START OF REFURBISHMENT WORK FOR SUPER-KAMIOKANDE
June 10, 2018

Overview

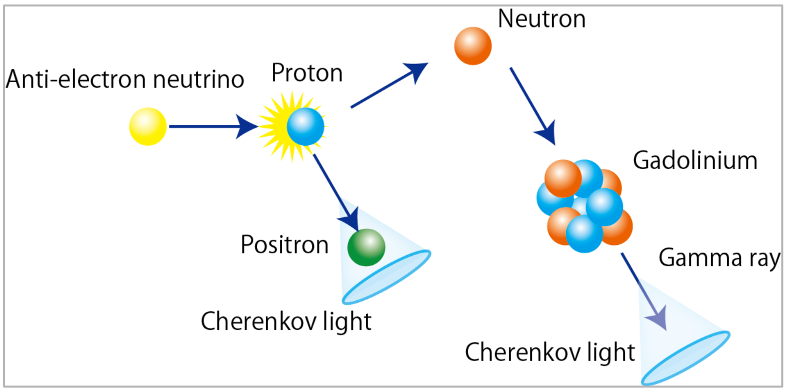
Super Kamiokande (SK) is preparing for the observation of supernova relic neutrinos emitted by all of the supernova explosions that have occurred since the beginning of the universe. Specifically, we aim to observe supernova relic neutrinos by adding gadolinium (Gd), a rare earth metal, to the pure water in the detector. For this reason, we plan on conducting refurbishment work during the period from June to September 2018, draining the water of the SK tank a little at a time as the work progresses.

Primary goal motivating refurbishment:
World's first observation of supernova relic neutrinos

In February of 1987, the Kamiokande detector, SK's predecessor, detected the world's first neutrinos from a supernova burst. Since then, no supernova explosion has occurred in or near our galaxy, so we have not observed any neutrinos from a supernova burst since then. The frequency of supernova explosions in our galaxy is rather low: once per 30-50 years. However there are hundreds of billions of galaxies in the universe, so supernova bursts are occurring once every few second in the whole universe. It is expected that the supernova relic neutrinos emitted by all of the supernova explosions since the birth of the universe to the present constitute a kind of diffuse gas which fills space; thousands of these neutrinos should pass through our hands every second, but they have not yet been detected. By observing these diffuse supernova neutrinos, we aim to understand the mechanism of supernova explosions and to clarify the history of stellar formation.

Observation method

These supernova relic neutrinos should have interacted several times a year in the SK detector, but up to now could not be distinguished from various background processes and could not be identified. By adding a substance called gadolinium, a rare earth metal, to the pure water in SK, it should become possible to distinguish these interactions. As shown in the figure, a relic supernova "anti-electron neutrino" reacts with protons in water and releases positrons and neutrons. The generated positrons emit Cherenkov light. After a short delay, the neutrons are captured by Gd and emit gamma rays; these gamma rays scatter off electrons in the water, emitting additional Cherenkov light. We are trying to distinguish supernova relic neutrinos by observing the characteristic signal of two consecutive bursts of Cherenkov light from almost the same place in the tank.



Points of this renovation

1. *Water sealing reinforcement work*

   Although it is not a problem of observation, about 1 ton of pure water leaks per day from the SK detector tank. According to previous studies, the point of leakage is believed to be at the bottom of the tank. Therefore, before dissolving Gd in the pure water of SK, we will apply waterproof material to the interior of the tank in order to stop the water leakage and to prevent water from leaking from the SK tank even if a disaster such as an earthquake occurred in the neighborhood. In particular, we will apply waterproofing agents at all welding joints of the stainless steel panels that make up the tank.

2. *Improvement of tank piping*

   Currently ultra pure water in the tank is circulated at a flow rate of 60 tons per hour. After Gd dissolution, to adjust the inside of the tank to a uniform Gd concentration as quickly as possible and to maintain high water transparency, we plan to improve the water piping and water systems so that they can process and circulate water to the tank at 120 tons per hour.

3. *Replace defective photomultiplier tubes (PMTs)*

   Since the last in-tank SK maintenance during 2005-2006, some malfunction (signal noise or light emission by internal discharge) has occurred in a few hundred PMTs out of the 13,000 in the tank. We will replace these tubes.

Future plan

(May 31, 2018: refurbishment work started)

- ~ Late June: PMT replacement work on the top of the tank, water leak prevention reinforcement work at the top of the side, piping reinforcement work at the top of the tank etc.
- Late June to August: While lowering the water level of the tank by 2 meter steps, the waterproof reinforcement work on the side, PMT replacement work
- Mid August: Pull out the rest of the tank water, the waterproof reinforcement work at the bottom. PMT replacement work
- End of September: End of work in the tank

- From the beginning of October to the middle of December: Supply ultra pure water to the tank
- Mid December: Restart of observation
- Next year or after: Gd dissolving to a concentration of 0.01% while coordinating with the data-taking period of the T2K experiment.