【Grant-in-Aid for Scientific Research (S)】

New frontiers of neutrino interaction physics explored by ultra-high resolution particle imaging

Principal Investigator	Kyoto University, Graduate School of Science, Professor NAKAYA Tsuyoshi Researcher Number:50314175
Project Information	Project Number : 23H05434 Project Period (FY) : 2023-2027 Keywords : Elementary Particle, Neutrino, Accelerator, Nuclear Emulsion

Purpose and Background of the Research

●Outline of the Research

How was the universe created as we know it today? The universe began as a very hot mass of energy, in which particles and antiparticles were created. Later, the antiparticles disappeared, leaving only particles, and stars and life were born. The mechanism by which antiparticle disappeared is thought to involve neutrinos, and it is important to investigate the difference between neutrinos and their antiparticles, the antineutrinos. However, neutrinos are also called ghost particles, and there are still many unknowns about their interaction process. In this research, neutrino interaction physics will be studied in detail using a neutrino beam produced by an accelerator and a particle detector called a “nuclear emulsion” that uses photographic technology. The experiment measuring this neutrino interaction is named NINJA.

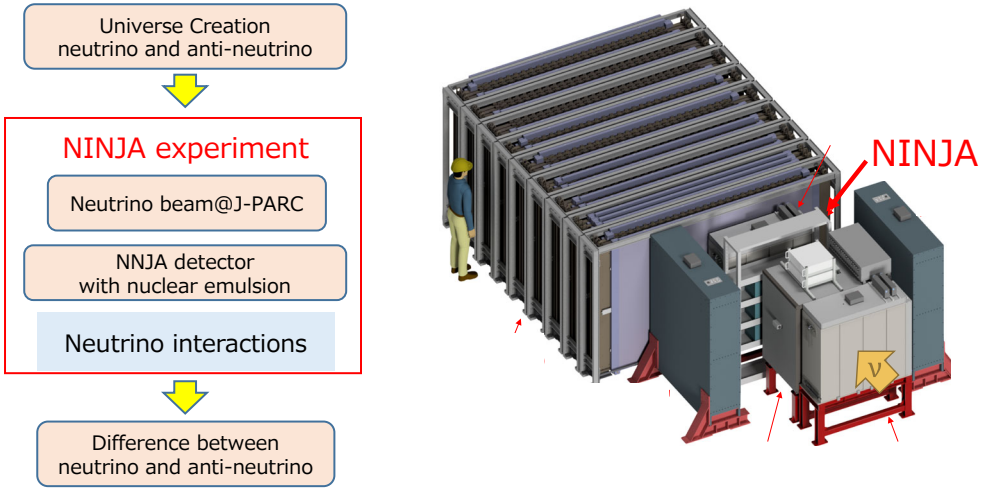

Figure 1. Image of the overall research (left) and the NINJA detector that measures neutrino interactions (right).

● Features of the NINJA Experiment and the goals

・The world's most intense neutrino beam (J-PARC, Japan Proton Accelerator Research Complex, Ibaraki) will be used.
・Nnuclear emulsions are used for ultra-high resolution imaging of elementary particles. Nagoya University is the only place to produce them.
・Neutrino research is considered a Japanese specialty (two Nobel Prizes), and the Hyper-Kamiokande experiment is under construction as a master project. The NINJA experiment will provide the information on neutrino interaction processes needed for Hyper-Kamiokande.

・All combined, we can study the world's most precise neutrino interaction data. We will explore new frontiers in neutrino interaction physics.
Figure 2 is a cartoon illustration of the NINJA experiment.

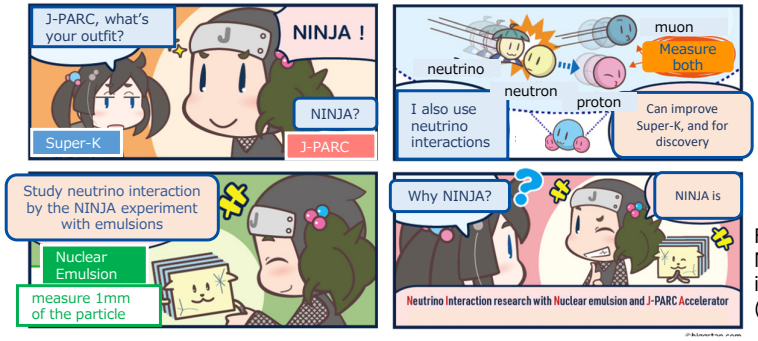

Figure 2. A manga of the NINJA experiment translated into English by T. Nakaya (https://higgstan.com)

Expected Research Achievements

● Precise measurement of neutrino interactions (Figures 3 and 4)

・Search for neutrino interaction that has not been observed yet.
・In neutrino interaction, the energy of a particle with a track length of 1 mm can be measured. This is an unique feature of the NINJA experiment.

● To ensure the difference between particles and anti-particles

・Hyper-Kamiokande will begin around the time the NINJA experiment is over, and will study the difference between particles and antiparticles. To ensure the difference, measurements from the NINJA experiment will be used.

● Application of nuclear emulsion

The nuclear emulsions being developed in our experiment are widely used for gamma-ray balloon observation, Volcano perspective, Pyramid perspective. It is important to improve the performance of nuclear emulsions through this research.

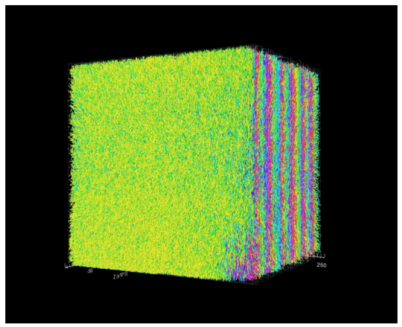

Figure 3. Myriad of particle tracks on many layers of nuclear emulsions

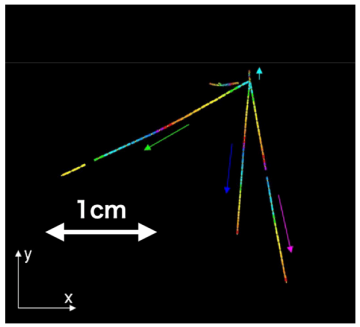

Figure 4. A signal of neutrino interaction. Selecting through the myriad of tracks in Figure 3.

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