MACSE : A SUPERCONDUCTING ACCELERATOR MODULE

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An accelerator test facility is being built at Saclay. First electron beam is expected through superconducting cavities by the end of year 1990.

Introduction

Since 1986, Saclay/DSM/DPhN has started an R&D program on superconducting cavities. State of the art cavities have been produced and tested [1]. In parallel, fundamental researches are made on RF superconducting surface properties as field emission, surface resistance [2], thin layer techniques, heat transfer models, ... Such results and such investigations are promising. Nethertheless, building and operating a superconducting accelerator facility ask for mastering many other technological aspects. This is the aim of the MACSE project. It is not a single prototype, but a succession of three different prototypes, so as to get experience, to improve reliability and cost. A cryomodule will contain four 1.5 GHz cavities accelerating a 100 µA beam of electrons up to about 15 MeV.

The project is funded since February 1989. The present 700 MeV electron accelerator ALS will be shut down on June 10th 1990 and partly taken apart to provide room for MACSE first prototype. Beam is expected by the end of year 1990. One year will then be dedicated to experiments and successive tests of prototype N° 1, 2 and 3.

General set-up, beam injector and diagnostics

Figure 1 shows, on the beam line, a 100 kV beam injector, a capture section which brings electron velocity to the speed of light, a small beam analysis, the main 4-cavity cryomodule and the final beam analysis.

The electron injector [3] has been delivered by the University of Illinois. This injector was originally built as a part of a microtron accelerator which has not been constructed. It consists of a high emittance electron gun, two chopping and a bunching copper cavities.

The capture section has to accelerate 100 kV electrons to about 2 MeV. This cannot be done by a standard, $\beta = 1$, cavity. A shorter (x 0.84), otherwise identical, 5-cell superconducting cavity has been designed for this purpose. It is installed in a single cavity cryomodule. This cryomodule, being similar to the main prototype, becomes a part of the R & D program.

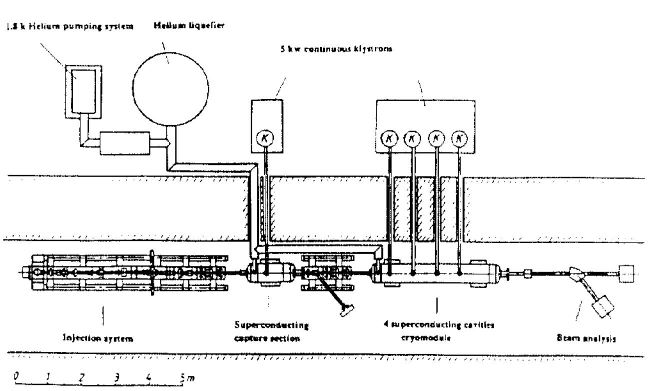

Figure 1 : MACSE in the ALS tunnel.

Cavities and cryomodules

MACSE first cryomodule (Fig. 2) contains four 1.5 GHz, 5-cell niobium cavities. The cavities are made by ATEA, a french company. They are immersed in an helium tank, the rigidity of which provides the right alignment bench. The train of four cavities is prepared by pairs in a class 100 clean room and finally assembled on a bench with cold frequency tuners. Those tuners are actuated by both stepping motors and magnetostriction rods immersed in the helium bath. Frequency resolution is about 1 Hz. The train is then inserted into the helium tank on ball bearing rails. Connections to the outside are done by warm feed-through or directly to the isolation vacuum. No ceramic or sapphire are allowed between cold helium and vacuum.

The main coupling lines are of coaxial type. The problems arising from the thermal gradient and heat deposit from RF along the lines are solved either by reduced thermal conduction (thin copper coated steel pipes) or by RF chokes. Both solutions will be tested.

The next cryomodules to be tested at the position of the first one, will contain other types of cavities. A 3-cell cavity has already been tested [4] and regarding the energy gain, it has shown a performance equivalent to the 5-cell prototype.

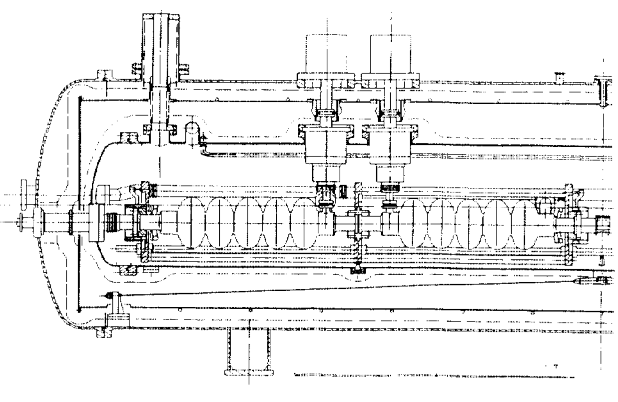

Figure 2 : Half view of the 4-cavity cryomodule.

RF power sources

The main amplifiers are Thomson, 1497 MHz, 5 kW klystrons (efficiency : 35%). Rectangular L-band wave guides with circulators and 5 kW charges connect the klystrons to the cryomodule. Three regulation loops [4] are provided : a slow one, reading the phase shift between klystron and cavity, acts on the cold frequency tuner and the two other loops, phase and amplitude, reading the signal from the cavity, act on the signal sent from the pilot to the klystron.

Helium refrigerator

A commercial helium liquefier has been purchased from Air Liquide (Helial 4000). Together with a pumping unit and a 4.2 K/1.8 K heat exchanger, the system (designed and assembled by Saclay/DSM/DPhPE/STIPE) is expected to provide a cooling power of 60 W at 1.8 K. In a second step, cold compressors and heat exchangers will be added to the present set-up in order to double the cooling power.

Conclusion

Most of the elements are presently in construction and under qualification process. This important effort for mastering the whole process of building and operating a superconducting accelerator, coming after the proper construction and operation of the Saclay 50 cavities superconducting heavy ion booster, is strengthening the road for modern European accelerator facilities of the future.

References

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[3] E. Klein et al., "The MACSE injector", this conference.

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