MEDICAL PROTON SYNCHROCYCLOTRON

E. Toyota, T. Hori, Y. Hirao* and S. Fukumoto**

Sumitomo Heavy Industries, Ltd.
*Institute for Nuclear Study, University of Tokyo
**National Laboratory for High Energy Physics

Abstract

Nowadays the synchrocyclotron is not newly built because of its lower beam intensity compared with the isochronous cyclotron. But its proton beam intensity can fill the demands required in diagnostics and treatment for cancer. It is worth while designing a synchrocyclotron dedicated to medical use when taking into consideration the merits such as easiness of operation and rather a little space occupation of the machine. The conceptual design of 230 MeV proton synchrocyclotron has been made and its main parameters are presented.

Introduction

The proton beam is used both for radiotherapy diagnostics and for therapy of cancer. When we provide 35 cm for the necessary penetration depth, the energy of 230 MeV is required and simultaneously this becomes the maximum acceleration energy. The required intensity is 1.35×10^{10} pps (2.2 nA) when the dose rate of 600 rad·liter/min is needed to be provided for the maximum value in therapy. A synchrocyclotron is adopted for the accelerator suitable to such intermediate energy region.

Outline of Synchrocyclotron

The most important factors for a medical accelerator are stability of the machine and easiness of operation and maintenance. When the range of frequency-modulation is taken to be wide, various difficulties are brought in design of the variable capacitor. On the other hand, according to reduce the width of frequency-modulation, the magnetic field must be set up to more isochronous one and the control of the magnetic field tends to be complicated by the need of trim coils.

In this design, the magnetic field is to increase according to the enlargement of radius, within the range in which trim coils are of no use and in the result the width of frequency-modulation is suppressed to 15% of initial RF. The focus strength is produced by the AVF method. For the simplicity of mechanism, the single dee type is adopted and acceleration is made with first harmonics. In order to protect the axle-bearing of the rotating capacitor from the damage caused by induced current, the rotating shaft is insulated electrically and the rotating capacitor consists of rotor plates in serial connection floated from the earth side.

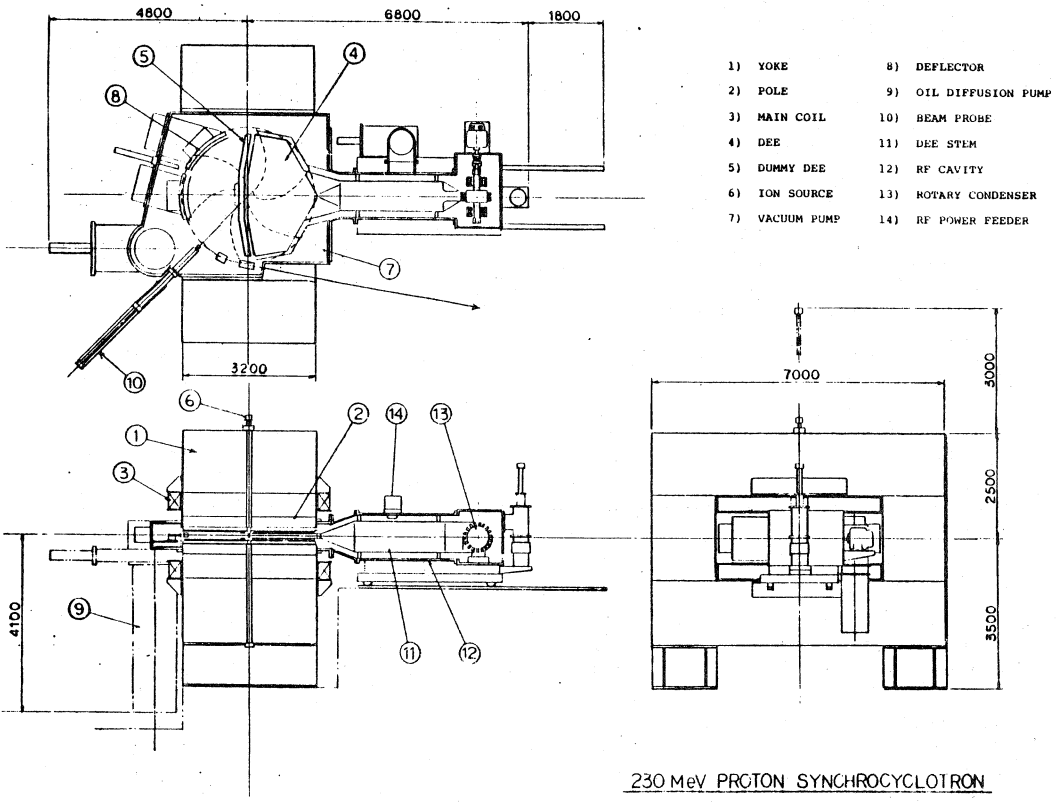
The solid-core magnet, the largest and most costly component of the synchrocyclotron, is estimated to 800 ton in total weight as the result of the safty first design. This heavy weight brings the difficulties in overhaul of the heavy iron yoke at the time of maintenance. But this matter is of no problem by the consideration of a dedicated overhauling procedure. By this

reason the possibility of reducing the total weight is not being investigated further. An idea of effective usage of iron core as a shielding material should be considered hereafter.

The main parameters of the synchrocyclotron are listed below together with the figure of design drawings.

Parameter List of 230 MeV Synchrocyclotron

Maximum Energy	Proton	230 MeV
Intensity		$>1\mu$ A
Magnet System		
AVF Field		3 Sector
Pole Diameter		3,200 mm
Average Field Strength		16.3 kGauss
Main Coils Power		360 kW
Weight		800 Ton
RF System		
Frequency Range		23 ~ 20 MHz
Dee Voltage		30 kV
Power		60 kW
Vacuum System		20,000 l/sec
		5×10^{-6} Torr



230 MeV PROTON SYNCHROCYCLOTRON