STATUS OF SUPERCONDUCTING LINAC BOOSTER FOR NSC PELLETRON*

A.Roy, P.N.Prakash, B.P.Ajithkumar, S.Ghosh, T.Changrani, A.Sarkar, R.Mehta, B.K.Sahu, A.Choudhury, J.Chacko, J.Anthony, M.V.Suresh Babu, M.Kumar, S.A.Krishnan, A.Mandal, G.O.Rodrigues, R.Kumar, R.K.Bhowmik and G.K.Mehta
Nuclear Science Centre, Aruna Asaf Ali Marg, P.O.Box 10502,
New Delhi -110 067,India

K.W.Shepard
Physics Division, Argonne National Laboratory,
9700 South Cass Avenue,Argonne,IL 60439, U.S.A.

Abstract

This paper reviews the progress made in the heavy ion superconducting linac booster project for the Nuclear Science Centre(NSC) Pelletron accelerator since the last workshop. The prototype resonator has surpassed design accelerating field at Argonne National Laboratory(ANL). A cryostat is being fabricated to house this prototype for in-beam tests. The cryogenic system has been installed and several rf modules have been constructed.

Introduction

The work for realisation of the superconducting linac booster for the 15 UD Pelletron accelerator at NSC [1] is continuing in full swing to achieve the goal of accelerating heavy ions up to mass 80 above the Coulomb barrier. The subsystems of the project are the basic accelerating structures, the rf instrumentation and control, the cryogenic system and the beam optics. The plan and the layout of these systems were presented in the earlier workshops [2]. We describe below the current status of each subsystem.

Resonators

The development of the optimised Quarter Wave Coaxial Line (QWCL) cavity resonator [3] for the linac booster has been completed. In recent cold tests it has exceeded the design goal of *3 MV/m at an RF loss of 4 W*. It has achieved a field of *4.2 MV/m at 4 W and 5.0 MV/m at 8 W of RF input*. The slow tuner bellows assembly has been tested at low temperatures and performs satisfactorily, providing the expected range of motion resulting in a frequecy tunability of about 70 kHz and causing no observable performance degradation at high field levels. The detailed results are presented in a separate paper at this workshop [4]. A contract has been signed between NSC and ANL for the fabrication of the first batch of ten QWCL cavities out of the total of 35 needed for the booster and production has started. These resonators would be housed in the first linac module. Each module would have 8 such QWCL cavities and four such modules are planned.

Cryogenics and Cryostats

A 600 W at 4.5 K helium reliquefier plant has been installed and commissioned. In the first phase this system will provide 330 W cooling capacity without liquid nitrogen in the pool boiling heat exchanger. The machine can also deliver 1200 watts at 60 K with the addition of another expansion engine in parallel to the warm engine. The reliquefier has been provided with two JT valves in series, to achieve 94% liquid and 6% vapour at the exit. A copper coil heat exchanger has been incorporated in the 1000 litre dewar to condense the balance 6% vapour. When used as a liquefier the machine can deliver 150 litres/hr of liquid helium. The machine will efficiently respond to the dynamic load variation between 25% to 100% loads.

A helium gas purifier operating at 78K temperature has been designed and built indigenously for helium gas. This purifier has been used successfully to purify helium gas obtained from the vendors before using in the refrigerator.

The closed loop liquid nitrogen reliquefier of capacity 5000 watts at 82 K, designed jointly by Nuclear Science Centre and M/s Stirling Cryogenics, the Netherlands, has been supplied and commissioned. It has delivered 5000 watts at 82 K with a spare capacity of 15%. The machine efficiently responds to the dynamic load variation between 25% to 100% loads. When used as a liquefier, the machine has delivered 50 litres/hr of liquid nitrogen. The total electric power required to run the system is 35 kW.

A cryostat is being fabricated to house the prototype resonator for in-beam tests. This cryostat would later be used as for testing resonators before putting them on-line. The buncher cryostat has been designed and is being ordered. The buncher would consist of a single QWCL cavity.

RF Instrumentation and Control

Powering of superconducting resonators require special circuitry due to their high Q-factor. Several electronic modules are required to operate the linac. The resonator controller module has as inputs, the instantanious RF field inside the resonator, amplitude reference, a master oscillator signal for the phase and frequency reference and a relative phase shift. It outputs the RF drive signal for the power amplifier which drives the resonator, a 25 KHz variable duty-cycle pulse for the PIN Diode pulser module and the phase and frequency error inputs for the slow tuner module. The power amplifiers are designed for 200 W load. A clock signal distribution system to provide phase reference signals at 97 MHz and its subharmonics has been designed.

Two resonator controller modules, two PIN Diode pulsers, eight channels of Slow tuners and one power amplifier have all been fabricated and tested with resonators on line at Argonne Tandem-Linac Accelerator System(ATLAS).

A multiharmonic buncher of ANL design [5] has been fabricated and is in the process of installation at the low energy end of the Pelletron accelerator. A spiral cavity phase detector [6] installed in the beam line after the analysing magnet of the Pelletron has been providing a stable reference pulse for timing experiments and would be used for the reference phase.

Beam Optics

The energy gain, layout of the beam line, ease of operation of the linac, depend very much on a thorough understanding of the beam optics and transport of the accelerated ions. The beam optics through the entire linac has been worked out using two computer codes, LINRAY [7] from ANL and NSCRAY [8] developed at NSC. The transverse focussing in the accelerating sections would be performed by superconducting solenoid magnets.

The energy gain, effect of misalignments of the resonators and the solenoids have been studied as well as the effect of randomly switching off of a few resonators and solenoids. Even with a solenoid in any cryostat switched off the beam can be transported to the target without any loss. The misalignment of the resonators do not pose a severe problem since misalignments of 1 mm can be tolerated, whereas the misalignments of solenoids by more that 0.1 mm produce a noticeable steering effect. A small magnetic steerer is being designed to go between the cryostats to correct for any such steering effects. Beam transport have been checked for the resonator fields varying over the range of quarter to one and a half times the design field as well as for all the resonators turned off. The placement of the buncher, linac modules and the rebuncher has been optimized from the consideration of close packing and the beam quality in both longitudinal and transverse phase space on target.

The quadrupoles and steering magnets for the beam lines are being designed in house and some of these have been fabricated indigenously. Laying of the beam line for the linac has started and several beam transport and diagnostic devices built in house are being used for this beam line.

Conclusion

The prototype resonator has been successfully tested and surpassed the design accelerating field. Production of the resonators for the first linac module has started at ANL. The civil construction for housing the linac and beam hall is complete. The cryogenic facilities comprising of liquid helium and liquid nitrogen systems are now ready. Beam optics studies have been completed and the beam line for the superbuncher installation has been laid. Several rf modules have been fabricated and tested.

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