In precision temperature metrology, particularly in cryogenics (below -196°C), sensor stability is a parameter as critical as accuracy. This instability, known as drift, can invalidate the results of months-long experiments. The sole current method for stability verification involves lengthy, expensive calibrations that provide no guarantee of a sensor's future performance. While research in the 1970s suggested a link between non-linear electrical effects and long-term stability, this concept remains underdeveloped and unverified with modern instrumentation. This absence of a rapid, non-destructive ex-ante (pre-use) qualification method hinders progress, especially for new sensor types, e.g., thin-film.

This project confronts this challenge. Our objective is to identify a unique electrical signature capable of forecasting a sensor's long-term stability. We hypothesize that the aging process is governed by the same microstructural defects and impurities that also generate measurable anomalies in the sensor's complex electrical response.

Our methodology rests on two pillars. First, we will conduct measurements of non-linear current-voltage (AC/DC) characteristics, assessing how the sensor's response deviates from ideal proportionality (Ohm's law) under high currents, which is highly sensitive to material defects. Second, we will utilize Impedance Spectroscopy (EIS) across a wide temperature range. EIS provides "deeper" insight into the sensor's structure, analyzing the impact of grain boundaries, contaminants, contact quality, or dielectric effects on its alternating current behavior.

We plan to investigate a cohort of Pt100/Pt1000 sensors and capsule-type cSPRTs (platinum resistance thermometers) - a standard for the International Temperature Scale (ITS-90) and for measurements in cryostats. We will compare their "as-new" electrical characteristics against the same characteristics measured at regular intervals during simulated aging protocols. We will employ two methods: (1) rapid cryogenic cycles (simulating multiple apparatus startups) and (2) prolonged continuous operation (simulating extended experiments).

Our goal is to establish a measurable correlation - a parameter or pattern in the EIS/ACDC data - enabling a rapid (hours versus months) and non-destructive prediction of long-term stability. Project success will equip metrology with a tool to select the best sensors post-production, which is critical for ensuring measurement consistency and fostering the development of new sensor technologies.