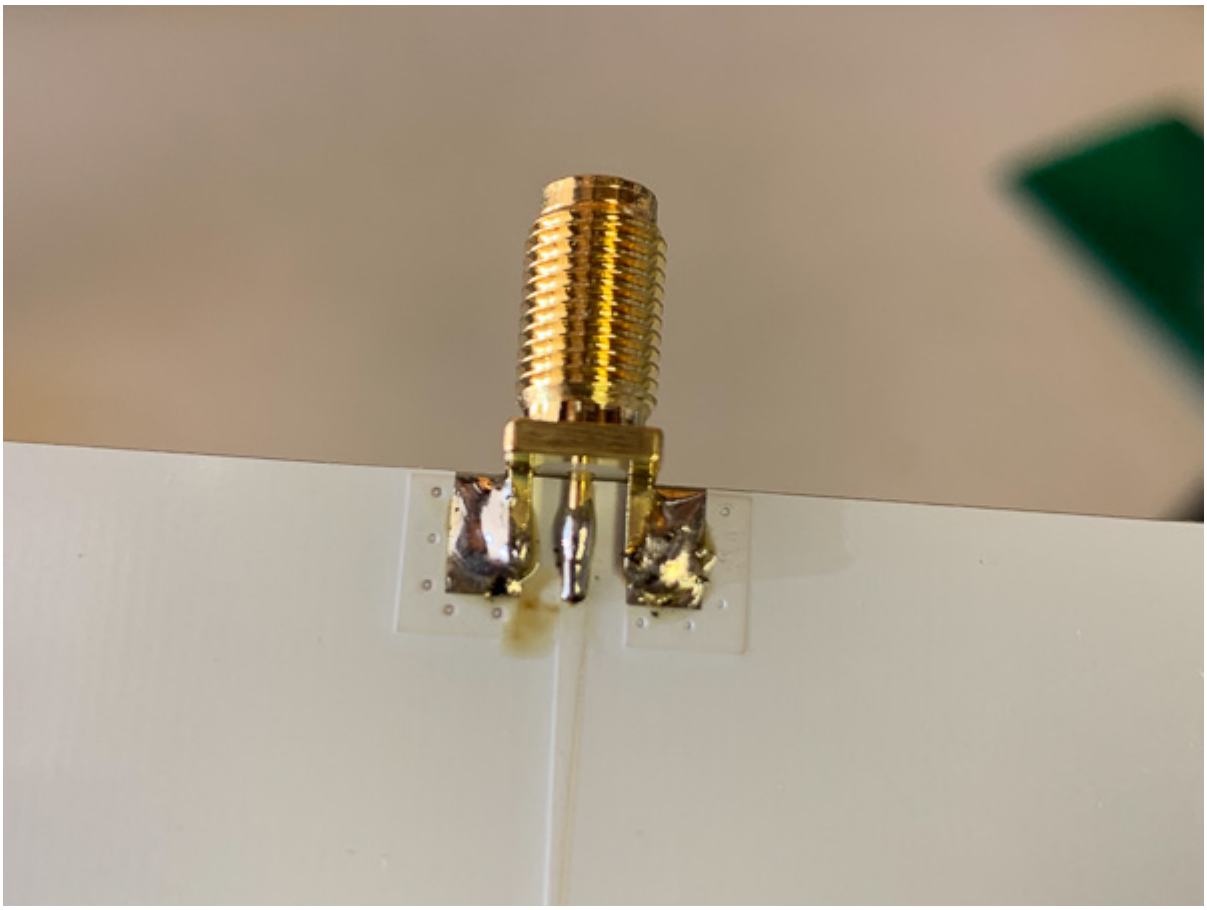
GRCon Antenna Badge Measurement

On August 15, 2019, Michelle Thompson, W5NYV, and Paul Williamson, KB5MU, visited the garage lab of Kerry Banke, N6IZW, to evaluate the performance of the prototype antenna badges for GNU Radio Conference 2019.

Test Subjects

We had two each of two different generation prototype badges. The earlier "green" prototypes were made out thinner material, so thin that the badges were visibly warped. The new "white" prototypes were made out of much thicker material, so thick that the card-edge SMA connectors we had ordered would not fit on them. Kerry had card-edge SMA connectors in stock that did fit, and these were soldered onto the two white prototypes.



The intended thickness falls between the two generations of prototypes tested here.

The antenna badges are designed to operate over a frequency range of 1 GHz to 8 GHz.

We also had a single sample of the SMA-SMA coaxial cable that is to be provided with the badge. It is rated up to 3 GHz.

Test Conditions

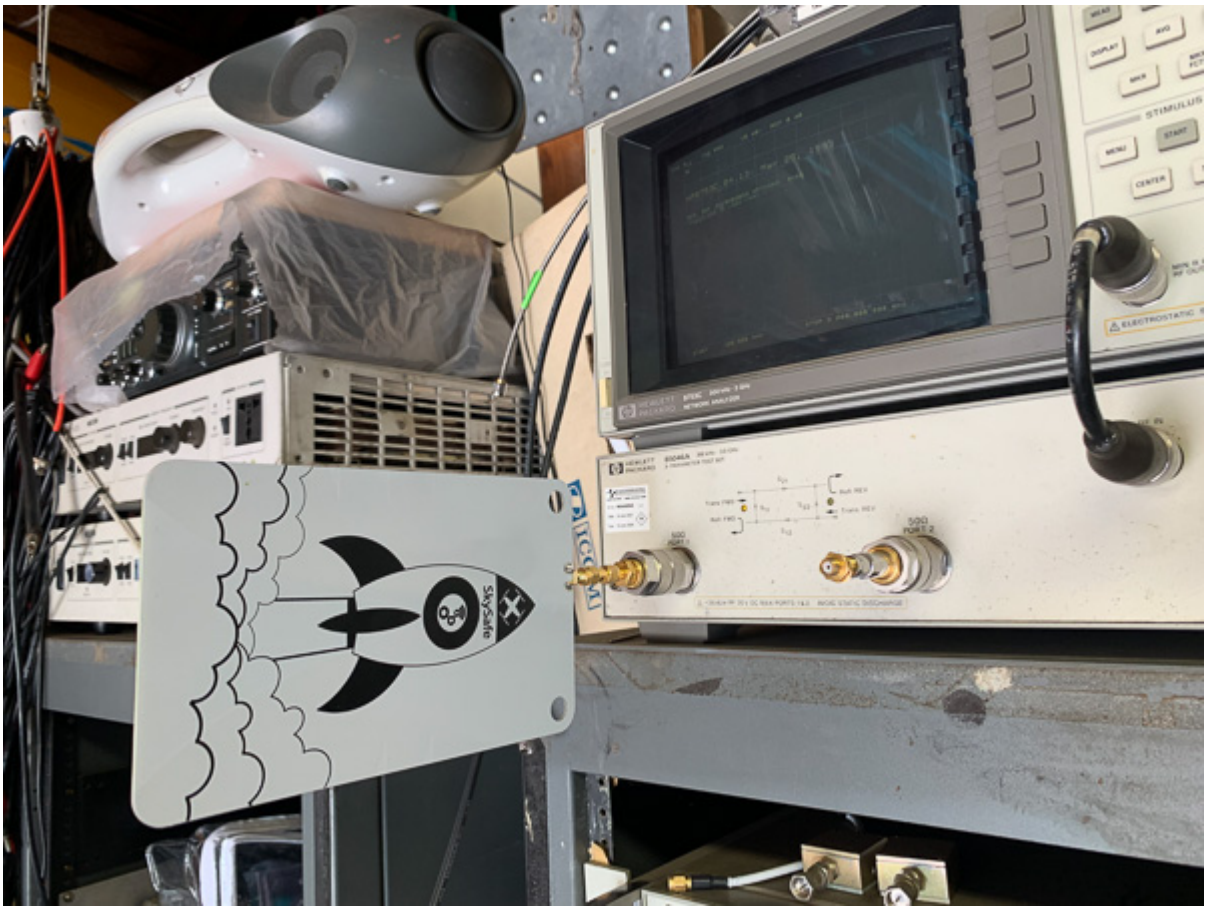
The tests were performed in a garage shop, not a controlled antenna test range, so quantitative results should be taken with a grain of salt. Kerry has quite a bit of experience comparing this kind

of test results to more controlled measurements, so we have confidence that the results are meaningful.

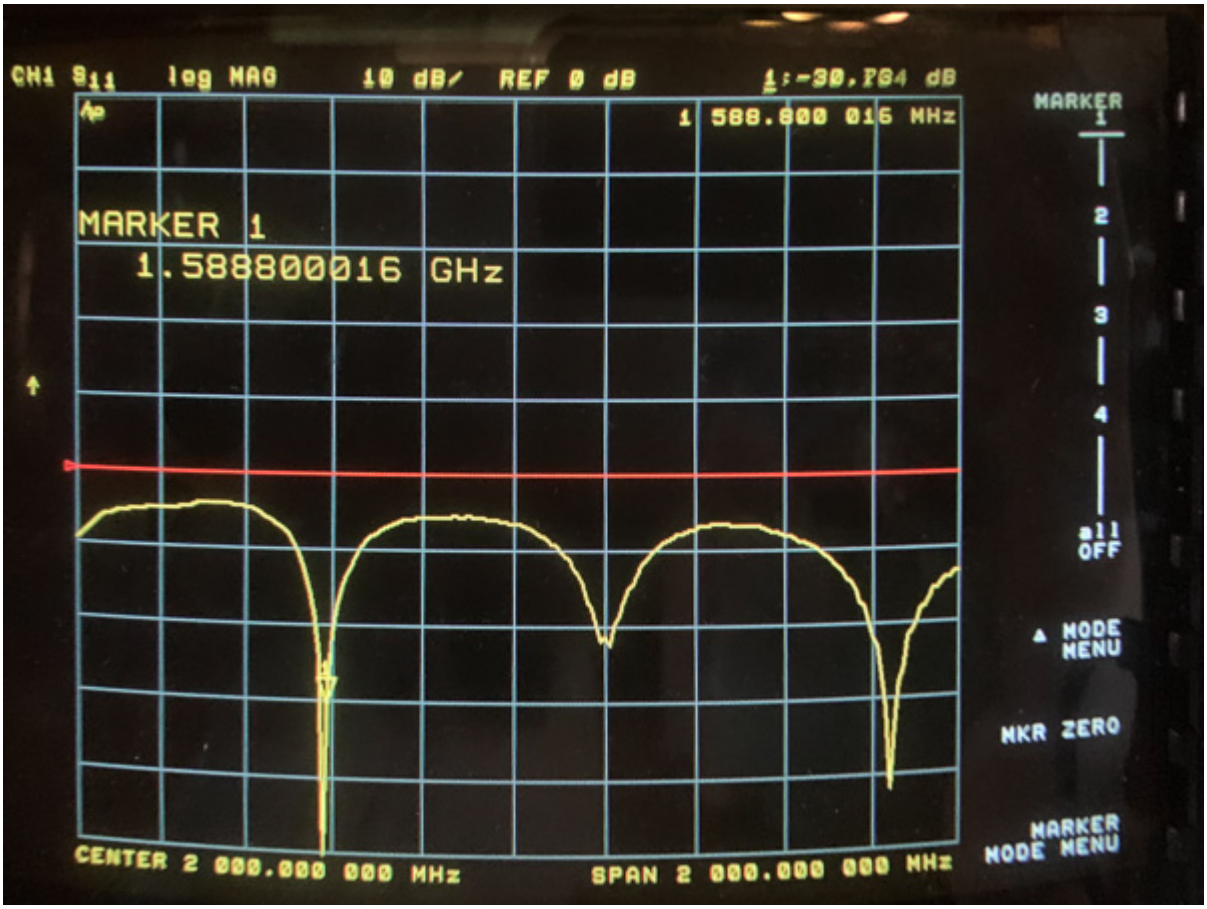
Badge Return Loss Measurement

Two different instruments were used to measure return loss. The first instrument covered a frequency range of 1 GHz to 3 GHz, and the second covered from 3 GHz to 8 GHz.

Here a white prototype is shown connected to the first instrument:



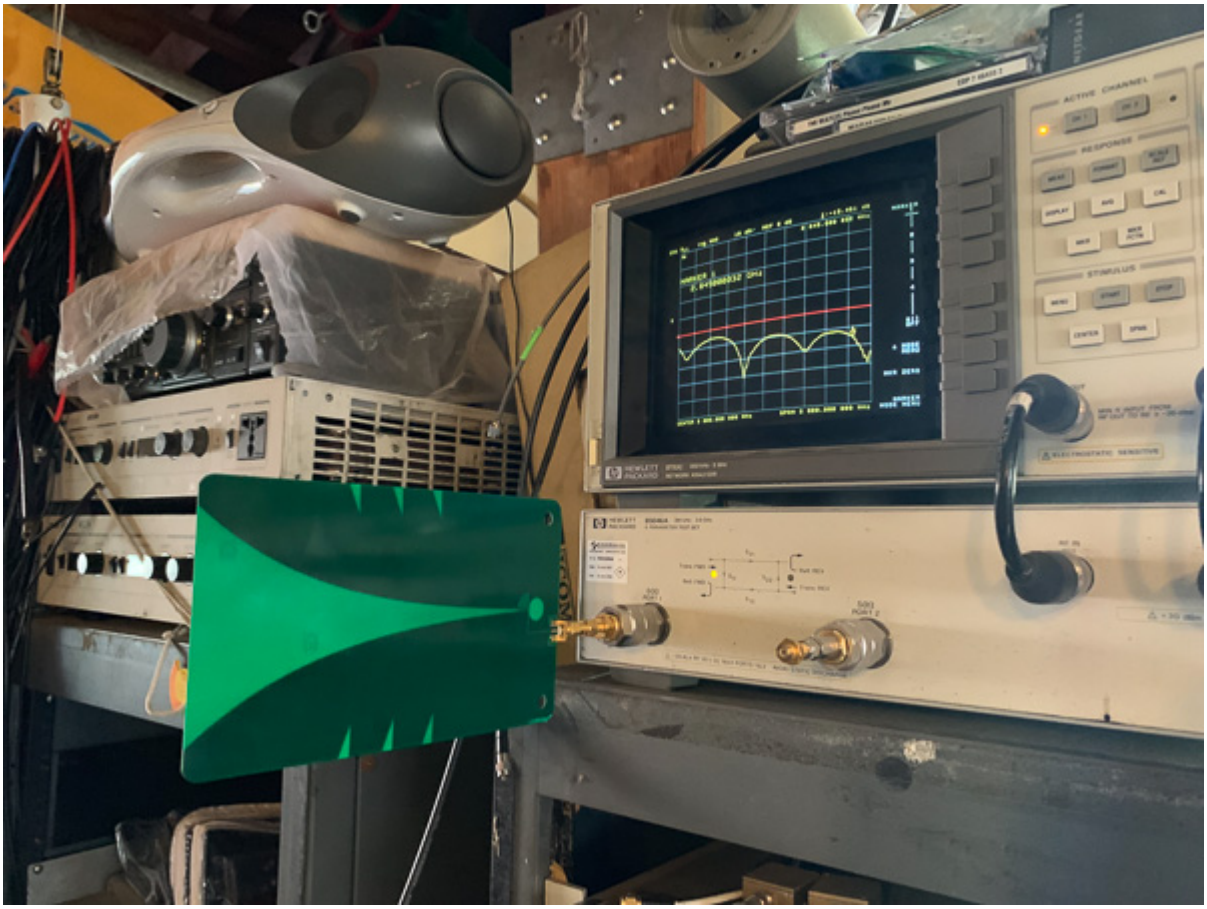
Here is a view of the results for the white prototype in the 1 GHz to 3 GHz range:



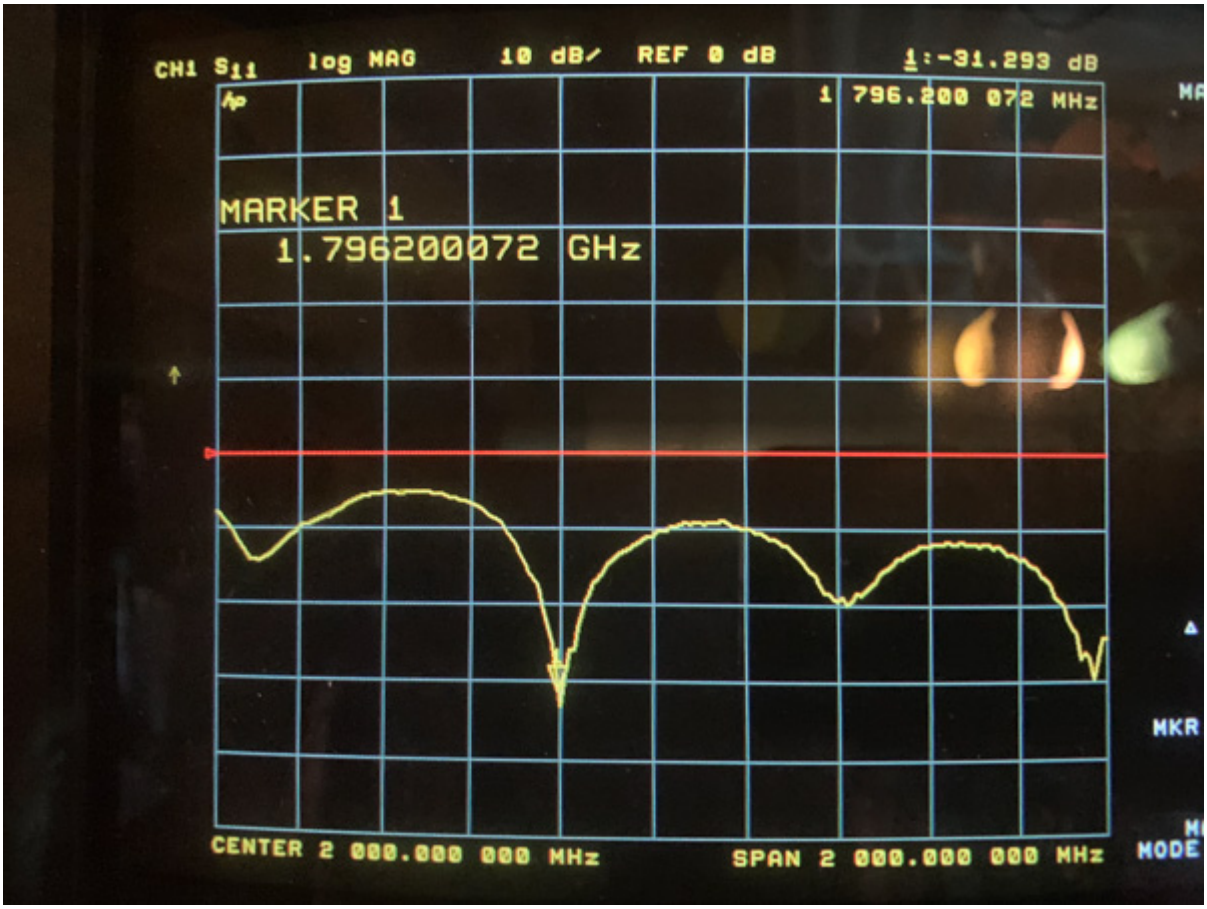
The red line is the reference level. The minimum return loss is less than 5 dB, which is not very good. There are three dips in the curve where return loss is excellent. These are at approximately 1.59 GHz, 2.20 GHz, and 2.85 GHz. As the frequency increases, return loss improves.

The exact shape of the curve was sensitive to the immediate environment around the antenna. That is, waving a hand in front of the antenna made the curve change substantially. This is a good sign.

Here a green prototype is shown connected to the first instrument:



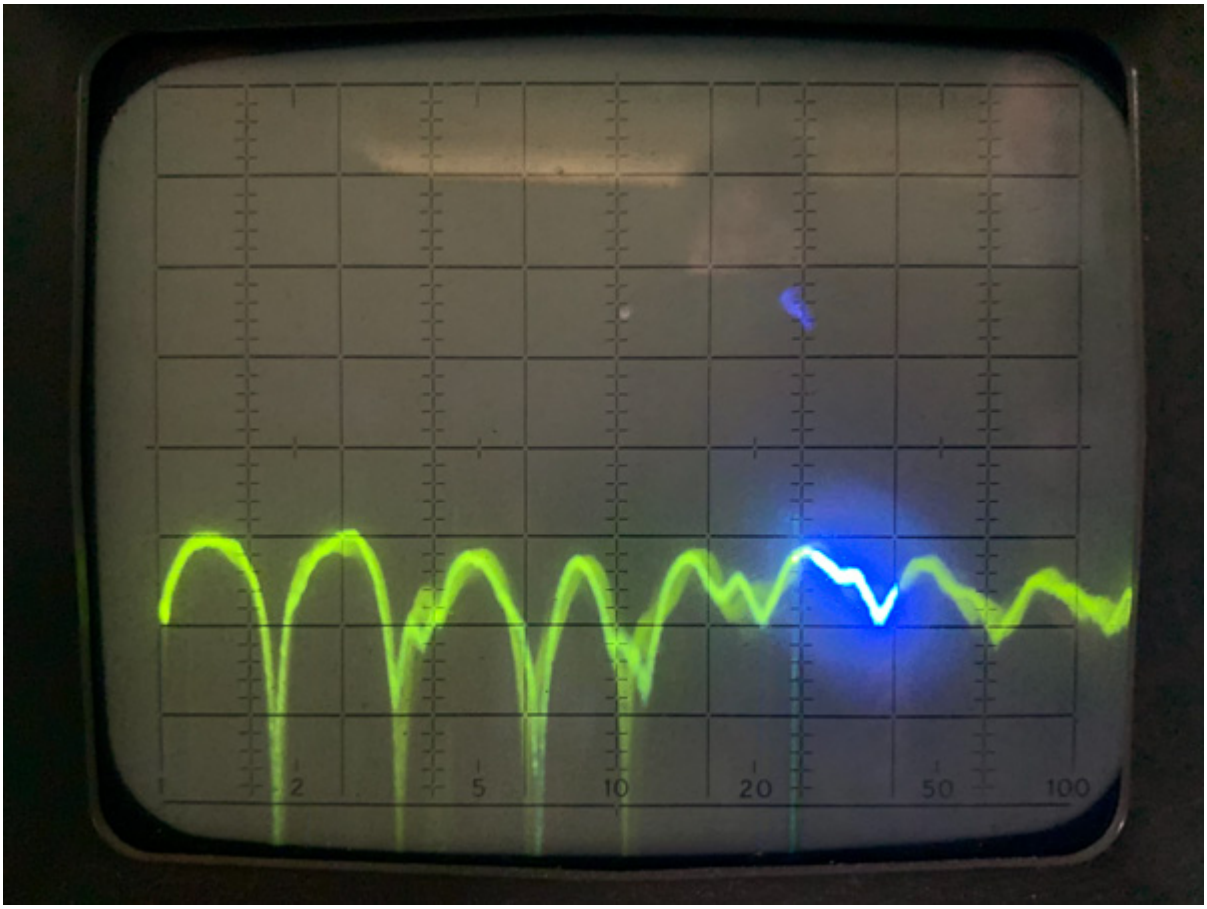
Here is a view of the results for the green prototype in the 1 GHz to 3 GHz range:



Here too, the minimum return loss is only about 5 dB, but return loss improves at higher frequencies. There are again dips in the return loss curve, including a sharp dip at about 1.80 GHz. These dips were also quite sensitive to a hand in front of the antenna.

Here is a green prototype being connected to the second instrument:

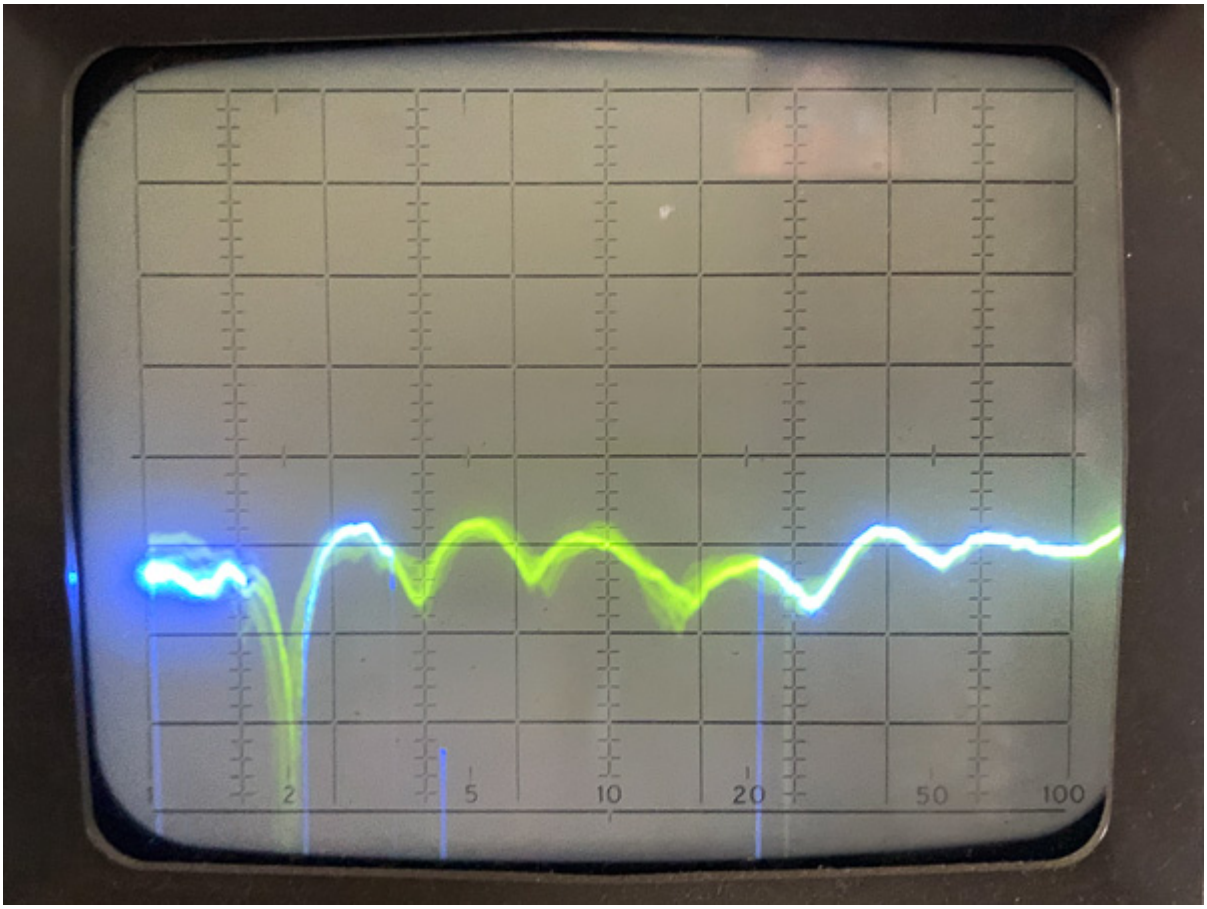
Here is a view of the results for the green prototype in the 3 GHz to 8 GHz range:



The center division is the reference level. Over this range the minimum return loss is about 10 dB to 15 dB, which is starting to be respectable. Again there are multiple dips in the curve where the return loss is excellent. This instrument doesn't make it easy to measure the exact frequency of these dips. The curve shape again varied with a hand wave, as expected.

Here is a white prototype being connected to the second instrument:

Here is a view of the results for the white prototype in the 3 GHz to 8 GHz range:



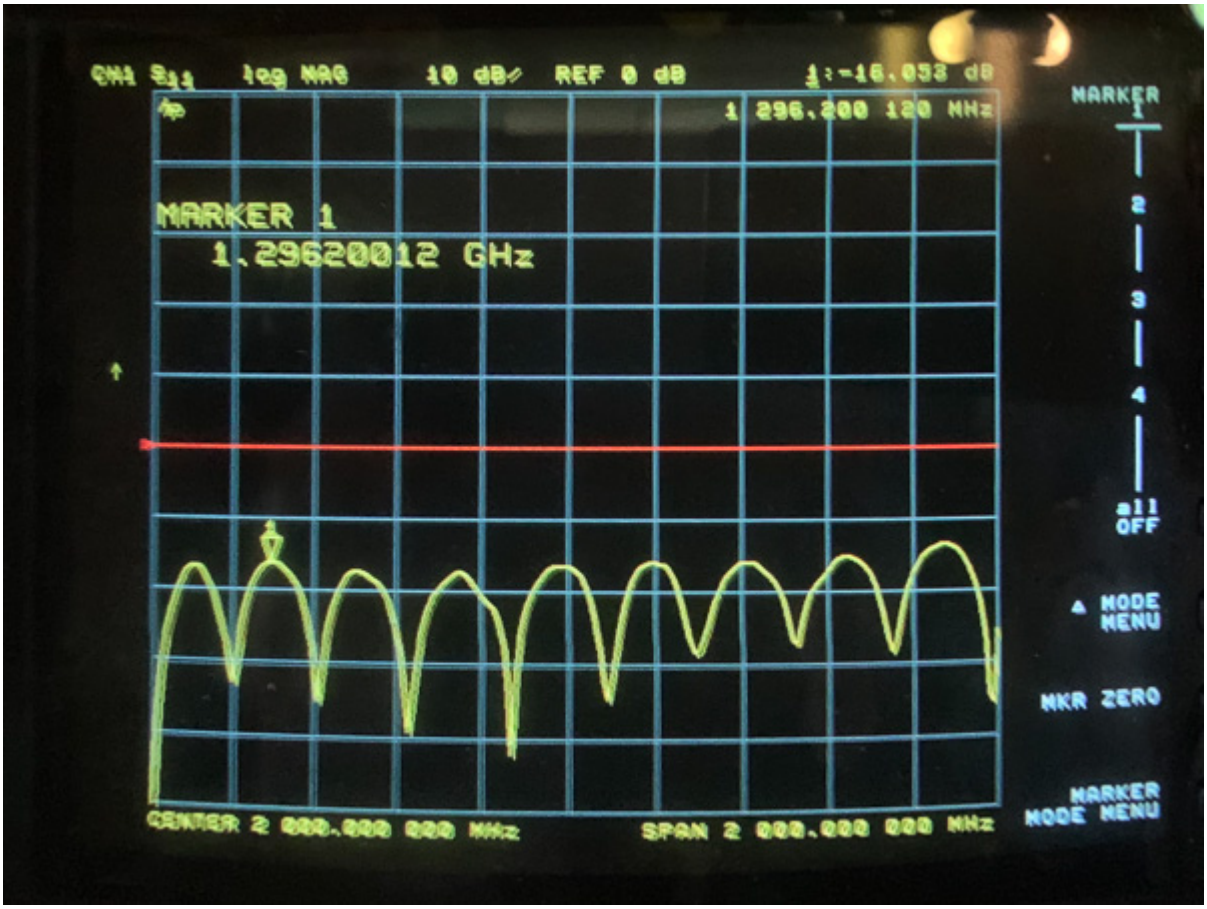
The minimum return loss of the white prototype in this range is about 8 dB to 10 dB, a little worse than the green prototype. Again there were dips in the curve, varying with a hand wave.

Cable Measurements

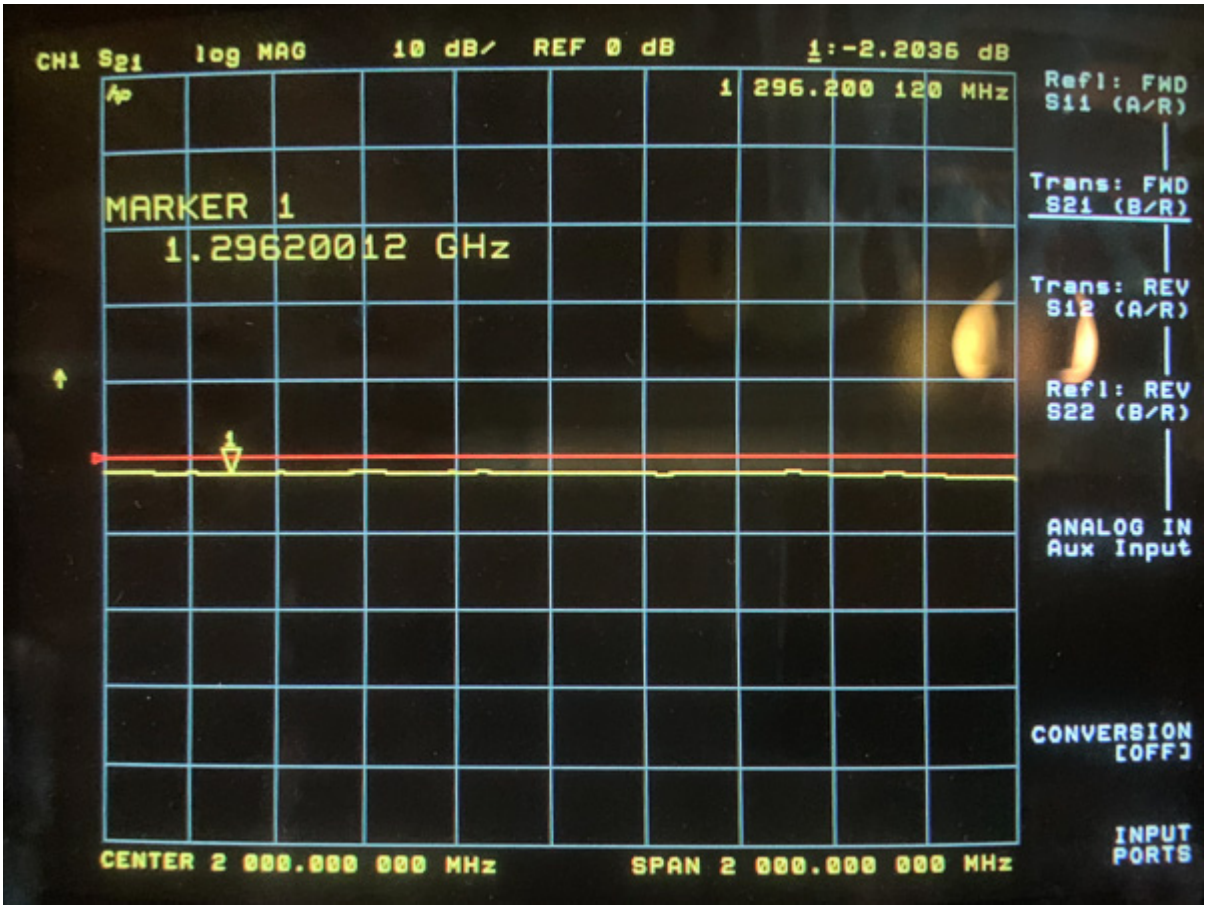
The cable was checked for return loss and forward loss at both frequency ranges, using the same two instruments. Its performance was quite good all the way to 8 GHz, well beyond the seller's specification.

Here's the cable test setup for 1 GHz to 3 GHz:

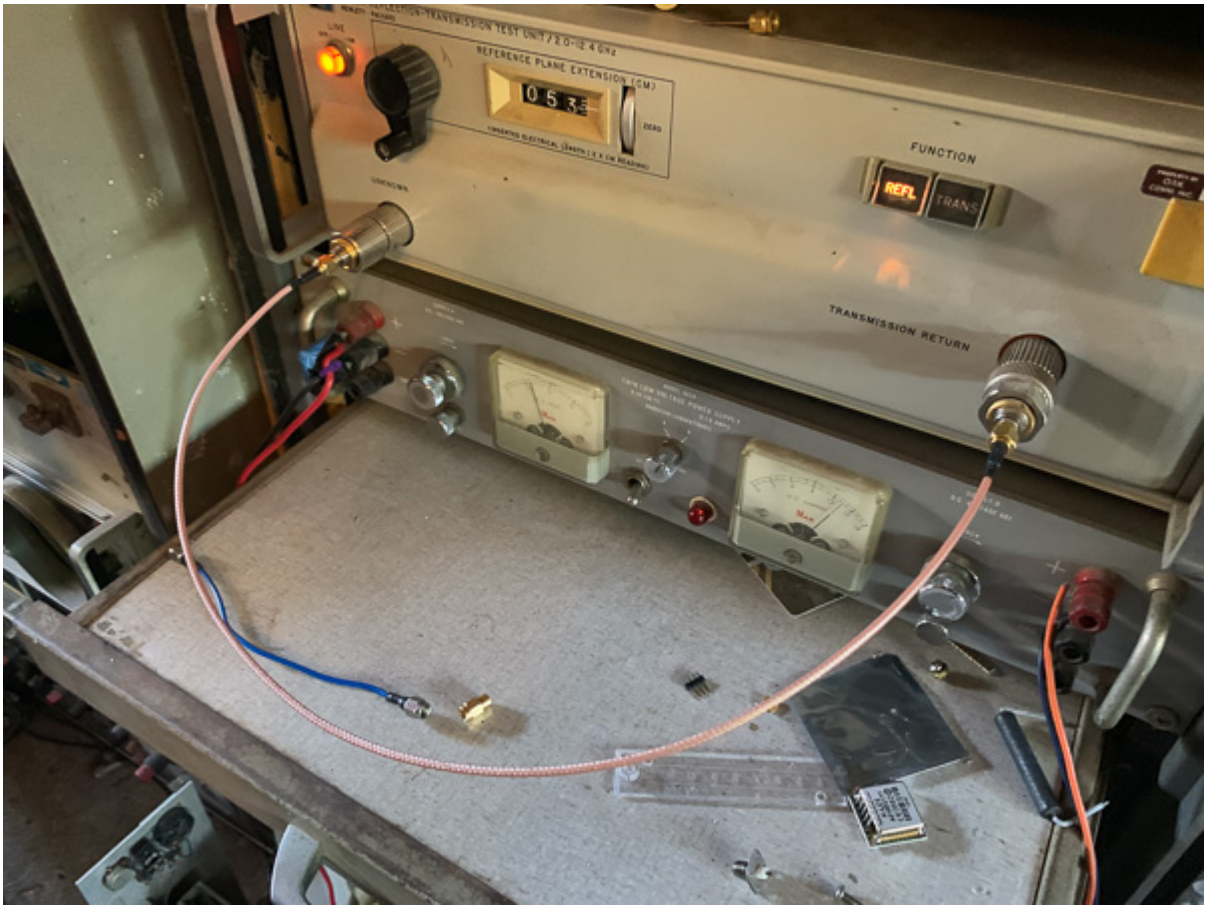
Here's the return loss result for 1 GHz to 3 GHz:



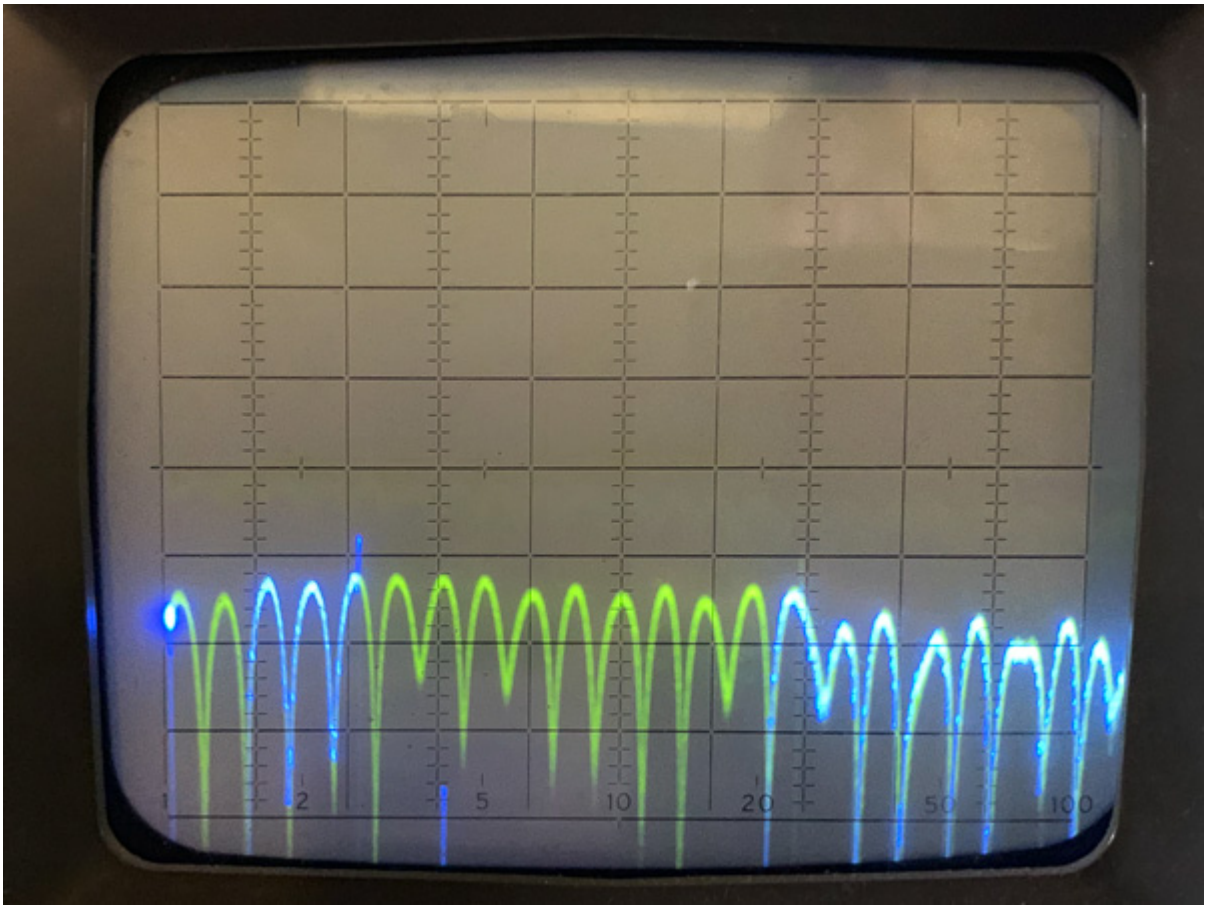
Here's the forward loss result for 1 GHz to 3 GHz:



Here's the cable test setup for 3 GHz to 8 GHz:



Here's the return loss result for 3 GHz to 8 GHz:



I evidently failed to photograph the forward loss results for 3 GHz to 8 GHz, but the cable loss stayed under a few dB all the way to 8 GHz.

Antenna Gain Measurement

In order to evaluate the gain of the antennas, the two samples of each generation were pointed at each other over a distance of approximately 10 feet. One antenna was connected to a signal generator, and the other antenna was connected to a spectrum analyzer, and a received signal strength measurement taken at each multiple of 1 GHz up to 8 GHz. Cable losses were calibrated out by repeating the measurements with a SMA barrel connector substituted in place of the two antennas. Free space loss was estimated by formula and the numbers combined in a spreadsheet to compute a forward gain figure for the antennas.

Here are the actual spreadsheets used:

- Green results
- White results

Here is a summary of the calculated gain per antenna:

Frequency	Green Gain	White Gain
1 GHz	3.8 dB	2.8 dB
2 GHz	7.3 dB	5.8 dB
3 GHz	9.0 dB	10.0 dB
4 GHz	10.3 dB	11.3 dB
5 GHz	12.7 dB	12.2 dB
6 GHz	13.5 dB	12.0 dB
7 GHz	11.7 dB	9.7 dB
8 GHz	11.3 dB	11.3 dB

While running the above measurements we also checked the signal strength with the badges cross-polarized by twisting one of the badges 90 degrees. Signal strength was reduced by 30 dB or more when cross-polarized, indicating that the badges are exhibit strong linear polarization, as expected.

Conclusions

Badges of both prototype generations behaved respectably well as antennas over the desired frequency range of 1 GHz to 8 GHz. No major differences were found between the two designs, so a production badge with an intermediate thickness can be expected to perform similarly.

The badges have substantial gain and are sensitive to polarization, so conference participants will need to pay attention to badge orientation when using it as an antenna.