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SIMULATION STUDIES FOR OPTIMIZATION OF 60 MHZ ROD TYPE RADIO FREQUENCY QUADRUPOLE ACCELERATOR DESIGN AT IPR

A 60 MHz Rod type "Radio Frequency Quadrupole Accelerator" has been designed for material studies through Ion Irradiation at Institute for Plasma Research, Gandhinagar, using indigenously developed RF source (35-65 MHz frequency @ 1 MW power.

The set-up mainly consists of an ECR (H+/D+) ion source coupled to (copper) Radio Frequency Quadrupole (RFQ) accelerator through a Low energy beam transport system (LEBT) to produce 1 MeV, 5mA hydrogen ion beams. Accelerated beam is then directed to the target using appropriate beam line components and required diagnostics. The accelerated ion beam produced by RFQ and the subsequent reaction of the beam with different targets will be used to sudy maerial characeristics.

The frequency, output energy, and current were preselected for the RFQ design. The frequency was fixed at 60 MHz for the RFQ in order to utilize available RF source @ 35-65 MHz at IPR. The normalized transverse beam emittance has been taken as 0.2 π mm mrad. The peak surface field for the design was chosen to be 1.8 E_k. (E_k = 9.5 MV/m @ 60 MHz). Parameters were optimized by allowing V and R_0 to vary while maintaining ρ/R_0 constant to 0.85 to achieve a good balance between fields limits and multipole effects.

First of all vane voltage, focusing factor (B) and characteristic radius (R_c) have been optimized. The vane voltage is chosen on the basis of Kilpatrick limit. Focussing factor B is fixed at ≈ 9 and maximum modulation m ≈ 3. The RFQ has been simulated using RFQGEN, written by Lloyd Young. Above considerations have resulted into vane voltage of 95 kV and characteristic radius of 1.56 cm. At the beginning of RFQ, a six cell radial matching section has been designed to match the DC beam from ECR ion source to time varying structure of RFQ by tapering the vanes. Number of iterations have been carried out to optimize beam energy, synchronous phase, aperture, modulation with cell number and focusing factor. Finally transmission of 97.4% has been achieved for 97 cells @ 5 mA beam current. A 4160 mm long RFQ with 24 vanes supported over 12 posts, enclosed in two Aluminium T-6061 chambers having 60.6 MHz resonant frequency has been designed and analysed.

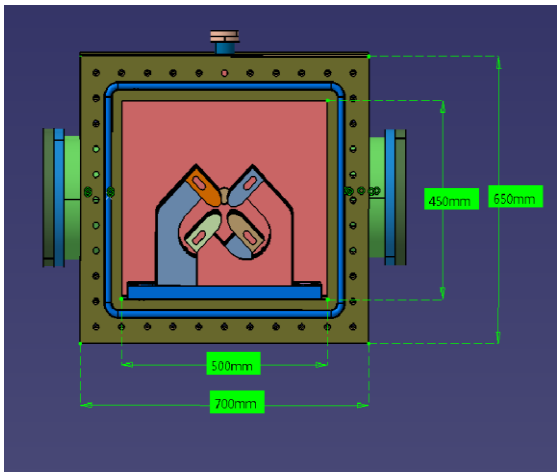

FIG. 1. Front View of RFQ

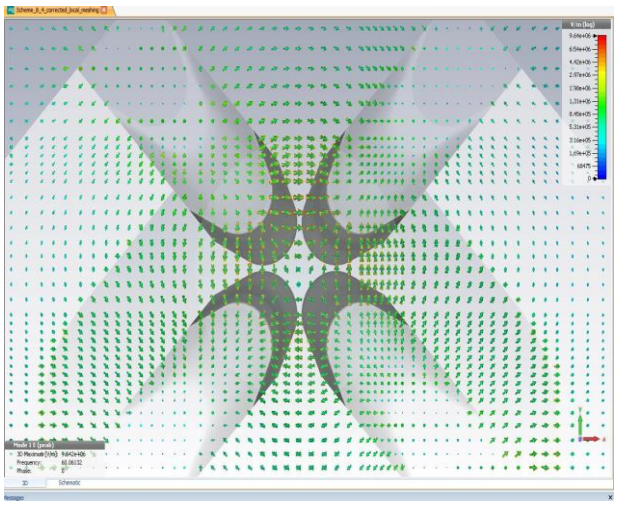

FIG. 2. Resonant Frequency simulation

20 cooling channels of 8 mm diameter have been optimized to restrict the temperature rise to 1^0C during pulsed operation while temperature variation is higher in steady state operation. Further optimization will be carried out in future to lower temperature variation in steady state operation.