RedPill PocketQube

J2050 – New Epoch Technologies

First Long Range communication Test Report

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1. Test objectives

1.1 Configuration

This report aims to give a complete analysis of the first long range test of RedPill's antenna. Using two prototypes of the self-built space antenna and a high gain antenna was possible to test the resonance frequency and the possibility to have a clear communication between different apparatus. A communication test was also done at different inclination angles, studying the response of the system, the signal strength and the ratio between signal and noise.

As a first long-range test, it was chosen to try a transmission between two stations within a distance of 20 km, searching for a clear path with the minor disturbance possibilities. We will identify the two communication system with the place of collocation: "Monte Ceva" will identify the ground station(45°17′24.72″N 11°46′50.52″E) and "Noventa" will identify the receiver(45° 24′ 28.85″ N, 11° 58′ 37.69″ E).

The hardware configuration of ground station was equipped with two devices, the self-built antenna(PICO) and a high gain antenna[1], both interchangeable and connected with a LoRa1268F30 module with Semtech SX1268 transceiver. The power supply was provided by a computer that was used also as an interface for communication and data saving.

The receiver's hardware was based on the same configuration, but it was equipped only with the self-built antenna.

1.2 Data acquisition

The communication test was completely managed by the ground station at Monte Ceva, sending different types of messages and receiving a check response by Noventa. With this approach was possible to obtain different type of data:

- RSSI and SNR for the message received by Noventa
- RSSI and SNR for the check message received by Monte Ceva
- Frequency shift for both messages

The communication test was done by acquiring 5 different measurement for each inclination angle(0°, 30°, 45°, 60°, 70° for the test between PICO and the high gain antenna - 0°, 30°, 45° for the test between PICO and PICO), which was set by using a compass, moving only the receiving antenna at Noventa knowing the relative position of Monte Ceva summit.

1.3 Software testing

During the test it was also possible to test and correct the software created for the communication control, searching for bugs and testing the database for saving data.

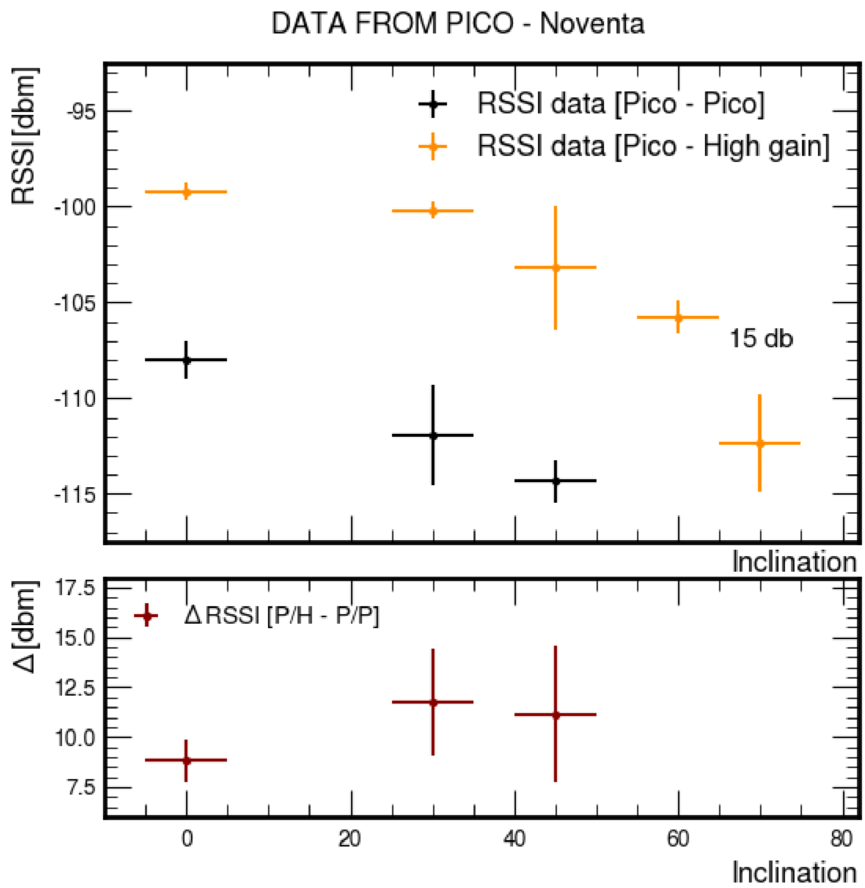
[1] Resonance frequency for the high gain antenna: 400 - 460 MHz

2. Acquired data

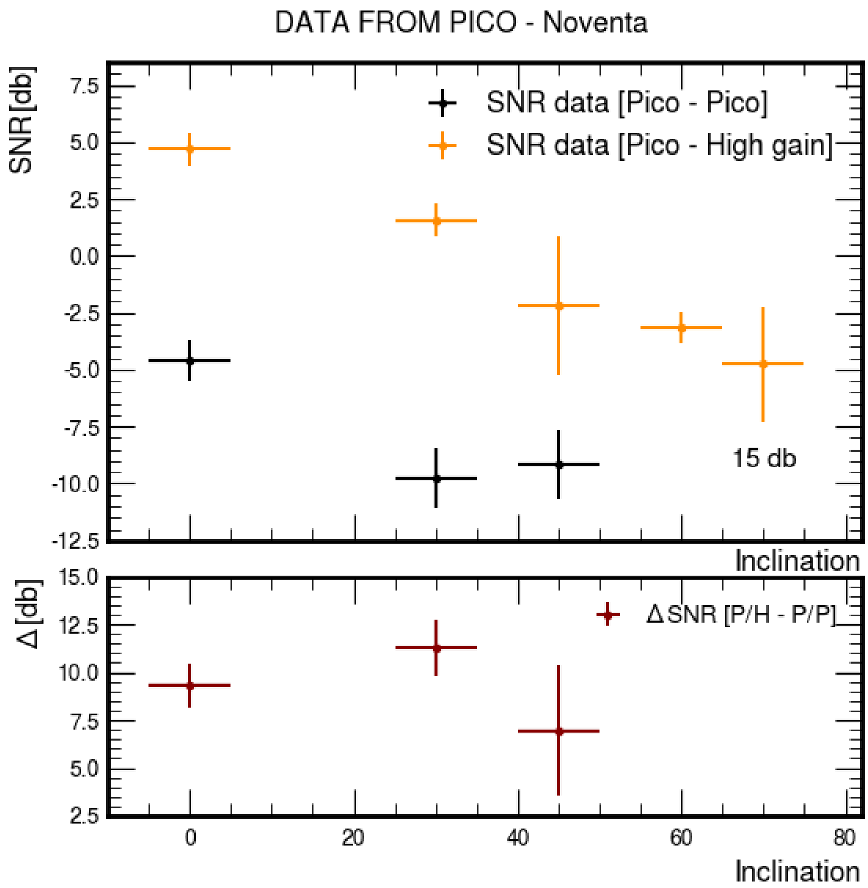
The following graphs represent RSSI and SNR values, detected from the PICO antenna collocated at Noventa and from the GS at Monte Ceva, in function of the inclination angle. Each value is obtained by the mean of 5 different measurements and the standard deviation of their distribution represents the measurement uncertainty within one sigma deviation. A 5 degrees angle is considered to be a reasonable estimation of the uncertainty on the angle measurement. This consideration is based on a series of possible systematic errors that could be made in the acquisition procedures. The hand-made positioning of both antennas could be in fact an important factor in the loss of accuracy in the angle's setting. The SNR gain is also reported.

For the last measure(at 70°) the power of the PICO antenna was increased to 15 db(normally It was set at 10 db).

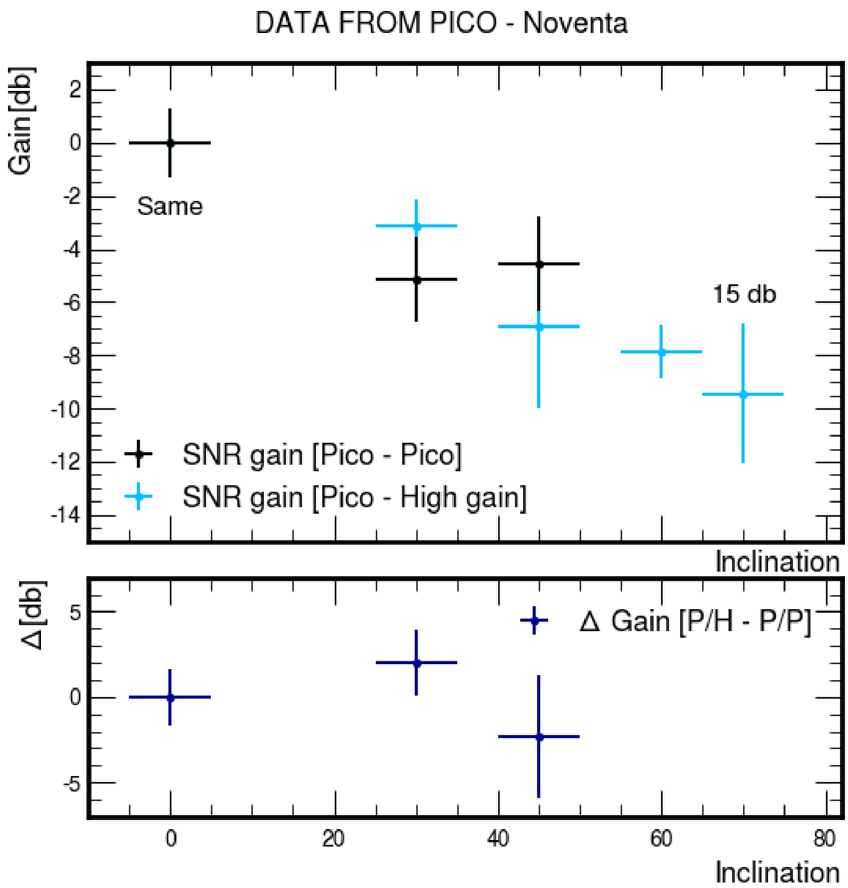
2.1 SNR and RSSI data received by Noventa's PICO



1.0 RSSI value for both configurations. It is also reported the difference between the two measurements for the common angles.

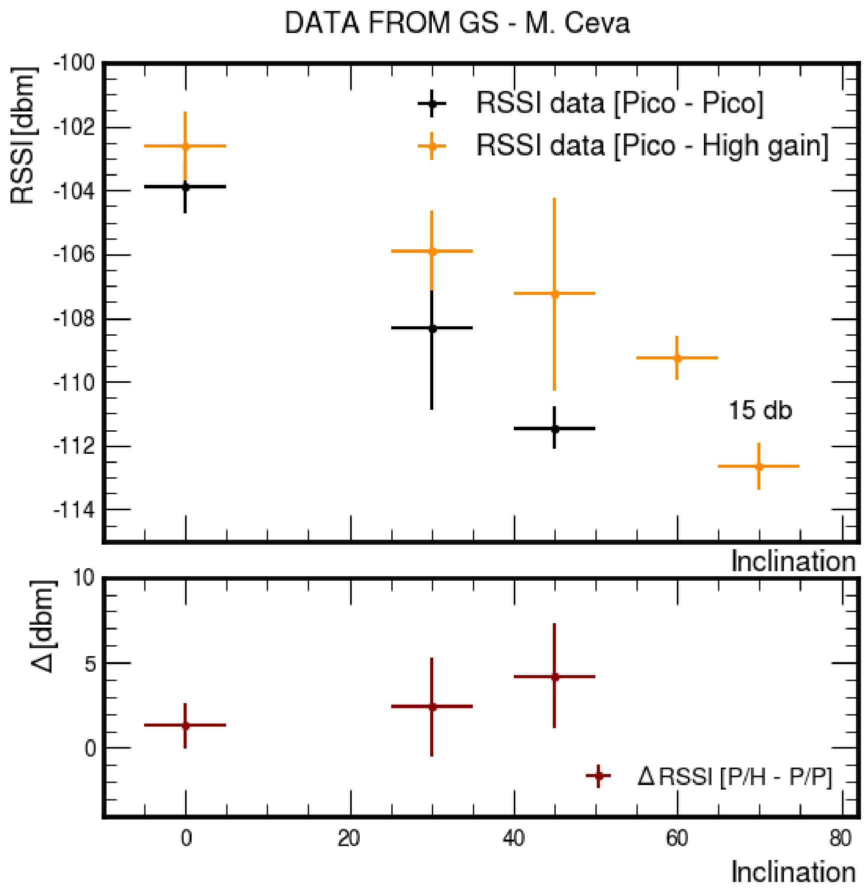


1.1 SNR value for both configurations. It is also reported the difference between the two measurements for the common angles.

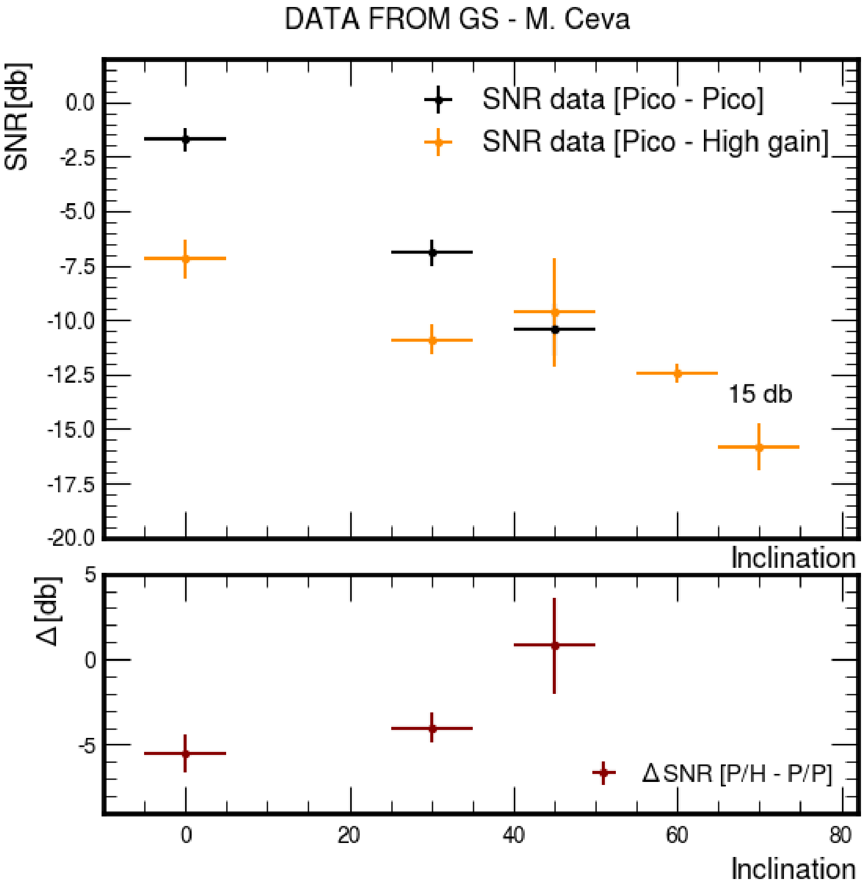


1.2 SNR gain value for both configurations. It is also reported the difference between the two measurements for the common angles. The first measure of reference is communally set to zero.

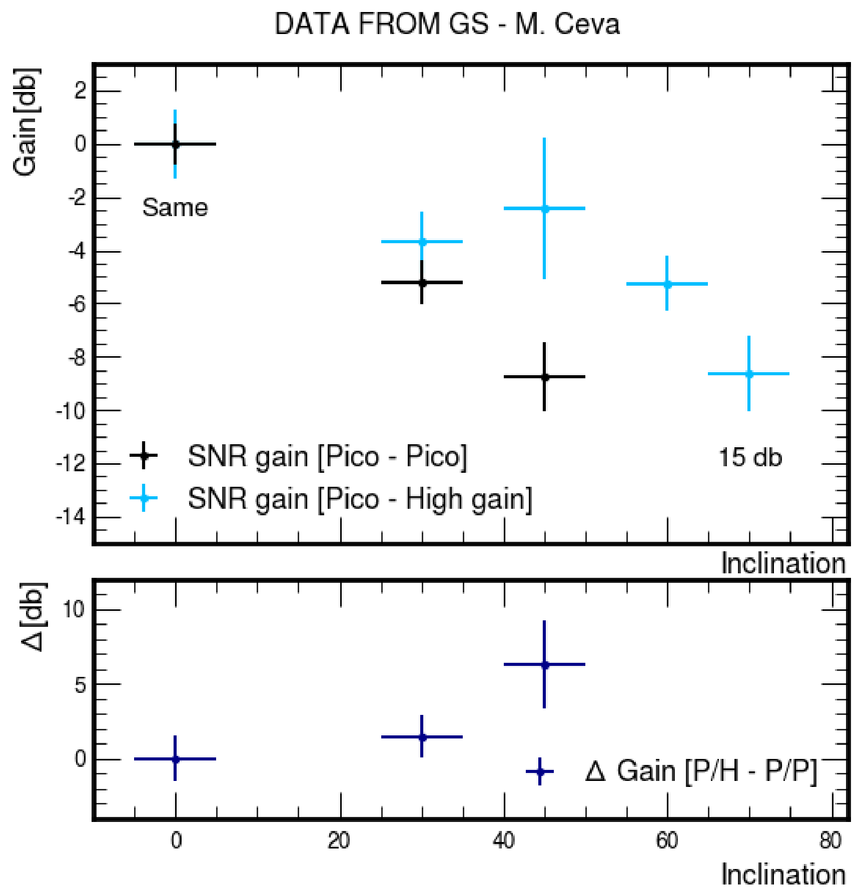
2.2 SNR and RSSI data received by Monte Ceva's GS



2.0 RSSI value for both configurations. It is also reported the difference between the two measurements for the common angles.

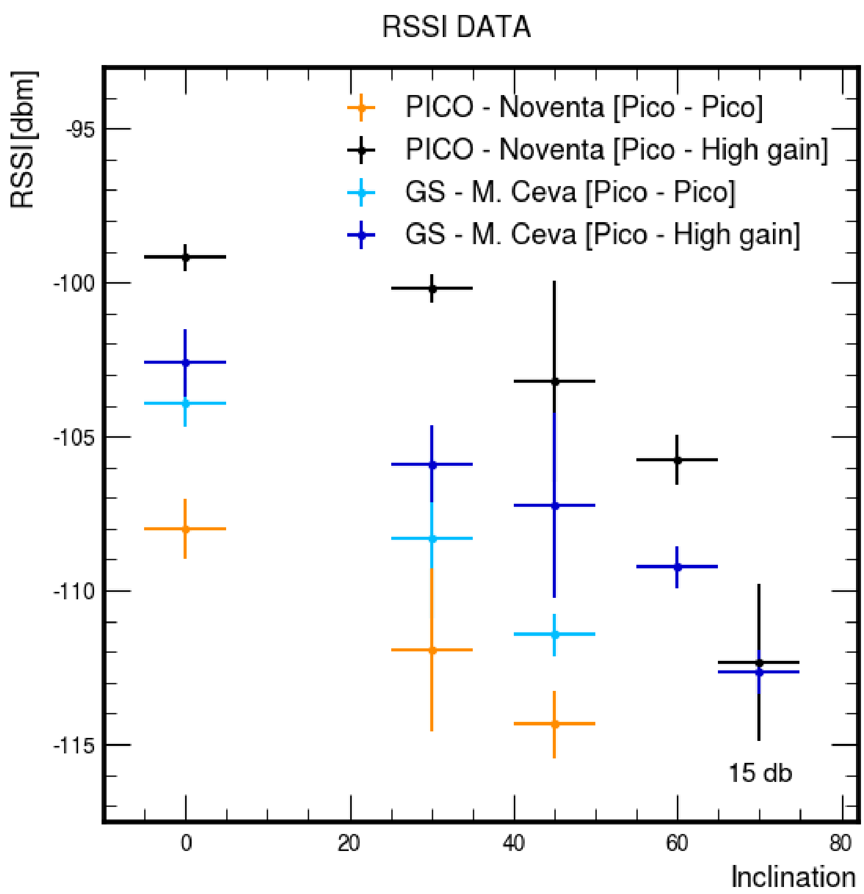


2.1 SNR value for both configurations. It is also reported the difference between the two measurements for the common angles.

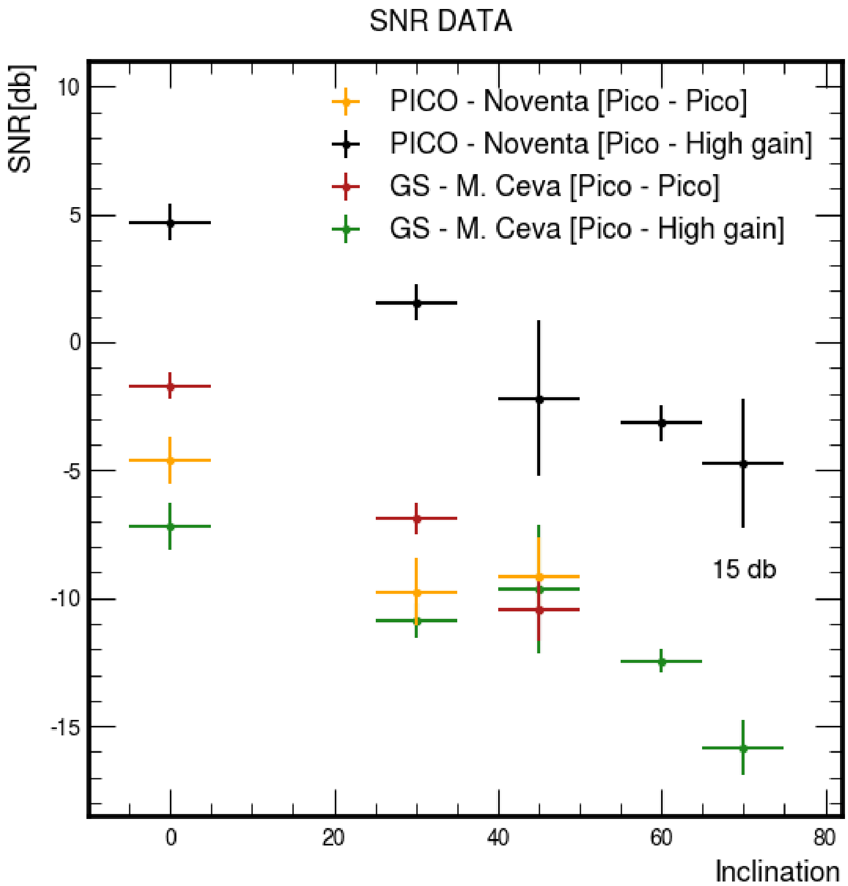


2.2 SNR gain value for both configurations. It is also reported the difference between the two measurements for the common angles. The first measure of reference is communally set to zero.

2.3 Comparison of data



3.0 Comparison of RSSI data with different configurations in function of the angle.



3.1 Comparison of SNR data with different configurations in function of the angle.

3. Data analysts

The distribution of the acquired data is generally in agreement with the theoretical trend, decreasing both RSSI and SNR values as the angle increases. Even if the trend seems to be correct it is necessary to explain the found values, studying in particular the comparison graphs.

3.1 Possible noise effect

As reported, graph **3.0** and **3.1** represents the distribution of SNR and RSSI acquired data, comparing the ones collected by Monte Ceva Ground station, in different configurations[2], and the ones collected by the receiver collocated in Noventa[3]. In particular, from graph **3.1** it is possible to see that SNR values detected by the ground station(Monte Ceva) are generally higher than the ones detected by the receiver for the “PICO - PICO” configuration. A possible explanation could be the higher noise effect seen by the receiver, closer to the town center than the ground station, and more influenced by possible noise sources. On the other hand, for the data distribution of the “PICO - High gain” configuration, the most evident anomaly is the high SNR value detected by Noventa. In particular it represents the only configuration where the signal strength is above the background noise(for the first two measurements). This

[2] PICO identifies the GS configuration with the home-built antenna and “High gain” the configuration using the high gain antenna.
[3] As said in section **1.1**, Noventa’s configuration is based only on the self-built antenna(PICO).

phenomenon could be explained by the use of a high gain antenna as a ground station collocated in Monte Ceva. In fact, this type of antenna is specifically designed to focus electromagnetic energy in a particular direction, increasing the Signal-to-noise ratio with a higher pointing precision. This last characteristic has also to be considered: the poor aiming ability of the apparatus could also be a possible source of systematic error.

3.1.2 Noise effect of the high gain antenna

Another particular evidence from data reported in graph **3.1** is the SNR value of the signal from the check message acquired by the high gain antenna at Monte Ceva. The data acquired with this configuration appeared to be those most affected by the background noise, presenting the lowest SNR value.

A possible explanation could be found in the structure of the high gain antenna itself. In fact, for its large bandwidth, it is able to acquire all the frequencies between 400 and 460 MHz, receiving not only the check message sent by Noventa but also all the different noise transmission from Padua. A possible solution to this type of problem, in the anticipation of a new long range test, could be a better collocation for the receiving station, selecting regions with a lower noise level.

3.2 Error in pointing precision

As mentioned in section **3.1** the manual pointing system is probably the most important source of error in the test procedures. For this reason it was chosen to consider a 5 degrees angle deviation as the error on the inclination measure. This overestimation is required to include all the possible sources of error in the angle setting, such as the movement of the GS antenna or the collocation error of the receiver. A more precise pointing method, like the creation of a specific structure/support, will be required for the next test sessions.

3.3 Comparison with the theoretical scenario

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4. Conclusion

The first long range test proved the effectiveness of the system, confirming the possibility of a 20 km range communication. The home-built antenna had guaranteed a stable connection between the two stations and the software designed worked correctly, managing the communication and saving the required data. It was also possible to find a series of new precautions that will be applied in future tests.