Developmental activities of the 18 GHz High Temperature Superconducting ECR Ion Source, PKDELIS, for the High Current Injector at IUAC.

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Abstract
Various developmental activities of the 18 GHz High Temperature Superconducting ECR Ion Source, PKDELIS have been carried out as a part of the High Current Injector programme. Emittance measurements using a simple technique has given important inputs for the design of downstream accelerators like RFQ, DTL and low beta cavities. The techniques allows for emittance matching by varying the emittance parameters to match with the acceptance of the accelerators. X-ray Bremstraahlung measurements from ECR plasma has shown that it is a diagnostic tool to optimize the production of highly charged ions. The ion optics through the low energy beam transport section has been benchmarked with various codes and given a handle to optimize the transmission. New techniques to improve the extraction efficiency of highly charged ions has been developed..

INTRODUCTION

At the Inter University Accelerator Centre, New Delhi, the accelerator augmentation programme involves the development of new accelerators for further boosting the beam energies to above 5 MeV/u (above Coulomb barrier) around mass 100 a.m.u. With the existing tandem accelerator, it was realised that the beam currents and mass range available were not sufficient for most of the experiments in nuclear physics and related areas The Pelletron-LINAC combination in parallel with a high current injector was proposed to meet the above design goal. An alternate high current injector was proposed based on a reasonable high performing electron cyclotron resonance ion source [1] capable of delivering higher beam currents and covering a wide mass range. In this paper, the developmental activities of the HTS-ECRIS PKDELIS at ground potential (presently) is described. This kind of source was designed for operation on a 400 kV high voltage platform to inject beams with initial velocities at 1 % of the velocity of light and further accelerate to ~ 8 % of the velocity of light before injection into the superconducting linear accelerator. In the near future, the source and low energy beam transport section will be finally shifted for installation on a high voltage platform to prepare for injection into the superconducting linear accelerator. The new beam hall III construction is complete and various beam hall utilities are nearing completion. Figure 1 depicts a schematic of the proposed High Current Injector with respect to the Pelletron-LINAC accelerator.

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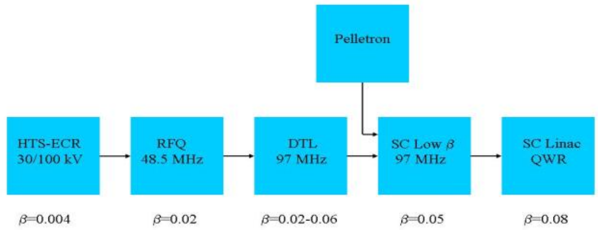

Figure 1: Schematic of the proposed High Current Injector with respect to the Pelletron-LINAC accelerator

EMITTANCE MEASUREMENTS

For the High Current Injector programme at Inter University Accelerator Centre, an HTS ECR ion source, PKDELIS, would provide the high charge state ions. The emittance of the ion source is an important parameter to design further beam transport system and to match the acceptances of the downstream radio frequency quadrupole and drift tube linac accelerators of the High Current Injector. The emittance of the analysed beam of the source has been measured utilizing the three beam size technique. A slit and two BPM's positioned at fixed distances from each other were used to measure the beam size. The digitized beam profiles have been analysed to determine the emittance of various multiply charged ions [2]. Figure 2 depicts the measured beam emittances for various heavy ions using a slit width of 5mm. Besides the mass dependence effect, where the emittance improves with increasing mass, within a charge state distribution, the higher charge states have a lower emittance. The lowest mass that can be accelerated through the SC-LINAC has been chosen to be oxygen and this gives an upper limit for the beam emittance as shown in figure 2. The influence of gas mixing (oxygen) on the beam emittance of argon has been measured. All these measurements has given important inputs for the design of the beam transport system and to match the acceptances of further downstream accelerators of RFQ and DTL of the high current injector programme at IUAC.

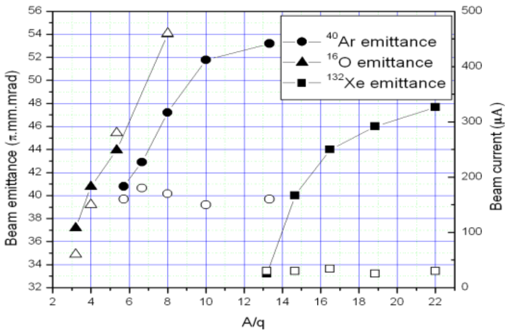

Figure 2. Measured beam emittances for various heavy ion beams using a slit width of 5 mm [2].

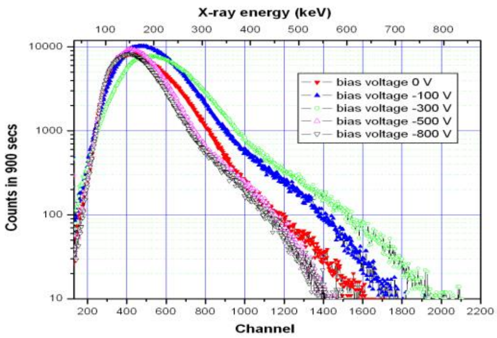

Figure 3. X-ray Bremsstrahlung spectra as a function of negative DC bias voltage with extraction voltage OFF [3]

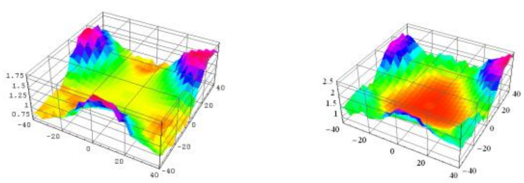

Figure 4.(Left) Magnetic holes (Right) Optimised structure without magnetic holes

X-RAY BREMSTRAAHLUNG MEASUREMENTS : DIAGNOSTIC TOOL

X-ray Bremstraahlung measurements from the 18 GHz HTS-ECRIS, PKDELIS were measured as a function of negative DC bias voltage keeping all other source operating parameters fixed and the extraction voltage in the off condition [3]. The optimization of medium and highly charged ions of argon with similar source operating parameters was carried out. It was observed that the high temperature component of the electron was altered significantly with the help of bias voltage and the electron population has to be maximised for obtaining higher currents (figure 3). This gives a handle to optimise the production of highly charged ions.

SOURCE EXTRACTION AND OPTICS

The observed beam profile from the extraction side shows that the beam is not cylindrically symmetric due to the influence of the hexapole magnet. However, it has been observed from various experiments that the simulated ion optics using 2D codes like GIOS, COSY and GICOSY matches reasonably well with the observed beam profiles after mass analysis. More detailed analysis is required using 3D codes and further work is in progress.

PRODUCTION OF INTENSE BEAMS OF HIGHLY CHARGED IONS

3D simulation studies [4] using RADIA code have been performed to optimise the magnetic holes in the high temperature superconducting electron cyclotron resonance (HTS-ECRIS) ion source for improving the extraction efficiency and beam intensities of highly charged ions. The magnetic field improvements using simple techniques like optimisation of iron regions was found to be economical (figure 4.). The extraction efficiency can be increased three-fold in the case of a hexapole magnet depending on the level of the uniformity of the fields in the high and low regions. This technique further minimises localized heating of the plasma chamber walls which can improve the vacuum conditions in an ECR ion source. The lifetime of synthetic high voltage insulators used between the plasma chamber and the cryostat can be increased further. For superconducting sources where the x-ray heat load poses severe problems during operation, such a reduction of heat load is of great significance. The typical triangular patterns of the plasma impact observed on the plasma electrode of HTS ECRIS at various tuning conditions are well reproduced by the simulations. After modification of the extraction system according to the simulations, preliminary experimental results had shown that the total beam current increased by a factor of 2 to 3. Beam stability aspects due to the larger currents extracted will be tried to improve further.

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