DESIGN OF THE SYNCHROTRON IN THE NUMATRON PROJECT

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Abstract

A synchrotron for acceleration of heavy ions up to uranium is designed. The injection energy is 10 MeV per nucleon and the maximum energies are 670 MeV and 1470 MeV per nucleon for uranium and lighter ions than argon, respectively.

1. Introduction

As a final stage of the accelerator complex of the NUMATRON project, a separated-function strong-focusing type synchrotron is designed. The operating rate is determined as 1 Hz in the present design. The operational scheme is shown in fig.1 together with those of the storage ring and the injector linac. The rate can be raised up to several Hz when the number of RF stacking in the storage ring is reduced.

The required vacuum pressure for 80% beam survival is estimated at 10^{-9} Torr for the present operation scheme.

2. Lattice Structure and Magnet System

The synchrotron has a lattice structure of 24 normal cells of FODO and 8 long straight sections. The lengths of dipole and quadrupole magnets are 1.25 m and 0.45 m, respectively. Eight long straight sections of the length of 6.6 m are made by omitting 8 pairs of dipole magnets from 8 normal cells, in order to provide the spaces to install the equipments for the injection, slow and fast ejections and RF acceleration. The mean radius and the circumference of the ring are 33.6 m and 211.2 m, respectively.

The ring has a superperiodicity of 8 and the number of betatron oscillations per revolution,ν, is determined as 6.25 for both horizontal and vertical directions. The value is sufficiently far from any dominant undesired resonances. Calculated beta and dispersion functions are shown in fig.2.

The maximum field of the dipole magnet and the maximum field gradient of the quadrupole magnet are 15.5 kG and 1.19 kG/cm, respectively. The maximum energy of uranium is raised up to 850 MeV per nucleon by excitation of the dipole and quadrupole magnets up to 18 kG and 1.38 kG/cm, respectively. The transition energy of the synchrotron is 4.33 GeV and all the ions are never accelerated through the transition energy.

3. RF Acceleration System

The revolution frequency of the uranium is changed from 0.21 MHz to 1.16 MHz during acceleration. The harmonic number is chosen as 8 and the RF frequency must be changed from 1.65 MHz to 9.24 MHz. For lighter ions than argon, final revolution frequency and RF frequency become 1.31 MHz and 10.49 MHz, respectively. The ratio of frequency change amounts to about 6 times which is larger than usual proton synchrotron. Through previous test of ferrite core, it is found that above swing of the RF frequency would be possible.

The required energy gain is 780 keV per turn for uranium.

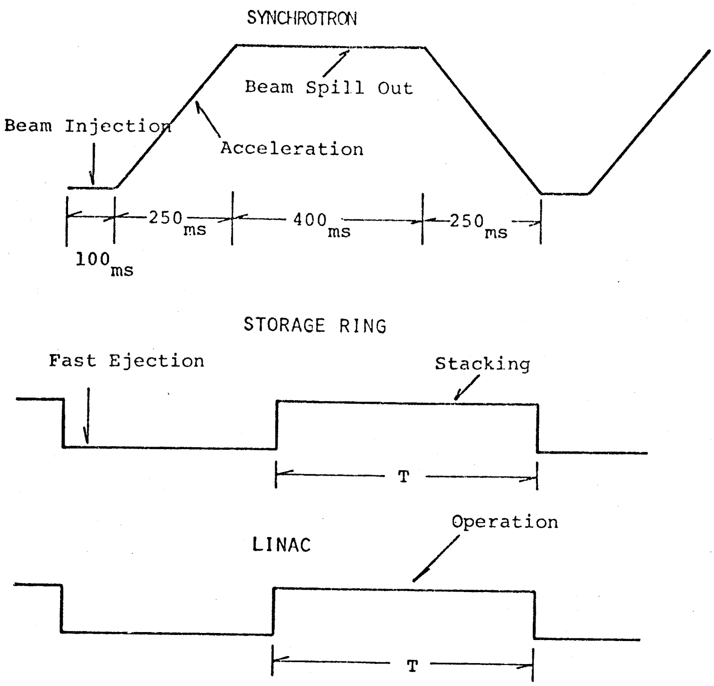

Fig.1. Operational Scheme of Synchrotron, Storage Ring and Linac.

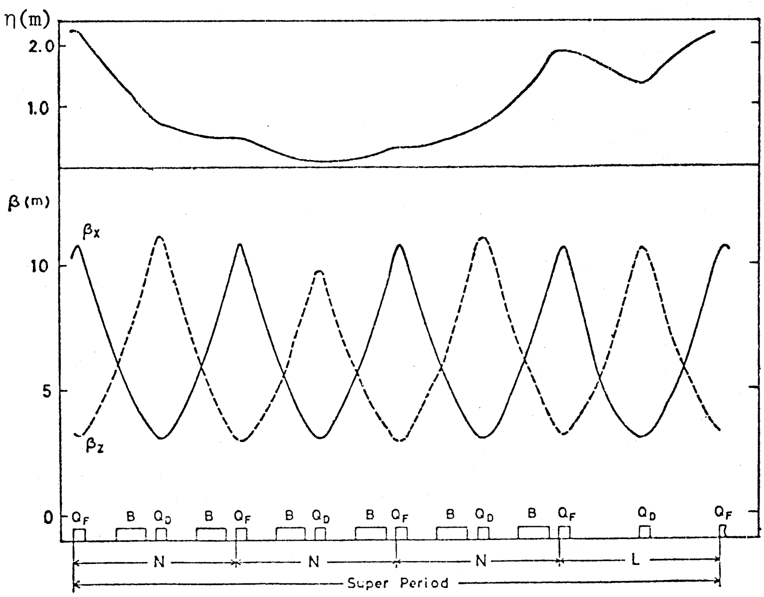

Fig.2. Beta-functions and Dispersion Function in a Superperiod.