The planned Hyper-Kamiokande detector will consist of an order of magnitude larger tank than the predecessor, Super-Kamiokande, and will be equipped with ultra high sensitivity photosensors. The Hyper-Kamiokande detector is both a "microscope," used to observe elementary particles, and a "telescope," used to study the Sun and supernovas through neutrinos. Hyper-Kamiokande aims to elucidate the Grand Unified Theory and explain the evolution of the Universe through the investigation of proton decay, CP violation (the difference between neutrinos and antineutrinos), and the observation of neutrinos from supernova explosions. The Hyper-Kamiokande experiment is an international research project aiming to become operational in 2027.

Peering into the Universe and its elementary particles from underground

The discovery of neutrino oscillations in the Super-Kamiokande experiment in 1998, for which the 2015 Nobel Prize in Physics was awarded, led to the investigation and measurement of the properties of the neutrino which indicate the need for an update of the Standard Model. In 2001, the solar neutrino oscillation was discovered. In 2011, the T2K experiment, which used a neutrino beam from the high intensity accelerator J-PARC and the Super-Kamiokande detector, confirmed the third neutrino oscillation. Now that all neutrino oscillation modes have been confirmed, the field of neutrino research has opened up for further investigations and discoveries. Based on the highly sensitive techniques for neutrino observation developed by Super-Kamiokande over the years, Hyper-Kamiokande represents a further improvement in sensitivity. Hyper-Kamiokande consists of a cylindrical tank, with a height of 72m and a diameter of 68m. The fiducial volume of the tank is approximately 10 times larger than that of the Super-Kamiokande detector. On the tank wall, 40,000 ultra high sensitivity photosensors will be installed in order to detect the very weak Cherenkov light generated in the water. Through the realization of the Hyper-Kamiokande experiment, we will lead neutrino research into the future.
Neutrinos and Neutrino oscillations

The matter in the Universe consist of elementary particles called quarks and leptons. For example, one proton, made of three quarks, and one electron, which is a kind of lepton, form a hydrogen atom. The neutrino is a kind of lepton without electric charge and exists in types; electron neutrino, mu neutrino and tau neutrino. The three types of neutrinos mix with each other and can change their type. This phenomenon is called “Neutrino oscillation” and was discovered by Super-Kamiokande in 1998. The detailed study of neutrino oscillation enables us to reveal the properties of neutrinos.

The Standard Model, which describes the elementary particle system, seemed to be completed by the discovery of the Higgs boson particle. However, the information about neutrino mass and its mixing rate obtained by previous studies have a large difference from those of quarks. It is considered that a more fundamental framework is needed beyond the Standard Model.

Neutrino oscillation experiments are expected to be a key to address what the fundamental framework of elementary particles is.