Radio Telescope

ICT Software Operation Support

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1 Linux installation

- Ubuntu 18.04.5-desktop-amd64 (`kernel 5.4.0-62-generic`)
- Gnuradio 3.7.13.5~gnuradio~bionic-4
- gr-osmosdr 0.1.4[1]
- Aisrpy mini[2]

Why: The gnuradio plugin[3] for astro is not compatible with Gnuradio 3.8 which completely change the language of blocks and gnuradio 3.7 is only compatible until unbuntu 18.04.

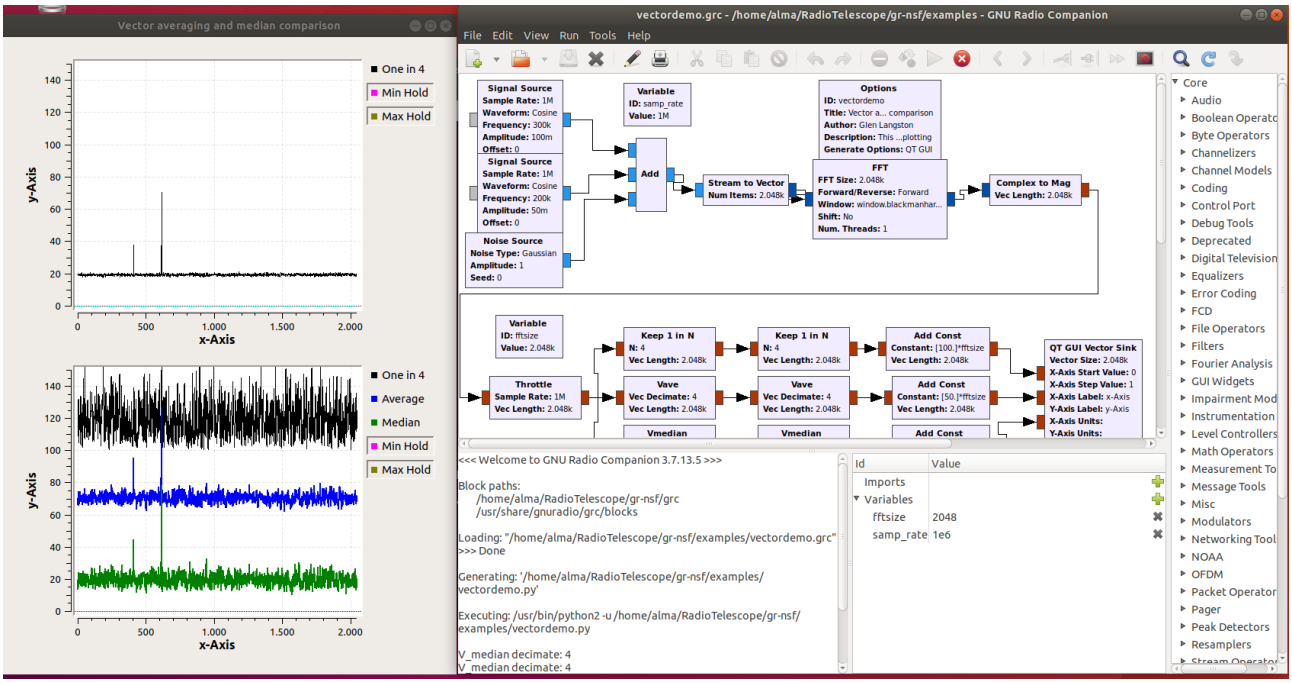
1 https://github.com/osmocom/gr-osmosdr/releases/tag/v0.1.4
2 https://airspy.com/airspy-mini/
3 https://github.com/glangsto/gr-nsf.git

Instalation

```
##############################################
#                                            #
#          Packages Installation             #
#                                            #
##############################################
sudo apt update
sudo apt install -y build-essential  # 50 Mb
sudo apt install -y radio airspy mono-complete libportaudio2 librtlsdr0 librtlsdr-dev gqrx-sdr rtl-sdr
cubicsdr python-dev python-pip xterm  # 200Mb
sudo pip install pyephem

##############################################
#                                            #
#          gnu radio Installation            #
#                                            #
##############################################
sudo apt update
sudo add-apt-repository -y ppa:gnuradio/gnuradio-releases-3.7
sudo apt install -y cmake git g++ libboost-all-dev python-dev python-mako \
python-numpy python-wxgtk3.0 python-sphinx python-cheetah swig libzmq3-dev \
libfftw3-dev libgsl-dev libcppunit-dev doxygen libcomedi-dev libqt4-opengl-dev \
python-qt4 libqwt-dev libsdl1.2-dev libusb-1.0-0-dev python-gtk2 python-lxml \
pkg-config python-sip-dev  # 500Mb
sudo apt install -y gnuradio  # 100Mb

##############################################
#                                            #
#          Create Working Directory          #
#                                            #
##############################################
mkdir /home/$USER/RadioTelescope/
cd /home/$USER/RadioTelescope/

##############################################
#                                            #
#             Install gr-nfs                 #
#  Gnu Radio - National Science Fundation    #
##############################################
cd /home/$USER/RadioTelescope/
git clone https://github.com/glangsto/gr-nsf.git
cd gr-nsf
sudo cp /home/$USER/RadioTelescope/gr-nsf/grc/* /usr/share/gnuradio/grc/blocks/

##############################################
#                                            #
#          Configure gr-nsf                  #
#                                            #
##############################################
sudo gedit /etc/gnuradio/conf.d/grc.conf
----Edit the following variables: ----
local_blocks_path = /home/alma/RadioTelescope/gr-nsf/grc
xterm_executable = /usr/bin/lxterm
```

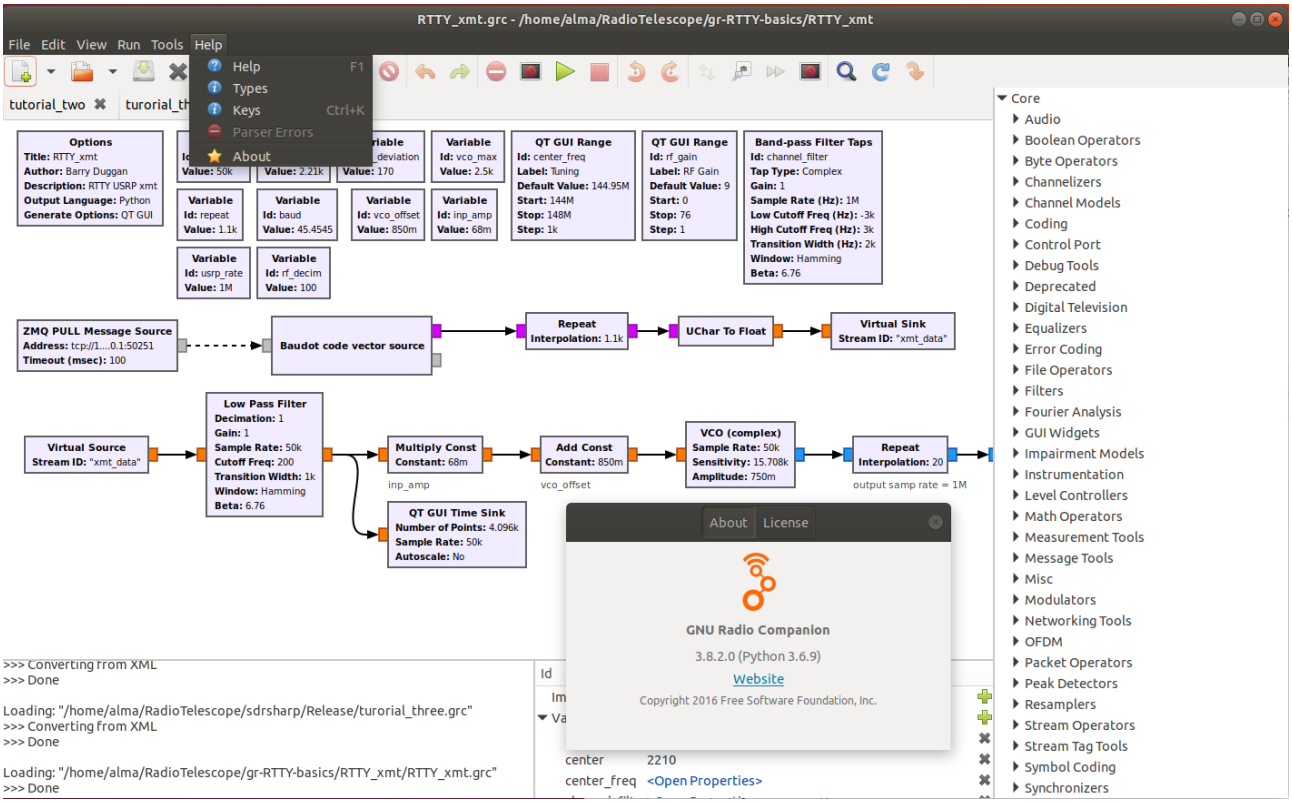
```
# Add plugin to PYTHONPATH
# after the change of the .profile file log out and then log in the session (or just run: "source
~/.profile" for current shell)
echo '# python configuration for glangsto gr-nsf grc modules
export PYTHONPATH=/home/alma/RadioTelescope/gr-nsf/python:$PYTHONPATH' > /home/alma/.profile


################################################
#                                              #
#          Download spyserver                  #
#                                              #
################################################
cd /home/$USER/RadioTelescope/
mkdir spyserver-linux-x64
cd spyserver-linux-x64
wget -O spyserver-linux.tgz https://airspy.com/?ddownload=4262
tar xvf spyserver-linux.tgz

################################################
#                                              #
#          Configure spy as service            #
#                                              #
################################################
cat /etc/systemd/system/spyserver.service  # No such file or directory
sudo cat << EOF | sudo tee /etc/systemd/system/spyserver.service > /dev/null # Copy until next EOF
[Unit]
Description=SPY Server
After=network.target
StartLimitIntervalSec=0

[Service]
Type=simple
Restart=always
RestartSec=1
User=alma
WorkingDirectory=/home/alma/RadioTelescope/spyserver-linux-x64
ExecStart=/home/alma/RadioTelescope/spyserver-linux-x64/spyserver spyserver.config

[Install]
WantedBy=multi-user.target
EOF
cat /etc/systemd/system/spyserver.service  # Happy now ?

sudo systemctl enable spyserver
sudo systemctl start spyserver
sudo systemctl status spyserver

################################################
#                                              #
#  Install, compile and configure sdsharp      #
#                                              #
################################################
cd /home/$USER/RadioTelescope/
git clone https://github.com/cgommel/sdrsharp
```

```
cd /home/$USER/RadioTelescope/sdrsharp/
xbuild /p:TargetFrameworkVersion="v4.5" /p:Configuration=Release
cd /home/$USER/RadioTelescope/sdrsharp/Release
ln -s /usr/lib/x86_64-linux-gnu/libportaudio.so.2 libportaudio.so
ln -s /usr/lib/x86_64-linux-gnu/librtlsdr.so.0 librtlsdr.dll


##############################################
#                                            #
#           How to run sdsharp?              #
#                                            #
##############################################
cd /home/$USER/RadioTelescope/sdrsharp/Release
mono SDRSharp.exe

##############################################
#                                            #
#    How to run ALMA_processing example?     #
#                                            #
##############################################
cd /home/$USER/RadioTelescope/gr-nsf/examples
# export PYTHONPATH=../python:$PYTHONPATH  # This should be done with ~/.profile
gnuradio-config-info --version
gnuradio-config-info --prefix
gnuradio-config-info --enabled-components
gnuradio-companion vectordemo.grc
```



2 Gnu Radio (and Companion)

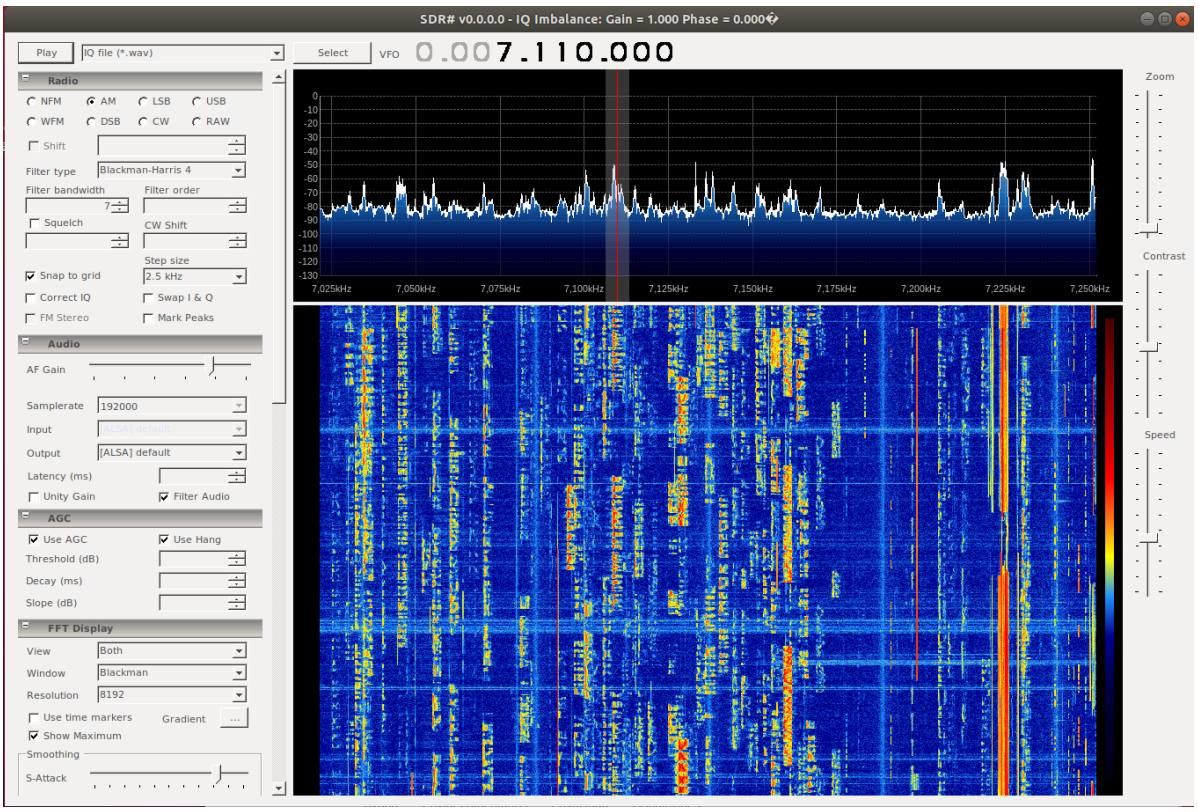
- **Language and License:** 100% Python and GPLv3
- **Draw:** arithmetic expression with flowchart ← format .GRC (for Gnu Radio Companion)
- **Output:** in nice plot (gnuplot or matplotlib IDK)
- **Input:** from specific devices or python script, or user parametrized virtual source
- **Bricks:** are in Python and code editable but this must not be necessary. Gnuradio is more than plugin oriented: a simple file .xml or .py can give many spec.



3 SdrSharp[4] (Software Defined Radio[5])

Radio demodulator GUI

Download some demo files[6] and run them, it may look like this:



4 https://airspy.com/quickstart/
5 https://en.wikipedia.org/wiki/Software-defined_radio
6 https://www.sdrplay.com/iq-demo-files/

4 Notes (for future classes)

Expand english dictionary

4.1 Easy dictionary

English	Spanish
Amplitude	Amplitud
Author	Autor
Frecuency	Frecuencia
Id	Identidad
In	Adentro
Out	Afuera
Start	Inicio
Stop	Detener
Title	Título
Value	Valor

4.2 Hard dictionary

English	Spanish
Bandwidth	Ancho de banda
Complex	Complejo (numero)
Float	Flotante (con coma)

English	Spanish
Label	Etiqueta
Offset	Compensación
Output language	Idioma de salida
Sample Rate	Frecuencia de muestreo
Throtlle	Accelerador

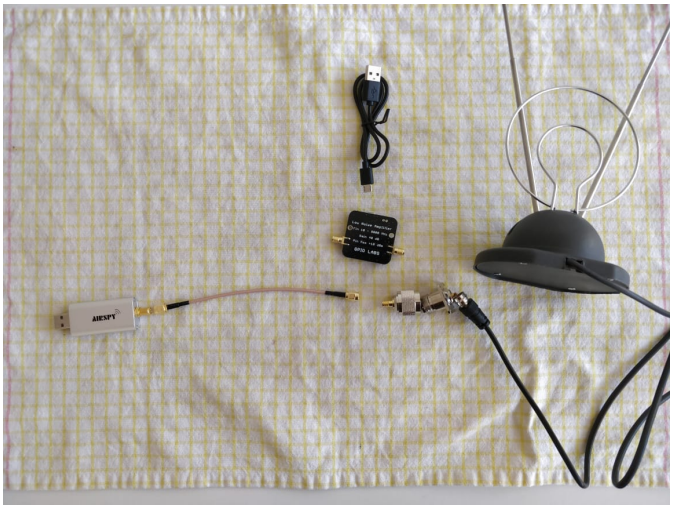
- Give the telescope a name
- Record the name of the observers

4.3 Light

- Emission, temperature or "electric noise"
- From source to eye, in straight line, called the front line like waves but can bounce (rebotar): "Frente de ola" donde la hola es alta (en general se dice solo la ola)
- Reception: visible light and invisible light. But artificiallly we can see all electromagnetic wave

- Alfa, Beta, Gamma, X-rays, UV, Visible, IR, radio (from 300GHz, 1mm, 3K to infinitely long waves).
- Every wavelenght other than "visible" is implicitely invisible and yet is exists.
- **No es porque no lo ves que no existe** (Martin: I like this quote, what do you think?)

5 Hardware



5.0.1 From computer to air

1. Airspy Mini[7]: usb cable (digital) → SMA cable (analog)
2. Cable[8]: SMA[9] male → SMA male (SubMiniature version A, a small coaxial cable)
3. Adapter[10]: SMA female → Coax N male (inside Screw and Male Pin)
4. Adatper[11]: Coax-N female → Aerial. Aerial means that is an exposed piece (small tube) of cober exposed to the air so that you can touch it with any cable
5. Antenna: with a copper cable touching the aerial part of the last adapter. Hopefully this "touch" is in a protected area (i.e in a Faraday cage).

5.0.2 Optionaly: Amplificators

They must receive power from a micro-usb[12] (as did phones in 2015, not the new symmetric one, the one just before)

1. Low noise amplifier, multi-purpose (the one the foto).
   - Warning: it is advised to turn-off wifi strong emitters before. Not sure what will break first, hopefully the amplifier.
2. Specific Hydrogen2 band applicators
   - This should not burn anything (if not used in a microwave oven).

5.0.3 Justification of this mount

A coaxial cable cannot receive e-waves from the air: it is actually the purpose of its shell (of the coaxial part).

But a stupid copper cable can.

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7 https://airspy.com/airspy-mini/
8 https://www.amazon.com/SDTC-Tech-Coaxial-Assembly-Extender/dp/B07NCLZWHH
9 https://es.wikipedia.org/wiki/SMA_(conector)
10 https://www.amazon.com/Maxmoral-Female-Connector-Coaxial-Adapter/dp/B01NCAL4DR
11 https://www.amazon.com/CESS-N-Type-Female-Aerial-Antenna/dp/B01GBWAXIY
12 https://it.wikipedia.org/wiki/Micro-USB

The following mount is to make a coper cable cleanly touch the airspy. Cleanly means wihout deteriorating the Airspy and permanently under e-cover to decrease noise from those cables receiving e-waves.

Then everything exposed (without shell) and touching this coper cable acting as antenna (air → cable), and the airspy alone is serving a digitalizer (cable → computer)

6 Links

- Doc Wiki Broadcast band[13]
- Doc UK: Radio specturm map[14]
- Doc: GRSS International Frecuency Allocation (Interactive)[15] (Geoscience and Remote Sensing Society)
- Doc Rtl-Sdr[16]: ReaLTek Usb and Osmocon wiki[17]
- Doc for class: Teacher background electromagnetic waves[18]
- Read: Glen Memos[19] (gnuradio[20])
- Read NRAO: Introduction to radioastronomy[21]
- Read: Subtel presentation with ALMA allocated bands:[22] Subsecretariat de las telecomunicaciones (Chilean equivalent of the International Telecommunication Union[23])

- Video: NRAO/Glen Tele school on gnuradio[24]: very nice content for us (classes are ready)
- Video: Radio hacking car tires[25]

- Ref: Ubuntu 18.04.5 Desktop (64-bit)[26] (main download directory[27])
- Ref: GnuRadio v3.7[28] (doc[29])
    - GNU Radio Companion (GRC)[30]

13 https://en.wikipedia.org/wiki/Broadcast_band
14 http://static.ofcom.org.uk/static/spectrum/map.html
15 http://www.grss-ieee.org/frequency_allocations.html
16 https://www.rtl-sdr.com/about-rtl-sdr/
17 https://osmocom.org/projects/rtl-sdr/wiki/Rtl-sdr
18 https://www.esrl.noaa.gov/gmd/outreach/info_activities/pdfs/TBI_electromagnetic_radiation.pdf
19 https://github.com/WVURAIL/lightwork
20 https://www.gb.nrao.edu/~glangsto/LightWorkMemo020-r3.pdf
21 https://www.cv.nrao.edu/course/astr534/Introradastro.html
22 https://sites.nationalacademies.org/cs/groups/bpasite/documents/webpage/bpa_057258.pdf
23 https://en.wikipedia.org/wiki/International_Telecommunication_Union
24 https://www.youtube.com/watch?v=WFMaEh4CekY
25 https://www.youtube.com/watch?v=1RipwqJG50c
26 https://releases.ubuntu.com/18.04/ubuntu-18.04.5-desktop-amd64.iso.torrent?_ga=2.87267871.683554448.1607527397-66620684.1594409447
27 https://ubuntu.com/download/alternative-downloads
28 https://github.com/gnuradio/gnuradio
29 https://wiki.gnuradio.org/index.php/Tutorials
30 https://wiki.gnuradio.org/index.php/Guided_Tutorial_GRC

7 Tasks

- [ ] Martin Tourneboeuf[31] Create a fake fm emission from gnuradio and some audio files (noise and stuff)
- [ ] Martin Tourneboeuf[32] Join visual info on FM, AM, Spectrum (poster?)
- [x] Rodrigo Cabezas[33] What is the frequency range you are able to receive? Do you have targets in mind (like a homemade emitter)?

  In the project, the science case is "to observe the 21 cm Hydrogen line", that means the system is optimized to seek for the 1,420,405,751.7667 Hz frequency. The antenna frequency is designed for this (cut off frequency) and the receiver is optimized just for this frequency.
  However, the AIRSPY SDR can handle 24 – 1700 MHz frequencies and one of the 2 RF amplifiers can handle up to 6000 MHz. This can open some other science cases.
  A new design, can open more.
  In addition, with a dipole antenna, some other "aficionados" cases can be opened, like air traffic communications, ADS from airplanes or perhaps GNSS frequencies (GPS, GLONASS, GALILEO)

31 https://confluence.alma.cl/display/~martin.tourneboeuf
32 https://confluence.alma.cl/display/~martin.tourneboeuf
33 https://confluence.alma.cl/display/~rodrigo.cabezas

8 Files

- ALMA Processing (.grc)[34]
- Windows instalation (docx)[35]
- Srd#: Demo files (.wav)[36]

34 https://confluence.alma.cl/download/attachments/61366799/ALMA_processing.grc?api=v2&modificationDate=1607822810000&version=1
35 https://confluence.alma.cl/download/attachments/61366024/Software%20e%20Instalaci%C3%B3n.docx?api=v2
36 https://www.sdrplay.com/iq-demo-files/