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

Search for supernova relic neutrinos in Super-Kamiokande

Principal Investigator	Okayama University, Faculty of of Environmental, Life, Natural Science and Technology, Associate Professor KOSHIO Yusuke　　Researcher Number : 80292960
Project Information	Project Number : 25H00396　　Project Period (FY) : 2025-2029 Keywords : Supernova, Neutrino, Super-Kamiokande, History of the universe

Purpose and Background of the Research

●Outline of the Research

Stars with more than eight times the mass of the Sun undergo a 'Supernova explosion' in their final stage, and neutrinos release more than 99% of the energy. Neutrinos from the supernova explosion in the Large Magellanic Cloud were observed in 1987. If a supernova explosion occurs close to Earth today, thousands of neutrino signals would be observed, and our understanding of supernova explosions would be greatly improved. However, the frequency is only once every few decades, and we have no idea when it will happen. Therefore..

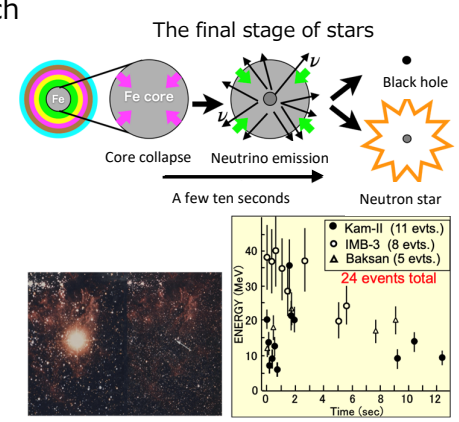


Figure 1. Supernova explosion.

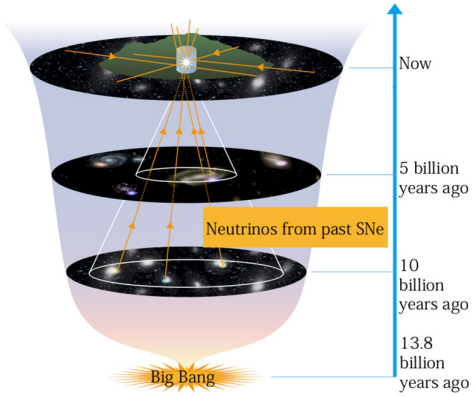


Figure 2. Supernova Relic Neutrinos

This research aims to be the first observation of 'Supernova Relic Neutrinos', which were emitted in past supernovae and now diffused through the present universe. The observations will solve several mysteries of the universe, such as when and how many stars were created, how often supernova explosions occurred, and so on.

●Super-Kamiokande

It won the Novel Prize in Physics in 2015 for the discovery of neutrino oscillations and succeeded in drastically reducing noise events by introducing gadolinium in 2020. This improvement has made the world's first observation of Supernova Relic Neutrinos a reality.

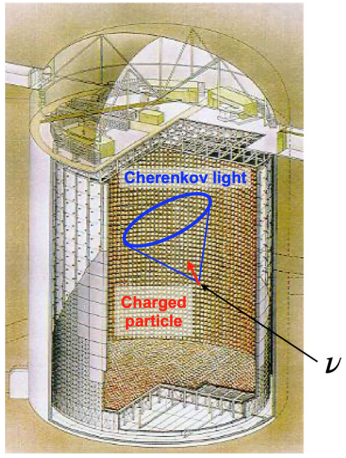
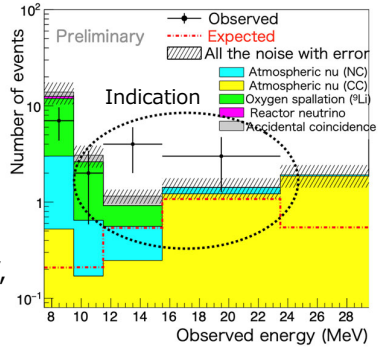


Figure 3. Super-Kamiokande

●Research status

The indication of a supernova relic neutrino was seen at the 95% confidence level using the data until 2023. It has been featured in Nature and the Journal of the Japan Academy. Next, reducing noise caused by atmospheric neutrinos is essential to turn the 'indication' into 'discovery', which is the purpose of this research.



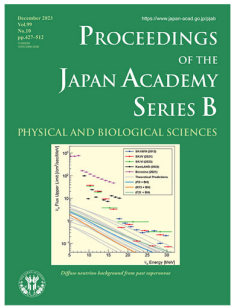


Figure 4. Latest research for Supernova Relic Neutrinos

Expected Research Achievements

●First observation of Supernova Relic Neutrinos by accelerator-based experiment!

Two topics : (1) Atmospheric neutrino background (2) Detector improvements

Reducing the uncertainties of atmospheric neutrino generation and interaction by precise accelerator measurements.

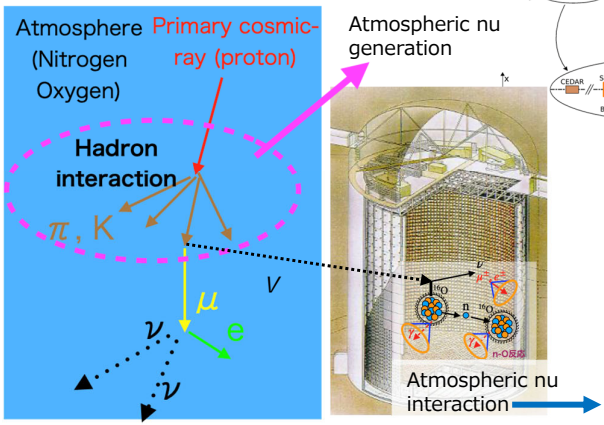


Figure 5. Atmospheric neutrino generation and interaction

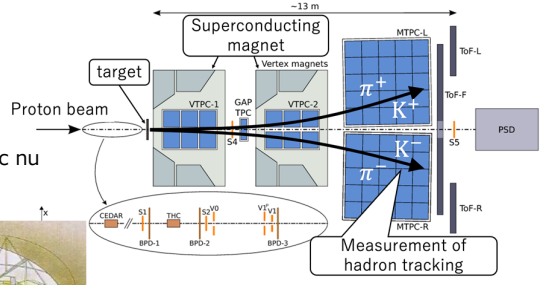


Figure 6. CERN NA61/SHINE

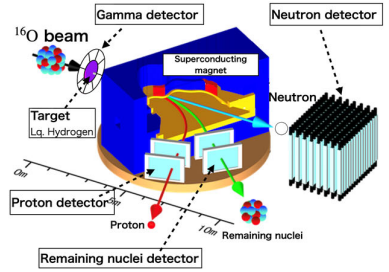


Figure 7. Riken Samurai experiment

A new filter will be installed in Super-Kamiokande to improve water quality. In addition, the machine learning method will be used to identify signals from noise.

The goal is to observe the Supernova Relic Neutrino at more than 99.7% confidence level in this research.

Figure 8. Absorption fiber (left) and filter cartridge (right)

Homepage Address, etc.	https://www-sk.icrr.u-tokyo.ac.jp/sk/ https://t2k-experiment.org/ja/ https://shine.web.cern.ch/ https://www.nishina.riken.jp/ribf/SAMURAI/overview.html