Form 8

Research Result Report
ICRR Inter-University Research Program 2022

Research Subject: Study of supernova neutrinos in Super-Kamiokande

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Summary of Research Result :

The purpose of this research is detection of the supernova neutrino in SK-Gd. There are two targets, one is neutrinos from nearby supernova explosion, the other is diffuse neutrinos from the past supernovae called 'Supernova Relic Neutrinos (SRN)'. The SK-Gd project is gadolinium (Gd) loading into Super-Kamiokande (SK) to increase inverse beta decay interactions of anti-electron neutrinos.

In 2020 summer, we've doped 13 tons of gadolinium sulfate into Super-Kamiokande, which is equivalent to 0.01% Gd mass concentration, and the SK-Gd experiment officially started. The neutron capture efficiency showed the expected performance, and the detector was operated stably. In 2022 summer, an additional 26 tons of gadolinium sulfate was introduced to the detection. (0.03% Gd mass concentration) We confirmed the delayed neutron signal using AmBe calibration source, which emits both gamma and neutron and makes mimic signal as supernova relic neutrinos. The neutron capture time is consistent with the expected value as shown in the left figure. The SK-Gd data taking is currently working well.

We are also conducting a search for SRN using data from about two years of the phase before the additional introduction. We expect to report the first results in Sk-Gd in published paper during FY2023. One of our members, M.Harada, played an important for performing the analysis, and he is now writing a paper. We also estimated the expected sensitivity of SRN in SK-Gd as shown in the right figure. The discovery will be expected within a few years though it depends on the model.

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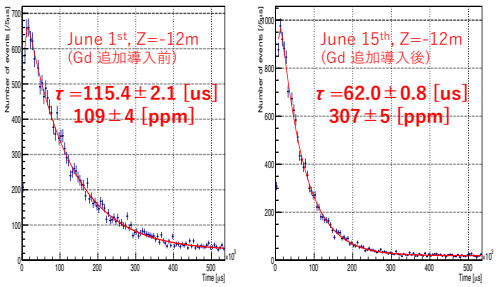
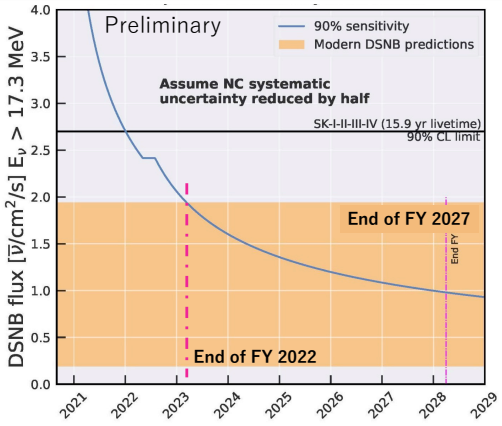


Neutron capture time by the AmBe source before (Gd 0.01%) and after (Gd 0.03%) additional Gd loading.



Expected sensitivity of SRN search in SK-Gd

Published paper

[1] K.Hosokawa et al, Development of ultra-pure gadolinium sulfate for the Super-Kamiokande gadolinium project, Progress of Theoretical and Experimental Physics, 2023, 013H01 (2023).

Presentations

(1) M.Harada, Evaluation of neutron tagging efficiency for SK-Gd experiment., ICHEP2022, Bologna, Italy, July 6-13, 2022.
(2) M.Harada, SK-Gd 実験における Gd 質量濃度 0.01%での超新星背景ニュートリノ探索、新学術「地下宇宙」第９回超新星ニュートリノ研究会 (in Japanese), Kyushu university, March 2-3, 2023.
(3) S. Sakai, SK-Gd 実験での超新星背景ニュートリノ探索における大気ニュートリノ背景事象の研究、新学術「地下宇宙」第９回超新星ニュートリノ研究会 (in Japanese), Kyushu university, March 2-3, 2023.
(4) T. Mueller, Latest results and perspectives for Super-Kamiokande, International Conference on the Physics of the Two Infinities, Kyoto university, March 27-30, 2023
(5) B.Quilain, Physics and status of the Hyper-Kamiokande experiment, International Conference on the Physics of the Two Infinities, Kyoto university, March 27-30, 2023
(6) T.Tada, Measurement of the charge ratio and the spin polarization of the cosmic-ray muons with the Super-Kamiokande. (poster), International Conference on the Physics of the Two Infinities, Kyoto university, March 27-30, 2023

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