Nicolaus Copernicus Astronomical Center
of the Polish Academy of Sciences

BUILDING OF A SMALL RADIO TELESCOPE

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Thanks to the development of Software Defined Radio (SDR) and mass production of satellite antenna equipment, it became possible to build a small radio telescope at home, for less than 100 EUR. Needed components are an antenna, low noise amplifier (LNA) and receiver. Previously needed expensive hardware like detectors, mixers, filters, amplifiers and modulators are substituted by software, which is performing mathematical operations on a digital signal, which can be processed on a computer.
Standard Nooelec "Lana" broadband amplifier or "Sawbird+H1" (for hydrogen 21cm line only) and "Smartee" receiver can be acquired online for 90eur. If you buy other type of receiver, it should have the "bias tee" option for powering LNA from the computer USB, it is simpler than adding the external powering. Beware that there are many low quality Chinese clones of this device on sale online and their performance is usually lacking.

A simple horn antenna can easily be made at home following the description below. The needed software is freely available online.

1 Building of a cardboard antenna

We choose horn antenna because of its superior sensitivity and a good shielding from the surrounding sources, which is important in the urban environment. Cardboard should be the hardest possible, to keep the shape. With a wavelength of interest of 21cm, precision to specification in the drawing of 1-2 cm is enough. The aluminium foil has to be glued to the cardboard in a way that whole interior would be electrically connected. The best check is to measure resistance between different points of the interior with a multimeter.
There should be a small, but finite resistance, up to 1 Ohm. After completion of the cardboard

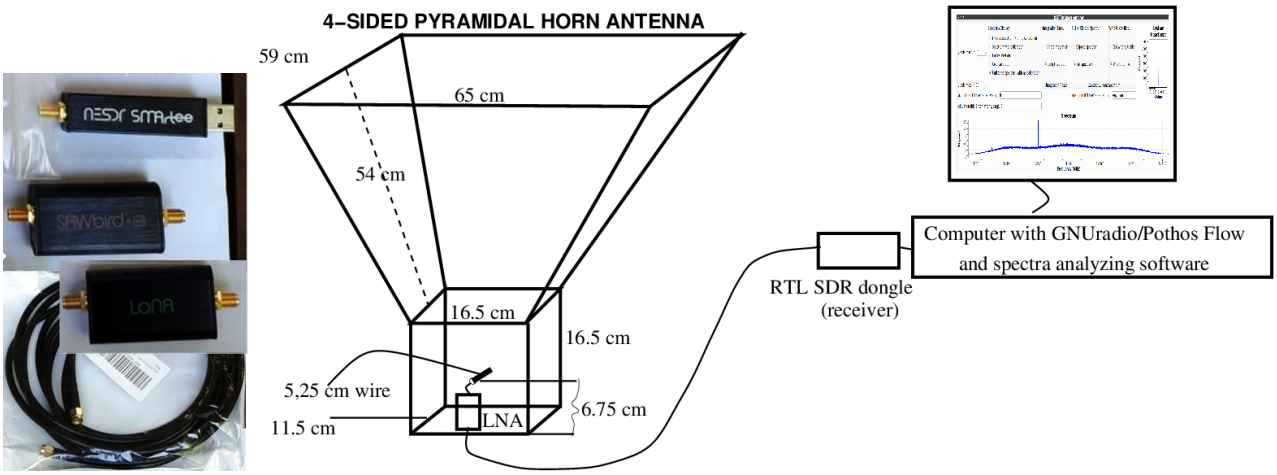

Figure 1: Schematic representation of the horn antenna with equipment needed for the small radio telescope.

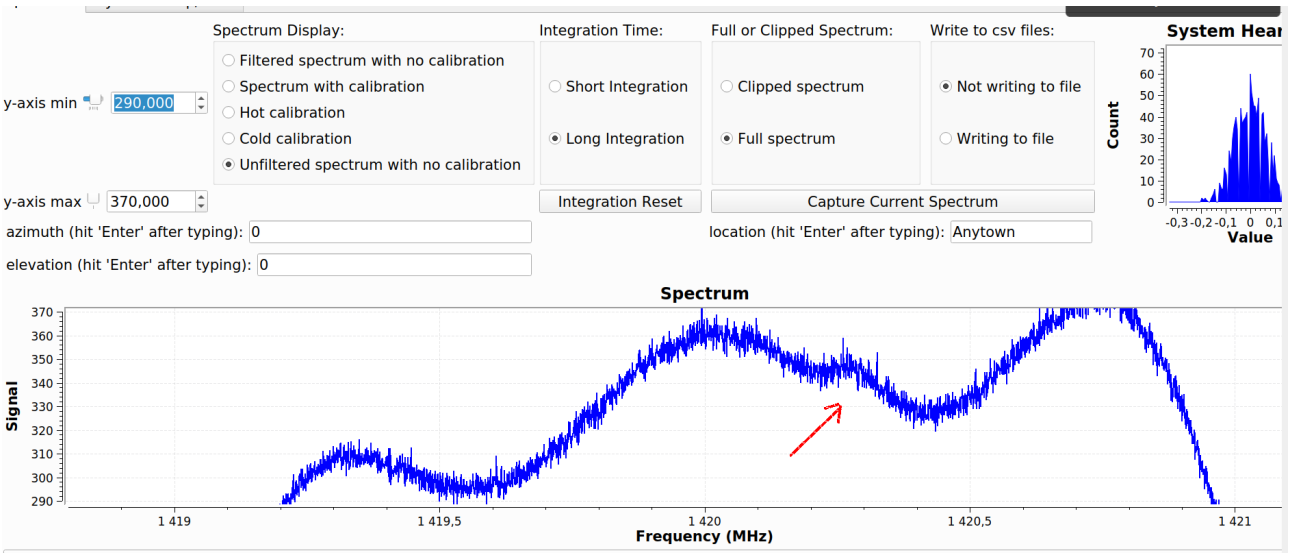

Figure 2: An example of the first result, with the arrow pointing to the Hydrogen line.

body, one should attach inside of the bottom part of the horn box a 5.25 cm of the stripped wire of at least 1 mm diameter. This will serve as an active antenna element. It should be firmly attached and well connected to the signal pin of the LNA. The "ground" part of the LNA connector should be electrically connected to the aluminium foil, but disconnected from the active wire of the antenna. This should also be checked with the multimeter. Antenna can be standing on the floor or table, with a support for wanted direction. Field of view is about 20°. Since the integration time is of the order of minutes, not hours, one does not need to follow the motion of the sky during the single measurement.

2 Installation of the software

Software Defined Radio (SDR) receiver is working on the digitalized version of the original (analog) signal, passed through an external Low-Noise Amplifier and digitalized through Analog/Digital (AD) converters. By the use of the Fast Fourier Transform (FFT) in a computer, such signal is next analyzed into a separate waveforms in a number of samples which are an input for the further processing.

The DSPIRA `gnuradio` software is freely available for download online, see https://osmocom.org/projects/rtl-sdr/wiki. It is designed for Linux, for observation at the 21 cm Hydrogen H1 line. For MSWindows there are many other versions of the free software available.

For a reference, in Figure 2 is shown a screenshot of the first test results. For more details, with step-by-step installation of the software, see my webpage:
https://users.camk.edu.pl/miki/malirt.html