Status of the High Brilliance Synchrotron Radiation Source BESSY II[+]

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1 Abstract

BESSY II, presently under construction at Berlin-Adlershof, is a low emittance high brilliance 3rd generation synchrotron radiation light source. After successful prototyping of machine elements series production of components was approved for the storage ring. The injector system has been prepared for installation in mid 1996, and first beam from the injector synchrotron is scheduled for the 2nd quarter of 1997. This paper describes the status of the project.

2 Introduction

The site of the Wissenschafts- und Wirtschaftsstandort Berlin-Adlershof (WISTA) is developing into a major scientific, technical and industrial center. With already existing institutes, plans to move the natural science departments of the Humboldt University on site are in progress. High tech industries nearby provide a challenging opportunity for basic researchers and industrial applicants to make use of synchrotron radiation as a versatile tool for R&D.

BESSY II is a 1.7/1.9 GeV synchrotron radiation source in the vacuum ultraviolett to soft X-ray regime. A 240 m circumference 6 nm·rad double-bend-achromate structure (DBA) of 8-fold symmetry was chosen for the storage ring [1]. Full energy injection is adopted using a fast-cycling 10 Hz synchrotron.

The storage ring offers 16 straight sections of alternating low (1 m) and high (18 m) horizontal beta functions. There is space for insertion devices (IDs) of 4.7 and 3.9 m length, respectively. Up to 14 IDs as undulators, wigglers and super-conducting wave length shifters (WLS) will be installed. Six undulators and two WLS are scheduled to be operational soon after commissioning of the storage ring. The status of IDs is reported in [2].

The brilliance obtained from the light source reaches from $3 \cdot 10^{14}$ [photons/sec·(mm·mrad)^2 0.1% BW] at the dipole beam lines to $3 \cdot 10^{18}$ [photons/sec·(mm·mrad)^2 0.1% BW] at U41 presently under construction, Fig. 1.

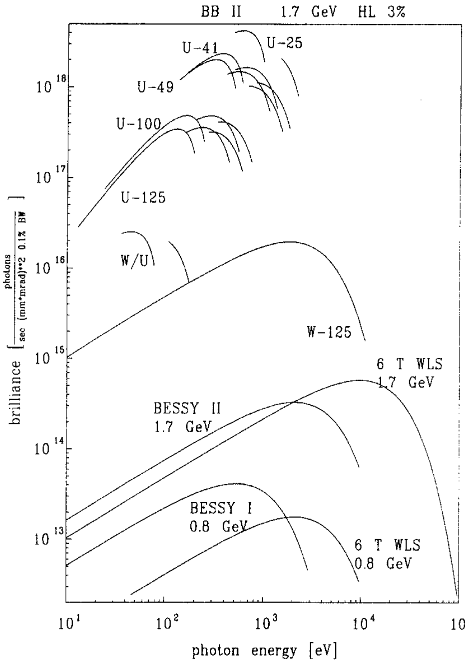

Fig. 1: Undulator tuning curves and averaged wiggler spectra of proposed insertion devices of a 100 mA 1.7 GeV electron beam

3 Conventional Buildings

Construction of a 120 m diameter experimental hall with a laboratory and office extension started in late1994. Shown in Fig. 2, the 12,000 sqm area building is now nearing

Fig. 2: Aerial view of the BESSY II facility

+ Funded by the Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF) and the Land Berlin

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completion. Due to the high sensitivity to vibrations and relative displacement of machine and experiments, the storage ring and the experimental area share a monolitic, strongly steel reinforced concrete floor of 0.6 m in thickness. The synchrotron as well as the technical equipment are mounted on a decoupled own foundation. Infrastructure with potential sources of vibrations is located in a separate building.

4 Injectors

For injection into the storage ring a full energy fast-cycling synchrotron fed by a 50 MeV race-track microton as the preinjector is presently set up [3].

After an upgrade program, the commercially built microtron has delivered pulses of 15 mA at a pulse length of 1 ms and a repetition rate of 10 Hz in routine operation. A 500 MHz prebuncher will lead to a further increase of beam current. The 10 Hz fast-cycling separated-function synchrotron is composed of 16 FODO cells. All magnetic elements of a cell are mounted on a common girder. After delivery and inspection of the magnets, the 0.3 mm thin-walled vacuum-chambers were installed into the magnets which now are waiting for installation in the tunnel scheduled in July. Commissioning of the synchrotron and first beam at full energy are expected for the 2^{nd} quarter 1997.

5 Storage Ring

5.1 Magnetic Elements

The DBA lattice of the storage ring consists of 32 C-shaped box-type dipole magnets, 144 figure-of-eight quadrupoles and 112 sextupoles. All lenses make use of exchangable inserts from soft magnetic iron at the magnets' symmetry plane. These spacers of nine different geometries are mounted between the upper and lower halves of lenses giving space for the beamline front ends to penetrate the return yokes.

Prototypes (e.g. 1 dipole, 3 types of quadrupole and 2 types of sextupole magnets) have been built prior to approval of series production. Detailed magnetic measurements [4] show that the magnets behave as expected. Chamfers at the pole ends were determined experimentally to achieve inhomogeneities of integrated quadrupole and sextupole fields $< 5\cdot10^{-4}$ and $< 1\cdot10^{-3,}$ respectively, in the useful aperture defined by a radius of r = 30 mm.

The dipole magnets are designed for a field of 1.3 T at 1.7 GeV, giving a critical energy of 2.5 keV to the photons. Since dipole radiation will be used as a radiometric standard, an inhomogeneity $\Delta B/B$ of $< 2\cdot10^{-4}$ is required at the source points of the bending magnets.

The quadrupoles (max. gradient 16.5 T/m) are equipped with trim coils which allow each magnet's focussing strength to be changed individually. The beta functions at any magnet position could then be determined independently. Fig. 3 shows the first batch of 33 quads recently delivered undergoing magnetic tests.

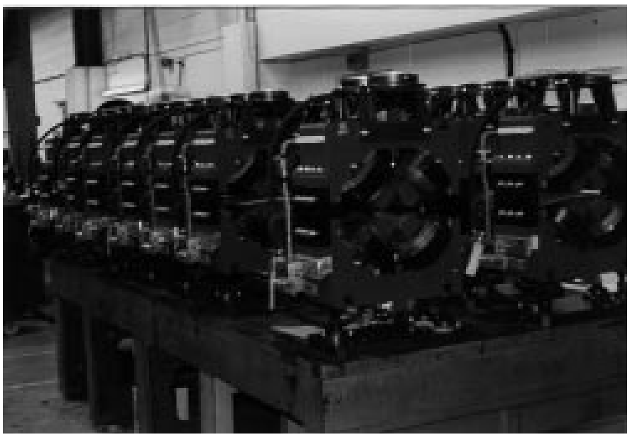

Fig. 3: Photo of the first storage ring series quadrupole magnets

The 16 achromats are densely packed with elements. Combined sextupole and steering fields had to be adopted rather than using lumped dipole correctors. In spite of a sextupole constant of S = 600 T/m^2, each sextupole is equipped with two additional coils per pole. This coil arrangement produces horizontal and vertical dipole fields allowing for a maximum kick of 3 mrad at full beam energy. This way 112 horizontal and vertical correctors can be realized, of which five horizontal and four vertical dipoles will be activated in the correction scheme.

5.2 Vacuum System

The storage ring vacuum system is designed to operate a 500 mA 1.9 GeV beam current at a mean vacuum pressure of $P < 2\cdot10^{-9}$ mbar which will ensure a beam lifetime of $\tau > 6$h.

In the arcs all chambers are made from AISI 316LN stainless steel. Crotch absorbers are mounted at the exit of the dipole chambers to cope with the linear synchrotron radiation power of up to 100 W/cm. In the straight sections, the chambers are subjected to a synchrotron radiation power of 1 - 20 W/cm, therefore OFHC-copper absorbers are explosion bonded to the chamber wall. At the location of the absorbers, the wall thickness of the stainless steel is 1 mm. By indirectly cooling, the surface temperature of the absorber is reduced to 40^{o} C instead of 120^{o} C as with a pure stainless steel surface.

The beam pipe is of eliptical cross section with major axes 32.5 and 17.5 mm, thus the conductance of the straight chambers is limited to $C \cong 13$ l/s m. 160 lumped sputter ion pumps (SIP) are distributed in the arcs, three in each straight section. At the location of crotch absorbers additional 500 l/s SIPs are placed directly underneath the crotch. Nonmagnetic NEG modules will be located at the 32 dipole chambers. The total pumping speed installed in the ring is 28800 l/s.

The complete machine vacuum system will be equipped with heating jackets for a controlled 200^{o} C in-situ bake-out.

Figure 4 shows a full scale prototype section that was used to study dynamical behavior of the components, especially mechanical hysteresis of chambers and beam position monitors (BPMs) during bake out and pumping down.

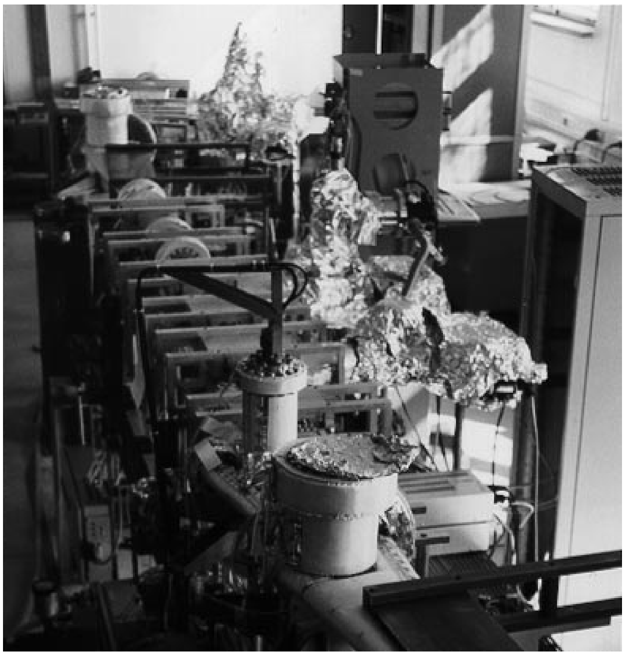

Fig. 4.: Photo of the full scale vacuum system prototype.

5.3 Diagnostics

For beam diagnosis in the ring, destructive fluorescent screen will be available for the first turn. Beam position monitors (BPM) are installed at 112 locations for measuring the horizontal and vertical position. The BPM electronics will allow for different operation modes. In the closed orbit mode a 70 dB wide range 1 mm resolution is achieved at bench tests whereas in the single turn mode up to 256 individual turns are recorded. A pinhole-array monitor is planned to monitor the beam emittance. In addition striplines, for tune measurement, and a parametric current transformer operating at 0.5 mA resolution, are presently under preparation.

5.4 Beam Position Feed Back

Beam position stability in the storage ring, especially in the IDs, is a key issue for all 3rd generation synchrotron light sources. Local beam-position feedback for the IDs using a closed-bump 4-magnet scheme is presently under construction. The system will allow to reduce orbit excursions by at least a factor of 5. The bandwidth of a prototype feedback that is expected to operate from the very beginning of commissioning is 1 - 100 Hz allowing to correct orbit amplitudes of ± 100 mm and angles of ± 0.4 mrad at full energy. A more detailed description of these items is given in [5] while first tests at the 800 MeV BESSY I ring are reported in [6].

5.5 RF System

The storage ring will be equipped by 4 DORIS-type 500 MHz cavities located in a low beta straight section. The resonators are fed by four 75 kW_{cw} rf transmitters using Thomson TH2133 klystrons and the first power plant is presently under test. The energy acceptance of the machine is in excess of $\Delta DE/E = 3\%$ at max. energy (1.9 GeV) for currents up to 200 mA.

6 Acknowledgement

The authors greatly acknowledge the BESSY technicians and workshops who are working with great skill and enthusiasm on the completion of the SR source.

7 References

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