

One of the biggest mysteries in modern science is understanding what makes up our Universe and why it looks the way it does. Neutrinos are among the most mysterious particles in Nature. They are incredibly light, barely interact with anything, and pass through us by the hundreds of billions every second without being noticed. Scientists believe that if we can understand neutrinos better, we may find answers to some of the most fundamental questions in physics.

A very rare nuclear decay, called neutrinoless double beta decay, could help to solve the neutrino mystery. If this process exists, it will prove that neutrinos are their own antiparticles, the so-called Majorana particles. It would also show that one of the basic rules of physics – the conservation of lepton number – can be broken. Most excitingly, it could help us to understand why the Universe is made mostly of matter, and not an equal mix of matter and antimatter.

The LEGEND experiment is a large international project aiming to find the neutrinoless double beta decay. It uses extremely sensitive detectors made of germanium enriched in Ge-76, an isotope in which the process may occur. Germanium crystals are immersed in liquid argon, which cools them down and blocks the unwanted local radioactivity. The germanium detectors are placed deep underground (1300 m under the mountain) to shield them from cosmic radiation. The experiment is being built in two stages: LEGEND-200 (200kg of germanium), which is already taking data, and LEGEND-1000 (1000 kg of germanium), currently under construction.

Crucial problems in the LEGEND experiment are to identify and to reduce background signals that mimic neutrinoless double beta decay but originate from different sources, for instance radioactive decays. A crucial method to distinguish signal from background is Pulse Shape Discrimination (PSD), a method that looks at the shape of electrical signals in the detector. These techniques are also being improved today using machine learning, a form of artificial intelligence. Within this project PSD methods will be developed to identify and reject the alpha decays. Alpha decays originating from residual contaminations of germanium detectors are one of the main background sources in the LEGEND-200 detector. Minimization of the alpha background contaminations would improve the overall sensitivity of the LEGEND detector and bring us closer to the potential discovery of the neutrinoless double beta decay.