LWA Single Baseline Interferometry Tutorial
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May 27, 2019

1 Introduction

The purpose of this tutorial is to provide instructions on the methods used for single baseline interferometry with the Long Wavelength Array (LWA). This tutorial will cover the process of finding the necessary and proper sources for observations, creating the schedules for observation, and briefly the data reduction process which is conducted in AIPS. In order to schedule observations for the LWA, it's recommended to have access to the LWA Software Library (LSL) python module and the extension SessionSchedule, which is available through the LWA site.

Because these are long wavelength observations, the ionosphere plays a significant role in the quality of observations. It is best to schedule observing time when the ionosphere is least active, such as evenings and nighttime. It is also important to take the weather and temperature into consideration as the LWA will shut down if it is too hot (roughly 87° F), if there is significant amounts of lightning in the area, or if there is a brownout. If you're unsure at what time the object you're interested in viewing is transiting, the LWA operations screen shows the LST for Socorro, New Mexico. This site also shows how operations at each of the LWA sites are doing and whether they are currently operative or not. Links to the resources mentioned so far are listed below.

- LWA Homepage: http://lwa.unm.edu

- LSL Module and Extensions: http://fornax.phys.unm.edu/lwa/trac/wiki

- LWA Operations Screen: https://lwalab.phys.unm.edu/OpScreen/os2.php

2 Finding Calibrators and a Check Source

This method of observation relies on having good calibrators– one for flux and one for phase– and a good check source, which serves to confirm that the source beam is operational. These sources, especially the phase calibrator, should be compact sources in order to guarantee good solutions during data reduction. Examples of a good and bad source are included in figure 1. Although looking for these sources can be done manually through the VLA Low-Frequency Sky Survey Redux (VLSSr), the
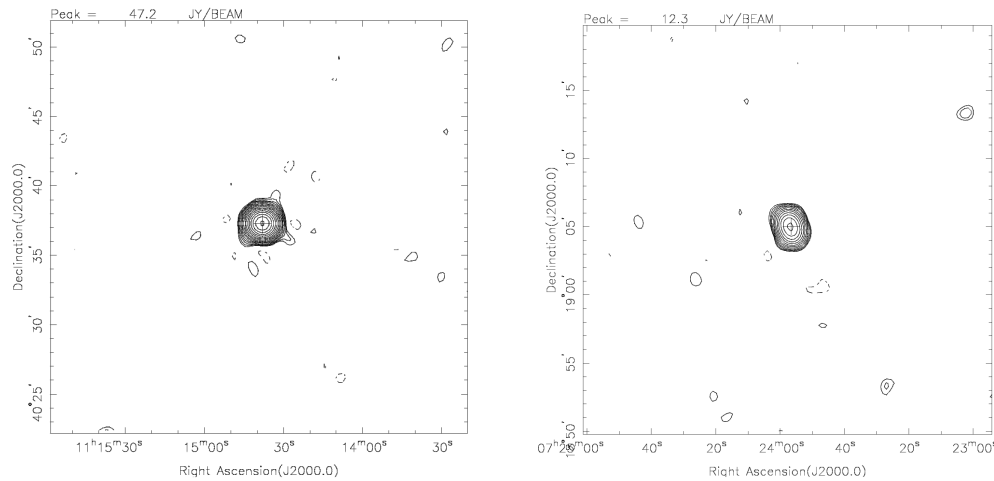
(a) This is an example of a good object to use as a phase calibrator or check source. It has a high flux density and, despite a bit of structure around it, is for the most part circular, indicating it's a point source.

(b) This is an example of an object you shouldn't use as a calibrator or check source. Although it has a reasonable flux density, its elongated shape indicates it is more than one source that could get resolved when viewed with the LWA at the same frequency or higher.

Figure 1: These images are examples of what qualifies as a good and bad source to use when looking for phase calibrators or check source. These contours are from the VLSSr with image dimensions of 0.5×0.5 degrees.

LWA has an extension in its software library which makes the search much simpler. It's also good to double check the sources that the calibratorSearch provides through the VLSSr.

- VLSSr Postage Stamp Server: https://www.cv.nrao.edu/vlss/VLSSpostage.shtml

With the VLSSr, you want to make sure the Equinox selected matches the Equinox for the coordinates you're using (J2000 will be most convenient for later in the tutorial). The desired image size should start out as 2.0×2.0 degrees. The image type should also be set to *Contour Map*. An example of this set up for the object 3C 295 is provided in figure 2 alongside what the resulting image should look like.

2.1 Flux Calibrator and Check Source

By nature of its role, the flux calibrator needs to have a substantial flux density, ideally at least around 50 Janskys (Jy) at 74 MHz. The information on a few popular flux calibrators and their associated check source are included in table 1. Although the flux calibrator does not need to be near the object that you're interested in viewing,

2

Equinox:	J2000 ▾
Object name *[optional]*:	3C 295
Central Right Ascension:	14 11 20.5
Central declination:	52 12 10
Desired image size (degrees): See Pixel Spacing for size limit.	2.0 2.0
Pixel spacing: Desired pixel size in arcseconds :e 262144 pixels, e.g. 512 x 512)	15.0 15.0
Projection:	Sine ▾
Desired rotation grees. (Use 0.0 for contour plots)	0.0
Image Type: if you've fetched more than one.	Contour Map ▾
	Clear Form (ALL!)

(a) Example of the ideal initial setup for the VLSSr. Including the name of the source you are looking at is optional.
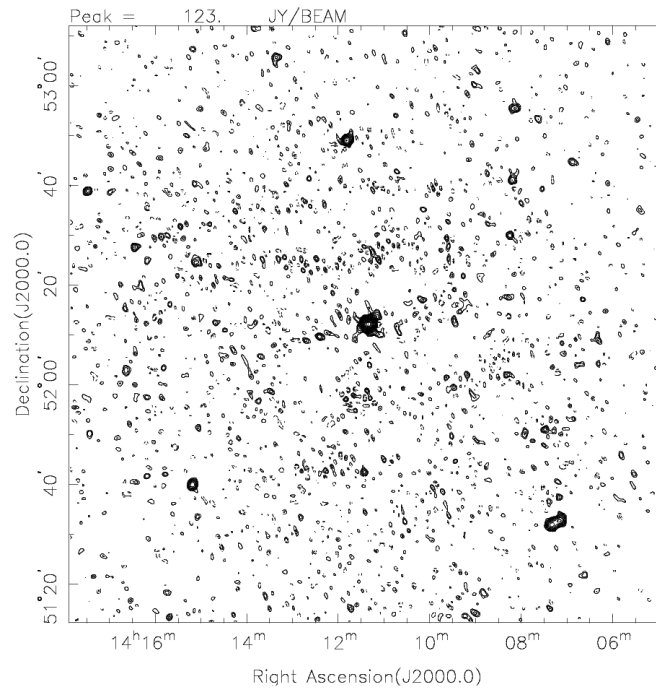
(b) Result of the inputs shown in figure 2a. 3C 295 is the source directly in the middle of the image.

Figure 2: The inputs and associated image for the flux calibrator 3C 295.

it does need to be visible at the same time as your object for the observations and correlation to work. Because the LWA is more sensitive to sources observed at zenith, make sure that whichever calibrator you use has a significant elevation while you observe it (ideally at least $45°$).

The check source for your flux calibrator should be relatively close to said calibrator. However, it should be safe to allow some extra distance given that the check source is bright (at least 20 Jy). Otherwise, the check source needs to be at least 10 Jy within $3°$ of the flux calibrator.

The object 3C 286 acting as a check source for 3C 295 is an example of a bright source ($\sim$30 Jy at 74 MHz) having a fairly significant distance (more than $20°$ from the flux calibrator). Although 3C 286 has shown to work adequately, an angular distance between the flux calibrator and check source this large should be avoided if possible.

	Name	Flux Density [Jy]	RA (J2000)	DEC (J2000)
Flux Cal.	3C 295	110- 120	14h 11m 20.5s	52° 12' 10"
Check Src.	3C 286	27.2- 30.3	13h 31m 08.29s	30° 30' 32.96"
Flux Cal.	3C 147	55- 53	05h 42m 36.1s	49° 51' 07"
Check Src.	4C +47.16	18.5 -20.3	05h 41m 49.25s	47° 29' 07.61"
Flux Cal.	3C 48	67.6- 71	01h 37m 41.3s	33° 09' 35"
Check Src.	3C 41	20.4- 22.5	01h 26m 44.389	33° 13' 11.21"

Table 1: Information on popular options for flux calibrators and associated check sources. The flux densities recorded here are of the objects at 74 MHz as provided by the VLA. More information on these calibrators at different frequencies can be found through the NASA Extragalactic Database (NED).

2.1.1 Finding a Check Source (calibratorSearch Method)

A much more time-friendly approach to looking for a phase calibrator and check source is to use the calibratorSearch extension available through the LSL. To use the tool, you can put in the name of the object of interest and click *Resolve* or put in the coordinates for it if there is significant proper motion. An example of using this tool for EQ Peg is shown in figure 3. calibratorSearch will highlight candidate check sources in red if the source is not a good choice and it is worth double checking the sources it provides through NED and the VLSSr. This extension can be accessed through the terminal with the following line:

```
.../ extensions/SessionSchedules/calibratorSearch.py
```

2.1.2 Finding a Check Source (VLSSr Method)

To start looking for the check source for your flux calibrator, setup the VLSSr server as in figure 2a so that it includes the RA and DEC for your flux calibrator. The following steps may need to be repeated multiple times.
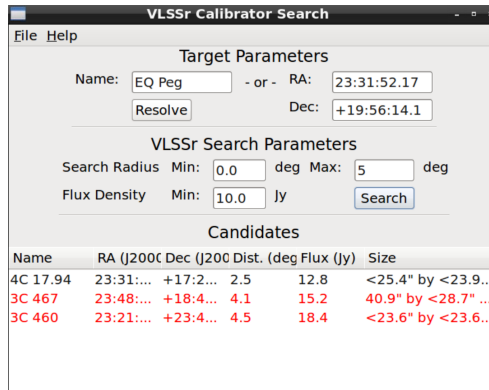
Figure 3: Using calibratorSearch.py to find a phase calibrator for EQ Peg. The red text is indicative of options that should be avoided.

1. If there are no other possible bright sources in the current image, increase the RA by 8 minutes, keeping all other parameters the same. Click submit.

2. In the top left corner of the resulting image, there will be an indicator for the peak value in Jy in the image.

   (a) If the peak value is less than 10 Jy *or* if there is no obvious point source:

      i. Either increase or decrease the DEC by $2°$ or decrease the RA by 16 minutes (so that it's 8 minutes less than the original RA). Click submit.

   (b) If the peak value is greater than 10 Jy *and* there appears to be a point source:

      i. Identify which of the sources in the image has the peak value. This source is typically the one with the densest contour.

      ii. Using the RA and DEC values on the axes of the image, change the RA and DEC values on the server so that it is centered on the object (it's okay to not be exact). You'll want to change the dimensions of the image from 2.0×2.0 degrees to 1.0×1.0 degrees. Click submit.

      iii. After changing the dimensions of the image so that you are zoomed in on the bright source, you will probably need to change the RA and DEC again so that you are better centered on the source. You will also want to change the dimensions again from 1.0×1.0 degrees to 0.5×0.5 degrees. Click submit.

      iv. Once at these dimensions, continue to fine tune the coordinates for the center of the source. This can take multiple tries.

      v. Once you've found the center of your source. Copy the coordinates into the search bar on NED (https://ned.ipac.caltech.edu). You'll be given a list of objects that are at or near the coordinates you provided. From this list, find the object with the coordinates that most closesly

match the ones you provided. You can further make sure it is the right object by clicking on the name of the object, going to the tab labelled *Photometry & SED*, and scrolling through the photometric measurements until you find the measurement taken at 74 MHz (most likely provided by the VLA). If this object is the same as the one you found on the VLSSr, the flux densities should be roughly the same. You'll want to keep track of the name, flux, and coordinates of this source.

3. Continue to change the RA and DEC by increments of 8 minutes or 2 degrees respectively, making sure to change the dimensions back to 2×2 degrees if you changed the dimensions earlier. The area and the relative coordinates should resemble table 2. If there was no bright point source within this area, expand the range by another 8 minutes in RA and 2 degrees in DEC and repeat the process.

+8 minutes +2°	+0 minutes +2°	−8 minutes +2°
+8 minutes +0°	Original Co-ordinates	−8 minutes +0°
+8 minutes −2°	+0 minutes −2°	−8 minutes −2°

Table 2: These values are the changes you should make to the RA and DEC relative to the original coordinates of the flux calibrator so that you encompass all the sky immediately surrounding it. If there isn't a bright point source within this area, then increase the range of the RA by another 8 minutes and the DEC by 2° in each direction.

2.2   Object and Phase Calibrator

Finding a phase calibrator for the object of interest follows the exact procedures as finding a check source for the flux calibrator. The only differences are that rather than starting your search centered at the coordinates of the flux calibrator, you start it at the coordinates of your object of interest and 3° should be the absolute limit for how far away the phase calibrator is from the object. If you are using the calibratorSearch method, then similarly you will put in the coordinates of the object of interest under Target Parameters and limit the search radius to 3°. It's important that the coordinates you use for your object take any proper motion into account, as any significant movement may move the object out of the area covered by the beam. Proper motion for objects – if there is any– can usually be found through SIMBAD. You will need to keep track of the name, coordinates, and flux density of the phase calibrator for scheduling.

3   Scheduling Observations

Once you've found the appropriate flux and phase calibrator and check source for your object of interest, you will need to access swarmGUI.py from the SessionSchedule extensions in order to make the observation schedules. To start a session, go to File >New or click ⬜. Before you can begin making the schedule, you'll need a user ID number and project ID number which you'll put in *ID Code* under *Project Information.* Each scheduled session for a given project must also have a unique session number included in *ID Number* under *Session Information.* The data return method should be *DRSU.* Once everything in the Observer Information window is filled out, go to Obervation >Add >DRX-RA/DEC or click **R** to begin the first observation of the schedule.

3.1   Calibration Beam

The calibration beam will alternate between the flux and phase calibrator, starting with the flux calibrator. In the first observation for this session, include the name of your flux calibrator and the time you want to begin observing (in UTC). You can either manually put in the coordinates of the calibrator or you can click the check box next to the Target and go to Scans >Resolve Selected. If you're using an abbreviated name as the Target name, you will need to put in the actual name of the calibrator for Target Name in the window that comes up. Clicking *Resolve* will give the coordinates of the calibrator and clicking *Apply* will apply those coordinates to the observation. The duration of this first observation should be five minutes, but for all other observations of the flux calibrator, the duration will be two minutes. The tunings you choose will depend on which frequencies you want to view your object. For filter code 6 (which corresponds to a bandwidth of 9.8 MHz), it's suggested you choose tunings that are 10 MHz apart. These tunings and filter code should be the same for *all* observations in the session.

   After filling out the information for the flux calibrator, start a new observation in the session for the phase calibrator. You should notice that the beginning of this observation has automatically been put at five minutes after the beginning of the first observation, so there is no need to manually input the start time. The observations of the phase calibrator will be 20 minutes.

   The flux and phase calibrators will alternate in observations for anywhere between about 1.5 to 2.5 hours, finishing on the flux calibrator observing for two minutes. To make sure that everything looks to be at a good elevation, go to Scans >Run at a Glance, which will show the elevation of the objects throughout the session. Information on how long each observation should last is in table 3 and an example for a calibration beam session is shown in figure 4.

3.2   Source Beam

After finishing the schedule for the calibration beam, start a new session file for the source beam. The ID Code under *Project Information* and ID Number under *Observer Information* should be the same as in the calibration beam file, but the ID Number

ID	Target	Intent	Comments	Start (UTC)	Duration	RA (Hour J200	Dec (Deg. J200	Tuning 1	Tuning 2	Filter Code
☐ 1	3C147	FluxCal	None pro...	UTC 2019 05 01...	00:05:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6
☐ 2	3C200	PhaseCal	None pro...	UTC 2019 05 01...	00:20:0...	08:27:25.39	+29:18:45.3	68.000...	78.00...	6
☐ 3	3C147	FluxCal	None pro...	UTC 2019 05 01...	00:02:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6
☐ 4	3C200	PhaseCal	None pro...	UTC 2019 05 01...	00:20:0...	08:27:25.39	+29:18:45.3	68.000...	78.00...	6
☐ 5	3C147	FluxCal	None pro...	UTC 2019 05 01...	00:02:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6
☐ 6	3C200	PhaseCal	None pro...	UTC 2019 05 01...	00:20:0...	08:27:25.39	+29:18:45.3	68.000...	78.00...	6
☐ 7	3C147	FluxCal	None pro...	UTC 2019 05 02...	00:02:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6
☐ 8	3C200	PhaseCal	None pro...	UTC 2019 05 02...	00:20:0...	08:27:25.39	+29:18:45.3	68.000...	78.00...	6
☐ 9	3C147	FluxCal	None pro...	UTC 2019 05 02...	00:02:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6
☐ 10	3C200	PhaseCal	None pro...	UTC 2019 05 02...	00:20:0...	08:27:25.39	+29:18:45.3	68.000...	78.00...	6
☐ 11	3C147	FluxCal	None pro...	UTC 2019 05 02...	00:02:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6
☐ 12	3C200	PhaseCal	None pro...	UTC 2019 05 02...	00:20:0...	08:27:25.39	+29:18:45.3	68.000...	78.00...	6
☐ 13	3C147	FluxCal	None pro...	UTC 2019 05 02...	00:02:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6
☐ 14	3C200	PhaseCal	None pro...	UTC 2019 05 02...	00:20:0...	08:27:25.39	+29:18:45.3	68.000...	78.00...	6
☐ 15	3C147	FluxCal	None pro...	UTC 2019 05 02...	00:02:0...	05:42:36.13	+49:51:07.2	68.000...	78.00...	6

Figure 4: An example session for the calibration beam

Target	Observation Duration
Flux Cal./Check source	5 minutes
Phase Cal./Object	20 minutes
Flux Cal./Check source	2 minutes
Phase Cal./Object	20 minutes
Flux Cal./Check source	2 minutes
$\vdots$	
Phase Cal./Object	20 minutes
Flux Cal./Check source	2 minutes

Table 3: Observation duration layout for the calibration beam session (left) and source beam session (right).

under *Session Information* needs to be different from the one used previously. The Data Return Method should still be DRSU.

The source beam will alternate between the check source and your object of interest, following the same pattern as observations for the calibration beam, starting with the check source for five minutes. Make sure the start time, tunings, filter code, and number of observations for the source beam match those of the calibration beam, or there will be errors with correlating the data. A guide for the observation pattern and durations for the source beam are also in table 3. You'll want to check the elevation of the targets with Run at a Glance like for the calibration beam. If you need to make any adjustments to the start time in this beam, make sure you make the same changes in the calibration beam.

3.3 Submitting Observations

3.3.1 Duplicating Files for Multiple Days of Observation

The SessionSchedule extension for the LSL has the script shiftIDF.py. This script has multiple capabilities, but for the purpose of recreating schedules quickly for multiple

days, we'll be using a command that changes the date and the start time. To use this feature, use the following input:

```
.../ extensions/SessionSchedules/shiftIDF.py −l
        originalfilename.idf  newfilename.idf
```

You'll be prompted to enter a new UTC start date for observing and then asked to provide a session ID number for the new file. The observations in the new file will begin on the date given and the start time will be shifted to keep the same LST. This needs to be done with all files for a given date.

3.3.2 Session File Validation

To submit your session files, go to the LWA Session Definition File Validator (http://fornax.phys.unm.edu/lwa/validator/index.html). Click *Choose File* and select the calibrator or source beam file; you can click *Add Another File* to add the other beam file. Select *LWA Swarm* under Target Interferometer and click *Validate* to validate and submit the files.

After all the files have been validated for each day you want to observe, as long as there are no schedule conflicts or problems with the LWA sites, your observations will be carried out during the observation times you provided.

4 Data Reduction

Our method of data reduction in AIPS focuses on making corrections in the data from the calibration beam and then applying these corrections to the source beam. The flux calibrator is responsible for most of the calibration since its flux density usually results in better corrections. Because the signal from the phase calibrators we use isn't usually as strong as the VLSSr and NED suggest, extra steps need to be taken when calibrating. A general outline of our process for reduction is provided below.

1. Before beginning the calibration, we use SPFLG with both IF's of the calibration beam file and flag any data that may've been missed by the automatic flagger. It's important to go through the different stokes and use different smoothing times to find any bad data. After confirming the flags, we use TACOP to copy the new FG file to the source beam. It's important to also check the source beam in SPFLG for anything that doesn't look like the signal you would expect from your object. Checking the rms display in both the calibration and source beam can reveal signals that may not show up in the amplitude display. An example of this is shown in figure 5.

2. To begin calibration, we use the flux calibrator as the calibration source in the task FRING in order to account for delays. The delays are assumed to be constant throughout the run, but this may not hold true for frequencies less than 70 MHz, sources at low elevations, or rainy days.

3. Adjustments are made to the SN table by multiplying the amplitudes with the task SNCOR. The CL table is updated from the SN table by CLCAL, using

antenna 51 as the reference antenna. During this process, a new CL table is made.

4. In the task BPASS, we again use the flux calibrator as the calibration source. The bandpass is assumed to be constant during the run. After the bandpass is made, we use TACOP to copy the new CL and BP tables from the calibration file to the source beam file.

5. SPLAT is used with the new bandpass table for both the calibration beam and source beam files. The first and final few channels are excluded and the IF's are averaged in this task.

6. The flux densities for the flux and phase calibrators are set in SETJY and QUACK is used to flag the first and final minute of the observation session.

7. The first CL table is used in the task CALIB, where the flux calibrator is used as the calibration source for both amplitude and phase solutions. The flux calibrator is also used as the calibration source for all sources in CLCAL.

8. CALIB is used again, this time using CL table 2 and with the phase calibrator as the calibration source for only phase solutions. The phase calibrator is also now used as the calibration source in CLCAL, but only using SN entries from itself and only updating CL table information about itself. A new CL table is made.

9. TACOP is used on the .SPLAT files to copy the FG and CL tables from the calibration to the source .SPLAT file.

10. UVPLT is used on the .SPLAT files to plot the amplitude and phase solutions in different stokes parameters. LWPLA is used to print the plots to a PostScript file. An example of the plot of the amplitude for a calibration beam is in figure 6.

11. SPLIT is used to make a file with UV data only from the object of interest. We then use UVAVG on the resulting file to integrate the object data over different intervals.

If at the end of calibration you find a substantial signal for your object of interest, it's worth double checking the calibration and source beam in SPFLG as well as using POSSM to check the cross power spectrum of the channels.
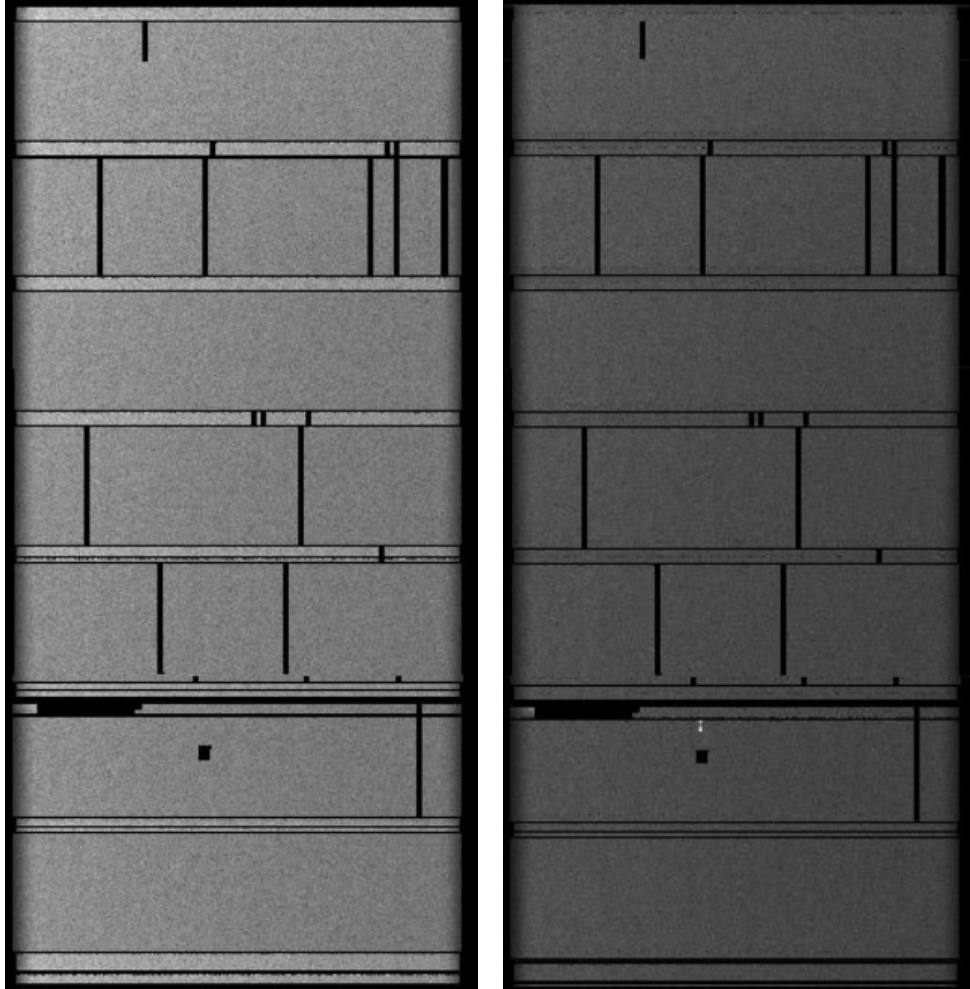
(a) The calibration beam in SPFLG displaying rms of amplitude.

(b) The source beam in SPFLG displaying rms of amplitude. There is a small amount of signal during the second 20 minute observation.

Figure 5: Both figures show the rms of the first IF of an observation in SPFLG, which was the only display mode where the signal in the source beam was visible. The object we were viewing is expected to have a broadband signal and so we were able to confidently flag the data in the source beam even though it didn't show up in the calibration beam.
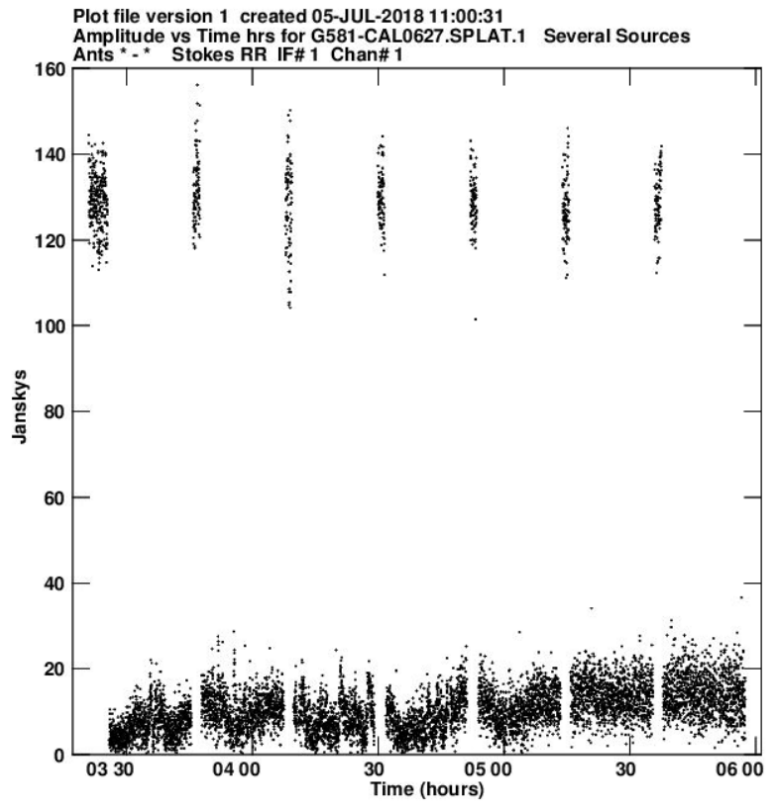
Plot file version 1 created 05-JUL-2018 11:00:31
Amplitude vs Time hrs for G581-CAL0627.SPLAT.1   Several Sources
Ants * - *   Stokes RR IF# 1 Chan# 1

Figure 6: The stokes RR amplitude plot for the flux calibrator 3C 295 (∼130 Jy) and phase calibrator 4C -05.64 (∼15 Jy). The fluctuation in the phase calibrator is most likely due to the ionosphere.

A Data Reduction Script

The following script is an example of how we reduce data. This script is for observations of the Gliese 581 system (referred to in the script as GL581) where the flux calibrator is 3C 295 (referred to as 3C295) and the phase calibrator is 4C -05.64 (referred to as 4C05). This works under the assumption that i is referring to the calibration LWSV file and j is referring to the source LWSV file.

```
**
Proc CALGL581(i,j)
* Attempt to calibrate Gliese 581 observations with LW1 LWA SV,
*
* set some stuff to be safe
  indi 3
  outdi 3
*
* clean up a little
  getn i
  inext 'bp'; inver 1; extdest
  getn j
  inext 'bp'; inver 1; extdest
*
  tget fring
  indi 3
  outdi 3
  getn i
  aparm 0 0 0 0 0 2 6
  dparm 1 5000 0 0.96 0
  calsour '3c295',''
  go fring; wait fring
*
  tget sncor
  indi 3
  outdi 3
  getn i
  opcode 'mula'; sncor 10 0
  go sncor; wait sncor
*
  task 'clcal'
  getn i
  opcode ' '; interp '2pt'; bparm 0; snver 1; inver 1;
  gainver 1; gainuse 2; refant 51
  go clcal; wait clcal
*
  tget bpass
  indi 3
  outdi 3
```

```
  getn i
  calsour '3c295','' 
  go bpass; wait bpass
*
  task 'possm'
  timer 0
  docalib 1; gainuse 2; aparm 0; aparm(8) 2;
  bif 1; eif 1; bchan 1; echan 0
  plver 0
  go possm; wait possm
  go tvpl; wait tvpl
  bif 2; eif 2;
  plver 0
  go tvpl; wait tvpl
*
  task 'tacop'
  getn i
  geto j
  inext 'bp'; inver 1; outver 1; ncount 1; go tacop
  inext 'cl'; inver 2; outver 2; ncount 1; go tacop
*
  print 'Multi-channel calibration completed'
*
  task 'splat'
  getn i
  source ''; bchan 25; echan 225; docalib 1; gainuse 2
  doband 1; bpver 1; bif 1; eif 2
  outn innam
  outcl 'splat'
  outseq 0; aparm 2 0; channel 1; ichansel 0; solint 0
  go splat; wait splat
  getn j; outn innam
  go splat; wait splat
*
  task 'setjy'
  getn (i+2)
  source '3c295','' 
  aparm 0; zerosp 125 0; optyp '' 
  go setjy; wait setjy
  source '4c05','' 
  aparm 0; zerosp 16 0; optyp '' 
  go setjy; wait setjy
*
  task 'quack'
  source '' 
  opcode 'beg'
```

```
  reason 'dunno'
  aparm 0 0.1667 0
  go quack; wait quack
  opcode 'endb'
  go quack; wait quack
*
  task 'calib'
  doband −1
  calsour '3c295'
  docalib 1; gainuse 1
  anten 0; basel 0
  smodel 125 0
  clro
  refant 51; aparm 2 0
  solmode 'a&p'; cparm 0; snver 1; solint 1
  go calib; wait calib
*
  task 'clcal'
  source ''; calsour '3C295'
  opcode ' '; interp '2pt'; bparm 0; snver 1; inver 1;
  gainver 1; gainuse 2; refant 51
  go clcal; wait clcal
*
  task 'calib'
  doband −1
  calsour '4c05'
  docalib 1; gainuse 2
  anten 0; basel 0
  solmode 'p'; cparm 0; snver 2; solint 10/60
  smodel 16 0
  go calib; wait calib
*
  task 'clcal'
  source '4c05'; calsour '4c05'
  opcode ' '; interp 'self'; bparm 0; snver 2; inver 2;
  gainver 2; gainuse 3; refant 51
  go clcal; wait clcal
  source '4c05'; calsour '4c05'
  interp 'self'
*
  task 'tacop'
  indi 3; outdi 3
  getn (i+2)
  geto (j+2)
  inext 'fg'; inver 1; outver 1; ncount 1; go tacop
  inext 'cl'; inver 2; outver 2; ncount 2; go tacop
```

```
*
  print 'Calibration completed successfully'
*
  task 'uvplt'
  getn (i+2)
  source ''
  stokes 'rr'
  timer 0
  xinc 1; bparm 11 1 0; bchan 1; echan 0; gainuse 3
  go uvplt; wait uvplt;
  plver 0; go tvpl; wait tvpl
  dparm 0; outfil 'home:'!!innam!!'.ps'
  go lwpla; wait lwpla
  xinc 1; bparm 11 2 0;
  go uvplt; wait uvplt;
  plver 0; go tvpl; wait tvpl
  dparm 0; outfil 'home:'!!innam!!'.ps'
  go lwpla; wait lwpla
*
  getn (j+2)
  source ''
  stokes 'rr'; doband −1
  timer 0
  xinc 1; bparm 11 1 0;
  go uvplt; wait uvplt;
  go lwpla; wait lwpla
  plver 0; go tvpl; wait tvpl
  xinc 1; bparm 11 2 0;
  go uvplt; wait uvplt;
  go lwpla; wait lwpla
  plver 0; go tvpl; wait tvpl
  source 'gl581',''
  bparm 11 1 0; stokes 'i'
  go uvplt; wait uvplt;
  go lwpla; wait lwpla
*
  task 'split'
  outcl 'split'
  source 'gl581',''
  docalib 1; gainuse 3; outseq 0; stokes ''
  go split; wait split
*
  getn (j+3)
  task 'uvavg'
  yinc 10; bif 1; eif 0
  docalib −1
```

```
   outn innam; outcl 'uva10'
   go uvavg; wait uvavg
   yinc 100; outcl 'uv100'
   go uvavg; wait uvavg
*
   getn (j+4)
   task 'uvplt'
   source 'gl581',''
   stokes 'i'; bif 1; eif 1; aparm 0
   bparm 11 1 0
   go uvplt; wait uvplt
   plver 0
   go tvpl; wait tvpl
   go lwpla; wait lwpla
*
   stokes 'v'
   go uvplt; wait uvplt
   plver 0
   go tvpl; wait tvpl
   go lwpla; wait lwpla
*
   getn (j+5)
   task 'uvplt'
   source 'gl581',''
   stokes 'i'; bif 1; eif 1; aparm 0
   bparm 11 1 0
   go uvplt; wait uvplt
   plver 0
   go tvpl; wait tvpl
   go lwpla; wait lwpla
*
   stokes 'v'
   go uvplt; wait uvplt
   plver 0
   go tvpl; wait tvpl
   go lwpla; wait lwpla
*
Finish
```