DEVELOPMENT OF HIGH CURRENT INJECTOR AT IUAC

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Abstract

The High Current Injector (HCI) is being developed at the Inter University Accelerator Centre, New Delhi as an alternate injector to the existing superconducting linear accelerator. The paper describes the present status and future plans for the development of the high current injector. The major components that make up the system are the ion source, buncher, radio frequency quadrupole and drift tube linac accelerators along with the beam optical components required for beam transport like dipole and quadrupole magnets and other beam diagnostic elements.

INTRODUCTION

The existing experimental facilities at the Inter University Accelerator Centre (IUAC) depend on the 14 MV tandem accelerator and the superconducting quarter wave resonator based linear accelerator operating at 97 MHz. The beams from the tandem are either used directly for experiments (in beam hall 1) or injected into the superconducting linac for further energy gain (and used in beam hall 2). An alternate source of ions for the superconducting linac was felt to be necessary so as to increase the beam currents and the number of species of ions. This would also enable the tandem to be used in a stand alone fashion.

The aim of the HCI is therefore to provide the superconducting linac with large currents of ion beams for almost species across the periodic table.

Among accelerating techniques available today, the radio frequency accelerators have been found to be efficient and flexible for particle acceleration to high energies. The high current injector at IUAC is planned to provide high currents of multiply charged ions to the superconducting linac. The ion source has been specifically designed to produce high currents of highly charged ion, while having a very low power consumption that enables it to be placed on a high voltage deck. Details on the performance of the ion source (PKDELIS) will be presented in a separate paper within these proceedings. It is envisaged that the ion source on the high voltage deck will provide ions of mass by charge ratio (A/q) equal to 6 at 8 keV/u. These would then be bunched by a multi-harmonic buncher (operating at a fundamental frequency 12.125 MHz) and focussed into a radio frequency quadrupole accelerator (RFQ) operating at 48.5 MHz. The RFQ will accelerate the beams to 180 keV/u and is followed by a re-buncher (at 48.5 MHz). The beam is then injected into a room temperature linac (several tanks) that bunch and accelerate to 1.2 MeV/u. The beam is then to be transported from the beam HCI beam hall to the linac injection centre. Separate papers in these proceedings give details on the status and preparation of the RFQ, DTL and beam optics for transport of the accelerated beam.

ACCELERATOR LAYOUT

A beam hall of size 33 by 10 meters adjoining the original pelletron experimental beam hall is being constructed to house the high current injector. The injector will be housed on the ground floor and a basement for future expansion is also being made available. Electrical and chilled water supply into the beam hall has already been established. An overhead crane for lifting heavy equipment is also ready. The chilled water and air handling equipment are all placed on the first floor.

The general accelerator layout for accelerating the beam up to 1.2 MeV/u is given in Figure 1 as a schematic

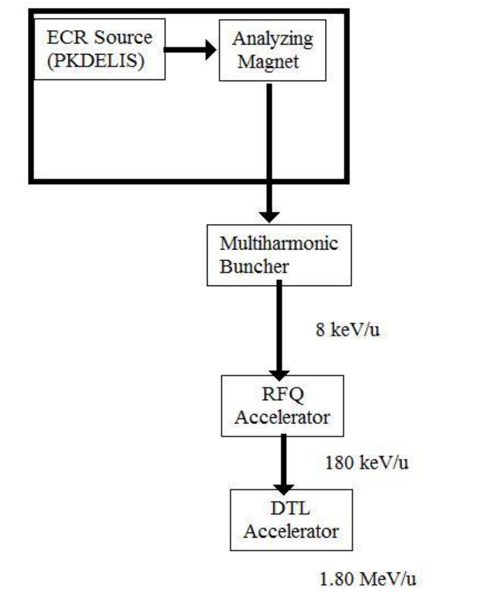

Figure 1 Schematic of the high current injector

ECR Source

The first element is a an Electron Cyclotron Resonance Source (ECR) which is specifically designed for this application. Since the source needs to be placed on a high voltage deck one of the important considerations is the power consumption by the source and associated control equipment. One of the major sources of the power consumption are the magnetic field producing coils. In the PKDELIS ion source, the radial confinement is produced by permanent magnets, while the axial confinement coils are made of High Tc superconducting wires, reducing the power required by drastic amounts. Details on the construction and operational experience is provided in a separate article within this volume [1].

High Voltage Deck

The ECR source, along with an analysing magnet, quadrupole lenses and steerers is going to be placed on a high voltage deck. The deck will be 4 by 4.5 m and will have space for the RF amplifier, ECR source, control electronics and vacuum conditioning equipment along with facilities for storage of gases and samples for beam production. The analysing magnet and quadrupole are already fabricated and operational. The isolation transformers required for powering the equipment is also ready to supply 3 phase 30 kVA at 400kV isolation. The ECR source can normally operate at 30kV extraction. For heavy ions (A>6) this will be unable to provide the 8 keV/u required by the radio frequency quadrupole accelerator. The high voltage deck will be used, along with an accelerator tube to raise the beam energy to exactly 8 keV/u.

The analysing magnet present on the high voltage deck will allow only the desired ions to pass through the accelerating column. This reduces the current requirement on the high voltage power supply from several 100 mA to a few micro-amperes.

Multiharmonic Buncher

The beam from the high voltage deck is a continuous (DC) beam. A conventional radio frequency accelerator would be able to adiabatically bunch and accelerate the beam. However, due to space constraints, it has been decided to use an external buncher to reduce the length of the RFQ. The buncher will be almost identical to the buncher [2] being used at the 16MV tandem accelerator. It will operate at 12.125 MHz along with the next two harmonics (24.25 and 48.5 MHz). The time focus of the buncher would be at the entrance of the RFQ.

Radio Frequency Quadrupole

The radio frequency quadrupole is designed to accelerate the beams from 8 keV/u to 180 keV/u. The rectangular tank houses a “Frankfurt” four-rod design cavity. The inter-vane voltage is expected to be 70 kV. A prototype tank has been fabricated to test the mechanical and RF properties of the proposed cavity. The length of the prototype is 1.17 m. The RFQ operational frequency is 48.5 MHz which is half that of the drift tube linac that follow it.

Two sets of vanes, one unmodulated and one modulated set were manufactured and assembled to form the RFQ cavity. The feasibility of machining all pieces (tanks, vane supports and vanes) to the specified tolerances was confirmed. The vanes and vane supports were also provided with water cooling channels. Vacuum and leak checks were successfully completed along with cooling water flow [3].

Low power RF tests [4] were performed on the assembled cavity to determine the resonant frequency, shunt impedance and inter-vane electric fields. It was noted that the frequency was very sensitive to the room temperature, but could be controlled by the processed water temperature.

A 30kW RF amplifier was used for high power tests. The cavity was powered upto 25 kW without problems. However, the base plate was found to be heating up and it was decided to provide cooling channels as well as change from copper plated SS304 to bulk copper.

At present design of the coupler, tuners and RF control electronics is ongoing.

Drift Tube Linac

Ion beams at 180 keV/u produced by the RFQ will be injected into a room temperature drift tube linac consisting of 6 tanks that shall accelerate the beams to 1.8 MeV/u while maintaining the bunched nature of the beam utilizing internal, integrated bunching sections.

The linac section shall consist of 6 tanks, each consisting of an IH cavity. The transverse focussing shall be done by quadrupole triplets, placed in between, but external to the tanks.

The drift tube linac section is proposed to comprise of 6 tanks. The various characteristics of these tanks are provided in Table 1. The RF power mentioned is as calculated from CST Microwave Studio calculations. A factor of two more is expected to be required.

Table 1: Drift tube linac specifications

Tank Number	**Length (cm)**	**Number of gaps**	**Energy Gain (MeV/u)**	**RF Power (kW)**
1	38.7	11	0.137	5
2	69.3	13	0.234	11
3	89.6	13	0.312	18
4	93.6	11	0.276	18
5	91.7	11	0.344	24
6	82	9	0.336	25

A prototype tank corresponding to the first accelerating tank has been fabricated, and low power RF test conducted. The tank was made from SS304. The mechanical structure of the stems, ridges and tubes of the IH structure was also fabricated and assembled out of Aluminium and Copper. Detailed reports are presented elsewhere in this volume [5].

Beam Transport

The accelerated beam as provided by the drift tube linac has now to be transported several meters to the superconducting linac. The bunched nature of the beam requires that we use rebunchers to maintain the temporal bunching. The use of achromatic magnetic bends is also a necessity since there is also an energy spread in the beam.

The beam also needs to be bunched between the exit of the RFQ and the entrance of the DTL. A buncher operating at 48.5 MHz is proposed. The low velocity of the beam at the beginning of the HCI means that high frequencies cannot be used due to the small drift tube length required.

Two possible beam transport configurations are being analysed at present. One is a visually simple, all 90 degree bend configuration. The other is more compact, angular scheme. Details of both the schemes have been provided elsewhere within this volume[6,7].

Both the schemes need two bunchers (operating at 97 MHz) and several dipole and quadrupole magnets before injection into the low beta cavity that precedes the superconducting linac.

SUMMARY

The High Current Injector is being developed at IUAC as an alternate injector into the superconducting LINAC. Various options for beam transport are being analysed, while prototype studies on RFQ and DTL structures are in an advanced stage. The ECR source is ready and functional. Design activity is at present in progress on bunchers, high voltage deck and control electronics. The beam hall is almost ready, final touches on the air conditioning system are in progress.

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