STATUS of BESSY II *
a High Brilliance Synchrotron Light Source in the VUV to XUV Range

D.Krämer for the BESSY II design team**
BESSY mbH, Lentzeallee 100, D-1000 Berlin 33, Germany

Abstract

The approval of the BESSY II project marked the start of the construction of the first third generation synchrotron light source in Germany. BESSY II, designed for low emittance ($\epsilon = 6 \cdot 10^{-9} radm$) and the incorporation of a large number of insertion devices (IDs) is expected to deliver VUV to XUV radiation with a brilliance in excess of $10^{18} photons/(sec \cdot mm^2 \cdot mrad^2 \cdot 0.1\% bandwidth)$, the photon energies ranging from 10 to 2000 eV from undulators and wigglers. Photon spectra with a critical energy of 11.5 keV will be generated in the 6 T field of a superconducting wavelength shifter (WLS) which is planned to be installed in one of the 14 straight sections available for insertion devices. The decision to build BESSY II at a new site at Berlin Adlershof gave the challenge for a complete redesign of the storage ring without the severe boundaries compared to earlier proposals [1], with respect to requirements and practicabilities of constructing an accelerator complex mid in the center of West-Berlin.

1. Introduction

On July 7^{th} 1992 a new third generation synchrotron light source was approved by the German Ministry of Research and Technology. This date marked the start for construction of the high brilliance synchrotron light source BESSY II to be located at the area of the former Academy of Science of the GDR at Berlin-Adlershof. BESSY II is optimized to accommodate up to 14 insertion devices providing radiation in the VUV to soft X-ray range using undulators and wigglers as well as standard bending magnets. A large number of user groups from physics and astrophysics, life science, chemistry, material science and catalytics, surface science and radiation metrology will use the new facility. Industrial applications especially deep X-ray lithography for micromechanics will benefit considerably from the new radiation source thus demonstrating the wide potential of synchrotron radiation in fundamental and applied research.

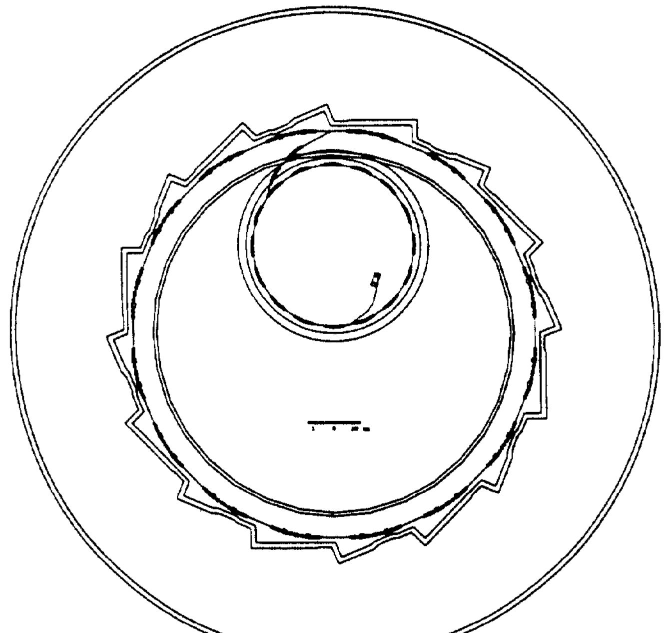

Figure 1: *Layout of the BESSY II synchrotron and storage ring. The diameter of the experimental hall will be 120 m.*

2. The accelerator

The accelerator complex BESSY II consists of three major components:

- a 50 MeV racetrack microtron as pre-injector,
- a full energy 10 Hz booster synchrotron and
- a storage ring capable to run at energies from 0.9 to 1.9 GeV.

Figure 1 gives a plan view on the 120 m diameter experimental hall with the storage ring and the injectors in the center. In table 1 the basic parameters of the injectors are listed.

As the new site for BESSY II offers significant advantages compared to former proposals with respect to spacial and technical boundaries a complete redesign for the storage ring has been done [2]. The result is a 2 times 8-fold Double Bend Achromat (DBA) structure with good emittance and large dynamic aperture. A quadrupole douplett at every second straight section enables high beta values in this straight whereas triplett focussing allows for a small horizontal beta function of less than 1 m. The DBA structure is very compact with a large flexibility of its 9 families of quadrupoles and 6 families of sextupoles. In table 2 the

*Funded by BMFT and Land Berlin

**W. Anders, J. Bahrdt, B. Bauda, T. Becker, K. Bürkmann, W. Braun, W. Dörhage, V. Dürr, G.v. Egan-Krieger, W. Gericke, A. Gaupp, W. Gudat, Ch. Geyer, M.v. Hartrott, E. Jaeschke, S. Khan, D. Krämer, B. Kuske, P. Kuske, M. Martin, R. Müller, K. Ott, W. Peatman, H. Prange, J. Rahn, D. Richter, M. Scheer, F. Senf, T. Schneegans, U. Strönisch, L. Schulz, E. Weihreter, G. Wüstefeld, Th. Westphal

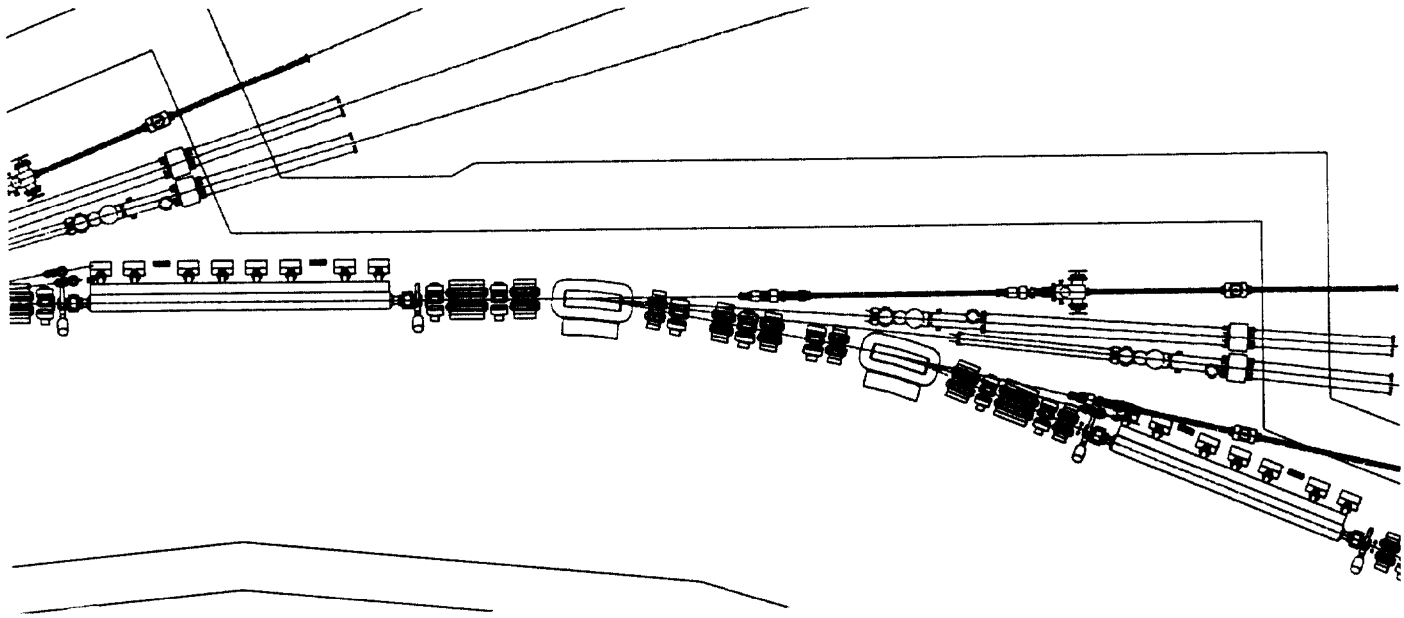

Figure 2: *Section of the storage ring. The straight sections on both sides of the achromat will accomodate Undulaters and Wigglers. Sychrotron Radiation beamlines are indicated.*

main parameters of the storage ring are summarised. Figure 2 gives a view on the achromat with the long straights.

Table 1: *Basic Parameters of the BESSY Injectors*

Racetrack Mikrotron	
Nominal energy	50 MeV
Energy spread	$\pm 2 \cdot 10^{-3}$
Max. current	25 mA
Emittance	$2 \cdot 10^{-7} radm$
Repetition frequency	10 Hz
Max. pulse duration	1 μs
Synchrotron	
Injection energy	50 MeV
Extraction energy	1.9 GeV
Extracted current	3 mA
Emittance at extraction	$1.4 \cdot 10^{-7} radm$
Natural energy spread	$\pm 5.5 \cdot 10^{-4}$
Lattice structure	FODO
Number of cells	16
Circumference	96 m
Harmonic number	160
Repetition frequency	10 Hz

The storage ring will have 16 long straight sections of which 14 are used for insertion devices . Half of the straight sections will have a useable length of 4.708 m while the others are of 3.888 m length. 'High' beta functions are foreseen in the long straights: $\beta_x = 16.2$ m, β_z =3.1 m to accomodate undulators whereas the short straights with 'low' beta functions of $\beta_x = 0.93$ m and $\beta_z = 2.1$ m are reserved for high field wigglers and superconducting wavelength shifters to minimize their impact on the beam.

3. The insertion devices

The IDs planned for BESSY II are ranging from permanent magnet undulators U140 - U30 to a 6 T wavelength shifter. There are 32 bending magnets generating synchrotron radiation of characteristic photon energy of 2.5 keV at nominal beam energy. Beam lines emerging from the dipoles can be set up with a max. length of 42.5 m. Space is available on the site to install super long beam lines (more than hundred meters). Table 3 gives a list of the IDs planned for operation in BESSY II.

Table 2: *General Parameters of the Storage Ring*

Energy range	0.9 - 1.9 GeV
Circumference	240 m
Number of cells	16
Natural emittance	$6.1 \cdot 10^{-9} radm$
Momentum compaction	$7.5 \cdot 10^{-4}$
Structure	$8 \cdot (S1, -S1)$
S1 = FDBDFFDBDFD	
Max. hor. beta function	17.2 m
Min. hor. beta function	0.384 m
Max. vert. beta function	20.5 m
Min. vert. beta function	2.44 m
Max. dispersion function	0.415 m
Nom. current multi bunch operation	100 mA
Rf frequency	500 MHz
Beam lifetime	10 h
Usable length of straight sections:	
'high' beta section	4.708 m
'low' beta section	3.888 m

Table 3: *List of Insertion Devices of BESSY II*						
ID name	U-140	U-100	U-52	U-30	W-100	WLS
Period λ_0 (mm)	140	100	52	30	100	
Number of periods	32	40	80	110	40	
Length (m)	4.48	4.0	4.16	3.3	4.0	1.0
Magnetic gap (mm)	24	24	24	12	24	
Vacuum gap (mm)	20	20	20	10	20	
K_{max}(NeFeB)	6.5	4.7	2.5	1.6	9.7	
1^{st} Harmonic (eV)	9 - 174	23 - 244	128 - 469	401 - 813		
K Region	6.5 - 0.5	4.7 - 0.5	2.5 - 0.5	1.6 - 0.5		
2^{nd} Harmonic (eV)	130 - 261	183 - 366	352 - 704	802 - 1220		
K Region	2.0 - 1.0	2.0 - 1.0	2.0 - 1.0	1.6 - 1.0		
3^{rd} Harmonic (eV)	143 - 392	200 - 549	384 - 1056	1204 - 1830		
K Region	2.5 - 1.0	2.5 - 1.0	2.5 - 1.0	1.6 - 1.0		
B_0 (T)	0.5	0.5	0.461	0.594	1.04	6
ρ_0 (m)	11.3	11.3	12.3	9.5	5.4	
Charact. Energy (eV)	961	961	886	1142	1995	11532
Radiated power (W)	203	185	202	197	789	
$\frac{dP}{d\Omega}\frac{W}{mrad^2}$	144	182	368	554	376	
Lin. tune shift $(\frac{1}{m})$ $\frac{\Delta Q_y}{\beta_y} = \frac{L}{8\pi\rho^2}$	$1.39 \cdot 10^{-3}$	$1.24 \cdot 10^{-3}$	$1.09 \cdot 10^{-3}$	$1.44 \cdot 10^{-3}$	$5.36 \cdot 10^{-3}$	
Nonlin. tune shift $(\frac{1}{m^3})$ $\frac{\Delta Q_y}{\beta_y \cdot y^2} = \frac{\pi L}{4(\lambda_0\rho)^2}$	1.40	2.44	7.99	31.6	10.6	

For the first phase of operation 6 undulators and wigglers and at least one wavelength shifter will be available. 6 beamlines will be prepared for experiments. Furthermore 8 dipole beamlines will be setup equipped with monochromators. Figure 3 gives the brilliance for the insertion devices under construction in comparison to the present 0.8 GeV BESSY I synchrotron radiation source.

4. Status of the project

After approval by the Federal Ministry of Research and Technology and the Senate of Berlin preparations for civil engineering are under way to start with the building in march 1994. According to the time schedule prototyping is in preparation to fit to the comissioning of the booster planned for June 1996 and start the storage ring commissioning in summer 1997 in order to deliver first synchrotron radiation from an undulator before 1998.

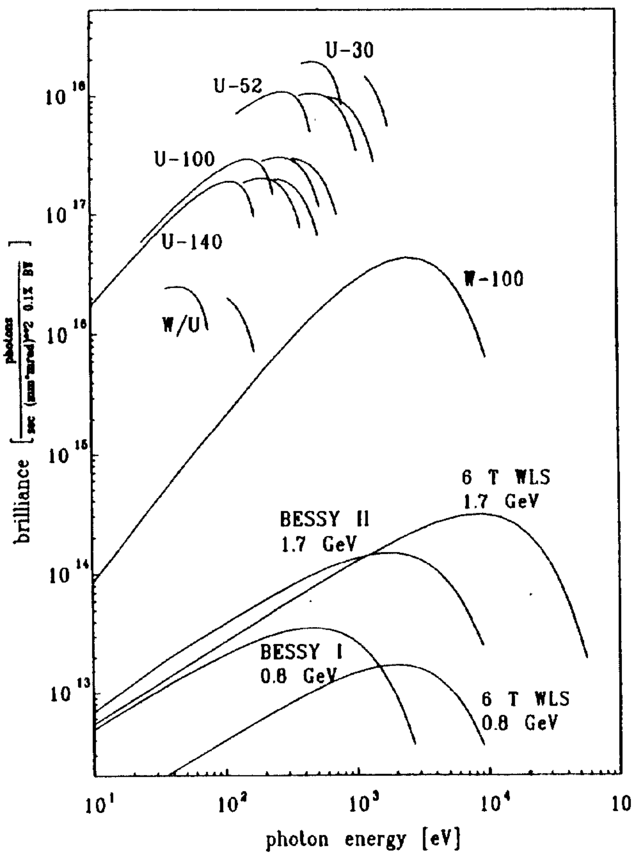

Figure 3: *Brilliance of radiation from insertion devices at BESSY II compared with radiation from dipoles and with the 0.8 GeV BESSY I synchrotron radiation source.*

References

[1] BESSY II - Eine optimierte Undulator/Wiggler Speicherring Lichtquelle für den VUV- und XUV Spektralbereich, Technische Studie, Berlin 1989

[2] *E. Jaeschke, D. Krämer, B. Kuske, P. Kuske, M. Scheer E. Weihreter, G. Wüstefeld* Lattice Design for the 1.7 GeV Light Source BESSY II, contribution to these proceedings