HEAVY ION MEDICAL SYNCHROTRON -HIMETRON-

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Introduction

The design work of a medical heavy ion accelerator is performed from a standpoint that heavy ion beams have various merits in medical science. The particle species to be accelerated are up to neon at most. A kinetic energy of 600 MeV per nucleon for neon ion is provided corresponding to a penetration range of 32 cm in tissue, and a beam intensity of 3×10^8 pps at an irradiation area corresponding to the dose rate of 600 rad·liter/min.

General Design

The accelerator consists of a preinjector, injector linacs and a synchrotron. As an ion source PIG-type is used and preinjector is a Cockcroft-Walton generator of 750 kV. Assuming the acceleration voltage of 700 kV for ions of ε=0.25, the injection energy to linac is 175 keV/u. Four Alvarez linacs of 272 cm in diameter and 20 m in total length with operating frequency of 80 MHz are adopted as the injector and a charge stripper is installed after No. 3 tank. The main parameters of linac are shown in Fig.1.

The final stage is a synchrotron, into which Ne^{10+} of 7.5 MeV /u is injected by multiturn method. Ten turn injection satisfies the required intensity. To keep flexibilities of operation, separated function type of FODO structure is studied and main parameters of the synchrotron is listed below. Bending magnets are designed as window-frame type having 80 x 230 mm^2 aperture. Designed synchrotron has a transition energy of 2 GeV/u and serious beam instability is occurred when intensity of neon beam exceeds 1.3×10^{10} /pulse, but both the factors need not be taken into account in this case. Acceleration is performed by two RF cavities with synchronous phase of 30°, those are composed of two $\lambda/4$ coaxial resonators of 40 cm in diameter and 160 cm in length. As for vacuum, the pressure of 1×10^{-8} torr is required and easily attained by use of 5 rough pumping station of 500 l/sec TMP and 800 l/sec SIP at each 12 section. Fig.2 shows the total layout of a radiotherapy facility.

Parameter List of Heavy Ion Synchrotron for Medical Use

General	
Energy	7.5∿600 MeV/u
Intensity	3×10^9 pps
Repitition Rate	2 Hz
Magnetic Field	1.38∿14.14 kG
Bending Radius	5.730 m
Mean Orbit Radius	17.95 m
Revolution Freq.	.335∿2.10 MHz
ν Values (ν_x/ν_z)	3.25/3.35
RF Systems (2 Cavities)	
Freq. Range	1.34∿8.40 MHz
Harmonic No.	4
Max. Acc. Voltage	15 kV
Shunt Impedance	1 kΩ
Total RF Power	100 kW

Magnet and Lattice			
Normal Cells/Superperiods		12	
Periodic Structure		FBBDO	
Bending Magnets/Q Magnets		24	
Q Magnet Length		0.3 m	
G_F/G_D		0.867/0.757 kG/cm	
		MAX(m)	MIN(m)
Dispersion (η)		2.872	1.385
β Function			
in Bend.	Horz.	12.69	3.12
	Vert.	12.66	3.33
in Q Mag.	Horz.	15.36	2.52
	Vert.	14.50	2.50

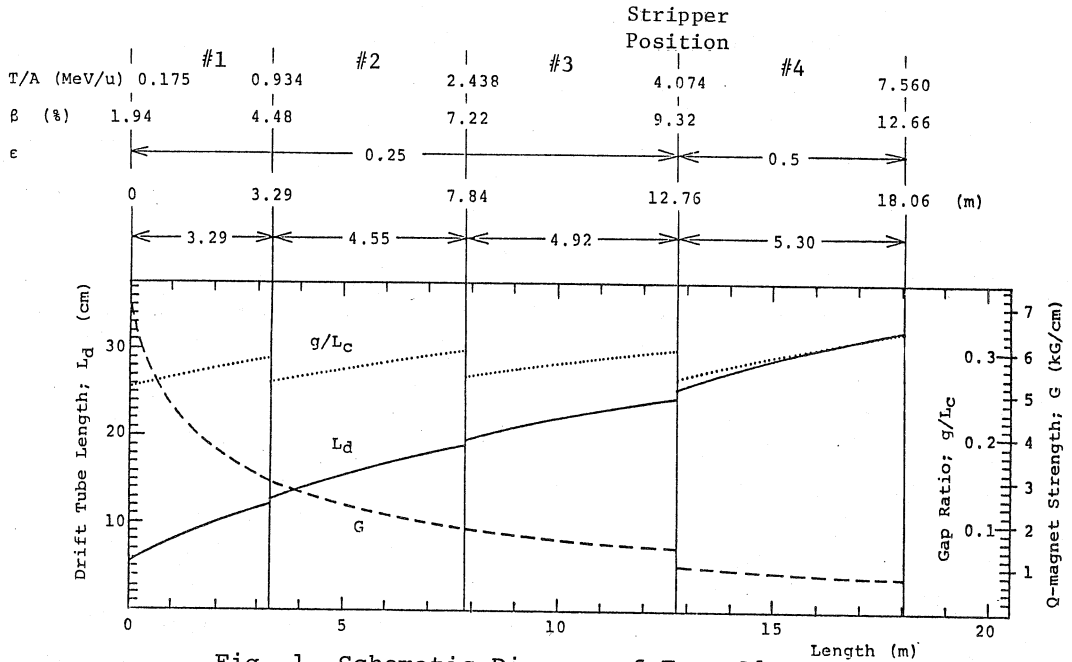

Fig. 1 Schematic Diagram of Four Alzarez

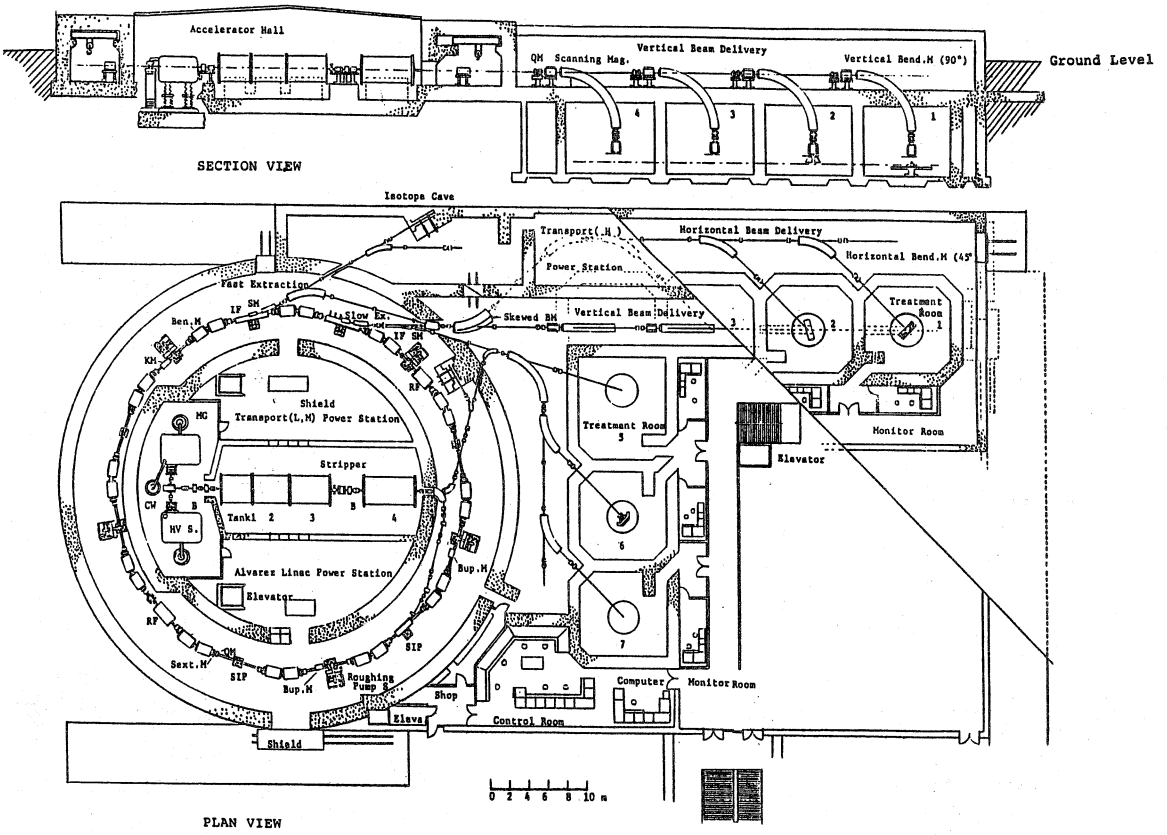

Fig. 2 Layout of Heavy Ion Accelerator and Therapy Facility