Joint France-Japan PhD thesis proposal

Search for charge-parity (CP) violation in neutrino oscillations and upgrade of the T2K Near Detector

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PhD thesis co-directors:

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The T2K experiment is a long-baseline neutrino oscillations experiment, currently taking data in Japan. T2K has been the first experiment to detect the appearance of electron neutrinos in a muon neutrino beam and is currently searching for CP violation in the lepton sector by precisely measuring appearance probabilities of neutrinos and antineutrinos. Such measurement requires both, larger statistics and a better understanding of systematics uncertainties. In order to improve the latter, an upgrade of the T2K Near Detector, ND280, is being conducted and is expected to significantly reduce the impact of systematics uncertainties on T2K oscillation analyses. The proposed PhD thesis will be centered around the ND280 upgrade project that is coordinated by researchers from LPNHE (Claudio Giganti) and University of Tokyo (Masashi Yokoyama). The PhD candidate will work under the supervision of Marco Zito and Claudio Giganti in France and of Masashi Yokoyama during his/her stay in Japan.

The ND280 upgrade will consist in replacing one of the sub-detectors, the P0D, the most upstream inner detector of ND280, with two horizontal TPCs and a horizontal fully active carbon target in the middle (Super-FGD). Six Time-Of-Flight (ToF) planes will be installed around the TPCs and the Super-FGD.

These detectors are being constructed and will be assembled, mostly at CERN, in 2020 and 2021 before being shipped to Japan in the second half of 2021. The installation and commissioning will be carried out at J-PARC and we expect to start the data taking with the upgraded J-PARC beam in 2022. The PhD candidate will then participate to all the phases of

the project and it is expected that he/she will be based at J-PARC and Univerity of Tokyo for at least one year during the installation and the commissioning of the detectors in Japan.

Sharing common expertise between French and Japanese groups will guarantee full support and guidance to the PhD student who will spend a significant fraction of time at the University of Tokyo, thus profiting from exciting and stimulating environment of both laboratories.

The proposed research plan is as follows.

During the first year he/she will participate to the analysis of test beam data of both, the new TPCs and the Super-FGD, will develop reconstruction algorithms for these detectors and will integrate the reconstruction in the already existing ND280 software framework. He/She will also participate to the work on the neutrino cross-section models in order to reduce the systematics uncertainties in the on-going T2K oscillation analysis.

During the second year, the PhD student will be mostly based in Japan and will participate to the installations of the detectors, their commissioning with cosmic rays and the analysis of the first data collected with the ND280 upgraded detector that is expected to start observing neutrino interactions from the J-PARC neutrino beam in 2022.

The third year of the PhD will be devoted to the analysis of the ND280-upgrade data, to the inclusion of these data in the T2K oscillation analyses and, of course, to the timely preparation of the PhD manuscript.

In addition, the T2K collaboration is currently working on the combination of the oscillation analysis with Super-Kamiokande and NOvA. Thanks to this combination it will be possible to boost the sensitivity to both, CP violation and neutrino mass ordering, with the already existing data. The PhD student is also expected to participate to this effort.

Finally, starting from the beginning of 2023 the student will focus on the preparation of the PhD manuscript with an expected defense in September 2023.