THE VUV RADIATION SOURCE SUPER-ACO

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Abstract

Super-ACO, the radiation source under construction at Orsay is described and the main features of the ring are presented.

The Synchrotron Light Source Environment at Orsay

Two former high energy physics storage rings are used at Orsay as dedicated synchrotron light sources.

ACO is an electron ring, which is operated since 1965. Its maximum energy is 540 MeV. Output ports are installed in 4 bending magnets, and an optical klystron in a straight section 1.88 m long is used for free electron laser work.

DCI is operated with positrons. At its maximum energy of 1.85 GeV, the beam emittance is 1.2×10^{-6} m.rad, and the critical wavelength 3.4 A°. The stored intensity at high energy is typically 250 mA, and the lifetime about 40 hours. A superconducting wiggler will be installed next winter, allowing to reach a critical wavelength of 1 A°.

The new ring is meant to replace ACO. Super-ACO will have a better brilliance, a shorter critical wavelength, and six straight sections available for undulators. Positrons obtained from the existing Linac will be injected up to the maximum energy of the ring. Experience with DCI has proved the advantages of positrons versus electrons. There is no emittance growth, and lifetime is better and more reliable.

Characteristics of the Ring

Table 1 gives the general characteristics of Super-ACO.

The lattice has four symmetric periods, each half period having almost symmetric beta functions. The design aims at a low emittance, with a zero dispersion in the odd numbered straight sections, and a sharp minimum of beta x near the middle of the bending magnets.

In order to achieve a small vertical angular dispersion, beta z is fairly high. This forbids the use of wigglers which would distort too much the optics. Undulators have a weaker effect, and one doesn't expect too much trouble from the tune shifts or half integer stop-bands.

The nominal lattice has a low emittance at the design energy of 800 MeV. For the operation of a free electron laser in the VUV range, an energy of 400 MeV is desirable. At this low energy , due to Touschek effect, a higher emittance is required. For both regimes, the coupling between horizontal and vertical emittances is assumed to be .1.

Two families of sextupoles located in the quadrupoles of the even sections will correct the chromatic tune shift. This arrangement is rather unusual, but has proved to be effective both in ACO and in DCI. It saves some valuable space, and reduces the strength of the sextupoles by a factor of 3 as compared to a more conventional scheme, mainly because of the better decoupling between the beta functions. Even these weaker sextupoles had a harmful effect on the dynamic aperture, reducing it to about 15×10^{-6} m.rad, a value too small for good injection efficiency. It has then been necessary to add two new families of sextupoles in the non-dispersive sections. Acceptance calculations were made with tracking programs BETA and PATRICIA. A semi-analytic method has been developped to estimate the values of the sextupoles which reduce the strength of non-linear resonances close to the working point. The acceptance was then raised above 60×10^{-6} m.rad.

We expect no drastic limitation due to single bunch instability, but multi bunch instabilities may be more severe and need some cure. At nominal current and energy, the Touschek lifetime is 18 hours, and the gas lifetime 14 hours at 10^{-9} Torr average pressure.

Table 1 - General Characteristics

- Energy	800 MeV
- Critical wavelength from the bends	18.5 A°
- Number of light ports : - from the bends	13
- from undulators	6
- Available space for undulators :	2×2.0 m
	2×2.4 m
	2×3.0 m
- Maximum current	500 mA
- Maximum radiated power	10 kW
- Circumference	72 m
- Number of periods	4
- Number of quadrupole families	4
- Number of sextupole families	4

Technical Features

The ring is located in a 2000 m^2 hall, and is shielded with walls .4 m thick.

All the magnet is made of solid steel. The C-shaped bending magnets have parallel faces with end plates. The gap height is 70 mm, and the radius of curvature 1.7 m. The quadrupole lenses have a bore diameter of 120 mm. Each has special coils to create a sextupolar field, and additional windings to create dipole and/or quadrupole correcting fields.

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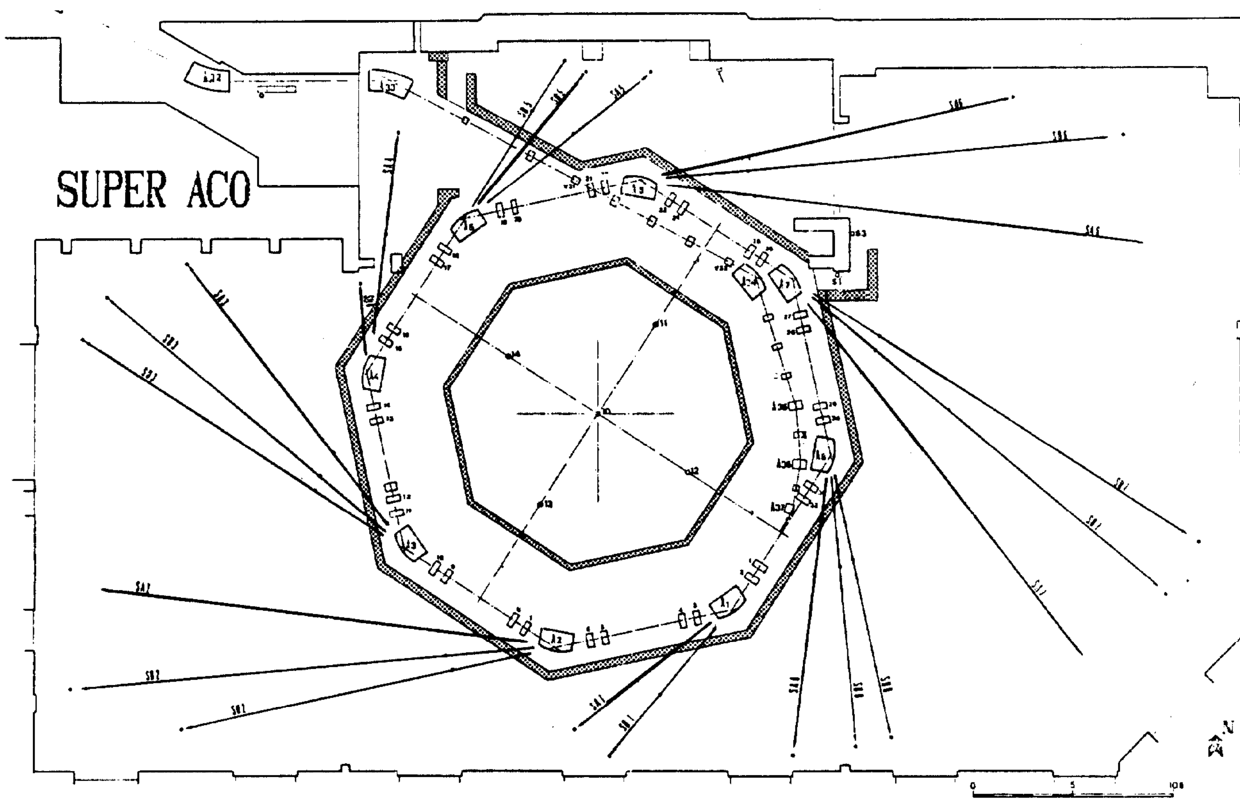

Fig.1. : General layout of Super-ACO

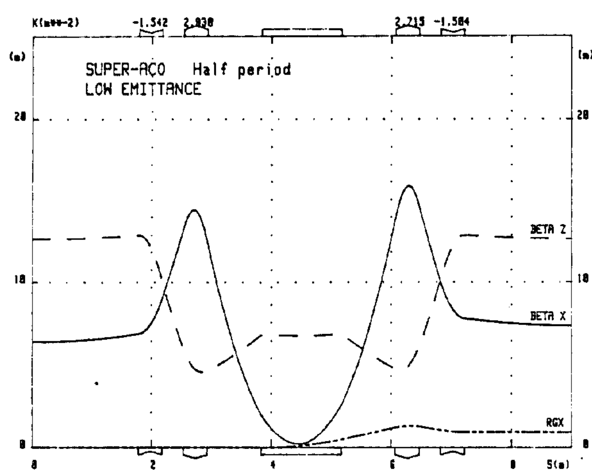

Fig.2. : Low Emittance Lattice Structure

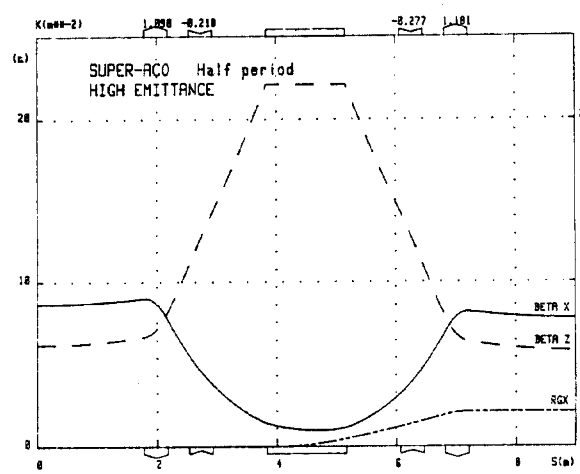

Fig.3. : High Emittance Lattice Structure

	Horizontal	Vertical
- Emittance	3.7×10^{-8}m.rad	3.7×10^{-9}m.rad
- Tunes	4.637	1.420
- Chromaticities	- 14	- 6.5
- Beam dimensions in odd magnets		
-	100 μm	158 μm
-	457 μrad	23 μrad
- Beam dimensions in odd straights		
-	486 μm	217 μm
-	76 μrad	17 μrad

- Energy spread 5.32×10^{-4}
- Bunch length @ 100 MHz RF, V = 200 kV, 20 mA/bunch : 42 mm (with 70 % lengthening expected from turbulent instability)
- Bunch length @ 500 MHz RF, V = 400 kV, 4 mA/bunch : 7 mm (no lengthening expected)

Table 2 : Low Emittance Optics (@ 800 MeV)

	Horizontal	Vertical
- Emittance	2.8×10^{-8} m.rad	2.8×10^{-9} m.rad
- Tunes	3.752	1.264
- Chromaticities	- 4	- 10
- Beam dimensions in odd magnets		
-	172 μm	250 μm
-	188 μrad	11 μrad
- Beam dimensions in odd straights		
-	493 μm	132 μm
-	57 μrad	21 μrad

- Energy spread 2.66×10^{-4}
- Bunch length @ 100 MHz RF, V = 200 kV, 20 mA/bunch : 42 mm (factor 5 lengthening expected from turbulent instability)
- Bunch length @ 500 MHz RF, V = 400 kV, 4 mA/bunch : 1 mm (factor 4 shortening expected from potential well !)

Table 3 : High Emittance Optics (@ 400 MeV)

The vacuum chamber is made of stainless steel with copper absorbers, and pumped out by seventeen 600 ℓ/s titanium sublimation pumps, eight 500 ℓ/s integrated ion pumps in the bends and sixteen 400 ℓ/s lumped ion pumps amounting to a total pumping speed over 20 000 ℓ/s, evenly distributed around the ring. The static pressure will be below 1×10^{-10} Torr after in situ bakeout at 250°.

The first RF system to be installed will work the 24th harmonic of the rotation frequency ($f \sim 100$ MHz). The cavity, made of aluminum, is slighty reentrant and has an internal diameter of 1.46 m. The shunt impedance of the cavity will be low enough to have joulean losses as big as the power absorbed by the beam. A second RF system working on the 120th harmonic ($f \sim 500$ MHz) will be installed eventually.

For injection, three fast kickers will give a maximum deflection of 7 mrad. Their yoke, made of ferrite, surrounds completely the ceramic vacuum chamber, apart from a small gap which cuts down RF losses from the circulating beam. A pulsed septum magnet, .7 m long, is designed for .7 T. The magnet is in the injection line vacuum, separated from the ring by a stainless steel window 25 μm thick.

The control system is organized around a PDP 11/44 minicomputer, with intelligence distributed in microcomputers built out of commercially available VME modules, using 68 k microprocessors. Interconnection is made through FACTOR, a local area network based on the CSMA/CD scheme, with a priority principle implemented.

Status

The hall which will house Super-ACO and the ancillary building are completed, and moving in has already begun. The bending magnets of the ring have been delivered, and magnetic measurements are on progress. The remaining of the magnets, including the beam transport line, are under construction. The power supplies are ordered, and delivery will start next summer. Hardware components for the vacuum system have already been delivered and are under test. The construction of the vacuum chamber itself has started. Tests are also beeing made on VME modules and on a model of the LAN. The other elements of the ring such as RF system, injection pulsed magnets, beam diagnostics are under way.

Commissionning is expected to take place in the fall of next year.