DESIGN AND DEVELOPMENT OF 75.6 MHZ LINAC FOR VECC-RIB FACILITY

P. S. Chauhan, T. K. mandi, D. P. Dutta, H. K. Pandey, M. Mondal,
A. Bandyopadhyay and A. chakrabarti
Variable Energy Cyclotron Center 1/AF Bidhannagar Kolkata-700064

Abstract
An ISOL post accelerator type of RIB facility is being developed at VECC. The radioactive ion beam will be accelerated by RFQ, LINAC-I and LINAC-II all operational at 37.8 MHz to reach energy of 286 keV/u. A third LINAC cavity designed for 75.6 MHz will be accelerating the ions upto 415KeV/u. The physics design; RF design, Mechanical analysis and cold model measurements of LINAC-III will be presented in this paper.

INTRODUCTION

Radioactive ion beams open a new dimension in the area of accelerator-based research. It gives flexibility to use short lived nuclei as a projectile in nuclear physics and allied science research. An ISOL type of RIB facility is being developed at our centre [1]. Light ion beams (p, α) from the k=130 cyclotron will be used as a primary beam for this facility. The primary reaction products will be ionised using an online ion source and mass separated to choose RIB of interest. Since the intensities of the RIBs are expected to be low, linear accelerators becomes the preferred choice for the acceleration of RIBs. The RIBs will be accelerated from 1-99 KeV/u using a heavy ion RFQ [2] operating at 37.8 MHz. Further acceleration up to 1.3 MeV/u will be done using IH LINAC cavities. The first two cavities operating at 37.8 MHz have been installed in the beam line. They accelerate the beam upto 286 KeV/u [3]. All of them are designed for q/A ≥1/14. This will be followed by third IH cavity designed for 75.6 MHz to reach 415 KeV/u. The design and development of the third cavity will be reported in this paper.

PHYSICS AND RF DESIGN

The LINAC design starts with the generation of the cell table, i.e. to find out the cell length, operating voltage, number of cells in the tank etc. For calculation of cell parameter starting point is drift tube geometry optimization where drift tube support, ridges and cavity details are ignored. For a particular drift tube geometry static electric field data is found from POISSON code, then this data along with the design value of phase and velocity is feed in the equation of motion to get cell parameters. With this gap and cell geometry, the cavity parameters have been optimized using FEM code ANSYS. Initial dimensions of cavity elements have been chosen from mechanical considerations (mechanical strength and space for cooling components) and they are further optimised to get maximum shunt impedance. The detailed beam dynamics have been studied using VECLIN code with interpolated field from ANSYS. The important parameters for the cavity are shown in Table 1.

Table 1: Important parameters of LINAC-III

Parameter	Value	Unit
Frequency	75.6	MHz
q/A	≥1/14	#
T_{in}	286	KeV/u
T_{out}	415	KeV/u
DT ID	25	mm
DT OD	35	mm
Gap length	24.8	mm
Accelerating gaps	17	#
Max. Field	$1.4xE_{kilpatric}$	
Sync. phase	-18	Degree
Cavity length	912.8	mm
Accln. gradient	1.99	MV/m per q
Shunt impedance	566	MΩ/m
Q-value	16982	#
RF power	~15	kW

COLD MODEL TEST OF LINAC-III

A full scale cold model of the LINAC-III cavity has been fabricated to test the RF structure. This cavity is made from 10mm thick aluminium plates assembled on octagonal steel structure. Inner components (drift tubes and ridges) are machined from solid aluminium blocks. In this model no RF contacts have been used. All the excitation modes up to 125 MHz have been measured. The results of these measurements are compared with ANSYS simulation results and are shown in Table-2.

Table 2: Results of LINAC-III cold model test

Mode	Calculated Freq	Measured Freq.
1	76.124 MHz	76.06 MHz
2	107.15 MHz	107.82MHz
3	120.30 MHz	121.82 MHz

The cavity has two capacitive tuners to modify the frequency. A movement of 100 mm of the tuners can achieve a frequency change of about 2% as shown in fig.1.

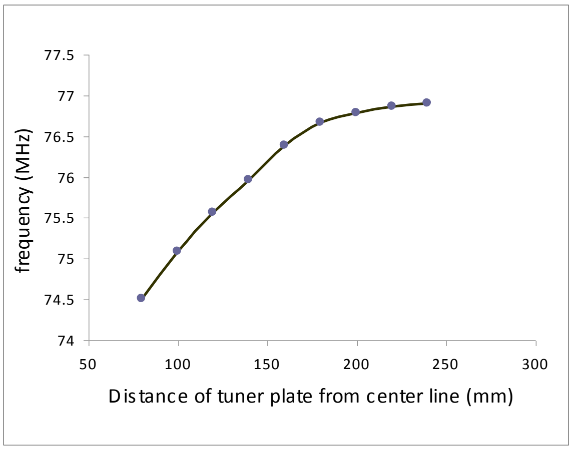

Figure 1 Variation of the frequency of the cold model cavity due to tuner movement.

MECHANICAL AND THERMAL ASPECTS

The LINAC is subjected to loads due to atmospheric pressure, gravity and temperature distribution. RF analysis data from ANSYS is used to calculate thermal loads on the cavity. These thermal loads are then used to optimise the cooling channels of the LINAC using adequate safety factor.

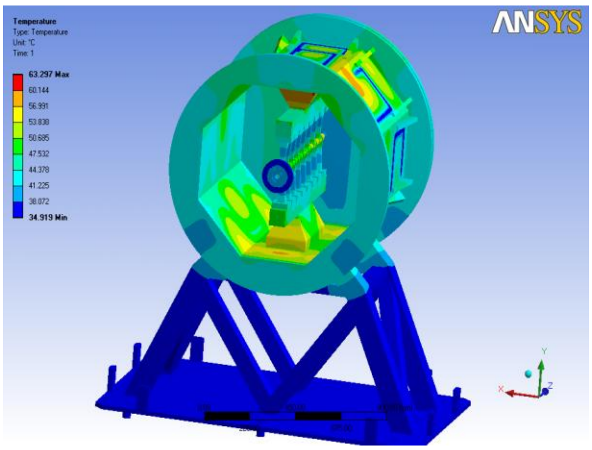

Figure 2 Temperature rise of LINAC-III cavity in steady state.

A typical example of such analysis is shown in figure 2. In the worst case scenario, there may be a temperature rise of about 28 ^{0}C at some locations within the cavity.

The deformation may affect the alignment of the drift tubes and may reduce end gaps of the LINAC. The thickness of the materials of the cavity and the end cover has been optimised to reduce this effect. In addition, circular reinforcements have been incorporated on the end covers and optimised to further minimise this effect. A typical simulation for directional deformation (y-axis) of the cavity is shown in figure 3.

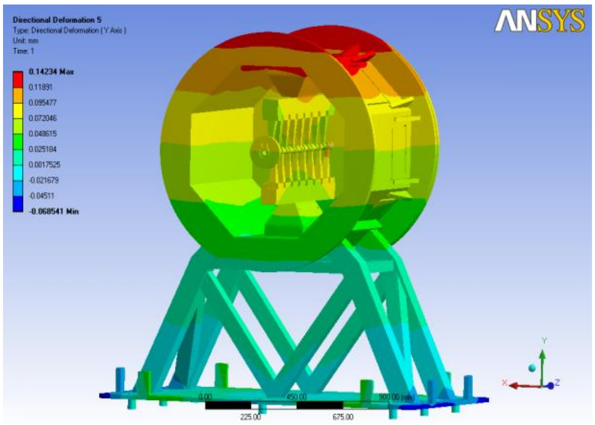

Figure 3 directional deformation (y-axis) of the LINAC-III cavity.

FINAL CAVITY OF LINAC-III

Final cavity of LINAC-III has been fabricated and delivered. The cavity has been fabricated using explosively bonded copper on steel. Each of the ridges and drift tubes has been fabricated from single block of ETP grade copper. The cavity has passed the vacuum performance test at manufacturer's site. Final cleaning and assembly of the cavity has been done. And it is now ready for low power RF test.

REFERANCES

[1] A. Bandyopadhyay, A Chakrabarti et al., "Rare Ion Beam Facility At Kolkata Present State of Development" PAC09, Vancouver, Canada, Paper ID FR5REP117

[2] S Dechoudhary,V Naik,Alok Chakrbarti et al.,"Design And Development of Radiofrequency Quadrupole postaccelerator for the Variable Energy Cyclotron Center rare ion beam project" Rev. Sci. Instrum. 81, 023301 (2010)

[3] A Bandyopadhyay, O. Kamigaito et al., "Design of LINAC post-accelerator for VECC RIB facility using realistic Field", Nucl. Instr. & Meth. 560 (2006) 182.