

# First Beam Test Results of the 10 MeV, 100 KW RHODOTRON

Y.Jongen, M.Abs, D.Defrise, F.Genin,  
Ion Beam Applications, Louvain-La-Neuve (Belgium)

J.M. Capdevila, O. Gal, A. Nguyen,  
CEA-DEIN Saclay (France).

## Abstract

The Rhodotron TT200 is the first IBA new generation model of CW electron accelerators, based on the principle of recirculating a beam throughout a single coaxial cavity resonating in metric waves.

The Rhodotron TT200 is designed to achieve high-energy (5 and 10 MeV) and high power beams (up to 100 kW). The accelerating cavity resonates at 107.5 MHz. The RF system involves in the final stage a 200 kW plate dissipation tetrode, which allows an energy gain of 1 MeV per crossing. Five or ten crossings using four or nine 180° bending magnets are therefore needed to reach respectively 5 and 10 MeV.

The first 1 MeV, 20 mA beam has been successfully accelerated as planned on October 29, 1993. Each crossing was then tuned step by step using beam viewers and current monitors. This measuring method allowed to fine tune the beam focusing by adjusting the pole face angle on the deflection magnets.

After optimizing beam focusing, the beam has been accelerated up to 10 MeV without losses. The optimization of magnet face angle has been achieved by correlation between accurate numerical analysis and experimental measurements. The Rhodotron TT200 has met its full specifications in April 1994. A complete report of technical performance data is presented in the paper.

## 1. INTRODUCTION

The collaboration agreement between IBA and the LETI/CEA came to a successful end on April 94, with the achievement of the full specifications (i.e. 100 kW at 10 MeV) of the Rhodotron TT200 first unit. This collaboration began in December 91 with the signature of the agreement giving IBA the exclusive right to industrialize a new generation of CW electron accelerators, called "Rhodotron". A large number of papers outline the principle of operation of the Rhodotron [1] as well as the operation of the prototype built in Saclay [2] and the description of the different subsystems of the first industrial unit built by IBA [3,4].

## 2. ACCELERATOR PARAMETERS

The first industrial model of the Rhodotron, called Rhodotron TT200 is designed to achieve high-energy (5 and 10 MeV) high power beams (up to 100 kW). The main parameters of the Rhodotron TT200 are presented in Table 1.

In the Rhodotron, the beam energy can be selected by switching off one of the bending magnets or by adjusting simultaneously the accelerating field in the cavity and the magnetic field in the deflection magnets. As the Rhodotron TT200's RF system has been designed to allow for an energy gain of 1 MeV per crossing, the range of energy of this machine is virtually 1 to 10 MeV. Practically, a 10 MeV exit and an option for a 5 MeV exit are proposed, as these energies are those mainly utilized for the industrial irradiation processes.

The RF system uses a tetrode which has been designed to deliver 200 kW. As 85 kW of power is required to establish the electrical field allowing the energy gain of 1 MeV into the cavity, 115 kW of power are available to accelerate the electrons.

The beam intensity is regulated by the beam current injected by the electron gun, which can achieve a peak intensity of 200 mA.

Table 1  
Parameters of the Rhodotron TT200

Beam Energy	1 - 10 MeV
Beam intensity	1 - 10 mA
Output power of the RF System	200 kW
Frequency of the RF System	107.5 MHz

## 3. TECHNICAL STATUS OF THE RHODOTRON TT200

The engineering of the Rhodotron TT200 began in January 1992. Final drawing of the accelerator and its beam transport system and scanning horn is shown in figure 1.

All subsystems have been designed to optimize the reliability of the machine and achieve a continuous operation of at least 6,000 hours per year.

Standard commercial assemblies have been used as much as possible to proceed with easy and cost-effective maintenance.

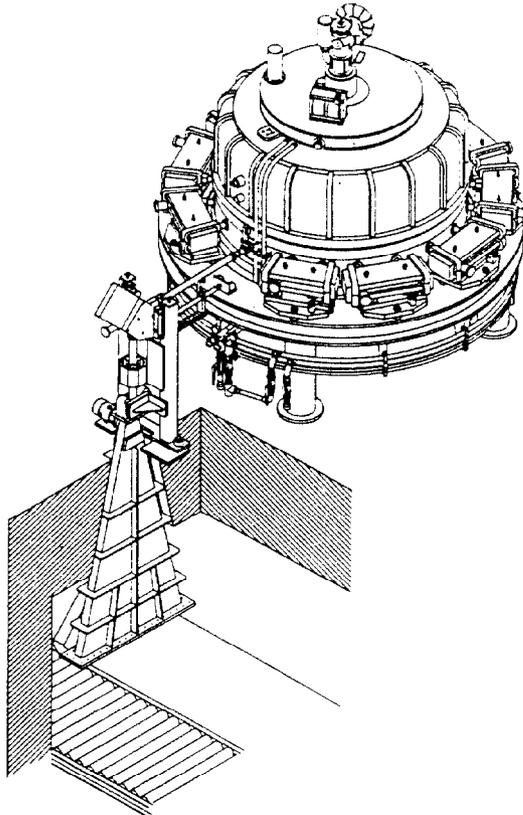


Figure 1:  
Overall view of the Rhodotron TT200, its beam transport system and scanning horn.

Major design features of the Rhodotron TT200 are:

- the RF system designed to be placed on the top of the accelerating cavity. This increases the compactness of the machine, simplifies the coupling and excludes the need of a pressurized wave guide.
- the deflection magnets designed as "window-frame" type to ensure a constant magnetic field along the electron orbit.
- the gun designed to integrate a standard commercial cathode and grid assembly.

All sub-systems have been assembled and tested during 1993 and the first 1 MeV, 20 mA beam has been successfully accelerated on October 29, 1993. Each crossing was then tuned step by step using successive beam viewers and current monitors. The beam transport system has been installed afterwards. It includes a 90° magnet and a water-cooled high-power target, shielded with lead. This work allowed to obtain full specifications (i.e. 100 kW at 10 MeV) in April 1994.

#### 4. MAGNET OPTIMIZATION

The optimization process has allowed to discover small errors in the calculation of the optical focusing properties of the magnets. The optimization of the magnet face angle has been achieved by correlation between accurate numerical analysis and experimental measurements. Beam focusing was adjusted by using pole edge shim pieces. This issue is further detailed in a paper presented by the engineers from the CEA/LETI in Saclay.

Using these devices, measurements of the current on the target vs. the emitted current from the gun demonstrated that more than 97 % of the beam is accelerated up to 10 MeV. High-energy losses (i.e. losses above 1 MeV) have been shown to be  $< 10^{-3}$ .

#### 5. POWER CONSUMPTION

As a result of the efficient design of the RF system of the Rhodotron TT200, low power requirements are needed for the operation of this machine. An efficiency of 40 % is attained at full beam power (Table 2).

Table 2  
Power requirements of the Rhodotron TT200

Beam Power (kW)	Power requirement (kW)
50	< 200
70	< 225
100	< 265

#### 6. LONG-TERM CW OPERATION TEST

At the end of the beam tests, a CW test of 10 hours at 70 kW has been performed without any problems. Longer test runs are in progress to demonstrate the long-term reliability of the Rhodotron.

## ACKNOWLEDGEMENTS

The unique success of the Rhodotron project is the result of the dedication of high-skilled engineers, technicians and scientists from both the IBA company and the CEA. Their competence is gratefully acknowledged.

## REFERENCES

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