Status of the New High Brilliance Synchrotron Light Source BESSY II[1)]

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Abstract

The 3rd generation synchrotron light source BESSY II under construction in Berlin will provide low emittance beams at energies from 0.9 to 1.9 GeV [1]. The compact lattice structure allows for up to 14 insertion devices in the 16 straights with alternating high and low beta values. Synchrotron radiation in the VUV to XUV regime is generated in excess of 10^{18} photons/(s· mm²·mrad²·0.1%bw) with emphasis on photon energies ranging from10 eV to 2 keV from undulators and yielding critical photon energies of about 11 keV from superconducting wavelength shifters. The new light source will serve as a valuable tool for fundamental research as well as for industry related research and development.

1. INTRODUCTION

After approval of the new synchrotron light source BESSY II by the Federal Ministry of Research and Technology and the state of Berlin work focused on fixing the machine parameters to start prototyping of machine elements. In parallel the experimental hall which also houses storage ring and injectors had to be specified to allow for official ground breaking on July 4th 1994. This paper reports on the status of the project.

2. THE STORAGE RING

2.1 Storage Ring Optics

The 1.9 GeV low emittance lattice structure of the storage ring is of a modified Chasman-Green type with two pairs of quadrupole doubletts in-between the bending magnets. The lattice is built up from 16 achromats with 5.6 m long dispersion-free straights. The basic structure has alternating high and low horizontal beta functions in the straight sections to accomodate undulators, wigglers and wavelength shifters. The ring circumference is 240 m. Due to the compact design of the arcs about 30% of the machine circumference is available for insertion devices.

The low emittance is achieved by small horizontal betas in the dipoles generating beta values of 17 m in the adjacent quadrupoles. As a consequence chromaticity is large and requires strong sextupoles. Main lattice parameters are listed in table 1.

Table 1: Lattice parameters of BESSY II

Energy range		0.9 - 1.9 GeV
Circumference		240 m
Natural emittance		$6 \cdot 10^{9}$ rad·m
Momentum compaction		$7.5 \cdot 10^{-4}$
Betatron tune	horizontal	17.84
	vertical	6.82
Chromaticity	horizontal	-50
	vertical	-25
Momentum acceptance		± 3%
Beam life time for multi bunch		> 8 h

A more detailed description of the optical layout of the ring is given in [2] whereas studies on beam life time are reported in [3] .

2.2. Magnetic Lattice Elements

The BESSY II storage ring is an isomagnetic lattice optimized for 16 long straight sections allowing the installation of 14 IDs. Consequently all elements were optimized in longitudinal size resulting in different lengths for quadrupoles and sextupoles with gradients of 18 T/m and 600 T/m². Fig. 1 gives a birdseye view on one of the 16 arcs of the storage ring. Due to the SR beam lines intersecting the yokes of the magnets all elements are „open“ to the ring's outer side in the horizontal symmetry plane. In table 2 a comprehensive list of magnet parameters is given. Prototyping of magnets is under way expecting the pre-series magnets at beginning of 1995.

As the limited space between elements does not allow for individual dipole correctors, all 112 sextupoles are equipped with additional coils to generate horizontal and vertical dipole fields as well as skew quadrupole components.

A careful study on closed orbit correction resulted in tolerable closed orbit distortions of less than 0.13 mm rms utilizing a scheme of 3 horizontal and 2 vertical correctors per arc. To allow for individual matching of the source points in dipole magnets to the accompanying SR beam lines local bumps are produced by 2 horizontal and 2 vertical steerers being added in those arcs where dipoles radiation is extracted.

1) Funded by the Bundesministerium für Forschung und Technologie and by the Land Berlin

2) W. Anders, B. Bauda, T. Becker, R. Bender, T. Birke, J. Borninkhof, K. Bürkmann, V. Dürr, G. v.Egan-Krieger, D. Faulbaum, W. Gericke, C. Geyer, S. Giray, M. v.Hartrott, H.G. Hoberg, E. Jaeschke, S. Khan, J. Kolbe, D. Krämer, B. Kuner, B. Kuske, P. Kuske, R. Lange, H. Lehmann, M. Loßmann, K. Ludwig, M. Martin, T. Mayer, D. Müller, R. Müller, K. Ott, H. Prange, O. Reil, D. Richter, H. Rüdiger, D. Schirmer, T. Schneegans, F. Schönfeld, D. Simmering, U. Strönisch, L. Schulz, M. Tebling, A. Ulrich, S. Vogt, E. Weihreter, T. Westphal, G. Wüstefeld

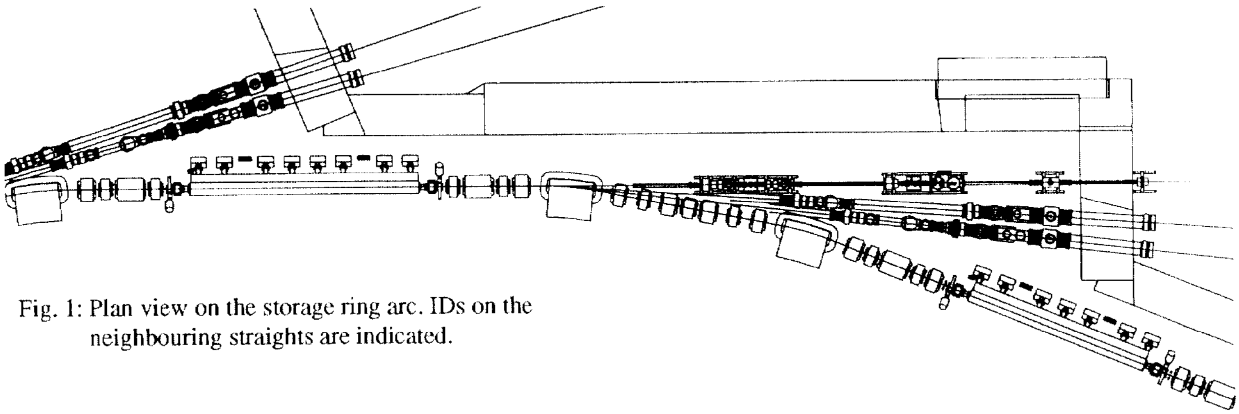

Fig. 1: Plan view on the storage ring arc. IDs on the neighbouring straights are indicated.

For stabilizing beam motion at frequencies in excess of 0.1 Hz a fast position feed back system made up from 4 individual dipoles grouped around undulators will allow for beam position stability inside the IDs well below the 10 µm level. Upper frequency limit of the closed bump will be above 50 Hz. This will be essential to avoid fast movement of the closed orbit due to distortion resulting e.g. from vibration expected to lead to beam excursions in the 1 to 10 µm range when calculating the quadrupole excursions generated from the vibration amplitudes measured taking into account for their propagation in the concrete foundation of the building as well as the damping/antidamping of the girder transfer function.

Table 2: Parameters of main magnets

No. of dipole magnets	32
Typ	C-type box magnet
Nominal field	1.45 T
Gap	50 mm
Magnetic length	0.855 m
Good field area (h·v)	50 mm·40 mm
Sagitta	10.5 mm
No. of quadrupole magnets	144
Gradient g	18 T/m
Magnetic length	0.5/0.25/0.20 m
Aperture radius	35 mm
Good field radius	30 mm
No. of sextupoles	112
Gradient g'	600 T/m^2
Magnetic length	0.21/0.16 m
Aperture radius	38 mm
Good field radius	30 mm
Aux. windings for horiz./vert. dipole/skew quad.	

2.3 Injectors

To avoid ramping of the storage ring injection at full energy is under construction. A 50 MeV race track microtron will feed the 10 Hz booster synchrotron. Fig. 2 shows one of the 16 FODO cells with all magnetic elements mounted on one common girder. A more detailed description of the magnetic lattice is given in [4]. Currents expected of the 96 m circumference synchrotron will be 3 mA at an emittance of $1.4 \cdot 10^{-7}$ rad·m. Injection and ejection to and from the booster are described in [5] .

2.4 Civil Engineering

The SR light source will be located in a 120 m diameter experimental hall as shown in figure 3.

About 8000 m^2 of experimental area will be available to house up to 78 beamlines of a length up to 42.5 m. Very long beamlines in excess of 150 m can be realized on the site. The storage ring is located inside a tunnel with the injectors arranged in the middle. To damp excitation caused by the 10 Hz booster the foundation is made from two monolithic plates of 0.6 m in thickness one for the storage ring and experimental area and one for the injectors. Both slabs are isolated with respect to vibrations. This should give the smallest vertical distortions to machines and beamlines.

All supplies for the accelerator are arranged on a gallery near the innner radius of the storage ring tunnel giving short distances to the components and full access to the devices during

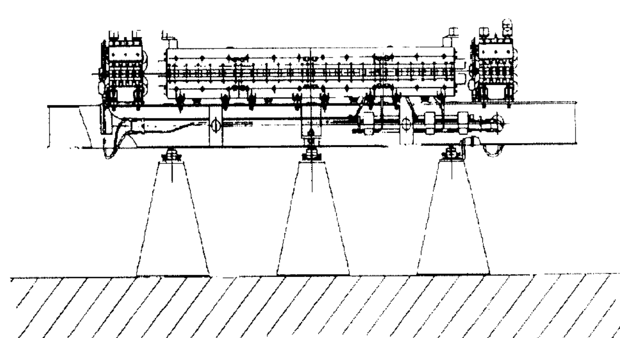

Fig. 2: View of a full synchrotron FODO cell.

operation. All major components suspected to create vibrations as transformers, water pumps etc. were located in a separate building outside the experimental hall. A tunnel below the experimental floor will give the possibility to transfer electrons from the synchrotron to a separate building. Thus the booster can serve external experiments during the long periods between fillings of the storage ring. This new 1000 m^2 hall is expected to be used for R&D efforts is near completion.

A four-storeyed building with offices and laboratories directly linked to the experimental hall will provide adequate conditions for the German Bureau of Standards (PTB) for metrology as well as for the KfK group working on deep X-ray lithography.

3. SUMMARY

After all existing buildings on the site have been demolished, construction of the main hall is expected to start in October 1994 giving access to the tunnel for first installation of machine elements as early as by the end of 1995. Thus starting commissioning of the booster synchrotron in late 1996. Storage ring commissioning is scheduled for the second half of 1997 to allow for routine operation early in 1998.

4. REFERENCES

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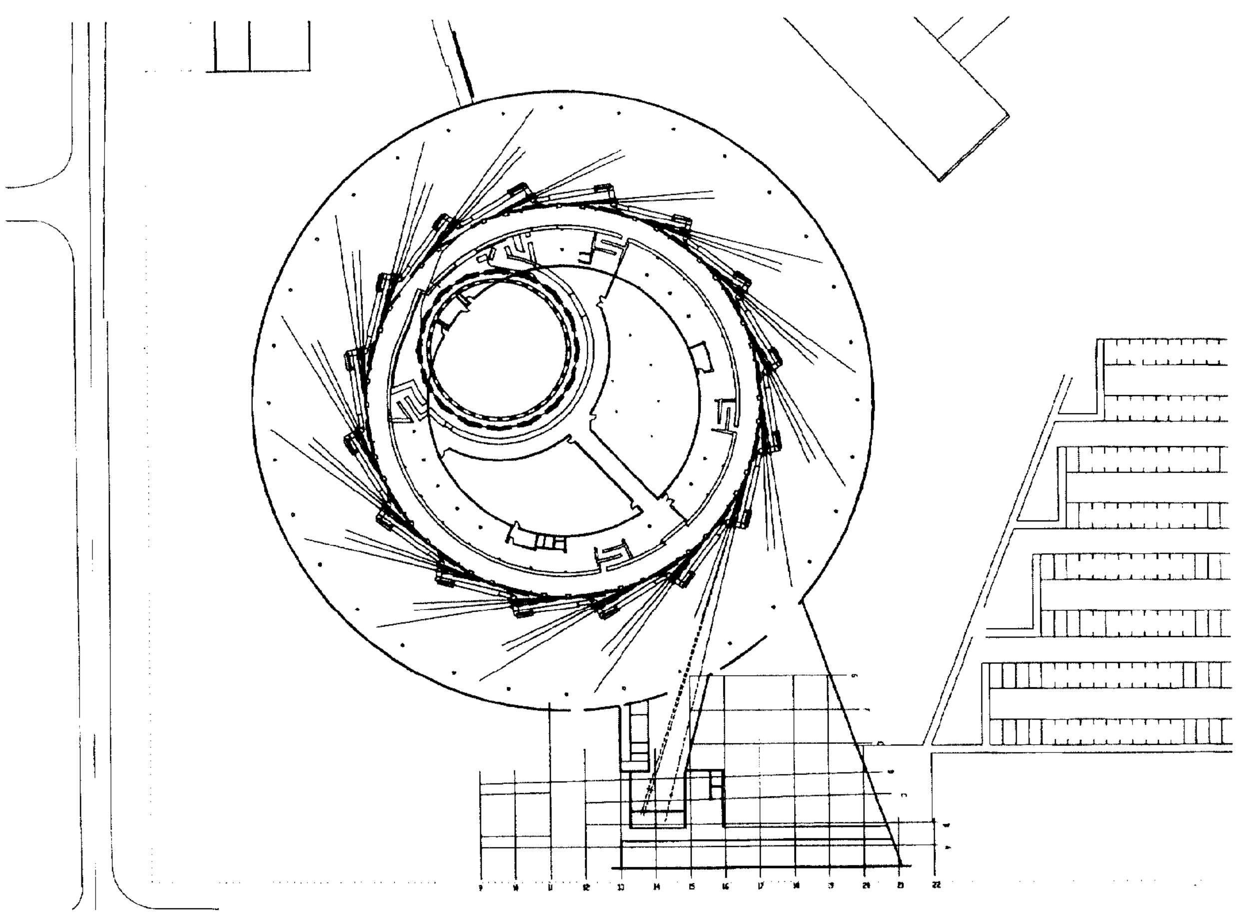

Fig. 3: General layout of the BESSY II experimental hall with storage ring and injectors in the center. SR beamlines are indicated.