2. Design goals

2.1 Design goals

The main goal of the SLS design has been to achieve very high quality sources of synchrotron radiation. The source quality (*brightness*) is mainly determined by the electron beam quality (*low emittance*). The SLS storage ring design has been optimised to ensure the lowest beam emittance for a given ring size (cost). Summary of the main parameters of the storage ring is given in Table t21_a.

Ring energy: spectral coverage

The storage ring design energy is 2.4 GeV, which allows optimal coverage of the VUV/XUV spectral range with undulators. The low end, starting from around 5 eV, can be covered by a long period (200 mm) undulator that would produce a diffraction limited source of circularly polarised, fast switchable radiation. The high end, up to 17.5 keV is served with minigap, in-vacuo short period undulators (19 mm). The originally planned substitution of some of the central magnets of the triple bend achromats by superconducting dipoles has been abandoned for the first installation phase, but is still kept as an option. To extend the spectral range to the hard X-ray region, a minigap wiggler with the spectral coverage between 5 keV and 40 keV is foreseen.

Emittance

The ring lattice is optimised for the natural electron beam emittance below $5\cdot10^{-9}$ m·rad (in the following we refer to the values of emittance in units of nanometers, meaning 10^{-9} m·rad units). With the expected value of emittance coupling of 1%, this corresponds to the vertical beam emittance below 0.05 nm. These emittances are achieved with the optics that has zero dispersion function in all the straight sections. An emittance value of less than 4 nm can be achieved with optics that has non-zero dispersion in at least some of the straight sections.

Beam current

The design current in multibunch operation is specified at 400 mA (current per bunch of 1 mA, corresponding to 0.96 nC charge per bunch, or to $6\cdot10^{9}$ electrons per bunch). In the single or few bunch operation mode the current per bunch is specified at 10 mA. Peak currents in excess of 200 A should be attainable.

Table t21_a: Main storage ring parameters

Design energy	E	[GeV]	2.4
Design current (multibunch mode)	I	[mA]	400
Design bunch current (single bunch)	I_b	[mA]	10
Circumference	C	[m]	288
Equilibrium emittance	ε_{x0}	[nm·rad]	4.8
Emittance coupling	κ	[%]	1
Equilibrium relative energy spread (rms)	δ		$9\cdot10^{-4}$
Equilibrium bunch length (rms, 2.1 MV)	σ_s	[mm]	4
Straight sections		[m]	3x11, 3x7, 6x4

Beam lifetime

The lifetime of the electron beam in multibunch operation is specified to be greater than 10 hours. In single or few bunch operation mode it is planned to widen the overall energy acceptance of the ring by introducing a passive superconducting RF cavity, thus increasing the Touschek limited beam lifetime to 5 hours.

In other possible operating modes of the storage ring that would result in even higher phase space density of the electron beam and correspondingly short Touschek limited lifetime, it is planned to test and introduce the so-called continuous "top-up" injection. In this case the beam intensity is kept constant by very frequent injection of new electrons to compensate for the lost ones. The heat load on optical elements such as mirrors and monochromators would stay constant as well, resulting in very stable conditions for experiments. On the other hand, in the top-up mode, the experimenters will have to deal with higher radiation backgrounds.

Stability

The stability of the electron beam position is designed to be better than 10% of the rms beam size for the case of nominal 4 nm beam emittance with 1% coupling.

Flexibility

The SLS lattice has been designed to be very flexible to be able to accommodate alternative operating modes. These include:

- low emittance mode with non-zero dispersion in the straight sections, resulting in electron beam below 4 nm
- isochronous mode with close to zero momentum compaction factor for e.g. short pulse, high peak brightness applications
- relaxed mode, with larger emittance and larger values of the beta functions in the straight sections, for commissioning

Another aspect of the lattice flexibility is the ability to match the optics to a variety of possible insertion devices, in order to optimise brightness and to minimise deleterious effects on the electron beam:

- ability to accommodate long straight sections for the long period electromagnetic undulator based diffraction limited sources, possible two colour experiments or a possible ring based Free Electron Laser
- ability to provide mini-beta optics in the short straight sections needed for short period, minigap (4 mm) in-vacuum undulators and wigglers, as well as for superconducting wavelength shifters