Third semester PhD report
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Design and realization of an RF impedance measurement system at cryogenic temperature

Introduction and project description:

The introduction and basics of the project are described in the first-semester report.

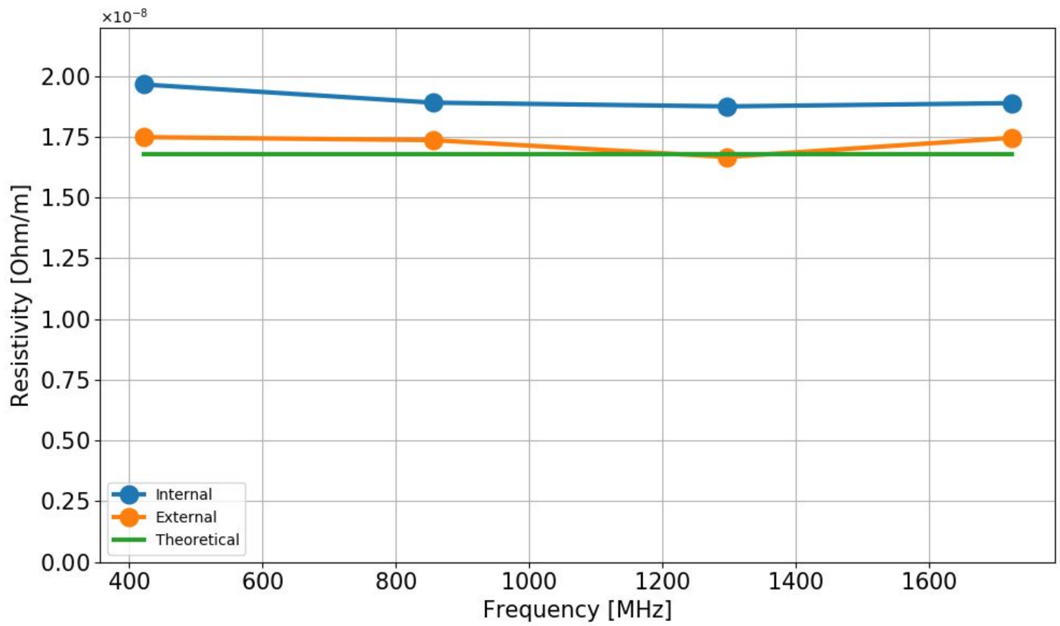
Work carried out during the semester:

In this semester I was working on the second prototype of my project. The goal of this step of my PhD was to identify difficulties in the measurement of the surface resistivity of a "beam screen" at low temperature. The setup was similar to the one used last semester, which I discussed in the last report, so here I only mention the differences between the two.

- The length was reduced from 1025 mm to 400 mm since this length fits into the cryostat used to cool down the setup. Also, the device which we are working towards has similar size restrictions. This increases the fundamental resonant frequency from 155 MHz to 420 MHz.
- The measurement is done in the vertical orientation (since the cryostat used is vertical).
- The antennas through which we couple the VNA to the cavity have been switched to antennas which have type SMA connectors on the outside, and on the inside are ending in a straight pin
- We no longer have a "mode splitter" in between the rods, because the modes are separated by around 3 MHz anyways (due to end effects).
- Due to our concerns with respect to the thermal contraction of Teflon, we switched the material of the inside setups to G10 (a glass fibre epoxy resin mixture used often in cryogenic environments). This caused the resonance to be much lossier (due to volume losses in the material), so since then new supports have been designed using Teflon again.
- The inside rods used are not hollow any more. This increases their mass (and causes more pressure on the supports), but the coupling is significantly less sensitive to small movement of the antennas.

After the prototype was manufactured early September, it was tested to see if the results it provides at room temperature are comparable or better than in the case of the first prototype. We measured the first 4 harmonics of the cavity because this already covers the range of frequency we are interested in (below 2GHz). This measurement was done using the "old" Teflon supports in the horizontal orientation.

The measurement and analysis of the results were moved completely to Python. The measured resistivity of the copper rods (internal) and the copper tube (external) as functions of the frequency (at the frequency points of the fundamental mode and the first 3 harmonics) is visible in the figure below. The green line shows the theoretical value of copper resistivity.



This is comparable to (and actually a bit better than) the results of the first prototype (presented in my 2nd-semester report).

After this, the setup was inserted to a cryostat of the Cryolab at CERN and cooled down to 4.2 K using liquid helium. Since in the cryostat, we were using the G10 supports, the resonances were so wide, that the measured peaks of the fundamental modes were overlapping. This made the analysis completely impossible to carry out. To find out the reason for the loss of precision I was trying out different coaxial feedthroughs, different coaxial cables, trying the measurement in horizontal, and vertical orientation, and switching the G10 supports back to Teflon. In the end I identified the G10 as the main cause of measurement errors. To accommodate for the thermal contraction of the Teflon, new type of supports were designed, and simulated. New measurements will be carried out using these supports in the near future.

Plan for next semester:

Next semester I will measure the cryogenic prototype at low temperature, as well as start working on the design of the device to be inserted into the FRESCA cryo-magnet. The goal of my PhD is to produce this device, and test real beam screen demonstrators. For example HTS coated beam screens as one of the candidates to be used in FCC-hh, the next-generation collider ring.

University studies:

I attended a single course at university this semester, “Experimental methods in particle physics 2” taught by Gabriella Pasztor, and Gabor Veres. I would say this course was really useful since it continued to deepen my knowledge of particle physics detector systems, as well as providing a minor understanding of the analysis methods used to track single particles and reconstruct particle jets.

In January 2020 I shortly presented my work on a workshop organized at CERN for the people working on the study of HTS-coated beam screens for the FCC-hh.