EUROnu WP2 Note 12-01

The SPL-based Neutrino Super Beam: final design report

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Abstract

The purpose of this note is to present the conceptual design of the target and horn for the SPL-based Super Beam. We first introduce the object of this study and give a rapid overview of the experimental setup. In the main part of this note we present the design of the target and horn.

Keywords: Super Beam, EUROnu, neutrino oscillations, target, horn

Contents

1. Introduction

The EUROnu Super Beam work package studies the SPL (CERN) to MEMPHYS (Fréjus) project, with a baseline of 130 km and a beam power of 4 MW. This note presents the preliminary design of the target and collector for this project. It is organized as follows. In this introduction, we present an overview of the target and collector. We then present the design of the target (Section 3), as well as two detailed studies on pion production (Section **??**) and energy deposition (Section **??**) in the target. We then describe the horn, a dynamical study in the case of a classical design (Section **??**) and a study of the horn stresses in the case of a combined target and horn (Section **??**).

For reference, the SPL parameters [1] used in this report are shown in Table 1.

Table 1: Parameters of the SPL [1]

Parameters	unit	SPL
Energy	[GeV]	4.5
Beam power	[MW]	4.0
Repetition rate	[Hz]	50
Average pulse current	[mA]	40
Peak pulse current	[mA]	64
Chopping ratio	[%]	62
Beam Pulse length	[ms]	0.6
Protons per pulse for PS2	$[10^{14}]$	1.5
Beam duty cycle	[%]	2.0
Number of klystrons (LEP)		14
Number of klystrons (704 MHz)		57
Peak RF power	[MW]	219
Average power consumption	[MW]	38.5
Cryogenics av. power consumption	[MW]	4.5
Cryogenic temperature	[K]	2.0
Length	[m]	534

1.1. Overview of the target and collector

In this section we briefly present the overall conceptual design of the target station and its interface with the proton driver.

The baseline design is here summarized:

Figure 1: Schematic layout of the neutrino beamline setup.

1. Each target is embedded within the bore of a conventional pulsed current magnetic horn inside a magnetic reflector.
2. In order to mitigate the combined technical challenges of cycling the horn at 50 Hz and of the radiation damage and heat load generated in the target material, a target station composed of 4 targets and collectors is proposed with a switchyard to cycle consecutive beam pulses on the one target/collector in sequence.
3. A static solid target is viewed as being technically achievable.

Points 2) and 3) require further explanation. With the 4-target system, each target would accept a 1 MW beam but the heat load generated would only be around 50 kW for each target in the case of a low Z material. This is a factor of two greater than the T2K Phase 1 target and around the same as is anticipated for a T2K upgrade, and seems a reasonable objective. In addition to reducing the technical challenges, the multi-target and horn solution will increase the lifetime of both the target and horn by at least the same ratio.

A schematic layout of the neutrino beam line system is shown in Fig. 1. while the target and the horn are schematically shown in Fig. 2. The parameters of the beam at the target are summarized in Table 2. The horn optimization procedure and the physics sensitivity are fully described in [2].

Table 2: Parameters of the SPL based Super Beam at the target.

Parameters	unit	value
Energy	[GeV]	4.5
Total Beam power	[MW]	4.0
N of beam lines		4
Repetition rate (each beam)	[Hz]	12.5
Pulse duration	[μs]	5
Beam Gaussian width	mm	4

Figure 2: Schematic layout of the Super Beam target and horn.

2. The SPL

3. The target

4. The horn

5. The target and horn integration

6. The target station, decay tunnel and beam dump

7. Studies of activation and shielding

8. Beam optimization, fluxes and sensitivity

9. Conclusions

In this report we have presented the preliminary design of the target and horn for the SPL based neutrino Super Beam. We propose a target station hosting four identical horns and targets. For the target we have considered a solid low Z ”pencil-shaped” device (for instance made out of Beryllium) and a pebble-bed system composed of Titanium spheres in a canister. The studies of these two designs are ongoing.

For the target and horn we have considered either a classical design or a combined system where the target is an integral part of the horn and serves as the inner conductor. The combined design is currently disfavored. Studies of the dynamic stresses have also been presented.

Acknowledgments

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