THE LINEAR SUPERCONDUCTING ACCELERATOR (LISA) PROJECT AT FRASCATI INFN LABORATORIES

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Introduction

The construction of a 25 MeV superconducting (SC) radio-frequency (RF) electron linac is in progress at Frascati INFN Laboratories.

It will be a test machine for advanced technology oriented towards future linear colliders.

In a first phase of the project the machine will be applied to realize an infrared FEL.

In a second phase, in addition to the acquisition of general techniques related to SC RF acceleration, LISA will constitute the injector of a larger SC linac (ARES project).

A description and a status of LISA and a few words on future developments follow.

The machine

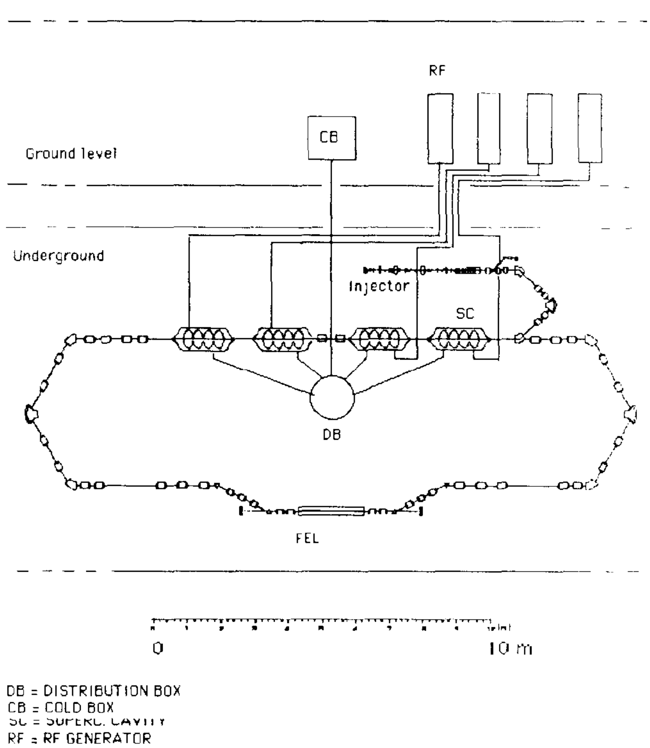

Fig. 1 - Schematic Layout of LISA Accelerator.

The machine has been described in previous conferences [1], however, for the reader's convenience, the main parameters are summarized in Tab. I and a layout is shown in Fig. 1.

Table I - Main Parameters of LISA.

Energy (MeV)	25 ÷ 49
Bunch length (mm)	2.5
Bunch charge (pC)	40
Peak current (A)	5
Duty cycle	≤ 2%
Average macropulse current (mA)	2
Invariant emittance (π m rad)	10^{-5}
Energy spread (@25 MeV)	$2 \cdot 10^{-3}$

The beam parameters are mainly defined by the FEL application whose characteristics are recalled in Tab. II. In the layout is shown a possible recirculation lattice, that has been studied [2,3], however, in a first phase a simpler direct transport line from the linac to the undulator may be implemented.

Table II - FEL: Main Parameters.

Beam energy (MeV)	25
Number of undulator periods	50
Undulator wavelength (cm)	4.4
Undulator parameter K_{rms}	0.5÷ 1
Radiation wavelength (μm)	11 ÷ 18
Optical cavity length (m)	6
Micropulse frequency	50 MHz
Macropulse frequency	10 Hz
Macropulse averaged power	500 W

In the first phase a normal room temperature injector will be used, consisting of a 100 KeV thermionic triode gun and a 1 MeV graded velocity buncher.

A detailed description of it can be found in this same conference [4]. It is envisaged to replace it later with a radio-frequency photocathode gun.

Downstream from the buncher the beam will be analyzed by means of a spectrometer and a special bunch length measuring system based on a deflecting cavity.

The beam is then deflected through a 180° achromatic and isochronous bend and injected into the four SC accelerating cavities.

Beam diagnostics consist of strip line position monitors placed in each quadrupole and fluorescent targets. On the quadrupoles will be also inserted additional windings that constitute correcting coils acting in both transverse directions. The SC cavities are made of bulk Nb and each one is placed in a separate cryostat, as shown in the sketch of Fig. 2. Their design characteristics are shown in Tab. III.

Table III - Parameters of the RF Cavities.

Frequency (MHz)	499.8
r/Q_0 (Ω/m)	380
Useful length (m)	1.2
Overall length (m)	2.5
Number of cells	4
Accelerating field (MV/m)	5
Q_0 (@ 4.2 K)	$2 \cdot 10^9$
Q_{ext}	$6.5 \cdot 10^6$

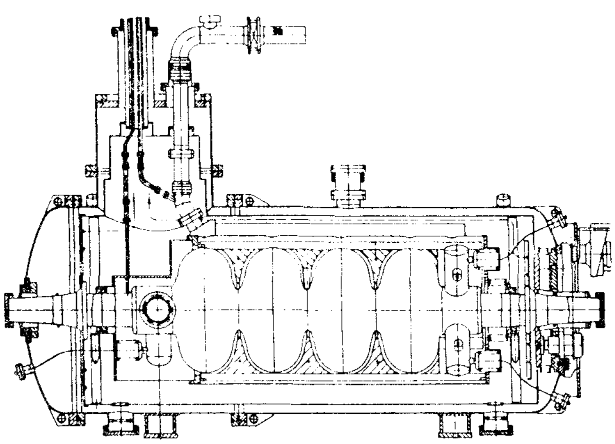

Fig. 2 - 500 MHz Accelerating Module.

The operation of the cavities requires the removal of about 200 W at liquid Helium temperature. To provide a reasonable safety factor a 300 W at 4.5 K refrigerator (Sulzer TCF-50) has been acquired. The refrigeration scheme features a distribution box between the cold box and the cryostats.

The RF system to power the cavities consists of four independent 15 KW klystrons, each separated from its cavity by a circulator.

The machine will be placed inside an underground vault while at ground level are situated the power generators, the refrigerator and the control room.

There is also a building dedicated to assembling, testing and development of SC cavities. It contains a dust free room, a clean water facility and a shielded zone for cavity tests.

Status of the project

The room temperature injector has been completed and its main parts tested.

Cold tests on one of the SC cavities have been performed at the manufacturing industry (Interatom). The cavity was completely assembled in its horizontal cryostat and it was powered through its main RF coupler.

The behaviour of the quality factor Q vs. the accelerating field E, determined by calorimetric measurements (boil off rate of LHe), is shown in Fig. 3. Measured stand by losses of the cryostat are 6 W.

The buildings are completed and installation of refrigerator, power generators and connecting cables is in progress.

The delivery of all four SC cavities is foreseen in November 1990 and completion of machine assembly is planned for the summer of 1991. Commissioning will follow immediately.

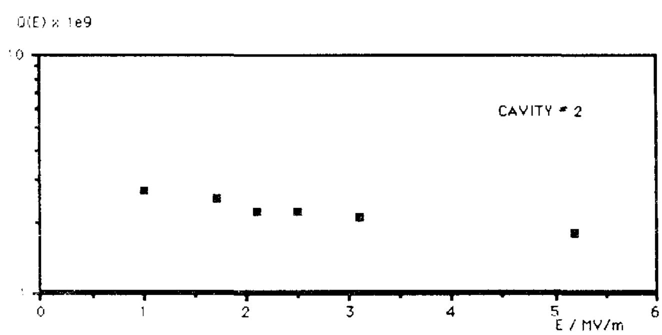

Fig. 3 - Behaviour of Quality Factor vs. Accelerating Field.

Future developments

The key to the realisation of high energy SC linear colliders is the achievement of high gradients with good quality factors in industrially produceable structures, and the generation and acceleration of very high peak current, low emittance electron beams.

Based on these considerations, a design study of an expanded SC linac, the ARES project [5], has been submitted to the management board of our Institution INFN, that has approved a program that will develop on a rather slow time scale (6 years), for compatibility with other programs in Frascati laboratories.

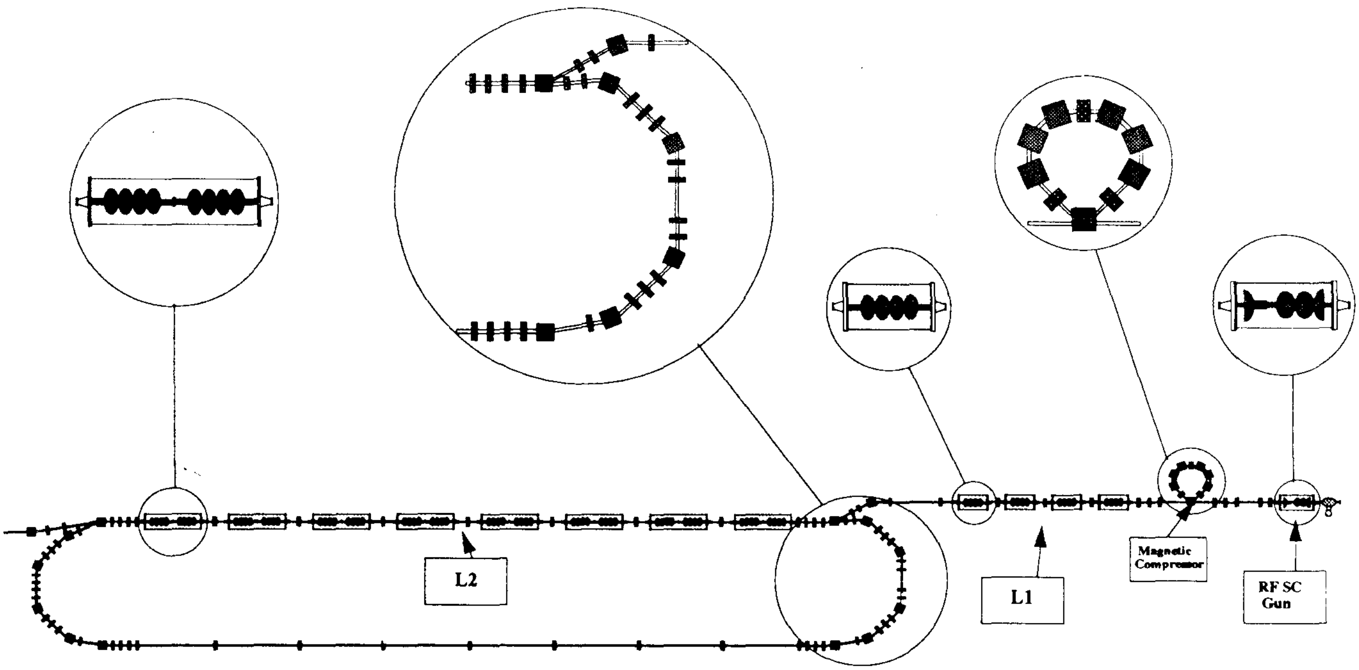

Fig. 4 - Sketch of the ARES Design Accelerator.

This program is intended as the natural continuation of the R&D work in progress on LISA and on SC-RF cavity design and construction techniques in collaboration with Italian industry, and will be developed by expanding the LISA buildings and facilities.

The final accelerator, as prospected in the ARES design study, will consist of twenty 500 MHz, four cells SC high performance cavities (the goal is E=10 MV/m at $Q=3x10^9$). Its nominal energy, 240 MeV, is high enough that recirculation without excessive deterioration of beam quality can be envisaged as a later upgrade. Such an energy would allow to extend the eventual FEL application to the X-VUV range. The beam will be generated by a RF gun with photocathode.

A sketch of the ARES design accelerator is shown in Fig. 4.

References

[1] A. Aragona et al.: "The Linear Superconducting Accelerator Project LISA", Proceedings of the 1988 EPAC, p. 52.

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[3] C. Biscari: "A new lattice for the 25 MeV transport line of LISA", Memo LIS-60. Oct. 1989.

[4] M. Castellano et al: "The injector of the superconducting linac LISA", (in this conference).

[5] "The ARES superconducting linac", LNF-90/035(R), May 1990.