# CARMA Correlator Graphical Setup

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CARMA Correlator Graphical Setup (CGS) is a Java tool to help users of the Combined Array for Research in Millimeter-wave Astronomy (CARMA) plan observations. It allows users to visualize the correlator bands overlaid on frequency space and view spectral lines within each band. Bands can be click-dragged to anywhere in frequency and can have their properties (e.g., bandwidth, quantization level, rest frequency) changed interactively. Spectral lines can be filtered from the view by expected line strength to reduce visual clutter.

Once the user is happy with the setup, a button click generates the Python commands needed to configure the correlator within the observing script. CGS can also read Python configurations from an observing script and reproduce the correlator setup that was used. Because the correlator hardware description is defined in an XML file, the tool can be rapidly reconfigured for changing hardware. This has been quite useful as CARMA has recently commissioned a new correlator.

The tool was written in Java by high school summer interns working in UMD's Laboratory for Millimeter Astronomy and has become an essential planning tool for CARMA PIs.

## Why

The Correlator Graphical Setup (CGS) was created to enhance the scientific utility of CARMA by providing astronomers with a tool to investigate and understand the capabilities of the CARMA correlator. CGS was important to create because a new correlator was coming online in 2009. Since the new correlator was going to be much more flexible and contain many more bands than the previous correlator, so we wanted users to be able to successfully take advantage of its capabilities. One way to do this is to allow astronomers to visualize the spectral lines and spectral windows in frequency space, and to modify the properties of the spectral windows in a natural way. With CGS, users can easily transfer the visual representation of their desired correlator set up into the actual Python commands that configure the correlator for observations.

## How

The capabilities of the correlator are specified in XML. These include the receiver IF ranges, the number of bands available, the bandwidth modes, the number of channels per mode, and variations of some these parameters as a function of quantization bit level. Specifying the capabilities in XML allows easy modification of the CGS tool as the telescope hardware evolves. For instance, not all of the new bands came online simultaneously and so we were able to have the CGS tool accurately track the current state of the commissioned bands by simple edits.

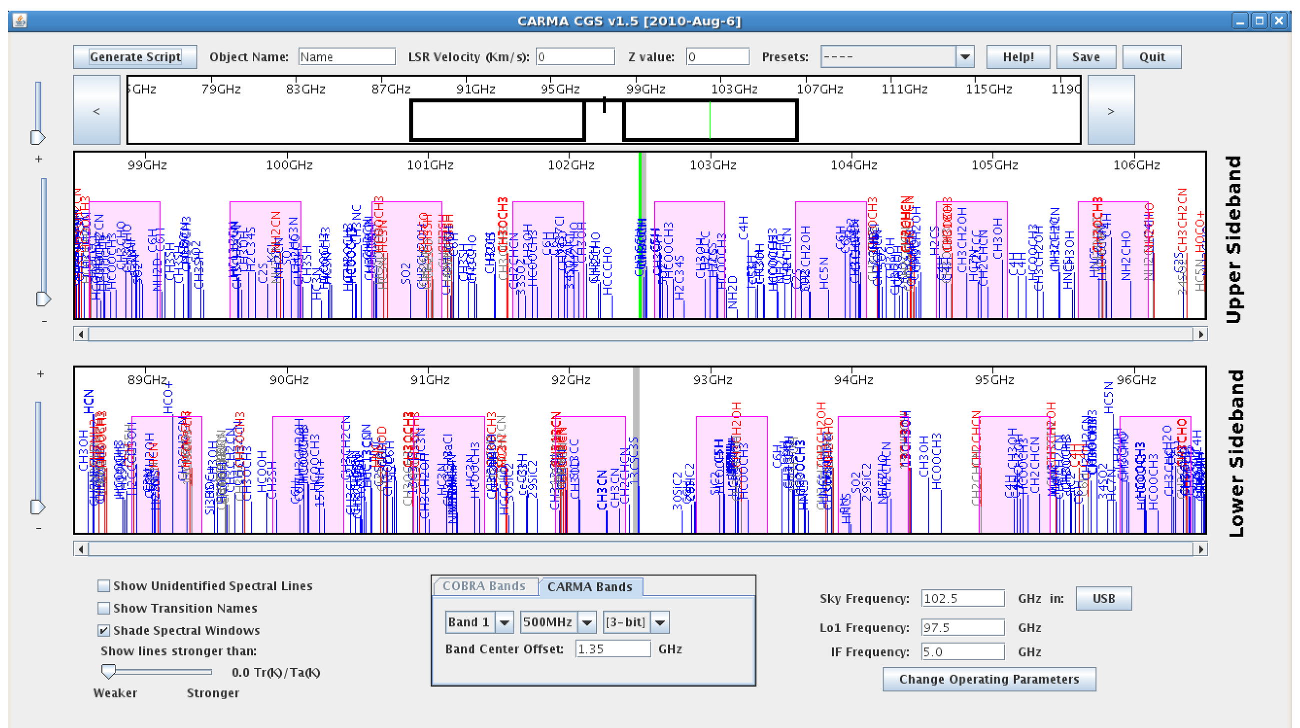
The spectral line characteristics are read in from a tabular version of the Lovas 3mm and 1mm catalogs. Using such a table also makes it easy to add spectral lines in the future, which is particularly important for planning high red-shift observations.

## Who

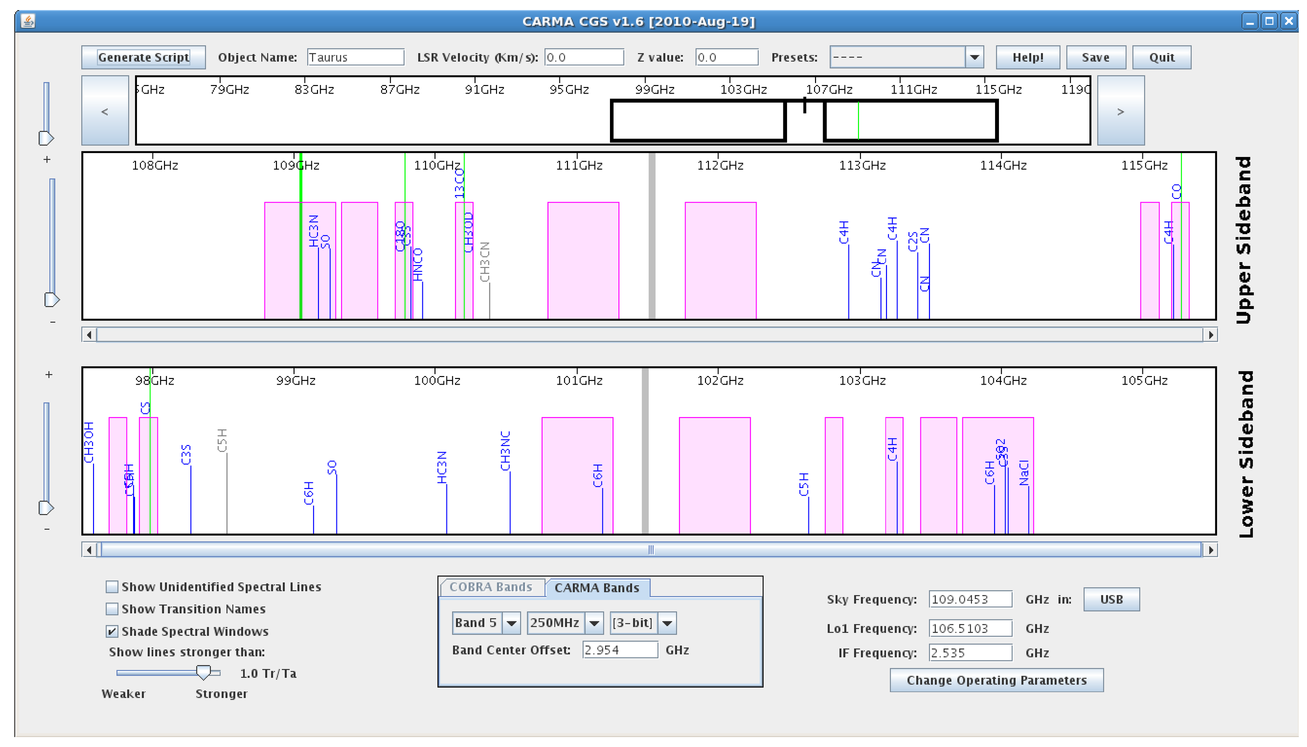
The Correlator Graphical Setup (CGS) was developed entirely by high school students working in UMD's Laboratory for Millimeter Astronomy. They wrote all of the software in Java with the Netbeans IDE under the guidance of Dr. Marc Pound. Ben Shaya started CGS during the summer following his 10th grade year at Montgomery Blair High School. He created a functional tool that contained all of the necessary initial features.

Later on, fellow student Dalton Wu made additional modifications to CGS during the summer following his 12th grade year at Montgomery Blair High. He fixed many bugs that were reported by users, and added additional features to meet the needs of current users. For example, many astronomers use Macbooks, and the older versions of CGS had a screen layout that did not fit on Macbooks! Dalton implemented this change as well as many others including: flexible bit configuration options that could be set for each individual band (thereby changing the bands properties), and spectral line frequencies that adjust for the Doppler effect of moving sources.

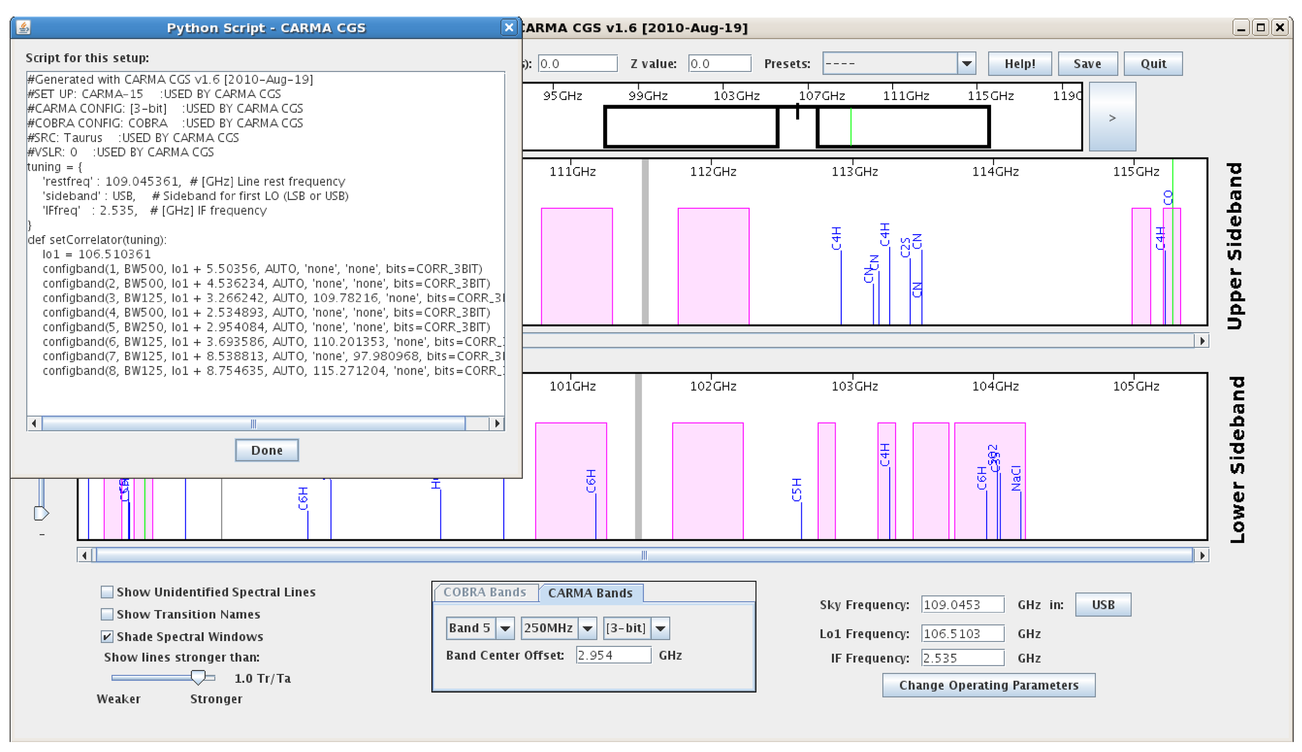
## Example CGS Usage



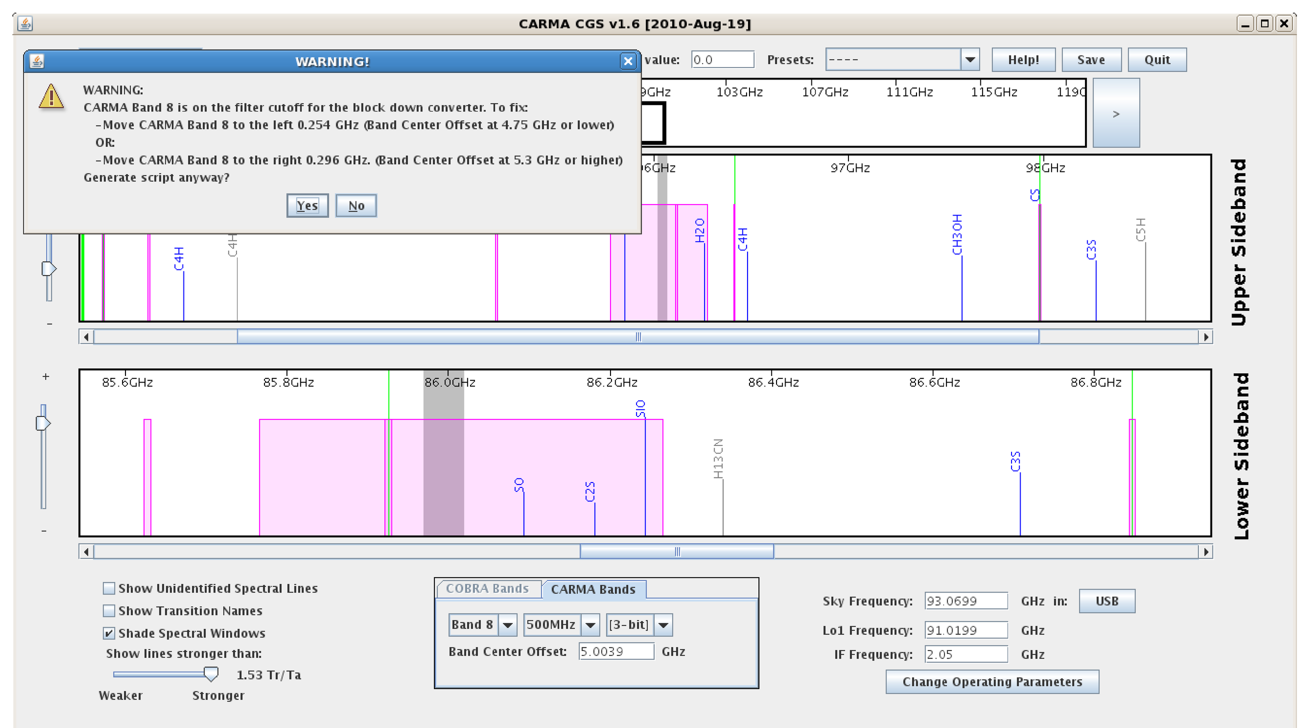
***1)*** This is the default view of CGS. The vertical lines represent spectral lines of known (blue) and unknown (red) intensity. Each of the pink rectangles represents one of the two spectral windows of each band. The properties of each band can be modified with the pull-down boxes inside the lower center box or with right-mouse clicks. Bands can be moved in frequency space with a mouse drag or by the Band Center Offset text box.



***2)*** This is an example of what CGS looks like after it has been configured by the user. This set-up covers 4 spectral lines: 12CO(1-0), 13CO(1-0), C18O(1-0), CS(2-1). The user has tagged each of these lines with its rest frequency shown by the vertical green lines, so that each band has its own velocity range. Note the feature to show only the strongest spectral lines (slider in the lower left), which reduces visual clutter.



***3)*** After the user clicks "Generate Script", CGS creates this pop-up window containing the Python commands for this set up. The user can now copy and paste the commands directly into an observing script to configure the correlator for the observations. A user may also save the script to a file which can be loaded back into CGS later via a file read or by pasting into an input text box. Commonly used set ups are available under the "Presets" menu.



***4)*** This is an example of CGS firing a warning to indicate that the desired set up has problems. The problem with this specific set up is that one of the bands is on the edge of the block down converter filter, which is marked by the light gray zone. This would cause some degradation of data from that band, so CGS warns the user. This figure also shows the zooming feature of CGS: the "Lower Sideband" panel is zoomed in more than the "Upper Sideband" panel. This can help in visualizing narrower bands or spectral lines which are closely spaced in frequency.

CARMA Array at Cedar Flat