Abstract for Hadron Physics Summer School 2018

Designing a Multipurpose Neutrino Detector

Livia Ludhova[1,2], Zara Bagdasarian[1], Yaping Cheng[1]
[1]IKP-2 Forschungszentrum Jülich D-52425 Jülich, Germany
[2]RWTH Aachen University, 52062 Aachen, Germany

In recent decades we came from the discovery of elusive neutrino in 1956 to discoveries in physics using neutrinos. Neutrino physics has been a booming field rewarded by four Nobel Prizes: in 1988, 1995, 2002, and 2015. Various detector techniques have been used for the neutrino detection, depending on the objectives of the particular experiment.

Liquid scintillator detectors allow for achieving low-energy threshold, due to the high light yield, crucial for detection of solar neutrinos and antineutrinos. The achievements of liquid scintillator experiments range from the confirmation of neutrino existence (Hanford), through the first observations of neutrino oscillation pattern (KamLAND), spectroscopy of neutrinos from the primary fusion process in the Sun (Borexino) and discovery of non-zero value of θ_{13} mixing angle (Double Chooz, Daya Bay, RENO).

However, due to the isotropic nature of scintillation light, the angular resolution is not a strong suit of liquid scintillators. Here is where water Cherenkov detectors come into play: particles moving faster than light in water leave the cone-like Cherenkov light, allowing for reconstruction of directional information. Water Cherenkov experiments have proved, most famously, the mechanisms of neutrino flavour conversion and oscillations (SNO, SuperKamiokande), and have achieved a high precision for the higher energy part of solar neutrino spectrum (due to the feasibility of big volumes). The disadvantage of the water Cherenkov technique is that due to the low light yield, the energy threshold cannot be lower than 4-5 MeV.

The next generation of neutrino experiments relies on the massive, high-precision detectors (e.g. water Cherenkov HyperKamiokande and liquid scintillator JUNO). Furthermore, the water-based liquid scintillator may offer a unique combination of advantages of both technologies (e.g. THEIA). By tuning relative ratios of water and liquid scintillator, one could obtain high light yield and thus low detection threshold, together with the possibility to preserve information about the directionality. As a result, a large-scale water-based liquid scintillator can address unprecedentedly wide physics goals.

In this working group, you will learn the fundamentals of neutrino physics and its detection technologies, as well as the perspective for future experiments in the field of solar, geo and reactor neutrinos.