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Preliminary Lattice Design for the PEPF Rapid Cycling Synchrotron*

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1. Introduction

The Proton Engineering Frontier Project (PEFP) is a research project to develop a 100 MeV, 20 mA pulsed proton linear accelerator to be used in basic/applied scientific R&D programs and industrial applications [1]. The PEFP proposes the 1-2 GeV Rapid Cycling Synchrotron (RCS) accelerator as an extension of the PEFP linac, which can be used for nuclear and high-energy physics experiment, spallation neutron source, radioisotope, medical research, etc. The spallation neutron source require high power and high current proton beam, but the radioisotope production and medical research facilities need relatively low energy and low current proton beam. The PEFP RCS with the extraction energy 1-2 GeV and injection energy 0.1-0.2 GeV is able to optimally support both the spallation neutron source and radioisotope production and medical research facility. The fast extraction system of PEPF RCS machine can be a spallation neutron source facility and the slow extraction system can be a radioisotope production and medical research facility simultaneously. The PEFP RCS is composed of magnet lattice of main ring, injection system and extraction system. And it initially is a 15 Hz RCS with injection energy 0.1 GeV and the target beam power is about 58 kW at 1.0 GeV at the first stage. In addition, the RCS is designed to have upgrade option of the beam power from 58 kW to 899 kW step by step.

In this paper, the conceptual design of the PEFP RCS for a pulsed proton beam is proposed. A basic lattice design and a conceptual design for the injection system as well as an extraction system are described.

2. Lattice

A basic lattice structure is determined by the disposal of magnets such as dipole, quadrupole, sextupole, etc. And the lattice magnet specifications generally depend on the extraction beam energy. The PEFP RCS machine has a four-fold symmetry. Although the low-order machine symmetry can give a dangerous low-order structure resonance, two or four symmetric lattice structure is usually accepted to ensure the space for other essential facilities [2]. The PEFP RCS has a four super-periodicity and a 20 pseudo-periodicity. The lattice of the straight section as well as the arc section is constituted of simple FODO cells.

Achromatic structure is used at the arc section to obtain a dispersion-free long straight section for establishing the injection and extraction system. Machine tune is 4.39 for x-direction and 4.29 for y-direction, which can avoid the crucial structure resonance. The schematic layout of the PEFP RCS machine is shown in Fig. 1.

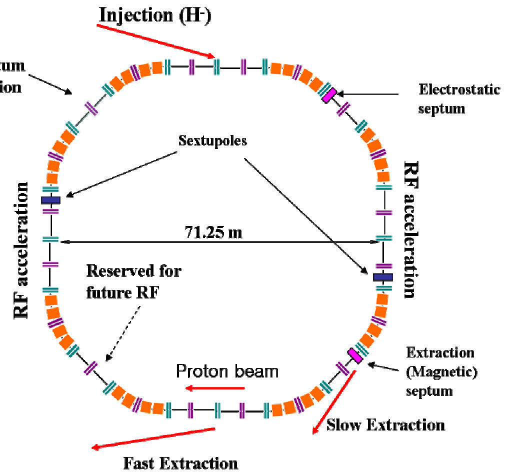

Figure 1. Lattice Layout for the PEFP RCS

Figure 2 shows the betatron functions and dispersion function for a super-period including the arc section of the PEFP RCS. Usually the momentum collimation is accomplished at the center of the arc section because of large momentum dispersions in this area. Crucial parameters regarding the PEFP RCS design are represented in Table 1.

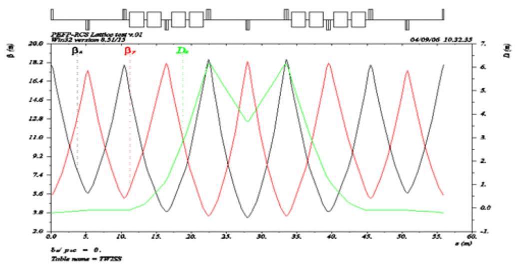

Figure 2. Betatron and dispersion function for a super-period

3. Injection System

The injection system from the linac to main ring is very important part in the entire accelerator system because most of the beam losses occur in this region. The PEFP injection system use the way of a charge exchange multi-turn injection, locate in the dispersion free long straight section. Figure 3 shows the schematic layout of the PEFP injection system and four kicker magnets for the horizontal orbit bump and other four kicker magnets for vertical orbit bump are used.

Table 1. Basic Parameters of the PEFP RCS

Injected particle	H-
Injection energy (GeV)	0.1 ~ 0.2
Extraction energy (GeV)	1 ~ 2
Repetition rate (Hz)	15 ~ 30 ~ 60
Beam power (kW)	58 ~ 899
Admittance (mm.mrad)	560
Beam emittance (mm.mrad)	280
Laslett tune shift	-0.2
Circumference (m)	223.824
Lattice structure	FODO
Super-period	4
Number of cell	20
Machine tune[Qx, Qy]	4.39/4.29
Transition	4.4
Number of dipoles	32
Power supply type	Resonant
RF harmonic	2

The Painting scheme is a correlated painting and the injection protons are about $2.42{*}10^{13}$ for the space charge tune shift -0.2.

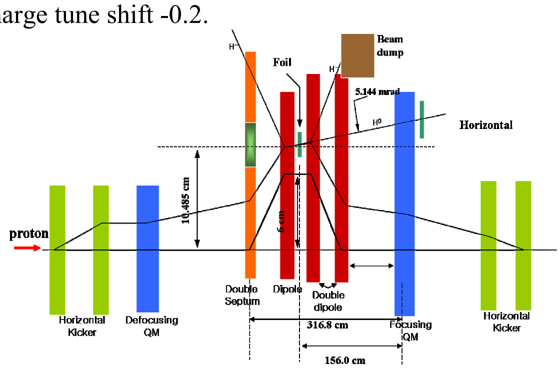

Figure 3. PEFP Injection Layout

4. Extraction System

The PEFP extraction system consists of two different facilities, one is a fast extraction system for the spallation neutron source something and the other one is a slow extraction system for the radioisotope production or the medical application. Figure 4 shows the PEFP fast extraction system which consists of 5-6 kicker magnets and one septum magnet. The required voltage at 2 GeV extraction is 37 kV for each kicker magnet when needed extraction displacement is 82.6 mm at the septum magnet.

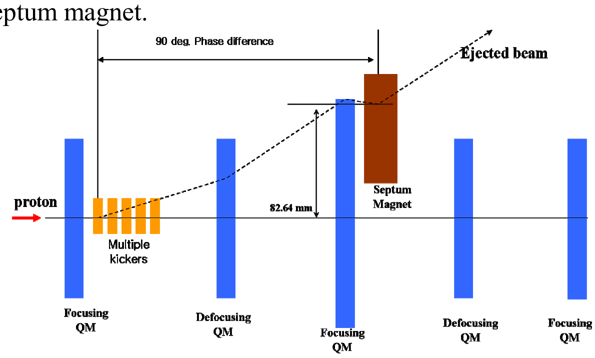

Figure 4. PEFP Fast Extraction System

A slow extraction can be achieved by the resonance which is caused by the closed orbit distortion via quadruole or sextupole errors [3]. The PEFP slow extraction is accomplished by the third order resonances of the sextupole magnet. The conceptual layout is given in Fig. 5. Both the electrostatic septum and the magnetic septum are used to reduce the beam loss at the extraction point. Two sextupole magnets are symmetrically located among the ordinary lattice magnets to control the third order resonance. The extracting beam current can be controlled by tuning the stop band width of the sextupole or by adjusting the tune of the machine.

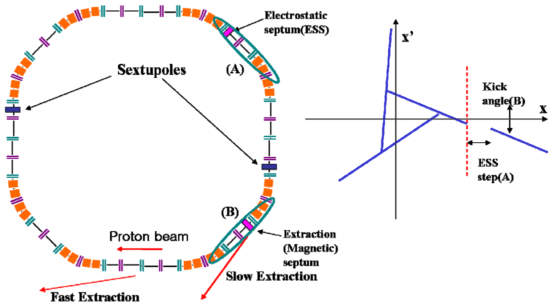

Figure 5. PEFP Slow Extraction : (A) Electrostatic Septum and (B) Magnetic Septum

5. Conclusion

The conceptual design of the Rapid Cycling Synchrotron as an extension of the PEFP linac has been accomplished. The proton accelerator from 0.1-0.2GeV to 1-2GeV has been considered as well as the injection and extraction system. In the initial stage, the target beam power is about 58 kW at 1 GeV extraction. The unique feature of this machine is that it is applicable to the spallation neutron source facility via fast extraction and the medical research as well as the radioisotope production facility via slow extraction, simultaneously.

REFERENCES

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