DESIGN AND PERFORMANCES OF NEUTRINO SUPERBEAMS AT THE EUROPEAN NEUTRON SPALLATION SOURCE.

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The discovery of neutrino oscillations is up to now the only proof of a new physics beyond the Standard Model. The mixing angles of the PMNS (Pontecorvo-Maki-Nakagawa-Sakata) matrice have been measured with some precision, but many questions remain unanswered and the next step will be, in particular, to explore matter/antimatter asymmetry in the leptonic sector. Although the mass squared differences of the neutrinos are measured, their ordering (normal or inverted) still remains unknown. Since neutrinos take part in the dynamics of numerous phenomena at several scales (solar fusion reactions, supernova explosion, …), they might play an important role in the early universe, depending on some properties which remain to be discovered.

Long baseline neutrino experiments using accelerators are being developed to meet these different challenges. In this context, the European Spallation Source [1] will use a proton linear accelerator with a power of 5 MW and thus will offer an unique opportunity to build the most powerful neutrino superbeam in the world. The ESSnuSB project (http://essnusb.eu/), whose the main objective is to study the matter/antimatter asymmetry in the Universe in the leptonic sector, has demonstrated its feasibility by upgrading this European facility and has proven that the measurement of the δ_{CP} phase within a precision of 8° is achievable [2]. The objective of the next phase of the project, called ESSnuSB+, will be to extend the ESSnuSB physics program, in particular, to the study of sterile neutrinos and to the measurement of neutrino cross sections.

Our institute is responsible for the design of the target station which is the key element for the production of the neutrino beam. The protons coming from the linear accelerator will be sent to a solid titanium target equipped with a hadronic collector which will focus the pions on an extraction device located at the interface between the target station facility and a decay ring. The neutrino beam will be produced by the decay in flight of muons resulting of pion decay in the ring.

To optimize the parameters of these devices, it will be necessary to simulate all the interaction processes in the target and propagate the particles until their decays. Depending on the intensity and energy spectrum obtained, it will be necessary to study the repercussions on the physics to be extracted.

The goal of this PhD thesis will be to participate in these simulations to obtain the most optimal design for the various physics objectives under consideration.

Bibliography:

[1] A. Alekou et Al, « **The European Spallation Source neutrino super-beam conceptual design report** », *Eur.Phys.J.ST* 231 (2022) 21, 3779-3955 ;
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[2] A. Alekou et Al, « **The ESSnuSB design study: overview and future prospects** », arXiv:2303.17356 **;** DOI : https://doi.org/10.48550/arXiv.2303.17356