Status Report on the SPring-8

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Abstract

The SPring-8 is a high energy third generation synchrotron radiation source designed to deliver X-ray beam with a brilliance more than 10^{19} photons/sec/mm^2/mrad^2/0.1%b.w. The facility consists of a 1 GeV linac, an 8 GeV booster synchrotron and an 8 GeV low emittance storage ring. The construction was started in 1990. Accumulated budget to date amounted to about a half of the total budget. Commissioning of the storage ring is expected in Feb. 1997.

1. INTRODUCTION

The SPring-8 is designed and constructed by Japan Atomic Energy Research Institute (JAERI) and The Institute of Physical and Chemical Research (RIKEN). After construction, Japan Synchrotron Radiation Research Institute (JASRI), which was established in 1990 as a nonprofit research institute, will be responsible for the management and operation in collaboration with JAERI and RIKEN. This is a user facility for SR researchers from universities, national laboratories, and industries not only in Japan but also from abroad. In Phase I, from '91 to '98, construction and commissioning of the accelerators and 10 beamlines are included. In Phase II, construction of beamlines will continue.

2. INJECTORS

2.1. Injector Linac

The SPring-8 linac has 26 accelerating columns. Each column is 2.835 m long and operated at the gradient of 16 MeV/m. The linac has space for electron/positron converter at 250 MeV, and can accelerate electron or positron up to 1.15 or 0.9 GeV. Main parameters of the linac is listed in Table 1.

Table 1 Parameters of linac

Output Energy	1 GeV
Operation Rate	60 Hz
Radio Frequency	2856 MHz
Type of Acc. Column	Travel. Wave
Length of Acc. Column	2.835 m
Number of Columns	26
Total Length	140 m
Klystron Max. Power	80 MW
Emittance (1 GeV)	< 1.0 πmm•mrad
Energy spread	± 1.0 %

The construction of the injector linac was started in 1991. The preinjector part of the linac has been operational in Tokai campus and the beam performance has already been evaluated. Measured emittance was about 5 πmm•mrad(9 MeV), and the pulse width for short pulse mode was less than 1 nsec. All the accelerating columns have already been delivered in the site. The performance test for the first fabricated one was good enough to satisfy the specification. Construction of linac building will be completed in September '94. Detailed description is in reference [1].

2.2 Booster Synchrotron

The booster synchrotron has 2-fold symmetric 40 FODO cells. Two straight sections are used for injection, extraction and RF acceleration. Eight 5-cell cavities with inductive coupling slots are adopted and the RF power of 508.58 MHz is provided by Two 1.2-MW klystrons. Maximum RF voltage is 18.2 MV/turn with 10 sec of quantum lifetime. The construction of the synchrotron was started in March 1993. All the components have been ordered to manufacturers and each preceding component (dipole, quadrupole, sextupole, cavity etc.) has manufactured and now under testing. Construction of the synchrotron building will be completed in March 1995.

Table 2 Parameters of synchrotron

Injection Energy	1 GeV
Max. Energy	8 GeV
Circumference	396.12 m
Repetition Rate	1 sec
Natural Emittance	230 n m•rad.
Momentum Spread	0.00126
Number of Cells	40
Nominal Tune (ν_x/ν_y)	11.73/8.78
Radio Frequency	508.58 MHz
Radiation Loss(8 GeV)	12.27 MeV/turn

3. STORAGE RING

3.1. Lattice and fundamental features

Design principles of the SPring-8 storage ring are as follows;

1) insertion device oriented ring,

2) the first harmonic undulator radiation from 10-20 keV with more than 10^{19} photons/sec/mm^2/mrad^2/0.1%b.w.,

3) several very long straight sections for special insertion devices,

4) low emittance lower than 10 n m•rad.,

5) good photon beam stability,

6) good time structure.

To satisfy above requirements, energy of 8 GeV and Chasman-Green lattice structure was adopted. The ring has a 4-fold symmetric structure with 44 normal cells and 4 straight cells, and total circumference is 1436 m. A normal cell has 2 dipole, 10 quadrupole, 7 sextupole magnets, and a 6.65 m long straight section, while a straight cell has no dipole magnets and can be changed to 30 m long straight section by rearranging Q and S magnets at a matured phase. This long straight section is one of the special merits of SPring-8[2,3]. Table 3 summarizes major parameters of the storage ring.

Table 3 Major parameters of the SPring-8 storage ring

Electron Energy	8 GeV
Current (multi-bunch)	100 mA
(single-bunch)	5 mA
Circumference	1435.95 m
Synchrotron Radiation	
Energy Loss per Turn	9.23 MeV/turn arc
	12.4 MeV/turn with ID
Critical Photon Energy	28.9 keV
Length of Straight Section	6.65 m normal
	~30 m long
Bending Radius	39.272 m
Natural Emittance	5.55 nm•rad.
Synchrotron Frequency	0.01005
Momentum Compaction	1.46×10^{-4}
Type of Lattice	Chasman-Green
Number of Cells	44 Normal cell
	4 Straight cell
Energy Spread	0.001094
Harmonic Number	2436
Radio Frequency	508.58 MHz
RF Voltage	17 MV
Bunch Length σ	3.63 mm

About a half of the main magnets (dipole, quadrupole, sextupole ones) have already been delivered in the site and the remainings are under fabrication. A part of power supplies for these magnets have been completed. Magnetic field measurement for bending magnet is underway. The measurement for 72 dipole magnets has been completed and the deviation of performance has been proved to be low. The measurement for QM and SM is to start. Field measuring instrument is being improved to get the field center within 10 μm. Magnet alignment will be performed in two stages. QMs, and SMs in a common girder are aligned within 50 μm, and girders are within 200 μm. Prototype girder has been made and under testing. Injection system of the storage ring has 5 bump magnets and DC and pulse septum magnets. One extra bump magnet will be used for on-axis injection only at commissioning phase.

3.2. Vacuum System

Vacuum system consists of two types of vacuum chamber, crotches, absorbers, and various components such as bellows, flanges and valves. One cell components (2 bending chambers, 3 straight chambers, crotches, absorbers, pumps and so on) have been assembled in a test bench with girders and magnets. In this test bench, various test such as girder alignment, magnets set up and alignment, installing chambers and vacuum components (taking off the upper part of magnet), vacuum test, and baking, and so on, have already been performed. After the performance confirmation, construction of the rest 47 cells of chambers are to start.

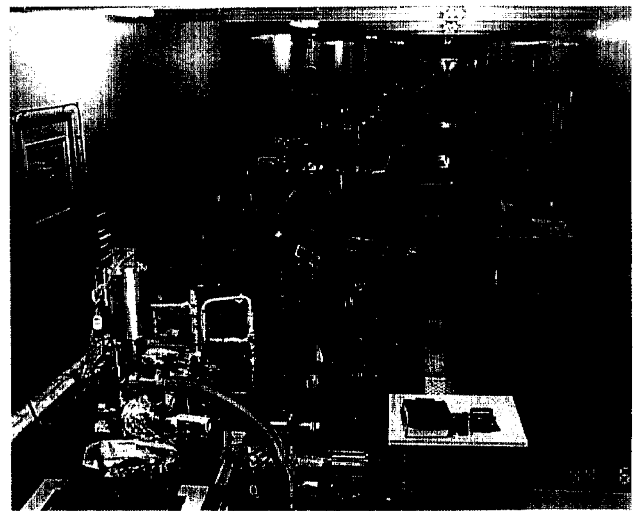

Figure 1. String test set up in one cell test bench.

3.3. RF system

The storage ring has 4 RF stations and each station has 8 single cell cavities which are powered by 1.2 MW klystron at 508.58 MHz. A klystron and a new type of high voltage power supply for one of the four RF stations was installed in Dec. 1993, and the test of the power supply is in progress. Some of the RF components were tested with high power[4]. HOM property of the prototype cavity has been completed and 8 cavities for one RF station have been ordered and will be fabricated in 1995.

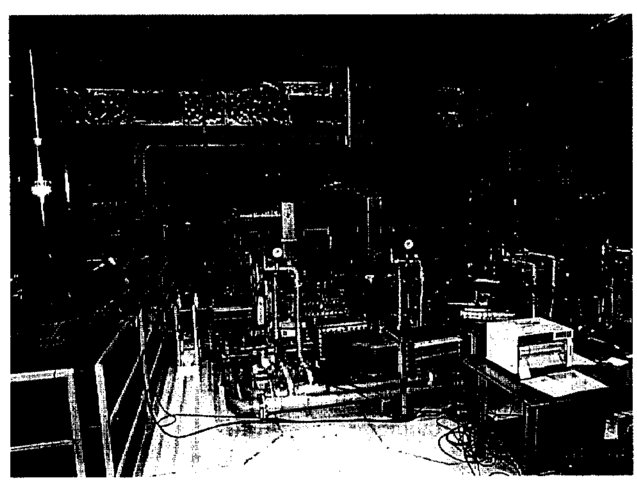

Figure 2. Klystron, waveguides, circulator, and dummy loads in D-RF station.

3.4. Control system

The SPring-8 control system adopts a distributed computer system using high speed optical fiber single layer FDDI network, and a replicated shared memory network for high speed information transfer. Engineering workstations (EWS) are used for man-machine interfaces and UNIX OS for the operation system. VME-bus is used for data acquisition system and HP-RT for its OS. Control programs for preinjector of the linac, magnets, RF system are being developed. Magnet power supply control system is presented in this conference [5].

4. CONVENTIONAL FACILITIES

Construction of the storage ring was started in 1991. The phase I (9%) and phase II (16%) construction has already completed. The completion of the shielding tunnel will be September 1995. The ring is built directly on the hard rock bed. Four expansion joint lines are introduced on the storage ring floor to separate the shielding tunnel and experimental hall from other structures to reduce the deformation and vibration transfer. Temperature inside the tunnel is kept at 27 ± 1 °C by air-conditioning [3].

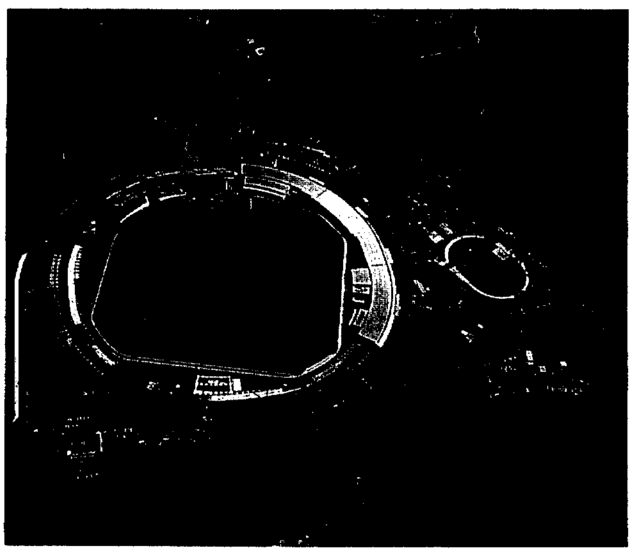

Figure 3. SPring-8 construction site.

5. BEAMLINES

The storage ring will be operated in the hybrid mode which has alternatively high and low betatron function at the dispersion-free straight sections. Table 4 shows the electron beam size at source points. Figure 4 shows spectral brilliance for typical source of the SPring-8.

Table 4 Electron beam size at source point

	BM1	BM2	high β	low β
β_x (m)	3.21	2.10	24.0	0.951
β_y (m)	19.4	18.2	11.9	5.50
σ_x (μm)	134	142	348	69.3
σ_y (μm)	104	95.9	77.6	52.7
$\sigma_{x'}$ (μrad)	76.1	104	14.5	72.8
$\sigma_{y'}$ (μrad)	5.58	5.33	6.51	9.58

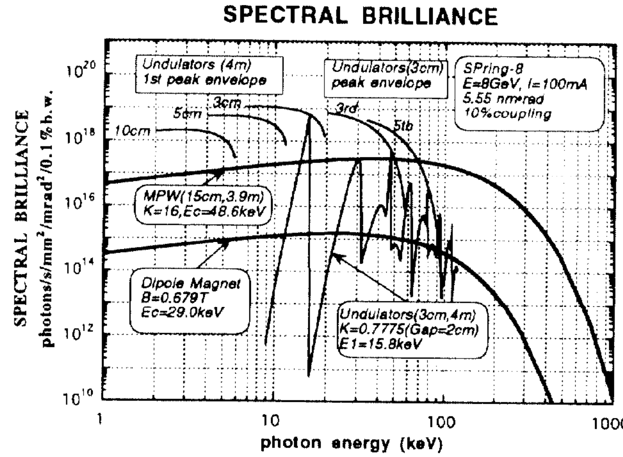

Fig. 4. Spectral Brilliance from the SPring-8 Light Sources

Total number of beamlines is 61 (38 ID and 23 BM). Among 38 ID beamlines, 4 are from straight cells. The length of normal beamlines is 80 m. Nine and three beamlines can be expanded up to 300 m and 1000 m. Beamlines of the SPring-8 are classified into 3 types. First type is public beamline which is constructed by the SPring-8 and open for general users. Second type is beamline for specific use and constructed by the user with their own expenses and sole use is permitted for a fixed term. Third type is beamline for machine study and monitoring. Concept of pilot beamline is introduced in the public beamline to establish design criteria of beamlines in advance and to standardize beamline components. Two pilot beamlines are adopted. One is a high energy undulator beamline for macromolecular crystallography. The other is a helical wiggler beamline for high resolution Compton scattering [6].

Development of insertion devices is in progress, and the general policy is to get hard X-rays by the first harmonic of undulator radiation, and to get high brilliance or high energy photons without unreasonable heat load, and to get undulator tuning at any time (independent tuning). Possible candidates are in-vacuum type undulators and helical undulators. On the other hand a new type planar helical undulator APPLE-1 has been developed [6]. This undulator can generate variously-polarized radiation without restricting the horizontal aperture for the electron beam. The effect of wiggler on beam dynamics has been investigated and to be reported [7].

6. REFERENCES

[1] S. Suzuki et al., in this conference.
[2] T. Ohta et al, Synchrotron Radiation Facilities in Asia, Tokyo: Ionics, 1994, PP. 17-34.
[3] SPring-8 Project Part I Facility Design 1991(Revised).
[4] H. Ego et al, in this conference.
[5] H. Takebe et al, in this conference.
[6] Digest of the 3rd Meeting of the Intern. Advisory Committee for the SPring-8 Project. Nov. 1993.
[7] K. Soutome et al, in this conference.