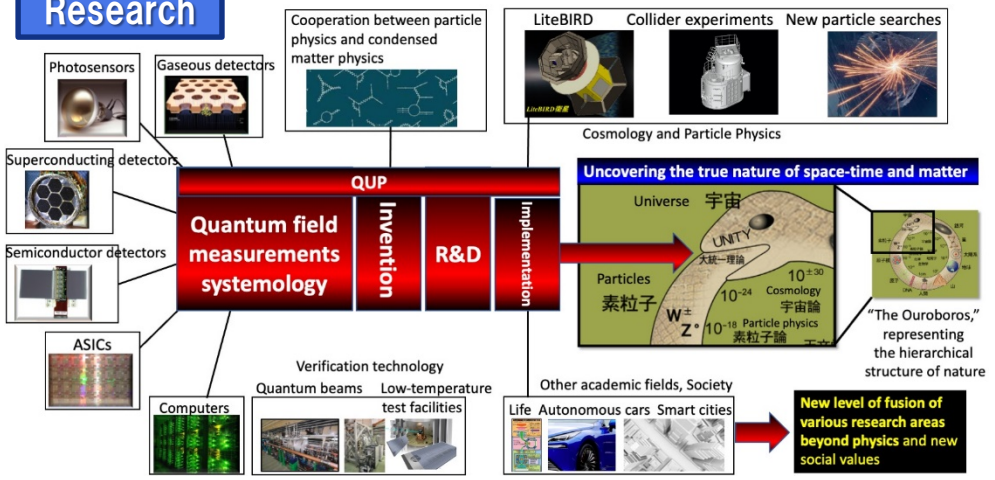
Leading the discovery of CP violation at the B-factory experiment in KEK which led to the Nobel Prize to Professors Kobayashi and Maskawa, I felt like I touched the depths of nature with my bare hands. After that, I succeeded in the first observation of the gravitational lens effect on the polarization of the cosmic microwave background in the POLARBEAR project, and proposed the LiteBIRD satellite project to explore the universe before the Big Bang. My dream as a researcher is to provide new knowledge about "the zero time in the universe" and to bring about the discovery of a novel quantum field in the research activities of this center.

Mission

"Quantum Field" is the the backbone of reality from particles to the cosmos. QUP will:

- integrate particle physics, astrophysics, condensed matter physics, measurement science, and systems science;
- invent and develop new systems for measuring quantum fields and bring innovation to measurements in cosmological observations and particle experiments, and elucidate the true nature of space-time and matter, with fusion of various research areas; and
- establish a new measurement science, quantum field measurement systemology, as a science of means through the above practices and create a new level of fusion of various research areas beyond physics and new social values through application to other fields and social implementation.

Research



1) Development and implementation of the superconducting detector array for the LiteBIRD satellite project.
2) The invention of methods (e.g., those using quasiparticles) for measuring novel quantum fields (e.g., axions), and proposal and promotion of new projects based on these methods.
3) Pioneering the most efficient means for large-scale projects in basic science (e.g., automatic ASIC design generation) and theorizing them based on practice (establishing systemology.)
4) Research with social implementation (e.g., smart cities, autonomous driving, etc.) as an outcome (e.g., application of the Casimir effect to devices) and development of applications in a wide range of academic fields (e.g., neuroaesthetics, archaeology, etc.)

Above are typical examples, and a variety of fusion research that goes beyond these will be carried out.

Identities

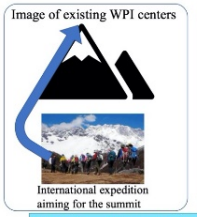
I. The only center in the world that integrates the invention of new measurement principles for experimental cosmology and particle physics, the development of systems to realize these principles, and the execution of projects.

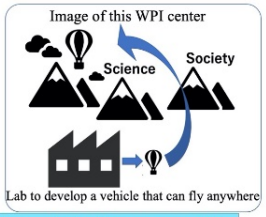
II. This center will conduct interdisciplinary research on "means" or "methodologies." It is at the meta-level, leading to a new level of fusion of various research areas to produce academic and social values. In particular, for social implementation, we are promoting interdisciplinary research that transcends the boundaries between industry and academia with the cooperation of the Toyota Group.

III. Capability of characterizing measurement systems using the various quantum beams provided by KEK's accelerator facilities.

IV. Leveraging our experience as a host of large-scale international collaborative experiments in fundamental research fields to conduct international research collaborations at an unparalleled level.

V. Leveraging our experience as an inter-university research institute, we will lead the world and make significant contributions to the research and education of universities and research institutions in Japan and abroad.





Meta-level interdisciplinary fusion for means, not for a single goal, to produce academic and social values

Satellite Offices

Toyota Central R&D Labs — Research toward Social Implementation

High Energy Accelerator Research Organization (KEK)

Japan Aerospace Exploration Agency (JAXA) Institute of Space and Astronautical Science (ISAS)

University of California, Berkeley

Development of superconducting detectors