Tuning the JUNO Top Tracker Simulation using the Top Tracker Prototype

The experimental observation of neutrino oscillations was an essential discovery at the end of the last century. This discovery demonstrated that neutrinos have a non-zero mass in disagreement to the expectation from the Standard Model of Particle Physics.

Neutrino oscillations are described by the PMNS mixing matrix (parametrized by 3 mixing angles and 1 CP violating phase) and the squared mass difference between the different mass states. Since the discovery of neutrino oscillations several of those parameters have been measured, however there are still two unknowns: the CP violating phase and the neutrino mass ordering, that is which neutrino is the lightest. JUNO [1] is currently in construction in China with its main goal to measure the neutrino mass ordering using reactor neutrinos.

The JUNO detector is composed of 3 different parts: the Central Detector (CD), the Water Cherenkov Detector (WCD), and the Top Tracker (TT). The CD is the part of JUNO where neutrinos are measured, while the TT and WCD are part of the Veto System of JUNO that is designed to identify and suppress the external backgrounds.

One of the main backgrounds in JUNO, to measure reactor neutrino oscillations, is cosmogenic isotopes produced in JUNO's CD by the passage of atmospheric muons. The difficulty of rejecting these events comes from the fact that, from the detector point of view, they have the same characteristics as neutrino interactions. In order to effectively reject them, it is necessary that we track almost all atmospheric muons crossing the CD and then reject events looking like neutrinos that are correlated in space and time to these muons. One key component in this strategy is the TT.

The TT is a plastic scintillator detector placed on top of the WCD, which surrounds the CD, to track atmospheric muons passing through it's volume. The IPHC is one of the leading contributors to the TT – historically, the TT was built at IPHC for the OPERA experiment, and after the end of OPERA it is being re-purposed to be used in JUNO. In order to be able to use the TT in JUNO it was essential to design new electronics cards capable of accepting the expected rate in JUNO. The IPHC has played an essential part in their development.

At IPHC we also have a prototype of the detector, built with the same parts as the TT but in a smaller scale. This prototype is essential to test the new electronics in a more realistic condition. In addition to that, the prototype will permit us to tune the JUNO simulation and reconstruction using data before the full detector is assembled. It can also be used to measure the atmospheric muon flux locally.

In this internship the student will be led to take and analyse data from the TT prototype in Strasbourg. This data will then be used to validate and improve the JUNO simulation. The data will also be used to measure the atmospheric muon flux at Strasbourg and through that to measure experimentally the precision of this device, which can then be compared to the expected precision.

[1] F. An *et al.* [JUNO Collab.], J. Phys. G **43** (2016) no.3, 030401 [arXiv:1507.05613].

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