COMMISSIONING OF THE INJECTOR LINAC OF THE IFUSP MICROTRON*

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Abstract

The Instituto de Física da Universidade de São Paulo (IFUSP) is building a two-stage 38 MeV continuous wave racetrack microtron. This accelerator consists of a linac injector that delivers a 1.8 MeV beam to a microtron (booster) with 5-MeV output energy. A transport line guides the beam to the main microtron to be accelerated to energies up to 38 MeV in steps of 0.9 MeV. This work describes the commissioning of the linac injector that comprises the first two accelerating structures of the IFUSP Microtron. A provisional beam line was built at the end of the linac to provide energy and current measurements. We also present results concerning RF power, RF phase, and temperature control of the accelerating structures. The first results of the chopper and buncher systems are also presented.

INTRODUCTION

The Instituto de Fsica da Universidade de So Paulo (IFUSP) is building a two stage continuous wave racetrack microtron. This accelerator consists of a linac as an injector that delivers a 1.8 MeV beam to a five-turn microtron booster that feeds the 38 MeV main microtron. Figure 1 shows a view of the accelerator and the beam transport line.

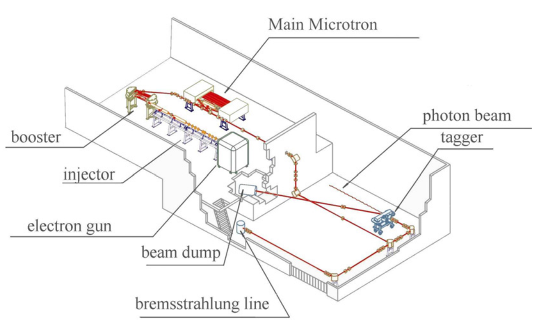

Figure 1: View of the IFUSP microtron.

The accelerator has four accelerating structures powered by a single 50 kW klystron, operating at 2450 MHz.

The injector linac consists of a beam conforming stage [1] with chopper and buncher systems and a pre-accelerating section composed by two accelerating structures, the first one with variable β and the second one divided into two parts with different β [2].

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A waveguide based RF distribution system feeds the structures. Each structure has a high power attenuator and phase shifter to control amplitude and phase [3]. The resonance frequency of the accelerating structures is kept constant by using tuning plungers located at the two extremes of the structures [4, 5]. The operating temperature of the structures must be stabilized around 39°C, to allow for an efficient range of operation of the plungers.

In this work we describe the commissioning of the pre-accelerating section (the first two accelerating structures) and the first results of the chopper and buncher system.

COOLING SYSTEM

The accelerator cooling system consists of two main water circuits. The first one is an open circuit that supplies fresh water to the input of a heat exchanger. The second one is a closed loop connected to the output of this heat exchanger that runs with distilled water.

The closed loop water pump is connected to a controller that enables regulation of the water flow. Initially, the flow of water is maintained very low, allowing the dissipated power in the klystron anode to rise the water temperature up to the operating point of the accelerating structures (about 39°C). At this moment, the RF is applied to the accelerating structures and the plunger control is turned on.

To avoid excessive rise of the temperature, the pump velocity controller increases the water flow, so that the temperature in the accelerating structures is maintained stable within ±0.5°C. Figure 2 depicts the temperature behavior of the three first structures and the klystron anode along the operation time.

RF POWER AND PHASE

When the resonance condition is achieved, the phase difference between the RF input and a sample extracted from the structures (using an antenna) is 90°. This is translated to a voltage, using a microwave mixer, and sent to the plunger control system [4, 6]. To ensure the desired energy resolution, this phase difference should be kept around 90° within 5.6° [2]. Figure 3 shows the time behavior of this phase difference after the RF was applied to the structures. The plungers are activated every time the phase difference exceeds 2°.

To verify the proper functioning of the phase and power control system of each structure, the klystron output power was slowly changed while the phase and the power at the structures were monitored [6]. It must be noted that when

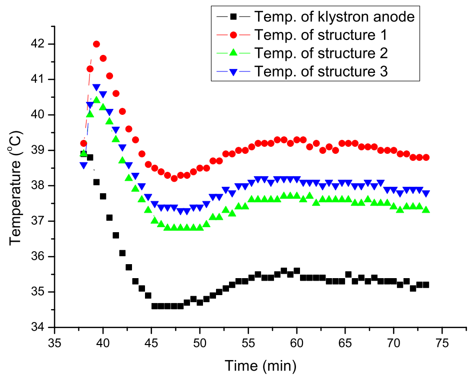

Figure 2: Temperature behavior as a function of time. The plot begins when the RF is applied to the first three accelerating structures.

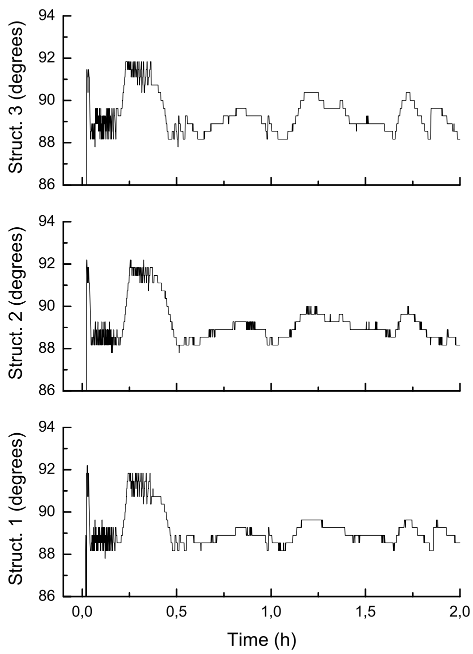

Figure 3: Phase difference in the first three accelerating structures, indicating the resonance condition.

an attenuator adjusts the power delivered to a structure, it causes a change in the phase, so that the phase shifter also needs to make a correction. Figures 4 and 5 show the results of such variations with nominal power applied to the structures and with the plunger control system on.

PROVISIONAL BEAM LINE

A provisional beam line was built to check if the electron beam energy was in accordance with the designed specifications for injection in the microtron booster (1.8 MeV).

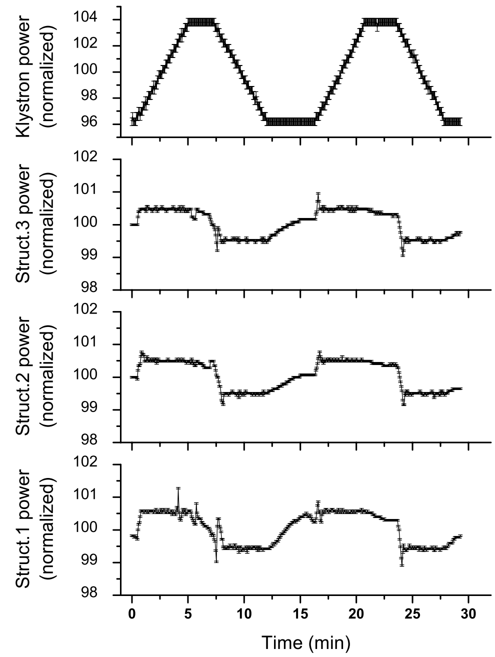

Figure 4: RF power at the structures as a function of time, while the klystron power (top plot) is changed.

A 45° dipole was inserted at the exit of the second accelerating structure, followed by a view-screen and a Faraday cup. By measuring the magnetic field needed do deflect the beam, it was possible to determine the beam energy. Figure 6 depicts a drawing of the provisional line.

After careful tuning of the parameters, a 1.85(3) MeV electron beam was produced.

CHOPPER AND BUNCHER SYSTEMS

The chopper system comprises two RF cavities working in the TE102 mode, two symmetrical solenoids, and an adjustable slit. The first cavity produces a magnetic field that deflects the beam horizontally. After that, the beam collides with the slit, which blocks everything except for a 40° phase interval around the maximum deflection point. The symmetrical solenoids are placed around the slit, and are responsible for refocussing the beam on the second RF cavity, where the phase and amplitude are adjusted to cancel the beam transverse momentum caused by the first cavity [7].

Forty centimeters after the chopper is placed a cylindrical buncher cavity, working in the TE010 mode. Once the phase and amplitude are adjusted, the electrical field in this cavity compresses the beam in the longitudinal dimension. Figures 7 and 8 depict the beam after the first chopper cavity and after the buncher cavity, respectively.

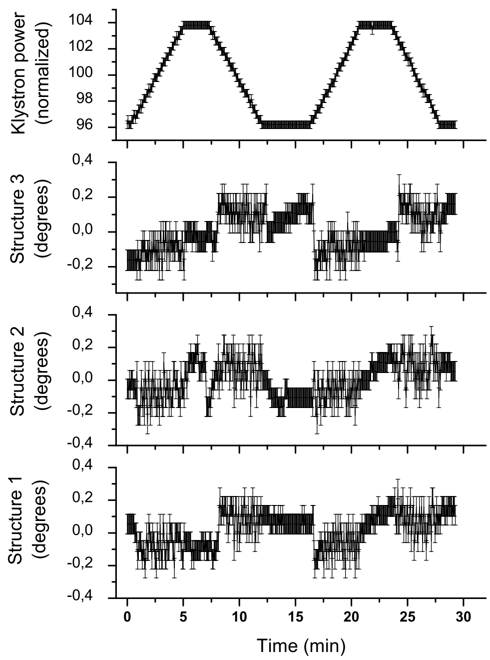

Figure 5: RF phase at the structures as a function of time, while the klystron power (top plot) is changed.

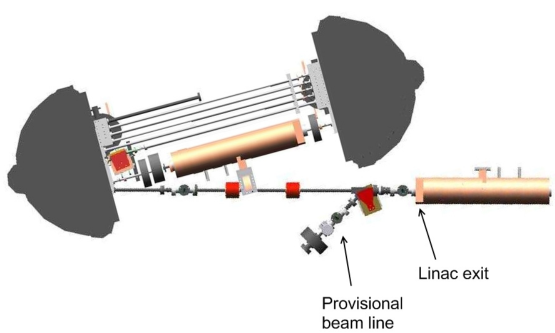

Figure 6: Provisional beam line to allow energy measurements.

CONCLUSIONS

The injector line of the IFUSP Microtron has been successfully commissioned. A 1.85 MeV electron beam, within the energy specs for the booster was produced. Other beam properties are under study.

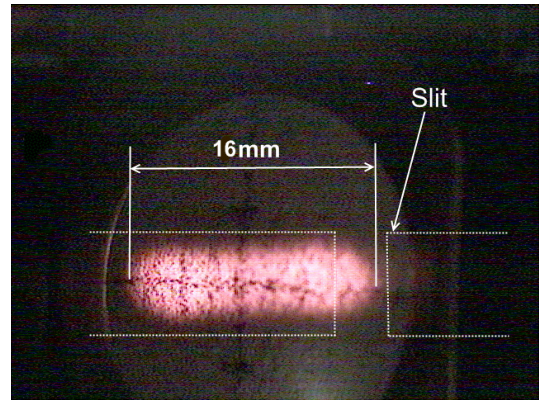

Figure 7: Beam deflected horizontally after the first chopper cavity. The dotted points indicate the slit behind this view-screen.

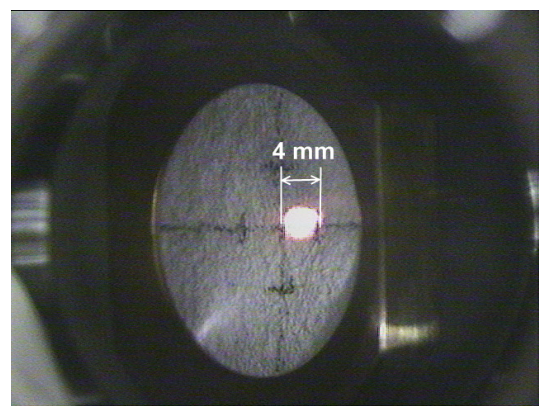

Figure 8: Beam after the chopper and buncher cavities.

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