The year 2014 will mark the 60th anniversary since the neutrino detector of Frederick Reines and Clyde L. Cowan, Jr. was turned (neutrino detection in 1956). After many years, Super-Kamiokande [1] showed in 1998 that neutrinos are massive. Today, neutrino physics has become a very active research field: there is a plethora of different neutrino experiments and theoretical studies. Subsequent measurements [2–6] of the two neutrino mass squared differences and the leptonic mixing parameters lead to a phase of precision experiments in neutrino physics. Recently the last remaining mixing angle, the 1–3 mixing angle, has been measured by the Daya Bay [7, 8], Double Chooz [9, 10], and RENO [11] experiments after initial hints by T2K [12] and MINOS [13, 14]. Contrary to theoretical expectations from flavor symmetry considerations, it turned out to be large.

The next main goals of the experimental program are the measurement of the mass hierarchy and the Dirac CP phase, which is facilitated by the relatively large 1–3 mixing angles. These measurements will help to pin down the theoretical origin of neutrino mass and mixing, for example, confirming or refuting the idea of a flavor symmetry in the lepton sector. Additionally precision measurements of neutrino properties will also permit using neutrinos as a tool for probing new physics connected with neutrinos, like dark matter or dark energy. There are a huge number of ongoing and upcoming neutrino experiments worldwide studying these issues.

To celebrate the 60th anniversary of the first neutrino detector, we have collected original research articles as well as review articles for this special issue focusing mainly on physics at underground detectors and its complementary studies at the LHC to uncover the nature of neutrinos as well as physics beyond standard model.

The article “The low-scale approach to neutrino masses” by S. M. Boucenna et al. provides a short review on low-scale models of neutrino mass generation including the phenomenological potential signatures associated with direct neutrino mass messenger production at the LHC, messenger-induced lepton flavor violation processes, and the presence of WIMP cold dark matter candidates.

The article “Beyond standard model searches in the MiniBooNE experiment” by Teppi Katori and Janet Conrad provides a review on the contribution of the MiniBooNE Experiment to beyond standard model searches in the neutrino sector. MiniBooNE observed excesses of $\nu_e$ and antineutrino $\bar{\nu}_e$ candidate events in neutrino and antineutrino mode, respectively. To date, these excesses have not been explained within the neutrino Standard Model, the Standard Model extended by three massive neutrinos. The results set for the first time strict limits on Lorentz violating extensions of the Standard Model. Most recently, MiniBooNE is running with a beam tuned in beam-dump mode to search for dark sector particles.

The article “Searching for neutrinoless double-beta decay of $^{130}\text{Te}$ with CUORE” by D. R. Artusa et al. provides a review on the experimental techniques used in Cryogenic Underground Observatory for Rare Events (CUORE), its current status, and anticipated physics reach. CUORE is an upcoming experiment designed to search for neutrinoless double-beta decay of $^{130}\text{Te}$ using an array of 988 TeO$_2$ crystal bolometers operated at 10 mK. The detector will contain 206 kg of $^{130}\text{Te}$ and have an average energy resolution of 5 keV. The projected half-life sensitivity after five years of live time is $1.6 \times 10^{25}$ y at 1 $\sigma$ ($9.5 \times 10^{25}$ y at the 90% confidence
The papers included in this special issue cover a small number of the diverse issues in neutrino physics. We are certain that the short reviews on different aspects in neutrino physics will help new researchers and the original research articles will have an impact on the future development of neutrino physics.

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References


