# THE BOOSTER FOR THE PELLETRON OF SAO PAULO

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## Abstract

This paper describes the necessary modifications in the present acceleration system for the coupling of a superconducting linac to the tandem of Sao Paulo. Final laboratory projectile energies of 15 MV/A to elements from C to Fe should be achieved after installing the two first cryostats (phase I). The superconducting linac will consist of split-ring niobium resonant cavities ($F_o$ = 97 MHz and beta = 0.060, 0.105) that are being built in the Argonne National Laboratory.

## Introduction

Historically, our accelerator experience began in the $50^s$ with the construction of a 3.5 MV Van der Graff and was extended in the $70^s$ with the purchase of a NEC pelletron type electrostatic accelerator, a first design, which gave Sao Paulo the lead in the new technology of pelletrons. In 1982 it became evident that it was time for a major upgrade of our facilities to offer the new generation a more modern and stimulating environment for nuclear physics research.

Thus began a series of studies to ascertain what type of accelerator would best serve our research interests yet not overtax our resources of manpower and economic support. This analysis was summarized in a report in 1982 [1] where it was concluded that the best path to take would be the construction of a superconducting linac based on the designs of the ATLAS [2] project developed at Argonne National Laboratory.

Furthermore, in dominating the technology of superconducting resonant cavities, we would enter an area of accelerator physics and technology which, by all indications, is the one destined to be used exclusively in the design and construction of future particle accelerators.

## The Linac

The Linac of Sao Paulo will be used as a booster for the existing Pelletron Accelerator (8 MV nominal) and will be consisted of niobium split-ring superconducting resonators ($F_o$ = 97 MHz) based on the Argonne design.

In the phase I, the superconducting linac will be consisted of 14 niobium split-ring resonators (4 low beta (0.060) and 10 high beta (0.105)) in four cryostats. Two small crystats for one resonator to the superbuncher (low beta) and rebuncher (high beta) and two cryostats for the other 12 resonators. The configuration of 3 low beta and 10 high beta resonators was the best compromise in the mass region compatible with our experimental program. Figure 1 shows the scheme intended for the Pelletron-Linac system, as well as the distribution of the resonators in the cryostats. The cryostats will be based on the Argonne design.

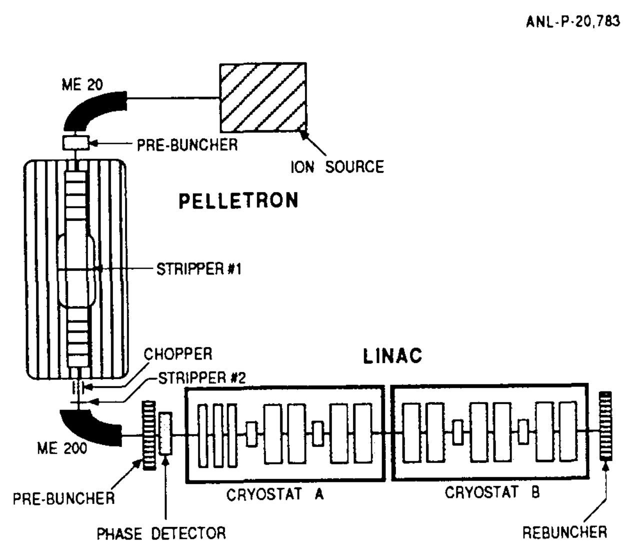


**Fig. 1** Schematic view of the projected Pelletron-Linac System

### Coupling Linac-Tandem

The beam entering the linac should be bunched into short time pulses of about 100 ps. This is accomplished by a two stage bunching system. The first (or prebuncher) consists of a single gap harmonic buncher (three harmonics, fundamental frequency about 12 MHz) which operates at room temperature and is positioned a few meters upstream from the first accelerating electrode of the tandem. The second stage is a superconducting buncher consisting of one RF resonator situated about 25 meters or so downstream from the tandem exit at the entrance to the linac. The continuous beam out of the ion source is bunched into 1 ns pulses with a 70% efficiency in preserving the beam intensity by the prebuncher and then into 100 ps pulses with almost no loss of intensity by the superconducting buncher. The mechanical part of the pre-buncher is already installed and the RF control system is being built.

Because of the variations which exists in the ion transit time through the tandem, a phase detector is used for dynamic control of the RF phase of the prebuncher pulses, so that the beam pulses arrived at the superconducting buncher with the correct time. Our phase detetor will be a 48.5 MHz, spiral loaded resonant cavity based on the design described by Takeuchi and Shepard [3].

The elimination of parasitic beams will be provide by positioning an RF chopper before the analyzing magnet. The chopper will have a 20 mm gap and will be positioned at about 2 m from the chopper slits. In this case 5 KV should be enough to separate the parasitic beams. The RF chopper will operate at about 6 MHz.

The structure of the accelerator tube of our tandem was modified in order to increase the voltage from 8 to 9 MV in the terminal. Basicly, "dead" regions were switched by acceleration tubes with 6 electrodes each. In this way we maximize the energy of the beam entering into the linac. The tandem has been operating satisfactorily after the modifications.

## Cryogenic System

The closed-cycle helium system, which may be operated in a wide variety of conditions, consists of two Sullair compressors and a CCI refrigerator that nominally yields 300 watts of cooling or alternatively, liquefies 75 liters per hour of helium, if no liquid nitrogen pre-cooling is used. The proposed schematic helium distribution system is shown in figure 2.

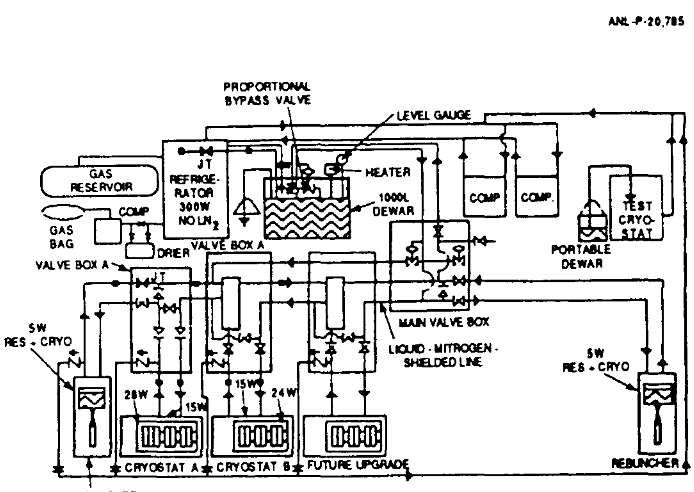


**Fig. 2** Schematic view of the helium distribution system

The system was designed to provide a continuous flow of cold helium through the superconducting resonators and solenoids. The static heat leak of each cryostat was assumed to be 15 watts, for the cryostats with more than one element, and 5 watts, for the superbuncher and rebuncher cryostats (including the cooling due to RF power dissipation for one resonator). A typical value of 4 watts [4] is expected for the RF power dissipation for each resonator.

Only one of the compressors will be used in phase I because, as it is shown in figure 2, the 150 watts of refrigeration capacity available in this configuration should be enough to maintain the temperature through the accelerator.

## Resonators

Niobium split-ring resonators were chosen to be the acceleration structure in the Sao Paulo project. The fact of niobium is a better superconductor than lead and Brazil is the largest producer of niobium guided our choice of the material.

The Argonne split-ring resonator has the advantages of more boost per resonator, greater durability of the superconducting surface. Additionally, sections of the Argonne booster, similar to our requirements, were already in operation. Based on these reasons, the choice for this type of resonator was natural.

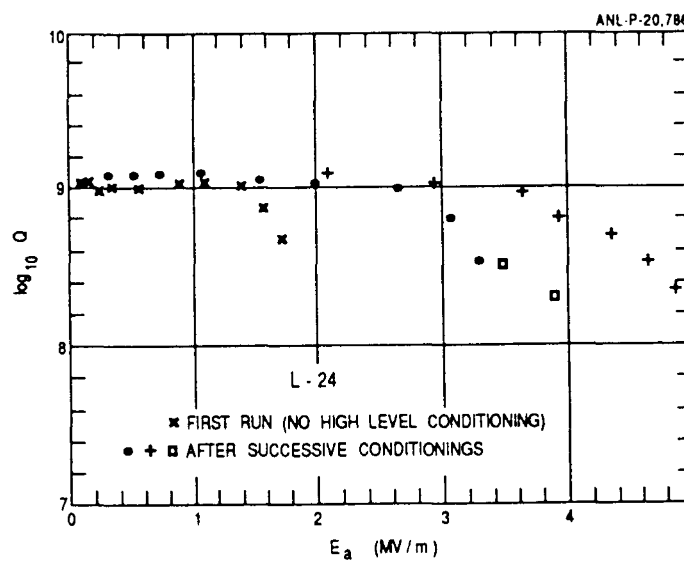


**Fig. 3** Q curve against average electric field for L-24

Our first low beta resonator was assembled in the beginning of this month at Argonne and the Q curve obtained for this resonator (L-24) is shown in figure 3. Two high beta resonators are assembled and waiting for being tested. Final eletropolishing is missing in three other high beta resonators. The other 8 resonators will be ready for the final eletropolishing in the beginning of 1993.

### Final Comments

The phase I is completely defined and will use the Argonne niobium split-ring design for the resonators. With the objective of learning this technology, 14 resonators are being constructed at Argonne with the active participation of physicists and engineers sent from Sao Paulo.

The phase II, the high energy extension of the Linac, will be carried out in Sao Paulo and the type of structure for the resonator is still to be chosen.

We expect that the Linac-tandem accelerator should be operational in 1995, depending on the economical situation of the country.

### Acknowledgement

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