Solar radio emissions observed at Bucharest CALLISTO Station in 2022

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ABSTRACT

We present several observations of radio emissions from the Sun, recorded with the CALLISTO spectrometer installed at the Astronomical Institute of the Romanian Academy, in Bucharest. We developed a front-end for the antenna, in order to increase signal to noise ratio and avoid radio frequency interference and cross-modulation in the receiver caused by strong terrestrial radio stations.

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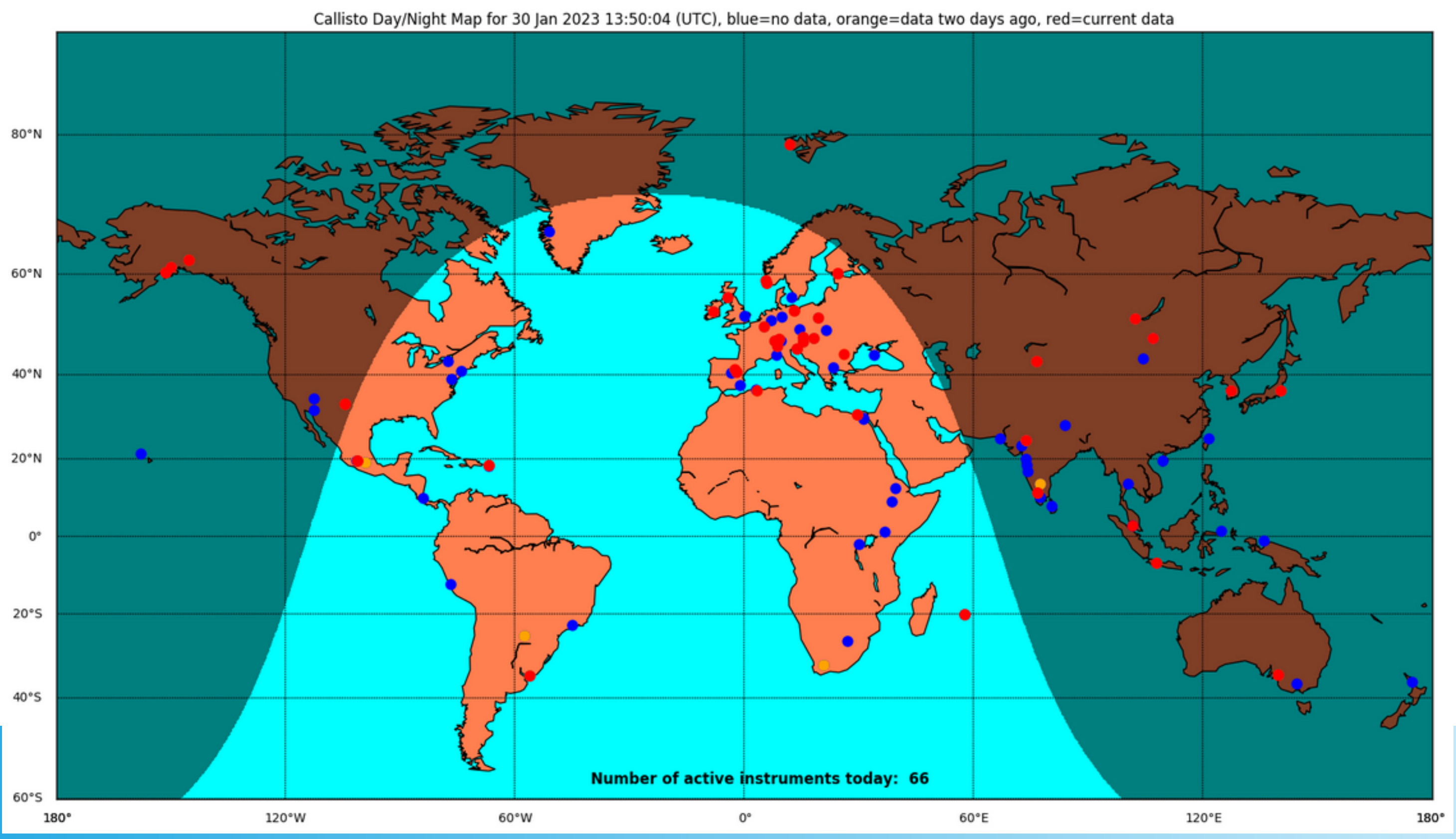
INTRODUCTION

CALLISTO = Compound Astronomical Low frequency Low cost Instrument for Spectroscopy and Transportable Observatory - developed by Christian Monstein (Istituto Ricerche SOLari Aldo e Cele Daccò, Locarno (IRSOL), Switzerland).

- e-callisto network = International Network of Solar Radio Spectrometers, a Space Weather Instrument Array, 24h/day
- all relevant information can be find on the web page of the network: https://www.e-callisto.org/



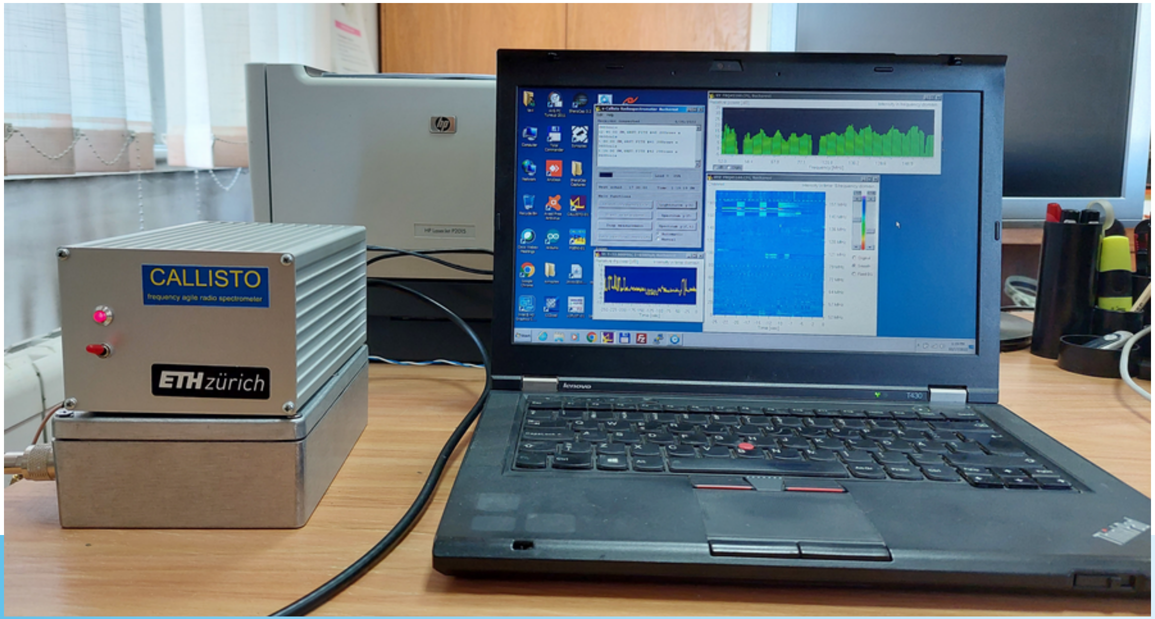
Bucharest CALLISTO Station

We use a simple 20.1 MHz dipole antenna, a front end composed by a high pass filter, a FM notch filter and a 12 dB gain ultra low noise amplifier. The data is recorded with the custom software for Windows developed by Christian Monstein. It is capable to record radio burst following C class flares/eruptions or greater.

FITS files of 15 minute recording time are uploaded on the https://www.e-callisto.org/Data/data.html server and is freely available.

On the site you can find other data:

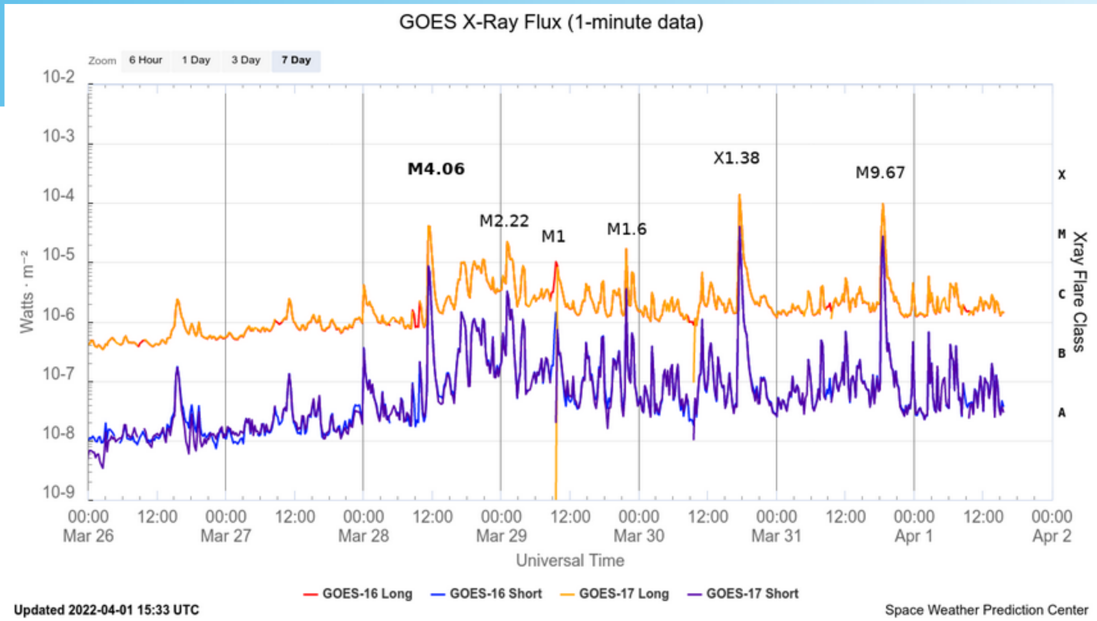
- daily spectral overview and light curve for each instrument
- event list with time, type of the burst and stations that record them

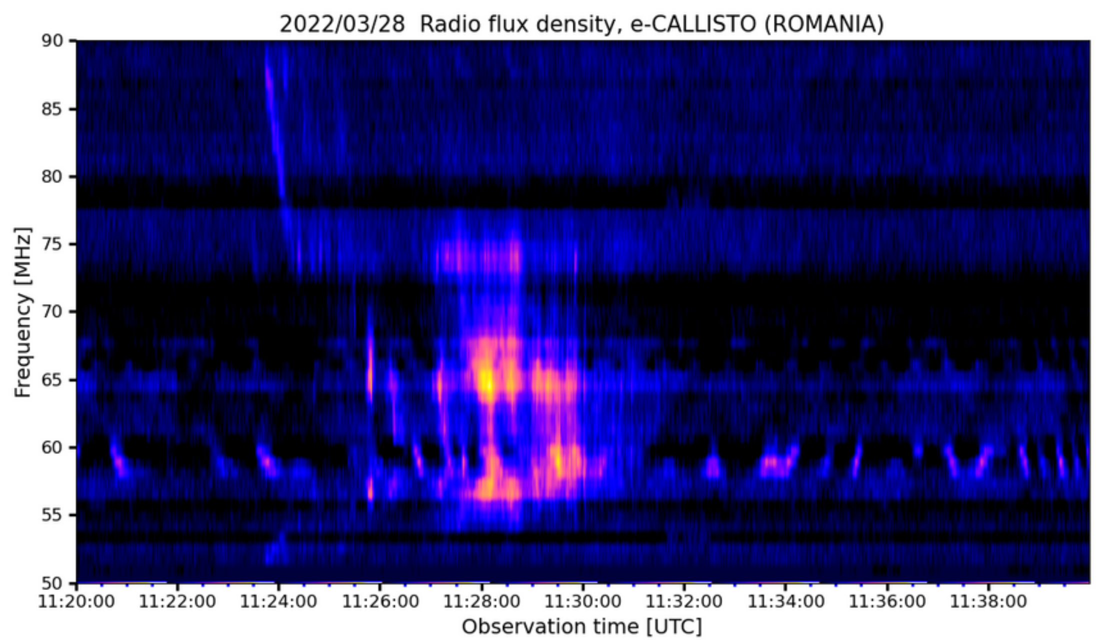


OBSERVATIONS

The first event recorded at Bucharest CALLISTO Station in 23 march 2022 began at 11:24 UTC and the amplitude of signal decreased below the detection level after about 20 minutes. The radio burst follows the M4.06 flare occurs in AR12975 (GOES X-ray Flux – upper left). The radio burst was seen by many other stations on the network with better sensitivity. Based on spectrograms recorded by other stations the radio burst was classified as type II. It had a fundamental and harmonic emissions caused by the shock wave of a big CME.

The image was obtained with a Java Viewer software and is a zoom-in from the FIT file. Background noise and terrestrial emissions was subtracted and the wide band emissions from the Sun was highlighted (C. Monstein)

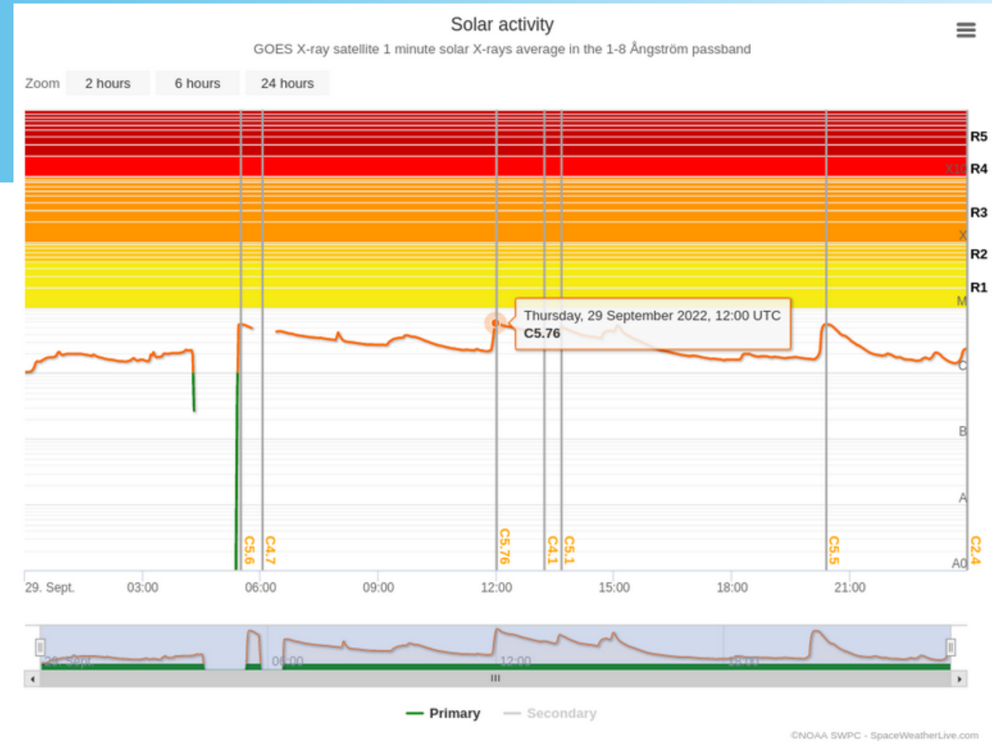


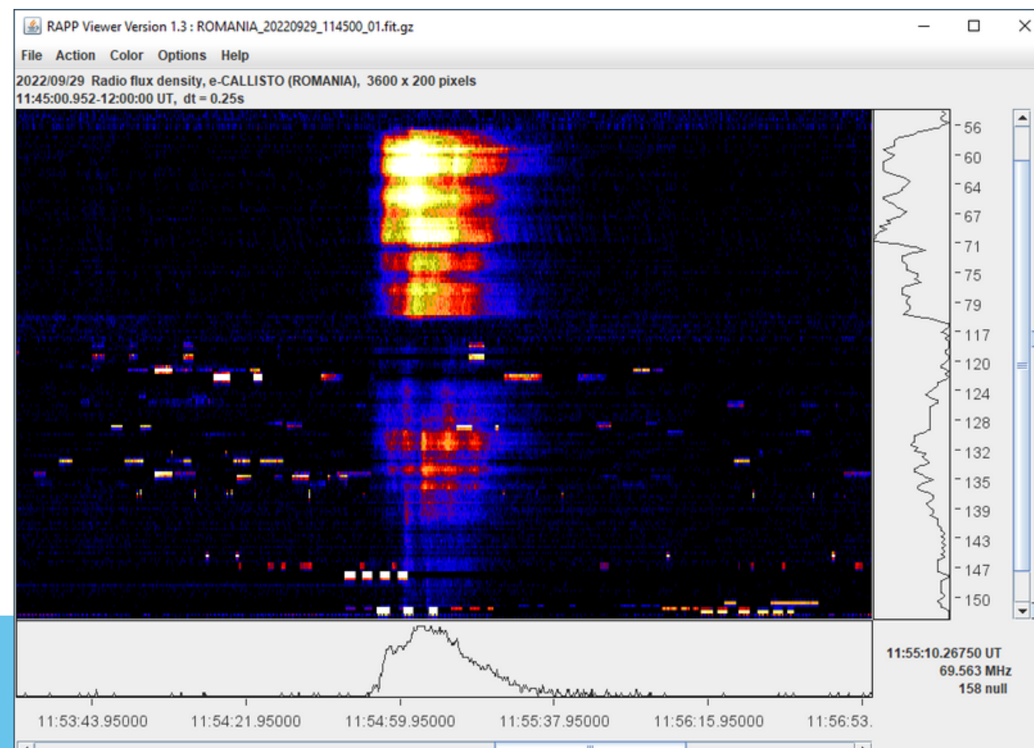


In the bottom picture is a Type V radio burst recorded in 29 september 2022 at 11.54 UTC with a duration of 5 minutes. It follows a C5.76 flare in AR 13112.

There is “poor correlation between intensity of the radio bursts and X-ray flare, they are generated from different physical processes on the Sun, especially depending on the radial location (near the surface or far out in the corona). Low frequency burst are always far out in the corona, even in inter-planetary space while x-ray is mostly close to the surface of the Sun.” (C. Monstein)

However, the events are correlated in time – the PC must be synchronized with a Network Time Control (NTC) to UTC. We can compare detections with spectrograms from other stations and GOES X-ray flux to confirm, classify or dismiss false ones.

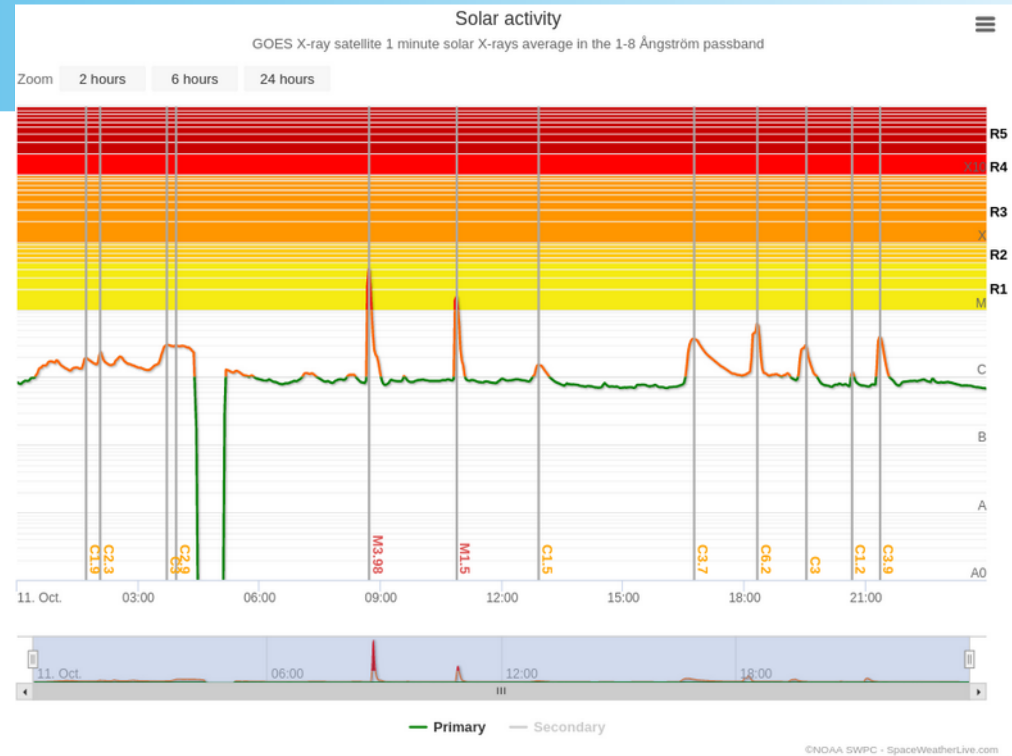


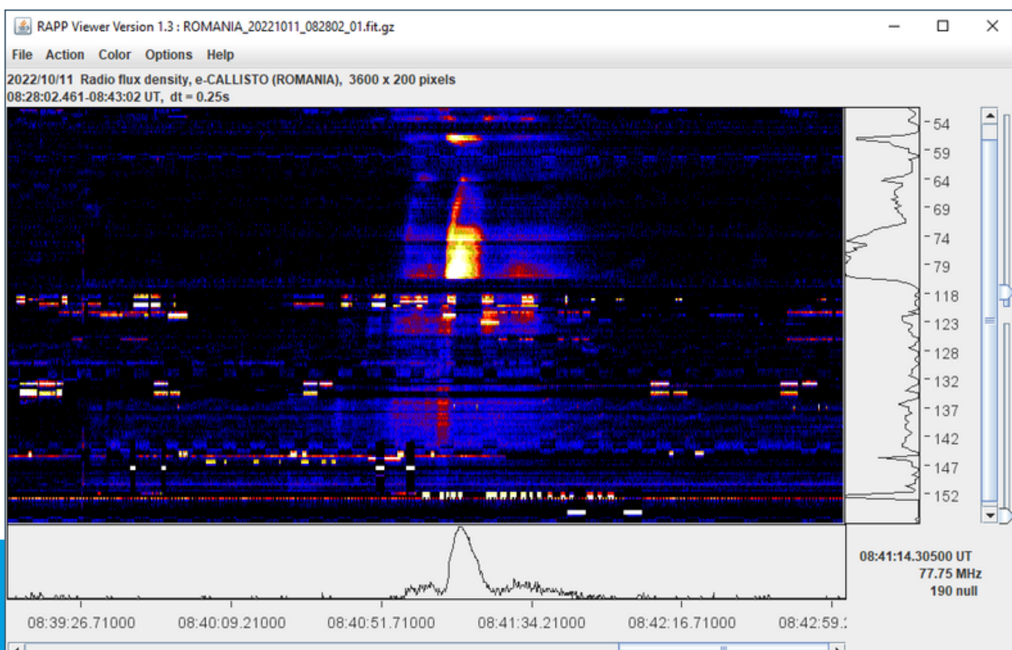


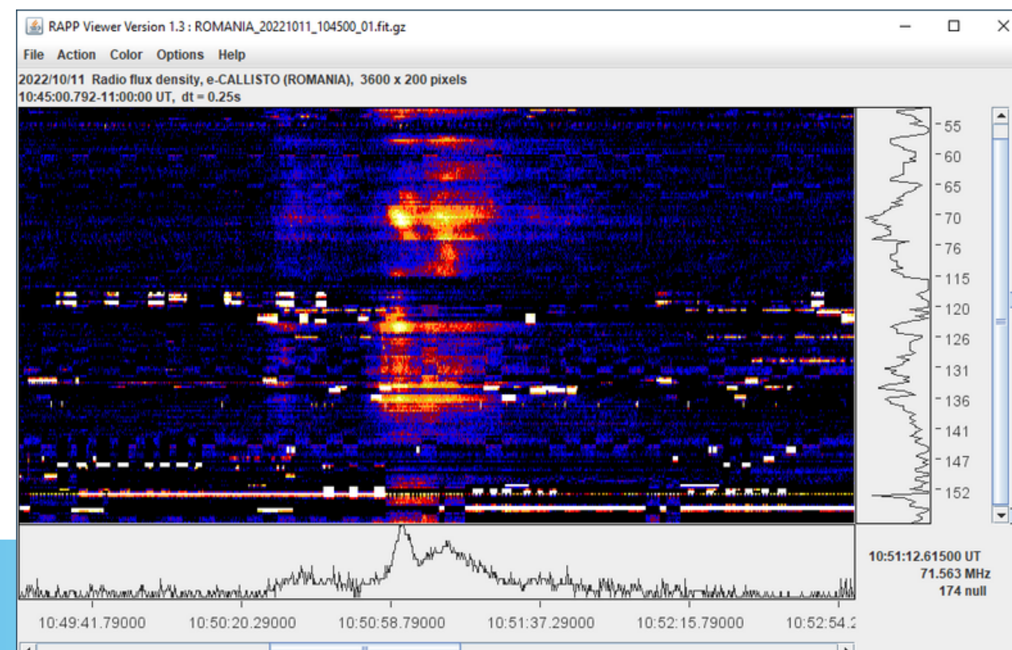
After installing the new front end we record two radio burst in the same day, 11.10.2022.

At 8:40 UTC was a type V burst (lower left) following a M3.98 flare
At 10:50 UTC was a type III burst (lower right) following a M1.5 flare

These radio emissions was generated by the coronal activity of the AR13112, a very productive region of the 25th cycle, with many M and C class flares.



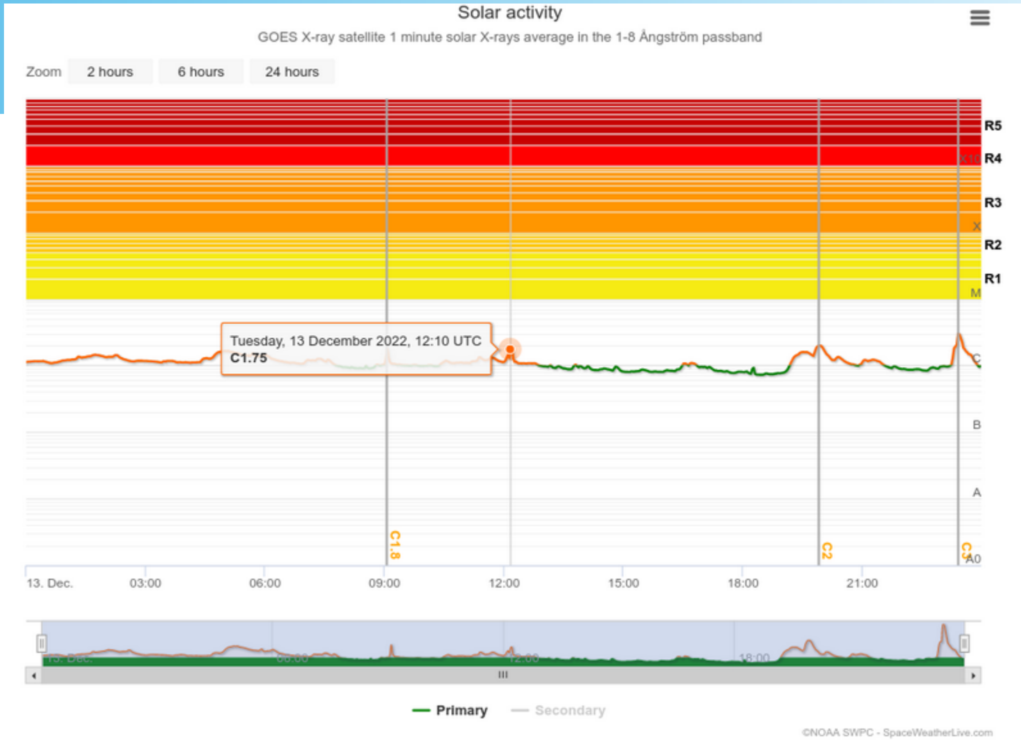


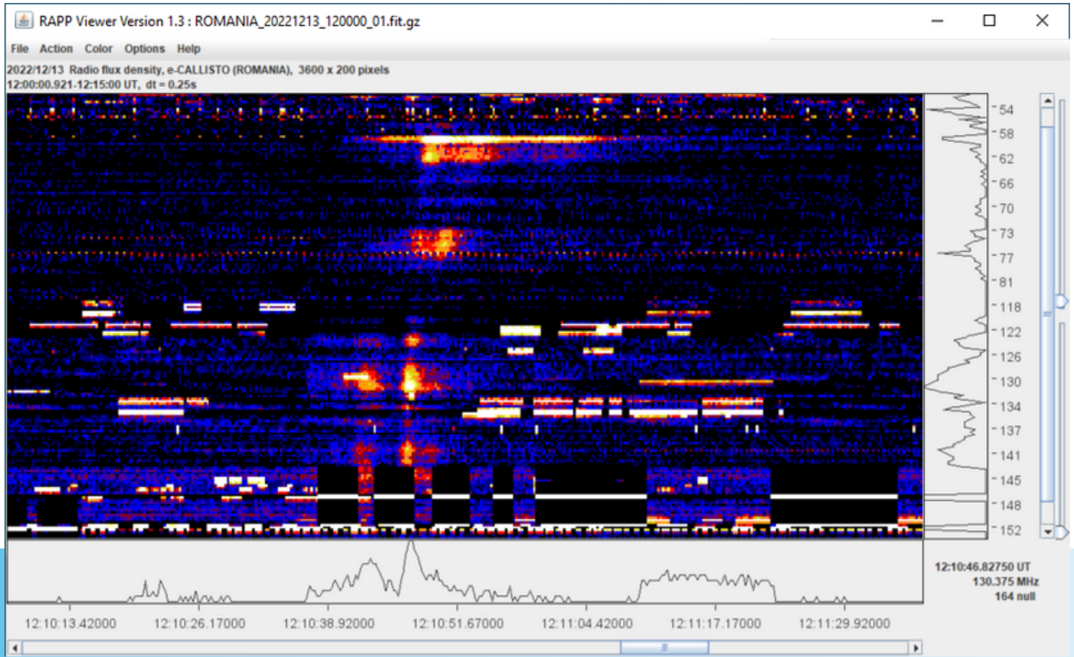


Another type III radio burst was detected in 13.12.2022 following a C 1.75 flare. This is the lowest energy X-ray flare that cause clear detection of a radio burst on the Bucharest CALLISTO station.

Other minor radio bursts was detected, few are so weak that require some fantasy to be seen in the spectrograms.

There are also high energy flares that don't cause any radio bursts and some radio bursts not correlated by a flare.

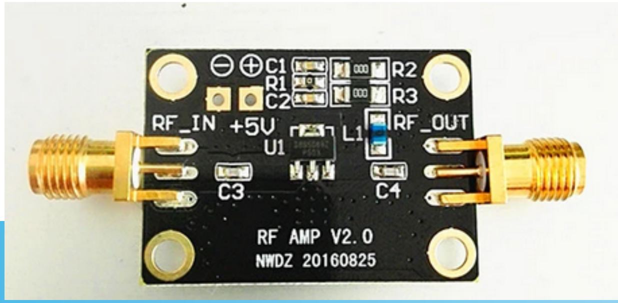




DEVELOPING THE FRONT END

- Sun’s emissions are low power, only strong radio burst can be received with a simple antenna
- electromagnetic radiation from the sun is very wide band, continuous or impulsive noise
- Environment Radio Frequency Interferences caused by local and far transmitters/sources limit the usable band and gain
- ultra Low Noise Amplifier: pHEMT MMIC GaAs transistors (SPF5189, PGA103+), high linearity, ultra wide band, <1dB noise figure
- Filters: High Pass, Low Pass, Band Pass: reject undesired bands of frequencies
- Butterworth, high order (7th order)
- FM notch rejection filter (9th order)

We tried to improve the reception adding a front end near the instrument because the box is to heavy to install at the antenna wire. To avoid the local RFI seen in the overview spectrogram we decided to reject undesired lower frequencies and FM broadcasting and use a small gain LNA of 12 dB. Two filters is needed, we had a commercial FM notch filter and designed and built a custom high pass filter for 52 MHz.

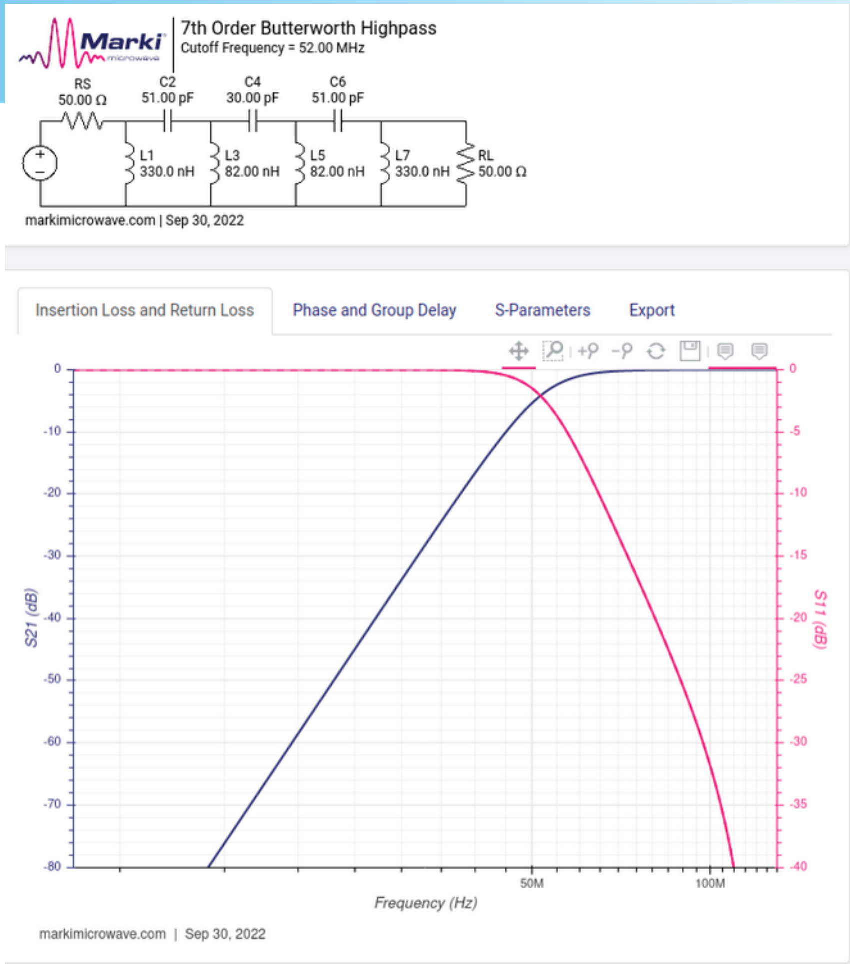


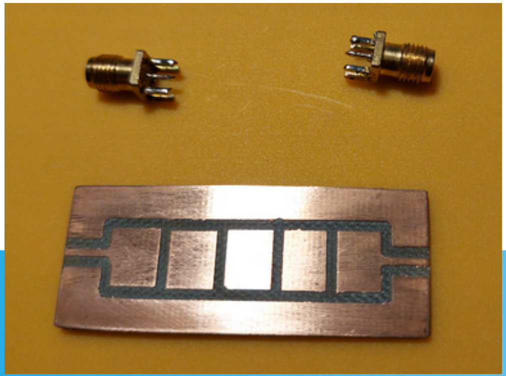
High pass filter was designed with a free online calculator, https://rf-tools.com/lc-filter/
52MHz cut-off frequency was selected to avoid cross-modulation from a near radio amateur transmitter

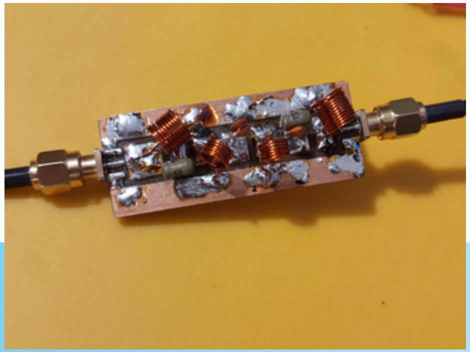
The air coils was hand-made from 0.5mm enameled wire, an online calculator was used: https://www.translatorscafe.com/unit-converter/en-US/calculator/coil-inductance/

The filter was assembled on a double sided copper clad laminate and the circuit was made on a small milling machine (left).

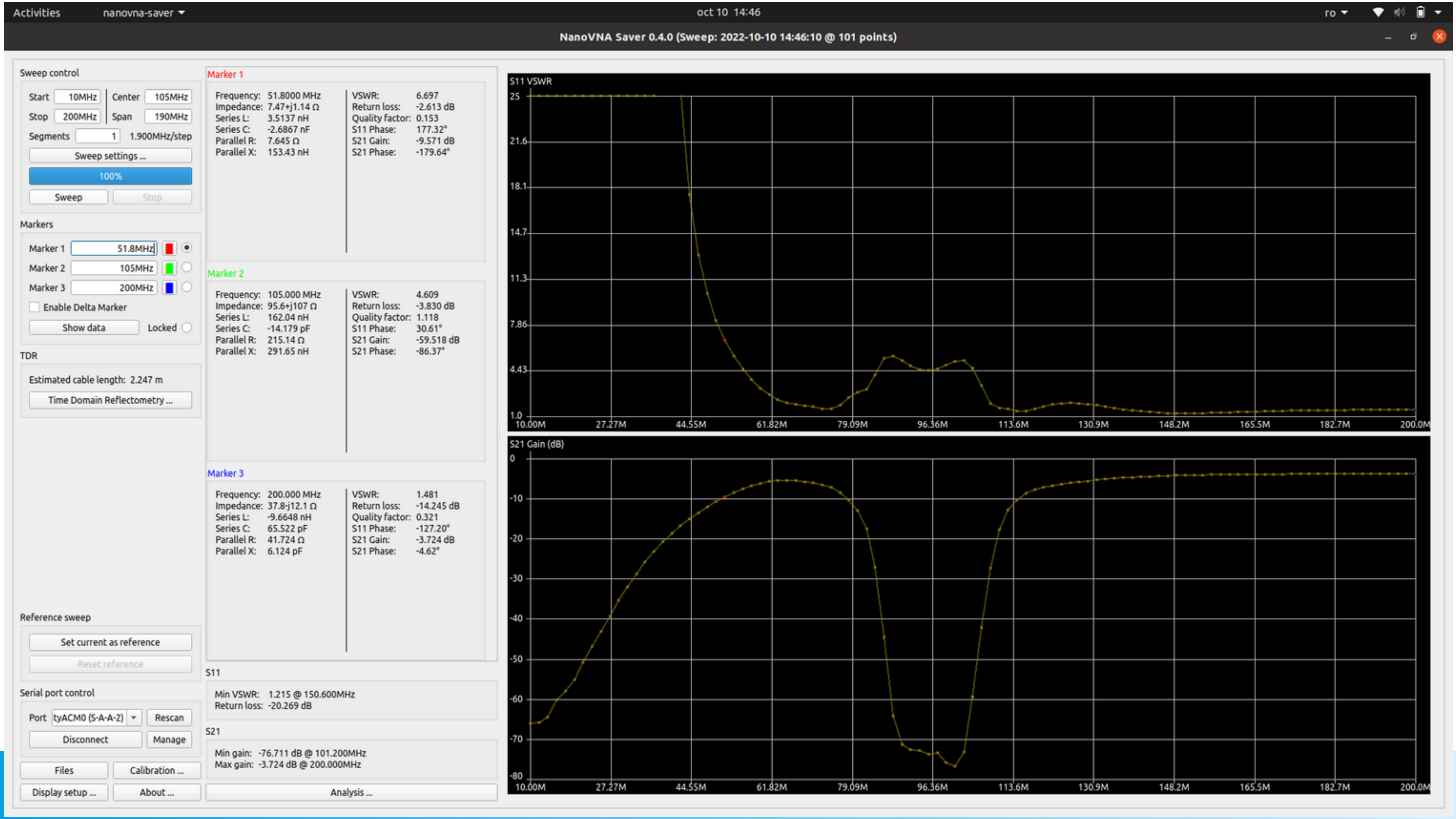
Assembled filter was tested with a nanoVNA instrument and installed in an aluminum case.



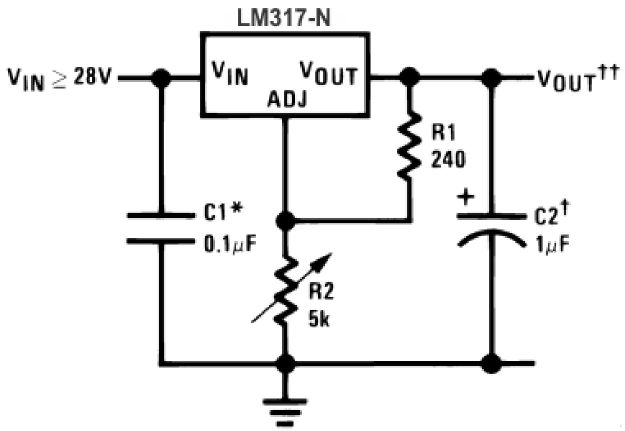




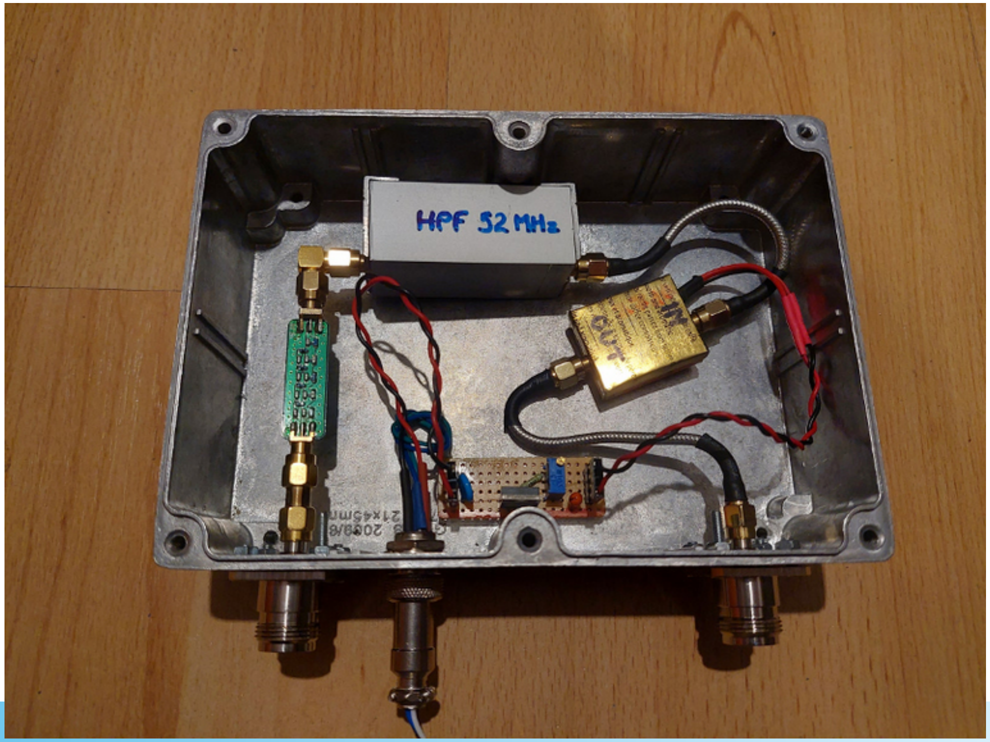
The FM notch and high pass filter was tested with the nanoVNA instrument. The graphic in the lower part show the effect of the filters to suppress undesired frequencies below 52 MHz and between 88-108 MHz. In the upper graphic the Voltage Standing Wave Ratio (VSWR) is shown.



The LNA gain depends on the voltage applied so we use an adjustable linear regulator to set the gain at 12 dB. A simple circuit (left) with LM317 was used. The gain was measured with nanoVNA.



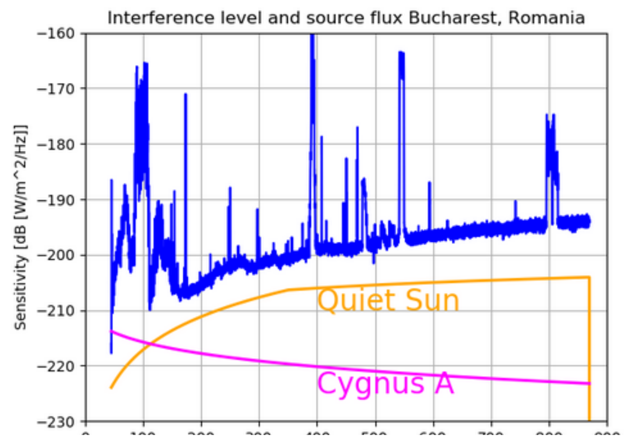
The front end for antenna was assembled in a cast aluminum case:
- FM band notch filter (left)
- High pass filter 52MHz (up)
- ultra Low Noise Amplifier (right)
- linear adjustable voltage stabilizer LM317 (bottom)

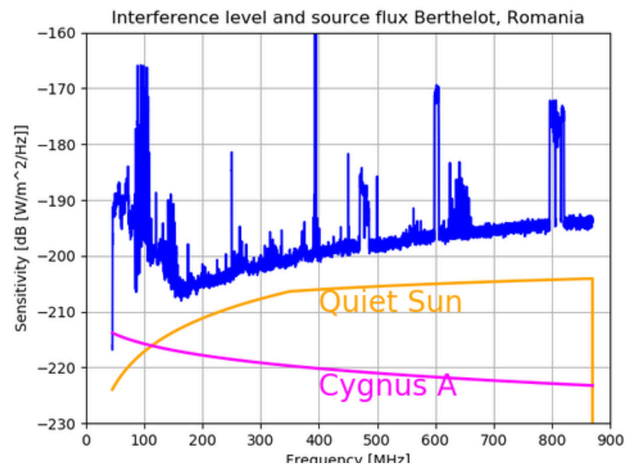


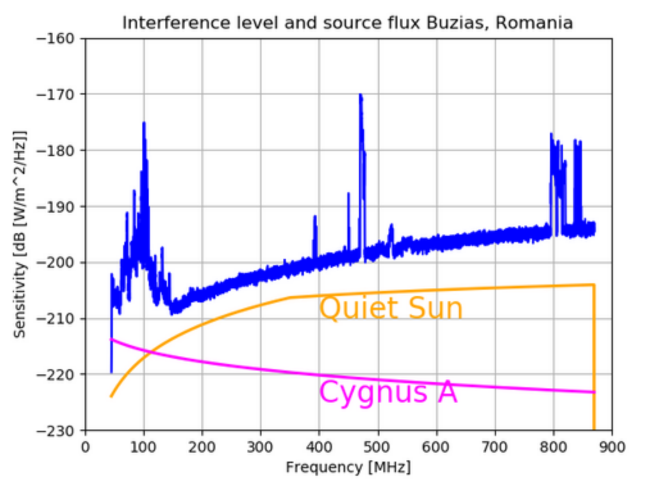
The front end was installed in the office, near the CALLISTO instrument.
A part of the received signal from antenna is lost on the down-link cable.

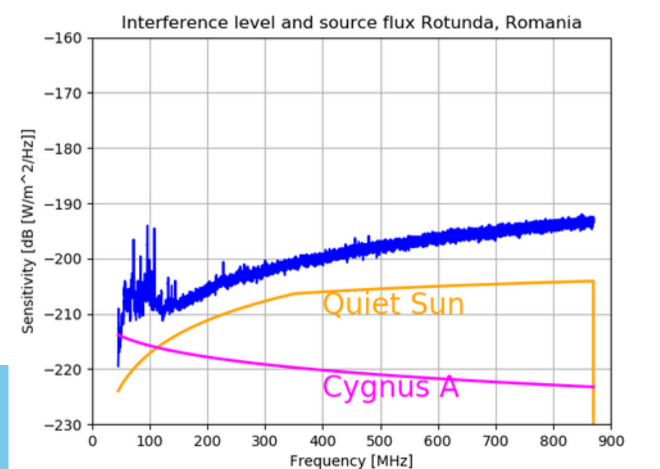
FINDING A BETTER PLACE

Using the CALLISTO instrument and a simple whip antenna we recorded full spectrum overviews from 45MHz to 830MHz in several locations. Bucharest and Berthelot have high level of RFI especially in HF frequencies and strong FM broadcasting, Tetra and GSM. At Buzias is a bit better but the best place found so far is in the Retezat Mountains at Rotunda Cabin. Unfortunately, Rotunda is inaccessible in winter and there are high mountains around that will limit the Sun visibility.









CONCLUSIONS

The radio environment in Bucharest is very noisy and the gain of the antenna used is low to avoid cross-modulation from the strong signals of near radio transmitters

Future work:

- we prepare a new active antenna with a better LNA installed in the middle to avoid cable loss, a new band-pass filter is needed
- a new station will be installed in the future in Romania, in a remote area with a low level of RFI. A high gain antenna will record smaller amplitude events. We choice a Log Periodic Dipole Array wide band antenna installed on an alt-azimuth mount to follow the Sun. This antenna is used in many other CALLISTO stations with best results.

Thank you!