# Quick Start Instructions for Using the spectrum_w_cal.grc Program

Features of the *spectrum_w_cal.grc* Gnuradio Program

- Data is calibrated and displayed on the fly without the need for any post-run manipulations of the spectrum and calibration data.

- During a run various display options are available: ***filtered spectrum with no calibration***, ***spectrum with calibration***, ***hot calibration***, ***cold calibration***, and ***unfiltered spectrum with no calibration***.

- The scale of the signal axis can be adjusted during the run.

- The live spectrum being displayed on the main graph can be captured in a .csv text file for easy access later.

- There is an option to have the spectrum written to newly created files once per integration time. This enables data to be collected without the user's presence.

- Writing to an hdf5 file can be stopped and continued during the run.

- All of the files are named with a time stamp.
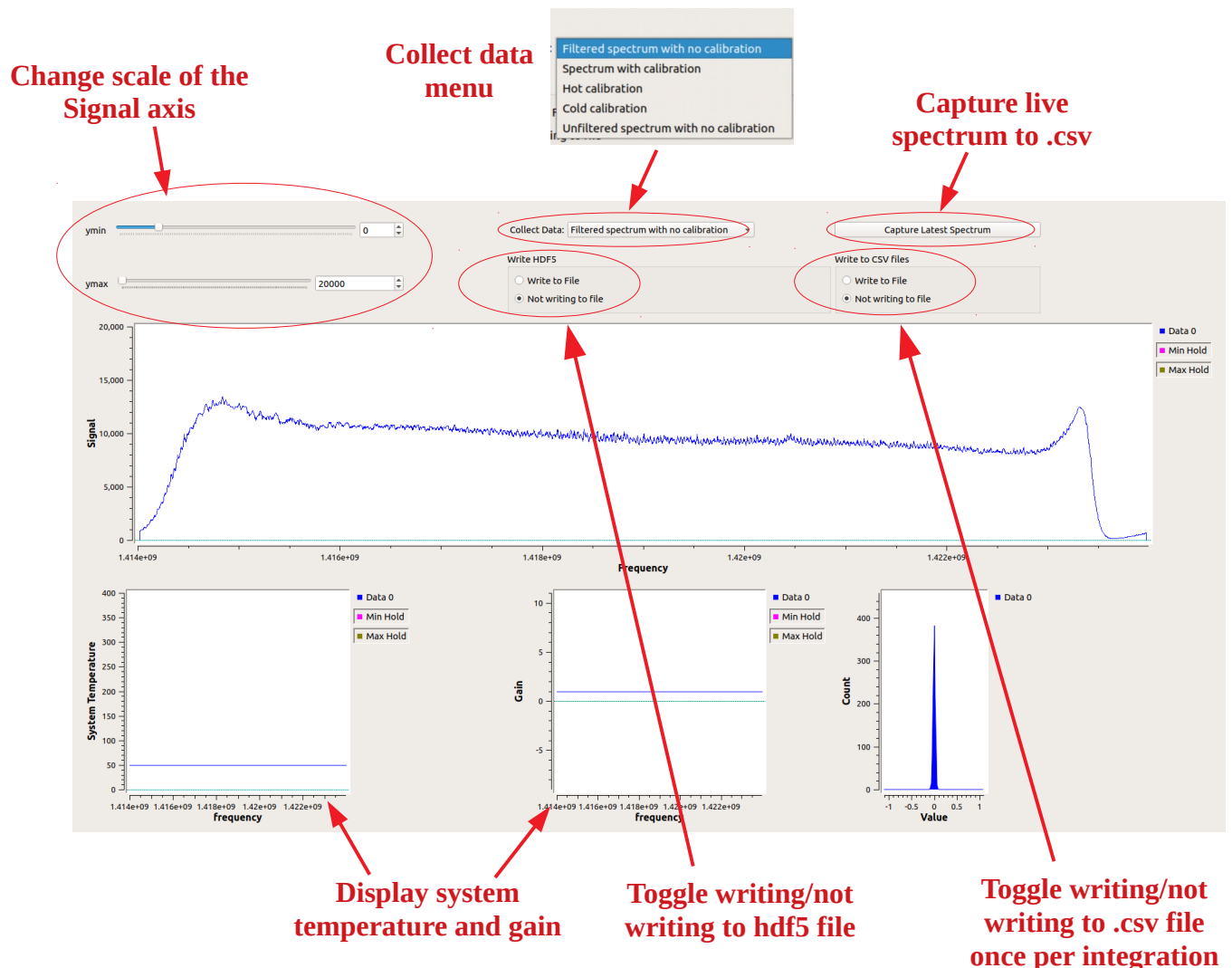
PROCEDURE: Collecting Spectra Using the *spectrum_w_cal.grc* Program

1. Connect horn, LNA, Airspy, and computer USB. Then open the *spectrum_w_cal.grc* program in Gnuradio.

2. Before running the program, check the user-defined settings. These can be found in the blocks on the upper right corner of the Gnuradio canvas, as illustrated:
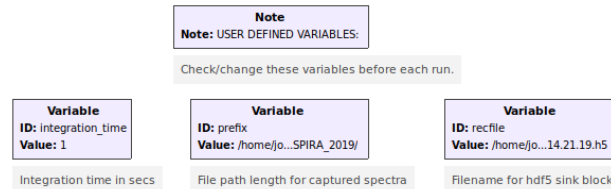
   - **integration_time** – in seconds. NOTE: The gnuradio program does not accept all integration times (reason unknown). So test it out before settling on your run. Suggested times: 1 s, 2 s, 5 s, 10 s.
   - **prefix** - sets the path to the directory that all files will be written to.
   - **recfile** - the name of the hdf5 file that will be written to the directory defined by the **prefix** variable. This does not need to be changed unless the user wants a different path and/or filename.

   NOTE: Gnuradio does not like folder names with capitals in them. In naming file path lengths and folders, use only lower case. Also no spaces in folder names nor in file names!

3. Start the program running.

4. Check the file path and file name: It is advised to run the program for a short time (at least one integration time) and select the "Write to File" options and hit the "Capture Latest Spectrum" button. Then stop the program, and go to the folder defined in the Prefix box to check that the files were created properly. The misnaming of a file directory path or filename are common errors that will prevent the program from running.

5. When the file paths and names are set, re-start the program.

6. If everything is running okay, the **Count vs. Value** histogram graph in the lower right corner of the display should show some activity by continuously fluctuating. This is the "heartbeat" of the program; as long as its "beating" things are good. If this graph looks frozen, then the program has probably stopped running.

7. Assuming the telescope is pointed toward the sky, a spectrum will appear on the main **Signal vs. Frequency** graph. The first iteration of this graph will take longer than the actual integration time, up to a minute sometimes, depending on the integration time. Be patient.

   The **Collect Data** chooser at the top defaults to the **unfiltered spectrum with no calibration** option.

   The **System Temperature** and **Gain** graphs will display default constant values, as the system has not yet been calibrated.

8. **Calibration**:

When you are ready to calibrate, proceed as follows:

a. Hot calibration:

    i. Point the horn at the ground at a roughly 45º angle.

    ii. Change the **Collect Data** chooser at the top to **Hot calibration**.

    iii. Wait for the graph to cycle through a few integration times and settle to a repeated pattern. You may want to adjust the **ymax** value for the spectrum to fit in the graph.

    iv. Once you are satisfied that the hot calibration spectrum is steady, switch the **Collect Data** chooser to *Cold calibration* or *Filtered spectrum with no calibration* <u>*BEFORE MOVING THE TELESCOPE*</u>.

b. Cold calibration:

    i. Point the horn at the blank sky where there is no HI signal.

    ii. Change the **Collect Data** chooser to **Cold calibration**.

    iii. Wait for the graph to settle to a repeated pattern. You may want to adjust the **ymax** value.

    iv. Once you are satisfied that the cold calibration spectrum is steady, switch the **Collect Data** chooser to **Spectrum with calibration** <u>*BEFORE MOVING THE TELESCOPE*</u>.

    v. The **System Temperature** and **Gain** graphs should show some meaningful data as functions of frequency. You are now ready to view calibrated spectra.

9. **Making Observations**

a. Select **Spectrum with calibration**. The signal should drop significantly to a value that is typically less than 100 K. So you will need to change the **ymax** value accordingly.

The main graph should be almost completely flat except for where there are HI peaks are.

NOTE: The method of data smoothing and calibration uses the data at the beginning and end of the spectrum. As a result, the first 50 data points and last 50 points of the spectrum are set at artificial values that make those regions look square. Ignore these parts of the spectrum.

b. Depending on how well the system has warmed up, it is possible that the spectrum may drift below 0 K. The data is okay, just offset a little. The **ymin** value can be changed to negative values to fit the spectrum on the graph if needed. Or re-calibrate, especially the cold calibration. This usually fixes the issue.

c. If you wish to update the system temperature and gain, the hot and cold calibrations can be re-done at any time without stopping the program.

d. The active spectrum will be written to the hdf5 file whenever the "**Write to File**" radio button is selected in the **Write to HDF5** window. Data will stop writing to this file when "**Not Writing to File**" is selected, but data will resume being added to the same file if "**Write to File**" is re-selected.

e. Any time you want to write the current spectrum to a "[timestamp]__spectrum.csv" file, hit the "**Capture Latest Spectrum**" button. The timestamp will distinguish these files from one another. It is recommended that you rename them later to more descriptive names.

f. If the "**Write to File**" radio button is selected in the **Write to csv files** window, the spectrum will be written to a newly created file once per integration time. This can result in a lot of files for a long run, depending on the integration time. This should not be a problem as long as the computer has enough memory space. Each .csv file uses approximately 205 kB of memory.

The format of these .csv files is *Frequency* in the first column, and *Signal* in the second column. If the spectrum is calibrated, then the Signal is Temperature in Kelvin.

10. **Finishing An Observation**

a. When you are ready to quit a run, be sure to select "**Not Writing to File**" before closing the program by hitting "x" in the upper righthand corner. If not, the hdf5 file will not be properly saved.

b. Re-starting the program will write to a new hdf5 file with a different time stamp.

Recommendations and Tips

• Plan your viewing ahead of time to help keep track of the .csv files you plan on capturing.

• Keep notes of the files captured to make it easier to sort them out later.

• Capturing the hot and cold calibrations to .csv files can be useful for some post-observation applications.

• CAUTION: If you run the program on a laptop without the power cord plugged in, the computer may go into a sleep mode and stop running the Gnuradio program, depending on the length of the run. Change the power settings on your computer so that it never suspends or goes to sleep.

• It is recommended that you keep a log of when the spectra were captured for reference later on when renaming the files.