Abstract

The existence of dark matter in the universe is one of the most intriguing components. The evidence for dark matter ranges from galactic to cosmological scales, from its indirect effects. Weakly Interacting Massive Particles (WIMPs) are considered one of the leading candidates for dark matter, with most direct searches consisting of underground-based experiments. The work of the present thesis will focus on the DarkSide program.

For rare event search experiments, highly pure target materials are needed to reach the required sensitivity. For the case of the DarkSide collaboration, argon was used in the DarkSide-50 (DS-50) experiment. (Add pulse shape discrimination, cost/scaling up, easy to purify)The argon was transported from Colorado (US) to LNGS (Italy) by shipping and aerial transport. Due to the interaction of cosmic rays with the liquid argon, an impurity of ^{37}Ar was produced, which was present in the setup of DS-50. This study involves determining the activation of ^{37}Ar using DS-50 data and is compared with the production estimation of ^{37}Ar during transport. The results from both measurement and estimation agree within 1 σ. The results from DS-50 ^{37}Ar measurements are crucial for validating the cosmic activation estimates of ^{39}Ar and for future detectors.

Cosmogenic muons can produce backgrounds in underground detectors. It can produce high-energy neutrons or neutron sources by interacting with the experimental setup or the laboratory materials. Due to their nature neutrons can penetrate the DS-20k shielding and create a WIMP-like event. To assess the impact of these backgrounds, a comprehensive study was performed using FLUKA simulation to model the cosmogenic muon backgrounds in the detector. A series of physics selection cuts were applied to reject the background. A correlation study of events in the TPC and outer detector was also performed. This study provides useful information regarding veto selection cuts optimization for DS-20k.

The DarkSide-20k experiment, currently under construction at Gran Sasso National Laboratory (INFN-LNGS, Italy), will use a dual-phase liquid argon time projection chamber (LAr-TPC). The DS-20k is designed to achieve very high sensitivity and is built on the success of the DarkSide-50 experiment. For this type of experiment, suppression of background noise is very important to have a sensitive detector. To achieve this, DS-20k will use a set of cryogenic silicon photomultipliers (SiPMs), and a sophisticated neutron veto - critical to the performance of DS-20k. Therefore, it is of utmost importance to develop, and test, Veto PhotoDetection Units (vPDUs) capable of reaching the desired

performance (while detecting individual photons). Strict Quality Assurance and Quality Control (QA/QC) measures have been implemented to minimize potential sources of background noise. Two vPDUs were tested at CEZAMAT, bench-marking the setup for further testing of vPDUs. Various tests were performed on the vPDUs, including the calculation of breakdown voltages ($\sim$54 V), shining the LED on the vPDUs to produce photoelectron peaks (distinct photo-electron peaks), measuring the dark count rate (< 0.1 Hz/mm^2), and signal to noise ratio ($<$8). The results produced from vPDUs are within the requirements of the DS-20k specifications.