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PhD course of National Interest in Technologies for
Fundamental Research in Physics and Astrophysics

Annual report

Name and surname: Gaurav Rajesh Mota

Cycle and a.a.: 39° cycle 2024/2025

Supervisor: Prof. Nicola Pompeo and Prof. Enrico Silva.

- Research activity carried out during the year**

Research Topic: *Surface Impedance of Superconductors under Conditions of Interest for Fundamental Physics.*

During the second year, I continued learning and help perform measurement of surface impedance in superconductors under extreme conditions (high frequencies, strong magnetic fields, and cryogenic temperatures), with a focus on developing robust wideband measurement techniques for characterizing superconducting materials intended for accelerator and axion detection applications.

A major milestone was the **refinement of the Corbino disk cell**, with particular attention to mechanical stability, compactness for cryostat integration, and consistent thermalization. After critically analysing the initial design, the refined second design version incorporates improved spring-based contact mechanisms, optimized flange geometries, and dedicated mounts for heaters and temperature sensors. With the revised design we expect to see improved repeatability and reduced noise in the measurement of the complex reflection coefficient at microwave frequencies. The design process is thus ongoing with the aim to realize a prototype to be actually tested, initially at room temperature.

A critical issue addressed this year was the **non-interchangeability of RF cables** in the calibration chain of the Vector Network Analyser (VNA). By characterizing multiple supposedly identical cables, it was shown that minor differences in phase delay and return loss significantly affect error correction models and final output of the reflection coefficients. To overcome this, I plan to work with the help of a colleague for integration of a **MEMS-based microwave switch (Menlo Micro MM5230-03NDB-TR)**. The switch allows automated routing of calibration standards and DUTs, enabling more stable and repeatable calibrations without multiple cables or disconnecting cable. Its low insertion loss and high isolation make it suitable for cryogenic microwave setups.

Additionally, I carried out the **electrical characterization of titanium thin films** (50 nm and 100 nm) using the Van der Pauw method. The unexpected temperature dependence of resistivity raised questions about substrate interaction, prompting a plan to test new dielectrics



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substrates. These Ti films are being evaluated as possible calibration loads or resistive standards for future Corbino-based experiments.

I am also learning LabVIEW for automating the experimental measurements and creating post-processing routines through MATLAB, specifically tailored for extracting vortex dynamics parameters.

- **List of attended courses and passed exams**

Advance scientific programming in MATLAB. (2024/25) (6 CFU)

- **List of attended workshops and schools, with mention of the presented talks**

Joint Universities Accelerator School (JUAS) (17Feb - 21March, 2025) (9CFU)

Course 2 - The Technology & Applications of Particle Accelerators.

Attended full curriculum Lectures (71h15), Seminars (9h), Workshops (21h),
Visits (17h)

- **Thesis title**

“Development of advanced wideband techniques for the measurement of the surface impedance in Superconductors in high magnetic fields”

Date, 03/10/2025

Signature *Gaurav*

Seen, the supervisor