ISBN: 978-3-95450-194-6 ISSN: 2226-0366 doi:10.18429/JACoW-LINAC2018-THPO080

DESIGN VALIDATION OF A CHOPPING AND DEFLECTING SYSTEM FOR THE HIGH CURRENT INJECTOR AT IUAC

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Abstract

A chopping and deflecting system (CDS) has been designed and developed to provide the chopped beam with various repetition rates to the experimental facilities at the Inter-University Accelerator Centre (IUAC). The CDS consists of four pairs of deflecting plates with increasing gap from 15 mm to 21 mm to provide the maximum effective electric field and to achieve the maximum current within the same voltage conditions. The design of CDS has been validated with various simulation codes including CST MWS, Solid Works, Python and TRACE 3D etc. The deflecting plates, bushes and spacer have been fabricated and assembled within the accuracy of 100 microns. The mechanical measurements were carried out using a slip gauge and Coordinate Measuring Machine. A high vacuum chamber has been designed and developed to incorporate the entire inner assembly. The whole assembly has been installed in the high vacuum chamber and aligned using theodolite. The assembly has been leak tested using helium leak detector in the range of $1x10^{-9}$ mbar.liter/sec. The electrical design of CDS has been validated by installing and testing in the Low Energy Ion Beam Facility (LEIBF) at IUAC. A slit has been introduced to cut the undesired particles, and a beam profile monitor and Faraday cup has been installed to measure the amount of deflection and beam current respectively. The DC voltage has been applied across the four pairs of deflecting plates and amount of deflection was measured accordingly. The design, development, and DC beam test will be discussed in the article.

INTRODUCTION

The accelerator-based experimental facilities at the Inter-University Accelerator Centre (IUAC) depend on the 15 UD Pelletron [1] accelerator and the niobium superconducting quarter wave resonator based superconducting linear accelerator operating (SC-LINAC) at 97 MHz [2]. The ion beams delivered by Pelletron accelerator can be used directly for the experiments or injected into the superconducting linear accelerator for further energy gain. An alternative injector was felt to be necessary due to the limitation of the existing Pelletron accelerator. The High Current Injector (HCI) [3] accelerator has been designed to overcome the limitation of the existing Pelletron accelerator and to provide the high current with varieties of the ion species including inert gases etc. which are not feasible with the existing 15 UD Pelletron accelerator. The HCI was proposed as an alternative injector to the SC-LINAC, and the current Pelletron accelerator will serve as a standalone facility.

The HCI consists of various normal conducting RF cavities including Radio Frequency Quadrupole [4], Six IH type Drift Tube Linear Accelerator [5], Spiral Buncher [6] and low beta cavity. The nuclear physics experimental facilities at IUAC require a clean pulsed beam without dark current at various repetition rates. A requirement of a chopper and deflector was found to be necessary to provide a chopped beam with multiple repetition rates to the IUAC experimental facilities. The LEBT section was found to be the most suitable section for CDS since it needs lower voltage to deflect the undesired charged particles. Due to space constraint, both chopper and travelling wave deflector (TWD) has to combine, and a single device has been designed called chopping and deflecting system [7]. The CDS has been designed within 220 mm space along the beam direction (see Fig. 1).

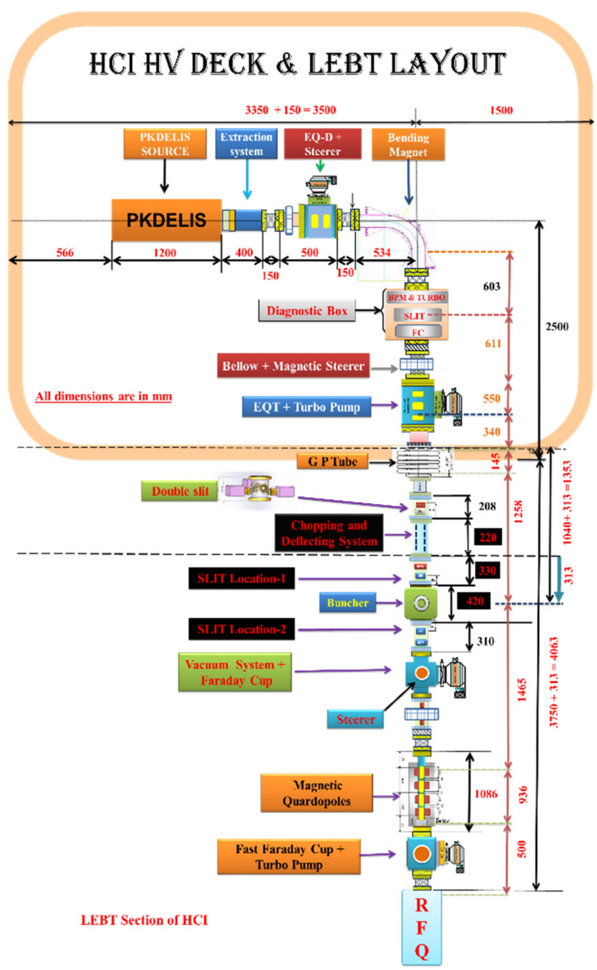

Figure 1: The location of CDS has been depicted in the layout of the LEBT section of the High Current Injector.

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DESIGN AND SIMULATIONS

Electrical Design

The CDS incorporates the four pairs of deflecting plates with varying gaps between the deflecting plates, and the separation between the pairs of deflecting has been kept constant as shown in Fig. 2.

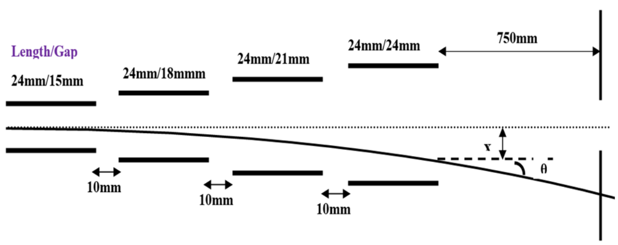

Figure 2: The 2D design of chopping cum deflecting system for HCI.

The length of the deflecting plate has been optimised to achieve the maximum current in the bunch of 60 ns. The gap between the deflectors has been chosen to increase the effective electric field within the same voltage conditions. The centre to centre spacing between the pair of deflectors has been kept constant which is equivalents to 28.3 ns transit time period. A delay will be fixed to provide the synchronisation. The semi-cylindrical contour has been incorporated in the deflector plates to improve the linearity and effective voltage as shown in Fig. 3. Two slit locations have been traced out to cut the undesired charged particles. It was simulated that the second slit location which is located at 750 mm is capable of providing more no of charged particles comparatively.

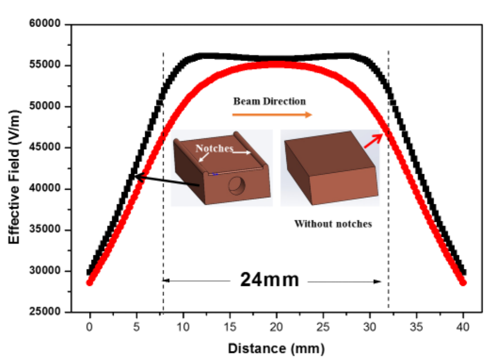

Figure 3: The plate design modification to improve the linearity and effective electric field.

By the incorporation of the contour, the linearity has been increased by a multiplication factor of two and effective field seen by the charged particle has been increased by 10% [7]. The various simulation codes have been used to validate the electric design.

Mechanical Fabrication and Installation

The mechanical fabrication has been divided into two steps inner assembly and outer assembly (see Fig. 4). The inner assembly consists of deflector plates, bushes, spacers, top plate and bottom plate etc. The OFHC copper has been used to fabricate the deflector plates. The inner assembly has been built, cleaned using an ultra-sonic coater and assembled within the accuracy of 100 microns. The outer housing consists of a vacuum chamber. The outer chamber has been fabricated, and leak tested in the range of 1×10^{-9} mbar.liter/sec. The outer chamber has two 8 inches CFF flange to install the chamber in the beam line. The inner assembly has been mounted in the vacuum chamber and aligned using theodolite. The mechanical measurements were carried out using a slip gauge and Coordinate Measuring Machine within the error of 3%.

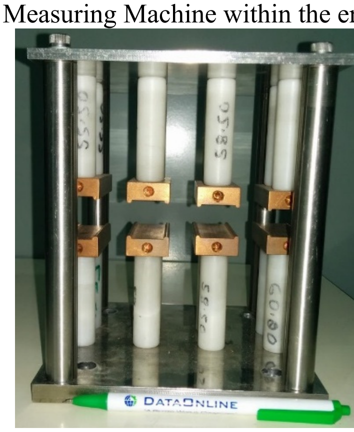

Figure 4: The complete inner assembly with its four pairs of deflecting plates.

The complete CDS system with its accessories has been installed in the LEIBF to validate the electric design. A compact diagnostic box [8] including a slit, Faraday cup and slit scanner has been installed at 750 mm far away from the CDS system as shown in Fig. 5. The deflector plates have been provided with a DC bias voltage using four feed-throughs as shown in Fig. 6. The SHV connectors and high voltage power supplies have been used to produce the DC voltage to deflectors. All the deflectors are electrically isolated to each other. The field of opposite polarity has been provided to the pair of deflectors to minimise the fringing field.

RESULTS AND DISCUSSIONS

The chamber has been installed in the LEIBF facility and aligned using theodolite. The high vacuum has been achieved within ~5 hours. The deflectors have been connected to the high voltage power supplies. Due to unavailability of the beam time in the LEIBF facility, the beam test has been postponed. A python code has been developed to validate the design parameters. The design parameters closely match with the simulated value. The beam test will be presented separately.

CONCLUSION

The design, development of CDS have been completed. We are in the process to purchase and development of a 4 MHz RF pulsers in collaboration with BHELKE company. The RF pulsers has been designed to provide the 60 ns off time at various frequencies including 4, 2, 1, 0.5, 0.125. The beam test will be discussed separately after procuring the RF pulsers.

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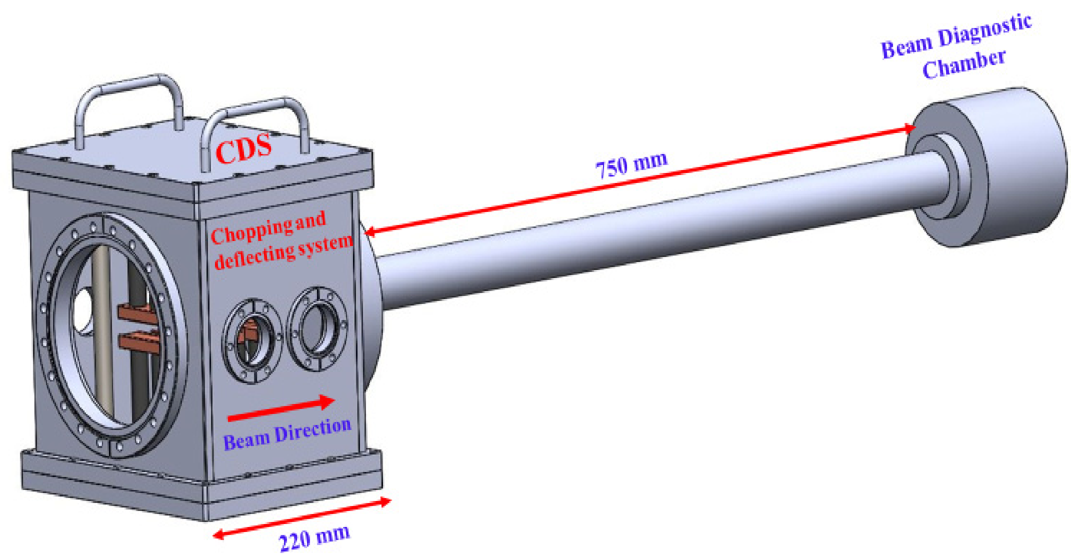

Figure 5: The CDS system including inner assembly, an outer chamber, the drift of length 750 mm, and a diagnostic box.

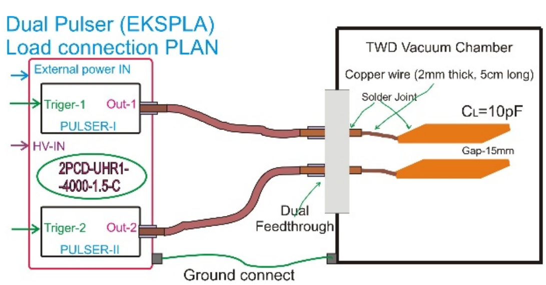

Figure 6: The deflector plates are connected to the power supply using feedthroughs.Results and Discussions.

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