Preliminary Design of Low Energy Beam Transport (LEBT) system for Accelerator based 14 MeV Neutron Generator

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Introduction

Accelerator based 14 MeV Neutron Generator (NG) is being upgraded at Fusion Neutronics Laboratory (FNL) of Institute for Plasma Research (IPR) for high yield neutron production of 10^{12} n/s to be used in fusion neutronics studies. The neutron generator consists of ECR ion source, Low Energy Beam Transport (LEBT), Acceleration system, vacuum system, beam diagnostic system, high voltage power supplies and water cooled rotating tritium target. The ECR ion source from PANTECHNIK will be used to produce deuterium plasma and extract ion beam of 30mA and emittance of 0.2 pi mm mrad. This ion beam will be further transported through LEBT and then enter the acceleration tube to increase its energy up to 300 keV. Accelerated deuterium beam will strike the rotating tritium target and produce 14-MeV neutrons. LEBT is the key transport system to control and focus the beam in to the acceleration column. To design the LEBT system, the “GRAPHIC TRANSPORT FRAMEWORK” [1] ion optics Code is used. This paper presents the design of LEBT system and its beam dynamics.

LEBT System

The LEBT system extends from magnetic lens to Quadrupole triplet placed before the acceleration column. LEBT system consists of 90 degree bending magnet, beam diagnostic system and quadruple triplet. The beam is extracted at 40 keV from ECR ion source. The initial beam parameters are listed in Table 1. [2]

90 degree double focusing dipole magnet

Use of 90 degree bending magnet ensures an efficient separation of the deuteron D^+ beam from main pollutants (D_2^+ ,D_3^+ heavier 1+ beams) [3]. The magnetic rigidity gives the bending radius for D^+ ions as 21.0 cm. All the other ions get dumped while passing through dipole magnet. Hence excessive heating on the target is avoided. Neutron yield is also affected if foreign ions reach the target. The dipole magnet has edge angles of around 30° at both edges for vertical focusing [4] and u=v=2ρ [5].

Table 1 initial beam parameters

Emittance (rms) normalized	0.2πmm mrad
Extraction voltage	40keV
Accelerating voltage	300keV
Beam current	30mA
Beam size	15mm

Quadrupole Triplet (QT)

Beam has to travel a long distance before entering the acceleration tube due to the presence of beam diagnostic systems, therefore beam diverges traversing this length. So, QT is used to focus the beam with unity magnification.

Ion optical design of LEBT

The beam optics for LEBT section is done using a standard code “GRAPHIC TRANSPORT FRAMEWORK”. The predesigned parameter for Dipole magnet and Quadrupole triplet are listed in Table 2 and Table 3. The beam optics is shown in Figure 1 below.

Table 2 Preliminary design parameter for Quadrupole triplet

Quadrupole	Effective magnet length (m)	Field at pole tip B (kG)	Half aperture a (mm)
Q1	0.159	0.4074	39
Q2	0.318	-0.3051	39
Q3	0.159	0.4074	39

Table 3 Preliminary design parameter for Bending magnet

Magnetic field (kG)	1.938
Pole gap (mm)	40
Bending angle (degree)	90
Edge angle entrance and exit	29.812

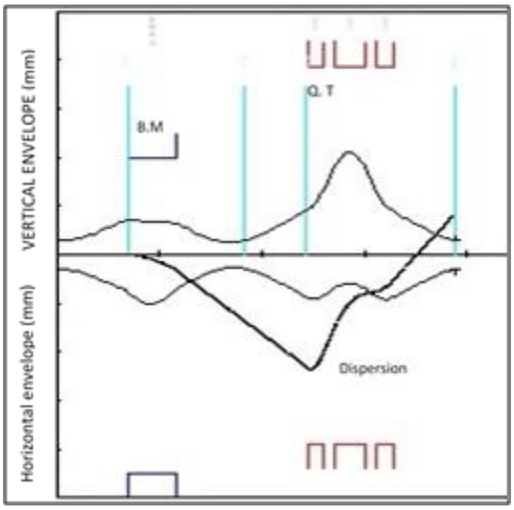

Fig.1 Ion optics of LEBT using TRANSPORT

Conclusion

The beam optics for LEBT section gives us the predesigned parameter for dipole magnet and Quadrupole triplet. The approximate length for the same has been determined. The beam optics design is performed without considering the space charge effect. Further study is planned with space charge effects. The simulation results are summarized in Table 2 and 3.

Acknowledgement

The authors would like to thank A. Mandal, G.O. Rodrigues and Sarvesh kumar (IUAC New Delhi, India) for their valuable suggestions.

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