The Synchrotron Light Source ROSY

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Abstract:

ROSY, a 3rd generation synchrotron radiation source, has been proposed to be built at the Research Center Rossendorf in the region Dresden of the country Saxony in Germany. ROSY will be dedicated to material research and industrial application. The critical wavelength of the synchrotron radiation spectrum has to be 0.15 nm corresponding to a critical photon energy of 8.4 keV. Electrons with an energy of 3 GeV deflected in a 1.4 T bending magnet provide this spectrum. It is proposed to use a "Modified Multiple Bend Achromat (MBA)" lattice in order to get a compact machine as well as a low emittance. For 3 GeV an emittance smaller than 30 nm rad can be obtained. With a fourfold symmetry and two larger straight sections within the achromatic arcs the circumference is 148.1 m. 23% of the circumference can be used for installing insertion devices. The natural chromaticies and the compensating sextupole strengths are moderate, the dynamic aperture as well as the momentum acceptance are sufficient.

I. INTRODUCTION

In the region Dresden of Germany exists a concentration of institutes and universities working in the field of material research, solid state- and surface physics. All these institutes require a synchrotron radiation source for analytical purposes. The Research Center Rossendorf as the biggest of these institutes will use the synchrotron radiation source in material research related to ion beam techniques as well as in radiochemistry, nuclear physics, biomedical- and radiopharmaceutical research [1]. The Institute of Solid State and Material Research as well as the Institute of Polymer Research, both located in Dresden, cover a wide field of applications too. The Fraunhofer Society runs establishments with active among others in the fields of layer technology, ceramics, sintered materials powder metallurgy, electron beam- and plasma technology. Beside all this activities in Saxony research institutes in Poland and Czechia are also interested in using the light source ROSY [2]. According to the demands of the research fields mentioned above ROSY should emit synchrotron light in the energy region between 5 and 18 keV with a high brilliance. The emittance should be small and the design of the source must have enough space for installing insertion devices. In short, ROSY has to be a 3rd generation light source.

II. LATTICE

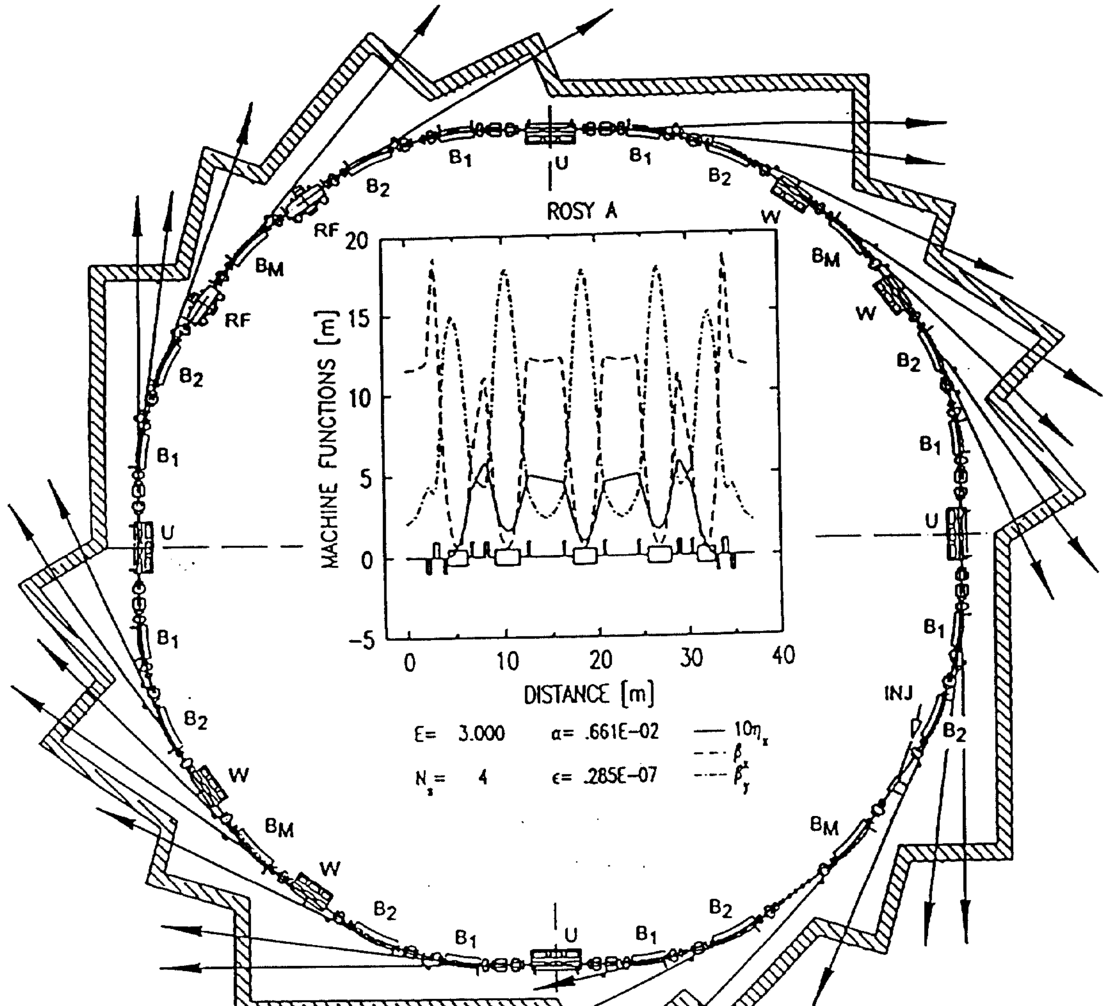
As lattices for SR-sources the FODO-, DBA- and TBA- structures are well known and discussed in many papers [3 - 7]. Substantially different is the behaviour of a modified QBA-structure [8]. One gets with this lattice a low emittance as well as a smaller circumference. The idea of the *Modified QBA-Optics* has been adopted for ROSY.

The achromat (Figure 1) contains three bending magnets named B_2 and B_M, respectively with a deflection angle of 20 degrees as well as two bending magnets (B1) with 15 degrees. The bending magnets are also vertically focusing in order to built a compact machine and to obtain a minimum of the β_x and η_x functions within the magnets. This minimum of both twiss functions results in an optimized emittance. Due to the gradient in the bending magnets the emittance will be further reduced, because the partition function J_x is larger than one. With this lattice one gets for a 3 GeV machine and a circumference of 148 m an emittance of less than 30 π nm rad. The cross section of the beam in the middle of the bending magnets is roughly a circle with a radius of 200 μm.

ROSY has a fourfold symmetrie (Figure 1) with 4.1 m long straight sections. The dispersion function in this four regions is zero in order to obtain a high brilliance from the insertion devices. To reduce the influence of wigglers and undulators on the behaviour of the lattice the β_y functions have been fitted to small values. Within the arc of the achromat there are two more straight sections with a length of 3.5 m. Four of the eight straight sections are used for the injection, the rf-cavities and the beam diagnostics. The four other sections within the arc can be used for insertion devices. Because of their non-vanishing dispersion function the brilliance is here smaller than in the 4.1 m long straight sections. They are useful for many experiments wherever the photon flux is important. The β_y function has a minimum in this region and reduces the influence of the wigglers. The main parameters of the storage ring ROSY are given in Table 1.

III. DYNAMICAL APERTURE

With respect to the dynamical aperture a lot of working points have been investigated. It is possible to run ROSY in the region $7.5 \leq Q_x \leq 9.2$ and $3.0 \leq Q_y \leq 5.5$.



B_1: bending magnet, deflection angle 15 °
B_2/B_M: bending magnet, deflection angle 20 °

W: Wiggler, λ_u= 12 cm, k_{max}=12.33, B_{max}=1.1
U: Undulator, λ_u=5.2 cm, k_{max}=2.24, B_{max}= 0.46

Fig.1: Layout of the 3rd Generation Synchrotron Light Source ROSY including the Lattice and Twiss Functions within one Achromat

Tab. 1: Main Parameters of the Light Source ROSY

Critical Energy of S.R.	E_c	8.4 keV
Critical Wavelength	λ_c	0.15 nm
Energy of Electrons	E_o	3.0 GeV
Electron Current	I_o	0.1 (0.25)* A
Nat. Emittance	ε_{nat}	28.6 π mm mrad
Beam Life Time	τ_b	$\geq$ 6 hrs.
Lattice Structure	Modified MBA	
Circumference	U	148.1 m
Periodicy of the Lattice		4
Natural Energy Width		0.1 %
Momentum Compaction	α	7.2 10^{-3}
Radio Frequency	f	352 MHz
Working Points	Q_X/Q_Y	8.84/4.75
Nat. Chromaticy	ξ_x/ξ_y	-18.5/-11.1
Number of Dipoles 15°/20°		8 / 12
Radius of Curvature on Orbit	ρ_o	7.148 m
Magnetic Field on Orbit	B_{max}	1.4 T
Gradient in the Dipoles		2.018 T/m

Number of Quadrupoles (QP)		
0.28/0.4/0.6 m		24/24/8
Max. Gradient in QP		20 T/m
QP-Strength	K	2 m^{-2}
Number of Sextupoles (SP) 0.1m		56
Diff. Gradient	G′	262 T/m^2
SP-Strength	M	35 m^{-3}
Injector		LINAC
Injection Energy	E_{inj}	800 MeV
Pulse Current	$I_{inj(p)}$	10 mA
Pulse Repetition Rate		10 Hz
Places for Insertion Devices		8
(23 % of the total Circumference)		
Length of Straight Sections		4.1/3.6

(*in a future phase of ROSY is planned, to store 250 mA electrons)

The favorite working points are Q_x=5.13 / Q_y=8.72 and Q_x=8.84 / Q_y= 4.75. The dynamic aperture for the tune Q_x=8.84 and Q_y=4.75 are given in figure 2. These calculations have been done with four wigglers in the straight sections and four undulators in the arcs. The code used was RACETRACK [9]. The dynamical aperture with X≥60 mm (≥120 σ_x) and Y≥15 mm (≥190 σ_y) gives enough space for the injection and a long beam life time.

IV. COMPONENTS OF ROSY

For the time being a lot of 3rd generation light sources have been built. ROSY takes adventage of this fact and most of the components for ROSY will be copied or modified using the experiences and cooperations of other laboratories.

The basic design of the bending magnets and the quadrupoles is that one of ELETTRA, only the pole shape will be redesigned in order to obtain the gradient desired. For the sextupoles we intent to use the ESRF design because of its additional steerer function.

A comparison between well established rf-systems (ALS, LEP/ESRF, ELETTRA,DORIS,PETRA) led to the choice of two LEP cavities [10] because of the lowest power consumption at the required parameters (cavity peak voltage of 3450 kV ,quantum lifetime 10 hrs., beam power 118 kW /295 kW respectively at I_e=0.1A/0.25A).

As the basic concept for the control system is to be proposed a distributed control system with four network layers. Further details can be seen in [11].

The vacuum system is designed in a close cooperation with DESY.We intent to use the HERA profile for the vacuum chambers.

V. ACKNOWLEDGEMENTS

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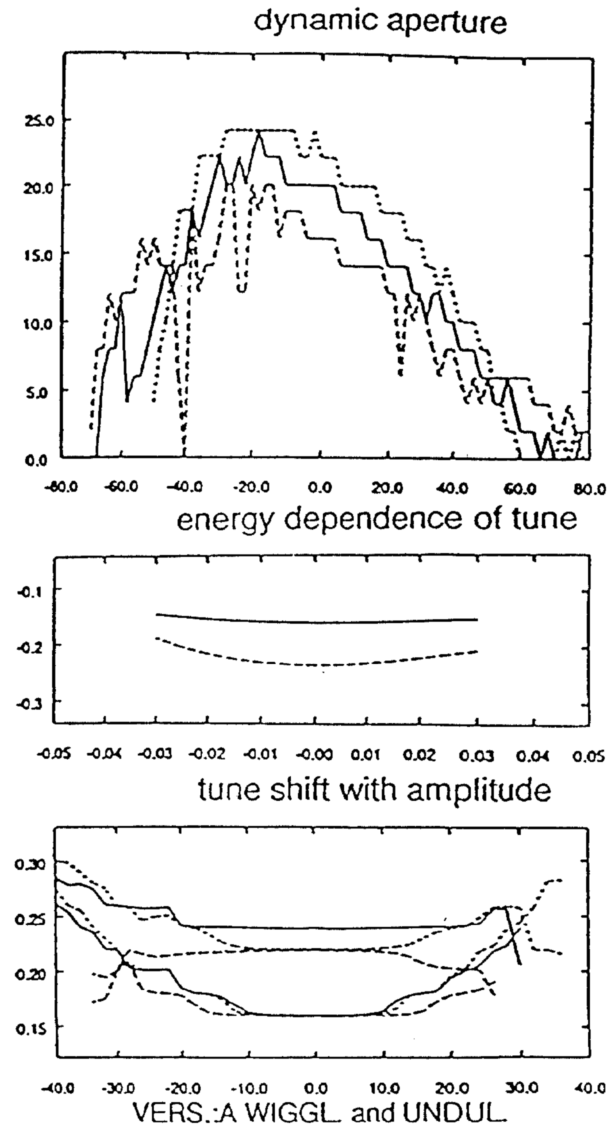

Fig 2: Dynamic Aperture and Tune Shift with Momentum as well as Amplitude for ROSY. Solid line: Δp/p: 0, Dotted line: Δp/p: +2%, Dashed line: Δp/p:-2%

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