Status of the LISA superconducting linac project

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Abstract

The installation of the 25 MeV superconducting electron linac LISA is in progress at Frascati INFN National Laboratory. The installation is scheduled to be completed in Summer 1991 and commissioning will follow immediately. The status of the project is reviewed and the results of the first tests on various components are presented.

I- INTRODUCTION

The goal of the LISA project is to build a linear superconducting (SC) accelerator to acquire experience on some of the problems of SC linacs and on the generation of electron beams of high intensity and brilliance, in the mainframe of the ARES project , promoted by INFN in the field of SC radiofrequency applied to accelerators.

The design energy of the machine is 25 MeV and the beam current, averaged on a pulse duration of the order of 1 msec, is 2 mA. The repetition rate must be compatible with 1 KW average beam power.

The peak current , 5 A , is sufficient to build an infrared free electron laser (FEL). The FEL program will be carried out in collaboration with the Italian Department of Energy (ENEA).

The structure of the machine has been widely described in various conferences [1]. The only change is in the transport arc from the linac to the undulator. A layout of the machine with the arc is shown in Fig. 1 .

II - STATUS

In fall 91 the main body of the buildings and the auxilliary services have been completed, thus allowing to begin the installation of the RF, the refrigerator and the cooling plants. The construction of the SC cavities (bulk Niobium, 4 cells, with HOM suppressors) and their cryostats, entirely ordered to

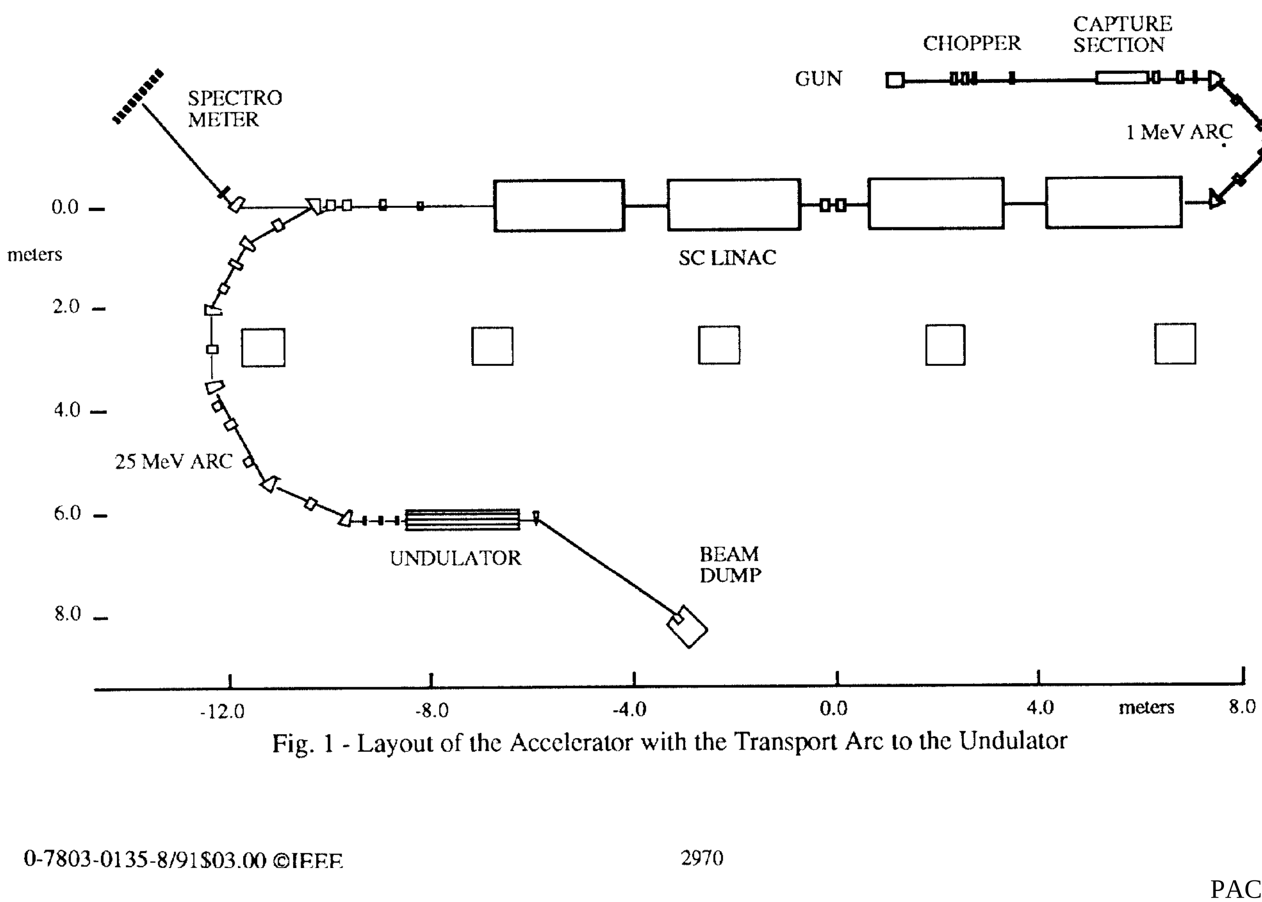

Fig. 1 - Layout of the Accelerator with the Transport Arc to the Undulator

industry, has met with some minor difficulties. In particular, the first test evidenced a few design problems that needed correction. In February and April 91 two of the modules have been successfully tested at the factory and delivered. At present the useful field limit is 4 MV/m because of electron loading. However, pulsed fields of about 6 MV/m have been reached. A short period of He processing (about 30 minutes) has shown a tendency to improvement and it is foreseen that the design goal of 5 MV/m @ 2 109 will be reached after a reasonable processing period. Tab. 1 shows the results of the tests on one of the modules. The unloaded Q factor has been measured calorimetrically, driving the cavity through the main coupler at full power and measuring the flow of He gas at standard temperature and pressure.

Table 1
Measured Characteristics of a SC Module

Accelerating field (MV/m)	1.0 ; 2.2 ; 5
Cavity Q(x10^9)	2.2 ; 2.0 ; 1.1
Q (main coupler)	4.0 10^6
Frequency	500.060 MHz
Tuning range / rate	± 300 KHz / 60 KHz/mm
Cryostat standby loss	5.4 W

The new arc is made of three achromatic dipole doublets. It is not isochronous, but the dispersion is very low. At the nominal energy spread $\Delta E/E \leq 2\%$ the pulse lengthening is $\approx$ 150 μm (i. e. $\approx$ 5% of the pulse length).

The lengthening due to second order terms in the trajectory equation, depending on both the transverse beam size and energy spread, have been calculated with DIMAD; their contribution, at nominal emittance and $\Delta E/E$, is smaller by one order of magnitude than that of the first order term.

The first magnet of the arc can be independently turned off allowing the beam to go straight into the spectrometer arm.

The strength of the first four quadrupoles at the linac exit is common to the spectrometer and the arc lattice, allowing simple beam switching between spectrometer or transport line. The spectrometer resolution is $\approx 5\ 10^{-4}$.

The dispersion free regions between the doublets are used to shape the optical functions for the right focus in the undulator.

The thermionic gun (nominal values of current and normalized emittance are 200 mA and 1.0 10^{-5} m rads) has been successfully tested. Emittance measurements have been made by analyzing the variations of the dimensions of the image on a fluorescent screen versus the strength of a focusing solenoid.

The screen image, given by a high linearity CCD TV camera with a resolution of 512 x 512 pixels, is digitized and memorised by a special purpose image grabber. The same instrument will be a permanent part of the machine diagnostic and control system, allowing on-line emittance measurements.

Good gun performances have been obtained up to 100 kV and 270 mA, with routine operation at 90 kV.

In Fig. 2 a 3-D elaboration of a typical beam image, obtained at 90 kV and 200 mA, is shown.

For each value of voltage and current, the square of the rms spot dimension is fitted with a parabolic function to the square of the solenoid current, and the fitted values are used to evaluate the rms emittance defined as

$$\varepsilon = \sqrt{<x>^2<x'>^2-<x\ x'>^2}.$$

In Fig. 3 the results obtained for different values of voltage and current are shown.

The space charge effect with increasing current and its dependance on beam energy are clearly visible.

At low current the experimental results show a large discrepancy with the prediction of the E-Gun code, which gives a much larger emittance. This could be due to the effect of the grid, whose effect has not yet been analysed in detail and it is not considered in the code.

A more detailed description of these measurements will be published separately.

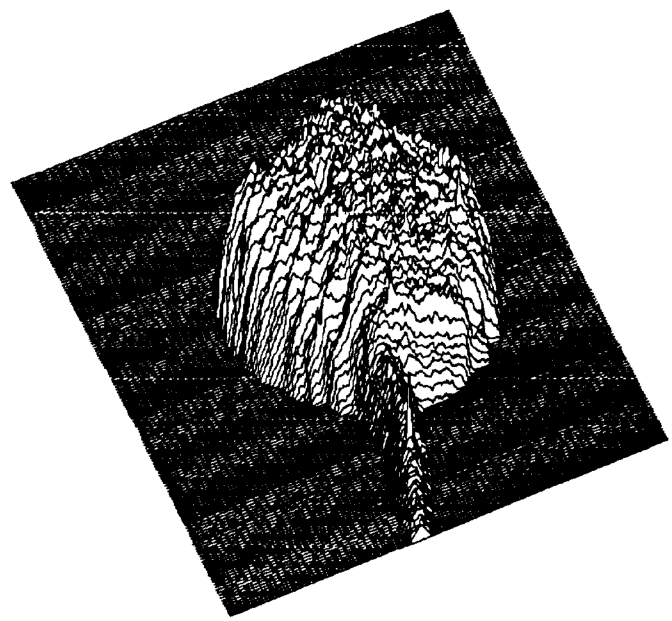

Fig. 2 - 3-D view of a beam image

At the time of this conference the auxiliary plants are practically completed and the refrigerator is ready for commissioning. Magnetic measurements on the quadrupoles have been performed and have given the expected results, while those on the dipoles are in progress. Reference points for the alignment of the accelerator have been laid down and the main parts have been positioned. A prototype of the beam position monitor has been tested and the series construction is nearly completed.

The development of the Control System [2] has followed the planned time schedule.

The communication protocols between different processor levels has been tested and most of the lowest level control codes have been written and tested.

The development of the graphic interface to the operator is in progress, following the definition of all control procedures.

The completition of the installation of the Control System is scheduled in May 91, and hardware tests will follow.

It is foreseen that the assembly of the machine will be completed in the Summer of '91.

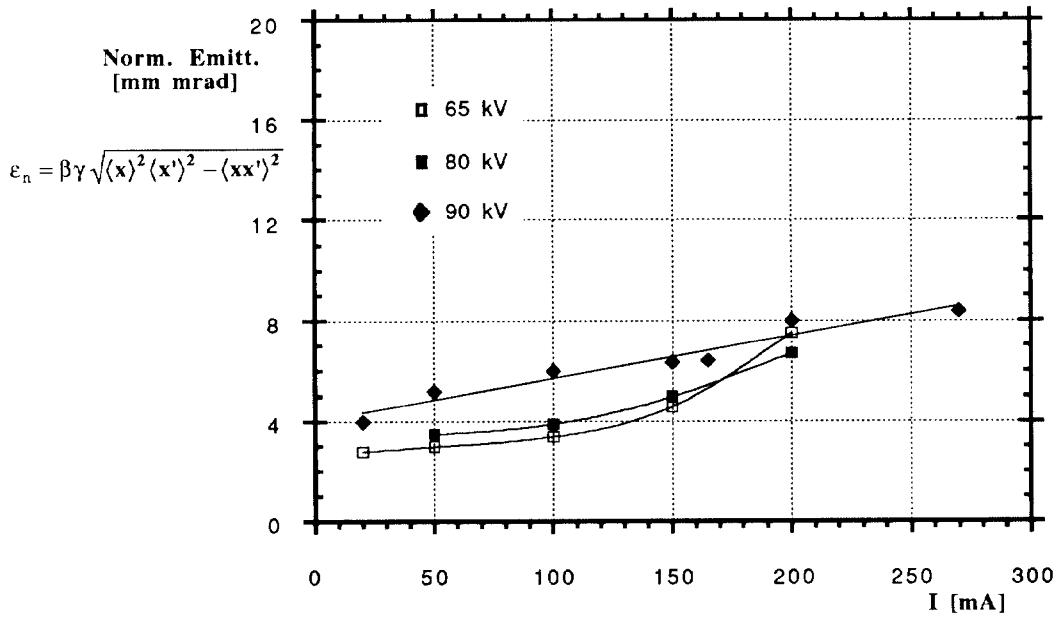

Fig. 3 - Rms Normalized Emittance vs. Gun Current and Voltage

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