STUDIES OF THE ALIGNMENT TOLERANCE FOR THE INJECTOR SYSTEM OF THE IFUSP MICROTRON

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Abstract

In this work, we describe the determination of the alignment tolerances for the injector system of the IFUSP Microtron. This stage consists of a linear accelerator with input energy of 100 keV and output energy of 1.8 MeV. Simulations were made using a method based on rotation matrices that allow for misalignments in the optical elements. Results of beam loss as a function of the alignment tolerance are presented.

INTRODUCTION

The Instituto de Física da Universidade de São Paulo (IFUSP) is building a two-stage 38 MeV continuous wave racetrack microtron. Figure 1 shows an isometric view of the accelerator and the beam transport line [1], where it can be seen that the beam is generated and pre-accelerated in a linear accelerator.

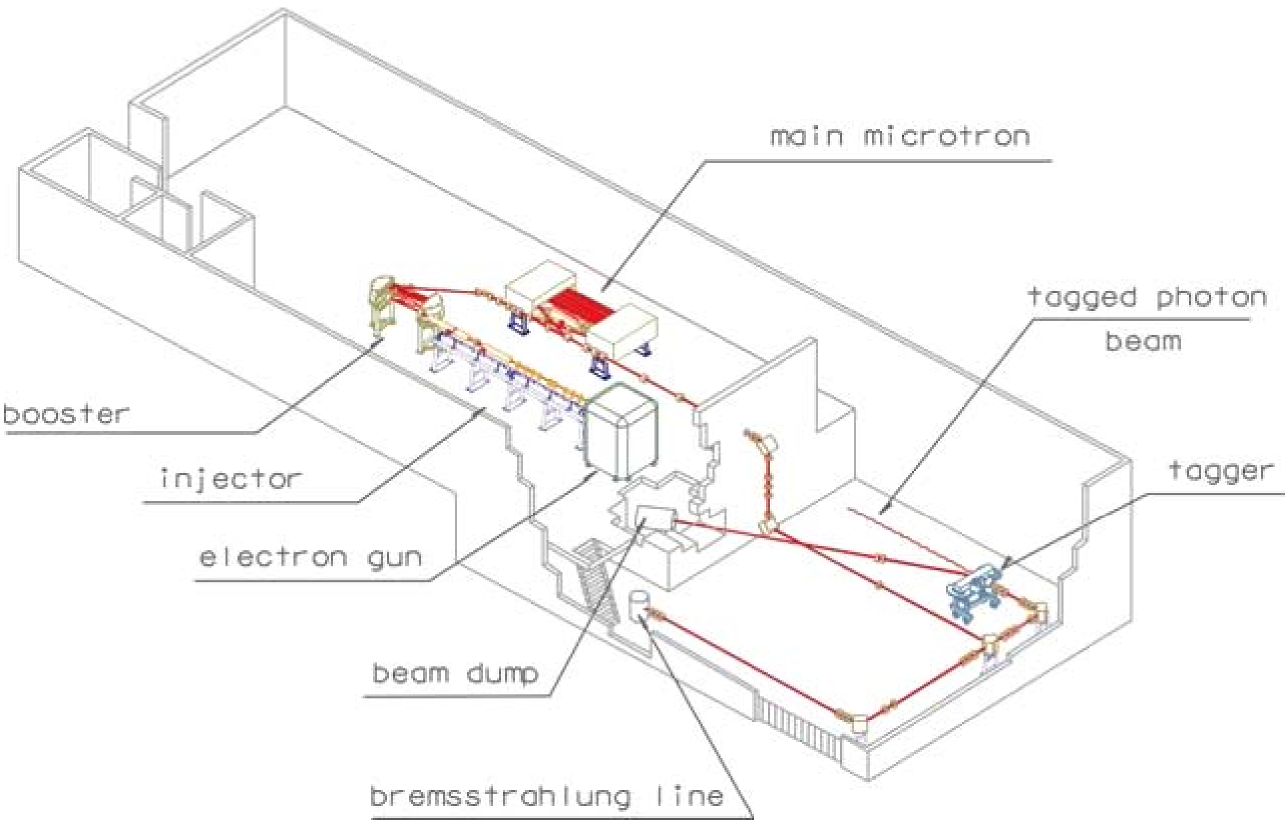

Figure 1: Isometric view of the accelerator in the accelerator building.

The injector linac consists of a beam conforming stage, with chopper and buncher systems, and two acceleration structures [2] (the first one with variable β, and the second one divided into two parts with different β). There is a 3-mm diameter collimator at the entrance to the first acceleration structure.

The beam focalization is made by solenoids, and correcting coils are provided for steering. Figure 2 shows the injector stage in detail.

In this work we describe the alignment tolerances for the injector system. This study involves analysis of our possibilities of alignment, and the beam specifications for the acceleration structures. Simulations were made using a method based on rotation matrices that allows for misalignments in the optical elements [3].

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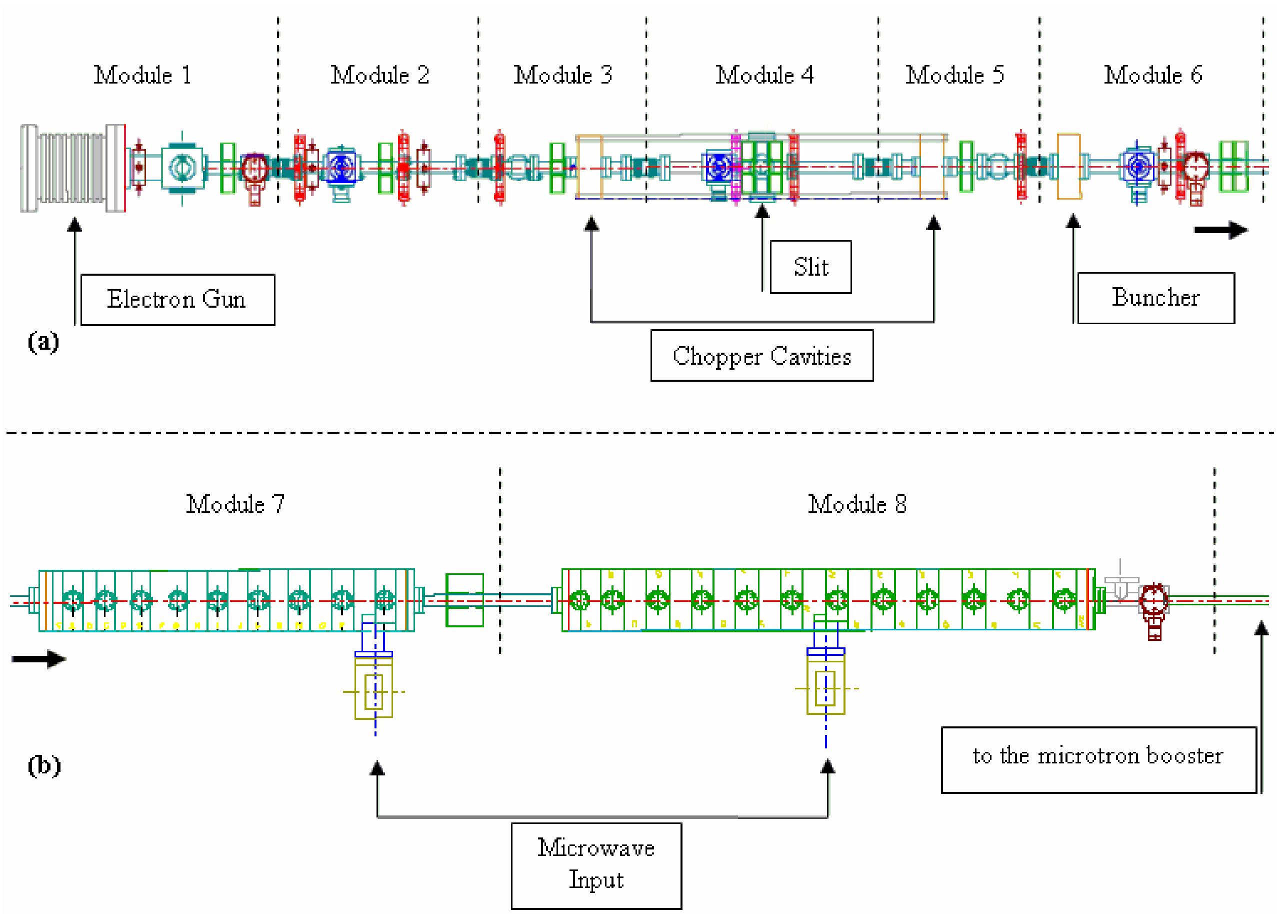

Figure 2: The injector system of the IFUSP microtron.

METHODOLOGY

As it can be seen in figure 2 (a), the conforming stage can be divided into six modules connected by bellows. Each end of these modules represents an alignment point, where a pointer for theodolite readings may be fixed. It is important to notice that the first module (electron gun) is fixed in the high voltage shield. Therefore, all subsequent modules must be aligned relative to it.

A MatLab [4] routine was developed to propagate a beam through elements of an accelerator. This routine uses rotation matrices and Lorentz transformations to propagate the beam, and allows for misalignments [3] in some elements. In an automatic process, the routine simulates the elements of the injector system using a normal distribution to generate a misalignment configuration. A tolerance parameter, given by the user, is interpreted as the standard deviation of the normal misalignment distribution used to shuffle the configuration.

Figure 3 presents a comparison among results from the MatLab routine and TRASNPORT [5] code (full line) obtained in simulations of the injector system without any misalignment, showing good agreement.

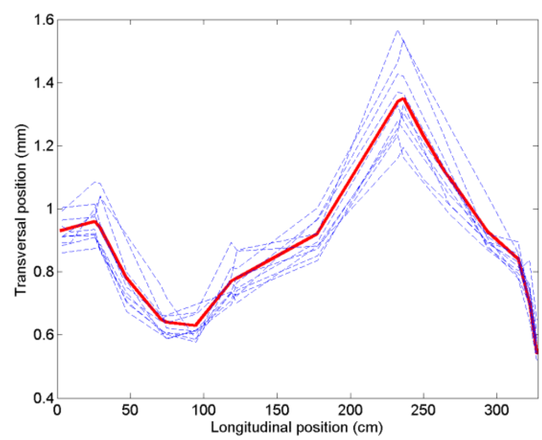

Figure 3: Comparison among results of the MatLab routine (dotted lines) and TRANSPORT code (full line) without misalignments.

Figure 4 presents a comparison among results from the MatLab routine and the TRANSPORT code (full line) obtained in simulations of the injector system with a 0.5-mm tolerance.

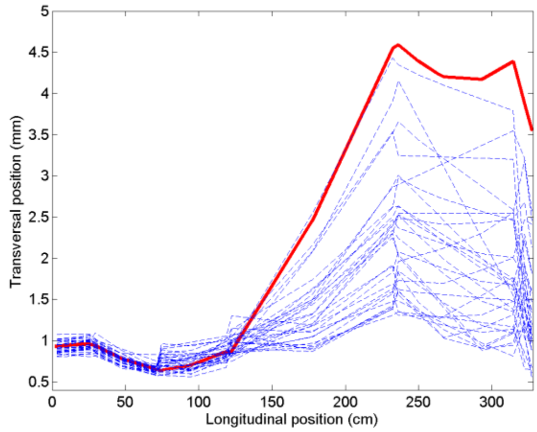

Figure 4: Comparison among results of the MatLab routine (dotted lines) and TRANSPORT code (full line) with a misalignment tolerance of 0.5 mm.

Due to the statistical character of the MatLab routine, the agreement between both codes is achieved if the beam envelope given by the TRANSPORT code involves most of the routine results.

SIMULATIONS RESULTS

To study the tolerance in the alignment, the injector system was simulated in an automatic process where the tolerance parameter was varied from 0.00-mm to 0.30-mm in 0.05-mm steps.

Each parameter was simulated five hundred times, and the mean value of the beam losses in the collimator of the first accelerator structure was determined. Results are presented in figure 5.

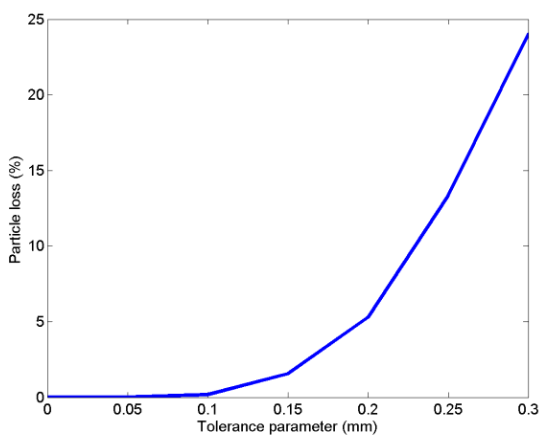

Figure 5: Particle loss in the collimator at the entrance of the first accelerator structure as a function of the tolerance parameter.

DISCUSSION

As it can be seen in figure 5, the particle loss in the collimator at the accelerator structure entrance depends strongly on the alignment tolerance parameter. An acceptable loss (10%) is achieved at a 0.23-mm tolerance.

With the available tools, it is possible to achieve an alignment tolerance of 0.18-mm over the whole injector.

It is important to notice that no correcting coils (steerings) were included in the simulations. Therefore better results can be expected in a real situation, when steering corrections are adequately used.

CONCLUSIONS

The alignment tolerance for the injector system of the IFUSP microtron was determined as 0.23 mm, for a beam loss at the first accelerator structure collimator limited to 10 %.

A 0.18-mm tolerance was achieved with our positioning devices.

The method used here presents advantages in comparison with methods based on beam envelopes, since one can obtain statistical information about the beam behavior.

ACKNOWLEDGEMENTS

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