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The IASA RaceTrack Microtron Facility

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The design of the 240 MeV two-stage CW RaceTrack Microtron of the Institute of Accelerating Systems & Applications (IASA) is presented. The present status on the performance of the already installed 100 keV line, the diagnostic line for measuring the transverse beam emittance and the on-going installation of the complete injector is discussed. Plans for a simple and very cost effective upgrade to a 650 MeV two-stage cascaded RTM machine are also presented.

1. INTRODUCTION

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 design of a 240 MeV two-stage CW cascade RaceTrack Microtron (RTM) making optimal use of the available linac sections, RF equipment and End-magnets from the NIST/LANL Racetrack Microtron and the University of Illinois R&D RTM projects, has been completed[1]. Both the optical design and the civil construction plans for the RTM have been reviewed and met the approval of an international committee of experts. During the on-going period of design and construction of the accelerator vault and associated experimental areas for the RTM Laboratory, a staging area has been set up which provides adequate space and supporting facilities for the installation, testing and operation of important projects for the realization of the accelerator [2].

2. DESIGN OF THE 240 MeV ACCELERATOR

The design philosophy of the IASA Accelerator is based on a two stage cascade Microtron and comprises of a 6.5 MeV injector followed by the first stage 41 MeV RTM and the second stage 240 MeV RTM [3]. The layout of the whole accelerator is given in Fig. 1. An incremental number $\nu=1$ has been chosen, leading to a simplified tuning and operation

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of the accelerator, and modest RF power consumption. The main characteristics of the machine are summarized in the left part of Table 1.

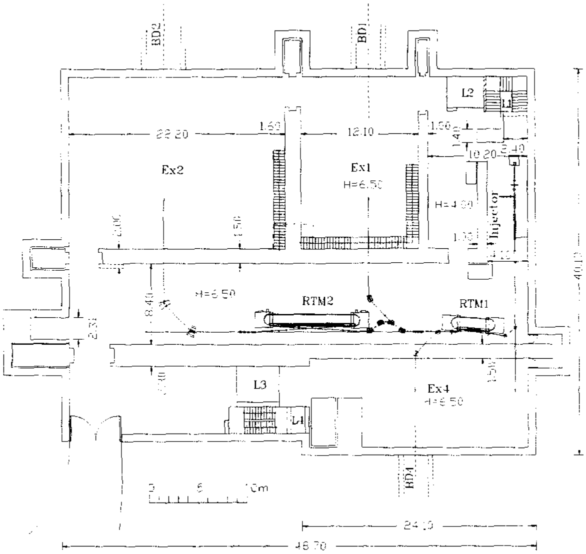

Figure 1. Layout of the IASA 240 MeV two-stage RaceTrack Microtron Accelerator and civil construction.

Injector optics calculations [4] show that the injector can be tuned such as to match the first Microtron in longitudinal as well as in transverse space without any further measures. Both microtron stages use quadrupole doublets on either side of the Linac for transverse focusing, they use the MAMI schemes [3] for injection and variable energy extraction. The first Microtron (RTM1) is designed to operate with an asymptotic synchronous phase of 18 deg; this choice 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. By incorporating a weak quadrupole in the extraction magnet in the return paths, the beam can be made free of dispersion at the exit from RTM1. This results in very simple beam optics downstream RTM1. The second Microtron (RTM2) is to be operated at a synchronous phase of 16 deg as a best compromise between RF stability and energy width.

The civil construction, seen in Fig. 1, has been designed in such a way as to allow a future machine upgrade to energies up to 650 MeV. The optical design of such an accelerator has been preliminary studied, leading to a determination of the additional components (End magnets, RF equipment) required. All building and facility designs have undergone strict safety considerations, based on the results of detailed shielding calculations.

Table 1
The main characteristics of the IASA Two Stage RaceTrack Microtron.

	Standard 240 MeV Scheme			Upgraded 650 MeV Scheme		
	INJ	RTM1	RTM2	INJ	RTM1	RTM2
Injection Energy [MeV]		6.5	41		8.3	65
Gain per Turn [MeV]		1.32	8.0		2.10	8.0
Number of Recirculations		26	25		27	73
Max Output Energy [MeV]	6.5	41	240	8.3	65.0	649.1
Max Current [μA]	600	100	100	600	100	100
Frequency [MHz]	2380	2380	2380	2380	2380	2380
Incremental Number ν		1	1		1	1
Magnets Field [Tesla]		0.2196	1.338		0.3486	1.338
Spacing [m]	8.8	3.25	8.69	10.1	3.76	8.69
RF Power Consump. [kW]	116.9	28.9	167.7	123.4	46.0	206.1

3. THE 650 MeV BEAM ENERGY UPGRADE

The present design of the IASA 240 MeV, two stage cascaded Racetrack Microtron [3], is based on the assumption of making optimal use of the NIST and Illinois equipment now available at IASA. Anticipating a future higher beam energy expansion, a feasibility study has been performed in order to find the best upgrade scheme for a 650 MeV beam energy machine. Although the simple solution of adding a third microtron leaves the fisrt two stages unchanged, it introduces a lot of complications in the present civil construction design. As pointed out in a recent study [5], the most economical way to achieve it under optimal RF consumption, is by increasing the number of recirculations and of course the End-Magnet pair in RTM2. Because the ratio of the output- to the input-energy for beam optics stability inside an RTM has to be kept around 10, some slight modifications to RTM1 and to the injector part are necessary. The characteristics of the proposed 650 MeV, two stage cascaded Microtron, are summarized in the right part of Table 1.

This solution leaves the building unmodified and the necessary extra space has to be achieved by internal modifications in the region of the machine vault. The new End Magnets of the second stage need to have a diameter of $\approx$ 4m; their magnetic field and spacing remain the same. In RTM1 the Dipole End Magnet field strength changes to 0.3486 Tesla (comfortably achievable). The increased energy gain per turn will lead to an increased number of cells in the RF structure; consequently the injection energy has to be increased from 6.5 to 8.2 MeV.

4. PRESENT STATUS AND FURTHER DEVELOPMENT

The first injector part consisting of the thermionic e-gun and the 100 keV Line, which is designed to define the transverse beam emittance and to chop and bunch the beam, has been already installed and successfully operated. A new RF drive system for the

100 keV Line has been built. A 2380 MHz, 230 Watt magnetron, injection locked for phase stability, is used to drive the two chopping and the bunching cavities. The system has been designed to make a negligible contribution to the transverse beam emittance during chopping. The Control System for the IASA Microtron is being developed on the EPICS environment. A DC electron beam of more than 200 μA has been extracted out of the electron gun and guided up to the Faraday cup [1], [2].

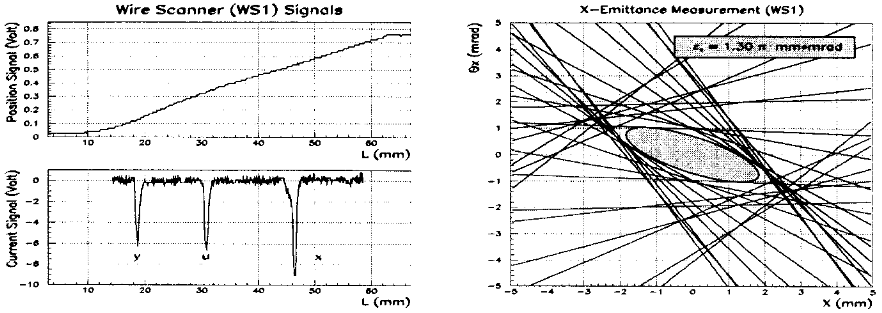

Figure 2. Left: Digitized signals from the wire scanner WS1. (a) Transducer signal used for position calibration. (b) Beam profile signals in the y, u (45 deg) and x directions. Right: Typical emittance measurement in the x-plane.

In order to perform transverse emittance measurements a so called T-line has also been installed at the end of the 100 keV Line. It comprises of three successive subsystems, each consisting of a lens followed by a wire scanner. Gold on Tungsten wires 20 μm in diameter are used in the scanners to measure the beam current profile. The measured values (Fig 2) allow the calculation of the transverse emittance. The so extracted value of the emittance is about 1.5 π mm mrad (100 keV) for both planes with an uncertainty of about 20%.

Current activities are being focused on the construction of the complete injector system taking in account the high power RF-requirements. Work on the power station needed for the klystron [6], the wave-guiding system, the chiller, safety and other important infrastructure needs is under way.

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