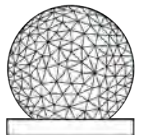


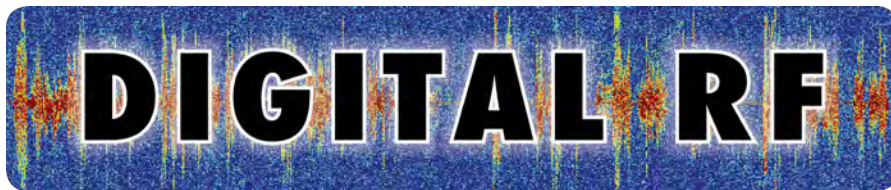
# Radio Science Education at Haystack

John Swoboda



MIT  
HAYSTACK  
OBSERVATORY

# Software



# Python and Anaconda



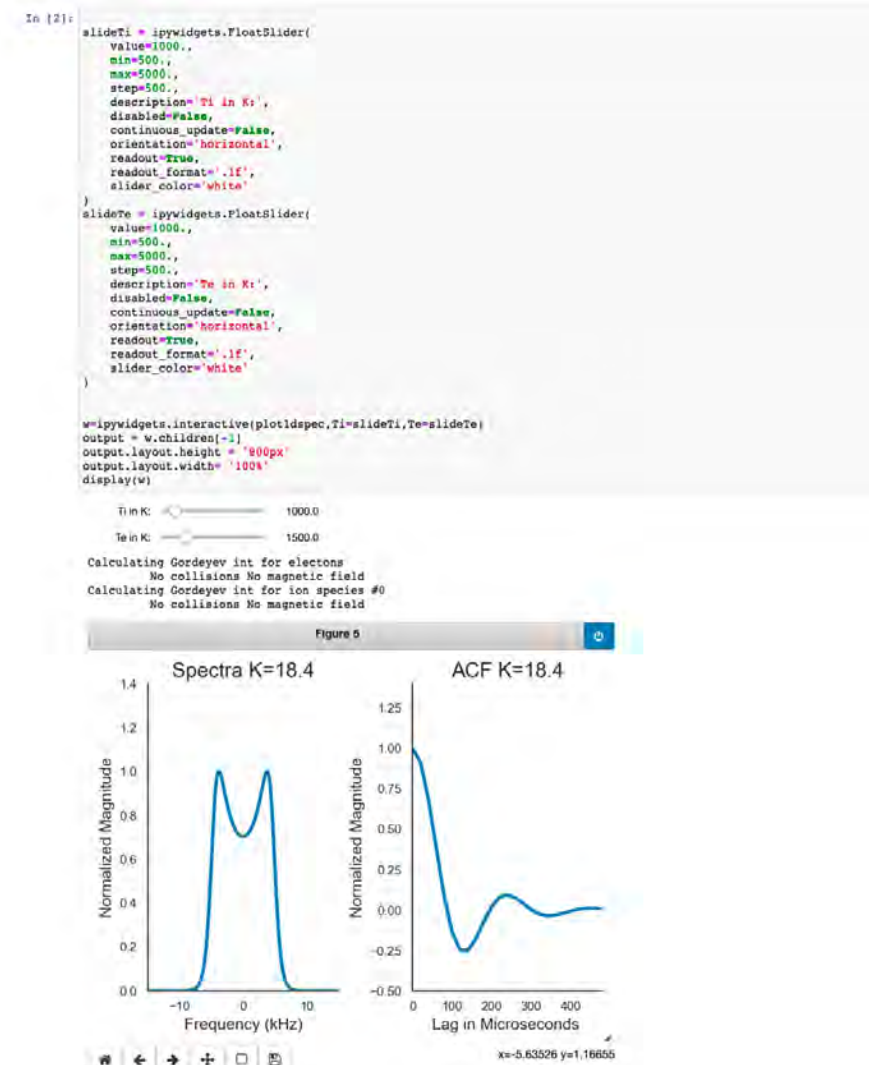
- Programming language
- Open-source
- Free!
- Many scientific libraries
- One of the most used programming languages



- Package manager
- Free!
- Compatible with Windows Mac and Linux
- Avoids having to build from source
- Can create environments

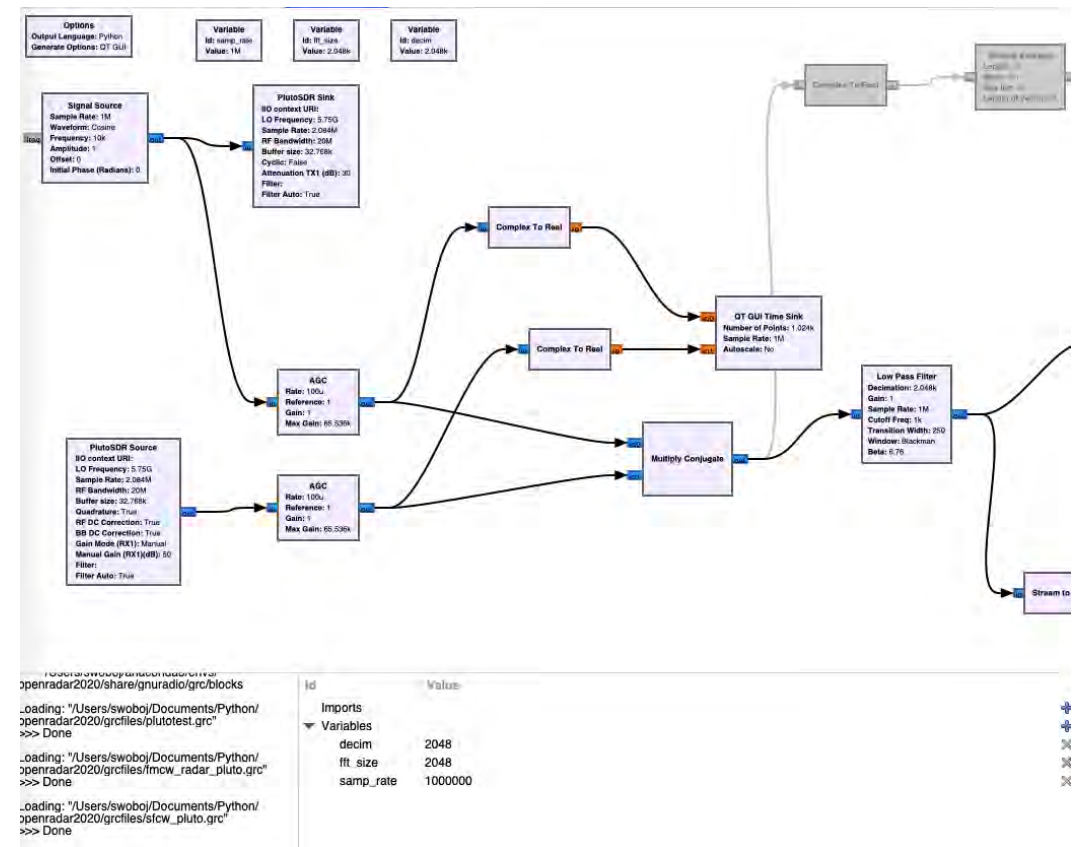
# Jupyter Notebooks

- Documents “containing code, visualizations and narrative text”
- Allow for easy sharing in education environment
- Used in the remote ISR Summer School



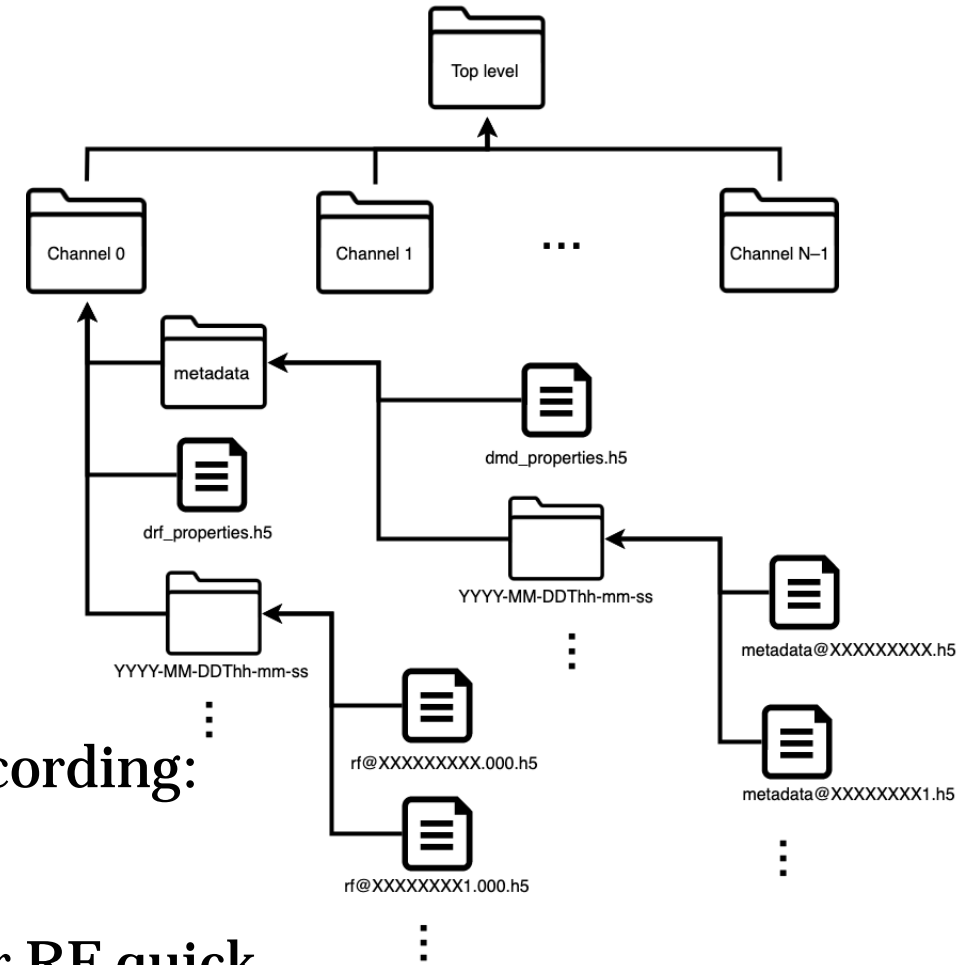
# GNURadio

- Tool kit to implement software radios
- Includes signal processing tools
- Contains a GUI interface for making flow graphs to implement radio processes



# Digital RF and Digital Metadata

- Self-documenting for data archival
- $O(1)$  sample lookup for quickly reading any segment of data
- Included with package:
  - Easy-to-use command-line program for data recording: the Haystack Observatory Recorder (thor)
  - Snapshot and ring buffer tools
  - Plotting tools built in for easy debugging and for RF quick-look spectrograms
  - Geophysical measurement examples
    - Satellite beacon receiver
    - Ionospheric sounder



Digital RF/Metadata file structure

# Open Radar Workshop

**Participants (7)**

**Panelists (7)**    **Attendees (0)**

Find a panelist

- John Swoboda (Host, me)
- Ryan Volz (Co-host)
- Frank David Lind
- Diego Pefalozza Aponte (Guest)
- DS Diego Sanchez (Guest)
- HG Hannah Goldberg (Guest)
- OK Onemo Kang (Guest)

Invite    Mute All    Unmute All    More

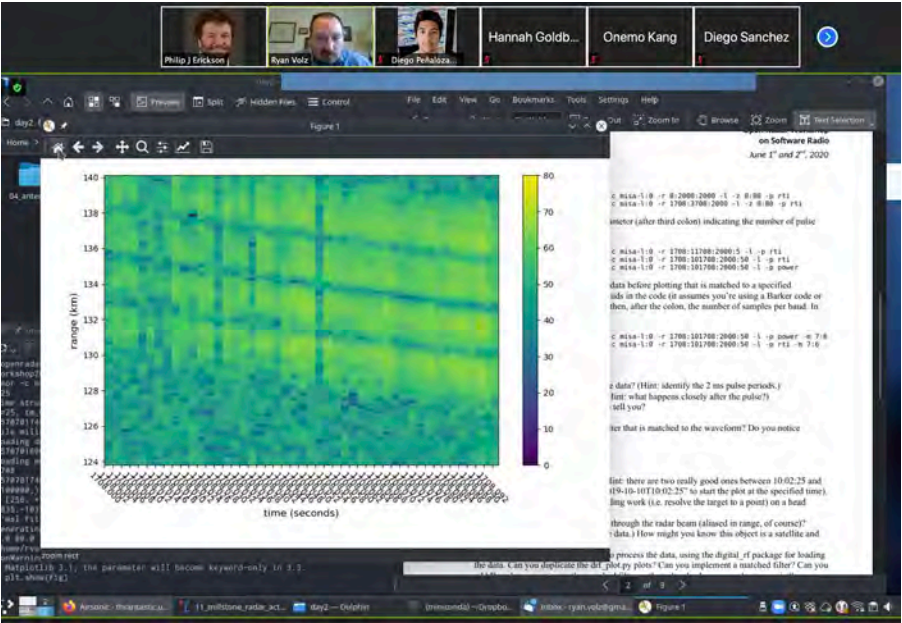
**Chat**

I seem to be able to get everything to work now - but just getting things to work seems to take a while. I suggest longer times for testing out and a few more textbook examples to work through. This maybe straightforward for everyone else, but I don't think so.

From Frank David Lind to All panelists and attendees:  
btw. Building your own SDRs isn't impossible but it can be very hard. The RFSoC is about 2- to 3 years of development just to make the PCB.

From Philip J Erickson to All panelists and attendees:  
I will go over "Langmuir line" and "ion acoustic line" in the IS radar talk.  
"Plasma line" = Langmuir resonance line, a strong function of electron density (and a weaker function of electron temperature)

To: **bc** (Privately)    Type message here...



**Ionospheric Parameters**  
GPS can be used to measure:

- Ground Based Receiver
  - Total Electron
  - Scintillation
- Space Based Receiver
  - Electron Dens
  - Scintillation

is the ensemble  
is the phase of the signal.  
where  $\phi$  is the phase of the signal.

The Open Radar Initiative  
www.openradar.org