MHD calculations, microwave heating scenarios simulations and diagnostics updates on SCR-1 stellarator

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Motivation

The work presents the latest MHD calculations and simulations of microwave heating scenarios in the Stellarator of Costa Rica 1 (SCR-1); as well as the updates in the diagnostics systems with the design and implementation of a bolometer, Mirnov coils, Rogowski coils and diamagnetic loops. MHD equilibrium calculations were performed using the VMEC code in free boundary mode including the poloidal cross-section of the magnetic flux surfaces at different toroidal positions, profiles of the rotational transform, magnetic well, magnetic shear and total magnetic field norm. The rotational transform (iota) for 0°, magnetic well and magnetic shear profiles are shown. Regarding the diagnostics, the mechanical design of the bolometer is presented, as well as the designs of magnetic diagnostics that have been developed

SCR-1 parameters

- 2-field period modular Stellarator
- Major radius R= 247.7 mm
- Aspect ratio = 6.2
- Low shear configuration
- ι_o=0.312 and ι_a=0.264
- 6061-T6 aluminum vacuum vessel
- ECH power 5 kW (2.45 GHz), second harmonic
- (B = 43.8 mT), $\langle \boldsymbol{B} \rangle$ = 41.99 mT
- 12 modular coils with 6 turns each
- 725 A per turn, providing a total toroidal field (TF) current of 4.35 kA-turn per coil
- The coils will be supplied by a bank of cell batteries of 120 V
- Plasma pulse between 4 s to 10 s

SCR-1 plasma parameters

- Minor plasma radius: 39.95 mm
- Line averaged electron density: 5 $\times 10^{16}$ m^{-3}
- Plasma density cut-off value of 7.45$\times 10^{16}$ m^{-3}
- Estimated energy confinement time: 5.70 $\times 10^{-4}$ ms (of ISS04 [Ref.2])
- Plasma volume: 7.8 liters (0.0078 m^3)
- β_{Total}=0.01 %
- Electron temperature: 6 - 14 eV

Conclusions

- MHD calculations show that outer magnetic flux surfaces bend more sharply than inner surfaces and that there is a plasma region where the electron drift waves propagation is stable
- New diagnostics are being implemented in the SCR-1 to enhance the diagnostics capacity
- A bolometer has been designed and built and is ready for implementation
- Magnetic diagnostics are in test and construction phases

MHD Calculations

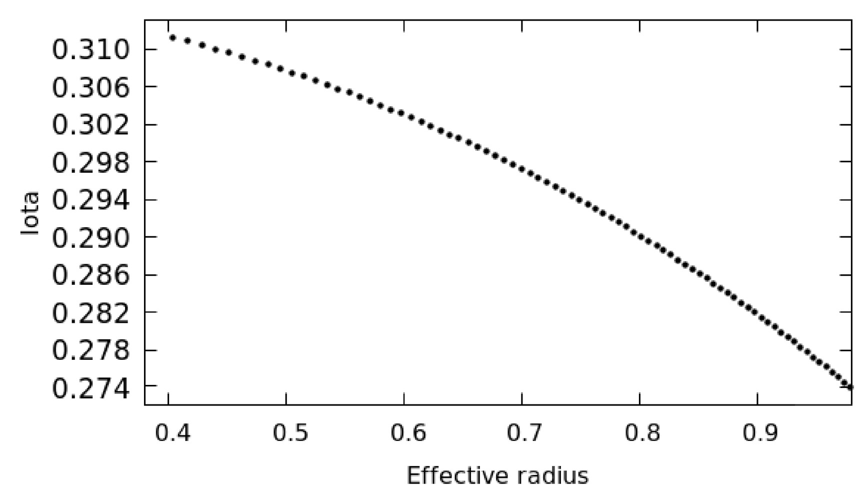

Figure 1. Rotational transform at 0° toroidal angle

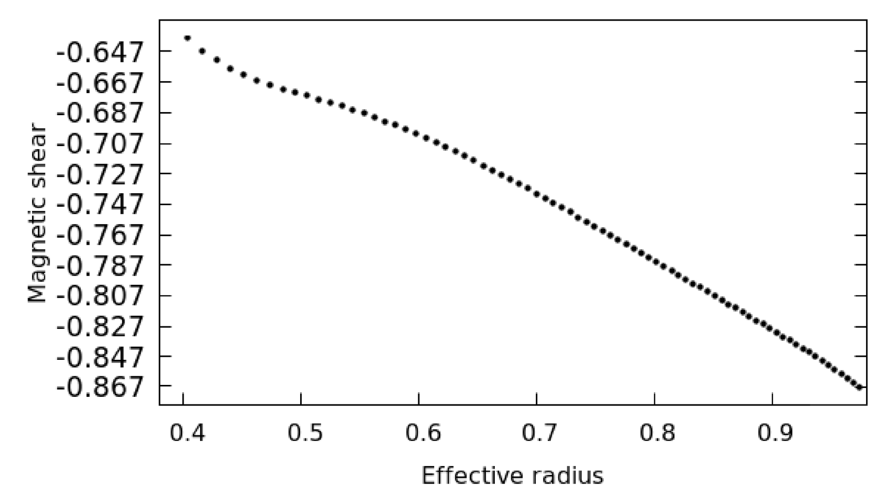

Figure 2. Magnetic shear at 0° toroidal angle

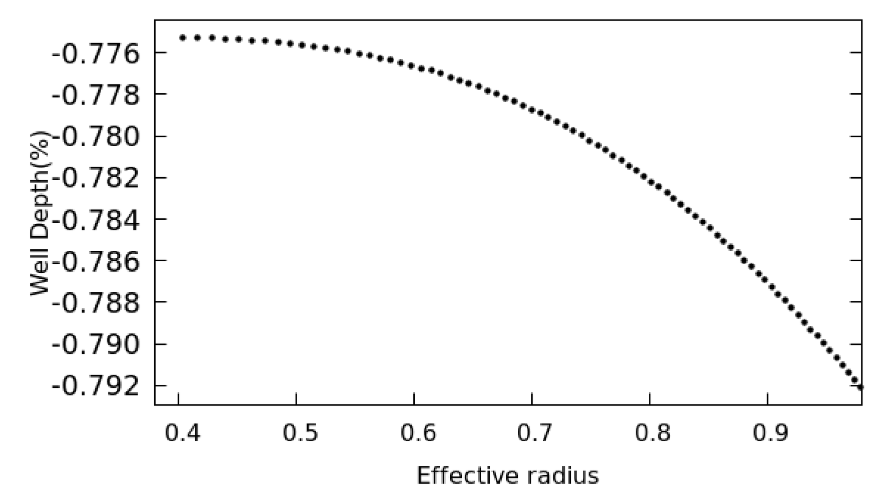

Figure 3. Well depth at 0° toroidal angle

Bolometer

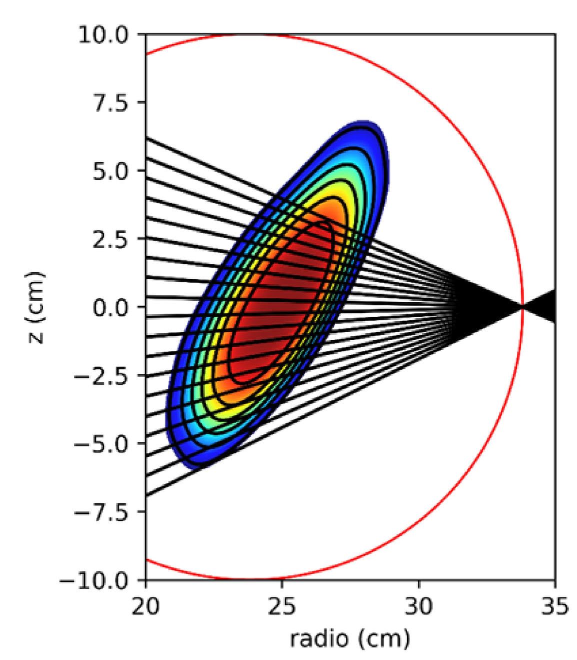

Figure 4. Integration chords diagram

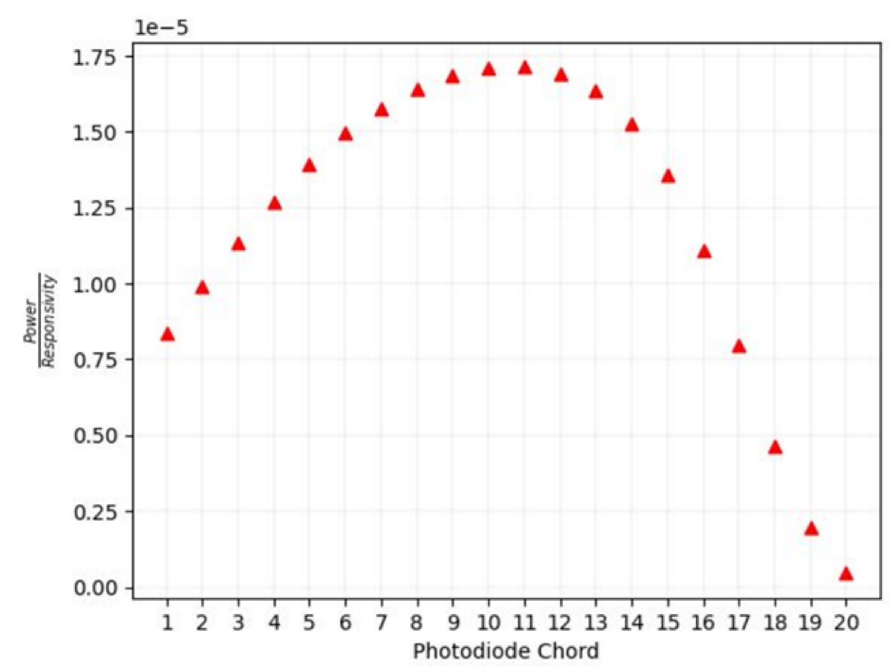

Figure 5. Estimated brightness at each point

Figure 6. Bolometer electronics. On the left, AXUV20ELGDS photodiode array. On the right, the case, the PCB circuit, and the flange with a DB-25 connector

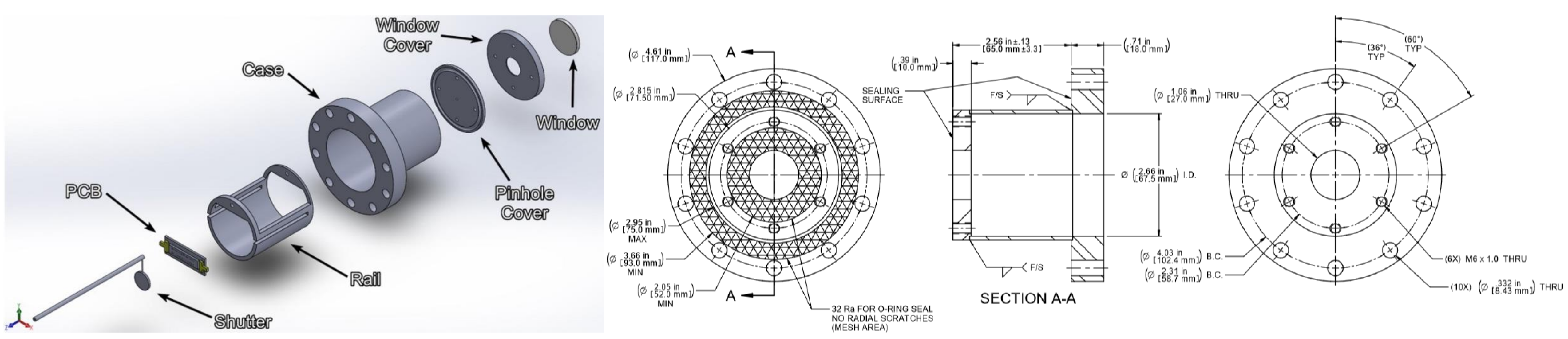

Figure 7. Mechanical design of the bolometer.

Magnetic Diagnostics

Table 1. Design parameters of the magnetic diagnostics

Diagnostic	External diameter (mm)	Internal diameter (mm)	Width (mm)	Loops
Diamagnetic loops	183.898	181.85	8.19	16
Rogowski coils	12.024	11	571	557
Mirnov coils	40.148	38.1	33.724	66

Figure 1. Assembled Rogowski coil

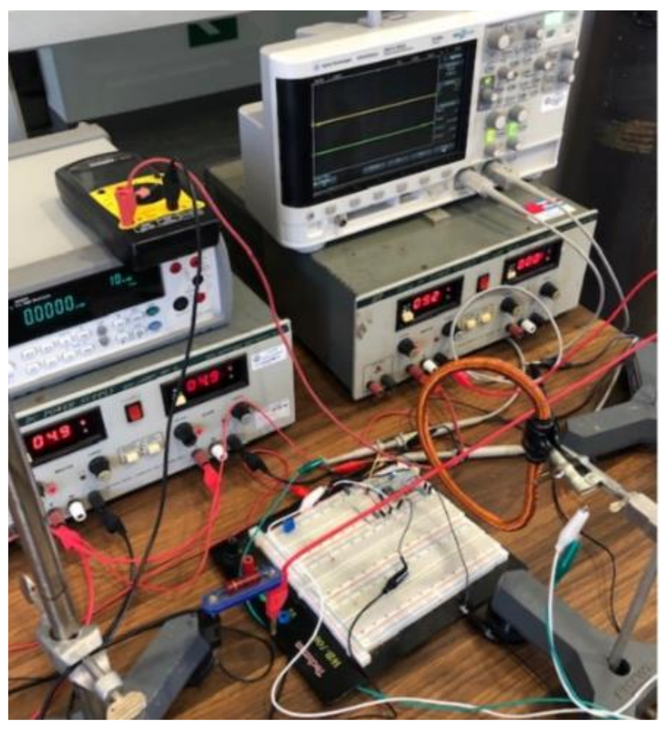

Figure 1. Testing setup

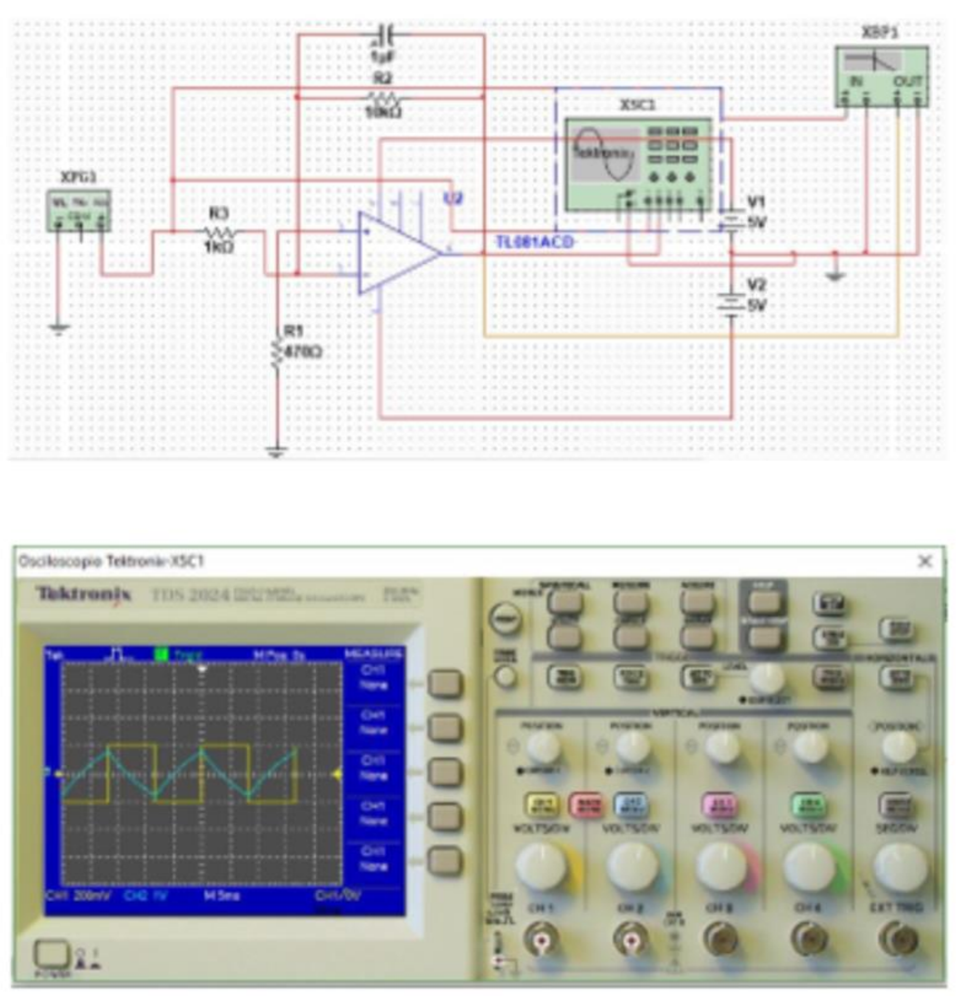

Figure 1. Rogowski coils circuit simulation

References

[1] VARGAS, V.I., et al, Implementation of Stellarator of Costa Rica 1 (SCR-1), in Proceedings of the 2015 IEEE 26th Symposium on Fusion Engineering (SOFE), May 31-June 4, 2015, Austin, Texas, USA

[2] CASTELLANO, J. et al, Magnetic well and instability thresholds in the TJ-II stellarator. Physics of Plasmas 9. (2002)

[3] COTO-VÍLCHEZ, F et al. Vacuum magnetic flux surface measurements on the SCR-1 stellarator. In Proceedings of the 16th Latin American Workshop on Plasma Physics (LAWPP), pp. 43–46. IEEE. (2017)

[4] VARGAS, V. I et al. Conversion of electrostatic Bernstein waves in the SCR-1 stellarator using a full wave code. In 27th IAEA Fusion Energy Conference (FEC 2018). IAEA. (2018)

[5] JIMÉNEZ, D. et. al, BS-SOLCTRA: Towards a parallel magnetic plasma confinement simulation framework for modular stellarator devices. In Communications in Computer and Information Science, Latin America High Performance Computing Conference (CARLA2019), pp. 33–48. Springer. (2020)

[6] KÖHN, A. et al, Plasma Physics and Controlled Fusion 55, 1 (2013).