Research Outline of Research Areas

New Horizons in Negative Muon Science: A Transdisciplinary Integration of Knowledge Bridging Matter, the Universe, and Humanity

http://mu-horizons.kek.jp

Number of Research Area	:	26A205	Term of Project :	FY2026-2030
Head Investigator	:	SHIMOMURA Koichiro		
Research Institution	:	High Energy Accelerator Research Organization, Institute of Materials Structure Science		

1. Details of Research Area

In 21st-century science and technology, the negatively charged muon (negative muon) is highly anticipated as a new fundamental particle to succeed the electron. Utilizing Japan's world-leading high-intensity muon facilities (J-PARC MUSE and RCNP MuSIC), this research area aims to create a new academic framework, "Negative Muon Integrated Science." This framework is centered on two key physical phenomena induced by negative muons in matter: muonic atom formation and nuclear muon capture.

Specifically, we will promote cross-disciplinary and collaborative research—ranging from particle and nuclear physics to Earth and planetary science, quantum sensing, medicine, and the humanities—centered on two innovative approaches: non-destructive elemental analysis and selective transmutation. Through these efforts, we aim to establish an innovative research foundation that connects the resolution of fundamental questions in natural science to the challenges of human society.

2. Call for Proposals and Expectations for Publicly Offered Research, etc.

This research area invites creative and original research proposals that will broaden and deepen the "New Horizons in Negative Muon Science" presented by our Planned Research projects. In particular, we welcome the introduction of new perspectives and technologies that extend beyond the current scope of the Planned Research. Examples of expected research topics include:

- Advancement and Expansion of Muon Utilization: Research on accelerator and measurement technologies contributing to next-generation muon science, as well as techniques for the generation, cooling, and trapping of exotic quantum systems.
- Expansion Toward Societal Implementation: Engineering applications of muon-induced nuclear transmutation; development of radiopharmaceuticals using novel radiotheranostic isotopes; further transdisciplinary (Humanitics) research with cultural heritage studies; and new developments in Earth and planetary sciences.
- Deepening of Theory and Analysis: Development of new analytical methods using muonic X-rays and induced gamma rays; collaborative theoretical and experimental research with unstable nuclear science.
- Fostering the Next Generation: Promotion of muon science to younger generations (elementary, middle, and high school students) and proposals for next-generation education and training programs.

3. Research Group, Upper Limit of Annual Budget and Number of research projects scheduled to be selected

Research Group Number	Research Group	Upper Limit of Annual Budget (Million yen)	Number of research projects scheduled to be selected
A01	Elucidation of Negative Muon-Induced Nuclear Reaction and Establishment of Nuclear Data for Applications		
A02	Cooling and Precision Measurements of Negative Muon		
B01	Exotic Nuclear Physics with Negative Muons		
B02	Physical Observation and Simulation of Negative-Muon-Induced Soft Errors		
C01	Research on Fundamental Symmetries Using Laser-Cooled Heavy Elements Produced by Negative Muon Nuclear Capture Reactions	2 5	8 6
C02	Investigation of the evolution of the solar system through negative muon elemental analysis		
D01	Exploration of medical radionuclides produced by negative muon capture and development of target chemistry for radiotheranostics		
D02	Unraveling the Wisdom of Human Technology via Muonic X-ray Spectroscopy		