# Neutrino Oscillation Studies with KM3NeT/ORCA

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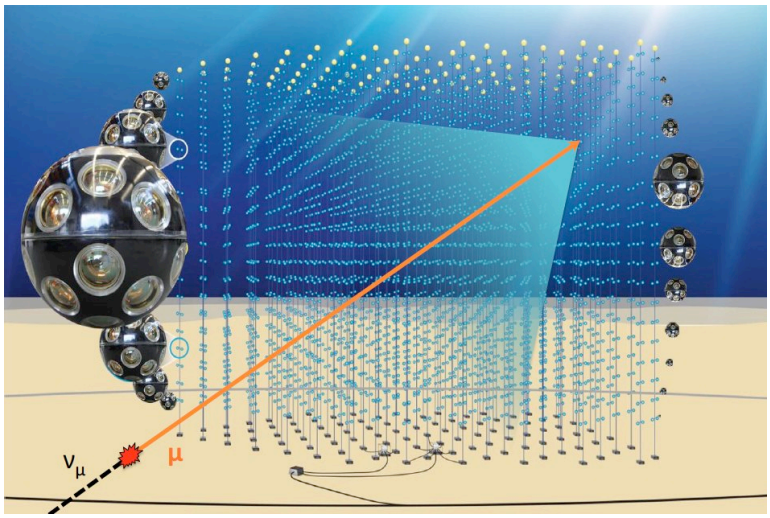
## Master internship project proposed by the KM3NeT group at Laboratoire Astroparticules et Cosmologie (APC)

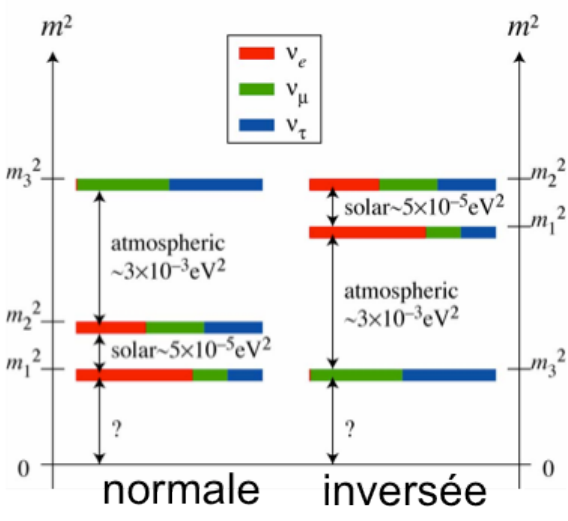
ORCA (Oscillation Research with Cosmics in the Abyss) is the low-energy branch of KM3NeT, the next-generation neutrino Cherenkov detector currently being built in the Mediterranean Sea with the aim of measuring the neutrino mass ordering and searching for high-energy cosmic neutrino sources [1]. The ORCA detector will consist of a dense configuration of 115 vertical strings with an horizontal spacing of 20m, anchored on the seabed off the shore of Toulon, France (see figure left). Each string supports 18 digital optical modules with a vertical spacing of 9m. With this configuration, ORCA will focus on the study of atmospheric neutrino oscillations in the energy range 1-100 GeV, with 5.7 Mton of instrumented seawater. The cable and main junction box for the ORCA detector are already installed on the seabed and the first detection 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.

We propose a master internship (M1 or M2, adaptable to the level of the candidate) to perform sensitivity studies with the ORCA simulation chain developed at APC (and possibly validate it with available data from the prototype). The candidate will participate to the effort of optimization and improvement of the simulation code. Through this work, he/she will become familiar with state-of-the-art questions in neutrino physics, while acquiring some experience in programming (C++, ROOT, databases…) and in the statistical methods necessary to his/her project.




The KM3NeT neutrino Cherenkov detector




The neutrino mass hierarchy: normal or inverted

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