Status of Sirius Storage Ring RF System

André Pontes Barbosa Lima
David Daminelli
Ruy Hanazaki do Amaral Farias
Felipe Koji Godinho Hoshino
Felipe Santiago de Oliveira
Ranieri Ramires do Canto Santos
Mark Hoffmann Wallner

CNPEM Engineering & Technology Division
Radiofrequency Group

Abstract

Sirius storage ring RF System is based on two superconducting RF cavities and eight 60 kW solid state amplifiers operating at 500 MHz. The current configuration, based on a 7-cell PETRA cavity, was initially planned for commissioning and initial tests of the beamlines. However, it has to remain in operation longer than planned. Sirius has been operating in decay mode for beamlines tests with an initial current of 70 mA. We present an overview of the first-year operation and the preparations for the installation of the superconducting cavities, which is expected to take place in 2023.

Sirius

Beam energy	3.0	GeV
Circumference	518	m
Beam current	350.0	mA
Energy loss/turn in dipoles	472.75	keV
Energy loss/turn in IDs	400	keV
Peak RF voltage	3	MV
RF Frequency	499.658	MHz
Harmonic Number	864	
Overvoltage	3.4	
RF Acceptance	5.13	%
Momentum compaction	1.6×10^{-4}	
Synchrotron Frequency	2.686	kHz
Natural Bunch Length	8.2	ps
Beam emittance	0.25	nm.rad

Sirius is based on a 3 GeV low emittance 4th generation storage ring

Bird's eye view of Sirius' building

Introduction

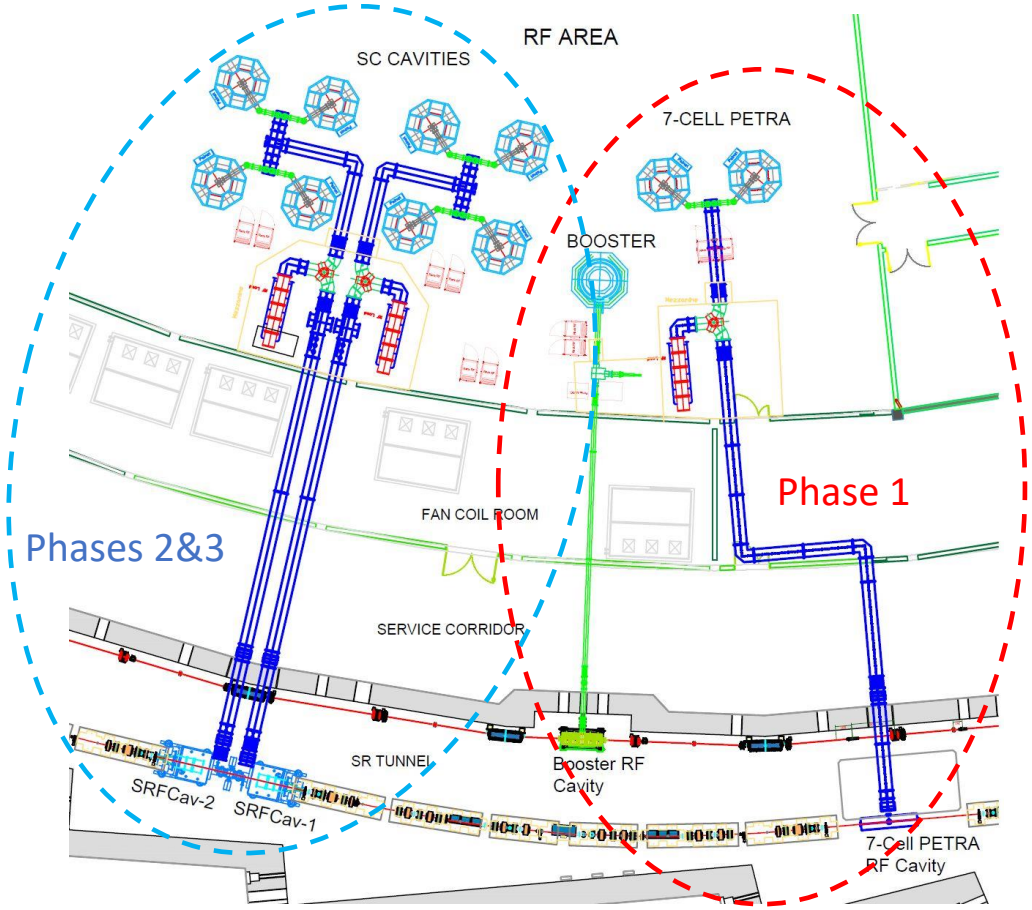
- Sirius RF system includes 2 SC cavities, each requiring up to 240 kW RF power for design beam current operation
- The system is planned to be installed in 3 phases
- Phase 1 includes a 7-cell NC cavity that is expected to be replaced only in 2023
  - NC cavity was planned just for commissioning and beamlines startup
  - The reason for that was a long delay to bid and contract the cryogenic plant
  - It is necessary to work on the RF to reach stable operation with higher beam currents

	Phase 1	Phase 2	Phase 3
Cavity type	7-cell NC	CESR	CESR
Number of cavities	1	2	2
RF Voltage (MV)	1.8	3	3
Beam current (mA)	50	250	350
E_{loss}/turn IDs (keV)	200	300	400
Energy acceptance (%)	3.5	5.1	5.1
Number of SSA	2	4	8
RF Power/Cav (kW)	120	120	240
Time schedule	2019	2023	2024

RF System installation phases

Installation: Phase 1

- 7-cell PETRA cavity
  - Temperature control allows setpoint from 25 to 50°C.
  - A fast pulsed conditioning is repeated when temperature setpoint changes
- RF power is provided by two 60 kW SSA
  - SSA built at LNLS using 550W modules designed at Soleil and produced by BBEF
- SIRIUS uses an updated version of ALBA Digital LLRF
- The transmission line includes a 300 kW high power circulator and load



Layout of the RF plants: (left) SC cavities, (centre) booster, (right) 7-cell cavity

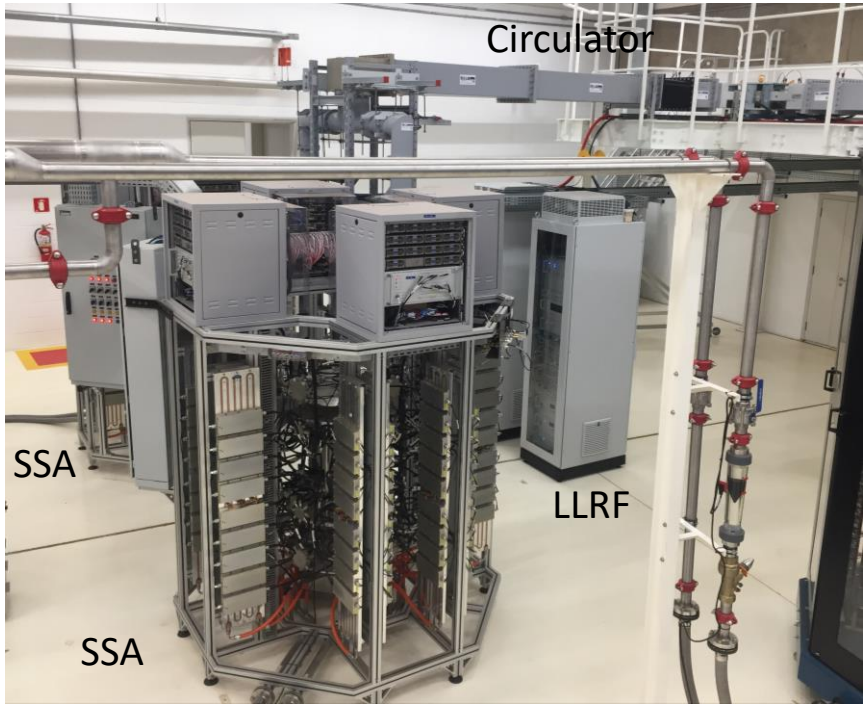
Installation: Phase 1

Images from the RF Room

Two 60 kW RF amplifiers installed at the RF Room

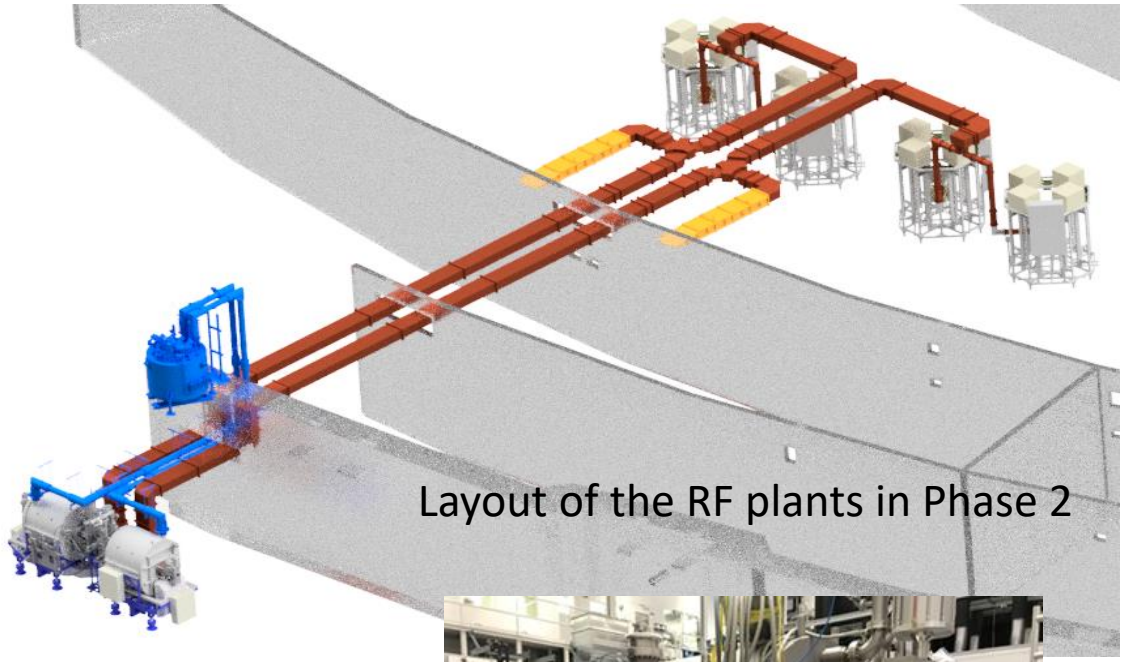
300 kW Circulator and load

Interlock & LLRF

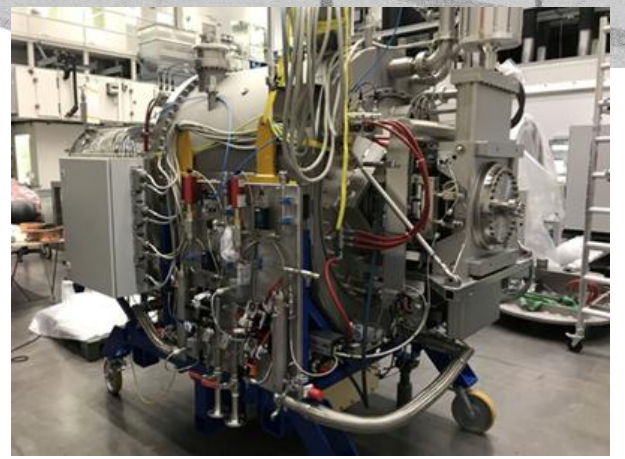


Installation: Phase 2

- SC cavities in final phase of production
  - First module passed the FAT
- Cryogenic Plant contracted
  - Expected to be ready in early 2023
- Installation of the SC cavities and 2 new 60 kW SSAs
- Phase 1 SSA have to be moved to new position
  - SSA design being modified to allow easier and faster relocation
- Assemblying of SSAs start in 2021
- Waveguides and circulators delivered



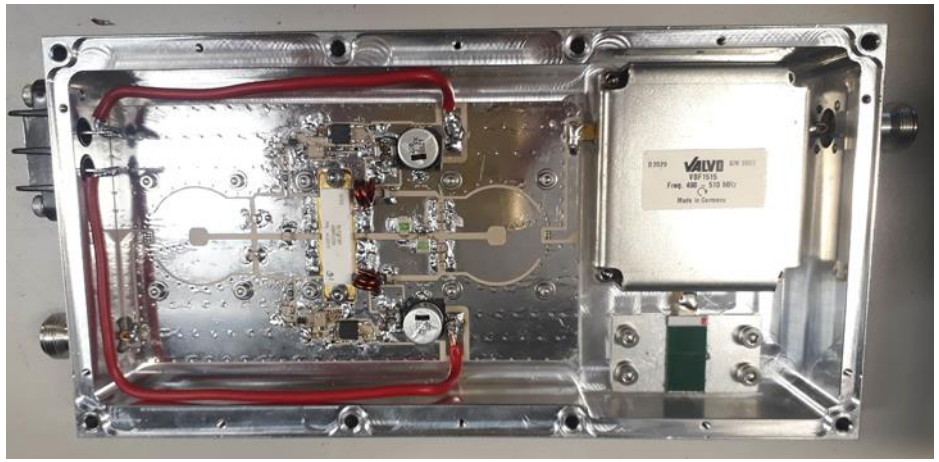
Layout of the RF plants in Phase 2



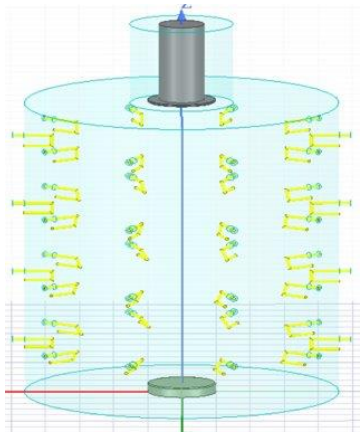
First Sirius SC cavity cryomodule

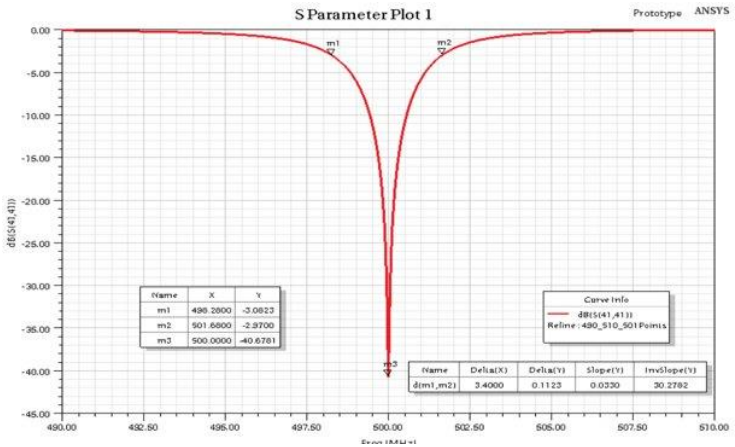
Installation: Phase 3

- Installation of the last 4 SSAs Towers
- New 850W amplifier module under development → **TUPAB358**
  - New transistor: higher gain, more efficient, higher power
- New power combination scheme
  - Cavity combiner with 80 ports
  - Eliminate cables between modules and combiner
  - Cavity in prototyping stage



Prototype of the new amplifier module



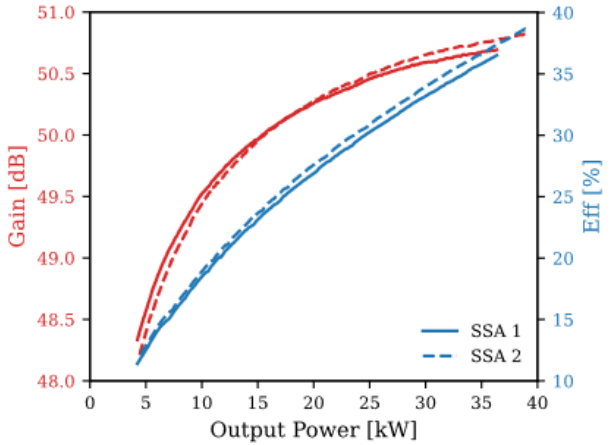


Cavity combiner simulations

Current Status

- 7-cell PETRA RF cavity, no HOM damping
  - Temperature sweep to find a better operation point
- Sirius running in decay mode with initial current = 70 mA (See invited oral **MOXA03**)
  - Efforts to increase current acting on cavity temperature, LLRF parameters and Longitudinal BbB settings.
  - Cavity at 38.8±0.15°C: no need for BbB
  - Limitations in the RF: temperature of the power coupler (80 mA, 80 kWfw)
- RF plant working with good reliability:
  - No SSA trips but 12% of the modules failed due to a filter in the gate drive: preventive replacement in scheduled maintenances
  - In 7500 hours, 2 out of 264 transistor failed
  - Trips of the plant mostly due to cavity interlocks

The 7-cell cavity



Efficiency and Gain of the 2 SSAs

Conclusion

- After one year the storage ring RF system has been operating smoothly. The amplifiers and the LLRF are very reliable, the cavity works as expected and the whole system is being fine-tuned in line with the efforts to increase beam current.
- Work is underway to prepare for the installation of the SC cavities