LAYOUT OF AN ELECTROSTATIC STORAGE RING*

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Abstract

An electrostatic storage ring can be seen as a cross between an electrostatic trap and magnetic rings. It combines small size, relatively low costs with a high flexibility in terms of the ions that can be stored and beam parameters. From the point of view of particle dynamics important differences to "classical" storage rings are the mass-independence of the fields and a coupling between the different planes of motion. At IAP the design of a small ring for ions of energies up to 50 keV has been made and a quarter ring section is being build up. Different possible geometrical shapes of the machine will be discussed and the corresponding particle dynamics will be shown. Limitations to storage times and envisaged experiments will be presented.

1 INTRODUCTION

The first electrostatic storage ring was build as a tool for molecular science in 1997 [1]. Many kinds of ions of energies around 20 keV have been stored in ELISA since. It could be shown that such a machine has many advantages in comparison to magnetic rings, i.e. small size, low costs and mass-independence of the fields. Due to this mass-independence, injection of all different kinds of ions from light protons to large biomolecules can be done.

Practical restrictions and the needs of the experimentalists reduce the number of possible layouts of an electrostatic storage ring.

At present, two different designs are under discussion at IAP [2]. Figure 1 shows an electrostatic ring of "classical" shape. The size of such a ring will be about 4* 4 meters, with the main space taken by the experimental sections. The advantage of this layout is the high symmetry of the machine and the space for experiments and future extensions.

A racetrack shape design as given in figure 2 reduces the size of the whole machine even further at the cost of a lower symmetric lattice.

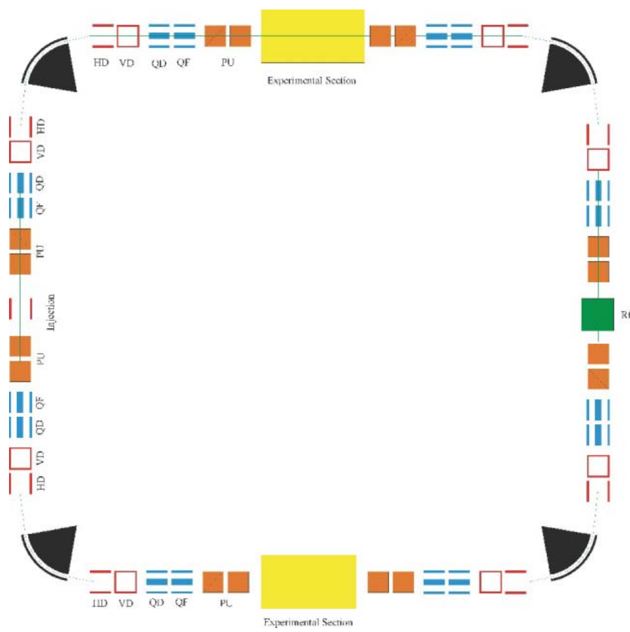

Fig. 1: classical "ring" shape

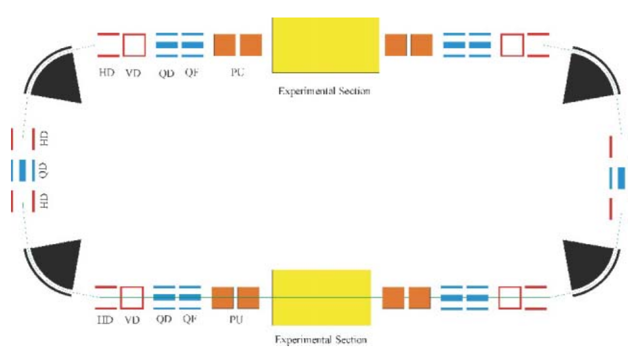

Fig. 2: racetrack shaped ring

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2 OPTICAL ELEMENTS

2.1 Injection

The existing ECR ion source at INP will be used to inject beams of energies up to 50 keV. After energy separation this beam enters the ring at an angle of 10° and will be bend towards the optical axis by a fast electrostatic inflector. A differential pumping system will be used to separate the XHV region in the ring from the source.

2.2 Deflecting elements

In order to guarantee stable operation, the total bend of 90° in the corners had to be split into two 10° parallel plate deflectors, as shown in figure 3, and a 70° bending section with cylindrical electrodes.

In addition, this allows the detection of neutral particles along the straight sections and the injection of electron / laser beams for interaction experiments.

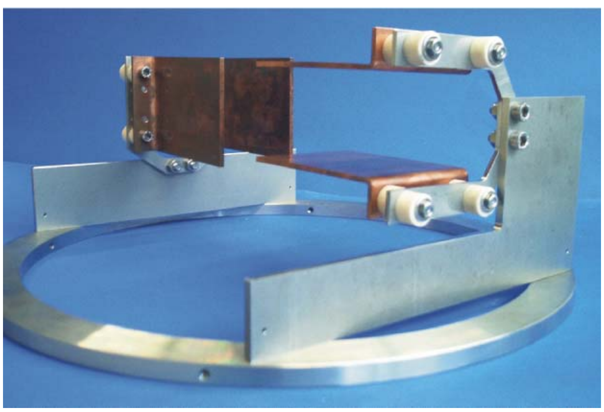

Fig. 3: 10° parallel plate deflector

The vertical deflector will be used for closed orbit correction during operation. Necessary voltages are about ±4.5 kV per electrode at plate distances of 5 cm.

As can be seen in figure 4, the fringe fields of the cylindrical deflector are reduced by grounded shields. The analysis of motion perturbation due to fringe fields is done in [3].

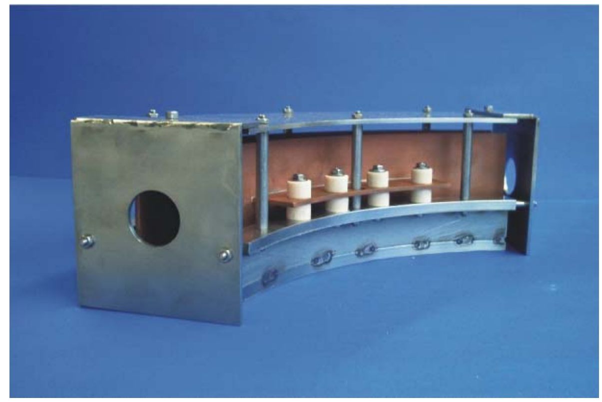

Fig. 4: 70° cylindrical deflector

2.3 Transverse Size

Pairs of electrostatic quadrupoles are used to control the transverse dimensions of the circulating beam. The ideal hyperbolic shape of the electrodes is approximated by cylindrical electrodes of radius $r = 1.1468 \cdot r_{aperture}$.

Fig. 5: 70° electrostatic quadrupole

As shown in figure 6 for protons, these lenses have more effective focussing strengths at low energies then their magnetic counterparts.

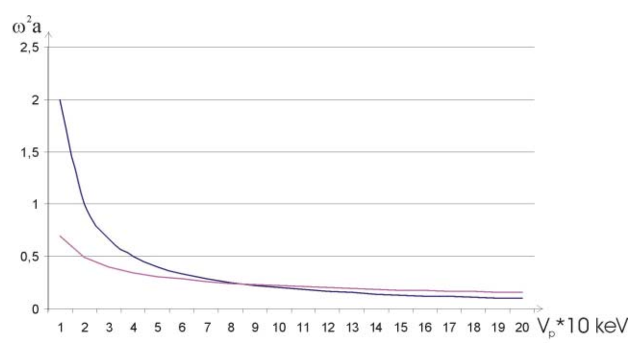

Fig. 6: effective focusing strength of magnetic and electrostatic quadrupoles as function of beam energy

3 VACUUM SYSTEM

The lifetime of the beam mainly depends on the achievable vacuum pressure in the ring. The probability of interaction of the circulating beam with the residual gas should be kept as low as possible. The envisaged final pressure is around 10^{-12} mbar and one of the main reasons why it was decided to first build up a quarter ring section. Besides NEG strips distributed all around the machine, which will do the main pumping, turbo and cryopumps will be used. After activation, this getter material is able to pump most of the gases at very high speeds [4].

4 STATUS

A quarter ring section as shown in figure 7 is being build up in Frankfurt. Size of the whole section is 2*2 meters. It allows studying injection, testing the vacuum components and verifying field calculations.

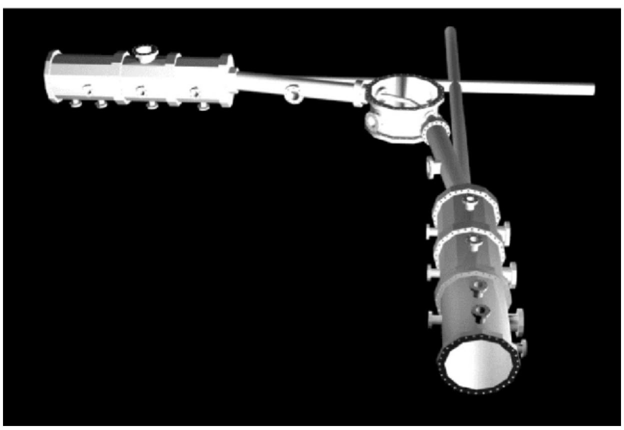

Fig. 7: Overview of the quarter ring section

A compact control system has been developed [5] to be able to record and manipulate all the necessary beam parameters. Furthermore, the online-analysis of data measured with beam position monitors and single particle detectors is possible.

Next steps will be to decide about the final layout and the construction of the whole ring.

Table 1: List of design parameters

General Parameters	
Maximum energy	50 keV
Circumference	17.91 m
Revolution time	3.5 µs (p)
10° deflectors	
Plate area	100 mm x 70 mm
Plate distance	50 mm
Voltage	+/- 4.5 kV
70° deflectors	
Height	70 mm
Radii	235 mm and 265 mm
Voltage	+/- 6 kV
Quadrupoles	
Length	100 mm
Outer Radius of electrodes	29 mm
Voltage	+/- 1 kV

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