THE PROJECT OF A MULTIFUNCTIONAL ACCELERATOR - STORAGE RING COMPLEX

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Abstract

The project of the multifunctional accelerator - storage ring complex with electron energy of up to 2 GeV is described. The structure of the complex was chosen with due account of the existing equipment, buildings, and infrastructure of the 2 GeV electron linear accelerator, the necessity of obtaining precise parameters of photon and electron beams, and the last but not least economic efficiency. The principal parameters of the storage ring are the circumference 91 m, the energy range 0.3 - 2.0 GeV, the natural beam emittance 25 nm and the stored beam current 0.5 A. This complex will be provide photon beams (6-7 lines at first stage, up to 20 later on) and CW electron beams (energy region 0.3 - 0.5 GeV) for scientific and industrial application.

1 DESIGN PHYLOSOPHY

Much interesting results were obtained during last decades in experimental studies of electromagnetic structure of nucleons and nuclei, that have been carried out at Kharkov 2 GeV linac, commissioned in 1965. At present time the possibilities for using this accelerator in fundamental or applied physics investigations are exhausted and some steps were taken for its upgrading. In late eighties the design project of pulse stretcher ring PSR-2000 [1] was developed that was also considered to operate in beam storage mode as synchrotron light source (SLS) [2]. The project was rather expensive, incorporated a large extent of civil engineering, and so it was not financed. Design goal of proposed upgrading is to develop the new accelerator ring facility in the existing experimental building incorporating 2 GeV linac as injector for production high quality SR beam for scientific and industrial applications and CW electron beam for nuclear research.

In order to combine both operating modes in one facility one needs to solve a number of problems. To obtain high quality photon beams one has to secure high beam oscillation damping in the ring. It provides a low natural emittance and a high spectral brightness of the SLS. On the other hand for producing CW electron beam by resonance extraction from the ring on has to minimize oscillation damping in the extraction plane in order to make this extraction method feasible. It is possible to combine these two operating modes in one ring if the peak energy of the stored beam in SLS operating mode is much higher the beam energy in PSR operating mode. Another problem is related to the necessity of using large-aperture magnets in PSR mode that increases the cost of ring. This problem can be alleviated by proper choice of magnetic lattice: if the lattice is optimized so as to obtain the minimal value of natural beam emittance then the radial amplitude function β_x in arcs is rather low and increasing of beam aperture relatively to its value in SLS mode will be reasonable

2 LATTICE STRUCTURE

The layout of the proposed storage ring facility, that meets the requirements mentioned above, is depicted in fig. 1. The main parameters of the ring are listed in table 1. The storage ring will be constructed in the existing experimental area that houses two magnetic spectrometers (SP-103 hall). It practically excludes expenses on civil engineering at first stage of upgrading so significantly reducing construction cost. Hall dimensions allowed to squeeze the ring with circumference of 91 m and peak beam energy of 2 GeV into existing building.

The ring represents the racetrack with two superperiods. Injection and extraction take place in one of the long straight sections. Other three straight sections accommodate RF-cavities, wiggler and undulator. Electron beam with energy of 500 MeV will be injected into the ring from the linac and in SLS mode the beam energy will be adiabatically raised up to 2 GeV. Straight sections are matched to arcs with triplets of quadrupole lenses. The accommodation of the radial defocusing quadrupole lense to arc lattice gives an opportunity to change operating modes. Fig. 2 shows the lattice and optic functions of the ring (one superperiod) in SLS operating mode.

2.1. Beam emittance

The choice of arc structure was strongly restricted by the perimeter dimensions of the existing building area. We optimized the arc structure and parameters under these restrictions in order to obtain the minimal value of natural beam emittance. As a result of these studies we have 5 dipole magnets in each arc: 3 of them have a bending angle of 22.5° and two end magnets of the arc have a bending angle of 11.25°. This arc structure allows to attain the natural beam emittance of 25 nm at maximal stored beam energy. In figure 3 a comparison is presented between the proposed facility (SLS mode) and the dedicated SLS SOLEIL which is under design in France [3].

2.2. Dynamic aperture

The low grade of ring symmetry (N=2) gives rise to a rich spectrum of disturbance harmonics that complicates the task of achieving a high dynamic aperture. Computer simulations for both operating modes show that after corrections being applied with help of sextupole lenses, located in long straight sections the dynamic aperture exceeds the physical aperture. It should be mentioned that the dynamic aperture in PSR operating mode is larger then that in SLS mode, it being the result of betatrone tunes changing.

2.3. Slow extraction

For slow beam extraction from the ring it is proposed to use the half integer resonance $2Q_x=13$. Phase relations in the injection-extraction region for this extraction mode allow extracted the beam without losses on injection elements. The maximal energy of the extracted beam is equal to the maximal injection energy.

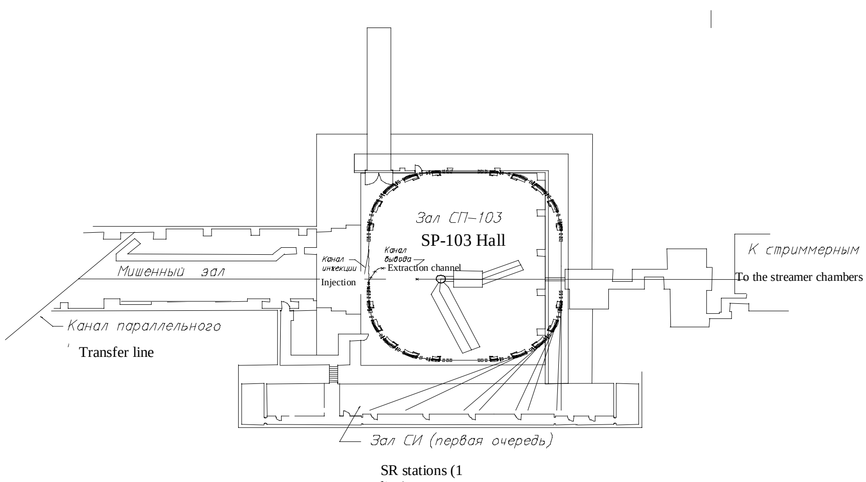

Fig. 1. The storage ring layout in the experimental hall SP-103.

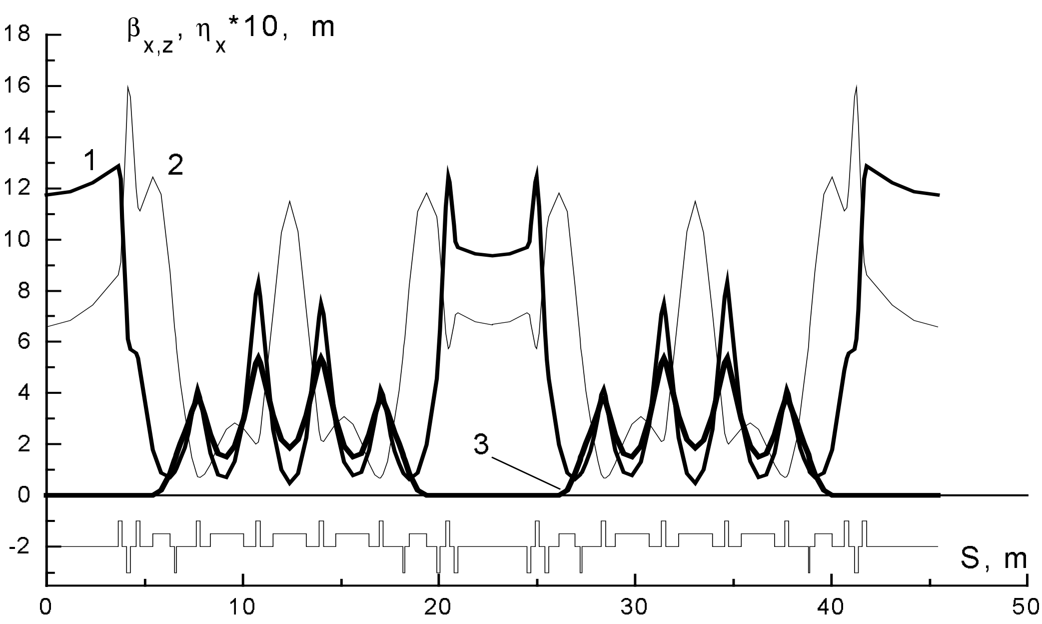

Fig. 2. Lattice functions β_x - (1), β_z - (2) and $\eta_x \cdot 10$ - (3) the proposed ring in SLS operating mode.

Table 1.Main ring parameters for two operating modes

Parameter	SLS mode	PSR mode
Injection beam energy, GeV	0.3-0.5	0.3-0.5
Peak beam energy, GeV	2	0.5
Natural emittance, nm	25	
Circumference, m	90.88	
Bending magnet length, m	0.854, 1.708	
Bend radius, m	4.351	
Dipole field (at peak energy), T	1.53	0.38
Magnet field index	11.5	
Betatrone tunes		
horizontal Q_x	7.20	6.46
vertical Q_z	4.26	4.40
Natural chromaticity		
horizontal ζ_X	-12.3	-10.8
vertical ζ_Z	-7.9	-8.7
RF - voltage, MV	1.6	0.2
RF - frequency, MHz	699.3	
Harmonic number	212	
Momentum compaction factor	0.011	0.017

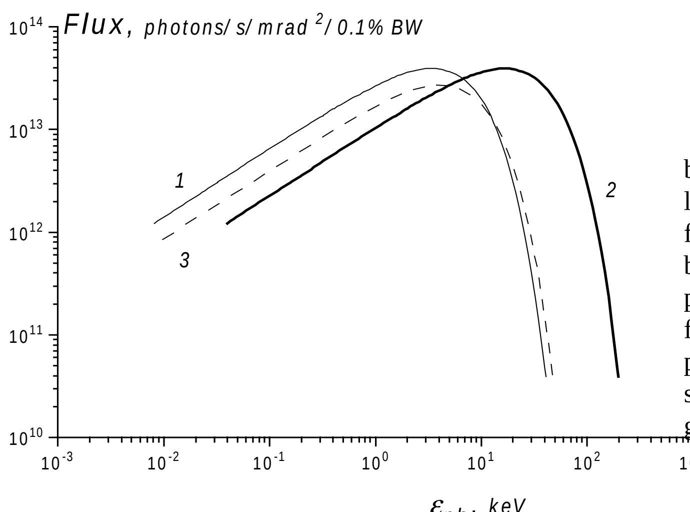

Fig. 3. Spectral flux of SR from:
1 - bending magnet (this project)
2 - 7T-wiggler (this project)
3 - bending magnet (SOLEIL)

3 CONCLUSION AND FUTURE DEVELOPMENT

Construction of the storage ring in the existing building previously used for experiments at 2 GeV linac will allow to develop the new experimental facility for production of SR beams and CW electron beam of high quality. For the time being the design project is under development and a technological area for fabrication of basic ring components is at stage of preparation (Much efforts are applied to get financial support both from national government and non-government organizations.)

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