THE IASA RACETRACK MICROTRON FACILITY, A PROGRESS REPORT

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Abstract

The Institute of Accelerating Systems and Applications (IASA) is pursuing research and facilitates postgraduate studies in traditional and cross-disciplinary areas where accelerators play an important role. The first major facility of IASA, now under construction, is a 242 MeV two-stage CW cascade microtron. During the ongoing period of civil construction a staging area has been set up for the installation of the injector and the testing of several key subsystems. A progress report on this project is presented here.

1 INTRODUCTION

The first large scale facility of IASA is a 242 MeV microtron[1]. It is being constructed largely out of the components of the NBS/LANL CW RaceTrack Microtron (RTM) [2] supplemented by those of the University of Illinois R&D RTM project[3]. The available equipment from the above two projects combined with the additional equipment produced by IASA in the last two years, allows a design based on a cascade (two stage) RTM. The accelerator comprises of a 6.5 MeV injector and two cascaded RTMs (RTM1 and RTM2) with output energies 41 MeV and 242 MeV respectively (Fig. 1).

Two interfacing sections match the output of the injector to the acceptance of RTM1 and the output of the latter to the acceptance of RTM2. They also serve to transport the beam to experimental areas. Both RTMs are designed for variable energy extraction[4][5]. The main characteristics of the machine are summarized in Table 1.

	INJ	RTM1	RTM2
Injection Energy [MeV]		6.5	41
Gain per Turn [MeV]		1.32	8.04
Number of Recirculations		26	25
Max Output Energy [MeV]	6.5	41	242
Max Current [μA]	600	100	100
Frequency [MHz]	2380	2380	2380
Incremental Number ν		1	1
Magnets Field [T]		0.2196	1.338
RF Power Consum. [KW]	118.7	29.0	169.3
Spacing [m]	8.8	3.25	8.7

Table 1: The main characteristics of the IASA Cascade RaceTrack Microtron

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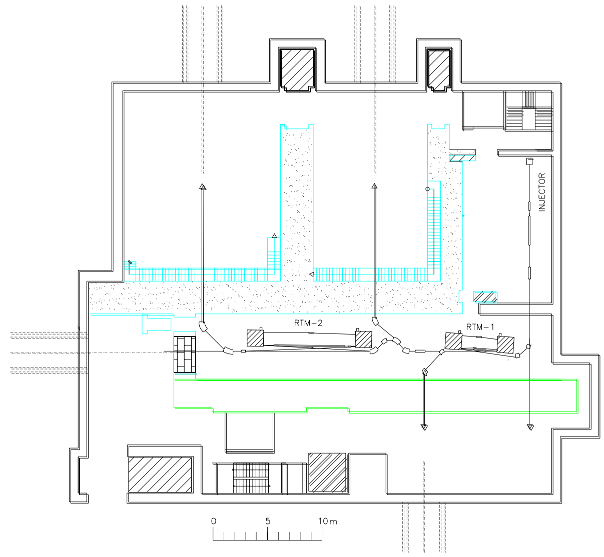

Figure 1: Layout of the planned IASA CW cascade (two-stage) microtron. The accelerator vaults and experimental areas are shown.

2 DESIGN AND OPTICS CALCULATIONS

The design philosophy is such as to result in stable operation, simple tuning and optimal use of the available linac sections, RF equipment and End-Magnets.

The injector consists of a 100 keV electron gun, a chopping and bunching system, a capture section, a preaccelerator and a booster. This design increases the initial NIST injector energy of 5 MeV to 6.5 MeV. Its optics has extensively been studied with the code PARMELA[6]. Most favorably, it turned out that the injector can be tuned such as to match RTM1 longitudinally without any further measures. This is demonstrated in Fig. 2[7].

Both microtron stages use quadrupole doublets on either side of the linac for transverse focusing, and both use the MAMI schemes[8] for injection and extraction, respectively. For RTM1, it was possible to apply a variant of this extraction scheme which provides achromatic extraction directly[9].

The first microtron (RTM1) is designed to operate with an asymptotic synchronous phase of 18 deg. The choice of that particular phase is made on the basis of keeping the longitudinal acceptance of RTM1 sufficiently high while relaxing the need of an extremely demanding control of the RF stability and injector output energy. The accelerating

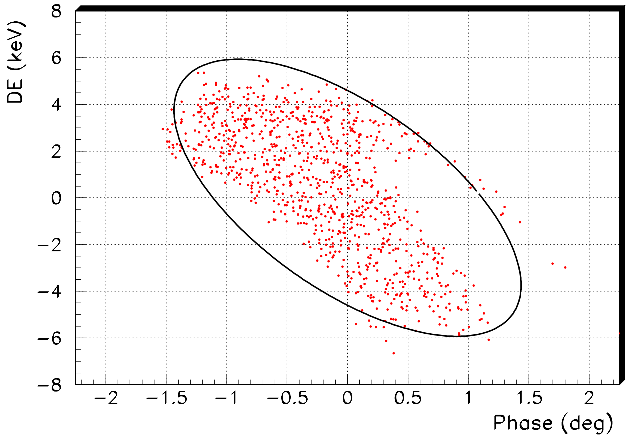

Figure 2: PARMELA simulation of the 6.5 MeV injector: Longitudinal emittance (dots) with the input eigenellipse of RTM1 with 6.5π keV deg. Chopper range is $\pm 30^o$.

section consists of a 15 cell (0.95 m) RF structure, to be constructed by reconfiguring the two 4 m main linac sections of the original NIST RTM. The second (RTM2) is to be operated at a synchronous phase of 16 deg as a best compromise between RF stability demands and energy width. The accelerating section consists of a 93 cell (5.9 m) RF structure, assembled by reconfiguring the NIST structure.

Microtrons and interfacing systems have been designed using the interactive codes OMEN for first order beam dynamics and LONGIDYN for nonlinear longitudinal dynamics[10]. Main design goals were ease of manufacture and operation, while finding a best match between layout of machine and civil construction (see Fig. 1)[9]. The design thus obtained was finally checked independently by the higher order code PTRACE[11] which also allowed to study the effects on cross coupling and quadrupole imperfections. For the latter, a sextupole moment of 2% at the pole tips (aperture radius = 10 mm) of all quadrupoles has been assumed. These calculations reproduced the design within close limits.

The results for RTM1 as the most critical subsystem are briefly communicated:

The acceptance (“bucket”) of a microtron, as well known, has a rather irregular shape as roughly indicated by the dotted line in Fig. 3. For practical purposes, it is wise to consider some inner polygon of the bucket as useful area which might be called “practical emittance”. It is drawn in Fig. 3 in bold line covering an area of 219π keV deg. The design emittance of 6.5π keV deg is shown for comparison (ellipse).

Using the practical emittance for the longitudinal phase space and a value as high as thirty times the design transverse emittance at injection (which is very conservatively assumed as 0.17π mm mrad at 6.5 MeV) it was verified by PTRACE that the RTM1 operation is stable even under those quite unfavorable conditions.

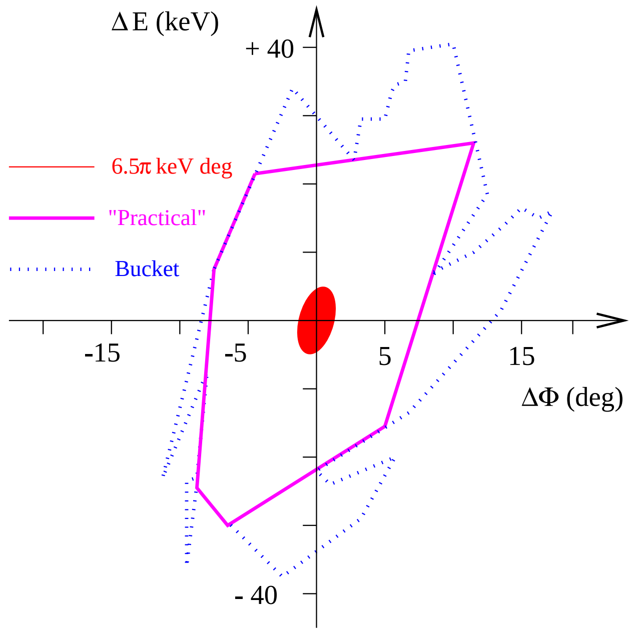

Figure 3: Calculated acceptance for RTM1 shown together with the design emittance (ellipse) and the practical emittance.

3 INJECTOR STATUS

The electron gun and the 100 keV chopping and bunching system have been installed. Several changes from the original NIST installation have been made at the electron gun to incorporate a new High Voltage Power Supply, an Isolation Transformer, and new control electronics (VME based) for the High Voltage terminal of the gun. So far, the system has been successfully operated in D.C. mode. The RF supply of chopper and buncher is being prepared. A beam line for measuring the transverse emittance of the beam is under construction[12], while a second line for measuring the longitudinal emittance of the beam is being designed[13].

4 RF SYSTEM AND MAGNET LAB

The currently adopted RF architecture for the cascade RTM calls for two power sources, both based on the Varian VKS 8270 klystrons. The first source will drive the 100 keV beam line, the capture, preaccelerator and boost/matching section, while the second the RTM1 and RTM2. The RF power needed for the implementation of both stages is shown in Table 2.

	INJ	RTM1	RTM2
Acc. Length [m]	4.7	1	6
Acc. Grad [MV/m]	1.3-1.5	1.5	1.5
Gain Amplitude [MeV]	6.65	1.388	8.36
Diss. RF Power [KW]	114.9	25.5	149.2
Beam RF Power [KW]	3.8	3.5	20.1
Total RF Power [KW]	118.7	29.0	169.3

Table 2: RF-related parameters for the IASA Microtron

The Magnet Lab deals with the powering, controlling and testing of all magnetic elements. Its major task is the field mapping of the small components, as well as of the End-Magnets.

5 CONTROL SYSTEM

The Control System for the IASA Microtron is totally revised, since the architecture of the NIST and UIUC machines is considered to be outdated[14]. The new system is being developed on the EPICS environment using Sun Sparc Stations and VME electronics.

The system architecture for the 100 keV injector has been finalized and in the major part realized. This includes the full control of the basic magnetic elements (solenoids, steerers), the high voltage power supply for the e-gun and monitoring of various readout parameters (currents at apertures, vacuum, etc.). An EPICS control screen created with the display manager (medm) for the IASA RTM injector is shown in Fig. 4.

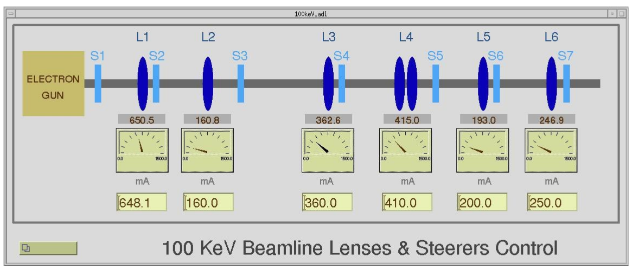

Figure 4: EPICS display screen (medm) for the control of the solenoids and steerers of the 100 keV injector

Further development of the system includes the integration of the programmable filament and bias supplies for the electron gun via fiber-optics for dc and pulsed beam operation, interlocks and other safety controls.

6 CONCLUSION

The two-stage cascade scheme for the Athens CW Microtron described here has been chosen because of its simplicity, stable operation and optimal use of the available equipment. The design of the accelerator is for all practical purposes completed. The 100 keV injector line has been installed and the first electron dc beams have been extracted. Basic elements of the electron gun and the injector line are controlled by a new system based on the EPICS environment.

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