Fabrication and Installation of a Table Top Accelerator (TTA) at Manipal

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Introduction

Improvements in accelerator technology over the past many decades have provided opportunities for increasingly sophisticated investigations into the fundamental properties of matter. Over the years, the size and complexity has grown to include a vast range of beam energies and detection equipment spanning the disciplines of nuclear physics and high energy particle physics. For low energy nuclear physics, two accelerator facilities are currently available to users in the country: the 14UD BARC-TIFR Pelletron, TIFR [1], Mumbai and 15UD IUAC Pelletron at New Delhi [2]. Both are mature facilities with limited scope for hands-on training of entry level students and young faculty in accelerator science. The Nuclear Physics group at the Manipal Centre for Natural Sciences (MCNS) in collaboration with GSI and University of Giessen, Germany, has already proposed the design of a mass separator "SuperSHIP" for heavy elements [3-5]. The need to provide an easily accessible tool for training students and beginning researchers in the most basic aspects of accelerator design including critical components such as ion optics, beam transport and vacuum systems, became evident and the current project was initiated. The design and fabrication is entirely indigenous allowing for maximum flexibility in future upgrades.

Design & fabrication

In house design of all parts based on technical drawings provided by IUAC, New Delhi was carried out by an engineering team within the Centre using Autocad-2016 and ANSYS program for analysis. 2D engineering drawings were rendered with extreme precision in 3D for each mechanical part and component in the highest detail. Rendered 3D parts with tolerance limits were depicted as a blow up showing assembly prior to the fabrication.

The main components of the TTA are as follows.

a) Ion source:

The cold plasma-based PIG ion source was fabricated and installed with MCNS 50 kV ion accelerator. With this, it has been possible to get a stable beam with 300 micro amps. The full ion source is assembled in nylon housing and connected to 50 kV power supply. It is suitable for many ions. Presently the charge state is 1. Since E=qV, for hydrogen as q=1 and = 50KeV.

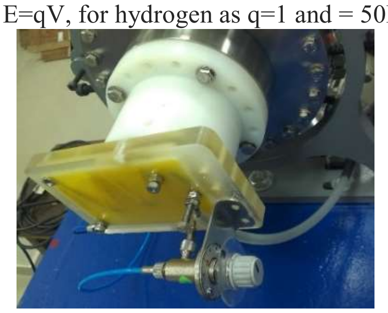

Fig.1. The ion source assembly with the needle valve for the controlled gas flow.

b) The focusing unit:

The electrostatic quadrupole triplet (QT) was designed and fabricated following simulations using LISE++ [6]. The simulation result will be presented. The QT assembly is inside a stainless steel (SS) vacuum jacket. The full QT is made up SS material. It has 60 mm aperture & poles of 100, 185, 100 mm long with 56 mm radius made out of SS. Out of 10 ports four have been used for the high voltage power supply input, one 8" OD CF port for mounting turbo molecular pump (nEXT 400 model from Edwards and the RV12 rotary backing pump) and remaining are for vacuum gauge connection. The existing QT (inner pole assembly) has been shown in Fig. 2.

c) Bending magnet:

A 90^0 bending magnet is and mounted on the beam line.

Fig.2. The QT with the poles mounted at different locations. The outer SS jacket is not shown.

The magnet simulation has been done by using LISE++. The magnet is created by assembling a number of small permanent Nd magnets arranged inside a housing. The size of each magnet pellet is 50×25×12.5 mm. The extracted stable B field is between 1100-2600 Gauss as required for different ions species. The B field has been measured using Hall probe. All the Nd pellets are Inserted in the magnet housing which has been made up of two 20 mm thick MS plates acting as poles. There is a hand wheel to control the height of the shorting plates. The shorting plates are used to vary the B field. the full Bending magnet has been shown in Fig.3

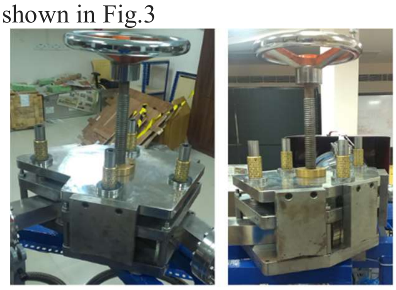

Fig.3. The Bending magnet assembly with wave guide (beam pipe). (Left/Right) front/ back view.

d) Scattering chamber:

A large scattering chamber with a diameter of 38 cm was designed at MCNS for multipurpose use with 7 ports. A unique ladder design for the target holder enables 4 targets (in addition to a flux monitoring beam stop for in-beam diagnostics). The chamber has 3 CF-100 port, 4 CF-35 port and one CF-150 port. There are two view ports and one electrical feed-through port. All the 4 CF-35 port are for air inlet and vacuum gauge connection. It has also been equipped with a linear and rotary drive to set the target at any desired position and angle. There is another independent rotary drive to change the detector position to any angle 0-360^0 rotation. The full chamber has been shown in Fig.4.

Fig.4. The Scattering chamber with all the rotary and liner drive. The holes are to set the detector in any desired positions.

Summary and conclusion

A facility has been developed at MCNS Manipal for students, young researchers who may want to do experiments using low energy ion beams without any radiation hazard. Radiation field was measured around th TTA and found to be negligible. This facility will be useful for the low energy nuclear/Astrophysics study using suitable detection systems. This will be another promising facility for testing of all types of detection system. Facility tests are under way expected to be commissioned by November 2018.

Acknowledgment

One of us (PKR) expresses profound gratitude to the Director Dr Mohini Gupta for allowing me to work on this project. I am also very much thankful to Dr. Kanjilal (former director IUAC) to allow the technical support. I am grateful to Dr. C. P. Safvan and Dr. Rajkumar from IUAC for their full cooperation from staring to installation of TTA. I also express my gratitude to MCNS faculty, post docs and non-teaching staff.

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