COMPLETION OF THE FIRST PHASE AND STUDIES FOR THE UPGRADING OF THE ALPI PROJECT AT LNL

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Abstract

The installation of the $\beta = 0.11$ section of the linac ALPI is to be completed within 1992. This section, consisting of 48 lead plated superconducting quarter wave resonators (QWR), will boost the medium-heavy ion beams delivered by the 16 MV XTU Tandem in the energy range between 6 and 15 MeV/u. Progress in bulk niobium 80 MHz $\beta = 0.05$ QWR fabrication and related tests, in addition to the performance of the $\beta = 0.1$ 160 MHz Nb sputtered QWR prototype, is presented. Studies and experimental results of the new high intensity heavy ion injector based on a 14.4 GHz ECR source and SC-RFQ-Let are also discussed.

1 INTRODUCTION

The ALPI linac is a superconducting booster for heavy ions, presently under construction at Laboratori Nazionali di Legnaro [1]. The project has been divided in two phases; in the first phase 48 medium-β (optimum velocity β_o=0.11) lead plated copper 160 MHz quarter wave resonators will boost ions with mass number up to 100 delivered by the Legnaro XTU Tandem; in the second phase 24 low-β (β_o=0.055) 80 MHz and 21 high-β (β_o=0.15) 160 MHz resonators will be added, together with a new positive ion injector based on the Legnaro ECR source ALICE. In the final configuration ALPI will be able to accelerate all kinds of ions above the Coulomb barrier for any beam-target system.

2 STATUS OF ALPI, PHASE 1

The first phase of the project is at present in an advanced stage. The installation and alignment of the magnets, (2×90^o, 6×45^o and 2×6^o dipoles, 6 quadrupole singlets, 3 doublets and 23 triplets) [2] is almost completed. The cryogenic system - phase 1, consisting of a cold box, 10 distribution boxes, transfer lines and a 150 m^3/h gas recovery system was installed and tested with one cryostat connected to it. The system can produce up to 500 W in liquid helium at 4.5 K and 1500 W in helium gas at 7 bars and 60 K.

The cryostats for medium-β resonators are being delivered at a frequency of 1 per month. Four resonators and their associated equipment are then mounted in each cryostat and installed in the linac. At present one cryostat containing the 160 MHz bulk niobium superbuncher [3] and one containing the first 4 copper-lead plated resonators of the linac are in place.

The installation of the new pulsing system, based upon a 5 MHz double drift buncher [7], is also near completion and the preliminary measurements show that the system efficiency is over 50% and meets the design requirements for ALPI-phase 1.

The development and installation of the control system [4] will be completed within the current year. Preliminary tests were performed; the results were satisfactory and the goals of the system design (standardization and easy maintenance, network distributed control capability and friendly man-machine interface with fast response to operator commands) seemed to be met.

The production of diagnostic boxes has been started [5]; the first ones are being installed in the beam lines leading to the experimental halls. One box will be installed every second cryostat, i.e. in each beam waist; this choice will facilitate the linac set up. The diagnostic system provides informations on beam profile (vertical and horizontal grids), current (faraday cups), energy (silicon detectors) and time distribution (silicon and micro-channel plate detectors).

3 PROGRESS IN SUPERCONDUCTING RESONATORS

During 1991 the research on superconducting resonators at LNL has continued. A bulk niobium prototype for the 80 MHz low-β resonators of ALPI-phase 2 was constructed and tested [6]. Unfortunately, a serious vacuum accident (the cryostat imploded) damaged the resonator just before the measurements, changing the resonance frequency by 0.4 MHz and lowering the quality factor (the resonator gave 2 MV/m at 5 W input power). Nevertheless, the test has shown that the goals of the design were met: the multipactoring conditioning was easy, the cavity was mechanically and thermally stable and therefore the performance was determined mainly on the surface quality.

In parallel with the construction of the ALPI Linac, a research activity looking into high performance and low cost QWRs made of niobium sputtered on copper was initiated and is continued.

A sputtering apparatus, designed and constructed entirely at LNL, can routinely produce high uniformity films having superconducting critical temperature 9.25 K or better over the resonator internal surface. The new prototypes produced up to now prove the feasibility of Nb-Cu sputtered cavities and provide very encouraging results [8]. Moreover, the progressive improvements, achieved test by test, make this technology attractive and promising for the immediate future.

In ALPI-phase 1 48 lead plated copper 160 MHz resonators [9] will be used. One year ago, since we were waiting for cryostats and since a satisfactory lead-plating procedure seemed to be well estabilished, the plating program was suspended. It was restarted very recently and the usual procedure did not give, until now, results as good as previously; with slight modifications in the procedure, we are approaching the design goal of 3 MV/m accelerating field with 5 watts input power.

A theoretical and experimental work was done in order to calculate the strength of dipole and quadrupole components of the field in the LNL QWRs [10]; the work has shown that the usual donut-shaped drift tube, absent in the LNL resonators, is not needed as far as the beam dynamics is concerned.

4 STATUS OF THE ECR SOURCE PROJECT

The assembly of the ECR ion source "ALICE" [11] was completed during November 1991; one month later the first Ar beam was extracted. The source, working at 14.4 GHz, will be part of the positive ion injector foreseen in ALPI-phase 2. Experiments for optimizing the source parameters are being conducted keeping the maximum microwave power within 100 W; typical currents of 4 μA for O^{6+} and 235 nA for O^{7+} ions are obtained. Also other ions, like He and Ar were tested and successfully extracted [12].

5 STUDIES FOR ALPI-PHASE 2

In ALPI-phase 2 the acceleration of high mass ions is foreseen, and ions with velocities down to $\beta = 0.045$ will be injected into the linac; therefore a set of 24 low-β resonators will be added. Moreover, the tandem injection line will be upgraded with a 300 kV platform for the negative ion source, in order to keep the transverse and longitudinal emittance of ion beams with mass higher than $\simeq 100$ within acceptable limits. When such ions are used, a gas stripper allows to avoid problems due to short lifetime of the stripper foils, at the price of a lower stripping efficiency.

The solution of a positive, high charge ions injector is being studied at LNL. The project foresees a 350 kV platform for the ECR source ALICE and a set of six superconducting RFQs bringing the ions from $\beta = 0.01$ to $\beta = 0.05$. The construction of the positive high voltage platform will start during the next year.

The research on superconducting RFQ was performed mainly at the State University of New York at Stony Brook in collaboration with the Laboratori Nazionali di Legnaro.

In order to have a suitable structure for both, heavy ion acceleration and superconducting operation, a new design philosophy has been developed. The result of this study is a very short RFQ resonator, which we call RFQ-let, based on the four rod structure and containing only a few acceleration gaps, typically four.

Using the possibility of controlling the phase of the single resonator, the beam dynamics of the line by applying the "modulated phase focusing" technique [13] in order to achieve the required transverse stability was studied .

A prototype was built at Stony Brook [14]. The construction of a full chain of resonators operating at 80 MHz is foreseen in Legnaro.

6 CONCLUSIONS

All the elements of the heavy ion superconducting linac ALPI-phase 1 have been developed and the production and mounting has started; the installation of the medium-β section will be completed within 1992. The studies and the experimental work for ALPI-phase 2 are in an advanced stage; the LNL ECR source gave the first beams and a low-β resonator prototype was constructed and tested; the first results of the LNL Cu-Nb sputtered quarter wave resonators are very encouraging and this technique is close to becoming competitive.

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View of the ALPI vault