Study of atmospheric neutrinos with the deep-sea Cherenkov detector KM3NeT/ORCA

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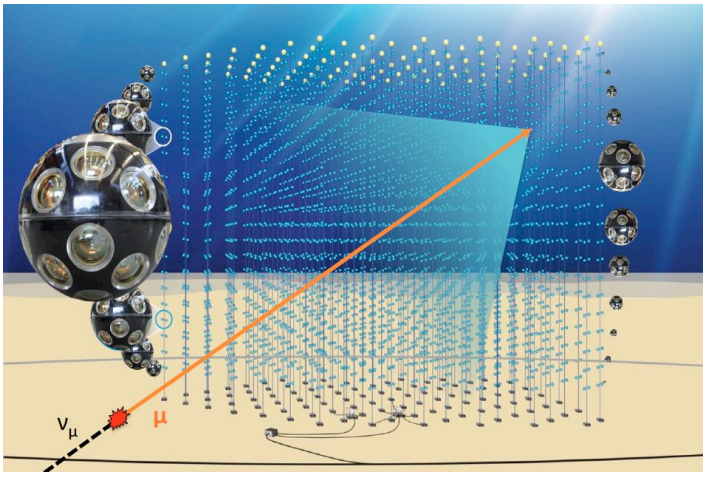
Ph. D project proposed by the ANTARES/KM3NeT group at Laboratoire Astroparticules et Cosmologie (APC)



ORCA (Oscillation Research with Cosmics in the Abyss) is the low-energy branch of KM3NeT [1], the next-generation neutrino Cherenkov detector currently being built in the Mediterranean Sea with the aim of measuring the neutrino mass ordering and searching for high-energy cosmic neutrino sources. The ORCA detector will consist of a network of 115 vertical strings supporting optical modules, anchored on the seabed off the shore of Toulon, France (see figure right).

ORCA will focus on the study of atmospheric neutrino oscillations in the energy range 1-100 GeV, with Mton of instrumented seawater. The detector construction has already started and is expected to be completed by 2021. The first detection line, connected in September 2017, is already providing data and more lines are expected to be deployed in the upcoming months.

Due to coherent forward scattering on electrons, the flavour oscillations of atmospheric neutrinos propagating through the Earth matter are modified with respect to vacuum oscillations: this is known as the MSW effect, which has proven to be an important ingredient in our global picture of neutrino oscillations. A precise measurement of this effect, based on the angular, energy and flavour distribution of neutrino interactions in ORCA, could allow the determination of the neutrino mass hierarchy (see figure right). This still unknown parameter is crucial for the interpretation of the neutrino fundamental properties in a global frame possibly involving physics beyond the Standard Model. The KM3NeT-ORCA team at APC is actively participating to the simulation studies assessing the performances of ORCA with respect to the NMH measurement and to exotic models possibly involving sterile neutrinos.

This Ph.D. project aims more specifically at studying and characterizing the down-going atmospheric neutrino flux as detected by ORCA. A precise measurement of its energy spectrum and flavor content is indeed crucial for controlling the systematics affecting the measurement of the NMH and for an efficient rejection of the background of down-going muons. This goal will e.g. require the development (on basis of simulations) of new event selection and reconstruction tools, that will be tested on real data. The candidate will participate to the effort of optimization and improvement of the software framework developed at APC for the determination of the ORCA sensitivity to the NMH, as well as for Earth tomography studies. She/he will take part in the commissioning and analysis of the first data recorded by the detector. The project may also include instrumental activities related to the development and the exploitation of the APC test benches for the characterization of multi-PMT optical modules for ORCA.

The applicant's research activities will be carried out within the ANTARES/KM3NeT group at APC and in tight link with other French and European research groups participating to the KM3NeT Collaboration. Through his work, she/he will become familiar with state-of-the-art questions in neutrino physics, while acquiring experience in programming (C++, ROOT, python, databases…) and in the statistical methods necessary to her/his project. The technical aspects of the project will also provide insight into detector devices (in particular photomultipliers) widely used in contemporary (astro-)particle physics.

[1] S. Adrián-Martínez et al. [KM3NeT Collaboration], *Letter of Intent for KM3NeT Phase 2*, J. Phys. G43 (2016) no.8, 084001