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PRESENT STATUS OF TARN II

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Abstract

The test accumulation ring,TARN,had been constructed for the developement for heavy ion accelerator and the experiments of the beam accumulation and the stochastic cooling was made successfully. TARN was converted into new heavy ion ring,TARN II, which has the magnetic rigidity of 6.8 T·m corresponding to the maximum energy of 1.3 GeV and 450 MeV/u for proton and heavy ions with charge to mass ratio of 1/2, respectively. This ring has two operation modes as follows: 1) normal synchrotron operation, and 2) cooler ring mode. Especially, the electron beam cooling system is designed to be applied at the energy region of 200 MeV/u for heavy ions.

Introduction

Presently, TARN II is under construction and is to be completed in 1989. The ion from SF cyclotron with K-number of 67 is injected to TARN II. This ring has the performance which accelerate ions up to the energy of 1.3 GeV for protons and 450 MeV/u for heavier ions, respectively. An electron beam cooling device with the maximum electron energy of 120 keV is designed as one of the impotant problem aimed at TARN II. And also, a slow extracted beam methode is to be provided for a proposition as the basic property of the accelerator.

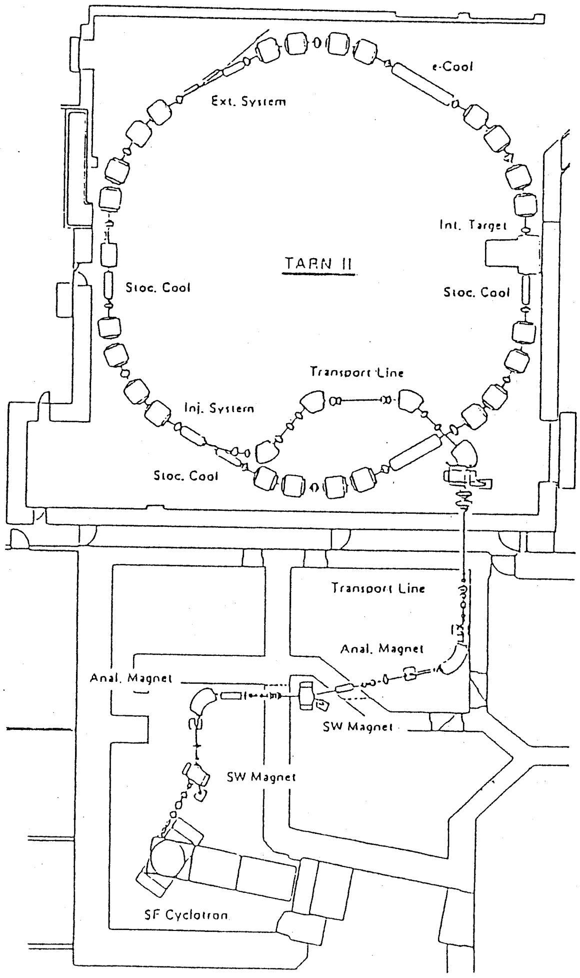


Fig. 1 Layout of TARN II

General Description

The new accelerator,TARN II, is installed in a new hall which is remodeled the hall for TARN and the old experimental room of FM cyclotron. The former transport line for the injection from SF cyclotron is used for TARN II. A layout is shown in Fig. 1. The final specifications is listed on Table 1. But in the first phase of operations, the maximum acceleration energy of ions is limited to the energy of about 350 MeV/u coresponding to the exitation current of the magnets and the repetition rate of the power supply is chosen to be 0.1 Hz because of the restriction on electric power capability of our institute at present. Also,the maximum voltage of 1.9 kV of RF cavity is the sufficient value in this system.

The ions injected from SF cyclotron to TARN II has the energy of 2.7 MeV/u. The intensity of accelerated ions in TARN II is estimated to be 1 x 10^8/pulse for protons and 5 x 10^6/pulse for heavier ions, respectively.

The two operation modes of synchrotron mode and cooler ring mode are avairable according to purposes.

Magnetic System and Operation Mode

The lattice of TARN II is designed on FODO structure by 24 dipole magnets and 18 quadrupole magnets. The superperiodicities of 6 and 3 on this ring are proposed for synchrotron and cooler ring modes, respectively. In cooler ring mode, double achromatic section is made up at long straight section as shown in Fig 2 for installation for experiments of electron cooling.

With the power supply for the frist phase, the dipole magnets and the quadrupole magnets are to be excited up to the maximum currents of 2500 and 400 amp corresponding to 15.5 kG and 1.1 GeV proton energy. The excited pattern of magnets with the rise time of 3.5 sec and the periodicity of 0.1 Hz is designed. The current and voltage patterns of the dipole magnets are shown in Fig. 3. In this case, the electric power is estimated to be 500 kW.

Table 1 Final Specification of TARN II

Maximum Beam Energy (MeV/u)	proton 1300
	ions with e/m=1/2 450
Circumference (m)	77.761
Average Radius (m)	12.376
Radius of Curvature (m)	3.820
Focusing Structure	FBDBFO
Superperiodicity	6
" for Cooler Ring Mode	3
Betatron Tune Value	around 1.75
" for Cooler Ring Mode	around 2.25
Transition	1.87
Repetition Rate for Synchrotron Mode (Hz)	1/2
Maxmum Field of Dipole Magnets (kG)	18
Deflection Angle of Dipole Magnets(°)	15
Maximum Gradient of Quadrupole Magnets (kG/m)	70
Revolution Frequency (MHz)	0.305-3.51
Acceleration Frequency (MHz)	0.61- 7.02
Harmonic Number	2
Maxmum RF Voltage (kV)	6
Vacuum Pressure (Torr)	better than 10^{-10}

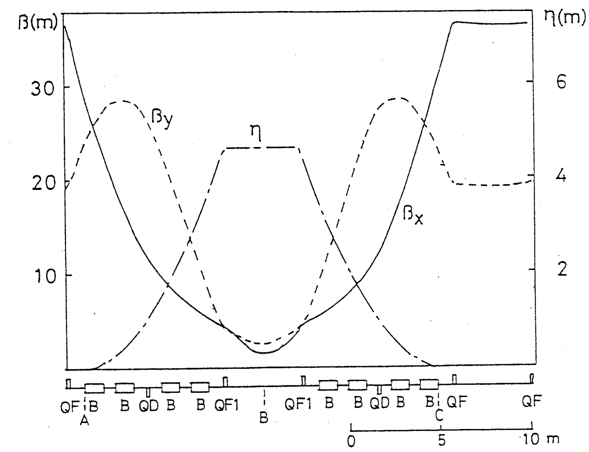


Fig. 2 *β* and Dispersion Functions of Cooler Ring Mode

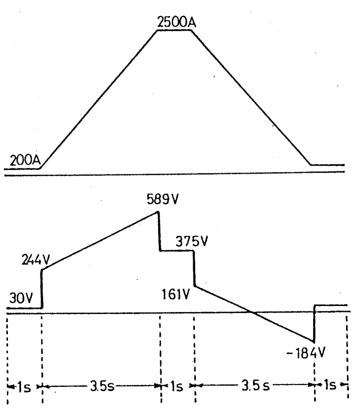
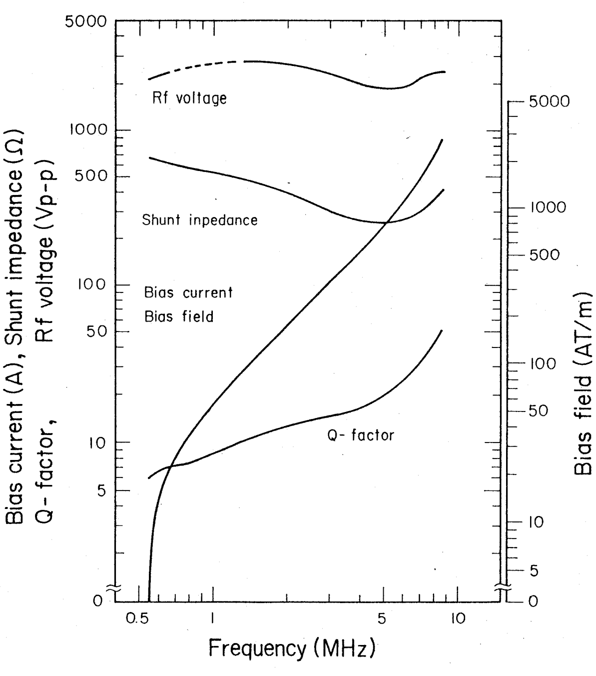


Fig. 3 Current and Voltage Pattern of Dipole Magnet



Fig/ 4 RF Characteristics of Fundamental Resonance

RF Acceleration System

The wide range RF cavity for TARN II is required in relation to the low energy injection enery of 2.7 MeV/u. Presently, the powerful RF cavity with the frequency range from 550 kHz to 8.7 MHz and the acceleration voltage higher than 1.9 kV was attained.
In consequence, the injection ions of 2.7 MeV/u are accelerated up to the maximum energy of 1.3 GeV/u in a case of the harmonic number of 2. The characteristics of the fundamental resonance of the cavity are shown in Fig. 4.

Vacuum System

The vacuum pressure better than 10^{-10} Torr is required to obtain long life time of heavy ions for beam storage and cooling experiments at TARN II. The vacuum chambers (Fig. 5) in the dipole magnet section are made of 316L stainless steel 4mm in thickness, because the rise time is rather slow as 3.5 sec. Presently, the vacuum pressure of 3 x 10^{-11} Torr was obtained in evacuation test of these chambers and the out gassing rate of chamber wall is estimated less than 1 x 10^{-12} Torr·l/sec·cm^2.

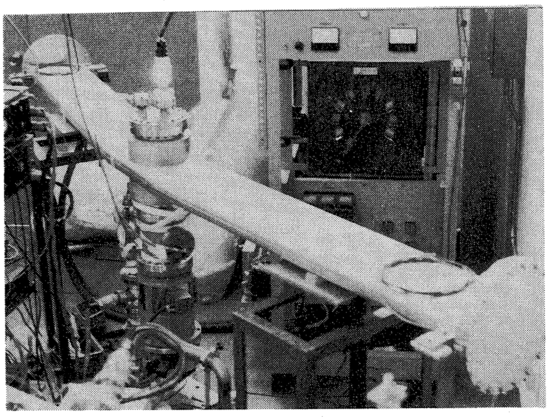


Fig. 5 Picture of Vacuum Chamber

Slow Extraction System

The beam extraction is a very impotant problem in the accelerator. The slow extraxtion system at TARN II is designed using the resonance extraction method. The third integer resonance of Q_{res}=5/3 is considered. The high efficiency extraction of 98% was indicated in the case of the circulating beam with emittance of 120π mm·mrad.

Electron Beam Cooling

The electron beam cooling system with the electron enery of 120 keV and the maximum electon current of 10 amp is developed. The ion beam up to 200 MeV/u is cooled by this device and the cooled ion with the momentum spread of 5 x 10^{-5} are expected.

Acknowledgements

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