SIRIUS STATUS REPORT

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Abstract

Sirius is a Synchrotron Light Source Facility based on a 4th generation low emittance storage ring that is presently under construction in Campinas, Brazil. During the last year, accelerator activities concentrated on R&D of the various subsystem components. However, the number of components under production or already delivered is also increasing according to planning. The building construction started in the beginning of 2015 and machine commissioning is expected to start mid 2018. In this paper we report on the present status of the project with emphasis on the last year activities.

INTRODUCTION

The Sirius Light Source Facility is under construction at LNLS, in Campinas, Brazil. The first lattice design studies began in 2008 and the project was included in the Brazilian Federal Budget Law in 2012. Construction of the building started in the beginning of 2015 and is progressing within schedule, despite the recent difficulties in Brazil's economic situation. Start of machine installations is expected for the end of 2017 and beam commissioning for mid 2018. Figure 1 shows an aerial view of the construction site as of April 2016.

Figure 1: Aerial view of the Sirius construction site. Picture taken April 2016.

Sirius is based on a 3 GeV electron storage ring that uses a modified 5BA cell structure to achieve a bare lattice emittance of 0.25 nm·rad in a 518 m circumference ring with 20 straight sections. The injector is a full energy booster synchrotron sharing the same tunnel and concentric with the storage ring. The emittance of the 497 m circumference booster is 3.5 nm·rad at 3 GeV. A 150 MeV Linac is used as the booster injector.

The accelerator activities for the last year concentrated on R&D on the various subsystem components, such as the prototyping of booster sextupoles and dipoles, characterization of booster quadrupoles, design of storage ring magnets, prototyping girders, definition of the production process for vacuum components, design and prototyping of pulsed magnets, beam position monitors, RF systems.

The storage ring design optics has also been modified in order to accommodate new requests from the beamlines team. The number of low β sections increased from 10 to 15. In these sections, β_x and β_y are simultaneously focused to 1.5 m at the section center, optimizing the matching of the electron beam to the photon beam phase ellipse. It also allows for small horizontal and vertical gap insertion devices. A detailed description of this new optics is given in [1] and the main parameters are summarized in Table 1.

Table 1: Sirius Storage Ring Main Parameters

Energy	3.0	GeV
Circumference	518.4	m
Horizontal emittance	0.25 → 0.15	nm·rad
Betatron tunes (H/V)	49.11 / 14.16	
Natural chromaticity (H/V)	-119 / -80	
Natural energy spread	0.085	%
Natural bunch length	2.4	mm

MAGNETS

A strategic decision for the production of Sirius magnets was to start with the booster magnets. In this way all stages from design to production in a local Brazilian company (WEG) that had never produced accelerator magnets before could be tested and refined. For this reason, the requested tolerances for the booster magnets were tighter than the required from the beam dynamics point of view, approaching requirements for storage ring magnets. This strategy delayed the starting of the magnets production, but resulted in very good quality magnets for the booster, as confirmed by the measurements of delivered quadrupoles. The measured magnetic field centers with respect to geometrical centers and roll errors are shown in Fig. 2. There are systematic offsets of 10 µm and -26 µm in the horizontal and vertical directions, respectively, with RMS values less than 15 µm in both planes. For the roll errors there is a large systematic offset of -0.45 mrad but the RMS value is less than 0.1 mrad. The systematic offsets are being investigated and there is evidence that a large fraction comes from the rotating coil system. The relative field deviation is better than $3x10^{-4}$ up to 17.5 mm from the center. The booster magnets are fabricated with Fe-Si laminations, resulting in a factor 15 smaller remnant fields as compared to Fe-C laminations.

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The sextupole pilot scale batch is now being measured. A first dipole prototype has been produced as well.

With the booster magnets well underway, the design and prototyping of storage ring magnets is now being worked out. A magnet design that had a major change is the central dipole in the arc, which changed from a hybrid configuration with two magnetic regions, one excited by coils and another by permanent magnets, to a 100% permanent magnet configuration. The peak field in the dipole center increased from 2 T to 3.2 T, raising the critical photon energy from 12 to 19 keV, another request from beamline scientists.

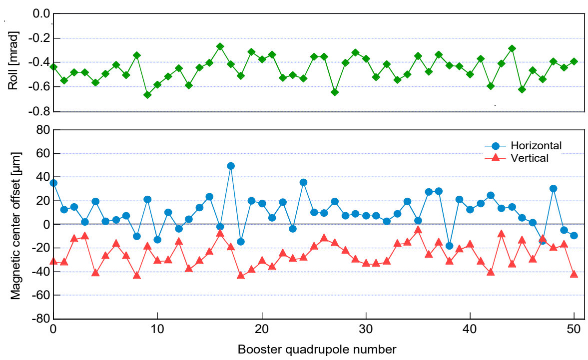

Figure 2: Measured horizontal and vertical magnetic field center and rotation around longitudinal axis for Sirius booster quadrupoles.

The magnetic measurement lab has been improved to meet the requirements of temperature stability and air quality. Many aspects of the rotating coil and its bench have been improved. The positioning repeatability of the rotating coil is less than 1 μm under constant temperature conditions and the accuracy, which is affected by systematic errors, is being investigated. See Fig. 3.

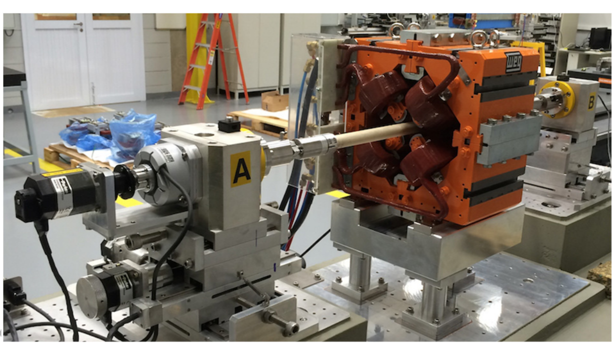

Figure 3: Rotating coil bench.

VACUUM SYSTEM

A sector of the Sirius storage ring vacuum system corresponding to 1/40 of the machine has been assembled in the vacuum laboratory, as shown in Fig. 4. The assembly is intended to check not only the components design and fabrication methods, but also to study the NEG activation process, the final pressure attained and the chamber deformation and accommodation with the proposed bellows configuration.

The vacuum system components have all been prototyped and the processes for machining, joining, cleaning and NEG deposition are all defined. A few examples are shown in Fig. 5. Some methods are still under optimization such as the curvature conformation and brazing of the cooling pipe for dipole vacuum chamber, the TIG welding of the dipole keyhole profile, and tests of the bellows RF shielding for thermal cycling and electrical contact.

Figure 4: Test assembly of 1/40 of the Sirius storage ring vacuum system.

The vacuum system components for the booster and transfer lines are under production and are expected to be delivered by the end of this year.

Figure 5: Prototype of Sirius storage ring vacuum system components: (a) dipole chamber, (b) bellows with RF shielding, and (c) pumping station/crotch absorber.

PULSED MAGNETS

A new pulser for the booster injection and extraction fast kicker prototypes has been assembled and successfully tested. In this version a half-sine (instead of trapezoidal) pulse current waveform is used to excite the field. A thyristor is used as switch and capacitors as pulse energy storage. The new waveform has been adopted with a compromise in the flat-top width specification, that dropped from 300 to 150 ns. The Sirius Linac can be operated with variable pulse length in the above interval without compromising the total charge per pulse.

A first prototype of a nonlinear kicker magnet for off-axis injection into the storage ring has been produced but the measurements showed large eddy current effects that prevented its use as planned. A second prototype using only current driven wires to excite the magnetic field has been designed and is currently being tested. The new design uses the same titanium coated ceramic chamber developed before with some modifications to support the wires. Simulations of the injection dynamics are described in [2]. The ceramic (alumina) chamber has been developed in collaboration with a Brazilian company (ENGECER) and is shown in Fig. 6.

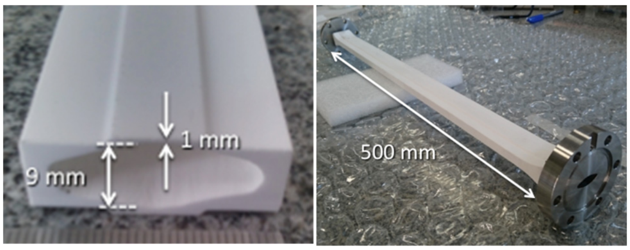

Figure 6: Alumina tube produced in collaboration with ENGECER for the Sirius nonlinear kicker.

BEAM DIAGNOSTICS

First prototypes of the storage ring BPM buttons, manufactured by local companies and brazed at LNLS, showed a high fail rate regarding vacuum leak and short circuit. A complete revision has been made on the mechanical design and tolerances for the components, as well as on the control of fabrication process. Almost 100 new components were manufactured in the last weeks with a surprisingly good performance, 94% were approved regarding vacuum leak and 100% regarding short circuit. The design of the BPM body has also been revised and prototypes have been manufactured at LNLS. Figure 7 shows two prototypes of the new BPM body fabricated at LNLS.

Other diagnostics components have also been designed, e.g. the storage ring striplines electromagnetic and mechanical designs described in [3].

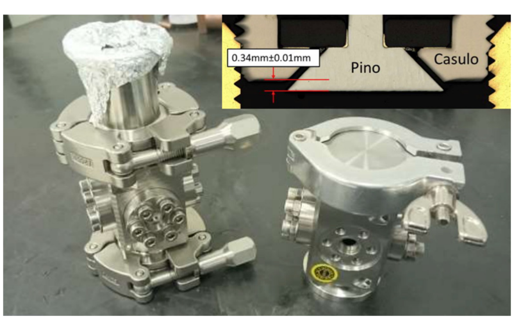

Figure 7: New Sirius storage ring BPM body prototypes. Featured in the corner is a button metallographic section showing good alignment between button and housing.

POWER SUPPLIES (PS)

Modifications to the first prototype of the digital power supply controller have been implemented. The new controller boards are now being used in the power supplies for measurement of the prototype magnets. PS prototypes for low and high power have been produced and are being tested. Figure 8 shows the mechanical design of a high power PS module.

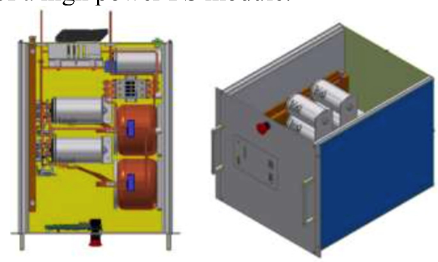

Figure 8: Mechanical design of high power PS modules.

GIRDERS

The vibration mode measurements of the first girder prototype carried out in 2014 showed a few resonance frequencies below 100 Hz, caused by the coupling between the girder and the concrete pedestal. The integrated set, consisting of pedestal, girder and magnets was redesigned in 2015 and new girder prototypes have been produced. The lowest girder frequency increased from 320 Hz to 590 Hz. New measurements will be performed in a few weeks (Fig. 9).

Figure 9: New girder prototype during dimensional measurement.

SHIELDING

Even with the Sirius building construction going on, some design changes to the shielding tunnel have been implemented. One modification altered the roof opening mechanism for a sliding system that eliminates the need for cranes to remove concrete blocks. See Fig. 10. The number of openings was reduced from 20 to 10 and the size was reduced as well. Another modification is the construction of a pivoting door to isolate the Linac tunnel from the storage ring tunnel. The cables trenches on the floor were also replaced by small holes on the walls close to the ceiling, simplifying the construction of the special high stability tunnel floor.

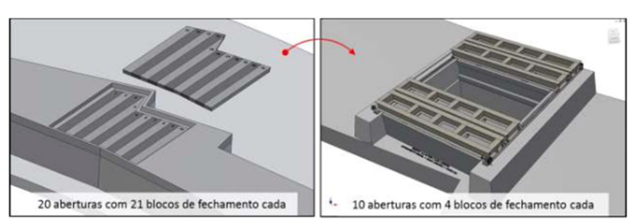

Figure 10: New design for the tunnel roof openings.

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