Overview of Hardware and Software Needs for Operating the Horn Telescope

Hardware Needed

- Computer running on Linux to run **GnuRadio**
    - NOTE: GnuRadio can be run on Windows or MACOS, but installation is a little more complicated. The instructions below are for systems running on Linux.
- Airspy software defined radio (SDR) dongle
- Low noise amplifier (LNA) for the 21 cm, 1420 MHz line spectrum for neutral hydrogen
- Coaxial cable to connect the LNA to the Airspy

Software Needed

- The Gnuradio .grc file titled *spectrometer_w_cal.grc.*
- The *spectrometer_w_cal.grc* file can be installed following the GnuRadio installation instructions below.

GnuRadio

GNU Radio is very popular and robust software defined radio (SDR) package. It is open source and is relatively very easy to use. All "coding" is done using flowgraphs comprised of interconnected Digital Signal Processing (DSP) blocks. Most commonly used blocks come predefined as part of the software package however one can program their own blocks as well.

To operate the horn telescope, one just needs to install Gnuradio on a computer, install the files from the *gr-radio_astro* repository (see below), and run the *spectrometer_w_cal.grc* file.

Installation Guide

(taken from the *Digital Signal Processing in Radio Astronomy* website at http://wvurail.org/dspira/labs/01/)

It is easy to install if you are installing on Linux, which we recommend. However, it is possible to install GnuRadio on a MacOS or Windows system, but it is a little more complicated.

For Linux (Ubuntu), first we install dependencies. Open the terminal, (open by right clicking on desktop and choosing open terminal from menu)

```
sudo apt-get install git
sudo apt-get install libyaml-dev
sudo apt-get install libssl-dev
sudo apt-get install python-dev
sudo apt-get install python-pip
sudo apt-get install python-apt
sudo pip install pyopengl pyopengl_accelerate
sudo apt-get install gnuradio gr-osmosdr
sudo apt-get install limesuite airspy
sudo apt-get install gqrx-sdr
```

Restart the computer once everything is installed for good measure.

Plug the Airspy box into the USB port. Open a terminal and type airspy_info. It should display some hardware info about the device.

GnuRadio Out-of-Tree (OOT) Radio Astronomy Package

The following describes how to install the files from the *gr-radio_astro* repository

1.) Clone the repository into an appropriate folder/repository:

```
git clone https://github.com/WVURAIL/gr-radio_astro.git
```

2.) Go to the gr-radio_astro folder/repository, create a build directory inside the repository:

```
cd gr-radio_astro
mkdir build
```

3.) run cmake inside the build directory:

```
cd build;  cmake ..
```

4.) run make inside build directory

```
make
```

5.) If no errors, install

```
sudo make install
```

Additionally, install h5py:

```
sudo pip install 'h5py==2.7.0'
sudo pip install pyephem
```

Blocks should now be available in gnuradio-companion, in the 'radio_astro' section.

Updating software

```
# go to gr-radio_astro directory
git pull # pull updated changes to software
cd build # change working directory to build
cmake ..
make
sudo make install
```

This will install the updated software.