FIRST OPERATION OF THE 850 MEV C. W. ELECTRON ACCELERATOR "MAMI"*)

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Abstract

The three stage normal conducting c.w. race track microtron "MAMI" (MAinz MIcrotron) of Mainz University has recently been operated for the first time at full energy. The parameters of the machine are briefly communicated. A preliminary report on its performance is given.

Introduction

At Mainz University a c.w. electron accelerator with output energy close to 1 GeV was demanded to allow coincidence experiments with electrons and photons in nuclear and medium energy physics. A maximum beam intensity of about 100 μA was considered to be ample for the experimental program envisaged. For the sake of ruggedness and reliability and to allow inhouse manufacture we decided to avoid the use of superconducting structure. Following these lines the concept of a cascade of three race track microtrons ("RTM") using normal conducting structure in c.w. operation was developed [1]. The first stage (14 MeV), using a van de Graaff at 2.1 MeV as an injector, was set into operation in 1979 [2], the second followed in 1983 [3]. This two stage version, called "MAMI A", was operated routinely for user experiments until fall of 1987 with output energies variable between 14 and 187 MeV [4], [5].

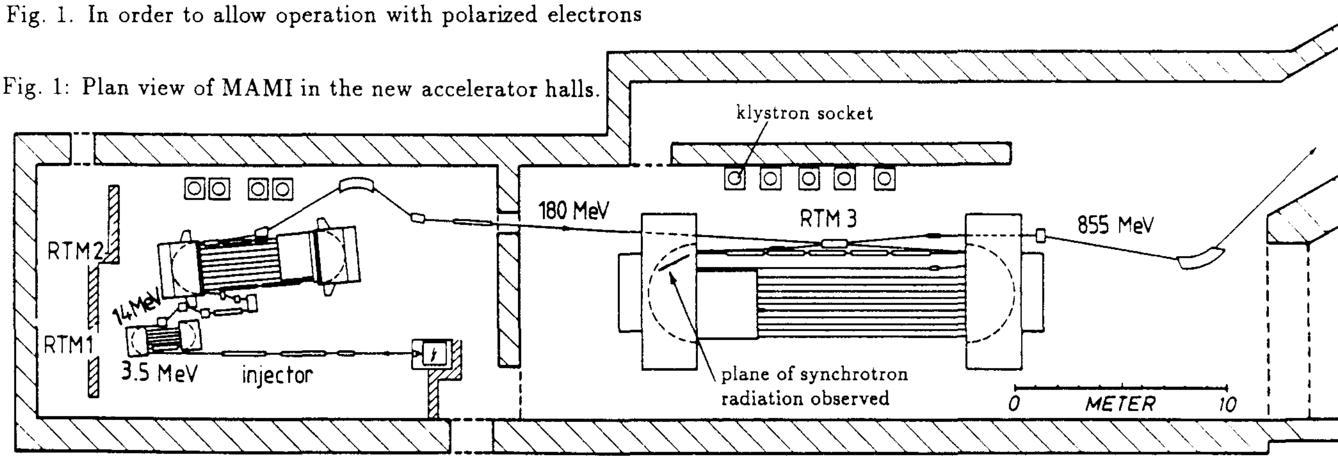
Setup of MAMI

The final setup of MAMI - sometimes called "MAMI B" - was carried out starting in 1986 in a new accelerator building on the site of the institute [6]. Its main parameters are compiled in Tab. 1. A plan view of the machine is shown in Fig. 1. In order to allow operation with polarized electrons

TABLE 1
Main Parameters of MAMI

General				
Stage No.		I	II	III
Input energy	MeV	3.46	14.39	179.8
Output energy	MeV	14.39	179.8	855
No. of recirculations		18	51	90
Magnet system				
Magnet distance	m	1.67	5.60	12.86
Flux density	T	0.1028	0.5553	1.2842
Max. orbit diam.	m	0.97	2.17	4.43
Weight per magn.	to	1.3	43	450
Gap width	cm	6	7	10
R.F. System				
No. of klystrons		1	2	5
Linac length (el.)	m	0.80	3.55	8.87
R.F. power dissip.	kW	8	48	103
R.F. beam power	kW	1.1	17	68
Energy gain	MeV	0.6	3.24	7.5
Beam (100 μA)				
Energy width	keV	± 9	± 18	± 60
Emittance vert.	μm	$< .17\ \pi$	$< .014\ \pi$	$\leq .04\ \pi$
Emittance hori.	μm	$< .17\ \pi$	$< .014\ \pi$	$\leq .14\ \pi$
Injection:	100 keV gun and three linac sections, fed by another klystron			
Extraction:	from each even numbered return path of RTM 3, i.e. in steps of 15 MeV			
R.F.-structure:	on-axis-coupled biperiodic standing wave, vacuum brazed OFHC copper			
Klystrons:	Thomson TH 2075, 50 kW c.w. max., 2449.6 MHz			

Fig. 1: Plan view of MAMI in the new accelerator halls.



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**) Affiliation changed meanwhile

[7] a 3.5 MeV linac is used now as an injector for the first microtron [8]. The first and second microtron are modified versions of the ones used with MAMI A. This new 180 MeV setup has been operated several times starting in June 1990, after considerable operational experience had been obtained earlier with the injector linac and the new 14 MeV stage. The general experience is that the new setup shows considerably better stability and reproducibility as compared to MAMI A. Most of this improvement is due to the new injector linac, whose performance is much better than that of the previously used van de Graaff. Further contributions are due to improved designs of several components like steerers, quadrupoles and monitoring devices, and a better understanding of the machine by use of computer simulations and computer aids in operation.

Yet further improvement is desireable if the new role of the 180 MeV assembly as a mere injector of the third stage is taken into account. There is some evidence that some of the reused components of the interface between stages one and two did not keep up with the new standards.

In the third stage, the beam has to be recirculated 90 times over a magnet distance of almost 13 meters and through a 12 mm diameter orifice (defined by a protection collimator in front of the linac). Therefore, we felt that in this stage careful homogenisation and adjustment of the reversing magnets would be particularly helpful to ensure sufficient operation comfort. Therefore, the method of field homogenisation by pole face correcting coils, already used with the magnets of stages one and two, was worked out further in several respects [9]. Also, great care was taken in calibration and presetting of the r.f. in the five accelerating sections.

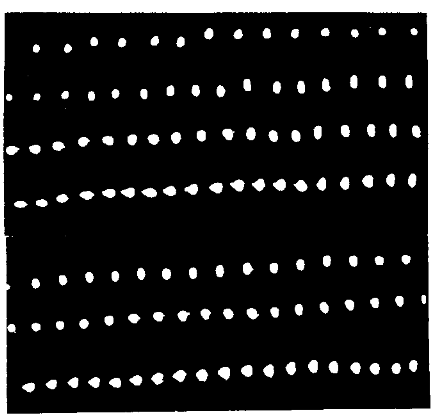

Fig. 2
Synchrotron radiation of the orbits in the left magnet of RTM3 as indicated in Fig. 1. Orbit number increasing from upper left to lower right.

On 10th of August 1990, when at the first time all parameters were set to their calibrated nominal values, the beam could be guided very easily within about half an hour through the 90 recirculations. During the procedure the beam was often ahead of the operator by up to about 10 turns. In fact, quite unexpectedly the first operation of the third stage was quicker and easier than that of the previous smaller ones and we assign this to the special precautions mentioned. Fig. 2 shows the synchrotron radiation of the recirculated beams, displayed in seven partially overlapping lines on two TV monitors. The size of the beam spots, as far as can be seen by a preliminary evaluation, is compatible with expectation. It is seen from the photograph that in this first, "historical" run there was still some mismatch, particularly in the vertical plane. Yet the beam transmission was 100 % as far as could be seen from the monitoring system. Beam intensity at this first run was below 1 μA c.w.. However, the intensity during the 10 nsec marking pulses for beam monitoring [1] was about 100 μA. This demonstrates that beam intensity is at least not limited by emittance.

In a later run, the c.w. beam intensity was raised without any readjustment up to 12 μA by just increasing the gun current. For safety reasons we refrained from a further increase because part of the monitoring and beam interlock system is still in a preliminary state. Anyway, the excellent beam transmission was confirmed by the low radiation level after this run.

Acknowledgements

The list of authors of this paper contains only the scientific staff involved. However, undoubtedly the realization of MAMI could not have been carried out without the commitment of the entire technical staff of the institute. We would like to especially commend G. Meyer, who deserved well of the mechanical engineering of MAMI B, H. Mussel for his conscientious work all over the r.f. system and R. Böhm whose expert know-how contributed much to the good performance of the MAMI electronics.

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