Progress Report on the Commissioning of the Lisa 25 MeV SC Linac

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Abstract

The 25 MeV linac, called Lisa, equipped with 4-cell, 500 MHz superconducting cavities, is in the commissioning stage. Data on the performance of the various components are presented together with the results of the first beam tests.

I. INTRODUCTION

The 25 MeV, 2 mA, SC linac LISA, the characteristics of which have been described in various conferences [1], has now been completely assembled and its commissioning is well advanced.

The beam has been transported through the 1 MeV injector to the entrance of the SC accelerating section.

The four 500 MHz, 4-cells SC cavities have all been partially reconditioned with RF power, reaching on the average an accelerating field of 3.5 MV/m, with quality factor $Q_0=1.5 \times 10^8$ limited by electron loading; the low field Q value is of the order of 2×10^9. Peak field is not limited by quench; in pulsed operation a peak value above 4 MV/m has been obtained. Further conditioning is required to reach the design goals.

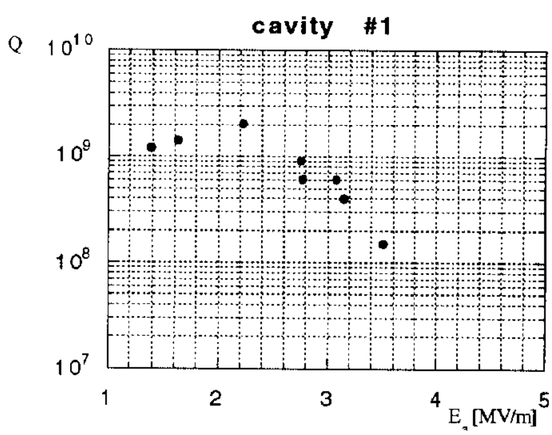

Figure 1. Q vs. E_{acc} for cavity n.1

Progress has also been made in the construction of the transport channel to the FEL experimental station. Magnetic elements, including the undulator, are in place and ready for alignment and the vacuum chamber has been delivered.

II. THE INJECTOR

The RF control circuits of the 1 MeV injector elements, inflector, chopper, prebuncher and capture section, are operational, though still needing improvement, and under computer control. A preliminary optimization of their parameters has been performed by maximizing the current transported through the 1 MeV, 180° bending arc that has a momentum acceptance of approximately 5%.

Table 1
Beam transport measured data

Gun voltage	90 KV
Gun current	120 mA
Chopping angle	90 deg
Pulse length	1 msec
Avg. current after capt. sect.	1 mA
Avg. Current after 180° arc	0.5 mA

The chopper performance is at present not at its best, because the original design structure has been provisionally replaced by a fluorescent oxidized Aluminum collimator with a hole of larger diameter (8 mm instead of 4 mm) and at a less favorable optical position. The replacement was motivated by the difficulty of transporting the beam through the aperture without additional beam position diagnostics.

The beam transport measured performance is summarized in Table 1.

The transverse diagnostics, consisting in fluorescent targets and strip-line electrodes, is working satisfactorily.

Oxidized Aluminum targets have given good results, avoiding the adverse effects of charge build-up observed with ceramic targets at low energy and high charge levels.

III. THE SC CAVITIES

The four 500 MHz, 4-cell, bulk Nb cavities have all been partially reconditioned after several months of idleness.

They had been kept evacuated by ion pumps, but one of them had been, by accident, sealed off in static vacuum. Notwithstanding this, no particular difficulty has been found in restarting them up to fields of about 3 MV/m. Above this threshold heavy electron loading impaired the Q factor but a rapid improvement was brought about by pulsing the RF at high power .

In some of the cavities the apparent field limit for electron emission onset (evidenced by X ray emission) was somewhat lower than 3 MV/m and this was attributed to unflatness of the field distribution, producing higher peak fields in some cells. To check this we have measured the dispersion curves of the four cavities and compared them with the theoretical one. Two of them are shown in Fig.2.

The cavities with mode frequencies farther away from the theoretical ones are in fact those with lower field thresholds.

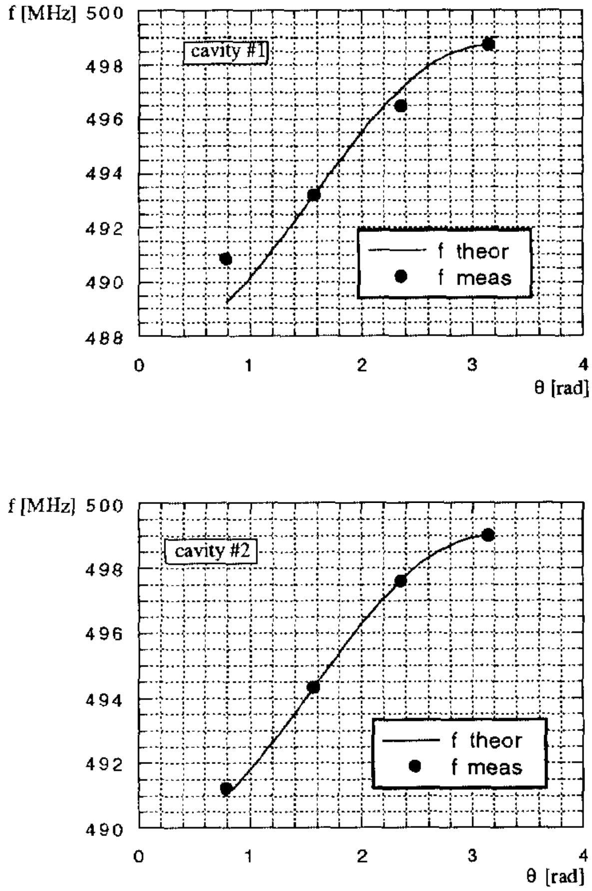

Figure 2. Dispersion curves of cavities 1 and 2.

The Q factor has been measured by measuring the level of liquid helium in the bath.

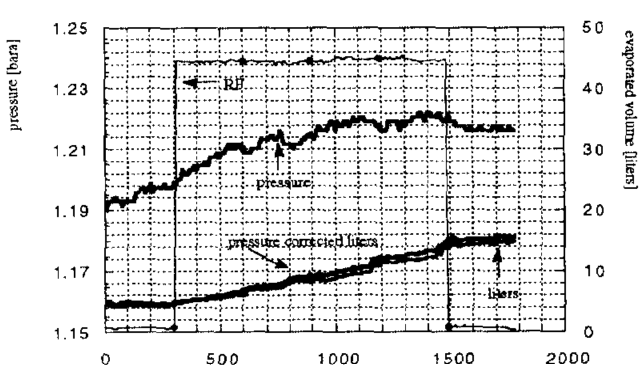

Figure 3. LHe level variation vs. time

Using the built-in heating resistors on the LHe container, we first introduce a known amount of power, much larger than static losses, in the cryostat and with the refrigerator in automatic operation wait until an average equilibrium state is reached. Under such conditions the LHe inlet valve performs small oscillations around its average position. Once the latter position has been determined, the valve is blocked there manually. The fixed LHe input then almost exactly compensates the overall heat input and the level remains sufficiently constant for tens of minutes. We can then switch on the RF and measure the liquid level fall rate $\Delta V/\Delta T$ and from this evaluate the dissipated RF power P_c. The Q factor is then determined from the value of the RF electric field, measured through a calibrated probe.

The method has been improved by taking into account pressure variations. In Fig. 3 we show the behaviour of pressure and a corrected level variation curve.

A description of these measurements will be published separately [2].

Q measurement data for cavity n.1 are reported in Tab.2.

Table 2
Cavity n.1 Q measurement data

duty cycle	c.w.	25 %	25 %	20 %	20 %	20 %
$\Delta V/\Delta T$ [l/s]	0.29	1.01	1.41	1.92	2.75	9.55
P_c [W]	7.9	27.2	38.2	51.9	74.3	258.1
E_a [MV/m]	2.22	2.75	2.77	3.08	3.15	3.51
$Q/10^9$	2	0.9	0.6	0.6	0.4	0.15

The mechanical tuning system has been tested on the cold cavities. The electronics consists of a phase detector that compares the incident voltage with that transmitted to the field probe. The output from the phase detector, above a given threshold, drives the step-motor that moves the mechanical actuator.

On the phase detector signal, in addition to some drift, we observe slow fluctuations with frequencies in the range of several tens of Hz, that however are well within the cavity bandwidth (≈ 100 Hz); they are eliminated by a low-pass filter with a cut-off frequency of a few Hz. Fast phase and amplitude fluctuations are counteracted by electronic loops. No special problem has been encountered although the cavity external Q is in the range of 10^8 .

IV. REFERENCES

[1] M. Castellano et al.- **Proc.EPAC 92**- p. 611.

[2] M. Castellano et al. "On line calorimetric measurement of the quality factor of superconducting accelerating cavities"- LNF 93/006 (P) Submitted to **Nucl. Instr. & Meth**