OPTICS FOR THE IASA CW RTM

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Abstract

A Continuous Wave Cascade Racetrack Microtron (RTM) is being built at the Institute of Accelerating Systems and Applications (IASA). Making optimal use of the available equipment (obtained from NIST and the University of Illinois), a two-stage $\nu = 1$ Cascade scheme with optics similar to those of the Mainz RTM was adopted. The IASA CW RTM will provide a variable output energy from 6.5 to 246 MeV, with current intensity exceeding $100\mu A$. The LANL side-coupled linear accelerator structure operates at the RF frequency of 2380 MHz. The new design provides excellent emittance characteristics. Details of the optics design, stability and operation criteria of the Athens CW Cascade RTM are presented.

1 INTRODUCTION

The IASA Continuous Wave Race Track Microtron is being built mainly from components of the NIST/LANL and the University of Illinois research RTM projects [1]. The adopted scheme consists of a 6.5 MeV injector linac followed by a cascade of two Race Track Microtrons with output energies of approximately 42 and 246 MeV respectively.

The reasons for this choice among other alternatives ([2]) were:

- Highest output energy obtainable with the available RF equipment and end magnets.
- Stable operating environment and a simple tuning procedure.

The cascade scheme philosophy was originally suggested and successfully realized in the MAMI accelerator [3].

2 GENERAL CONSIDERATIONS

A schematic view of the proposed IASA Cascade RTM is given in Figure 1. In this variant the injector consists of the original 5 MeV NIST injector linac, followed by a longitudinal matching system, which will also serve as an energy booster to 6.5 MeV [4]. This energy increase can easily be accomplished by a 1.0m/1.43MeV linac, which is realized by reconfiguring one of the two 4m main linac sections of the original NIST RTM. The first stage, RTM-I, also uses a similar 1m linac, while the remaining linac section, which is about 6m long, will be used for RTM-II. Studies for the longitudinal and transverse matching between injector and RTM-I (Interface-1), and between the two Microtrons (Interface-2) are now in progress.

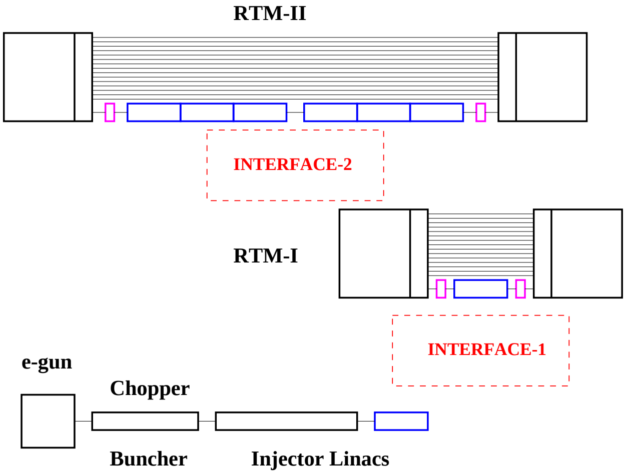

Figure 1: Schematic View of the IASA Cascade Microtron

The main characteristics of this configuration are summarized in Table 1.

	NIST	RTM-I	RTM-II
Injection Energy [MeV]	5	6.5	42.3
Gain per Turn [MeV]	12	1.43	8.5
Number of Recirculations	15	25	24
Max Output Energy [MeV]	185	42.3	246.7
Max Current [μA]	550	100	100
Frequency [MHz]	2380	2380	2380
Incremental Number ν	2	1	1
Magnets Field [T]	1.0	0.2379	1.414
RF Power Consum. [KW]	305	30	143
End Magnets Spacing [m]	12.5	3.25	8.6

Table 1: The main characteristics of the IASA Cascade RTM compared to the original NIST/LANL design.

3 RTM CALCULATIONS

The numerical code RTMTRACE [5] is being used to investigate the beam dynamics of the RTM. The results given below were obtained by integrating the equation of motion in the linac and the end magnets and by using matrix transformations to model the drift space and quadrupoles. RTM-

TRACE includes space charge effects and can calculate acceptances or input emittances for given output parameters.

Simple optics is used in both the first and second stage of the RTM. Transverse focusing is provided by a pair of quadrupoles symmetrically installed at each linac side on the common axis. This type of optics possess enough strength to ensure stable transverse oscillations.

3.1 Acceptance Calculation Results

The results of the longitudinal and transverse acceptance at the entrance of each Microtron are presented in Table 2. The area of the longitudinal acceptance is about two times larger than in the original NIST RTM-design.

Acceptance	RTM-I	RTM-II
Longitudinal [π MeV-deg]	1.04	10.65
Horizontal [π mm-mrad]	34.1	189.9
Vertical [π mm-mrad]	41.2	219

Table 2: Calculated longitudinal and transverse acceptance at the entrance of each Microtron.

3.2 Sensitivity Assessment

In order to estimate the sensitivity of the output beam parameters to misalignments or errors in the input beam parameters and field settings, the relative change of the longitudinal and horizontal RMS emittance has been investigated. The following misalignments have been simulated:

- Injection beam misalignment in Energy (ΔE) and in Phase ($\Delta\phi$)
- Error in the installation of the end magnets (Δd)
- Error in the field setting of the end magnets ($\Delta B/B$)
- Error in the accelerating field strength ($\Delta W/W$)

All these options of mismatching influence primarily the longitudinal beam characteristics. The relative change of the longitudinal emittance $(\epsilon_{out} - \epsilon_{inj})/\epsilon_{inj}$ is listed in Table 3.

$(\epsilon_{out} - \epsilon_{inj})\ /\ \epsilon_{inj}$ in 100%		
Simulated Misalignment	RTM-I	RTM-II
$\Delta E = 40keV$	1.8	0.
$\Delta\phi = 1deg$	0	0-77
$\Delta d = 0.3mm$	0.3	0.1
$\Delta B/B = 0.2\%$	3.6	1.7
$\Delta W/W = 0.2\%$	0.1	0.2

Table 3: Relative change (%) in the longitudinal emittance caused by simulated misalignments.

4 BEAM BREAKUP STUDY

One of the main processes that limits the beam current which can be accelerated is the Beam BreakUp effect (BBU). In cumulative BBU, RF noise in a transverse mode in the first section of a linear accelerator causes deflection of the beam which can result in an exponential size grow of the beam. In recirculative BBU, the primary beam is deflected by the magnetic field of the transverse mode. This beam then interacts on the second pass with the longitudinal electric field and energy is fed into the mode from the beam.

A vectorized two-dimensional beam breakup code [6] is being used to simulate bunch dynamics in a recirculating accelerator. The bunch position and momentum and cavity excitation diagnostics can be traced out and a BBU threshold current estimated. A preliminary BBU study for the Athens RTM comes to following conclusions:

- The threshold current is estimated to be $I_{thr} = 1.5mA$, well above the maximum current supplied.
- The threshold current in the second stage (RTM-II) is larger than the threshold current in the first stage (RTM-I).

5 INJECTOR OPTICS CALCULATIONS

The optics of the transport line and the preaccelerator section has also been extensively studied [7]. The purpose of this study is the better understanding of the injector functionality, since this part of the accelerator plays an important role in the definition of the beam characteristics and in the longitudinal matching with the first stage RTM-I. Both TRANSPORT and PARMELA codes used for the simulation show an identical beam behaviour (Figure 2).

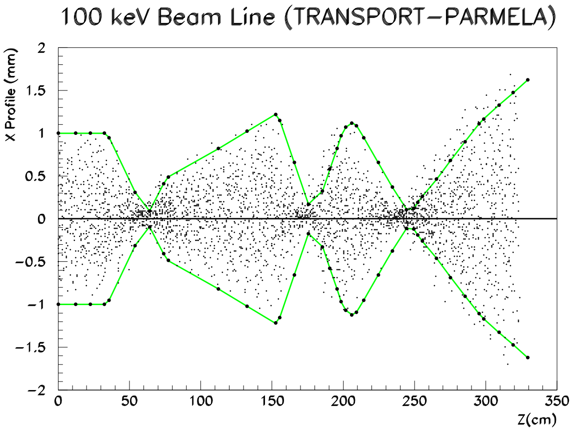

Figure 2: Comparison of the PARMELA and TRANSPORT (solid line) Results on the 100 keV Beam Profile. Main Focusing Elements are Solenoid Lenses.

Space charge effects are not negligible in this energy region but they can be compensated by the existing optical elements of the line.

6 CONCLUSION

The two-stage Cascade scheme for the Athens Microtron described here has been chosen among three variants because of its simplicity, stable operation and optimal use of the available equipment. It operates with smaller RF consumption than the original NIST configuration and provides a satisfactory acceptance and low sensitivity to external misalignments. The threshold current for a Beam Breakup effect is estimated to be well above the limits supplied by the machine, while optics studies for the injector and the matching systems are in progress.

7 REFERENCES

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