STATUS REPORT ON THE CONSTRUCTION OF THE ISAC DRIFT TUBE LINAC

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Abstract

The first phase of the ISAC radioactive ion beam facility at TRIUMF is well under way. It combines an isotope mass separator-on-line with a post accelerator. Required in the accelerator chain is a drift tube LINAC capable of accelerating unstable nuclei with a charge to mass ratio greater or equal to 1/6 from E = 0.15 MeV/nucleon to a final energy fully variable up to 1.5 MeV/nucleon. Due to the relatively low intensities of some of the radioactive species, continuous (cw) operation of the accelerator is required. A five tank interdigital H-type structure, operating at 106 MHz, has been chosen. A separated function DTL concept has been developed. Five independently phased IH tanks operating at $\Phi = 0°$ provide the main acceleration. Longitudinal focussing is provided by split-ring resonator structures positioned before the second, third and fourth IH tanks. Quadrupole triplets placed after each IH tank maintain transverse focussing.

The whole DTL, bunchers and quadrupole triplets are mounted on a large frame support to assure the best possible mechanical stability. Each component has an off axis alignment fixture to assure and maintain the alignment of the entire system.

1 INTRODUCTION

The TRIUMF‘s ISAC uses the isotope separation on line (ISOL) technique to produce radioactive ion beams (RIB). The ISOL system consists of a primary production beam, a target/ion source, a mass separator, and a beam transport system. These systems together act as the source of radioactive ion beams to be provided to the accelerator or the low-energy experimental areas. We use the 500 MeV - 100µA primary proton beam extracted from the H^- cyclotron. A new beam line has been built to transport this beam to two target stations. A radioactive ion beam (RIB) facility has been built at TRIUMF [1-3]. The ISAC facility uses the isotope separation on line (ISOL) technique to produce radioactive ion beams (RIB). The accelerator complex comprises an RFQ [4] to accelerate beams of $q/A \geq 1/30$ from 2 keV/u to 150 keV/u and a LINAC (DTL) to accelerate ions of $q/A \geq 1/6$ to a final energy between 0.15 MeV/u to 1.5 MeV/u. Both LINACs are required to operate cw to preserve beam intensity. A first proposal, in 1985 envisaged the use of a Wideroe structure for the ISAC DTL LINAC [5]. A second study envisaged the use of a superconducting structure [6,7] for the post stripper LINAC. After approval of the ISAC FIVE-YEAR plan in 1995, we decided to build a room temperature LINAC because of the very tight schedule. Due to the requirement of continuous energy variability and preservation of the time structure, the DTL structure has been configured as a separated function DTL [8,9]. Five independently phased IH tanks operating at $\phi_s = 0°$ provide the main acceleration. Longitudinal focussing is provided by three independently phased, split-ring resonator structures positioned before the second, third and fourth IH tanks. Quadrupole triplets placed after each of the four IH tanks maintain transverse focussing.

2 IH TANK FABRICATION

2.1 Simulations and specifications

The electromagnetic code MAFIA was used to simulate the DTL tank structure to assist in optimizing the dimensions of the selected configuration. This eliminates construction of a large number of scale models during the optimization process. The electric field distribution inside a cylindrical cavity operating in the H111-mode has a sinusoidal shape. The flatness of the gap voltage distribution along the beam axis is one main problem to solve. This means that we have to make the capacity and inductivity per unit length of the cavity constant. The capacity and/or inductivity per unit length of the cavity have to increase towards the ends. Several MAFIA simulations were performed to obtain the proper flux-inducer shape at both ends of the cavity. MAFIA was also used to predict the appropriate g/L dependence to flatten the field distribution.

Table 1 gives a summary of the RF characteristics of all five tanks.

2.2 Mechanical fabrication

The last four DTL-IH tanks are built from a forged mild steel cylinder, 2.54 cm thick. The first tank is 26 cm long and 96 cm in diameter. The last four are 70 cm in diameter by 50, 77, 90 and 98 cm long. The two lids are made from 25 mm thick copper. The IH cavity is made in four main components, the cylindrical wall, the ridges, the lids and the stems. The interior faces are machined to a surface finish of 16 µinch and then copper plated. The copper plating thickness is larger than the necessary RF required penetration depth to assure a very nice finish.

The ridges base rest on a flat machined on the inner tank wall after copper plating. Four bolts clamp the ridges in place and the vacuum seal is done using an o-ring. The faces of the ridges and bases are machined and polished to a finish less than 5 µinches to assure a very good rf contact as demonstrated on a test cavity. Provision for alignment was made by allowing an extra 1.5 mm at the base of each stem. At first, each stem was installed in the tank and the center of each drift-tube measure with precision. Then the base of each stem was machined to the right height as well as an o-ring groove to seal the vacuum from the cooling line. The stems are bolted down on the ridges at their final location and the alignment was checked to be better than ± 50 µm.

We had some minor problems with the copper plating of the RF groove on tank1 lids., The copper accumulates on the edges and there was not sufficient at several places in the groove. For the last four tanks we made the two end-plates from a copper sheet, 25 mm thick and machine the RF and the “O-ring” grooves in the two lids instead on the cylinder. Since we did not have to copper plate de lid, it eliminates the problem.

The lids require very little cooling. Each lid has two cooling line, 6 mm in diameter, drilled in the lid thickness. The same technique was retrofit to the three buncher’s cavities to help cooling the end-plate facing the quadrople triplets.

Table 1: ISAC IH-tank specifications

Tank	N Cells	R Cm	L Cm	Veff MV	FM MHz	F MHz	Q M	Q	Zeff M MΩ/m	Zeff MΩ/m
1	9	46	26	0.54	106.5	109.7	11000	9700	374	330
2	13	35	50	1.18	106.7	107.4	20050	11226	525	424
3	15	35	77	1.96	106.7	106.8	19700	11800	460	442
4	14	35	90	2.15	106.7	-------	21920	------	390	------
5	13	35	98	2.20	106.7	-------	22970	------	345	------

2.3 Field distribution

The electric field distribution on axis has been measured along the DTL axis for the first three tanks using the perturbation method. A small dielectric bead is moved on axis by step and the frequency is measured at each step. Figure3 shows the plot of the electric field strength extracted from the frequency variation. The field distributions are rather flat for tank 1 and 3. However, the field distribution has a 5% slope for tank 2. This can be due to the vacuum pump port on one side, making the current path unsymmetrical. This will be corrected by a mesh placed over the vacuum port.

3 DTL STAND AND ALIGNMENT PROCEDURE

Several options were envisaged for the DTL stand;

- solid concrete block like the one used for the RFQ,
- five posts bolted into the floor,
- a rigid frame that support the whole DTL

The solid concrete block was not possible because of its weight. Using independent post was rejected since the building floor is not completely settled. In some area, we can see floor movement of the order of several mm.

The solution we finally adopt consists of rigid structure supporting the whole DTL assembly. The frame is made of two large I-beams welded together. The structure rests on three completely independently adjustable legs. In any case, if the floor move we can just realign the DTL assembly in once. Each component is mounted with a three point adjustment fixture for alignment. Figure 2 shows two section views of the DTL assembly on its stand. The alignment of such a structure is an issue. Because of the small aperture, we will not have a straight view through the DTL. To overcome the problem we decided to have an off-axis line of sight. The five IH-tanks and the four quadrupole are equipped with alignment fixtures that permit to align them independently of each other without having to break the vacuum beam line. Figure. 2 b shows the alignment fixture on the right corner.

4 DTL X-RAYS SHIELDING

The DTL is located in the experimental hall very close to the low energy experimental area. The DTL is installed in an well shielded enclosure. The DTL x-ray shield is composed of 3 mm Pb placed between two 3/4” thick plywood sheet. Those panels are mounted on permanent steel frames bolted to the floor and the wall of the building. The panels can be easily removed in case we have to pull out one component of the DTL.

Fig. 1 Photograph of tank2 and buncher assembly being prepared for RF power test. The buncher is the small cavity in front of the tank.

5 STATUS OF THE DTL

All five IH-tanks, the three buncher cavities and the four magnetic quadrupole triplet has been fabricated and received. Tank one is already installed in its final location on the frame support in the experimental hall.

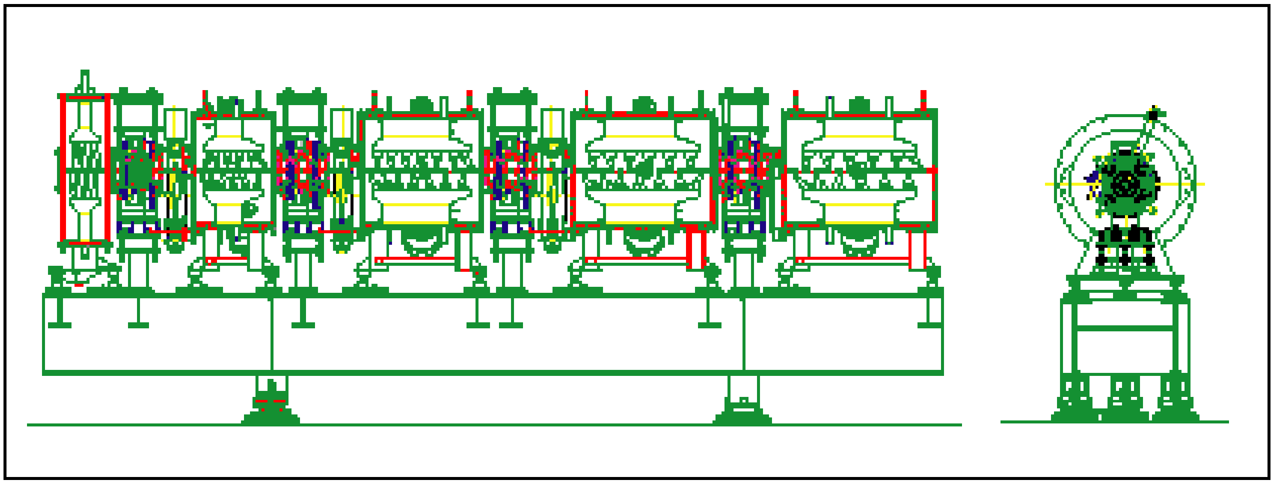

Fig. 2: Layout of the DTL on its stand.

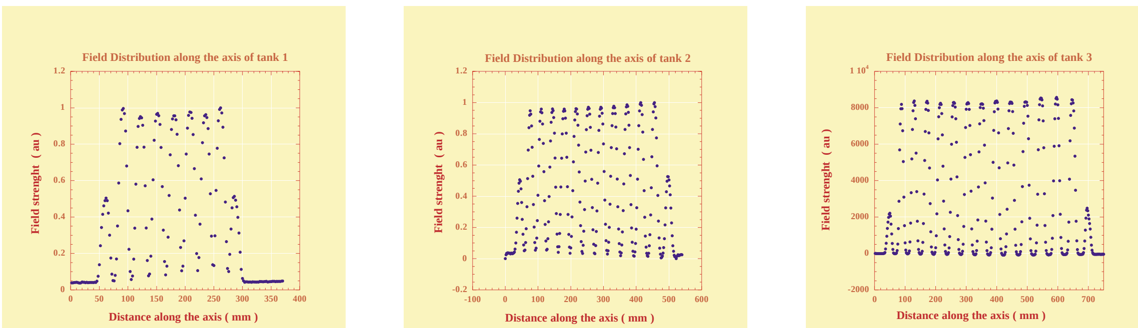

Fig. 3 Electric field distribution of the IH tank 1, 2 and 3.

The assembly of Tanks 2 and 3 is now completed. The field distributions has been measured using the bead perturbation method and are shown in fig. 3. Tank 2 and it associated buncher cavity assembly are ready for RF power test, see fig. 1.

The four magnetic quadrupole triplets have been assembled and three are field mapped. The results are in very good agreement with the predictions. First beam test through the RFQ, MEBT, first IH tank and buncher has been accomplished. Results are reported in this conference [10].

The installation and alignment of the tanks will proceed during the summer and we are planning to have our first accelerated beam through the whole LINAC at the end of this year.

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