PROCEEDINGS OF SCIENCE

Updates on the ESSνSB Target Station potentialities for CP violation discovery.

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The ESSνSB project proposes to use the very intense proton beam of the European Spallation Source (ESS) to produce a relatively low energy neutrino super beam. This will allow to reach the second maximum in the neutrino oscillation probability few hundreds of kilometers away from the target station, improving the sensitivity for the discovery of CP violation in the leptonic sector in the channel $\nu_\mu \rightarrow \nu_e$ compared with the first maximum. We present here a parametric study on the magnetic horn and the decay tunnel in order to improve the discovery potential of the project and its precision on the measurement of the value of δ_{CP}.

40th International Conference on High Energy physics - ICHEP2020
July 28 - August 6, 2020
Prague, Czech Republic (virtual meeting)

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PoS(ICHEP2020)218

1. The ESSνSB project

The ESS Neutrino Super Beam (ESSνSB) [1] is a European project of neutrino super beam which proposes to use the ESS [2] linac to deliver a 5 MW and 2.5 GeV kinetic energy proton beam. The beam is first sent to an accumulator ring in order to reduce the pulse duration from 2.86 ms to less than 1.5 μs and then shared between the four targets embedded each in a magnetic horn. The secondary particles produced in the targets, essentially charged pions, will then be focused by the magnetic field of the horn induced by a 350 kA current and reach the decay tunnel where they will decay into neutrinos. This neutrino beam will then be measured 540 kilometers away with a megaton Water Cerenkov detector.

2. The target station

The target station of ESSνSB is made of four major elements : the four magnetic horns, type van der Meer (Figure 1), supplied by a 350 kA pulsed current; the four packed-bed targets, 78 cm long and 1.5 cm radius each, made of 3 mm diameter titanium spheres; the 25 m long decay tunnel; the one-block graphite beam dump located at the end of the decay tunnel to stop the remaining hadrons. In the next section we will present a parametric study of the magnetic horn and the decay tunnel dimensions to improve the physics performances of ESSνSB.

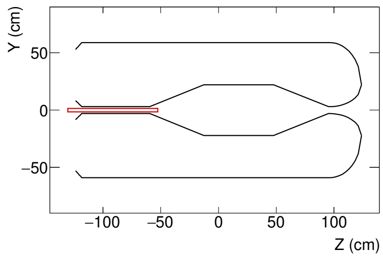

Figure 1: The shape of the ESSνSB magnetic horn.

3. A parametric study for the physics optimization of the target station

For this study, neutrino fluxes were generated with Geant4 [3–5] and used in GLoBES software [6, 7] to produce the sensitivity plots. The first study done is the influence of the current delivered to the horn on the physics performances. Figure 2 shows that an increase of the current would allow to discover CP violation in a widest range of values for δ_{CP} and give a better precision on the measurement of δ_{CP}. However, 350 kA is found to be a good compromise from the technical point of view. Then, an optimization of the dimensions of the horn and of the decay tunnel has been performed. In this study, we focus on "global" parameters of the horn, considering only the total length of the horn (L_{TOT}), its total radius (R_{TOT}) and a parameter called here scale factor (SF) which is a combination of the two previous parameters. We can see on Figure 2 that reducing by 5% the dimensions of the horn compared with the current baseline can give an improvement in the measurement of δ_{CP} for a true value of -90° (maximum CP violation). Finally, an increase of the length of the decay tunnel from 25 meters to 50 meters will allow more pions to decay and will improve the sensitivity, even if more muons will decay and bring a contamination to the beam.

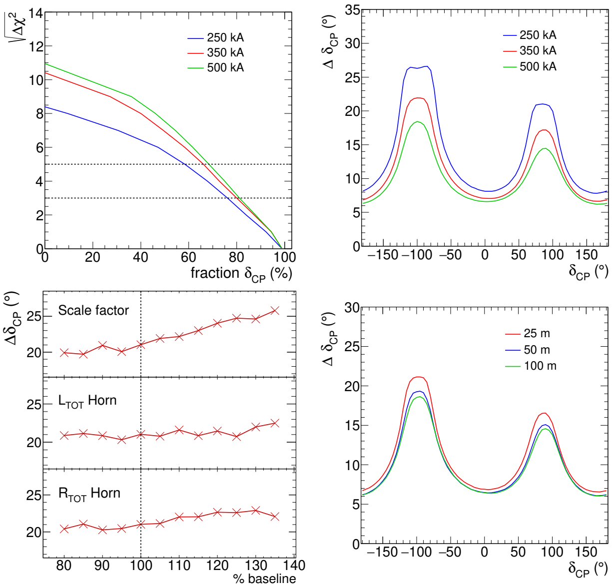

Figure 2: Fraction of δ_{CP} covered and precision on the measurement of δ_{CP} at 540 km for different values of the current (upper panels), horn parameters (bottom left) and tunnel length (bottom right).

Acknowledgments

This work is supported by the COST Action CA15139 "Combining forces for a novel European facility for neutrino-antineutrino symmetry-violation discovery" (EuroNuNet) and the European Union's Horizon 2020 research and innovation program under grant agreement No 777419.

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