

# STATUS OF THE NIOBIUM RESONATOR CONSTRUCTION PROJECT FOR THE NEW DELHI BOOSTER LINAC

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## Abstract

This paper reports the construction of niobium superconducting quarter wave resonant cavities for a booster linac for the 15 UD Pelletron accelerator at the Nuclear Science Centre. The resonators have been developed, and are being constructed, in collaboration with Argonne National Laboratory. Construction of the first batch of ten resonators started in May '97 and is expected to be completed by June '99. The incremental cost is expected to be about \$36K per cavity. Status and details of construction, and results of the first cold test are presented.

## 1. INTRODUCTION

A superconducting linear accelerator booster for the existing 15 UD tandem Pelletron accelerator [1], at the Nuclear Science Centre, is presently being constructed in collaboration with Argonne National Laboratory (ANL). A prototype quarter wave resonator (QWR) was designed, fabricated and tested successfully at ANL [2]. The linac will eventually consist of three cryostat modules each containing eight QWRs [3]. A total of twenty seven cavities, including one for the superbuncher and two for the rebuncher, will be needed for the linac. Construction of the first batch of ten resonators is presently nearing completion at ANL [4].

Figure 1 shows a schematic diagram of the 97 MHz quarter wave resonator optimised for a particle velocity  $\beta$  ( $=v/c$ ) = 0.08. Details of the cavity design have been presented elsewhere [5].

## 2. PRODUCTION DETAILS

The entire production is being carried out with commercial vendors in USA and India [6,7,8], unlike the prototype development project which was done in-house at ANL. Before the production started the technology of fabricating niobium resonators was transferred to the vendors. Considerable time and effort went into training vendors to perform the machining and sheet metal work

on niobium. Similarly, a major effort went into developing electron beam welding parameters for welding different thickness of niobium [9]. The electron beam welder is a five-axis CNC machine with movable gun and tilt, and a large vacuum chamber. The machine is equipped with a three head stock rotary fixture with matching tail stocks. To increase productivity, the entire weld fixturing was designed to perform multiple welds in a single pump down.

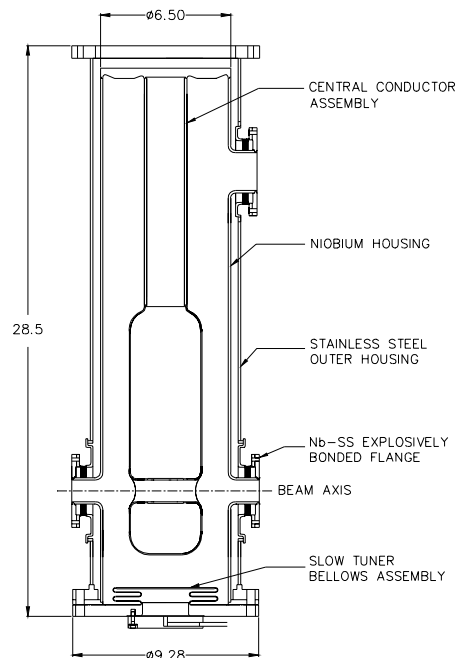


Figure 1: Schematic diagram of the 97 MHz quarter wave coaxial-line cavity. Dimensions are in inches.

The contract for the first batch of production calls for fabricating ten resonators. Because of higher productivity from the electron beam welder, than anticipated, we will produce twelve complete resonators and most of the parts for two more. The entire fabrication effort has been done in several major groups of tasks [4].

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### 3. PRESENT STATUS

At the time of writing this paper all the major sub-assemblies of the resonators, except the slow tuner bellows, have been fabricated. This represents about 85% of the total machining & sheet metal work, and about 66% of the total electron beam welding work for the project. Figures 2 and 3 show the bare niobium housings and the central conductor assemblies respectively.



Figure 2: Niobium housings with the beam & coupling ports.



Figure 3: Niobium central conductor assemblies.

We have completed fabricating two resonators, which are being tested. Figure 4 shows the first two resonators complete with the stainless steel jackets. The remainder are 70% complete, they have been tuned to frequency and the central conductor assemblies are being prepared for welding to the top flange. The slow tuner fabrication work will start shortly.

### 4. COLD TEST RESULTS

The first resonator was recently tested (without the slow tuner bellows) at 4.5 K and performed as shown in figure 5. The minimum performance goal of 3 MV/m with 4 watts of rf input power has been exceeded. The magnetic

shielding in the test cryostat has been found to be inadequate, and the higher rf losses in the cavity are thought to be from trapped magnetic flux from earth's magnetic field. Magnetic shielding is now being put around the test cryostat.



Figure 4: First two resonators complete with the stainless steel outer housings.

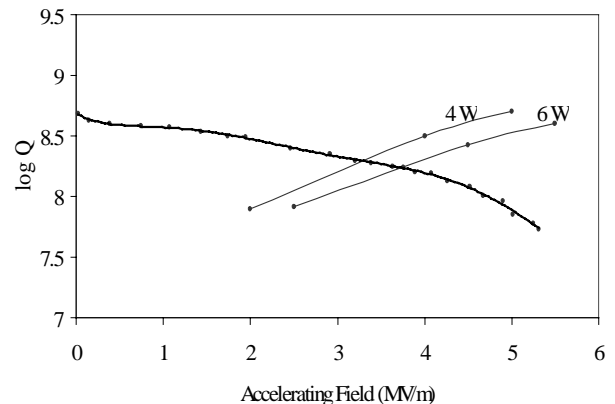


Figure 5: Resonator Q as a function of accelerating gradient at 4.5 K

### 5. COSTS AND EFFORT

Figure 6 shows the niobium material, fabrication and electron beam welding cost for the project. Several points should be noted:

- a) We are building twelve complete resonators and most of the parts for two more. We consider the effort to be equivalent to building thirteen resonators.
- b) The costs indicated represent the incremental costs and do not include the cost of the tooling. Most of the tooling made during the prototype resonator

- development project has been used. However, additional tooling was made as felt needed.
- c) The fabrication cost indicates the machining and sheet metal work on the niobium parts of the resonators. In addition to this cost, approximately 750 hours of effort was involved in fabricating the stainless steel parts at the vendor in reference 8.
  - d) The cost of fabrication is about \$60/hr, and the cost of electron beam welding is \$200/hr.

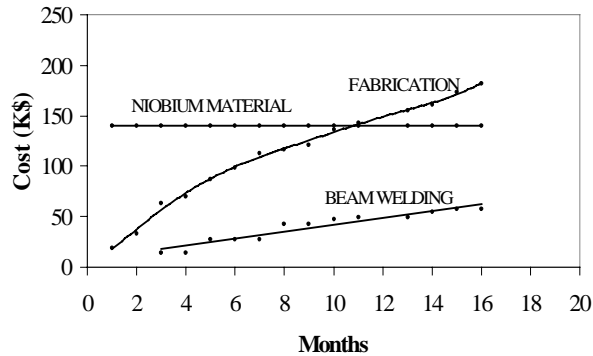


Figure 6: Production costs as a function of time. The entire work is expected to be completed before the end of the twentieth month.

- e) The electropolishing and heat treatment of the niobium parts is being performed in-house at ANL. The resonator tests are also performed at ANL.

## 6. CONCLUSIONS

Production of the first batch of resonators for the New Delhi linac is nearing completion. Major sub-assemblies of all the resonators have been fabricated and the entire production work is expected to be completed by June '99. Two cavities have been completed initially and the first resonator has performed above the nominal design goal. The incremental projected cost will be \$36K per cavity.

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