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Updated results of the Horn Study for the Nufact

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Abstract

An updated study of a magnetic horn as a possible option for the pion collection system at the Neutrino Factory is presented. The pion yield is similar to that obtained from the standard benchmark solenoid.

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1 Introduction

A horn focusing system for pions was proposed in [1] as a possible alternative to the standard solenoid [2] used for the front end of the Neutrino Factory. Advantages of horns are that i) they are sign selective, ii) they are radiation hard and the parts exposed to the radiation are relatively cheap, iii) there is some freedom to match the shape of the horn to the most favourable phase space accepted downstream, in the phase rotation and cooling channel. Studies presented in [1] are not directly comparable to those of the solenoid because of a different particle generation code, and because they concentrate on a thin target. Further studies are presented here, with which a comparison can be made.

2 Target simulation

In the CERN proton driver scheme, the energy of the incoming proton beam is 2.2 GeV. The pencil-like beam is parallel to the horn axis.
The protons impinge on a mercury target which is a cylinder 30 cm long ($\approx$ two interaction lengths) and 0.75 cm radius. We chose these dimensions to reproduce the same conditions as those studied for the pion collection with a solenoid [2]. The target is positioned inside the horn at the zero of the coordinate system, and it is parallel to the beam axis. This geometry is to be considered only for simulation purposes; we refer to [5] for a first realisation of a mercury jet. The secondary particle production is simulated by `MARS` [4].

3 Simulation

As presented in [1], the pions generated by `MARS` are transported through the horn magnetic field by `GEANT` [6]. Pions are counted at the exit of the horn and after one meter of drift space with no magnetic field. We considered different geometries for the horn inner conductor design, and different currents. The best pion capture is obtained by the triangular horn shape shown in Figure 1 and described in Table 1 with 300 kA. This current is estimated as a conservative value, taking into account mechanical and heating considerations. The simulation includes pion absorption due to the inner conductor material, which is aluminium. The thickness is about 16 mm in

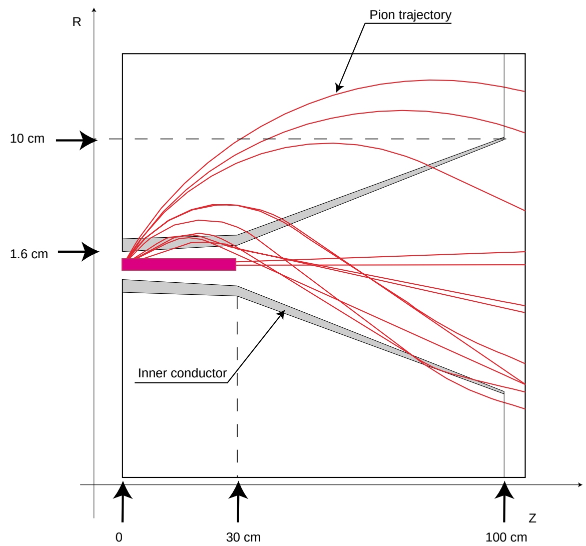

Figure 1: Pion trajectories for triangular horn shape

the section around the target and decreases to 1.8 mm downstream of the horn. This particular size was calculated by doubling the conductor section of the existing horn at CERN, where the current peak is 150 kA [7].

z (m)	R (cm)
0.0	1.6
0.3	2.0
1.0	10.0

Table 1: Inner conductor coordinates for the triangular horn.

4 Results

Table 2 gives the number of π^+ per POT (Proton On Target) per GeV collected at the exit, and at one meter after the end of the horn, with no matching solenoid [2]. In the case of solenoid capture, however, the pions are

[2]Similar results are found when a simulation with only MARS is run for the horn.

counted in a 1.25 T transport solenoid, one meter after the adiabatic section [2]. The 2 GeV and the 16 GeV [3] yields for the benchmark solenoid are computed from [3] and are shown in Table 3. The pions are selected in space in a radius of 30 cm and for a momentum window defined by 0.05 < p < 0.8 GeV/c.

Horn	π^+/POT/GeV	
300 kA after 1 m	0.021 0.014	no material absorption
300 kA after 1 m	**0.016** 0.010	with material absorption
400 kA after 1 m	0.020 0.014	with material absorption

Table 2: Flux of π^+ at the exit and 1 meter after the horn, with different currents and with and without material absorption for the inner conductor.

Solenoid	`MARS`	`MARS+GEANT321`	`MARS` 16 GeV
π^+/POT/GeV	**0.017**	0.020	0.025

Table 3: Flux of π^+ for solenoid capture after 1 m in the 1.25 T field for different simulation.

5 Conclusions

The performance of the triangular horn is comparable to that of the benchmark solenoid. Nevertheless we need to study and optimise the matching solenoid that connects the focusing system to the decay channel and the first section of phase rotation. A preliminary study shows that there is only a small loss of pions in the matching regions. However, a further study should quantify this loss and verify the performance of a possible reflector after the horn.

[3]For 16 GeV the flux is rescaled to 1 GeV, although π production does not scale exactly linearly with proton energy.

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