The Low Beta Section of the ALPI Accelerator

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Abstract

The construction of the low beta section of the linac ALPI has recently started. The line includes 21 resonators with optimum velocity $\beta_o = 0.055$, working at 80 MHz; one of the cavities will be used as a buncher. The resonators, made of bulk niobium, are copies of a prototype developed at Laboratori Nazionali di Legnaro and the first 6 cavities, recently delivered by the manufacturer, were built in Italy under our supervision; the final chemical polishing is being performed at CERN. The rf test of the first resonator of the production series showed very good performances: $Q_o = 1.2 \times 10^9$ and $E_a = 6\ MV/m$ accelerating field reached with 6 W power dissipation.

1 INTRODUCTION

The $\beta = 0.11$ section of the superconductive linac ALPI at Laboratori Nazionali di Legnaro [1] has recently started delivering ^{58}Ni beam for nuclear physics experiments. The interest of the nuclear physics community working at Legnaro, however, is moving more and more toward beams with mass A=100 or higher, at energies around 6 MeV/amu. For such ions the LNL Tandem, which is the injector of the linac, due to stripper lifetime problems must be operated with gas stripper and typical velocities of the output particles are $\beta = 0.055$ for ^{127}I and $\beta = 0.046$ for ^{197}Au; a low β acceleration line, then, is needed in order to increase this velocity up to the lower limit set by the existing medium beta cavities, i.e. $\beta = 0.07$.

2 THE LOW β SECTION

The low β section of ALPI will consist of 21 cavities with $\beta_o = 0.055$; one of them will be used as a buncher. The design constraints are the following: accelerating field $E_a \geq\ 3\ MV/m$, frequency $f_o = 80\ MHz$, maximum length along the beam axis 240 mm, maximum power dissipation 7 W per cavity. The total required acceleration voltage, then, is $10.8 MV$; this number must be multiplied by a transit time factor $T \geq 0.7$, depending on the velocity profile of each beam. The desired energy gain is obtained increasing the ions charge state by means of a second stripper located in front of the low beta accelerating section. Beam dynamics calculation showed that, for the higher mass ions, the defocusing effect in our linac could prevent us from using accelerating field above 3 MV/m, at least in the beginnin of the line.

The cryostats for the low beta section are very similar to the medium beta ones [2], except for: their vertical length, increased by 30 cm in order to house the 1 m long quarter wave resonators; a different design for holding the resonators, which makes the alignment procedure simpler, and, finally, four more vacuum flanges on the top plate in order to allow for mounting fast tuning devices.

The production of 6 cryostats has started and the first two should be delivered in autumn 1994.

3 THE LOW β RESONATORS

The 80 $MHz, \beta_o = 0.055$ quarter wave resonator was developed at LNL as part of a program which included also a medium beta 160 MHz and a high beta 240 MHz prototype [3],[4].

They are all niobium made, thus allowing for high temperature treatment, and their double-wall structure allows for direct cooling of all the niobium walls which are heated by rf. The tuning plate, where the amount of dissipated power is very small, is made of OFHC copper plated with niobium. The cavities, despite of their length, are lighter than the medium beta copper ones and can be handled by one person. The alignment of the resonators with the cryostat is obtained by proper machining of the aluminum flange which connects each resonator to the cryostat itself; the cavity, when mounted, sits automatically in the aligned position without any further regulation.

Following the good results obtained with the first pro-

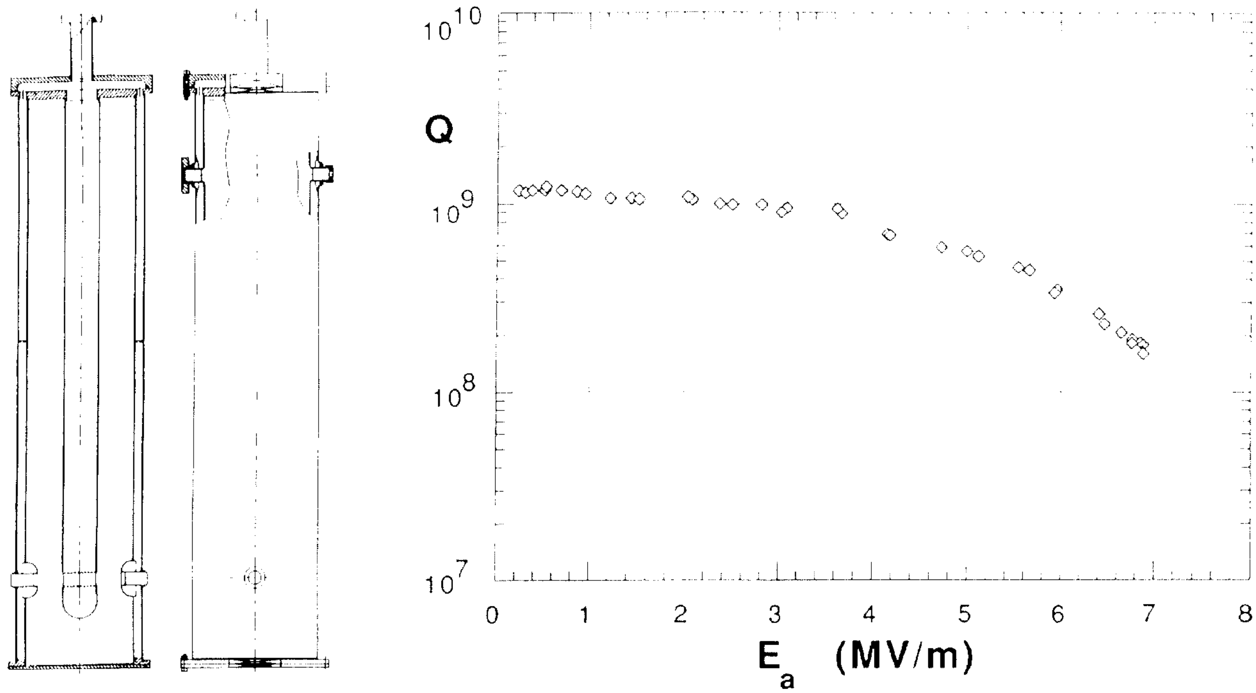

Figure 1: Schematic of the 80 MHz, low β niobium resonator and Q *vs* E_a curve of the first cavity delivered.

totype [5] the production of 6 units started at the end of 1993 and the delivery of the resonators is nearly complete. The cavities were manufactured under our supervision by the italian company E. Zanon s.p.a. of Schio (Vicenza); the final chemical polishing is being performed at CERN. A pressure test at $\Delta P = 2.5\ bar$ at room temperature for 1 hour was requested in order to prevent accidents due to fabrication defects.

The first resonator delivered was tested after chemical polishing. The test included Q *vs.* E_a measurements and phase and amplitude lock with the standard ALPI control system [6]. The multipactoring conditioning took 6 hours. The resonator showed rather good performance (see fig.1): $Q_o = 1.2 \times 10^9$, maximum field 6.9 MV/m at $Q = 1.8 \times 10^8$; the field level required by ALPI was obtained at only 0.5 W power dissipation, but the cavity could be used at 4 MV/m (1.3 W), 5 MV/m (2.6 W) and even 6 MV/m (6 W) without exceeding 7 W per cavity which is the limit set by the ALPI cryogenic system. 30' of rf processing and helium conditioning at 1 kW peak power did not change the results significantly.

The resonator was phase- and amplitude-locked for 1 hour with the ALPI rf controller at a field level of 6.5 MV/m. A strong overcoupling, limited by the maximum power of 60 W delivered by our amplifier, was required. The cavity, during this measurement, had never unlocked from the master oscillator even in the presence of mechanical noise induced artificially on the cryostat. Vibrations of the resonator were revealed by the phase and amplitude error signals when the noise was overcoming some treshold value; our impression, however, is that such a treshold should not be reached in a normal accelerator environment.

The test confirmed the results obtained previously on the 80 MHz prototype in more severe noise conditions but at a lower field level [5].

4 CONCLUSIONS

The construction of the low beta section of ALPI, which will extend, for any beam-target system, the linac capabilities to the acceleration of ion beams of all masses up to the Coulomb barrier energy, has started; the production of the first set of six cavities is near conclusion and the rf test of the first one gave excellent results. The field level reached is more than 6 MV/m at 7 W power, two times higher than the original ALPI project requirements; this could induce us to reconsider the beam dynamics calculation of the ALPI low beta section.

These results were obtained without applying high pressure water rinsing and high temperature treatment with the titanuim sublimation technique; these treatments, successfully applied also in our laboratory, should increase even more the resonator performance.

Even if no dangerous mechanical instability has shown up in the two low beta cavities tested up to now, we planned to develop a fast tuning device to be mounted in the resonator without modifications of the existing cryostats.

The first two cryostats, containing one buncher cavity and four accelerating ones respectively, will be installed in ALPI within 1994; the remaining 4 cryostats housing 16 cavities should be installed within 1995.

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