The Ifusp Racetrack Microtron*

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Abstract

Construction of a 31 MeV CW racetrack microtron (RTM) was started at the University of São Paulo in 1988. The RTM is a two stage microtron that includes a 1.93 MeV injector linac feeding a five turns microtron booster (RTM-1) that increases the energy to 5.1 MeV. The main microtron (RTM-2) delivers 31 MeV continous electron beam after 28 turns. The 100 KeV injection beam line and the end magnets of the microtron booster are being assembled. The machining of the side-coupled cavities for the accelerating sections has been initiated.

1 Introduction

A cw 31 MeV two-staged cascade racetrack microtron has been designed for nuclear physics research. The basic configuration of IFUSP RTM is shown in Fig. 1 and the detailed parameters are listed in table I. The proposed configuration permits an economical accelerator which produces a continous electron beam of up to 31 MeV with only 41 kW of RF power, provided by a single 50 kW cw klystron. In the following sections, details of individual systems are reported.

2 The injector Linac

All the rf systems have been designed to operate at 2.450 MHz. There is only one 50 kW cw klystron, made by Thomson CSF, isolated from the accelarating sections by a circulator.

The injector linac consists of a 100 keV ± 0.1% , 1 mA electron gun, rf choppers, pre-buncher, capture section and pre-accelarator. The chopper system consists of 2 chopper cavities, a sector shaped slit at the mid point of the cavities and 2 magnetic lenses placed simmetrically to the slit, so that the residual beam has a relative phase width of 60 degrees.

The beam is accelerated to 0.89 MeV in the capture section (1 meter) and further accelerated to 1.03 MeV in the pre-accelerator (1.47 meters). The total output energy is 1.93 MeV. The calculated results (PARMELA)

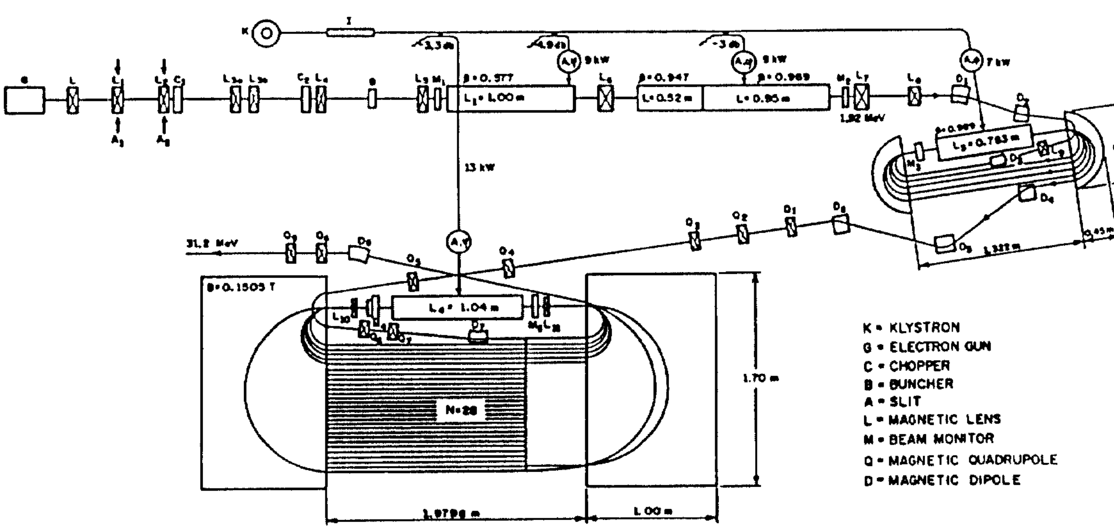

Figure 1: Plan view of the IFUSP two stage microtron.

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Table 1: Design parameters of the IFUSP microtron.

General	
Frequency (MHz)	2,450
Output Energy (MeV)	31.16
Output Beam Intensity (μA)	50
Energy dispersion (keV)	± 5
Transverse Emittance (πmm-mrad)	0.15
Number of Klystrons (50 kW C.W.)	1
Type of the linac	side coupled

Main Characteristics	Microtron booster.	Main microtron
Input Energy (MeV)	1.93	5.10
Output Energy (MeV)	5.10	31.16
Beam Intensity (μA)	50	50
Energy per Turn (MeV)	0.64	0.93
Number of Turns	05	28
Accelerator Length (m)	0.78	1.04
R.F. Power (kW)	7.0	15.0
Magnet Field (T)	0.1020	0.1586
Magnet Weight (tons)(each)	0.15	4
Magnet distance (m)	1.322	1.979
Gap width (cm)	4	7
Input Orbit radius (cm)	7.62	11.48
Output Orbit radius (cm)	18.22	68.56

of the transverse dimensions of the electron beam as it passes through the injector linac are shown in Fig. 2. Fig. 3 shows the phase space and the energy dispersion at the end of the injector.

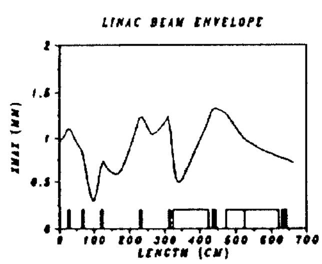

Figure 2: Calculated transverse dimensions along the injector.

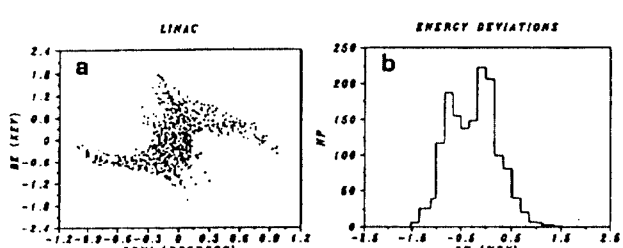

Figure 3: Results of PARMELA calculations of the (a) phase space and (b) energy dispersion of the electron beam as it leaves the injector.

3 Microtron Booster (Stage 1)

The 1.93 MeV output energy of the injector linac is too low. To reduce the phase slip in the first turns and to increase the beam blow-up threshold, the injection energy, for the main microtron (Stage 2) must be higher than 4 MeV.The total RF power required for the injector linac and the main microtron is 33 kW. So the RF power available to increase the beam energy of the injector up to 4 MeV is approximately 8 kW, which is too low for a conventional linac. The solution to this problem was the use of a small racetrack microtron (booster), with a few turns. The microtron booster increases the beam energy to 5.1 MeV with only 7 kW of rf power. The relatively low magnetic field (0.102 T) of the end magnets makes the radius of curvature (7.62 cm) of the beam large enough to minimize fringe field effects and to avoid hitting the linac section on the first return path. The short (0.78 m) $\beta = 0.989$ accelerating section minimizes the phase slip when the number of turns is limited to five. Fig. 4 ilustrates the phase stability in the booster. The injection system is the same that was used in the Mainz racetrack microtron (Mami A). The calculated transverse emittance and phase space of the electron beam are shown in Fig. 5.

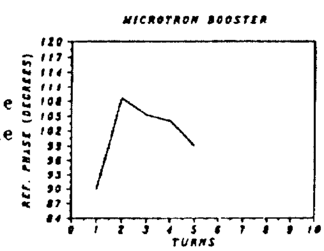

Figure 4: The phase of beam bunches in the booster.

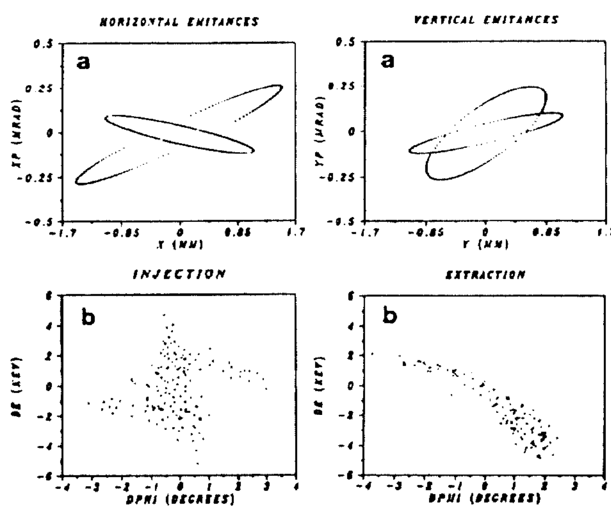

Figure 5: (a) Calculated transverse emittances (b) Phase space of the electron beam before and after the microtron booster.

4 Main Microtron (Stage 2)

The second stage microtron will operate in the $\nu = 1$ configuration. The injection of the 5.1 MeV electron beam from the booster takes place as shown in Fig. 1. The parameters of the "chicane-like" system are chosen so that the transverse beam dispersion at the output of the booster is canceled. The quadrupole triplet Q1Q2Q3 and the duplet Q4Q5 are matching elements for the transverse optics. The quadrupoles Q6 and Q7 are used to cancel the dispersion effect of the end magnet. The end magnets are large enough (1.70 m x 1.00 m) to permit as many as 28 turns resulting in a maximum output energy of 31 MeV. Lower energies can be obtained by extracting the beam before the last turn by a moving extraction magnet. The transverse optics is established by focusing elements placed on the common linac axis at each end of the linac. There are two correcting dipoles for each turn located near the end magnets for horizontal and vertical beam deflection of about ± 1 mrad. The end magnets are homogeneous magnets with a reverse field clamp to cancel the vertical fringe field defocusing. The field distribution will be homogenized by means of correcting currents in flat coils made of printed circuit boards that will be placed near the upper and lower pole faces. The field uniformity will be within ± 1/10000 over the region of interest.

5 Accelerating Sections

The accelerating sections will be side-coupled structures. We chose this kind of cavity because it's vacuum properties are better, permits operation at higher gradients if desired, has lower power flow droop and has a shunt impedance of 89 MOhms/m with a coupling factor of 3.5%. The engineering design is the Los Alamos one. There will be two tuning plungers located at both ends of each of the accelerating sections to compensate automatically for the variation in resonance frequency caused by eventual changes in the input rf power or cooling water temperature. The tuning plunger design will be based on the one used in Mainz.

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