BESSY II, a State of the Art Synchrotron Light Source for Berlin-Adlershof

E. Jaeschke*
BESSY GmbH
Lentzeallee 100
W-1000 Berlin 33

Abstract

BESSY II is a 1.7 GeV third generation synchrotron light source designed for low emittance ($\varepsilon \sim 6 \cdot 10^{-9}$ m·rad) to deliver high brightness VUV/XUV radiation from a multitude of insertion devices. The construction is foreseen to start shortly on a new site in Berlin-Adlershof. The storage ring injected at full energy from a 10 Hz synchrotron has a 10-fold super-symmetry, making use of the TBA concept. Very flexible triplett focussing allows the individual matching of various undulators/wigglers or even superconducting wavelength shifters in the 6 m long straight sections. The new site in Berlin-Adlershof now provides adequate space for a solution ensuring optimum conditions for the VUV-XUV user community.

1. Introduction

The high brilliance synchrotron light source BESSY II has been described in detail in the technical design studiy [1] and several publications [2-3]. Optimized to provide unprecedented research possibilities with radiation in the VUV to soft X-ray range, BESSY II will be a most valuable research tool for a large number of quite different fields as indicated in fig. 1. Applications range from fundamental research in physics and chemistry up to industrial applications. Life sciences, i.e. biology and medicine will profit especially, as X-ray microscopy on living cells can be done on a time scale allowing to take pictures of life processes without destroying the cells. In industrial applications, not only microelectronic development but also deep X-ray lithography for micromechanics will be possible at BESSY II.

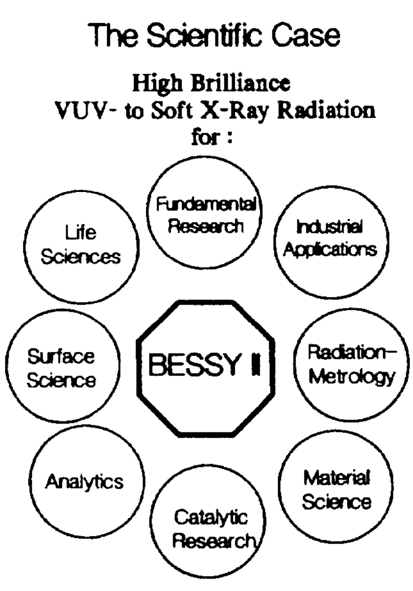

Fig. 1: A wide range of application fields is characteristic for the high brillance light source BESSY II.

Table I BESSY II Basic Parameters

Energy [GeV]	1.7 (0.9-1.9)
Electron Current [mA]	> 100
Lattice Type	TBA (10)
Circumference [m]	194.39
Harmonic Number	324
Bunch Length [ps]	20
Tune Q_x/Q_z	14.16/6.18
Chromaticity ξ_x/ξ_z	-39/-13
Momentum Compaction α	$1.6 \cdot 10^{-2}$
Natural Emittance [nmrad]	6.2
β_x/straight/max/min [m]	8.0/17.2/0.27
β_z/straight/max/min [m]	3.0/10.8/2.9
Energy Spread $\Delta E/E$	$7 \cdot 10^{-4}$
Beam Lifetime [h]	> 6
Defl. Radius ρ [m]	4.2
Dipole Field [T]	1.5
Length Straight [m]	5.8
Insertion Devices N	8 - 10
Pre-Accelerator:	50 MeV-Microtron
Injector:	Full Energy Synchrotron

2. The Machine Layout

As a high brilliance light source for the VUV to soft X-ray range (100 eV to 2 keV) BESSY II is able to fulfill the needs of this large community by a design described by the basic parameters in table I and the lattice functions shown for the TBA 10 design in fig. 2.

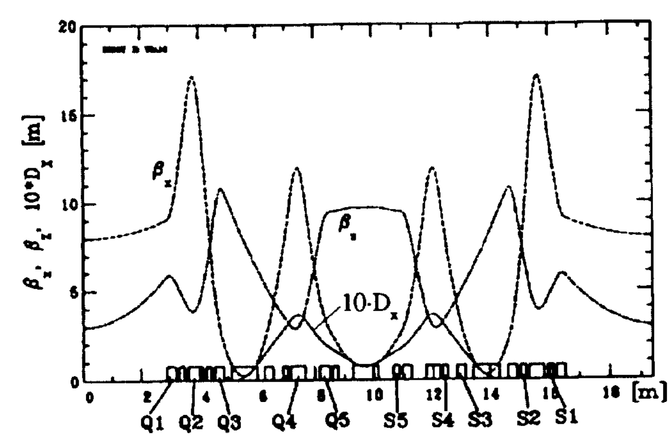

Fig. 2: Lattice functions β_x, β_z and $10 \cdot D_x$ for one superperiode of BESSY II.

* For the BESSY II design team, whose members are or were: W. Anders, J. Bahrdt, A.M. Bradshaw, W. Braun, B. Bauda, K. Bürkmann, G.v. Egan-Krieger, A. Gaupp, W. Gudat, M.v. Hartrott, G. Isoyama, E. Jaeschke, D. Klotz, E.-E. Koch, D. Krämer, B. Kuske, P. Kuske, H. Lehr, R. Maier, M. Martin, G. Mülhaupt, R. Müller, W. Peatman, H. Petersen, J. Rahn, L. Schulz, E. Weihreter, Th. Westphal.

Table II Insertion Devices at BESSY II

	U1/W2	U2	U2.5	U3	V1	WLS
Length [m]	4.0	4.2	4.16	3.3	3.5	1.2
λ_0 [mm]	100	70	52	30	77	-
N	40	60	80	110	23+22	3
B_0 [T]	1.04	0.72	0.46	0.59	0.31	6.0
h = 1 [eV]	91-244	130-350	176-470	400-810	120-316	ε_c 11.5keV
h = 3 [eV]	274-548	390-780	530-1050	1200-1800	360-710	-
Σ_x [µm]	224	224	224	224	224	
Σ_z [µm]	47-44	46-44	45-43	46-42		

The preaccelerator selected will be an already existing 50 MeV race track microtron, the injector a 10 Hz full energy synchrotron. An emittance value of 6 nmrad assures the required high brilliance radiation from the 8-10 insertion devices. Table II gives an overview of the planned devices ranging from planar permanent magnet undulators U1-U3 to a crossed field undulator V1 for variable polarisation and a superconducting 6 T-wavelength shifter WLS. The table indicates the spectral range in the first and third harmonic operation showing sufficient overlap between ~100 eV and 2 keV as required. Further listed are the source sizes Σ_x and Σ_z. The critical wavelength of the radiation from the 6 T-WLS is 11.5 keV giving possibilities for experiments with harder radiation. As demonstrated in reference [4] it is possible to introduce this high field superconducting wiggler without deteriorating the overall performance of the BESSY II machine.

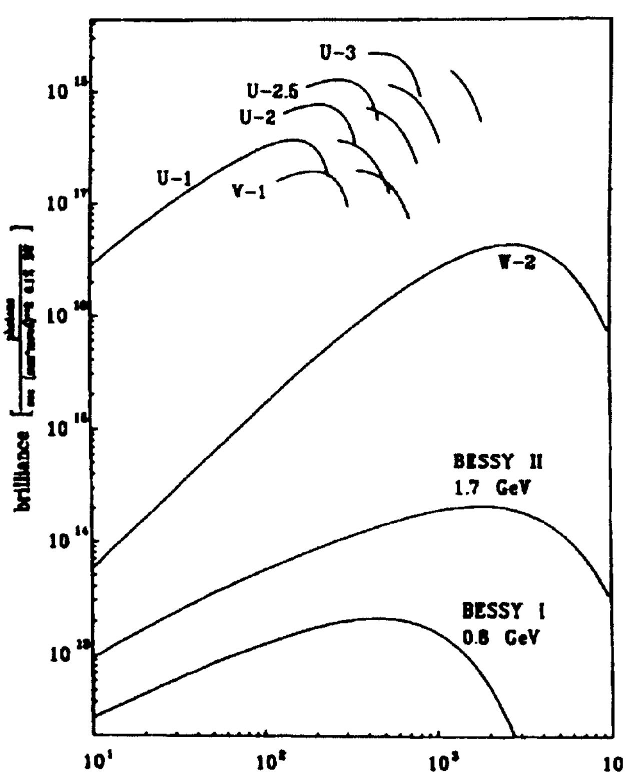

Fig.3: Brilliance of radiation from insertion devices at BESSY II compared with radiation from dipoles.

Fig. 3 is a plot of spectral brilliance versus photon energy for the insertion devices in comparison with radiation from dipoles in BESSY I and BESSY II. The tremendous increase in brilliance by more than a factor 10^3 can be seen clearly.

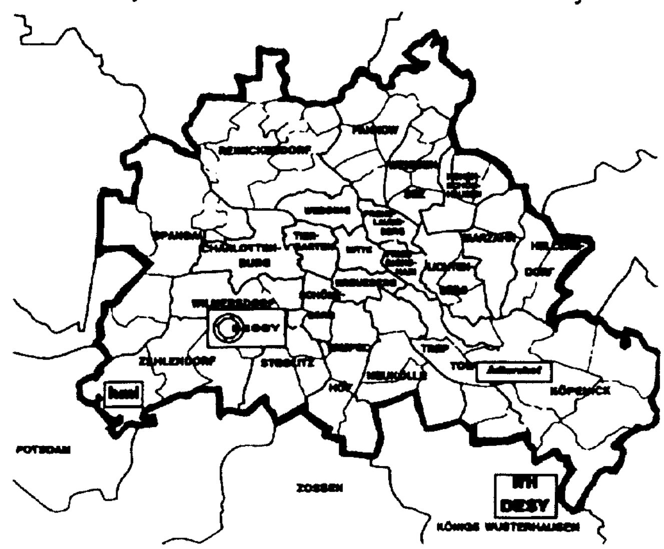

Fig. 4: The new construction site in Berlin-Adlershof.

3. The New Site

In the course of the German unification process a number of dramatic developments and changes to bring BESSY II closer to the point of decision could be registered. Most important of all is the new site selected for construction. BESSY II can now be built on a 30,000 m² area of the Academy of Science campus of the former GDR in Berlin-Adlershof. Fig. 4 shows a map of Berlin with the location of the BESSY I institute in Wilmerdorf and the new site in the southeast of Berlin in the science and technology park in Adlershof near the IfH-DESY branch in Zeuthen. Further indicated is the Hahn-Meitner-Institute (hmi).

Fig. 5 is an artist's view of the large ring hall housing the storage ring proper and the experimental area that now allows the installation of up to 50 m long beam lines. Fig. 6 gives a cut through the ring hall. In contrast to the formerly planned underground construction, an architectural solution on the surface has become possible. The full energy injector can now be placed outside the light source, ensuring easy access to essential components and providing possibilities for future developments. This way the beam from the booster can be used between injection periods for detector calibration in the nearby heavy weight hall by the IfH-DESY high energy physics laboratory. Already existing buildings around the ring hall-synchrotron complex will be used for the new BESSY laboratory. This way more than 3,500 m² space will be additionally available ensuring a really adequate solution for a user facility light source.

4. Status of the Project

The committee on fundamental research advising the Federal Minister of Research and Technology on future science policies, has carefully discussed and evaluated the project,

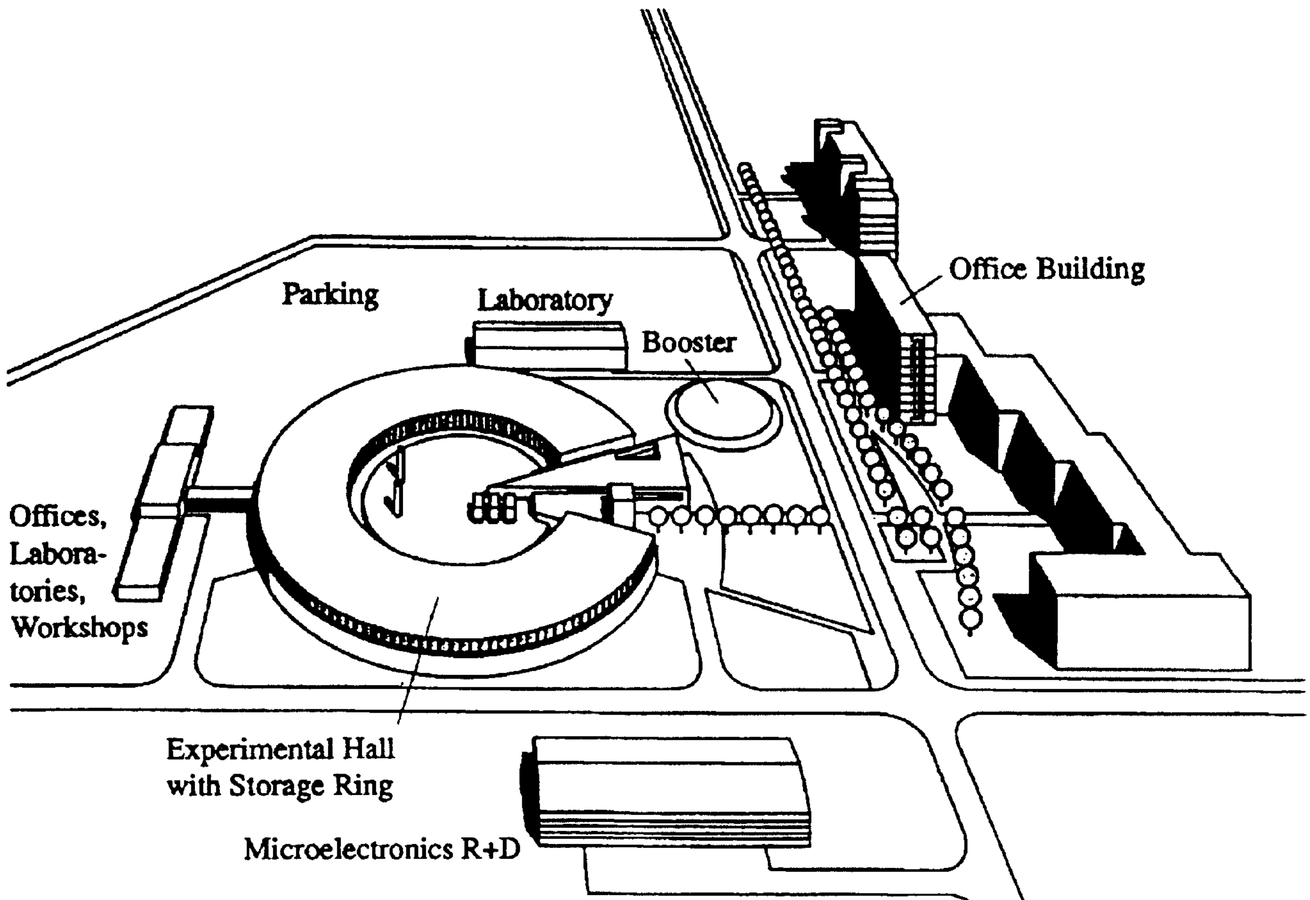

Fig. 5: Artist's View of BESSY II site at the science and technology park Berlin-Adlershof.

concluding that BESSY II should have a high priority of realization for scientific reasons, even taking the presently limited financial possibilities for German fundamental research into account. As the senate of Berlin has already committed itself to provide half of the investment and operating costs for the project, a final decision also by the federal government is expected in the very near future. Construction could start immediately and first light for experiments could already be delivered in 1996.

5. References

[1] BESSY II - Eine optimierte Undulator/Wiggler-Speicherring Lichtquelle für den VUV- und XUV-Spektralbereich, Teil 1, 1986 und Teil 2 Technische Studie, 1989

[2] G. Wüstefeld, G. Isoyama, H. Lehr, B. Simon "Lattice Comparison for the Synchrotron Light Source BESSY II" Proc. of the 1989 IEEE Particle Accelerator Conference, Chicago 1989, 1263-1267

[3] B. Kuske, G. Isoyama, H. Lehr, G. Wüstefeld "Layout of the BESSY II Lattice", Proc. of the 2nd Europan Particle Accelerator Conference, Nice 1990, 1420-1422

[4] M. Scheer, G. Wüstefeld "Impact of a Wavelength Shifter on the Performance of the Synchrotron Light Source BESSY II", contribution to this conference.

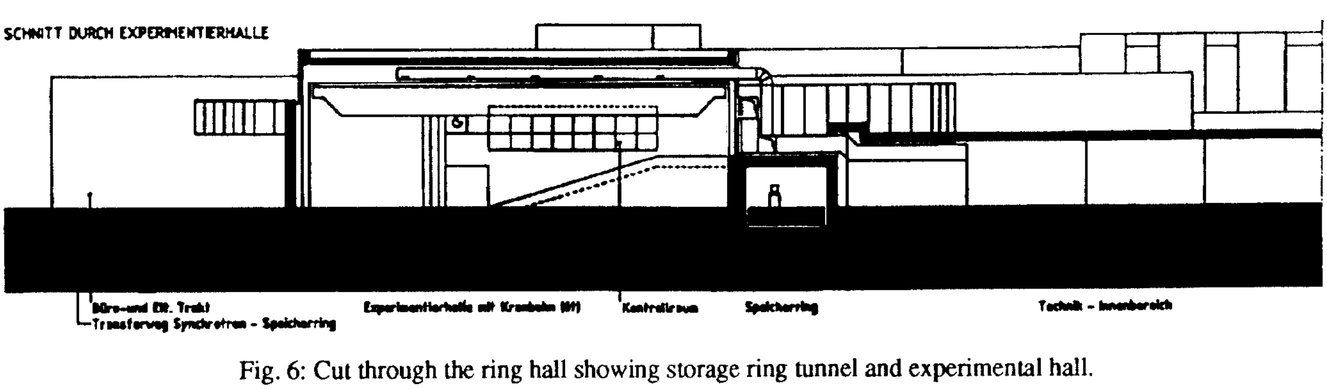

Fig. 6: Cut through the ring hall showing storage ring tunnel and experimental hall.