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Physics potential of the ESSnuSB

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The ESSνSB project proposes to base a neutrino "Super Beam"of unprecedented luminosity at the European Spallation Source. The original proposal identified the second peak of the oscillation probability as the optimal to maximize the discovery potential to leptonic CP violation. However this choice reduces the statistics at the detector and penalizes other complementary searches such as the determination of the atmospheric oscillation parameters, particularly the octant of θ23 as well as the neutrino mass ordering. We explore how these shortcomings can be alleviated by the combination of the beam data with the atmospheric neutrino sample that would also be collected at the detector. We find that the combination not only improves very significantly these drawbacks, but also enhances both the CP violation discovery potential and the precision in the measurement of the CP violating phase, for which the facility was originally optimized, by lifting parametric degeneracies. We then reassess the optimization of the ESSνSB setup when the atmospheric neutrino sample is considered, with an emphasis in performing a measurement of the CP violating phase as precise as possible. We find that for the presently preferred value of δ ∼-π/2, shorter baselines like that with the Zinkgruvan detector site (360km) and longer running time in neutrino mode would be optimal. In these conditions, a measurement better than 14° would be achievable for any value of the θ23 octant and the mass ordering. Conversely, if present and next generation facilities were not able to discover CP violation, longer baselines like that with the Garpenberg detector site (540 km) and more even splitting between neutrino and neutrino modes would be preferable. The latter choices would allow a 5 σ discovery of CP violation for around a 60\% of the possible values of δ and to determine its value with a precision around 6° if it is close to 0 or π.

Working group

WG1

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