The ESSνSB+ Target Station

ESS neutrino Super Beam plus

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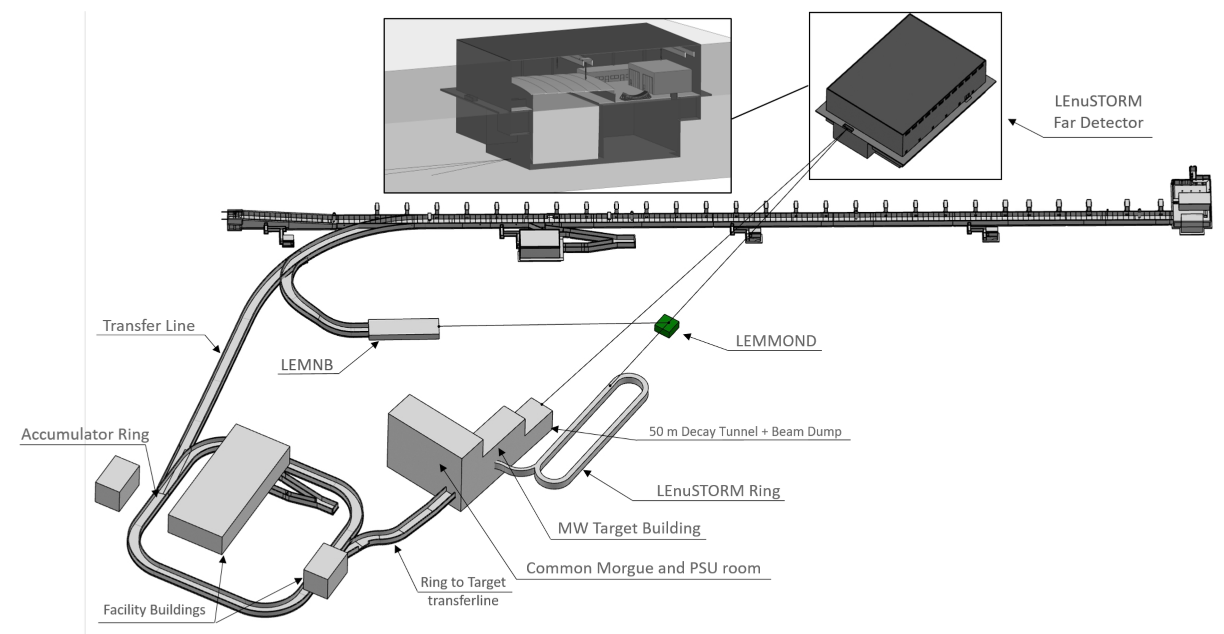
Introduction

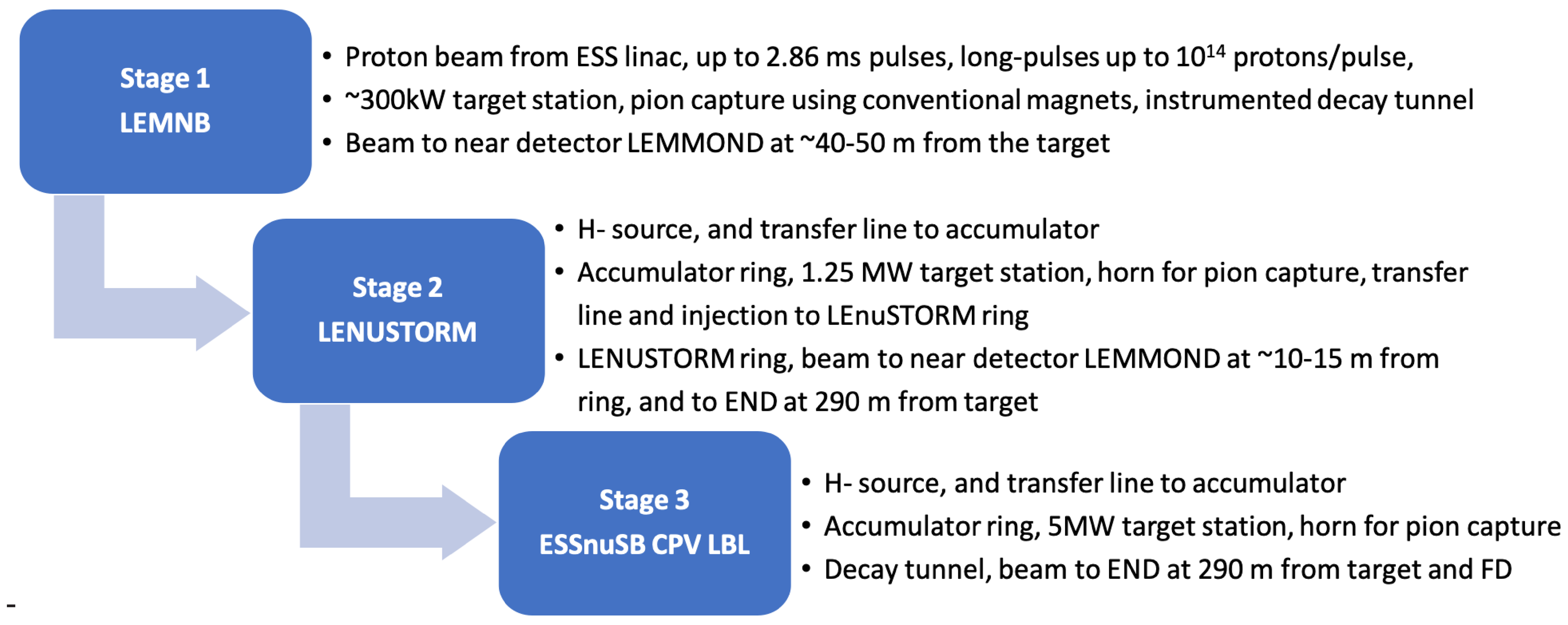
The next generation of neutrino experiments promises significant progresses in physics beyond Standard Model with a high discovery potential regarding in particular the matter/antimatter asymmetry and the mass hierarchy. One of the key points will be to use high intensity neutrino beam in combination with megaton scale detectors. In Europe, the ESSνSB project [1] realised a conceptual design study of a new superbeam facility based on the 5 MW proton linac of the European Spallation Source. This facility will offer the possibility to measure the CP-violating phase, δ_{CP}, at 8° precision level. The extended phase of the design study program, called ESSνSB+, will investigate the possibility to add facilities like a Low Energy nuSTORM racetrack ring and a Low Energy Monitored Beam to study complementary physics such the neutrino-nucleus cross-section measurements and the sterile neutrino hypothesis at neutrino energies below 600 MeV. This new project will adapt the concept of a the ESSνSB target station to the requirements of the complementary facilities. In this poster, the progress of the ESSνSB+ Target Station study will be presented.

Implementation at the European Spallation Source

The European Spallation Source (ESS) offers an unique opportunity to develop a high intensity beam in Europe. After the design of an long baseline neutrino experiment able to to measure δ_{CP} phase within 8° precision level [2], additional facilities are under investigation to bring a complementary program such the measurement of the neutrino cross section and the study of sterile neutrino.

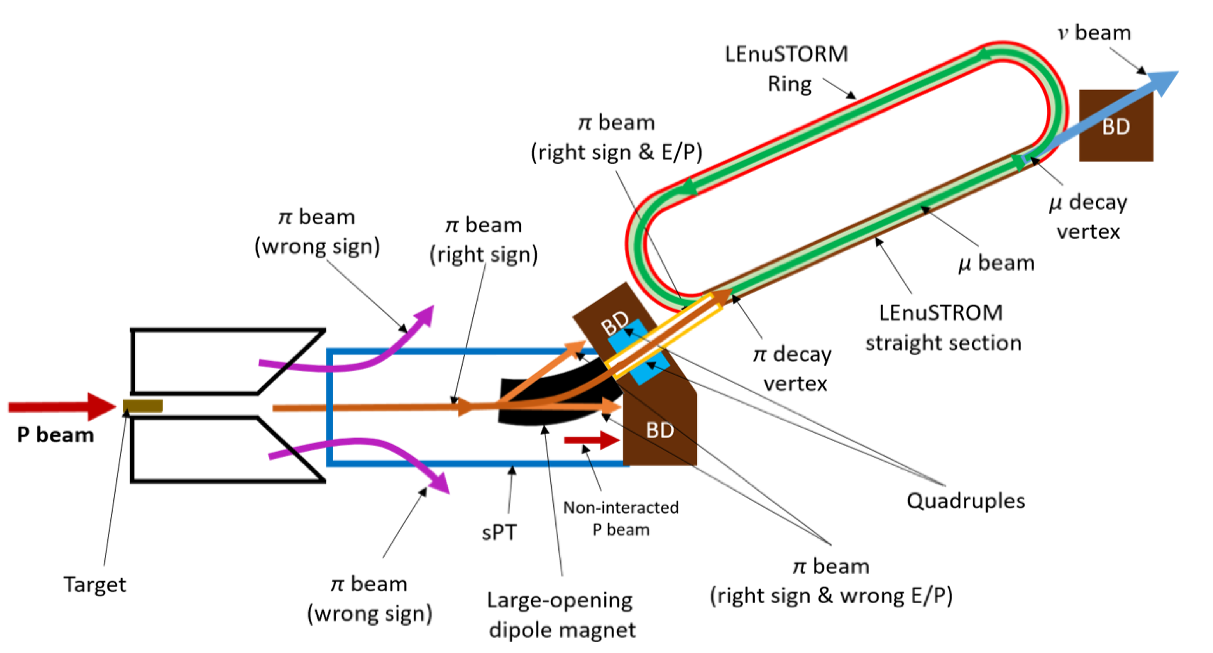


Implementation of the facilities on the ESS site.

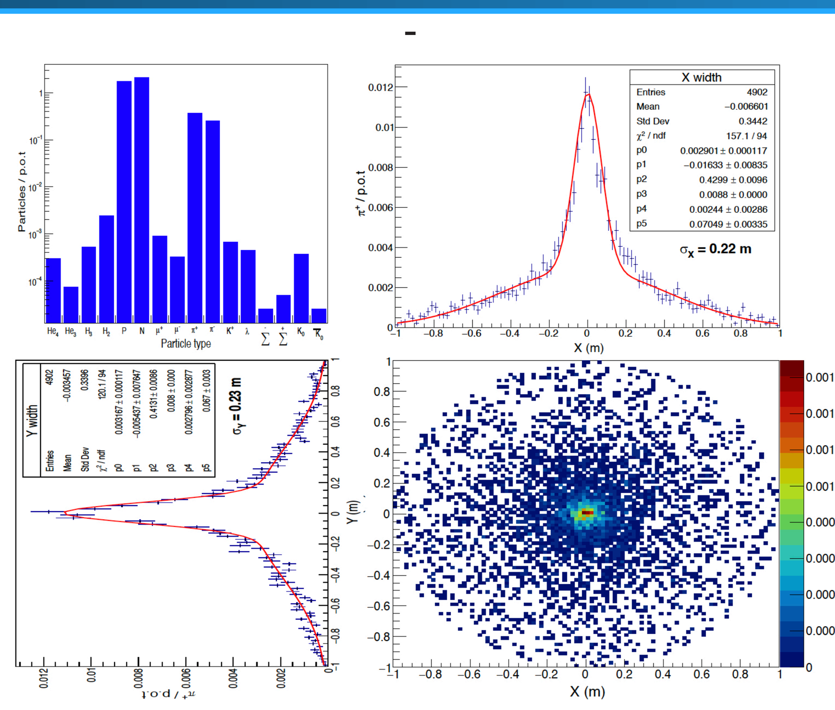


Staged Implementation.

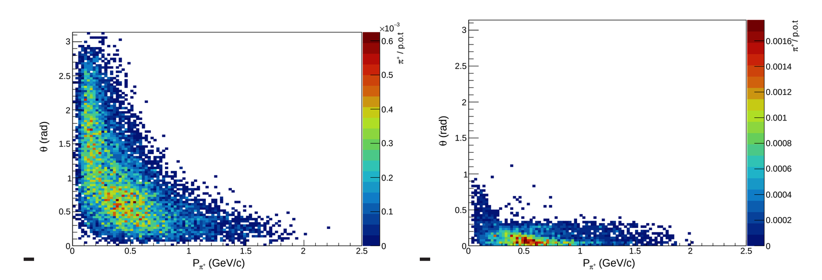
The Mega Watt target station



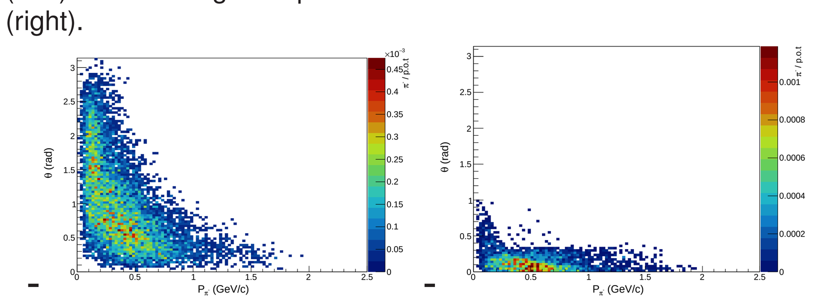
Concept of the LEnuSTORM Target Station.



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 fit.



Momentum vs. angle distribution of positive pions exiting the target (left) and entering the aperture of 2m diameter 40 cm from the horn (right).



Momentum vs. angle distribution of negative pions exiting the target (left) and entering the aperture of 2m diameter 40 cm from the horn (right).

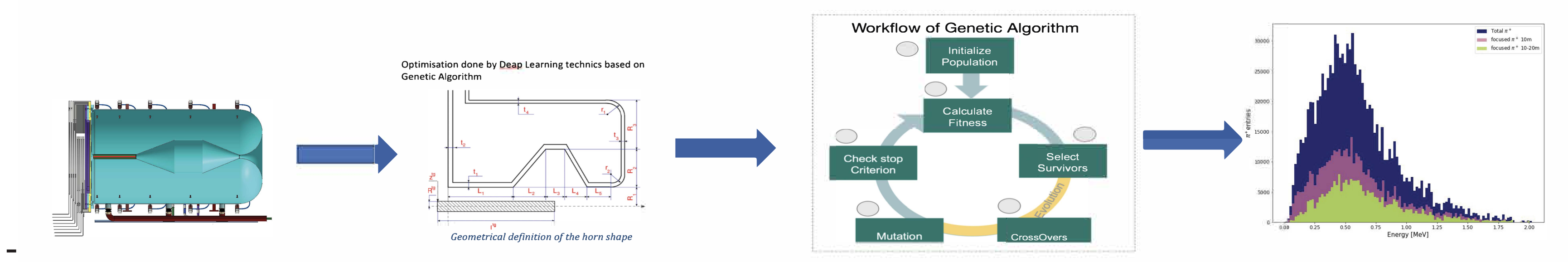
Goals:

- Produce $\pi^+\pi^-$ high intensity beam
- Feed the LEnuSTORM ring
- Withstand the energy deposition from the 1.25 MW proton beam on the one horn/target system

Requirements:

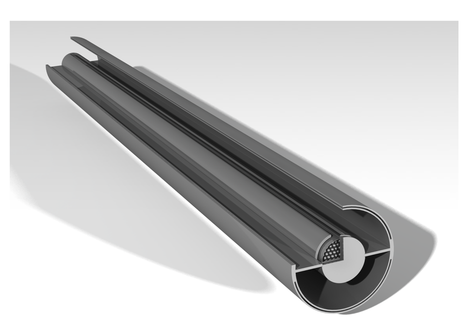
- Optimisation of the hadronic collector for pion production
- Design the pion extraction and deviation system
- Design the Power Supply Unit
- Radio safety studies

Optimisation methodology:



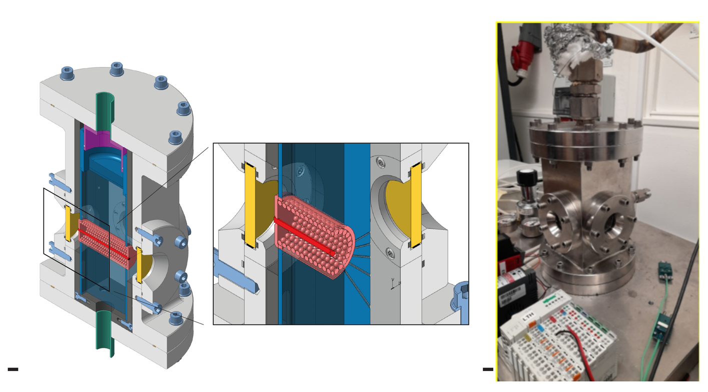
The Target Concept

The ESSnuSB+ target is based on the granular concept [3] allowing an efficient heat removal, low dynamic stresses and acceptable pressure drop can be achieved.



ESSnuSB+ target concept.

- The ESSnuSB+ target consists of a 78 cm long and 3 cm diameter titanium canister filled with 3 mm titanium spheres. This target produces the pions under 1.3 μs proton pulses at 14 Hz, and designed to absorb the 1.25 MW beam power.



ETHEL setup at Lund.

- ETHEL will be used to study the thermodynamic behavior of the granular target for ESSnuSB+ and its cooling system
- A 10 cm length and a 3 cm diameter Ti canister filled with 3 mm Ti spheres will be inserted in the test section of the system

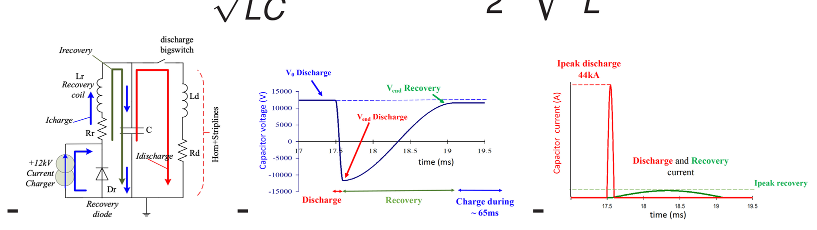
Power Supply Unit

The power supply unit will provide the high intensity current pulses producing the magnetic in the horn. The pulses are synchronised with the proton beam pulses at 14 Hz.

The evolution of the voltage capacitor is given by the general equation:

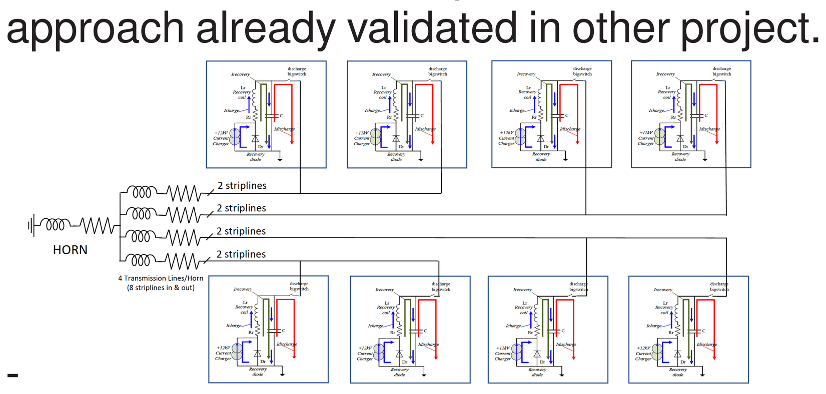
$$\frac{d^2V(t)}{dt^2} + 2m\omega\frac{dV(t)}{dt} + \omega^2 V(t) = 0$$

with $\omega = \frac{1}{\sqrt{LC}}$ and $m = \frac{R}{2}\cdot\sqrt{\frac{C}{L}}$



Power Supply working principle.

The ESSnuSB+ concept uses a modular approach already validated in other project.



Layout of the transmission and strip lines for one horn providing 350 kA at 14Hz.

References

[1] A. Alekou *et al.* [ESSnuSB], "The European Spallation Source neutrino super-beam conceptual design report," Eur. Phys. J. ST **231** (2022) no.21, 3779-3955 [erratum: Eur. Phys. J. ST **232** (2023), 15-16] doi:10.1140/epjs/s11734-022-00664-w

[2] A. Alekou *et al.* [ESSnuSB], "Updated physics performance of the ESSnuSB experiment: ESSnuSB collaboration," Eur. Phys. J. C **81** (2021) no.12, 1130 doi:10.1140/epjc/s10052-021-09845-8

[3] P. Sievers, Nucl. Instrum. Meth. A **503** (2001), 344-347 doi:10.1016/S0168-9002(03)00712-5

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