A 100 MeV Racetrack Microtron

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Abstract

The Scanditronix 100 MeV racetrack microtron is described. Examples of design data and measured performance are given.

I. INTRODUCTION

The racetrack microtron is an excellent choice as injector for electron synchrotrons and storage rings [1]. It is compact, easy to operate and offers a combination of high beam current with small emittance and very good energy resolution. The Scanditronix RTM100 racetrack microtron is a 19 orbit machine with a final energy of 100 MeV. It is based on the design of the Scanditronix RTM50, (with energies 10-50 MeV found in MM50 systems for radiation therapy) and was developed from accelerator concepts at University of Lund [1] and The Royal Institute of Technology in Stockholm [2]. Up to this time two RTM100 have been delivered and commissioned.

II. INJECTION AND FIRST ORBIT GEOMETRY

The electrons are supplied from a cylindrical Pierce-type gun, at injection voltages up to 100 kV. The current emitted from the cathode is approximately 1 A, but the anode aperture is limiting the current from the gun to about 200 mA, when operating in saturated space charge mode. The injection beamline consists of three focusing solenoids and an achromatic bending system, consisting of two 45° dipole magnets and a quadrupole, deflecting the electrons from the gun into the linac. The injection line can also be supplied with a 1 kW RF buncher system with an accelerating voltage of 30 kV, operating at 500 MHz. The RTM100 incorporates the reversed orbit geometry [3], where the electrons after the first pass through the linac are displaced by a magnet system and then directly reflected back into the linac by the main dipole. The acceleration phase during the first pass can be independently adjusted by sliding the linac along its axis, without affecting the phase for subsequent orbits. This also avoids any problem for the first orbit to clear the linac structure.

III. EXTRACTION

The extraction is carried out by deflection of the beam 5° into the extraction channel by a small dipole magnet in the last orbit. The extracted pulse current is 15 mA.

IV. TRANSVERSE STABILITY

The main dipole field in the RTM100 is 1.1 T, resulting in a final orbit radius of 0.3 m. The main dipoles are equipped with active field clamps producing a reversed field in the fringe field region [4], which together with a small gradient (2.4 %/m) in the main dipole field provide the vertical stability. The horizontal focusing is achieved by a quadrupole on the linac axis. The Twiss parameters after the extraction magnet were calculated to

$\beta_x = 12$ m and $\alpha_x = 0$ in the horizontal plane and
$\beta_y = 4.1$ m and $\alpha_y = 0.26$ in the vertical plane

(with an estimated accuracy of 10 - 20 %). Since the focusing is rather weak in the higher orbits the beam is sensitive for dipole errors, but these errors are easily corrected by small dipoles placed in the return orbits. In the RTM100 there are horizontal correction magnets in every return orbit and dipoles for vertical correction in every second orbit.

V. LINAC AND RF SYSTEM

The linac is of the sidecoupled standing wave type with 1/2 + 7 + 1/2 cavities, operating in the $\pi/2$ mode. RF-power is supplied from an 5 MW klystron operating at 3 GHz. The resulting energy gain is 5.26 MeV per orbit. The beam pulse width is continuously variable between 0.1 - 1.2 µs with a pulse repetition frequency of up to 10 Hz with the present modulator, but can easily be increased with an upgraded modulator (up to 5 µs and 300 Hz as in the Scanditronix RTM50, 50 MeV racetrack microtron).

VI. EMITTANCE AND MOMENTUM SPREAD

The emittance was found by measuring the beam profile of the synchrotron light observed from the beam inside one of the main dipoles, which together with the calculated Twiss parameters resulted in the following values for the horizontal emittance: $(0.10\pm0.04)\pi$ mm·mrad, and for the vertical emittance: $(0.20\pm0.06)\pi$ mm·mrad.

The momentum spread was measured using a 45° bending magnet and a slit system. The beam was focused on the slit by a quadrupole doublet and the current collected on the beam stop after the slit was integrated. The result found from this measurement was $dp/p = (1.0\pm0.1)\cdot10^{-3}$.

VII. SUMMARY OF DATA FOR THE SCANDITRONIX RTM100

Electron energy (MeV)	100
Main dipole field (T)	1.1
Beam pulse current (mA)	15
Pulse length (μs)	0.1-1.2 (5)
Pulse rep. freq. (Hz)	0.1-10 (300)
Hor. emittance (mm·mrad)	$(0.10\pm0.04)\pi$
Vert. emittance (mm·mrad)	$(0.20\pm0.06)\pi$
Momentum spread (%)	0.10 ± 0.01

Numbers in parenthesis for pulse length and pulse repetition frequency refer to a system with an upgraded modulator.

VIII. REFERENCES

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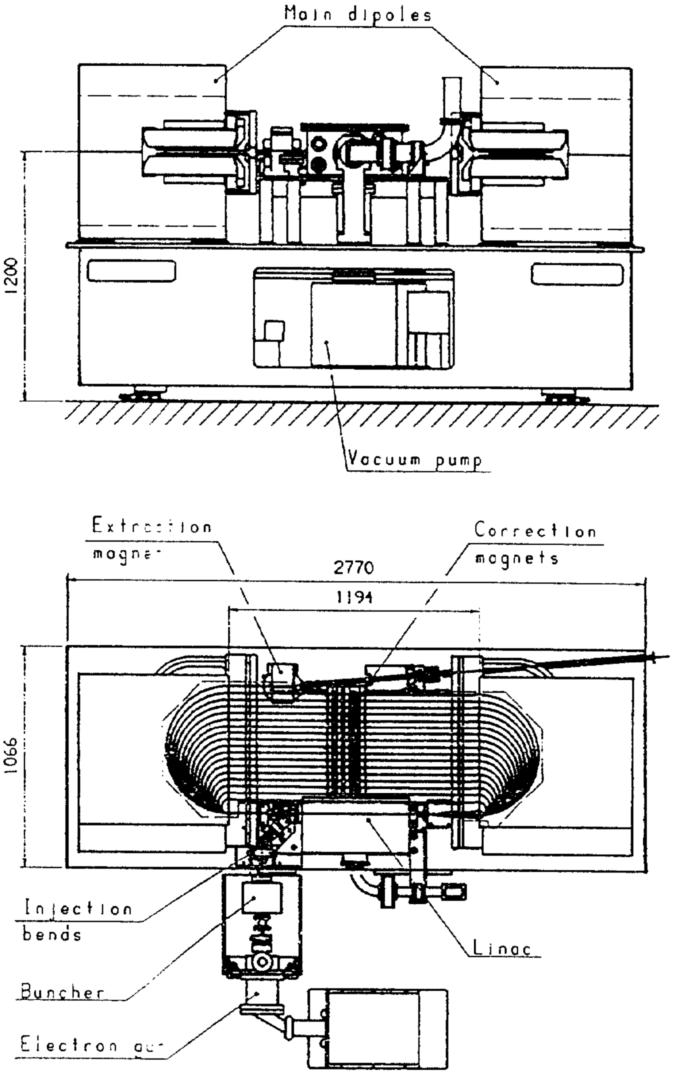

Side and top view of the RTM100