OPTICAL SCHEME OF AN ELECTROSTATIC STORAGE RING

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Abstract

We consider the optical scheme of an electrostatic storage ring for low energy heavy ions/molecules [1] with special requirements to type of optical functions. Results of calculation are presented.

INTRODUCTION

A small electrostatic storage ring for ions of energies up to 50 keV has been planned and is presently build at the Institut für Kernphysik in Frankfurt (IKF). The advantages of an electrostatic storage ring at low energy as compared to a magnetic ring are obvious, and one of them is the possibility to store different particles without readjustment of the optics. It will allow new methods to analyze complex many-particle systems from atoms to very large biomolecules.

We considered a racetrack shape of storage ring, which allows reducing the size of the machine and makes the ring transportable. This allows to use the storage ring in the future as the central machine of the Frankfurt Ion Storage Experiments (FIRE) at the new Stern-Gerlach Center of Frankfurt University.

RING LATTICE

A racetrack shape design is given in Fig. 1. In comparison to [1], the ring lattice was modified in some details. The machine consists of four superperiods with mirror symmetry. Each superperiod includes two different types of bending elements — parallel plate (PPD) and cylindrical (CD) deflectors — and quadrupole doublet (Q1Q2), singlet (Q3), and one half of triplet (Q4Q5Q4) for transverse focusing of the beam. We tried to keep the sizes of the elements identical (if possible) or closed to parameters described in [1-2]. The choice of the ring lattice was defined by the requirement to provide as high as possible densities of the circulating beam at two experimental points (IP) located in center of the straight section between Q1Q2 and PPD.

Deflecting elements

The 90° bend in the corners of the ring is split up into two elements.

A first 15° angle deflection is done in a parallel plate deflector. Necessary voltages are about ± 6.7 kV per electrode at plate distances of 100 mm.

The main bending of 75° is done in a cylindrical deflector. Necessary voltages are about ± 6.5 kV per electrode at electrode radii 235 and 265 mm.

Quadrupoles

The transverse dimensions of the circulating beam are controlled by electrostatic quadrupoles. All quadrupoles except Q3 are identical to quadrupoles described in [1-2] and are incorporated in four doublets and two triplets. The four quadrupoles Q3 are shorter (half the length of the other quadrupoles).

The electric and mechanic parameters of the machine and its components are summarized in Table I.

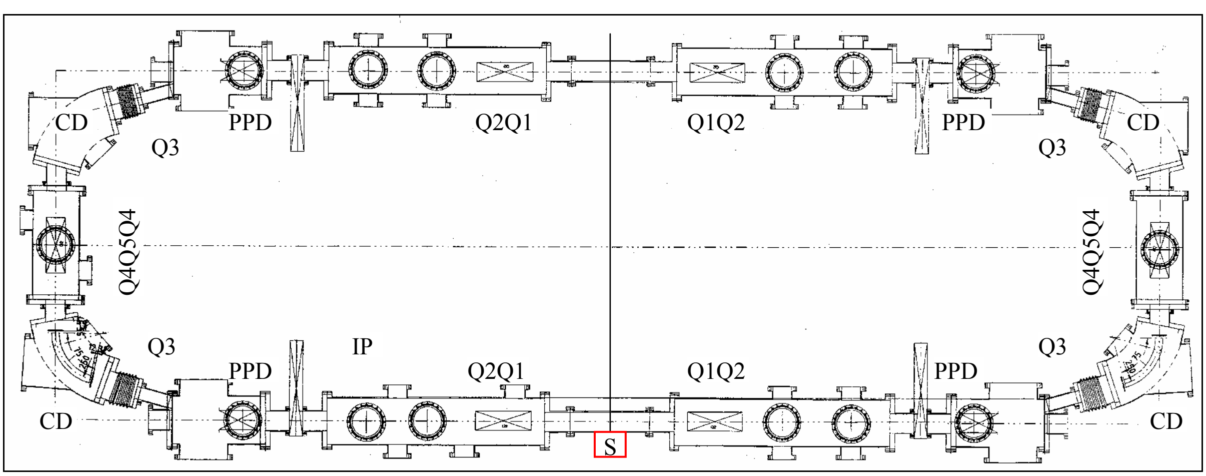

Figure 1. Schematic view of racetrack shaped ring. S is the start point in simulation.

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Table 1: List of Design Parameters

General parameters	
Maximum energy	50 keV
Circumference	14.17 m
15° deflectors	
Plate area	200 mm × 200 mm
Plate distance	100 mm
Voltage	± 6.7 kV
75° deflectors	
Height	100 mm
Radii	235 and 265 mm
Voltage	± 6.5 kV
Quadrupoles Length	50 or 100 mm
Doublets and Triplets	
Distance between lenses	90 mm
Aperture radius	25 mm
Voltage	± 3kV

RESULTS OF SIMULATION

Computer simulations have been performed by the MAD program [1]. The lattice parameters were optimized to achieve maximum beam densities at IP. Electric parameters, positions, number of quadrupoles and lengths of straight sections were varied.

All calculations were made for a beam with an emittance of ε = 30 π mm·mrad and an initial momentum spread of $\Delta p/p = 10^{-3}$.

Results of simulation are shown in Fig. 2 – 5 and Tables 2 – 3.

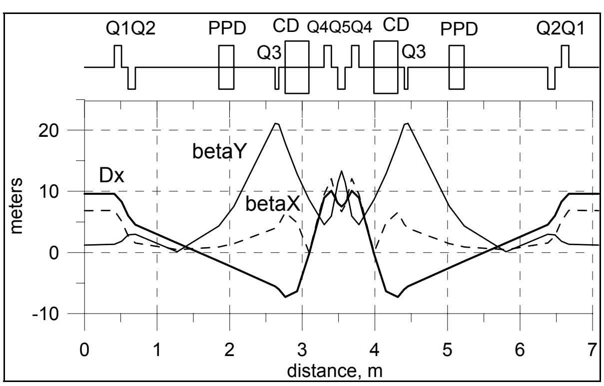

Figure 2: Lattice (above) and lattice functions in one half of ring.

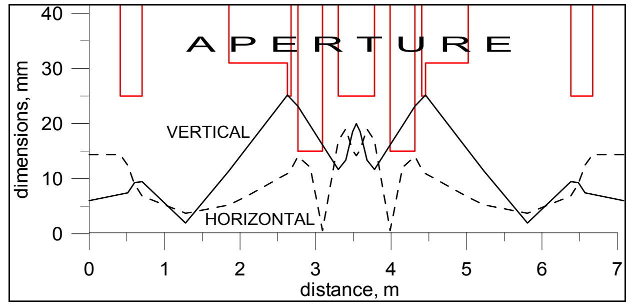

Figure 3: Beam sizes in one half of ring. (ε = 30 π mm·mrad).

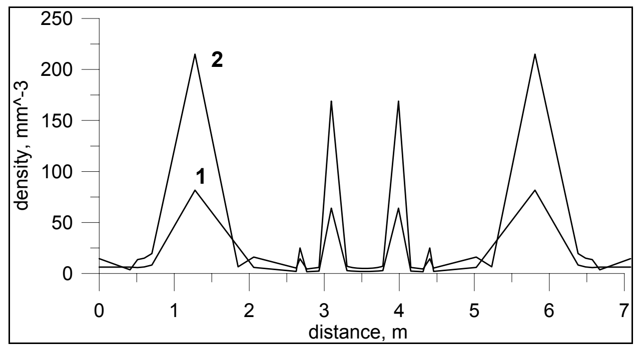

Figure 4: Particle density: 1 – ε = 30 π mm·mrad, 2 – ε = 10 π mm·mrad.

The necessary quadrupole strengths and voltages are given in Table 2.

Table 2: Quadrupole Parameters

Quadrupole	k_1, m^{-2}	Voltage, kV
Q1	2.77E+01	0.87
Q2	-3.96E+01	-1.24
Q3	-3.11E+01	-0.97
Q4	6.62E+01	2.07
Q5	-5.88E+01	-1.84

The calculated tune values and chromatisities are given in Table 3.

Table 3: Tune Values and Chromatisities

parameter	value
Q_x	3.575213
Q_y	2.116166
ξ_x	-23.466907
ξ_y	-13.303916

The working point (WP) is displayed in the tune diagram where resonances up to third order are shown; see Fig. 5.

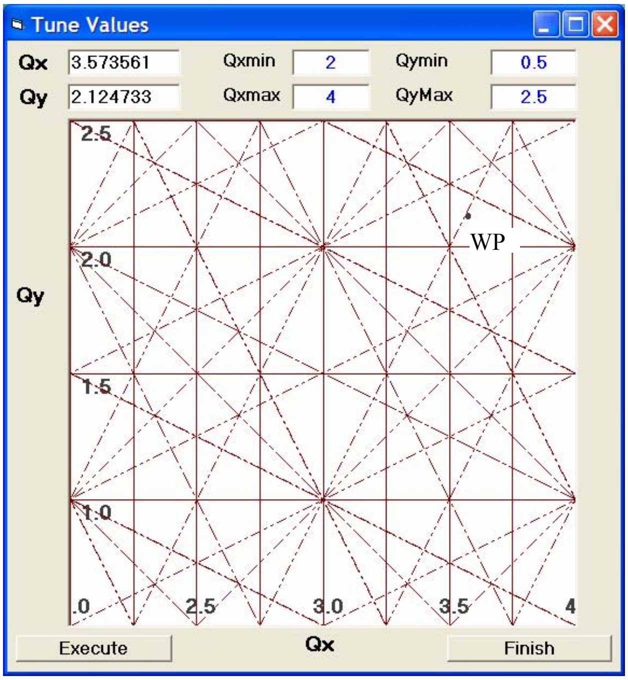

Figure 5: Tune diagram.

REFERENCES

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