M2 internship - PhD thesis

LPC Caen – UMR 6534, ENSICAEN, Université de CAEN

Study of atmospheric neutrino oscillations with the KM3NeT/ORCA neutrino telescope

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The neutrino is one of the most enigmatic ingredient of the standard model of particles physics. Despite significant experimental progress and because of its weak interaction with matter, its nature and its fundamental properties remain unknown: Dirac/Majorana, CP violation, mass hierarchy, absolute mass scale, other flavors… However, the neutrino is already being used as a new astrophysical probe. Indeed, given their tiny interaction cross-section, neutrinos travel cosmological distances without being deviated from their initial trajectory and are therefore excellent messengers. The KM3NeT (Cubic Kilometer Neutrino Telescope) project is in line with these topics, with a program dedicated to the determination of the fundamental properties of the neutrino on the one hand and to the mapping of high energy cosmic neutrino sources on the other hand.

The KM3NeT detector is a neutrino telescope installed in the Mediterranean Sea **[1-2]**. Once construction is completed, KM3NeT will consist of two sites: ARCA (Astroparticle Research with Cosmics in the Abyss), optimized for high-energy neutrino astronomy, and ORCA (Oscillations Research with Cosmics in the Abyss) for the study of atmospheric neutrino oscillations. Each site will comprise an array of several hundred vertical detection units immersed at a depth of more than 2000 m. Each detection unit consists of 18 optical modules spaced along its entire height, allowing the detection of Cherenkov light emitted by charged particles produced by the interaction of neutrinos with matter. They will constitute instrumented volumes of several megatons and will allow the observation of several thousand neutrino events per year. To date, about ten lines have been installed and data collection has already begun.

The proposed research topic will consist of the analysis of the experimental data from the ORCA component. It will involve the development of events reconstruction methods. First, the contamination of the detector background, composed of atmospheric muons, the disintegrations of the 40K contained in seawater as well as bioluminescence, will have to be properly identified and rejected. Then, the properties of the neutrinos (flavor, energy and direction) will have to be reconstructed using classification algorithms. The analysis work will be concentrated on the development of this data analysis chain, coupled with numerical simulations. Ultimately, the research topic will focus on the study of the oscillation mechanism of atmospheric neutrinos in order to provide new constraints on the PMNS mixing matrix.

The candidate, with an M2 level in subatomic physics, should have received training in nuclear physics, particle physics and radiation-matter interactions. He (she) should relish programming and analyzing data. He (she) should also possess a good editorial level and master English to be able to work within an international collaboration. This thesis will offer a complete training of

experimental physicists in fundamental physics (neutrino) as well as broader skills in simulation and data analysis.

[1] https://www.km3net.org/
[2] Letter of Intent for KM3NeT 2.0, Journal of Physics G: Nuclear and Particle Physics, 43 (8), 084001, 2016 [arXiv:1601.07459].

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