Annual meeting, summary of 2024

Mateusz Pietrzak

mpietrzak@camk.edu.pl

PhD student, supervisors: prof. T. Bulik and Dr. M. Suchenek

Group 3: Electronics and Data Acquisition and Processing

AstroCeNT

NICOLAUS COPERNICUS ASTRONOMICAL CENTER OF THE POLISH ACADEMY OF SCIENCES

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 952480

Dark Wave

European Funds Smart Growth

Republic of Poland

FNP Foundation for Polish Science

European Union European Regional Development Fund

Main area of research:

Developing **models for quartz resonators to improve synchronization in sensor networks**

Collaborating closely with **Group 2 (Seismic Sensors)** led by Prof. Tomasz Bulik and **Group 3 (Electronics Data Acquisition)** led by Dr. Mariusz Suchenek.

Contributing to projects focused on mitigating Newtonian Noise in gravitational wave detectors like Virgo and the Einstein Telescope.

AstroCeNT Sensors and Electronic Group:

Developing and testing seismic and infrasound sensors to reduce Newtonian Noise.

Improving these sensors helps detect gravitational waves more **precisely, especially at low frequencies.**

The goal is to enhance key components like seismic isolation and laser systems to improve wave detection capabilities.

The Role of AstroCeNT Sensors in Newtonian Noise Cancellation

- AstroCeNT sensors were critical for **measuring seismic noise** around the **Virgo** gravitational wave detector.
- The **110 vertical geophones** and more than **70 infrasound microphones** provided real-time data that helped cancel out environmental noise, improving the sensitivity of the detector.
- By reducing Newtonian Noise, the sensors can **improve the detection range for gravitational waves**, especially at low frequencies crucial for observing events like black hole mergers.

Seismic-infrasound system for Newtonian Noise cancellation in Virgo EGO.

Design and implementation of a seismic Newtonian noise cancellation system for the Virgo gravitational-wave detector

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Show authors

AstroCeNT sensors locations

ETpathfinder

Virgo interferometer

Sos Enattos mine

Visited to the Einstein Telescope Pathfinder for sensor installation

10 Infrasound microphones were created at AstroCeNT/NCAC by **Dr. Mariusz Suchenek's groups**

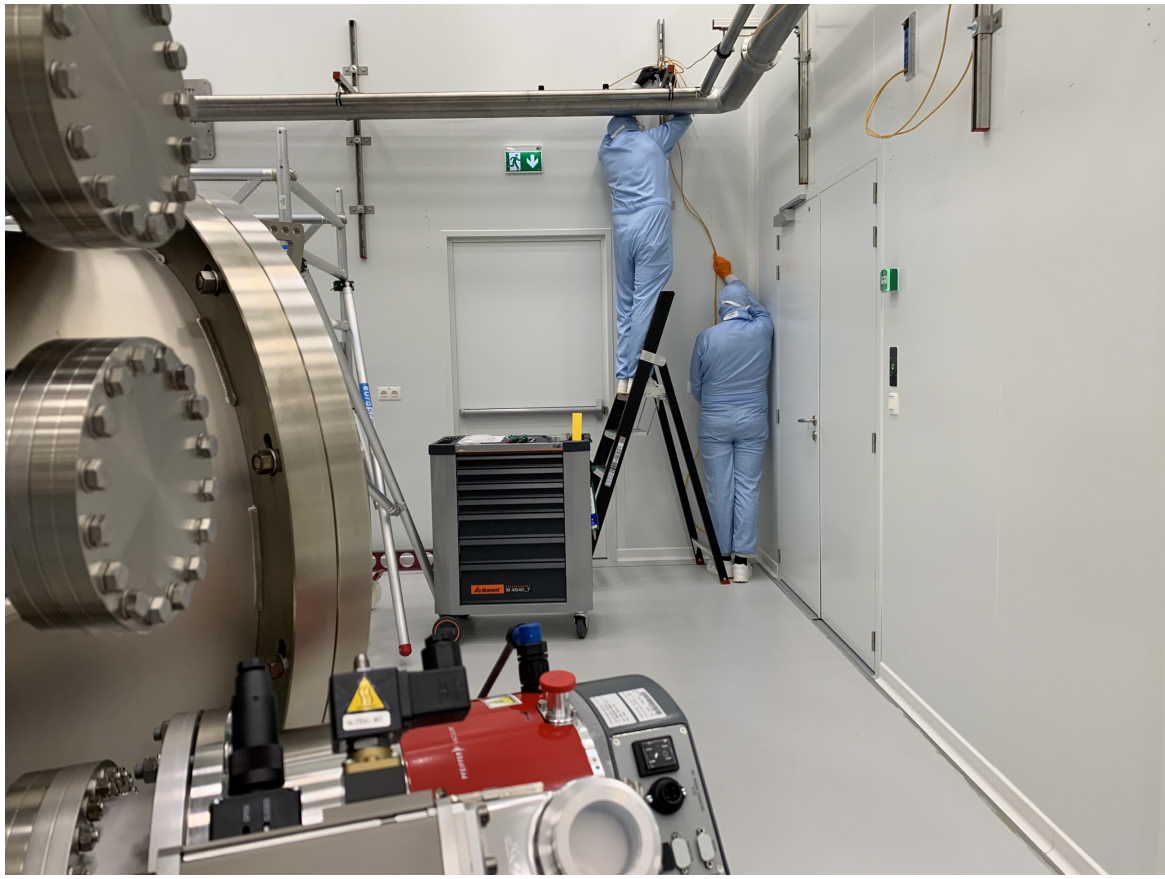
Installed **13 seismometers** were developed by Innoseis company and modified by University of Warsaw scientists.

The system will characterize the location where **optical solutions for the Einstein Telescope are tested**.

Characterizing disturbances generated in the facility e.g. from road infrastructure outside the laboratory.

Infrasound microphone,
Frequency range from 0.1 Hz to 120 Hz

Based Innoseis seismic sensors, 4.5 Hz, geophone

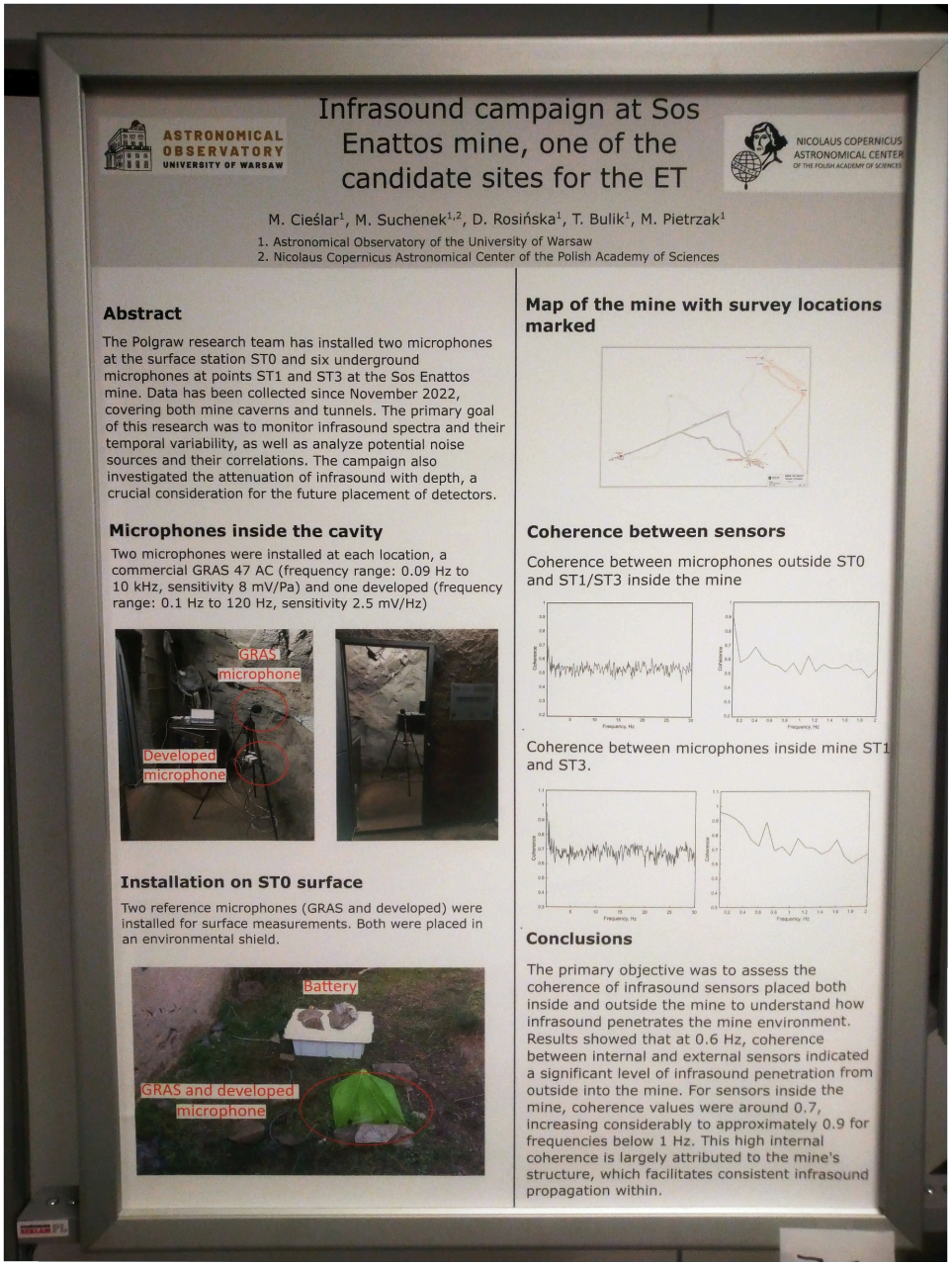


Installing sensor cabling

3rd Einstein Telescope Annual Meeting

From November 12–15, Warsaw hosted the 3rd Telescope Meeting Annual Einstein. The event was organized by the University of Warsaw (Astronomical Observatory) and the Nicolaus Copernicus Astronomical Center

3rd Einstein Telescope Annual Meeting



ASTRONOMICAL OBSERVATORY UNIVERSITY OF WARSAW

Infrasound campaign at Sos Enattos mine, one of the candidate sites for the ET

NICOLAUS COPERNICUS ASTRONOMICAL CENTER OF THE POLISH ACADEMY OF SCIENCES

M. Cieślar[1], M. Suchenek[1,2], D. Rosińska[1], T. Bulik[1], M. Pietrzak[1]

1. Astronomical Observatory of the University of Warsaw
2. Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences

Abstract

The Polgraw research team has installed two microphones at the surface station ST0 and six underground microphones at points ST1 and ST3 at the Sos Enattos mine. Data has been collected since November 2022, covering both mine caverns and tunnels. The primary goal of this research was to monitor infrasound spectra and their temporal variability, as well as analyze potential noise sources and their correlations. The campaign also investigated the attenuation of infrasound with depth, a crucial consideration for the future placement of detectors.

Microphones inside the cavity

Two microphones were installed at each location, a commercial GRAS 47 AC (frequency range: 0.09 Hz to 10 kHz, sensitivity 8 mV/Pa) and one developed (frequency range: 0.1 Hz to 120 Hz, sensitivity 2.5 mV/Hz)

Installation on ST0 surface

Two reference microphones (GRAS and developed) were installed for surface measurements. Both were placed in an environmental shield.

Map of the mine with survey locations marked

Coherence between sensors

Coherence between microphones outside ST0 and ST1/ST3 inside the mine

Coherence between microphones inside mine ST1 and ST3.

Conclusions

The primary objective was to assess the coherence of infrasound sensors placed both inside and outside the mine to understand how infrasound penetrates the mine environment. Results showed that at 0.6 Hz, coherence between internal and external sensors indicated a significant level of infrasound penetration from outside into the mine. For sensors inside the mine, coherence values were around 0.7, increasing considerably to approximately 0.9 for frequencies below 1 Hz. This high internal coherence is largely attributed to the mine's structure, which facilitates consistent infrasound propagation within.

Poster session presenting work on sensors in Sos Enattos, Sardinia

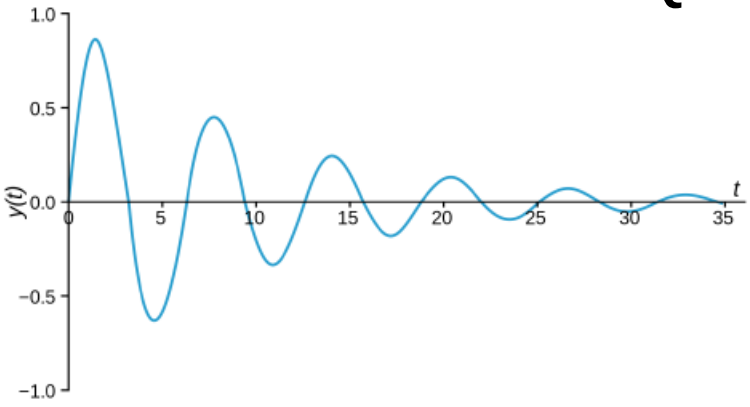
Investigating the Impact of Temperature on Quartz Resonators

Quartz sample

Quality factor

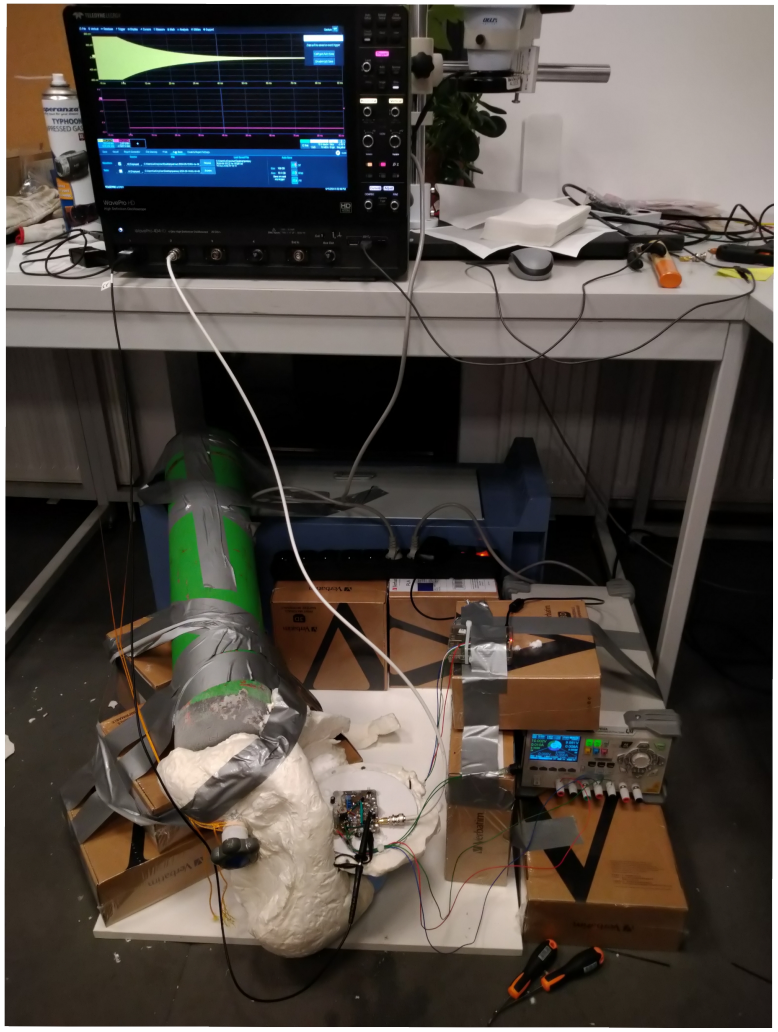
Q is the ratio of stored energy to the energy lost per cycle.

$$Q = 2\pi \frac{E_{\text{stored}}}{\Delta E_{\text{lost}}}$$

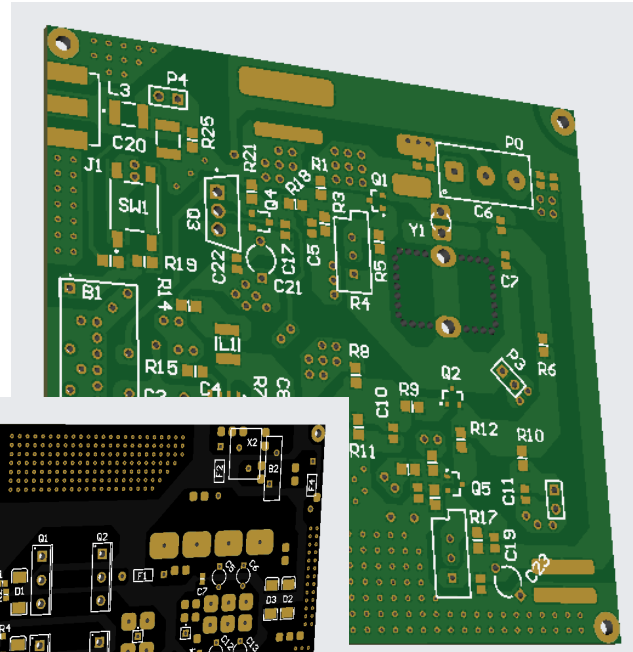


The higher the Q, the less energy is lost per cycle, indicating a more efficient resonator.

The research involves temperature controlled experiments to assess these effects



Measurement setup

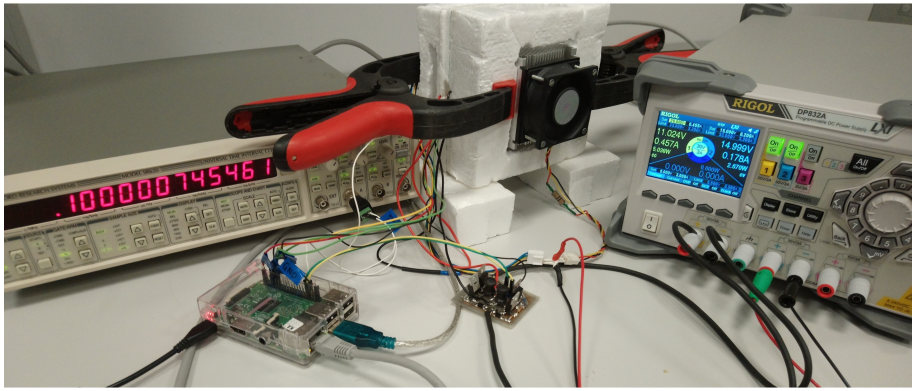


PCBs

Frequency counter

Temperature chamber based on Peltier modules

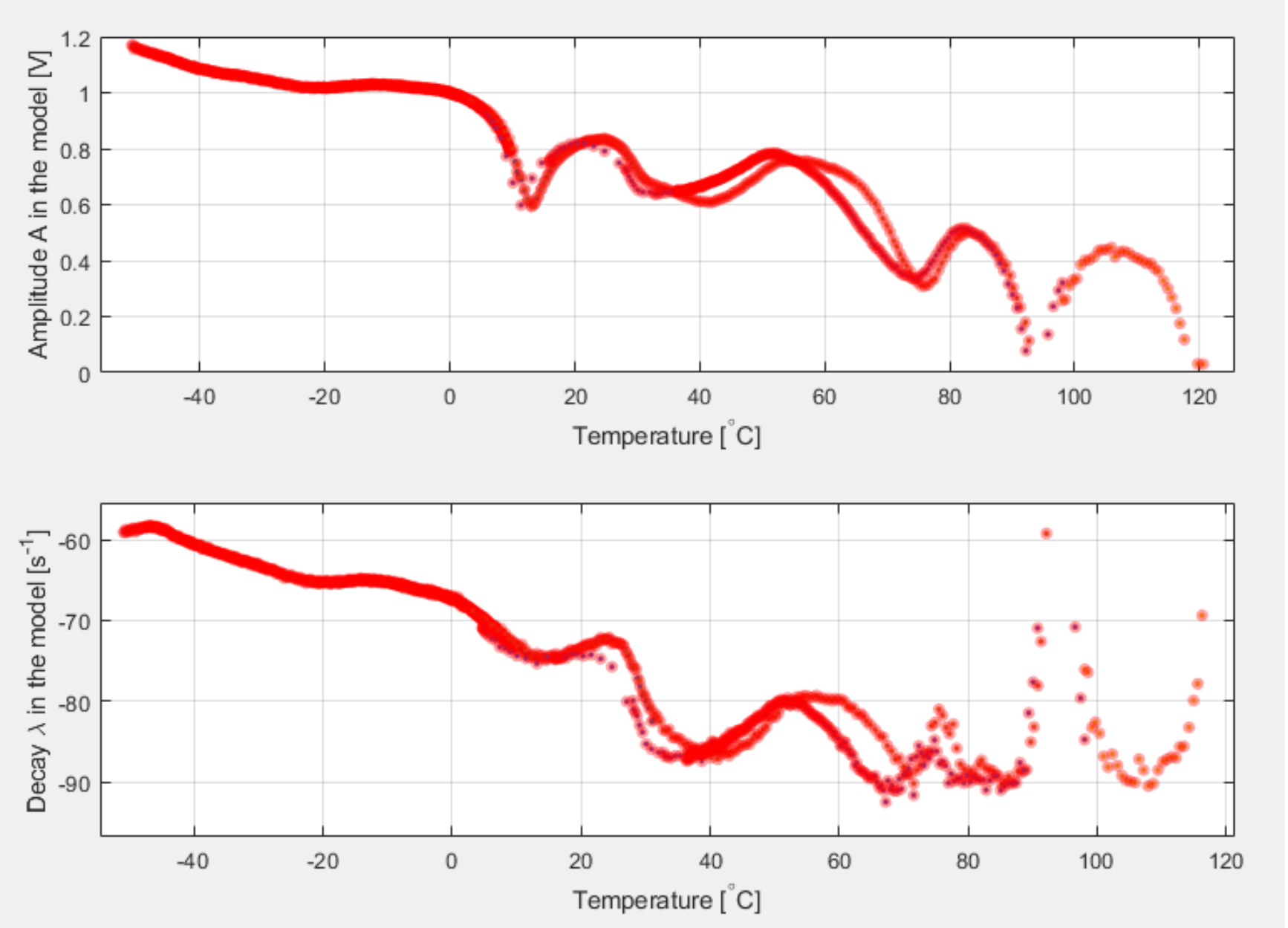
Power supply



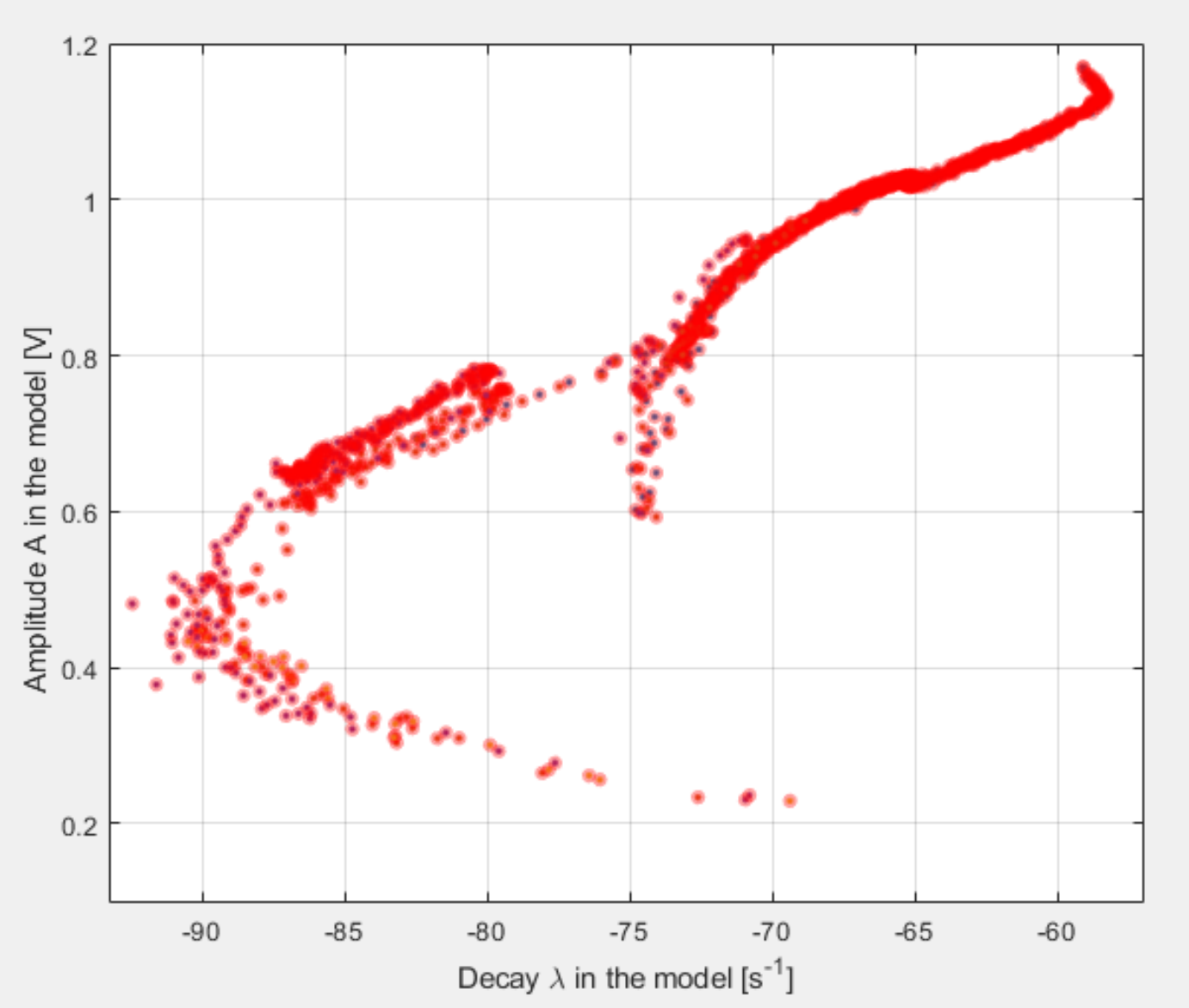
Single-board computer for system control and data acquisition

Current control circuit

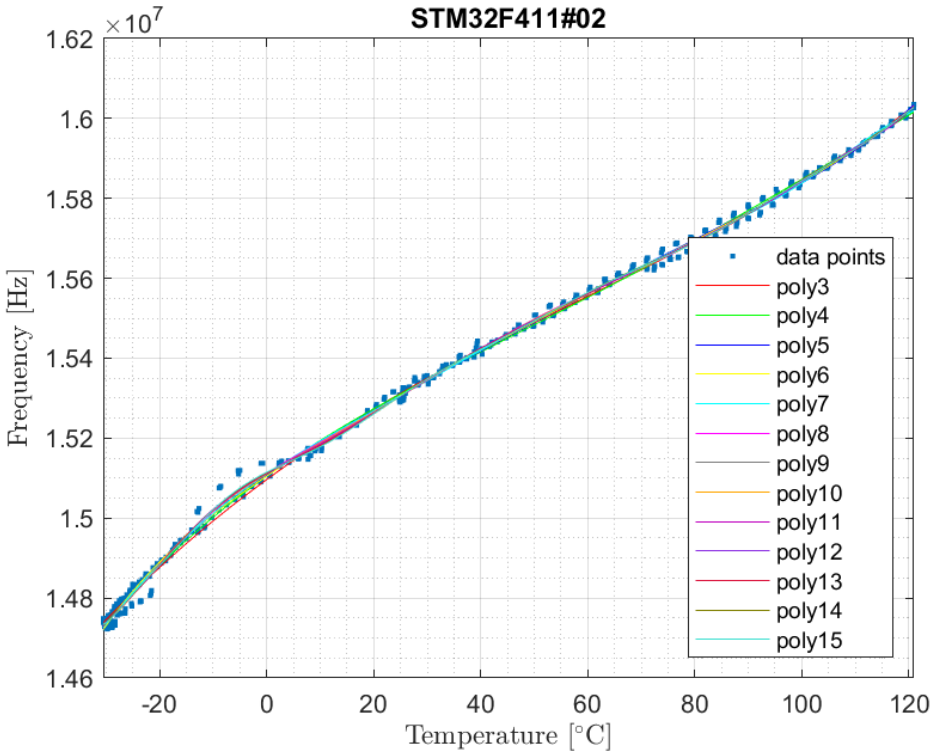
The the decay λ (lambda), as a function of temperature

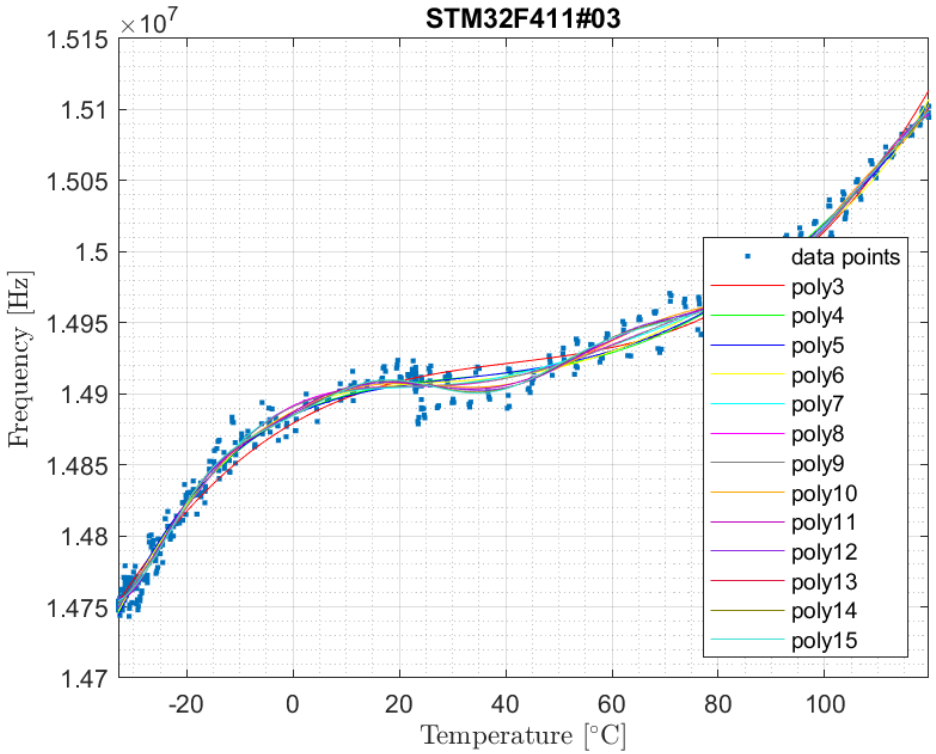


The decay and amplitude of oscillation



Fitting the Model to the Frequency Response Curves of Quartz





Conclusion

There is nothing left to do but to gather more data and **proceed with publishing the results**.

Thank you for your attention!