

# Updates on the ESSvSB Target Station potentialities for CP violation discovery

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*On behalf of the ESSvSB Collaboration*

# The ESSvSB project [1]

CP violation in leptonic sector is a candidate to explain the asymmetry between matter and anti-matter observed in the Universe :  $P(\nu_i \rightarrow \nu_j) \neq P(\bar{\nu}_i \rightarrow \bar{\nu}_j)$ .

The ESS Neutrino Super Beam project proposes to use the linac of ESS[2] to produce a high-intensity and low-energy neutrino beam.

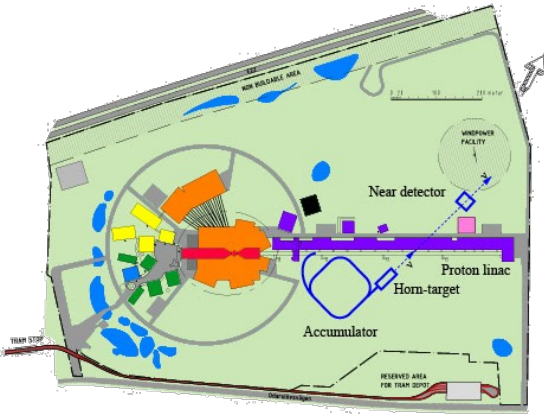


Fig. 1 : ESSvSB site in Lund

## Facility parameters

Proton beam kinetic energy (GeV)	2.5
Total beam power (MW)	5
Beam intensity (ppp)	$8.9 \times 10^{14}$
Beam pulse duration Linac / accumulator (ms/ $\mu$ s)	2.86 / < 1.5
Pulse repetition rate (Hz)	14
Distance target station - detector (km)	540
FD fiducial volume (kt)	540

This combination of high intensity and low energy will allow to access the second maximum in the neutrino oscillation probability.

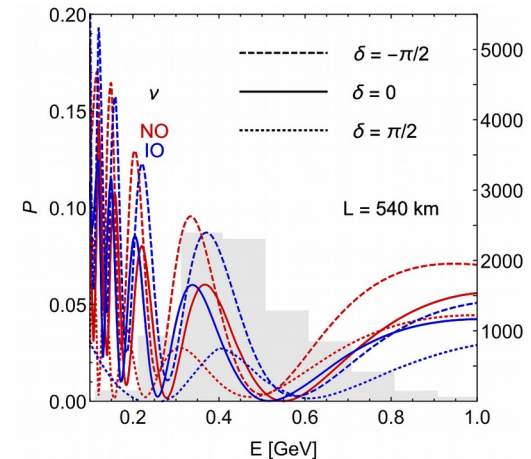


Fig. 2 : Oscillation probability as function of neutrino energy for different values of  $\delta_{CP}$  [3]

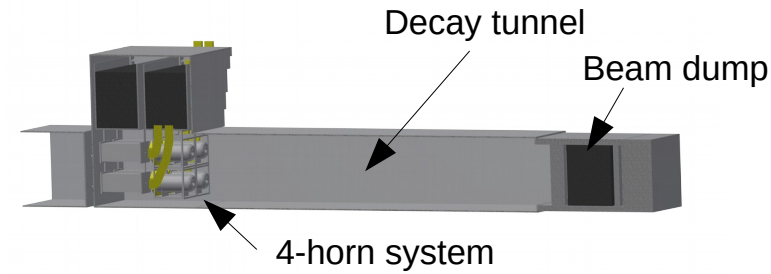
## References :

[1] <https://essnusb.eu>

[2] <https://europenspallationsource.se>

[3] M. Blennow et al, Eur. Phys. J. C **80** 190 (2020) [arXiv:1912.04309].

# The Target Station



The target station is made of three major elements : the hadron collector, the decay tunnel and the beam dump.

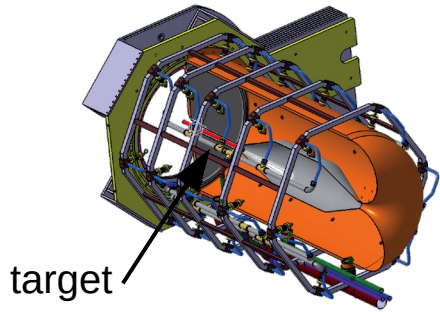


Fig. 3 : A magnetic horn<sup>[4][5]</sup>

## Hadron collector complex :

- 4 magnetic horn-target systems,
- 350 kA pulsed current,
- 2 focusing modes,
- Packed-bed targets : 3 mm diameter titanium spheres, 78 cm long, 1.5 cm radius.

**Decay tunnel** : 25 m long

**Beam dump** : one-block graphite (4\*4\*3.2 m<sup>3</sup>)

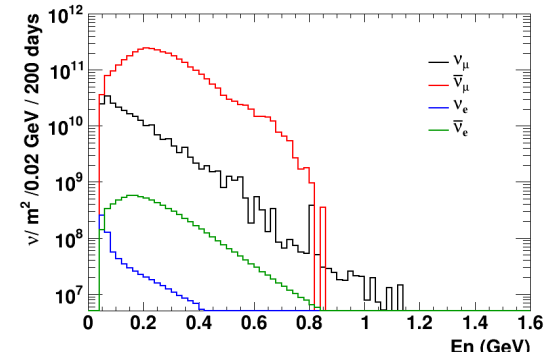
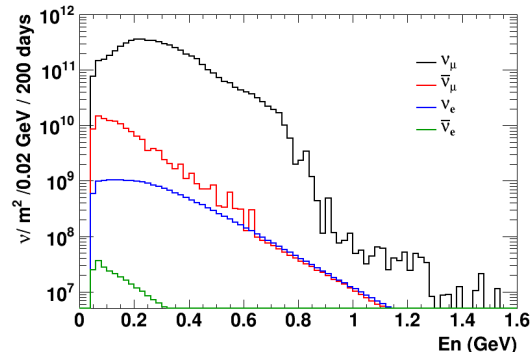


Fig. 4 : Neutrino fluxes as function of energy for a year of running time for positive and negative focusing respectively.<sup>[6]</sup>

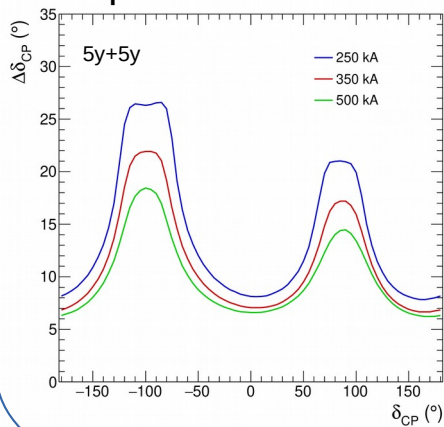
## References :

- [4] T. R. Edgecock et al, Phys. Rev. ST Accel. Beams **16** (2013), 021002, [arXiv:1305.4067 [physics.acc-ph]].
- [5] E. Baussan et al, Phys. Rev. ST Accel. Beams **17** (2014), 031001, [arXiv:1212.0732 [physics.acc-ph]].
- [6] L. D'Alessi, PoS, NuFact2019:062, 2020.

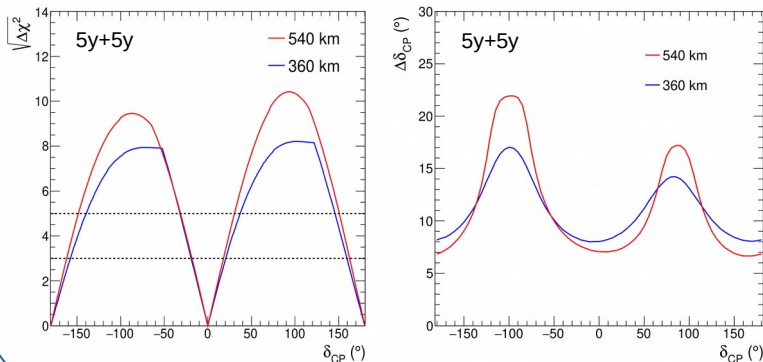
# A parameter study for physics optimization

Different studies have been done at the level of the target station facility and the magnetic horns in order to improve the sensitivity of ESSvSB for the measurement of  $\delta_{CP}$ .  $\nu$  fluxes were generated with Geant4<sup>[7][8][9]</sup> and sensitivity plots obtained with GLOBES<sup>[10][11]</sup>.

1. Influence of the current delivered to the horn on the performances.

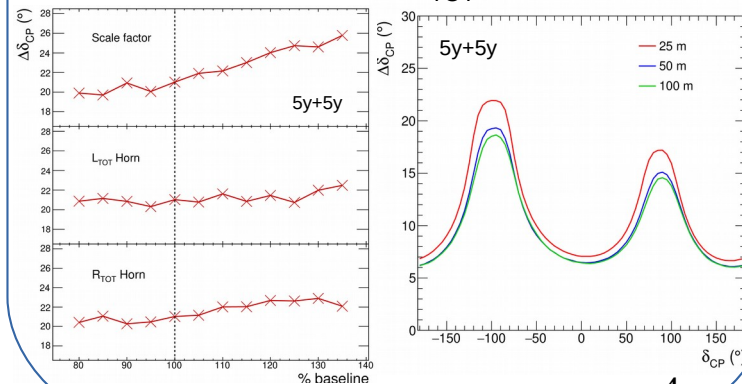


2. Influence of different baselines. There are two predominant choices : the mine of Garpenberg at 540 km and the mine of Zinkgruvan at 360 km.



3. A parametric study on the horn dimensions and the decay tunnel :

- Both total length and radius of the horn are modified (Scale Factor),
- Only the total length of the horn is modified ( $L_{TOT}$  Horn),
- Only the total radius of the horn is modified ( $R_{TOT}$  Horn).



## References :

- [7] S. Agostinelli et al, Nucl. Instrum. Methods A 506, 250-303 (2002) DOI:10.2172/799992  
 [8] S. Agostinelli et al, IEEE Trans. Nucl. Sci. 53, 70-278 (2006) DOI:10.1109/TNS.2006.869826  
 [9] J. Allison et al, Nucl. Instrum. Methods A 835, 186-225 (2016) DOI:10.1016/j.nima.2016.06.125  
 [10] P. Huber et al, Comput. Phys. Commun. **167** 195 (2005) [arXiv:hep-ph/0407333].  
 [11] P. Huber et al, Comput. Phys. Commun. **177** 432-438 (2007) [arXiv:hep-ph/0701187].