Integration of the muon veto and evaluation of its performance to the cosmogenic noise in the JUNO neutrino experiment

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The neutrino is a neutral particle interacting only through the weak interaction. It shows up today as the messenger of new physics beyond the Standard Model. Indeed, in this theory, this elementary particle is considered massless which runs counter to the experimental observation of neutrino oscillations, which is only possible if the neutrino masses are different. The observation of this phenomena constitutes a fundamental advance in particle physics, and awarded the 2015 Nobel prize to two experiments, Super-Kamiokande and SNO, which significantly contributed to this discovery.

Since this discovery in 1998, several experiments have studied this phenomena however there are still some parameters that haven't been measured yet. One of these unknown parameters is linked to the neutrino mass ordering, that is which of the neutrinos ν_1 (composed of mostly ν_e) or ν_3 (composed of a mix of ν_μ and ν_τ) is the lightest. The determination of this ordering could be essential to understand by which mechanism the neutrinos gets its mass and also to check expansion models of the Universe.

The JUNO (Jiangmen Underground Neutrino Observatory [1]) experiment's main goal is to answer this question. It is expected to reach a sensitivity of more than 3 σ to measure the neutrino mass ordering after 6 years of data taking. JUNO will also make it possible to precisely measure several parameters of the neutrino mixing matrix which will allow us to start testing its unitarity. JUNO will also perform measurements on geo-neutrinos, solar neutrinos, atmospheric neutrinos, and supernovae neutrinos. The construction of the experimental hall in southern China has started, and the detector construction is expected to start in 2018 with data taking starting at the end of 2020.

JUNO is an international experimental collaboration, regrouping 71 institutions all around the world. The experiment will use neutrinos from many nuclear power plants with a total power of 36 GW. The detector will be at 53 km from the cores of the reactors, and the target will be made of a liquid scintillator making it possible for us to detect electron anti-neutrinos emitted by the reactor cores. The scintillation light will be collected by about 17000 20 inch photomultiplier tubes (PMT) and 25000 3 inch photomultiplier tubes. The central detector, composed of the liquid scintillator inside an acrylic sphere, will be surrounded by a water pool equipped of PMTs – making a Cherenkov detector – that will identify atmospheric muons inducing cosmogenic background. An additional detector, the Top Tracker, will be installed above the central detector and the water pool to further identify atmospheric muons.

The Strasbourg group will use the Target Tracker of the OPERA experiment as the Top Tracker (TT) of JUNO. This fundamental part of the OPERA detector was fully IPHC's responsibility (construction, installation and data analysis). This contribution makes it possible for the IPHC group to have great visibility and have an essential role within the JUNO collaboration. OPERA's Target Tracker is currently in China, and will be installed in top of the JUNO detector. Changes to the electronic cards and acquisition system of the TT will have to be made as the counting rate expected is significantly larger than for OPERA. This work is taking place by the Strasbourg group in collaboration with other laboratories. The Strasbourg group will take part in the TT data analysis, particularly through the simulation, track reconstruction and estimation of background noise for JUNO.

The goal of this Ph.D. thesis is to optimize the Top Tracker before its foreseen installation in 2019, optimize the simulation and track reconstruction software, and then determine the TT performance to reduce the cosmogenic background noise and estimate its impact to JUNO's systematic uncertainties. In parallel to the work on the analysis, the student will join the testing of the new electronics for the TT.

[1] JUNO website: http://juno.ihep.cas.cn