START OF COMMISSIONING OF THE HIGH BRILLIANCE SYNCHROTRON RADIATION SOURCE BESSYII[+]

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Abstract

BESSY II, the new low emittance high brilliance 3rd generation synchrotron radiation light source at Berlin-Adlershof [1] started commissioning. Three months ahead of schedule an electron beam was successfully stored and accumulated on April 22nd. During these first tests the storage ring was operated at its design energy of 1.7 GeV.

The Synchrotron Radiation source is optimised for the generation of synchrotron light in the VUV to soft X-ray range operating at beam energies of 0.9 – 1.9 GeV. In the present stage 5 beam lines are being set up. Preparation for operating the first undulator already on place as well as installation of a first superconducting wiggler are well advanced allowing start of the regular scientific program in January 1999 according to schedule. This paper reviews the status of the facility and presents results of the first commissioning runs.

1 INTRODUCTION

BESSY II was approved in 1992 as a 1.7 GeV synchrotron radiation source in the vacuum ultraviolet to soft X-ray regime. Already in late 1996 the injectors, a 50 MeV race track microtron and a full energy (1.9 GeV) 10 Hz rapid cycling synchrotron were assembled. Commissioning of the synchrotron started in April 1997, the results of the first year of operation are reported elsewhere in this conference [2].

The storage ring offers 16 straight sections of alternating low (1m) and high (17 m) horizontal beta function. A usable length of 4.7 and 3.9 m is available in the straights for installation of up to 14 insertion devices (IDs); amongst these a 49 mm period length hybrid undulators and a 180 mm period electromagnetic device have passed final acceptance test, further undulators are under construction. There are two superconducting wave length shifters available and a 7 T device is ordered from industry.

2 TECHNICAL DESCRIPTION

2.1 Lattice and Magnet Structure

The lattice of the storage ring is built as an extended Double Bend Achromat structure with 16 fold symmetry to achieve a 6 nm·rad emittance.

The achromats consist of four figure-of-eight quadrupoles in the dispersive section while doublet and triplet focusing around the straight sections allow for alternating high and low horizontal beta functions. As these straight section quadrupole doublets and triplets are powered by 40 individual power supplies high flexibility in matching the beta functions is ensured whatever ID is located in the straights. 7 families of sextupoles in each unit cell, 112 altogether, are used for chromatic and harmonic correction.

The 32 dipole magnets are designed for a field of 1.3 T at 1.7 GeV giving a critical photon energy of 2.5 keV. The quadrupoles of maximum gradient 16.5 T/m are equipped with trim coils to allow for individual change of focusing strength giving the possibility to determine the beta function at any magnet position independently.

The achromats are densely packed with magnetic elements. Combined sextupole and steering fields had to be adopted rather than using lumped dipole correctors. The sextupoles are designed for a sextupole constant of $S=600\ T/m^2$. Each magnet is hooked to a multiplexer for adding a small extra current to allow beam based alignment. Additional coils generate horizontal and vertical dipole fields of a kick strength up to 3 mrad. The present correction schemes uses 80 horizontal and 64 vertical correctors. Fig. 1 shows a view to the storage ring structure.

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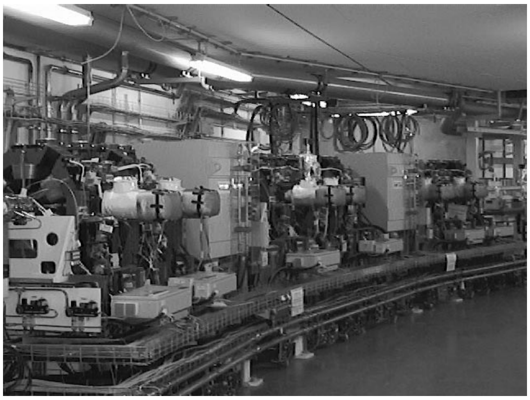

Fig. 1: Storage ring magnet structure.

Assembly of the 240 m circumference ring started in spring 1997. All magnetic multipoles, vacuum and diagnostic elements where mounted and aligned on 48 girders that where placed in the storage ring tunnel at their final position.

2.2 Injection

The beam extracted from the synchrotron is transferred to the storage ring via a 25 m long transferline. The beam is horizontally injected into the storage ring from the inner side of the ring. Two septa in a common vacuum tank bend the beam 22 mm off the central orbit. Four fast kicker magnets create a closed orbit bump next to the septum sheet. All elements are located in one of the long “high beta” straight sections.

2.3 Vacuum

The design of the storage ring vacuum system is to stand a 1.9 GeV beam current of 500 mA. All chambers are made from AISI 316LN stainless steel. Crotch absorbers are located at the dipole chambers which have been tested to cope with linear power densities in excess of 500 W/cm[3]. In the straight chambers copper absorbers are explosion bonded to the chamber wall. The beam pipe is of elliptical cross section with major axis 32.5 and 17.5 mm. 160 lumped sputter ion pumps (SIP) are distributed in the arcs and in the straight sections. A the location of crotch absorbers additional 500 l/s SIPs are placed directly underneath the crotch. A total pumping speed of approximately 20000 l/s is installed in the ring. The complete machine vacuum system is covered with heating jackets for a controlled 200^o C in-situ bake.

3.4 RF-System

The storage ring is equipped with 4 DORIS type 500 MHz single cell cavities located in one of the dispersion free low beta straights. Each resonator is fed by an individual 75 kW_{cw} rf transmitter connected via coaxial line and a circulator. Thus the energy acceptance of the machine is in excess of $\Delta E/E=3\%$ at design energy (1.7 GeV) for currents up to 250 mA.

2.5 Instrumentation

For first turn beam diagnosis nine destructive fluorescent screens are mounted in straight sections allowing to follow the beam once around the machine. Beam position monitors (BPM) are installed at 112 locations measuring the horizontal and vertical position. In the closed orbit mode complete beam orbits are updated every 2 s. 64 BPM electronics allow operation in single turn mode where pre-selective individual turns are reconstructed from four successive injections. In ref. [4] the BPM system and its use during the first commissioning runs is described.

A pinhole-array X-ray beam monitor [5] is avail-able to monitor beam emittance and orbit stability. In addition striplines for energy and tune measure-ment and a parametric current transformer are operating.

2.6 Controls System

The BESSY control system is based on a distributed architecture. Workstations communicating to VME single board computers using the EPICS toolkit as core software and the selection of distributed local intelligence of embedded controllers and CAN field bus networks for IO based device control proved to be an extremely robust control system. From the very beginning the system allowed the operator crew complete access to the accelerator components. Furthermore the various software applications were of great help to the operators during the present commissioning process. The control system is described elsewhere in this conference in more detail [6].

3 FIRST COMMISSIONING RESULTS

3.1 First beam signals

Commissioning of the storage ring started on April 21st, 1998 when all systems were ready to go. On early morning April 22nd the first turns could be observed in the storage ring. After activating 1 of the cavities the beam was circulating for several hundred turns. Finally on late evening the beam got stored and was circulating with a life time of several minutes. Another 5 h later the storage ring was accumulating. Within the next shifts up to 10 mA were accumulated at injection rates of 1mA/s. The current was limited at that time by an automatic halt to injection avoiding damage to the vacuum system as part of the photon absorbers were not cooled.

First emitted light was detected at the diagnostic beamline using the pinhole array camera, fig. 2.

Fig. 2 First SR light detected at the optical beamline.

3.2 Optics tuning

During the first run the uncorrected beam orbit showed large horizontal and vertical excursions. As for chromaticity compensation the sextupoles were set to their calculated values, the optics was strongly influenced by the off centre passage through these multipoles. Thus, despite of the high natural chromaticity of -50, a successful attempt was made to store beam without sextupoles. Up to 3 mA could be accumulated in this mode.

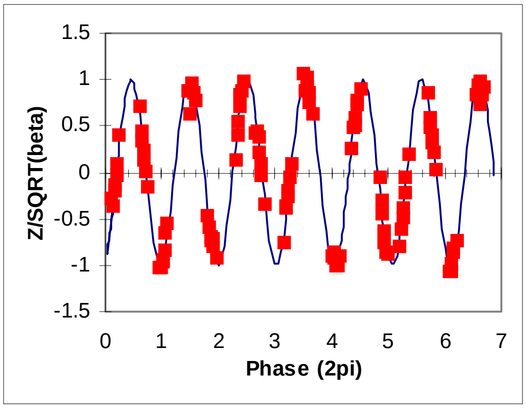

Fig. 3: Comparison of a measured (squares) and calculated difference orbit (solid line).

Measurements of the horizontal and vertical steerer response matrix revealed for the linear optics that small (2%) corrections had to be applied to the conversion factors for the quadrupole families. With the new current settings the design working point was established immediately [7].

The measured difference orbits generated by the steering magnet are in good agreement to the calculated ones of the design optics. Fig.3 shows a typical result for a vertical corrector.

Furthermore vertical and horizontal obit correction using SVD was successful performed, reducing the vertical rms. orbit displacement to σ_z=0.8 mm and horizontally to σ_x=1.1 mm. A more detailed description of the procedure is given in ref.[7].

3.3 Beam life time and Vacuum

Beam life time during the present runs is typically 20 min as the assembly of beam lines and final activities at the ring vacuum allowed for short pumping times only. Without beam the mean pressure readings at the gauge heads indicates 5 nTorr, taking into account that the gauge distance to the beam chamber, the pressure seen by the beam is estimated to be a factor of 3 larger. With 5 mA of beam the pressure readings are tripled. Thus the measured beam lifetime agrees reasonably well with the $5\cdot10^{-8}$ Torr pressure readings. Fig. 4 shows the intensity decay of a typical fill.

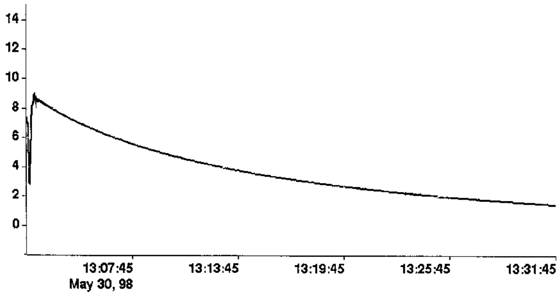

Fig. 4: Stored beam intensity vs. time.

4 ACKNOWLEDGEMENT

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