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SPEAR 3: A High Flux Synchrotron Light Source†

Jeff Corbett and Tom Elioff for the SPEAR 3 Technical Staff
Stanford Synchrotron Radiation Laboratory*

To better serve the expanding SSRL user community, SSRL will replace all major technical systems in a SPEAR upgrade in 2003. The 4-year, 58 M$ SPEAR 3 upgrade project is funded jointly by the DOE and the NIH. The main goals of the project are to increase photon flux and provide stable photon beams to the user community. To achieve these goals, SSRL will replace the entire tunnel floor, support rafts, vacuum chamber, magnet lattice, RF system, power supplies and cable plant in a 6-month shutdown period. The existing arrangement of 27 experimental beam lines with wiggler, undulator and bend magnet source points will remain largely unchanged.

The new SPEAR 3 storage ring will have 18 nm-radian emittance and straight sections available for up to 13 insertion devices. SPEAR 3 will provide stable, 3 GeV beam operation with currents up to 500 mA and beam lifetimes of >15 hours. Much of the storage ring hardware is based on PEP-II B-Factory technology, including the copper vacuum chamber and mode-damped rf cavities.

The accelerator layout of SPEAR 3 is shown in **Fig. 1** with the standard cell structure and first article raft assembly shown in **Fig. 2** and **3**. All systems are designed for a top energy of 3.3 GeV (350 mA). At 3.0 GeV, SPEAR 3 will provide 10–100 times higher flux density than SPEAR 2 opening new research opportunities in the fields of materials technology, high-throughput protein crystallography and environmental science.

Several features of the SPEAR 3 lattice have been optimized to improve photon beam quality. First, the emittance and betatron functions were reduced to decrease horizontal

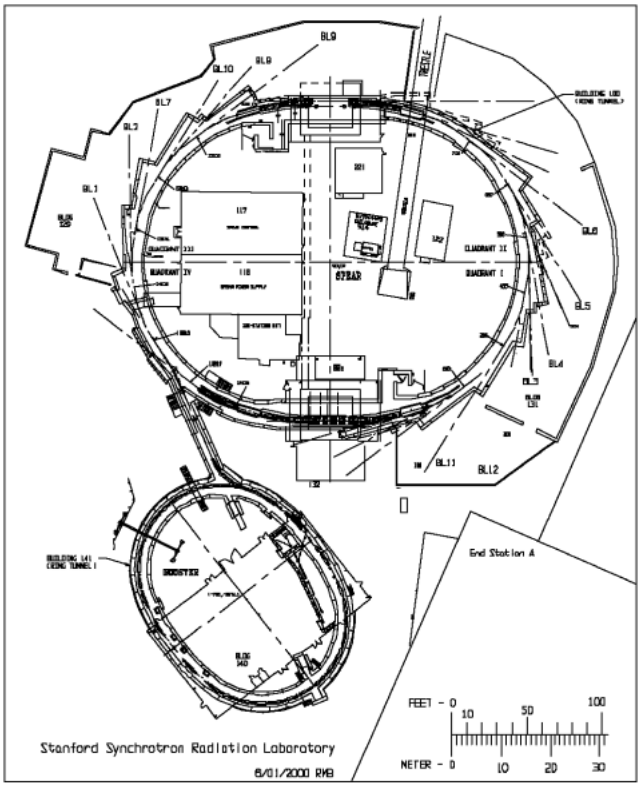

Figure 1.　SPEAR 3 Light Source.

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* Stanford Synchrotron Radiation Laboratory, P.O. Box 4349, Bin 69 Stanford, California 94309-0210, USA
TEL:　+1-650-926-3645　FAX:　+1-650-926-4100　E-mail:　corbett@slac.stanford.edu

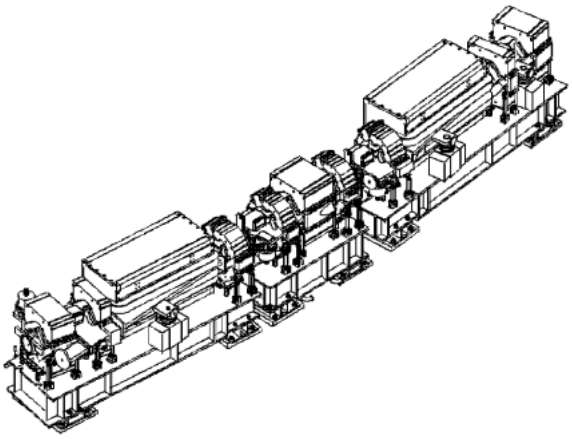

Figure 2. Standard cell assembled on three support rafts.

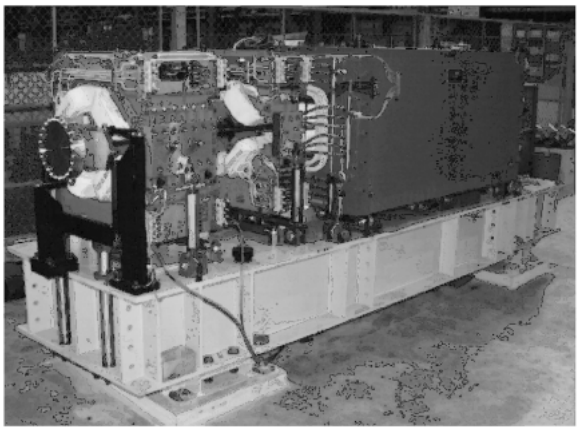

Figure 3. First Article Raft Assembly.

beam size from 2 mm to 430 micron. In the process, the dipole magnet strength was raised to boost critical energy from 4.8 to 7.6 keV. In the 20 keV range, bend magnet beam lines will produce photon beam flux densities comparable to the most intense wiggler beam in SPEAR 2 (BL 10–2). To provide for future dipole beam line expansion, 14 of the 18 magnet cells will have dipole-beam exit ports. For comparison, the main machine and electron beam parameters for SPEAR 2 and SPEAR 3 are shown in **Table 1**.

In addition, four 2.3 m straight sections in SPEAR 2 were increased to 4.8 m. Three of these 4.8 m straights will be available for new beamlines. ID sources under consideration include a 3.8-m elliptically polarized undulator for soft x-ray (250–2600 eV) applications. Finally, the collider physics straight sections were optimized to provide two 7.6 m straights. One of these straights will contain four PEP–II RF cavities. The other straight is available for either a long undulator or two 2-m, in-vacuum small-gap undulators for high brightness hard x-ray applications (>6 keV).

Table 1. Parameters for SPEAR 2 and SPEAR 3

	SPEAR 2	SPEAR 3
Energy	3 GeV	3 GeV
Current	100 mA	500 mA
Emittance (w/ID)	160 nm-rad	18 nm-rad
RF frequency	358.5 MHz	476.3 MHz
RF gap voltage	1.6 MV	3.2 MV
Lifetime@Imax	30 h	>18 h
Critical energy	4.8 keV	7.6 keV
Tunes (x, y, s)	7.18, 5.28, 0.019	14.19, 5.23, 0.007
e-σ (x, y, s)–ID	2.0, 0.05, 23 mm	0.43, 0.03, 4.9 mm
e-σ (x, y, s)–dipole	0.79, 0.20, 23 mm	0.16, 0.05, 4.9 mm
Injection energy	2.3 GeV	3 GeV

Along with the SPEAR 3 project comes a parallel beam line upgrade program to utilize the high power radiation beams. Existing bend magnet and wiggler beam lines will be optimized for applications exploiting high flux density photon beams with modest beam collimation (macromolecular crystallography measurements, XAS, etc.). Two 9 period 2.0 T wigglers will replace older 4 period, 1.8 T wigglers to further enhance output.

The current status of the SPEAR 3 project is approximately 70% completion of the overall technical systems design and 40% completion of machine fabrication. The SPEAR 3 magnets are being produced in collaboration with IHEP with over 50% delivered. The production of the copper vacuum chamber is fully underway utilizing the SLAC e-beam welder. The 1.2 MW klystron for the RF system has been received, and the RF cavities will be delivered by the end of the 2001. Shielding modifications will be 75% complete this year.

All technical systems are scheduled to be assembled 3 months ahead of the April 2003 shutdown. To minimize interruption to the user program, modifications to buildings and utilities will be made during maintenance periods before the 2003 shutdown. The SPEAR 3 accelerator will deliver beam at the earliest possible date in 2004.