PROGRESS REPORT ON THE CONSTRUCTION OF SOLEIL

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Abstract

SOLEIL is a 2.75 GeV third generation synchrotron radiation facility under construction near Paris. The construction is going towards its completion. The commissionings of the LINAC and of the first transfer line are starting, the booster is already installed in the tunnel and the tests of the equipments are under way, the installation of the storage ring is just beginning. This paper presents the status of the main storage ring equipments : magnets, power supplies, vacuum system, diagnostics, RF system, front ends and insertion devices.

INTRODUCTION

The main characteristics of the SOLEIL project were described in reference [1]. The project was launched in January 2002, the construction of the buildings started in August 2003 and all the major components were ordered before June 2004 [2]. Now, the construction comes near to its end. The progress report of the injection system, LINAC and Booster are related separately [3], [4]. The RF system is also presented in two different papers in this conference [5],[6], so we give here only a résumé and focus on the major storage ring components.

MAGNETS

The magnetic measurements campaign is nearly achieved. After the dipoles, the quadrupoles and the sextupoles are on the way to being all measured. All the 160 quadrupoles were delivered by DANFYSIK and are being measured by SOLEIL, whereas the construction and the measurements of the 120 sextupoles are almost finished at SIGMAPHI. The magnets are positioned onto the girder with respect to their magnetic axis, using small shims.

Quadrupoles

In order to reach the extreme precision required for the magnetic axis centering, a new sensor has been successfully developed for the rotating coil bench. The structure is perfectly rigid and the intrinsic defects are negligible. The obtained accuracies are: ±10µm in horizontal and vertical position and 0.1 mrad for the tilt. First statistical results concerning 49 short and 12 long quadrupoles (respectively 320 mm and 460 mm) are given in Table 1 and Table 2. The RMS gradient reproducibility from one quadrupole to the other is 1.0 10^{-3} except at maximum gradient (2.10^{-3}) where some saturation appears.

Table 1: Magnetic axis centering of quadrupoles

Axis centering	Mean value	RMS value
DX (microns)	2	10
DZ (microns)	3	7
Tilt (mrad)	-0.010	0.050

Table 2: Integrated multipolar components normalized to the main component (An = an/b2 ; Bn = bn/b2)

Harmonics (given in 10^{-4} at 30 mm)	Short Quadrupoles		Long Quadrupoles	
	Mean value	RMS value	Mean value	RMS value
A3	0.0	3.6	-1.6	4.5
B3	-1.4	2.4	3.1	1.3
B4	-4.0	3.3	-8.1	2.0
B6	1.8	0.4	0.6	0.5
B10	0.7 [1.4]	0.1	1.9 [1.8)	0.1
B14	0.9 [0.7]	0.1	1.0 [1.7]	0.1

The B6 component has been minimized by optimizing the chamfer during the prototypes measurements.
Design values for B10 and B14 are given in brackets.

Sextupoles

Up to now 53 sextupoles (41 compact and 12 with ears) had their measurements validated by SOLEIL and are ready to be installed on the ring. First statistical results are given below in Table 3 and Table 4. The RMS sextupolar strength reproducibility from one sextupole to the other is 3.0 10^{-3} at maximum strength.

Table 3: Magnetic axis centering of sextupoles

Axis centering	Mean value	RMS value
DX (microns)	4	20
DZ (microns)	3	15
Tilt (mrad)	0.02	0.15

In order to reduce the unexpected dipolar term B1 which was initially rather large, shims were installed on pole chamfers but the decapolar component B5 became systematic and non negligible. Its contribution will be minimized by affecting the sextupoles with strong B5 at a ring location where the sextupolar strength is weak.

Table 4: Integrated multipolar components normalized to the main component (Bn = bn/b3)

Harmonics (given in 10^{-4} at 32 mm)	Mean value	RMS value
B1	-5.7	12
B5	4.9	4.8
B7	3.0	1.5
B9	-8.6 [-3.5]	1.0
B15	-9.0 [-7.5]	0.7
B21	-21.0 [-21.0]	0.4
B27	0.9 [0.7]	0.4

Design values for B9, B15, B21 and B27 are given in brackets.

Correctors Efficiency

Dipole and skew quadrupole correctors are created by special coils mounted on sextupoles. For each sextupole and each type of correction, the corrector strength was measured for 3 current values per polarity. Some tests have been done showing that the different corrections do not interact. The corrector field varies linearly versus current for the three types of correction. The maximum strengths satisfy the requirements for orbit and coupling correction with a comfortable margin.

POWER SUPPLIES

All the SR power supplies are digitally regulated. 105 quadrupole PS were already delivered by Hazemeyer, and the receipt of the last series (65) is foreseen in week 22. All corrector power supplies are achieved, 130 over 154 were delivered by Bruker. The first sextupole power supply (75V-350A) was delivered in February by Hazemeyer. The stability exceeds the requirement. The other sextupole PS (4x75V-350A, and 5x140V-350A) are being tested at Hazemeyer and will all be delivered by the end of June. The receipt of the Dipole PS (Hazemeyer) (5610 V, 580 A) is scheduled in July.

VACUUM SYSTEM

The stainless steel vacuum chambers of the dipoles are being built by SDMS, who are also manufacturing the extruded aluminium vacuum chambers for the quadrupoles and sextupoles.

Dipole Vacuum Chamber

The main difficulty to manufacture these 2.5 m long vacuum chambers was to respect the very tight dimension tolerances: 1mm (± 0.5 mm) planarity in the areas facing the poles. 16 vacuum vessels have already been delivered. All the dipole vacuum vessels will be delivered by the end of June 2005.

Quadrupole Vacuum Chamber

Some delays have been experienced on the start of the series production at SDMS. SAES Getter (Italy) is performing the NEG coating on these vessels according to the method developed at CERN. In February, the first of series of vacuum vessel (1556mm long with 2 pumping ports) has been validated. This coating has been made on a new dedicated bench compatible with the large width due to the pumping ports. At the present moment, four batches which represent four cells have been delivered by SDMS to SAES Getter and have been successfully coated. All the vacuum quadrupole vacuum vessels shall be coated by the beginning of October.

BPM-Bellows

The first of series of BPM-bellows module (figure 1) and bellows module have been validated with vacuum tests. Electrical tests on the BPM electrodes allowed to validate also the beam position measurement efficiency. The series is being fabricated by RIAL Vacuum (Italy). Due to the lengthy procedure of machining some parts by electro-erosion, important delay has appeared and this equipment is now on the critical path fro the installation of the SR.

Figure 1: The first of series of BPM-bellows module

DIAGNOSTICS

Digital BPM Electronics

All the 127 modules have been built and were found to be within specs, except the noise level that was measured out of the very tight tolerances. The change of the VCXO (Voltage Controlled Internal Oscillator) with a new sampling frequency (109.21648 MHz) improved the performance and revealed a residual noise coming from speed control. An artificial shift of 2 kHz brought the noise within specifications for the feedback mode: 0.2 µm rms at 100 Hz acquisition rate.

The fast orbit feedback calculations will be directly implemented in the BPM FPGAs. Software for slow and fast orbit feedbacks will be delivered by July.

RF SYSTEM

Two cryo-modules, each containing a pair of superconducting cavities are required to provide the maximum power of 600 kW needed at 500 mA. Each of the four cavities will be powered by a 190 kW solid state amplifier consisting in a combination of four "towers" of about 50 kW. For the commissioning of the storage ring, only one cryomodule and two amplifiers will be available, allowing 300 mA beam intensity.

A first 50 kW tower was assembled and tested up to 48 kW CW on December 2004. However, during the reliability test run, several module failures occurred (12 over 180 modules after ~ 800 hours of operation). Even if these failures didn't stop the running of the transmitter, a solution was looked for together with the transistor manufacturer. A second 50 kW tower is being assembled for testing the new version of transistors (with a slightly lower gain - 1dB) by the end of May [5].

The cryomodule 1 was successfully tested at CERN after refurbishment [6]. The reached performance exceeds the requirements for the SOLEIL normal operation: 150 kW per coupler and 1.5 MV per cavity.

The cryogenic plant is under fabrication at Air Liquide. The liquefier is about to be finished the 2000 l DEWAR, the cryogenic valve box and the room temperature valve panel are completed. The compressor local, including compressors, oil removal systems and piping, should be complete at the end of June and the liquefier should be ready for commissioning end of July.

BEAMLINE FRONT-ENDS

Since last January, a complete front end beamline is under vacuum. It validates the mechanical design and the vacuum system of the front ends. Vacuum from 2.10^{-10} mbar, for the chamber to be connected to the dipole chamber ring, to $1.5.10^{-9}$ mbar for the chamber to be connected on the beamline side has been achieved after 24h bake out at 200°C.

Most of the modules ordered for 12 front ends have been delivered and tested at SOLEIL (gamma stoppers, acoustic delay lines, fixed absorbers, shutters, etc.).

The front end diaphragms (movable variable aperture for soft x-ray, movable fixed aperture for hard x-ray) will be made by CINEL and delivered at SOLEIL before September.

INSERTION DEVICES

SOLEIL is planned to start operation with several different insertion devices installed either from "day one" or within the first year [7]. The main characteristics of the different types are recalled below.

Table 5

ID	Type	Spectral Range	Polarization
HU640	EM (AC/DC)	5 eV-40 eV	Elliptical
HU256	EM (DC)	10 eV-300 eV	Elliptical
HU80	PM (APPLE-II)	35 eV-2 keV	Elliptical
U20	PM (hybrid)	4 keV-15 keV	linear

The ID names include their period length in millimetres. EM = electromagnetic, PM = permanent magnets.

HU640: HU640 is a 10 m long, fast switching device (0.1 s) in construction at DANFYSIK. It is composed of three types of coils, without iron yokes, offering all types of polarization. One set of coils produces horizontal magnetic field, the other two sets produce vertical field with one set being shifted longitudinally to respect to the other by a quarter of period. The mechanical structure is completely equipped and the fabrication of the coils is achieved. All the coils have been measured individually, in order to do a sorting to optimize the general assembling in term of field integral. The power supplies are near their completion. Tests on the device are scheduled end of May for a delivery foreseen beginning of June.

HU256: The three electromagnetic undulators HU256 and their power supplies are under construction respectively at BINP and DANFYSIK. The delivery of the first one is scheduled before this summer.

HU80: Three devices are ordered to ELETTRA, 2 complete and one mechanical support. RMP realizes the carriages. The first carriage was accepted at the end of February. ELETTRA team has already mounted the magnet system and the first phase of magnetic shimming gave very encouraging results. The second and the third carriages are still under fine assembly in the RMP workshop in order to reach the very tight tolerances.

U20 in-vacuum undulators: The first U20 is under construction at DANFYSIK. The delivery is scheduled in January 2006. SOLEIL will build the two other undulators, as replicates of the one built by DANFYSIK. The assembly of the modules followed by the magnetic shimming will start at SOLEIL end of June.

OTHER EQUIPMENT

All the pulsed elements - passive (eddy current) and active septum, injection kickers, machine study kickers as well as their pulsed power supplies were designed in-house assembled and tested by SOLEIL team. Their deliveries and tests are under way.

The machine control system is also well advanced and the high-level control applications are described in reference [8].

CONCLUSION

We are now in the last phase before the commissioning of SOLEIL. Most equipments which bring decisive improvement for a 3rd generation source have been delivered and successfully tested, although some difficulties were met in the realization of a few of them. The generated delays are, for a large part, in the shadow of the delays encountered in the construction of the synchrotron building and do not cumulate with them. The commissioning is scheduled before summer for the injector and in February 2006 for the storage ring.

REFERENCES

[1] M.P. Level et al, PAC03, p.229
[2] J.M. Filhol et al, EPAC04, p 2335
[3] B. Pottin et al, these proceedings WPAP001
[4] A. Loulergue et al, these proceedings RPAE030
[5] P. Marchand et al, these proceedings WPAT002
[6] P. Marchand et al, these proceedings RPPE058
[7] O. Chubar et al, EPAC04, p 369
[8] L.S. Nadolski et al, these proceedings ROPA005