Beam Performance

Beam Performance of the Storage Ring and Upgrades

Last summer, the optics of the storage ring were changed from the hybrid optics to "HHLV" optics (Fig. 1). The hybrid optics have a high horizontal β value for the straight section of every odd cell, and a low horizontal β value for every even cell. The optics were optimized for the beam commissioning to reduce the effect on beam instability due to the installation of RF cavities and wigglers in the low β section. The HHLV optics have High Horizontal β value and Low Vertical β value" for all straight sections, and were installed to improve effectively the brilliance for undulator use in the low beta section of the hybrid optics. After fine-tuning of new HHLV optics, beam performance has achieved comparable levels to hybrid optics. Table 1 shows the achieved beam performance and the design specifications of the storage ring.

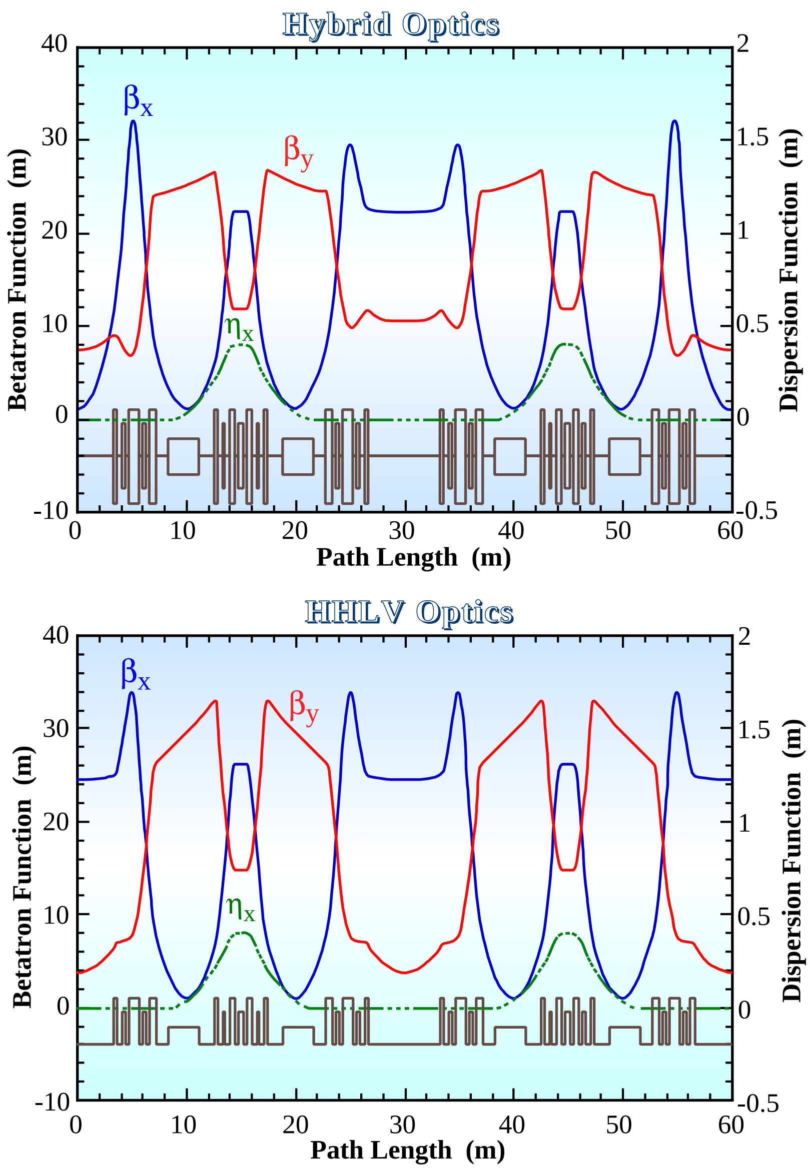

Fig. 1. Optical function

Table I : Beam Performance

	Designed Value Hybrid / HHLV	Achieved Hybrid	Achieved HHLV
Energy	8 GeV	8 GeV	8 GeV
Symmetry	24 / 48	24	48
(β_x / β_y) at ID		(24 / 10) (1 / 8)	(25 / 3.5)
Stored current multi / single	100 mA / 5 mA	100 mA / 16 mA	100 mA / 16 mA
Bunch length multi / single	35 psec	35 psec / 100 psec	
Emittance	6.9 / 6.2 nm•rad	6.8±0.5 nm•rad	6.2 nm•rad
Coupling	less than 10 %		
Visibility		< 0.2 %	< 0.2 %
Toucheck lifetime		~ 0.06 %	~ 0.06 %
Tunes (ν_x / ν_y)		51.16 / 16.36	43.16 / 21.36
Energy spread ($\Delta E/E$)	0.0011	0.0011	0.0011
Chromaticity (ξ_x / ξ_y)	0 / 0	3.2 / 3.9	7 / 4
Momentum acep.	1.8% (12 MV)	1.3 % (12 MV)	3 % (16 MV)
Lifetime			
Multibunch (100 mA)	24 hr	~ 55 h (2/3)	~ 160 h (24/29)
Single (1 mA / bunch)		~ 6 h	~ 32 h
Impurity		< 10^{-7}	< 10^{-7}
Beam size at ID			
Horizontal	400 μm / 86 μm	400 μm / 86 μm	390 μm
Vertical	80 μm / 74 μm	< 12 μm / < 10 μm	< 7 μm
Slow orbit change Hor./ Ver. (rms) at ID	10 % of the beam size	periodic correction < 0.5 μm / < 0.4 μm	periodic correction < 0.8 μm / < 0.5 μm
Fast orbit change Hor./ Ver. (rms) at ID	10 % of the beam size	no correction ~ 2 μm	no correction ~ 2 μm
Dispersion at ID		no correction	by 24 skew quad
Horizontal (rms)	0 cm	1.4 cm	1.0 cm
Vertical (rms)	0 cm	0.4 cm	< 0.1 cm

Installation of a fourth RF station

A fourth RF station has been installed in the storage ring to improve the Touschek lifetime, especially in the several bunch modes. Due to this installation, the total beam lifetime using HHLV has been improved from 11 hours to 32 hours in the several bunch modes with a coupling ratio of 0.1%, a bunch current of 1 mA/bunch and an RF voltage of 16 MV. In the multibunch operation mode, lifetime has been improved from 100 hours to 160 hours, with a coupling ratio of 0.1%, a current bunch of 0.05 mA/bunch, a beam current of 100 mA and an RF voltage of 16 MV. In this multibunch case, the lifetime due to the gas scattering and the Touschek lifetime are about 220 hours and 700 hours, respectively.

Fast-orbit vibration

The fast-orbit vibration as shown in Fig. 2 can be observed in an arc section of the storage ring. The amplitude in the horizontal and vertical directions is about 5 micron (rms). This vibration amplitude corresponds to 2 microns at every ID section. The sources of the vibration are due to a pressure fluctuation in the coolant water for the magnets and vacuum chambers. The vibration level of the magnets is about 10 nm. We are at present, developing a quiet water-cooling system.

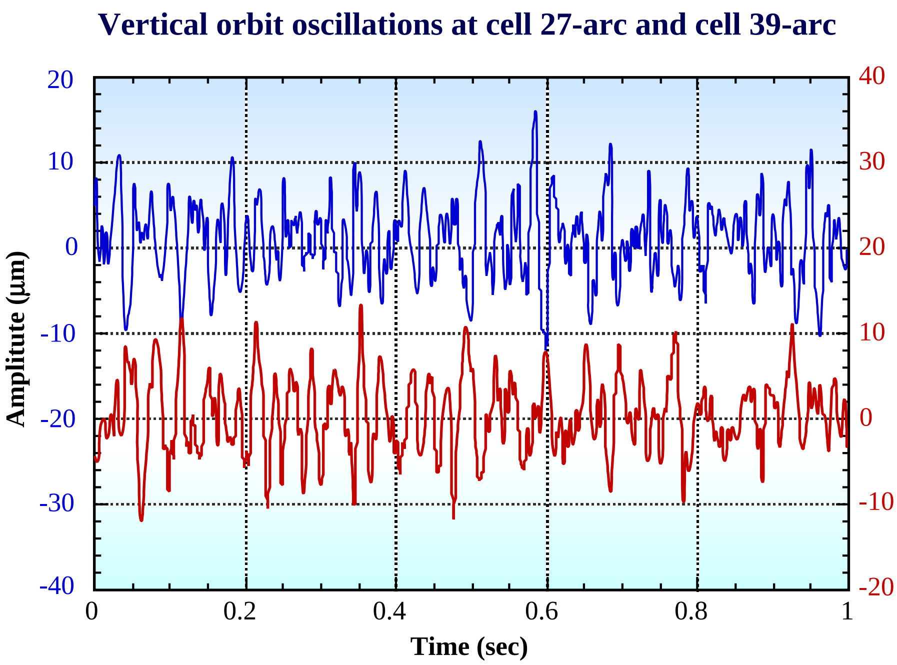

Fig. 2. Fast orbit vibration

Other studies and developments

The following studies and developments were carried out:

- Improvement of the orbit stability:

The temperature fluctuation of cooling water in magnet and vacuum systems was stabilized within 0.3 degrees by replacing the step response curve of the control logic in the cooling system with a continuous response curve.

- Reduction of the time lost due to a failure of the main magnet power supply:

A super magnet power supply, which can replace all of the main quadrupole and sextupole magnets power supplies, was developed and installed in the magnet power station.

- Construction of a beam diagnostic's beamline (BL38B2) to investigate the performance of the electron beam and to perform R&D on accelerator components such as analysis of the absorber heat load.

- Development of injection septum magnets with high magnetic performance and understanding of beam loss process at injection porch to install a top-up operation.

Beam Performance and Upgrade of Linac and Synchrotron

Linac

The beam qualities of linac have been studied in detail since the beam commissioning of 1996. The following improvements have been conducted since the commissioning:

- Fine tuning of optics.
- Stabilization of the RF power and RF phase due to the reduction of the temperature fluctuation of the atmosphere and cooling water in the klystron gallery.
- Installation of a chicane in the downstream of the last accelerator guide to monitor the injection energy of electron beams into the synchrotron.

As a result of these improvements, a horizontal and vertical beam emittances of 0.5 πmm•mrad and 0.3 πmm•mrad, respectively were achieved at 1 GeV, and the output current and the output energy were stabilized within $\pm$0.7% (1σ) and $\pm$0.1% (1σ), respectively.

Also, to improve the reliability of the RF system and the beam performance, the following developments have been carried out:

- A stable compact pulse modulator for 80 MW klystron using a 40 MHz inverter high voltage power supply has been developed and is now being tested.
- A photo-cathode single-cell RF gun was assembled in a test stand and high-power up to 18MW was fed into the cavity. A maximum electric-field gradient of 127 MV/m was achieved on the cathode. Photoelectrons induced by irradiation by the UV laser were extracted and the beam test is in progress.

Synchrotron

A single bunch beam has been formed by RF knockout (rf-KO) at the injection porch of the synchrotron since the beam commissioning in December 1996. To improve the purity of the single bunch beam in the storage ring, the installation of a high power rf-KO system and an increase in the time interval of the injection porch were performed. Consequently, an impurity level of less than 2×10^{-8} was achieved in the storage ring.

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