Status of the SPring-8 Project (Storage Ring)

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Abstract

SPring-8 is the third generation synchrotron radiation X-ray source facility which is under construction in Japan. The light source ring stores a low emittance (ε_n =7 nm•rad) electron beams and is optimized for the insertion devices to get high brilliance from undulators and high flux from wigglers in the X-ray region. This paper describes the general description and the present status of SPring-8 storage ring.

I. GENERAL DESCRIPTION

The accelerator system of the SPring-8 composed of 1 GeV linac, 8 GeV synchrotron, and the storage ring. The general layout of the facility is shown in figure 1 and the major parameters are listed in Table 1. The construction was started in 1990 and the facility is scheduled to come to operation in 1998. The ground preparation in Harima Science Garden City in Hyogo prefecture has been started and will be completed in 1992. Since the construction of the storage ring building is scheduled to start in this summer, the final specification of the related parts has been fixed. The design of the storage ring was reviewed mainly from the cost reduction point and a part of the magnets was ordered. The construction of the vacuum and RF systems will start this year. The detailed design of the storage ring building are in progress.

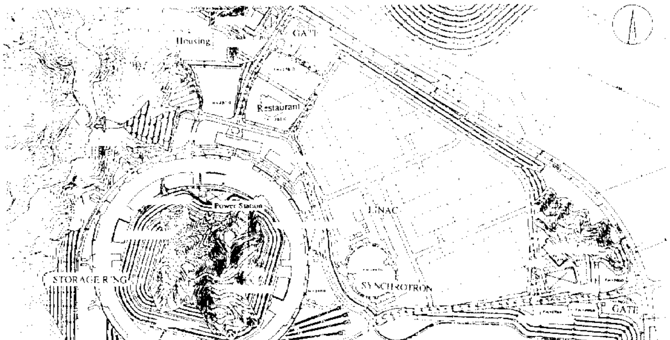

Fig. 1 Layout of SPring-8 facility

II. LATTICE

Chasman Green lattice structure has been adopted for the storage ring. There are 48 unit cells of which forty-four are normal and four are straight cells. A normal unit cell is composed of 2 dipoles, 10 quadrupoles, and 7 sextupoles. For a straight cell, dipole magnets are taken off. The optical characteristics are equivalent for straight and normal cells. The length of a straight section is 6.65 m for a normal cell. Figure 2 shows the betatron and dispersion functions through 6 cells. At a straight cell, a long straight section is formed where four spaces for insertion devices can be installed. This long straight section has a flexibility of expansion by rearranging magnets[1].

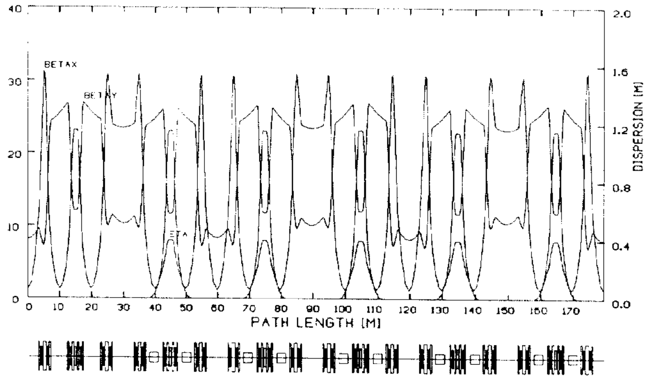

Fig. 2 Lattice functions through 6 cells including straight cell

Table 1 Major parameters of the storage ring

Energy (GeV)	8
Current(multi-bunch) (mA)	100
Current(single-bunch) (mA)	5
Circumference (m)	1435.948
Dipole magnetic field (T)	0.679
Bending radius (m)	39.2718
Type of lattice	Chasman-Green
Number of cells Normal/Straight	44/4
Length of straight section normal/long (m)	6.65/~30
Natural emittance (πnm·rad.)	6.99
Critical photon energy (keV)	28.90
Tune ν_x/ν_y	51.22/16.16
Synchrotron tune ν_s	0.01005036
Momentum compaction α	1.4597x10-4
Natural chromaticity ζ_x/ζ_y	-115.86/-40.03
Energy loss in the arcs (MeV/rev)	9.2263
Energy spread σ_e/E	0.0010936
Damping time $\tau_x/\tau_y/\tau_e$(msec)	8.30/8.31/4.15
Harmonic number	2436
R.F. voltage (MV)	17
R.F. frequency (MHz)	508.58
Bunch Length σ_s (mm)	3.63

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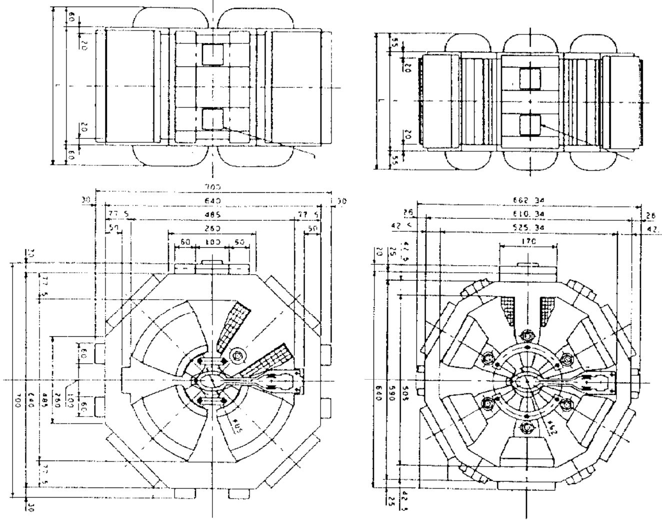
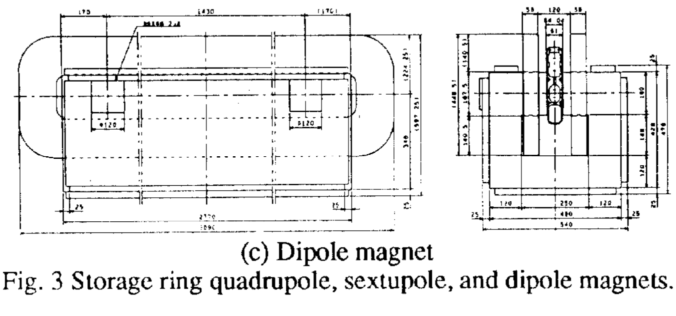
III. MAGNET SYSTEM

In the storage ring, 88 dipoles, 480 quadrupoles, 336 sextupoles, 480 steering magnets, 3 septum magnets, and 5 bump magnets are used. The final design of the main magnets (dipole, quadrupole and sextupole) have been completed based on the field measurement for prototypes and these magnets have already ordered[2]. The purpose of this review was in cutting down cost, making small and light, and saving waste without deteriorating specifications. Major alterations are shortening in width and length of dipole magnet, reducing bore radii and lengths of quadrupole and sextupole magnets, and making two types of cross sections for quadrupole and sextupole magnets in order to avoid the interference between yokes and photon beam extraction pipe. Steering magnets incorporated into sextupole magnets are separated. All the dipole magnets are electrically connected in series and powered by a single power supply. For quadrupole and sextupole magnets, corresponding magnets are connected in series considering the operation mode. Four buildings for power supply and water cooling are distributed along the inside of the ring. Design of the pulse magnets such as septum and bump magnets and power supplies for them are in progress. It is scheduled to make prototypes of pulse magnets and power supplies.

Magnet alignment is one of the most important things in the light source ring with low emittance. At present, geodetic points, monuments, building structure, magnets supports, fixing of the supports, and alignment method are intensively examined. Global positioning system (GPS) and new type of quadrupole and sextupole magnets alignment are investigated[3].



(a) Quadrupole magnet (b) Sextupole magnet



(c) Dipole magnet

Fig. 3 Storage ring quadrupole, sextupole, and dipole magnets.

IV. RF SYSTEM

A frequency of 508.58 MHz has been adopted for the storage and synchrotron rings[4,5]. The ring has five RF stations one of which is for the third harmonic system and used for bunch length and instability control. Each RF station has 1 MW klystron from which RF power is divided and fed to 8 single cell cavities. Figure 4 shows the layout of RF station. As for the high power transmission circuit, design is progressing. Since the stored current is limited by higher order modes (HOM) exited through electron beams, the cavity with low HOM impedances is investigated.

Teststand with 1 MW klystron has been constructed and high power test of the klystron has been completed[4]. Prototypes of single cell cavity, tuner, and coupler have also been constructed and delivered. High power test for prototypes are in progress. The final design of RF system based on these tests has to be fixed and the order for one RF station is scheduled within this year.

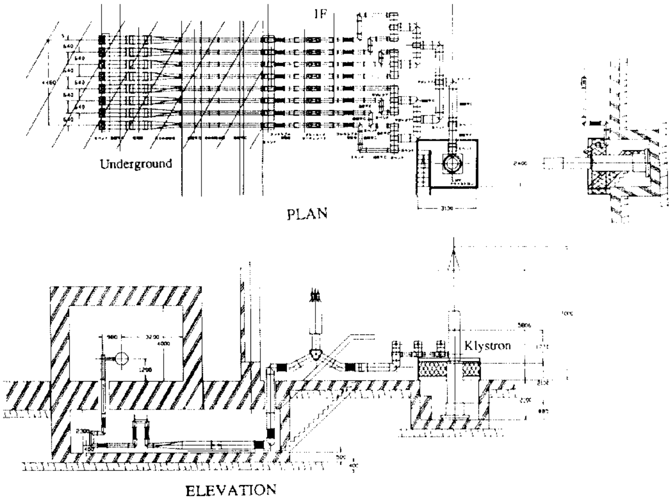


Fig. 4 Layout of the RF station

V. VACUUM SYTEM

Cross sectional shape of the vacuum chamber was slightly changed according to the reduction in bore radii of quadrupole and sextupole magnets. As for baking of vacuum chamber, heating method is changed from using sheath heater to using pressurized hot water.

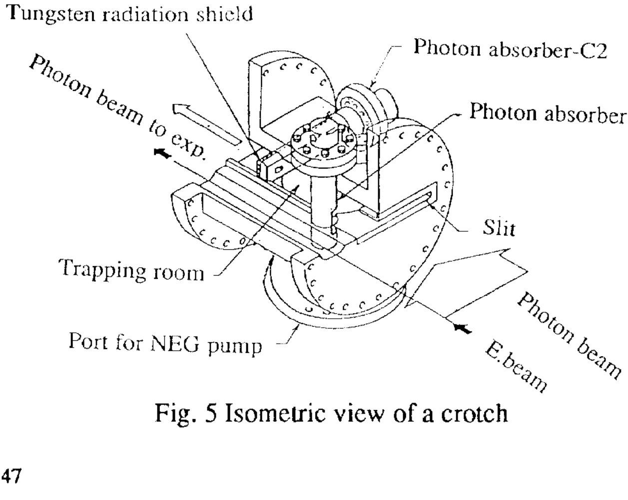


Fig. 5 Isometric view of a crotch

Most of the synchrotron radiation from bending magnets is intercepted by crotches and absorbers. The design of crotch and absorber was progressed. Size and weight of the crotch are reduced. Figure 5 shows the bird's eye view of the crotch. R&D of various vacuum components have made progress. Some of the vacuum chamber and components are scheduled to make order within this year.

VI. CONTROL SYSTEM

Design of the control system is in progress[7]. Distributed control system connecting computers through network is introduced for SPring-8. Figure 6 shows the schematic diagram of the system. This system consists of a central control system, a program developing system, and several local control systems for each accelerator. Each local system consists of a host computer, several front-end processors (FEP) and an operator's console. The FEPs linked at the lower hierarchy level are microprocessors such as VME (Versa Module European) crate systems and crate controllers. Integrated microprocessors are used at equipment levels for driving motors and so on. Engineering workstations are used as operator's consoles.

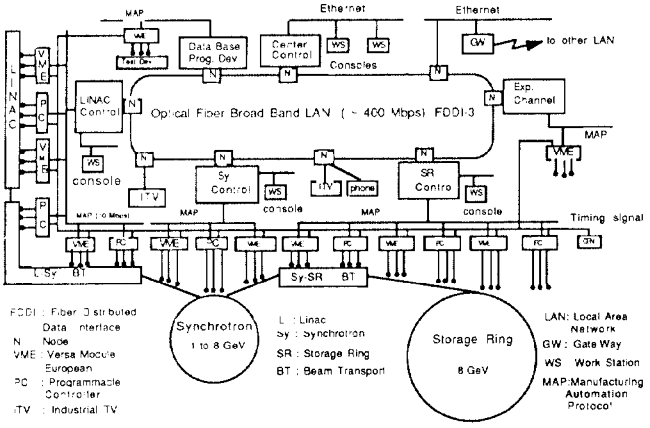


Fig. 6. Schematic diagram of control system for SPring-8.

VII. BEAMLINES

The storage ring has 44 straight sections thirty-eight of which are available for insertion devices. Twenty-three beam lines can be extracted from dipole magnets. The length of the beam line from the source is designed to be about 80 m. The length within the shielded tunnel is from 24 to 30 m. Eight beam lines can be expanded up to 300 m and three beam lines up to 1000 m. Horizontal angular aperture is limited within ±1 mrad to avoid the interference with magnets yokes. This limits the horizontal deflection parameter of a wiggler. Vertical angular aperture is limited at the slots of bending vacuum chamber and crotch within ±0.3 mrad. An octant of the experimental hall is shown in Fig. 8. Two preparation rooms are allotted to each beamline. At the backward of long straight sections, shielding wall has holes for alignment. These holes are also used for FEL experiment. At the commissioning, 10 beamlines (6 ID & 4 BM) are prepared. Spectral brilliance are shown in Fig. 8.

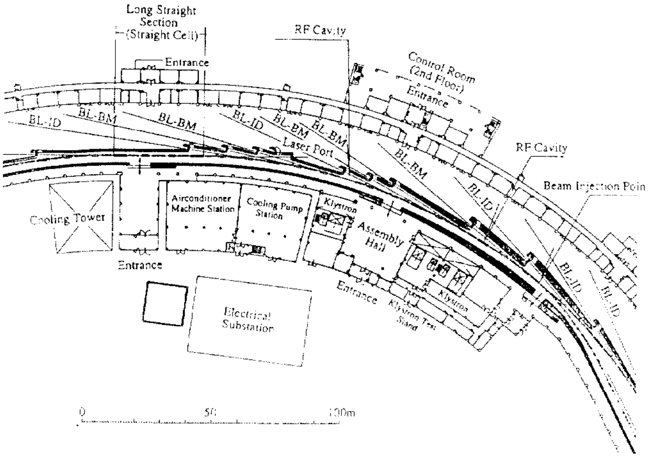


Fig. 7. An octant part of the experimental hall.

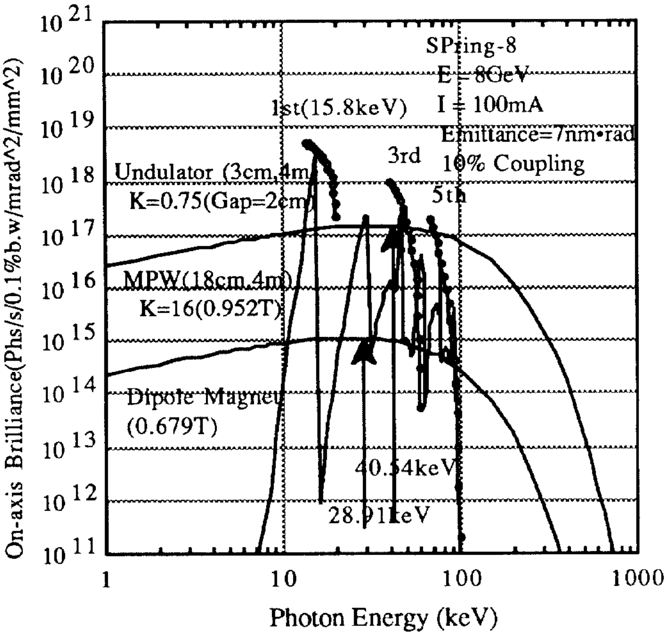


Fig. 8 On-axis brilliance in SPring-8

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