ESSnsSBplus Target Station Design Study

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Introduction

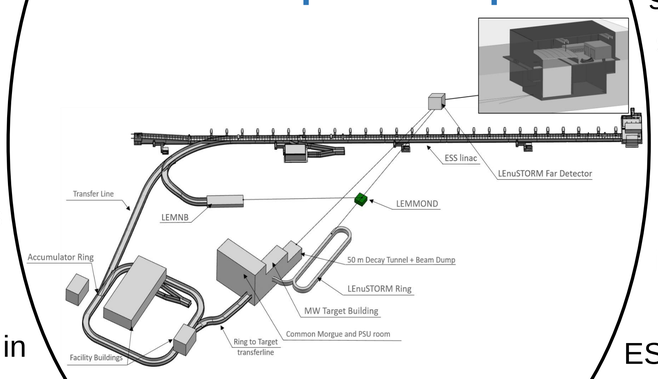
Violation of CP symmetry, which is a necessary condition to explain the matter dominance in the universe, was discovered in the quark sector in 1960s. However, the observed matter in the universe is much larger than the observed amount of CP violation.

Several leptogenesis models involving expelicitly CP violation in the lepton sector to describe the baryon asymmetry, and flavor models, describing the origin of neutrino flavors, cover a wide range of values for the Dirac CP-violating phase (δ_{CP}).

Therefore it is essential to measure δ_{CP} with the highest precision in order to confirm or reject these models.

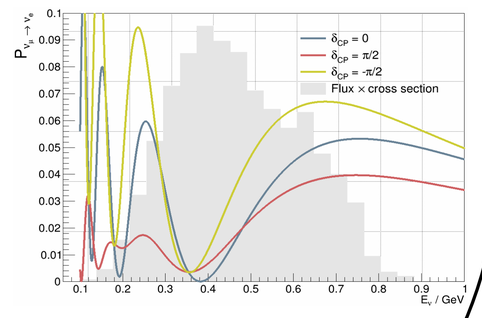
ESSnuSBplus

European Spallation Source neutrino Super Beam plus



Physics Motivation

ESSnuSB+[1] is the extension phase of the EU long-baseline neutrino design study program that will measure the CP-violation in the lepton sector with precision, taking the advantage of measuring at the second oscillation maximum, the ESSnuSB. ESSnuSB[2] aims to benefit from the high power of the ESS linac in Lund-Sweden, to produce the world's most intense neutrino beam.



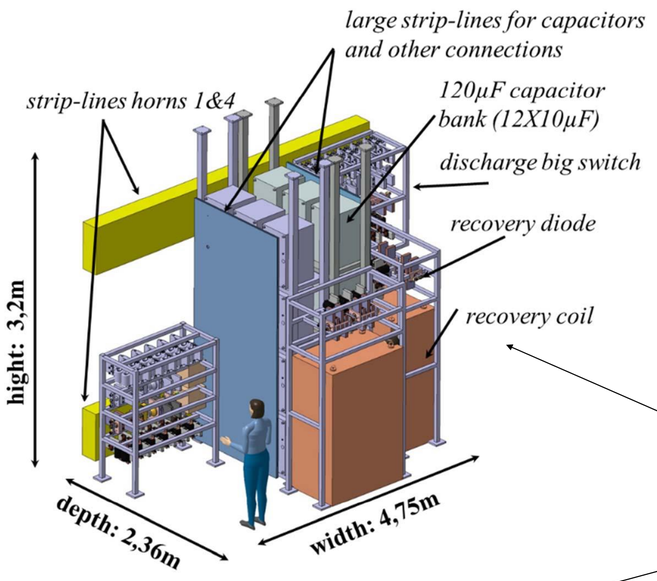
ESSnuSB+ aims at measuring the neutrino-nucleus cross-section below 0.6 MeV, to further reduce the systematic uncertainties of the experiment, using a LEMNB[3] and a LEnuSTORM[4] facilities.

ESSnuSBplus Target Station Facility

The ESSnuSB+ target station is aiming at producing a well-defined $\pi^{\pm}$ beam and direct it to the LEnuSTORM racetrack ring by a large opening dipole magnet. Its design must withstand the energy deposition from the 1.25 MW proton beam on a one horn-target system

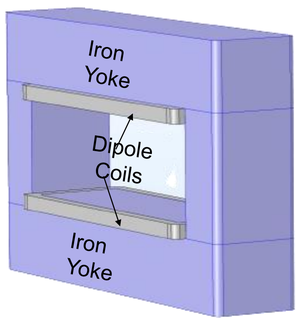
Power Supply Unit

- 4 modules (350 kA, 1.3 ms)
- Located above the switchyard
- Outside the radioactive part of the facility



Initial Focusing and Deviation System (dipole magnet)

- Large opening
- As close as possible to the horn exit
- Bend the charged pion beam to the LEnuSTORM transfer line

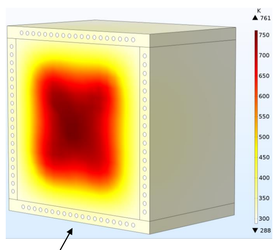


Hot Cell

- Able to manipulate/repair hadronic collector
- Work under Radioactive Environment

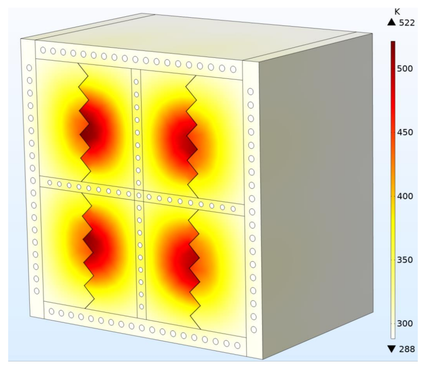
ESSnuSB+ Beam dump

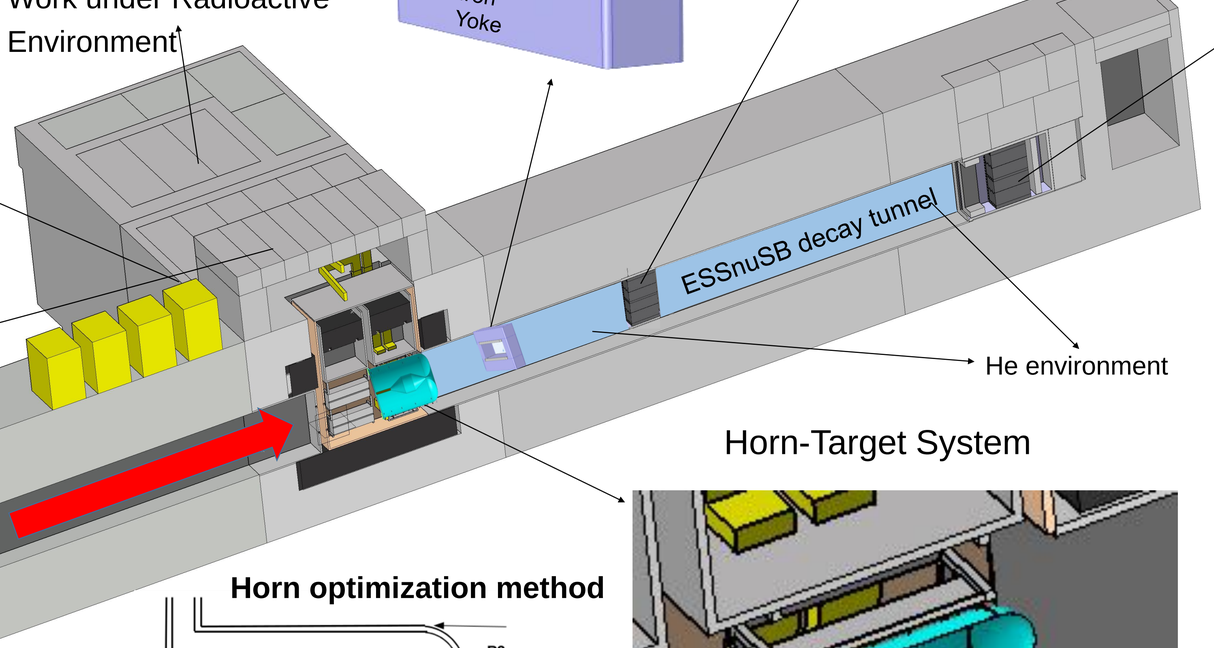
- Withstand energy deposition from 1.25 MW beam on one target
- Protects the underground site from the secondary beam



ESSnuSB Beam dump

- Withstand energy deposition from 5 MW beam on four targets
- Four independent core blocks, segments.
- Each block faces one of the four horns.
- Water-cooling with canals drilled in the support blocks.





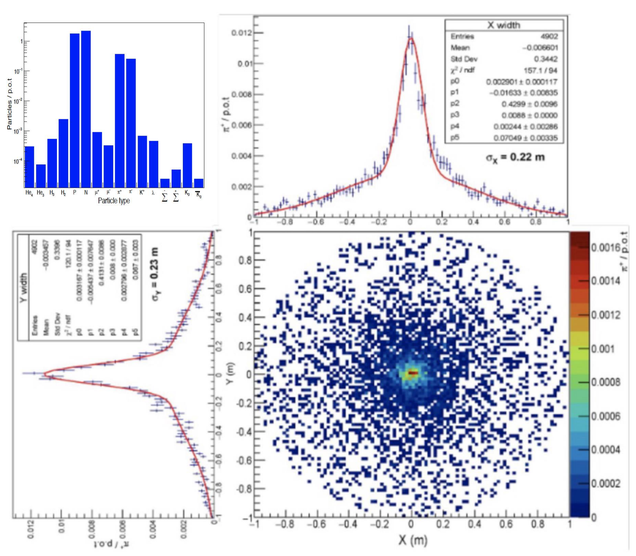
Morgue

- To Store radioactive wastes
- Create inventory to all radioactive material produced

Proton Beam (Ep=2.5 GeV, 14 Hz 1.25 MW)

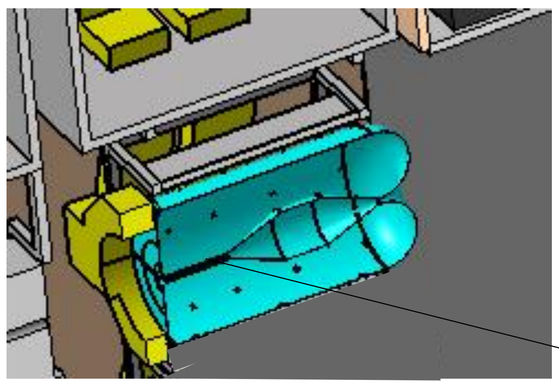
Horn

- Van der Meer style
- Optimized with ML-genetic algorithm code to maximize charged pion collection

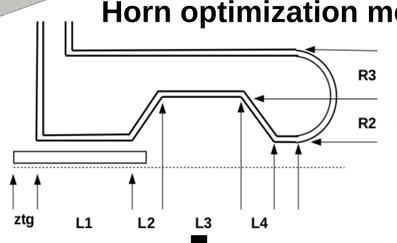


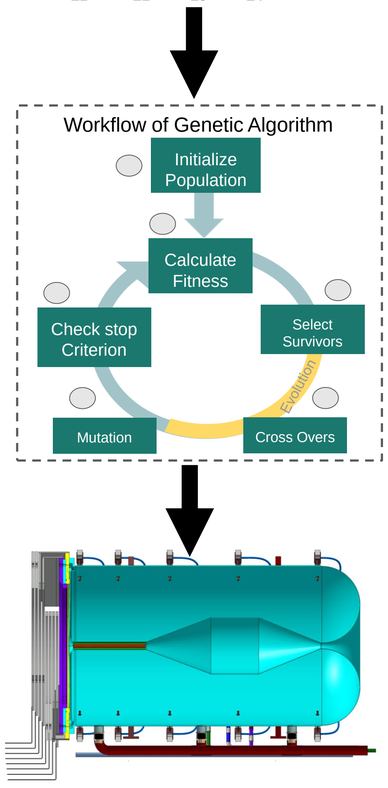
Pion beam spatial distribution at the entrance of the magnetic dipole. Upper and left plots show the projections on the X- and Y-axis of the pion beam distribution with Gaussian

Horn-Target System



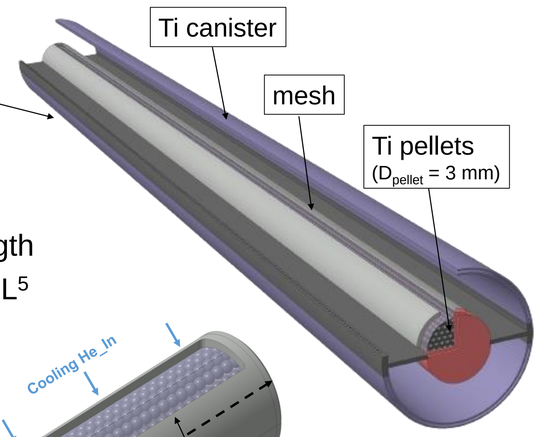
Horn optimization method





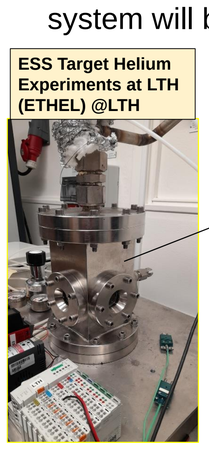
Target

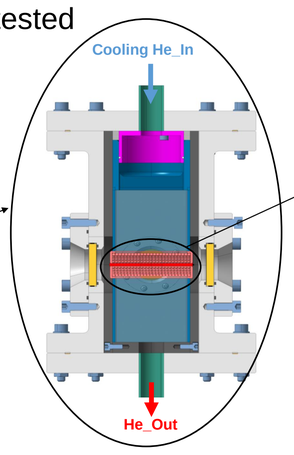
- Packed-bed, granular, style
- 78 cm length, 3 cm diameter canister
- Ti Canister filled with Ti pellets
- Cooled by flushing He gas

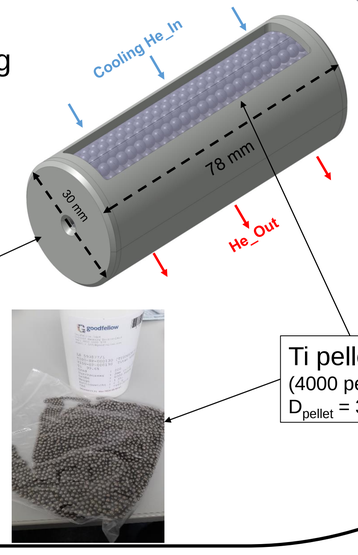


Target Prototyping

- A Prototype of the target canister of 7.8 cm length and a 3 cm diameter will be tested in the ETHEL[5] test facility at the ESS
- The design and performance of the cooling system will be tested







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[2] A. Aguilar et al., LHEP 517, (2024) 1
[3] A. Longhin and F. Terranova, [arXiv:hepex/2203.08319]
[4] L. A. Ruso et al., *In Proceedings of the Snowmass 2021*, 2022, [arXiv:hepex/2203.07545].
[4] https://indico.ess.eu/event/648/attachments/5153/7015/essDocumentDownload_002.pdf