Production of an X-band horn after a design of Dick Turrin, W2IMU

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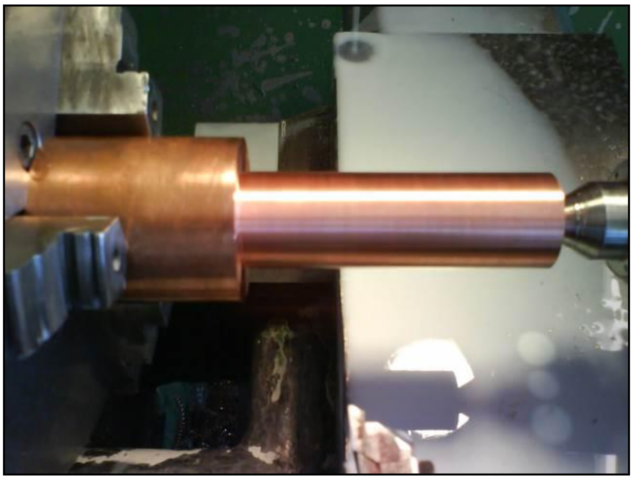
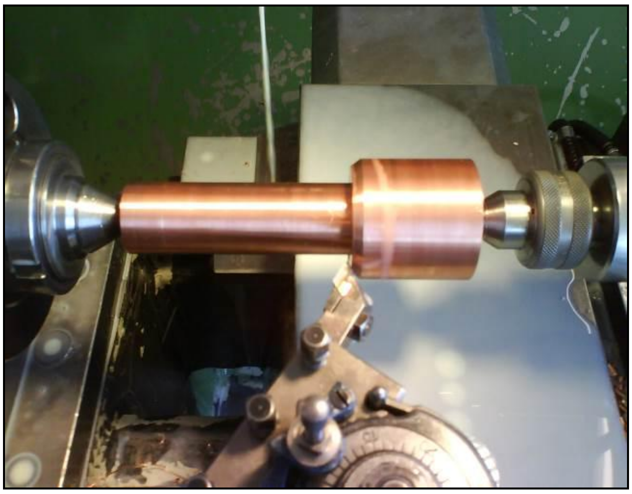
While looking for a nice, easy to perform and cheap students project in 2009, we investigated X-band (8 to 12 GHz) microwave devices. A 5 m parabolic dish antenna and an X-band down-converter were already available, but we had no antenna feed in our tool box. A web search yielded a simple feed horn design and found sketches and descriptions by Dick Turrin (W2IMU) from 1991 [1].

For those who are interested in the theory and basics of horn antennas, I suggest the documents mentioned in the **References and further reading** section at the end of this document. Here I only describe the mechanical construction and steps required to get a dual circular polarization septum horn antenna out of a massive piece of copper. I also provide some electrical measurements.

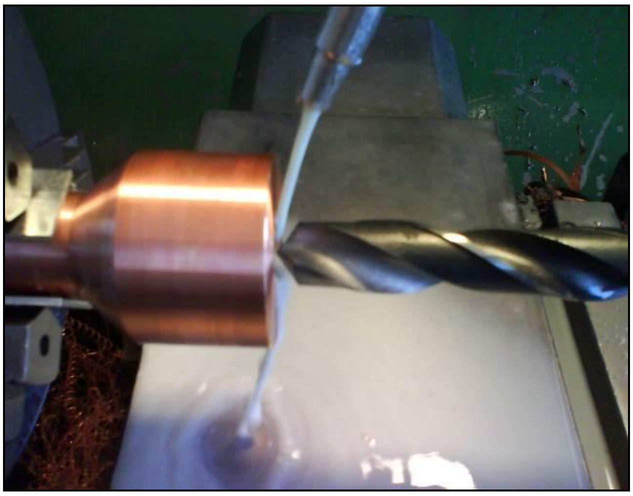
Step 1:
Get a piece of copper rod 150 mm long and 50 mm diameter. Fix it in a turning lathe and lathe the front surface flat.



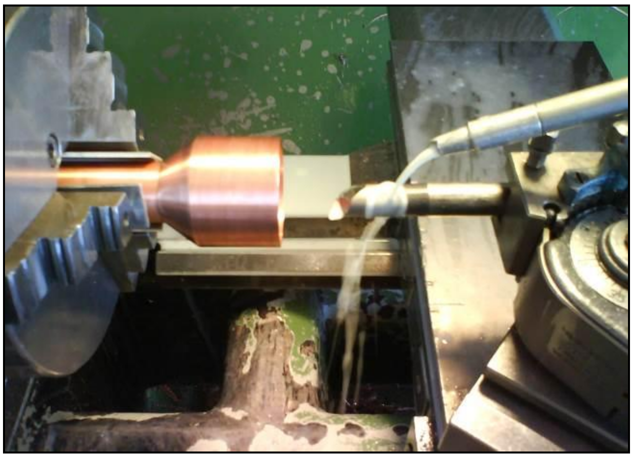
Step 2:
Cut the microwave tube for 92.01 mm length and 28.4 mm diameter. Then lathe the rest surface flat.



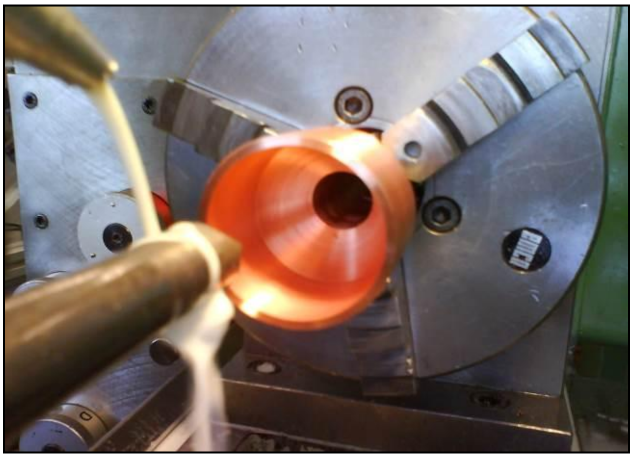
Step 3:
Cut the horn part and make a 36.42° angle at the edge.



Step 4:
Drill the core hole for the horn starting with a 20 mm drill. Extensive cooling of the drill is essential.

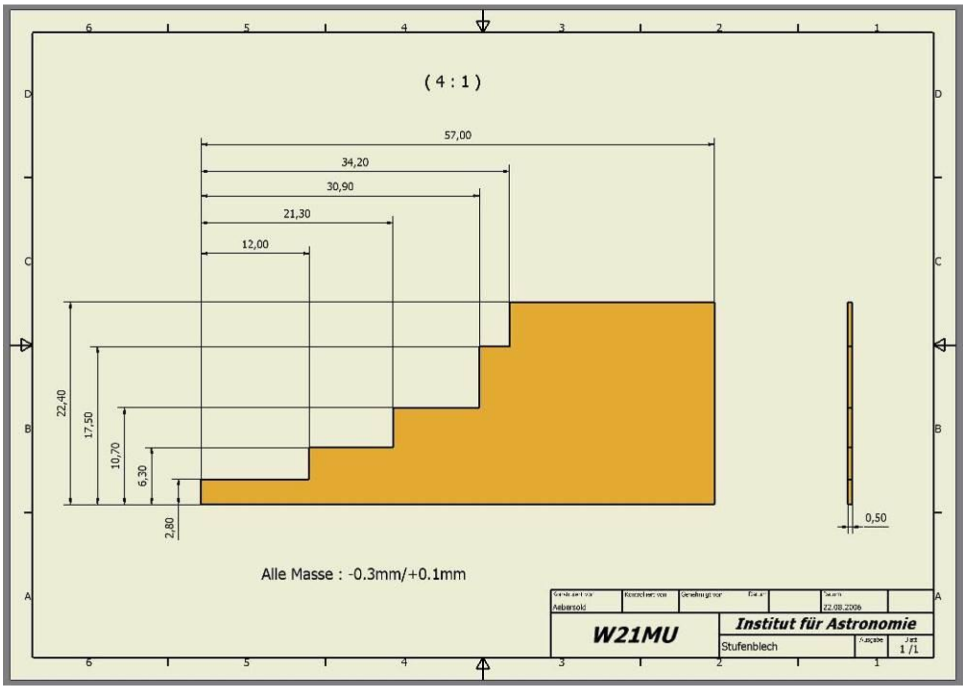


Step 5:
Use a turning tool to lathe the internal diameter to 33.8 mm. After that, lathe the inner cone to 43.5 mm.



Step 6:
Change tooling and lathe the inner part of the wave guide to 22.4 mm. Other tooling required to perform the mechanical work are drills, end milling cutter and face cutter.

Step 7:
Lathe two grooves as a platform to mount the SMA connectors. Drill holes for the SMA connectors and cut threads 2.5 mm to fix the SMA-connectors. Prepare the bottom plate 60 mm x 60 mm with mounting holes and threads 3.0 mm for M3 pan head screws with length 6 mm to adjust impedance matching. Polish all parts.



Step 8 (above): Drawing of the septum, which uses copper sheet of 0.5 mm thickness. The contour was cut with a laser metal-cutter and then soldered into the base plate of the horn. The septum provides separation of left-hand and righthand circular polarizations.

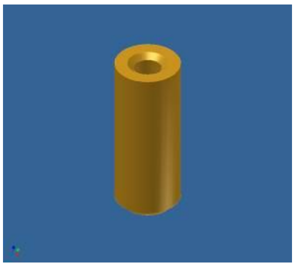
Step 8:
Soldering of base plate and horn and mounting of the two SMA connectors, one for left circular polarization (LHCP) and another one for right circular polarization (RHCP). Both SMA flange adapters are in line with the bottom plate, there is no space between flange SMA connector and base plate. Each flange SMA connector is screwed with 4 x M2.5 mm screws.

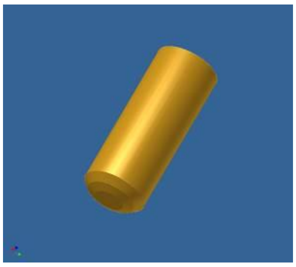
Step 9:
First measurement of impedance matching and cross coupling between the two polarizations. A Hewlett Packard, S-Parameter Network Analyzer 8720ES (50MHz-20GHz) was used for the measurements.

Step 10:
Gold plating inside and outside by a local company Dörrer AG Metallverarbeitung, Giesshübelstrasse 108, 8045 Zürich.

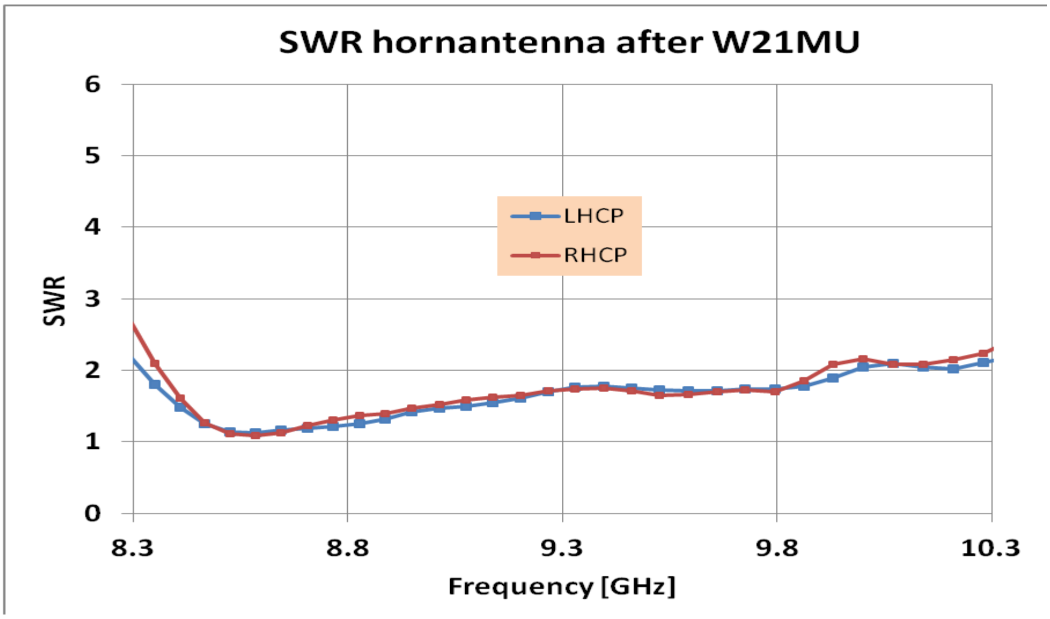
Processes to improve conductivity and to protect the horn from oxidation:

1. copper plating
2. nickel plating
3. gold plating (inside 0.2 µm, outside 0.5 µm)

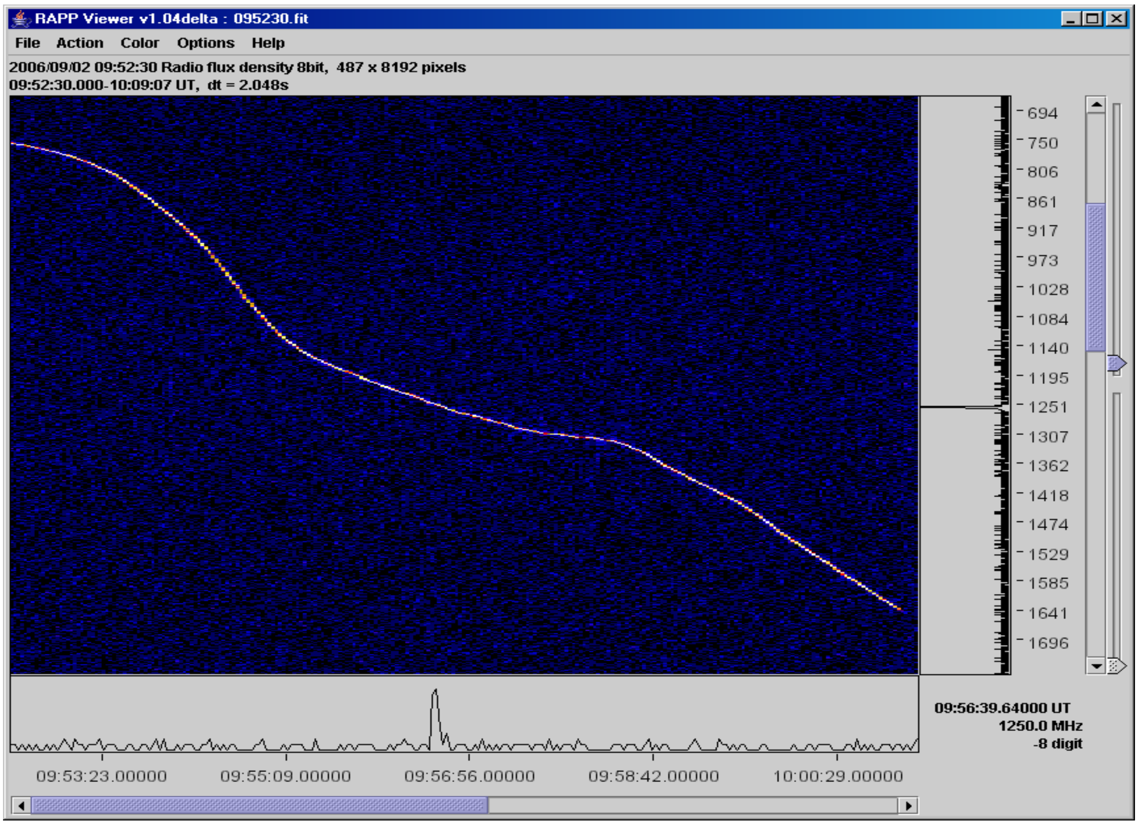




Step 11:
Sketches of the feed dipoles to be placed near the base on the inside of the horn. These were lathed out of brass and soldered to the inner conductor of each SMA connector. Impedance matching is sensitive to the geometry of the dipole. The best VSWR was found by experimenting with the diameter and length of the dipole. We found best performance with diameter=2.5 mm and length = 11.3 mm.



Step 12 (above):
Network analyzer measurement of impedance matching. The dipole dimensions were optimized for spacecraft probe transmissions around 8.5 GHz.



Step 13 (above): Test results of the feed horn in the focal plane of a 5 m parabolic dish antenna. Only one polarization was down-converted and fed into an SDR-IQ software defined radio receiver. The audio-file was then saved and converted into the FITS file format and visualized with a JAVA tool. Here we see the down-link of the Venus-Express spacecraft. (see http://www.esa.int/Our_Activities/Space_Science/Venus_Express
Y-axis is labeld in KHz with respect to the carrier-frequency.

For people interested, one horn is still available. Send requests via email to the author monstein(at)astro.phys.ethz.ch

References and further reading:

[1] Dick Turrin, W2IMU, Parabolic Reflector Antennas and Feeds, Pg 9-29, ARRL UHF/Microwave Experimenter's Manual, 1991

http://www.w1ghz.org/antbook/conf/SEPTUM.pdf
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Meet the author: Christian Monstein is a native of Switzerland and lives in Freienbach. He obtained Electronics Engineer, B.S. degree at Konstanz University, Germany. Christian is a SARA member and is licensed as amateur radio operator, HB9SCT. He has experience designing test systems in the telecommunications industry and is proficient in several programming languages including C and C++. He presently works at ETH-Zürich on the design of digital radio spectrometers (frequency agile and FFT) and is responsible for the hardware and software associated with the e-CALLISTO Project. He also has participated in the European Space Agency space telescope Herschel (HIFI), European Southern Observatory project MUSE for VLT in Chile, NASA/ESA project STIX, and NANTEN2 (delivery of the radio spectrometer for the Submillimeter Observatory at Pampa la Bola, Chile). He plays also the role of a coordinator of SetiLeague in Switzerland and he is also representing Switzerland within CRAF. Currently he is working on a low noise correlation receiver to observe red-shifted hydrogen line 980 MHz - 1350 MHz
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