

## A1. Storage Ring Parameters

The initial lattice structure of the SPring-8 storage ring was based on the double-bend achromat with 48 unit cells, which is called a 'Phase-I lattice'. There were four long straight cells with missing-bend. In summer shutdown of 2000, four magnet free long straight sections, which were about 27 m long, were realized by removing quadrupole and sextupole magnets in the straight cells and rearranging the sextet quadrupoles at both end of long straight cell. This new lattice structure is called a 'Phase-II lattice'.

We tried to reduce the emittance by breaking the achromat condition imposed on lattice structure. This method is effective for the case where undulators with a moderate field are used as insertion devices. The SPring-8 storage ring just meets this condition and the emittance can be reduced by half. From the last operation-cycle of 2002 to the 6th of 2003 this new optics was released to user operation.

The major beam parameters of the SPring-8 storage ring before and after introducing the low emittance optics are listed in Table 1.

Masaru Takao  
(Accelerator division)

Table 1. Performance of the SPring-8 storage ring

Optics		Achromat	Low Emittance
Energy [GeV]			8
Revolution time [ $\mu$ s]			4.78
Number of buckets			2436
Maximum current [mA]	Multi		100
	Single		10
Horizontal emittance [nmrad]		6.6	3.4
Emittance coupling ratio			0.002
Bunch length (FWHM) [ps]		32	34
Relative energy spread ( $\Delta E/E$ )			$1.1 \times 10^{-3}$
Horizontal beam size ( $\sigma$ ) [m]	ID	$4.01 \times 10^{-4}$	$3.01 \times 10^{-4}$
	Long ID	$3.93 \times 10^{-4}$	$2.95 \times 10^{-4}$
	B1	$1.48 \times 10^{-4}$	$1.07 \times 10^{-4}$
	B2	$1.49 \times 10^{-4}$	$1.14 \times 10^{-4}$
Vertical beam size ( $\sigma$ ) [m]	ID	$8.70 \times 10^{-6}$	$6.18 \times 10^{-6}$
	Long ID	$1.38 \times 10^{-5}$	$9.77 \times 10^{-6}$
	B1	$1.79 \times 10^{-5}$	$1.30 \times 10^{-5}$
	B2	$1.88 \times 10^{-5}$	$1.37 \times 10^{-5}$
Horizontal beam divergence ( $\sigma$ ) [rad]	ID	$1.64 \times 10^{-5}$	$1.23 \times 10^{-5}$
	Long ID	$1.67 \times 10^{-5}$	$1.25 \times 10^{-5}$
	B1	$7.49 \times 10^{-5}$	$5.62 \times 10^{-5}$
	B2	$1.05 \times 10^{-4}$	$7.42 \times 10^{-5}$
Vertical beam divergence ( $\sigma$ ) [rad]	ID	$1.51 \times 10^{-6}$	$1.10 \times 10^{-6}$
	Long ID	$9.54 \times 10^{-7}$	$6.96 \times 10^{-7}$
	B1	$7.99 \times 10^{-7}$	$5.85 \times 10^{-7}$
	B2	$7.86 \times 10^{-7}$	$5.75 \times 10^{-7}$