ISOCHRONOUS MAGNETOOPTICAL STRUCTURE OF RECIRCULATOR SALO

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Abstract

With goal to provide low energy spread of electron beam the magneto-optical structure of recirculator SALO has been modified. All of its parts (an injection tract and arcs) were made isochronous and achromatic. Besides, with the purpose of the accelerating structure arrangement the length of straight sections were enlarged.

The amplitude and dispersion functions on various recirculator sections and design characteristics of beam are submitted.

INTRODUCTION

With the purpose to minimize the energy spread of accelerated beam and taking into account the improved value of accelerating structure length, which outcome the length of straight sections has increased up to 25 m, the magneto-optical structure (MOS) of SALO recirculator [1] was modified.

ISOCHRONOUS MOS OF SALO RECIRCULATOR

The minimization of the beam energy spread has been reached by isochronicity of all sections of the beam line, since injection beam line and including two sites of beam recirculation.

For realization such structure it was necessary to refuse from uniform distribution of dipole magnets along the sections of the beam rotation on angle 180°. Besides, the straight section opposite accelerating one was made "lenses-free", that allows to make independent focusing of both sites of recirculation.



Figure 1: Recirculator lay-out.

On Fig. 1 the general view of reciculator SALO MOS new version together with injection beam lines is shown.

For injection the magnet b7, included in three magnets bypass (b5, b6, b7), is used. Such a system allows to produce injection of 9.5-MeV beam, bypassing magnet B10 of arc which designed for a field ~1.2 T and has the leakage fields intensive enough. Besides, such injection system allows to regulate smoothly the accelerated beam energy.

On Fig. 2 a, b is submitted the amplitude and dispersion functions for unpolarized beam injection beam line from injector *inj2*. The values of matrix elements R16, R26 and R56, defining achromatism and isochronism of injection beam line, are, respectively, $-1.63*10^{-3}$ m⁻¹, $7.3*10^{-4}$, $2*10^{-4}$ m⁻¹.





On Fig. 3 a, b are submitted the same functions for polarized beam injection beam line from injector *inj1*. The values of matrix elements R16, R26 and R56 are, respectively, $-3.4*10^{-4}$ m⁻¹, $2.5*10^{-3}$, 10^{-3} m⁻¹.



On Fig. 4 a, b are submitted the amplitude and dispersion functions for the first recirculating arc for the beam with energy 249.5 MeV. Since in SALO

recirculator the beam trajectories are placed in the same plane the bending magnets B1, B5, B6, B10 are, respectively, the spreaders and recombiners. Each magnet turns the beam with energy 249.5 MeV on the angle 36° . The values of matrix elements R16, R26 and R56 for this beam line are $6.5*10^{-4}$ m⁻¹, $6*10^{-4}$, $-8*10^{-5}$ m⁻¹ respectively. Magnitudes of the frequency dispersion dcosµ_x and dcosµ_y are equal accordingly-22.541,-13.874, that specifies a good stability of amplitude functions to energy variations.



On Fig. 5 a, b are submitted the amplitude and dispersion functions for the second recirculating arc for the beam with energy 489.5 MeV. Each of basic magnets (ten pieces) turns the beam on an angle 31.07° . The values of matrix elements R16, R26 and R56 for this beam line are $1.25 \times 10^{-3} \text{ m}^{-1}$, -5.3×10^{-4} , $-0.68 \times 10^{-5} \text{ m}^{-1}$ respectively. The magnitudes $d\cos\mu_x$ and $d\cos\mu_y$ are equal accordingly ~26 and ~-36.



In Table 1 the main parameters of recirculator SALO magnetic elements, obtained as a result of MOS optimization are submitted.

Table 1: Parameters of magnetic elements

| a. Dipole magnets b1,b2,b5,b7 | |
|-------------------------------|-------|
| Pole size, cm ² | 10×12 |
| Gap height, mm | 25 |
| Magnetic field, T | 0.15 |
| b. Dipole magnets b3,b4,b6 | |
| Pole size, cm ² | 10×12 |
| Gap height, mm | 25 |
| Magnetic field, T | 0.3 |
| c. Dipole magnets B1 –10 | |
| Pole size, cm ² | 10×48 |
| Gap height, mm | 25 |
| Magnetic field, T | 1.1 |

| d. Dipole magnets B11 –20 | | |
|---|-------|--|
| Pole size, cm ² | 61×12 | |
| Gap height, mm | 25 | |
| Magnetic field, T | 1.25 | |
| e. Quadrupole lenses q1 – q18 | | |
| Length, cm | 10 | |
| Aperture Ø, mm | 50 | |
| Maximum gradient, T/m | 6 | |
| f. Quadrupole lenses Q1 –16, Q19 –26, Q29 –32 | | |
| Length, cm | 30 | |
| Aperture Ø, mm | 50 | |
| Maximum gradient, T/m | 15 | |
| g. Quadrupole lenses Q17, Q18, Q27, Q28 | | |
| Length, cm | 15 | |
| Aperture Ø, mm | 50 | |
| Maximum gradient, T/m | 15 | |

With use of TRANSPORT code at initial energy spread in beam 0.1 % and a longitudinal size 0.082 cm the energy spread for a beam with energy 249.5, 489.5 and 729.5 MeV has been calculated. The values of relative energy spread are accordingly $6.5*10^{-5}$, $3*10^{-5}$, $2*10^{-5}$ for each energy. The maximum values of enveloping are $\sigma_x \approx 0.3$ cm, $\sigma_x \approx 0.65$ cm.

CONCLUSION

The offered isochronous MOS of SALO recirculator is optimized both by an amount of quadrupole lenses, and on their positions. It has allowed to reduce, at rather moderate quadrupole lenses gradients, not only resulting energy spread, but also the enveloping of beam circulating.

REFERENCES

[1] A.N. Dovbnya, I.S. Guk, S.G. Kononenko, F.A. Peev, M. van der Wiel, J.I.M. Botman, A.S. Tarasenko, "Magnetic structure of the NSC KIPT nuclear-and-high-energy-physics electron accelerator" Proceedings of EPAC 2004, Lucerne, July 2004, p.761.