# BR1202 Band 7 SV data: Calibration

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## 1 Summary of data-set

These data consist of a single measurement set (MS): uid___A002_X36ffba_X3ef.ms. The data were taken on January 14, 2012, with a total integration time of 1.2 hrs. There are regular $T_{\rm sys}$ measurements, and WVR measurements for every scan. Observations of BR1202 are properly flanked by phase calibration observations of 3c279. See Table 1 for a summary of the fields in this MS.

Table 1: Summary of Fields in MS

| Field ID | Field Name | Intent |
|---|---|---|
| 0 | 3c279 | Bandpass and phase calibrator |
| 1 | Titan | Amplitude calibrator |
| 2 | BR1202-0725 | Science target |

These data were taken in TDM mode with 128 channels. See Table 2 for a summary of the spectral setup. There were a total of 14 antennas for these observations.

Table 2: Spectral Setup

| SpwID | #Chans | Frame | Ch1(MHz) | ChanWid(kHz) | TotBW(kHz) | Corrs |
|---|---|---|---|---|---|---|
| 0 | 4 | TOPO | 184550 | 1500000 | 7500000 | I |
| 1 | 128 | TOPO | 334960.263 | 15625 | 2000000 | XX YY |
| 2 | 1 | TOPO | 333952.45 | 1796875 | 1796875 | XX YY |
| 3 | 128 | TOPO | 336892.187 | 15625 | 2000000 | XX YY |
| 4 | 1 | TOPO | 335884.375 | 1796875 | 1796875 | XX YY |
| 5 | 128 | TOPO | 345017.888 | 15625 | 2000000 | XX YY |
| 6 | 1 | TOPO | 345994.45 | 1796875 | 1796875 | XX YY |
| 7 | 128 | TOPO | 346907.813 | 15625 | 2000000 | XX YY |
| 8 | 1 | TOPO | 347884.375 | 1796875 | 1796875 | XX YY |

# 2 Calibration Steps

There is a python script that accompanies this document: BR1202_SV_Band7_Calibration_script.py. This can be run in CASA by:
**execfile('BR1202_SV_Band7_Calibration_script.py')**

The exact CASA commands used can be found in the python script. The steps are summarized here, along with critical notes about these data.

1. Run **listobs** to get information on the data (summarized in Section 1).

2. Run **plotants** to plot up antenna positions. From this, I choose DV06 as my reference antenna (used later). See Figure 1 below for antenna positions.

3. Use **flagdata** to carry out *a priori* flagging on data we don't need. Including:

   - Shadowed data
   - Autocorrelation data
   - Pointing, sideband ratio, and atmosperic data

   Use **flagmanager** to save this version of flagging as "Apriori".

4. Apply $T_{\rm sys}$, WVR, and antenna positions tables using **applycal**. NOTE: For reasons I don't understand, I could not set the *gainfield* option. This should not have a significant effect on the data. Used **plotms** to inspect "data" versus "corrected" columns after applycal. Find that scatter in amplitudes and phases decreases, so that's good. Used **split** to split out corrected column for spw's 1, 3, 5, and 7, which is saved as uid___A002_X36ffba_X3ef.wvrtsys.ms.

5. Carefully inspect all data and makes notes on things to flag.

   - Use **plotms** to inspect amplitude and phase versus time and frequency for all baselines to the reference antenna for the two calibrators. The major problems are listed in Table 3. Use **flagdata** to flag these problematic data.
   - After initial flagging use **plotms** to inspect amplitude and phase versus time and frequency for all baselines for the calibrators, to look for any remaining problems. See several baselines to DV16 and DV01 with low amplitudes (see Table 3). Decided to flag them, this removes only 8% of the total data.
   - Use **plotms** to look at amplitude versus time for all data, for each spectral window, at once, color-coded by field. Looks like the major problems have all been removed.
   - Use **plotms** to look at amplitude versus UV distance for both calibrators. Titan shows strong variation with UV dist. Is this due to contamination from Saturn or because Titan is somewhat resolved in Band 7? From visibility model of Titan on 15-Oct-2011, at 345 GHz, ES compact configuration, amplitude drops to 0.8×max

from 20 to 120 k$\lambda$. For these data, it drops to 0.7×max. So could be contamination from Saturn, or just change in visibility model of Titan since October. Check on this later. See Figure 2.

- Use flagmanager to save the state of the flags at this point. Save as "preCal".

Table 3: Information on Potentially Problematic Data

| Field | spw | corr | Antenna/baseline | Problem | Flagged? |
|---|---|---|---|---|---|
| *Amplitude versus time:* | | | | | |
| all | 0,1 | XX | DV42 | slighly low amp | yes |
| all | 0,1 | XX | DV05 | very low amp | yes |
| 3c279 | all | both | DV07, DV16 | dropout at 12:54:47 to 12:55:00 | yes |
| 3c279 | all | both | DV05, DV12 | dropout at 12:37:09 to 12:37:22 | yes |
| all | all | both | DV16& DA43, DV01, DV03, DV04, DV05, DV06, DV10, DV12, PM02 | low amplitude | yes |
| all | all | both | DV01& DV05, DV06, DV07, DV10, DV13, DV14 | low amplitude | yes |
| *Phase versus time:* | | | | | |
| 3c279 | all | both | DV01, DV13, DV14, DV03, DV05, DV10, DA43 | Smooth, but slow increase or decrease w/ time | no[a] |
| *Amplitude versus frequency:* | | | | | |
| all | all | both | all | Edge channels: 0-7, 121-127 | yes |
| Titan | 2 | both | all | Whole spw affected by Titan emission line | no[b] |

*Notes:* [a] Probably can solve for this in calibration. [b] Will need to use other spw's for amplitude calibration in spw=2.

6. Bandpass calibration: 3c279

   - Solve for temporal variations in phase on short timescales using **gaincal**. Ouput table: uid___A002_X36ffba_X3ef.bpphase.gcal
   - Solve for frequency variations in amplitude and phase on longer timescales using **bandpass**. Apply gaintable from previous step on-the-fly. Output table: uid___A002_X36ffba_X3ef.bandpass.bcal

- Use **plotcal** to look at solutions from previous two steps. *Weird:* Why do DV05, DV16 and DA42 get no solutions for spw 0 and 1? Should still have YY correlation data? Keep getting this message printed to the terminal: "Missing file is /export/lustre/kscott/BR1202_SV_Band7_UnCalibratedData/tab7263_2" Check on this later. Phase versus time for short interval solutions look good. Amplitude versus frequency for long interval bandpass solutions look smooth and flat. Phase versus frequency look good for the most part with gain phases ($\lesssim 10^o$ typically). A few exceptions to this are seen for spw=2, which shows larger gain phases of 20-40$^o$ for DV14, DV16, DV01, DV03, DV05, and DV07. *Why?* See Figures 3 and 4 for solutions.

7. Gain calibration: Titan (absolute flux) and 3c279 (gain and phase)

   - Use **setjy** to set the flux density of Titan. Note: leave out spw=2, will have to transfer fluxes later from other channels. Derive flux densities of 2.3, 2.3, and 2.5 Jy for spw 0, 1, and 3, respectively.
   - Solve for phase variation on short timescales using 3c279 and Titan using **gaincal** with solint='int'. Apply bandpass calibration table on-the-fly. Table is called uid___A002_X36ffba_X3ef.wvrtsys.intphase.gcal.
   - Solve for phase variation on long timescales using 3c279 and Titan using **gaincal** with solint='inf'. Apply bandpass calibration table on-the-fly. Table is called uid___A002_X36ffba_X3ef.wvrtsys.scanphase.gcal
   - Solve for amplitude variation on long timescales using 3c279 and Titan using **gaincal** with soling='inf'. Apply bandpass calibration and short-timescale phase solution on-the-fly. Table is called uid___A002_X36ffba_X3ef.wvrtsys.amp.gcal
   - Use **fluxscale** to set the flux of 3c279 with reference to Titan. Note that since spw=2 is swamped by an emission line in Titan, we use spw=1 as the reference for that spw. Find flux densities of 14.2, 14.1, 12.9, 13.1 Jy for spw 0, 1, 2, and 3, respectively. Table is called uid___A002_X36ffba_X3ef.wvrtsys.flux.gcal. Compared to flux measurement on December 9, 2011 with the SMA: flux density of 13.5$\pm$1 Jy at 340.8 GHz. This is consistent with our measurements.
   - Use **plotcal** to plot gain solutions and inspect. Amplitudes and phases look smooth with time. See Figures 5 and 6 for solutions.

8. Apply bandpass and gain calibration tables using **applycal**. Inspect the "corrected" data column to check that amplitude and phase versus time and frequency are all smooth. They are! See Figures 7 to 12 for plots of amplitude and phase versus time and frequency after calibration.

9. Split out data for BR1202 using **split**, keeping all spw's. Written to uid___A002_X36ffba_X3ef.cal.ms.

10. Make directory BR1202_SV_Band7_CalibratedData, and copy calibrated MS here. Make it into a tarball for distribution.

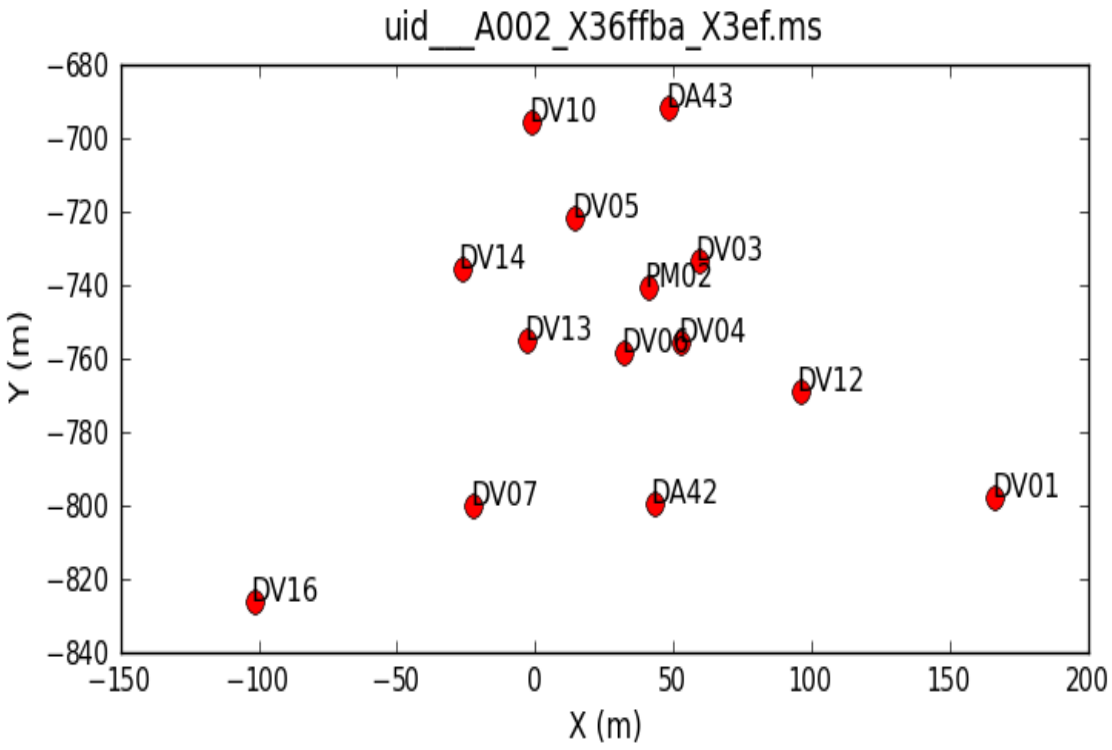


Figure 1: Antenna positions.

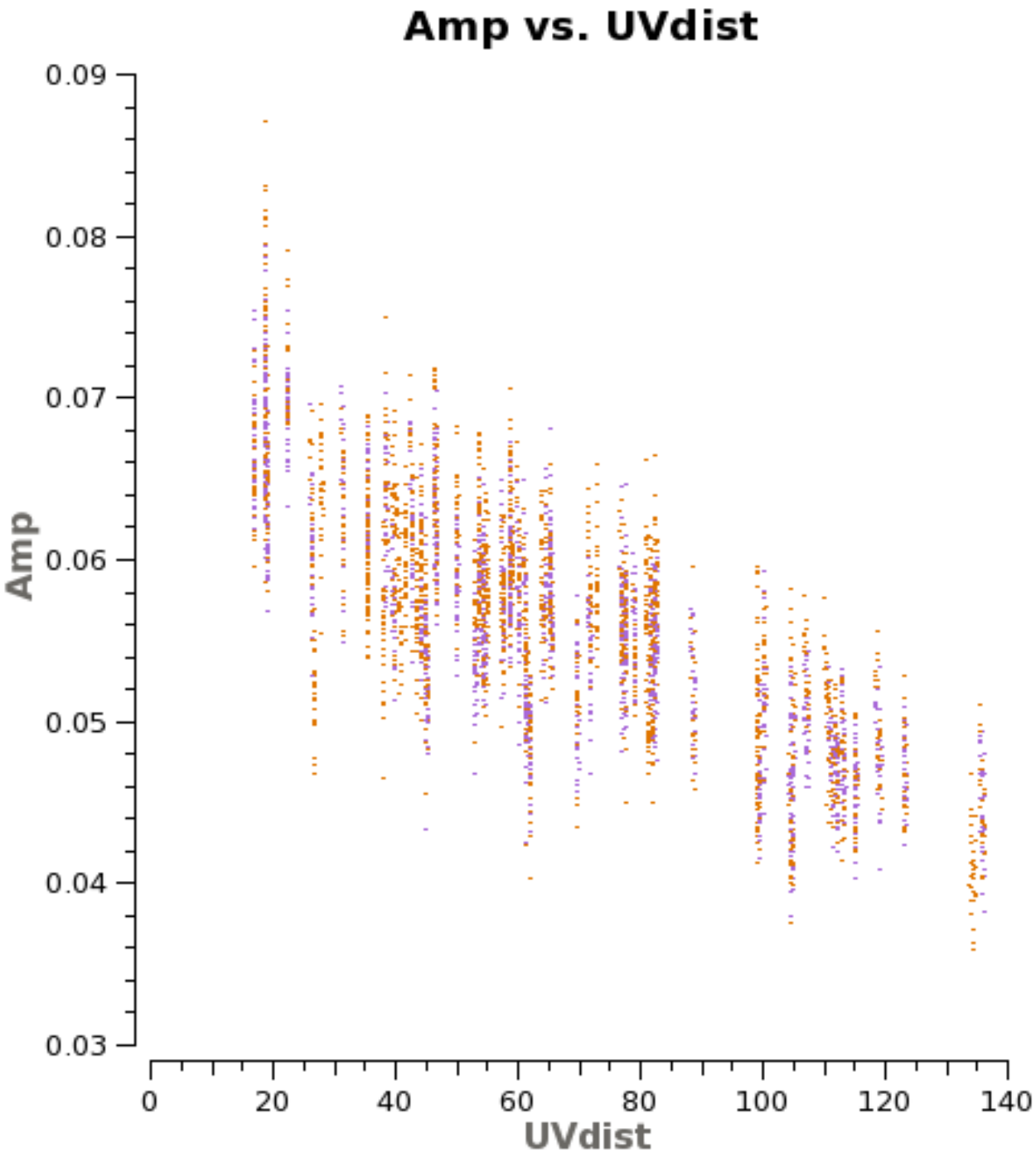


Figure 2: Amplitude versus UV distance for Titan (spw=0).

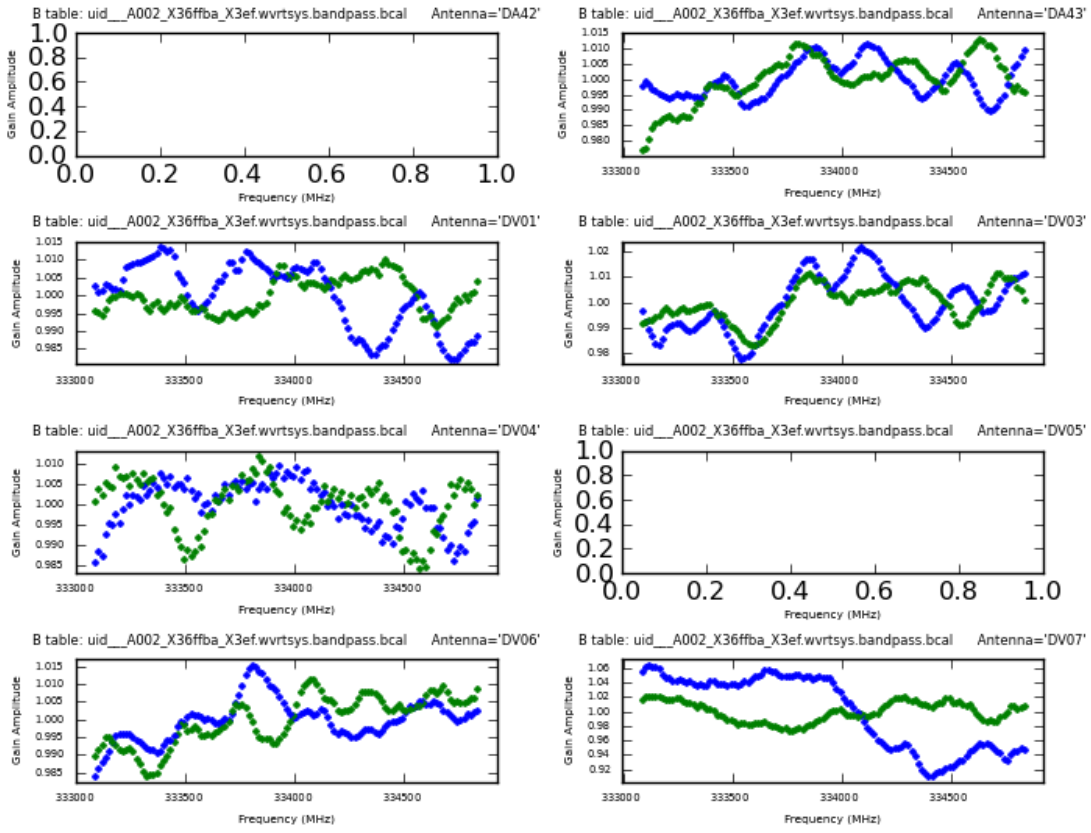


Figure 3: Bandpass solutions for first eight antennas, spw=0 (amplitude).

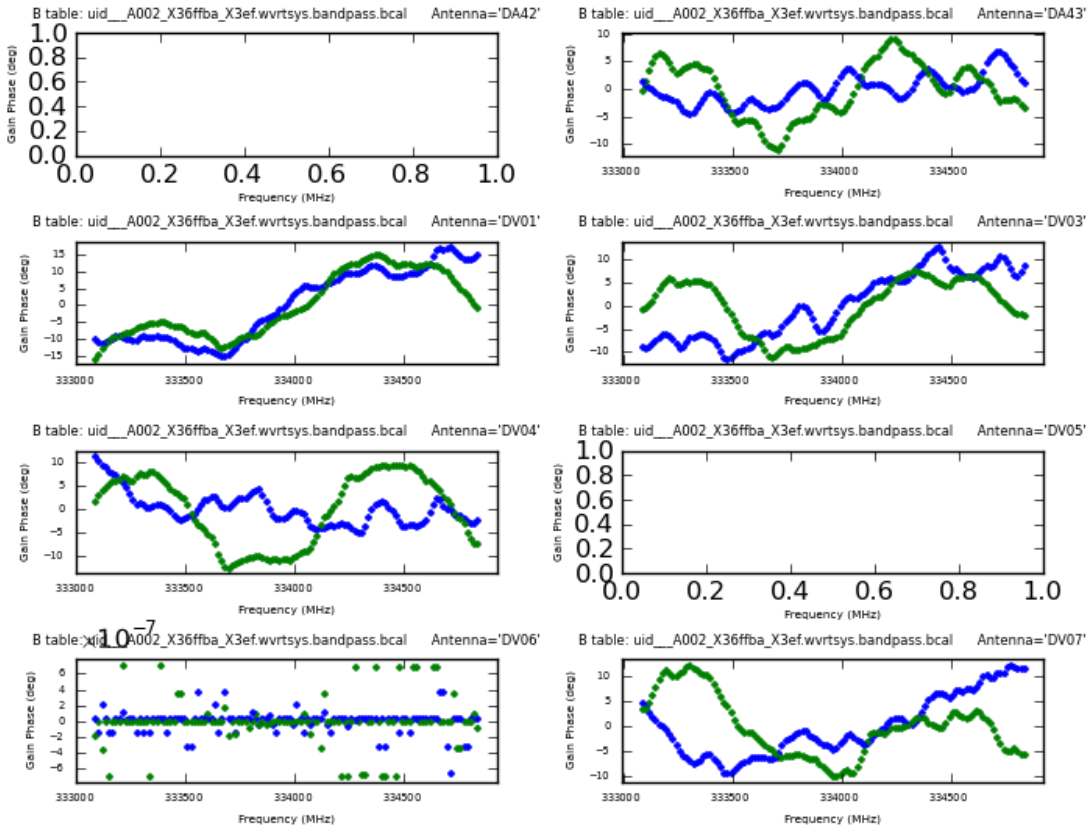


Figure 4: Bandpass solutions for first eight antennas, spw=0 (phase).

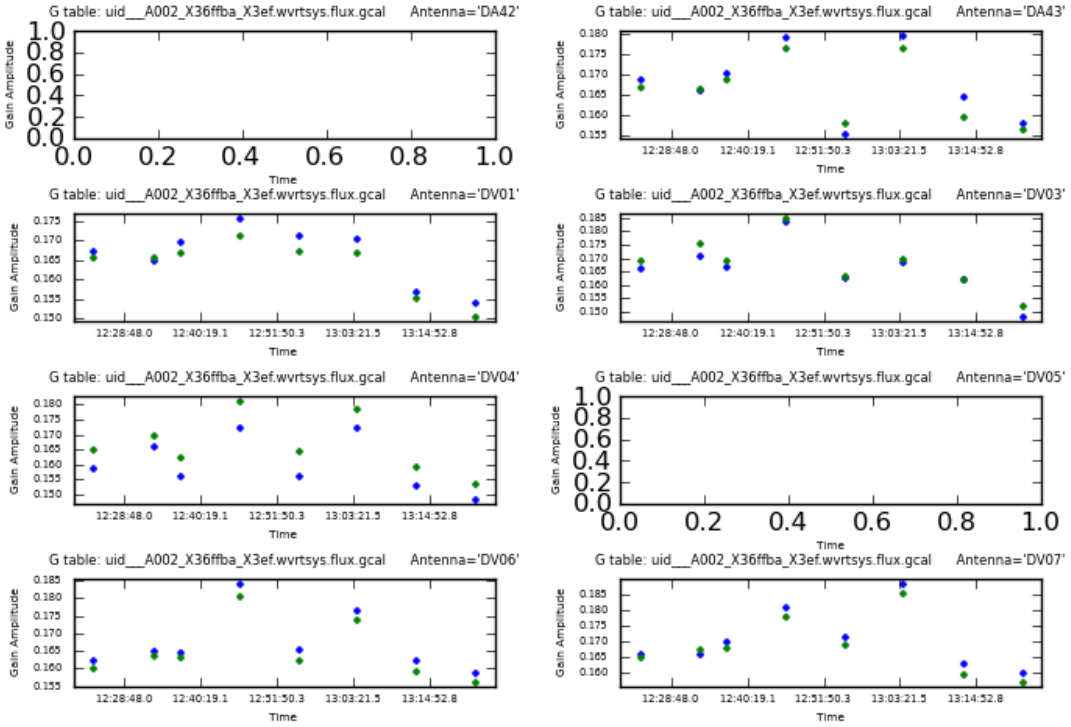


Figure 5: Gain solutions for first eight entennas, spw=0 (amplitude).

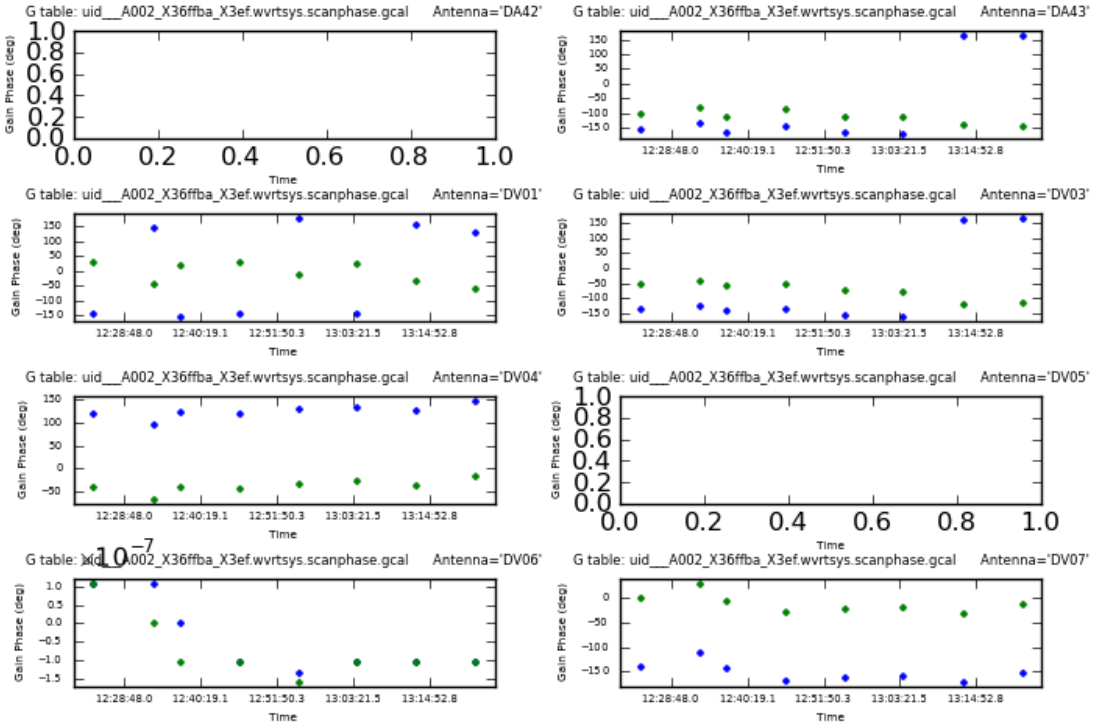


Figure 6: Gain solutions for first eight antennas, spw=0 (phase).

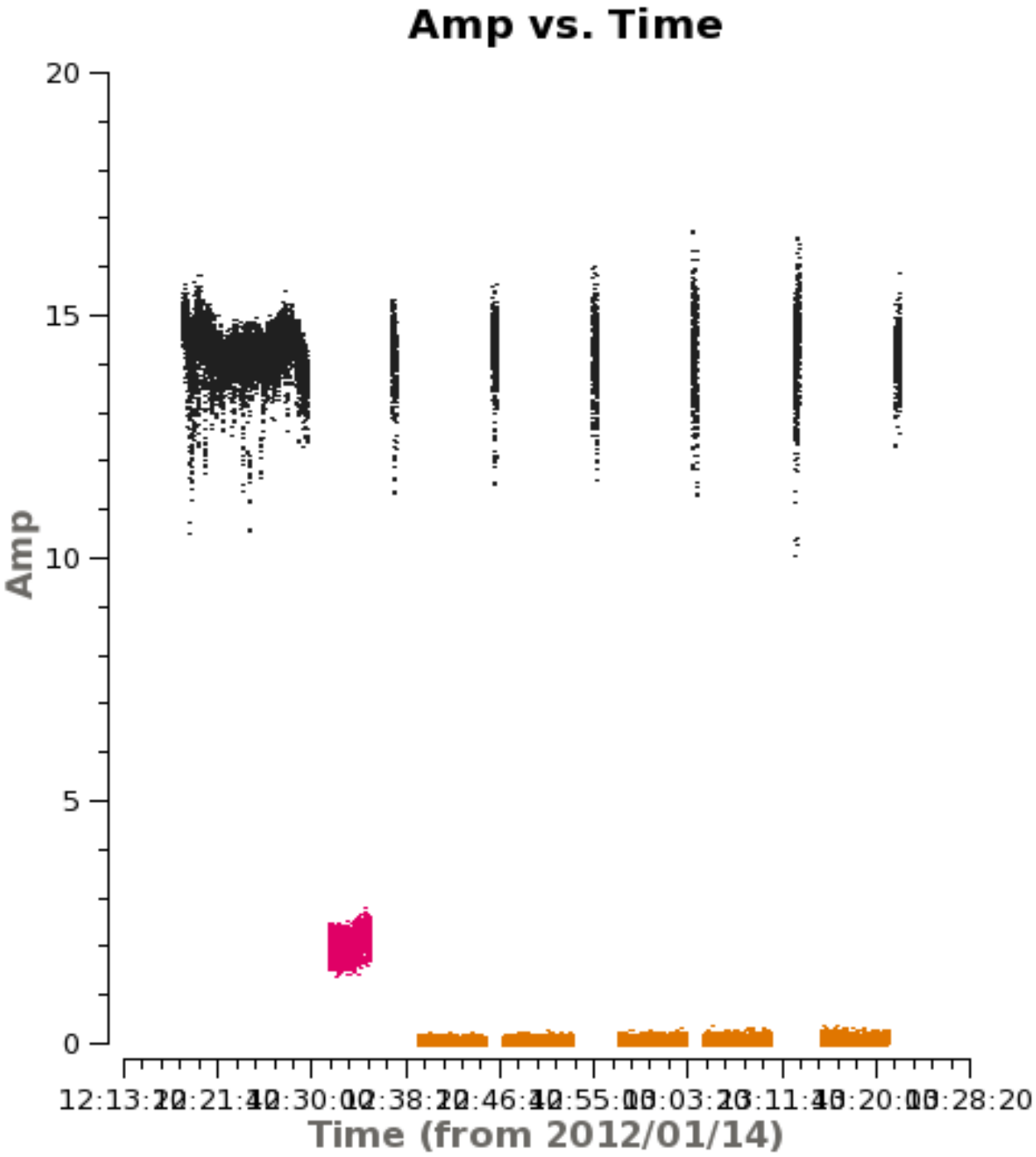


Figure 7: Amplitude versus time for all fields, after calibration (spw=0).

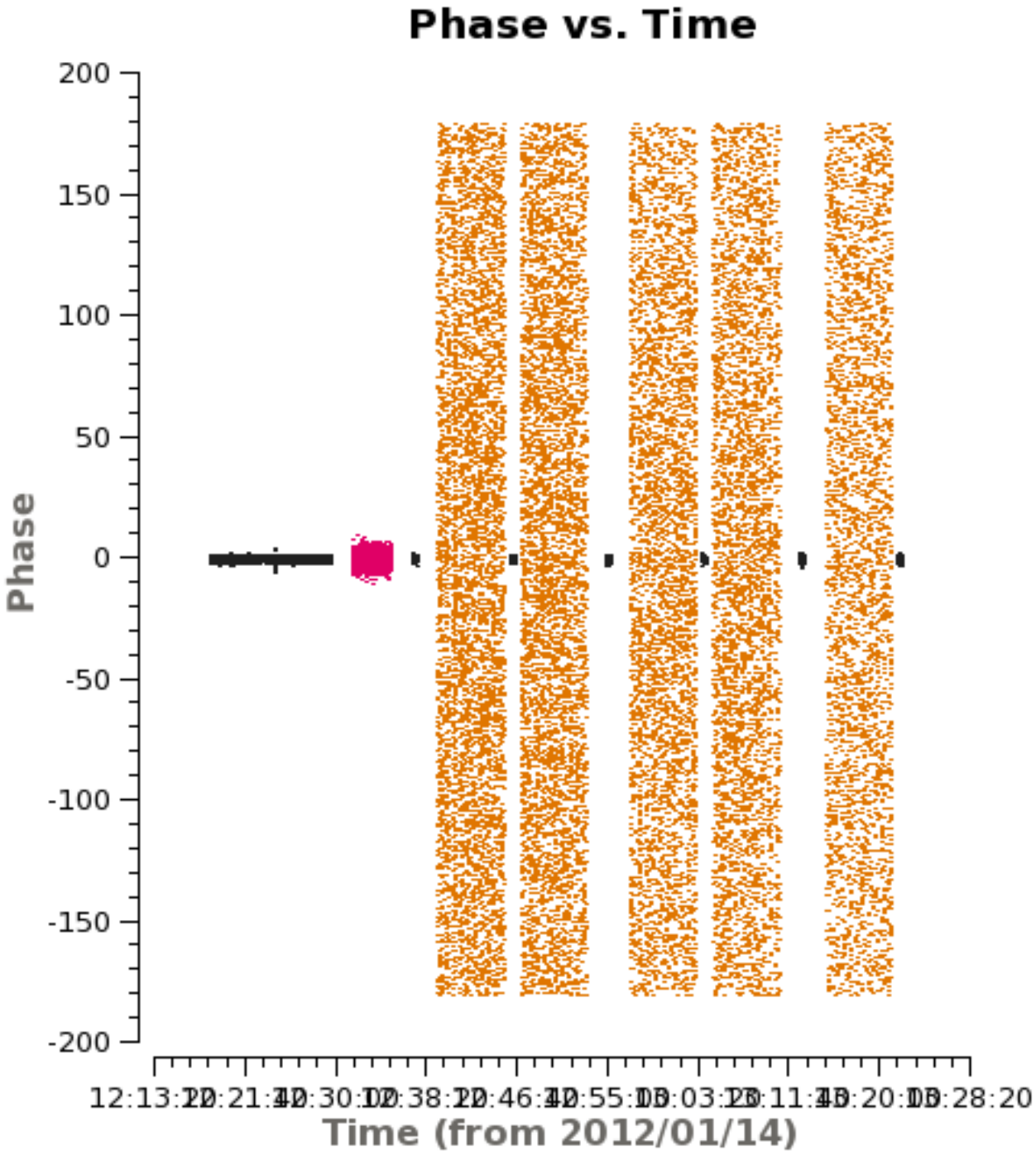


Figure 8: Phase versus time for all fields, after calibration (spw=0).

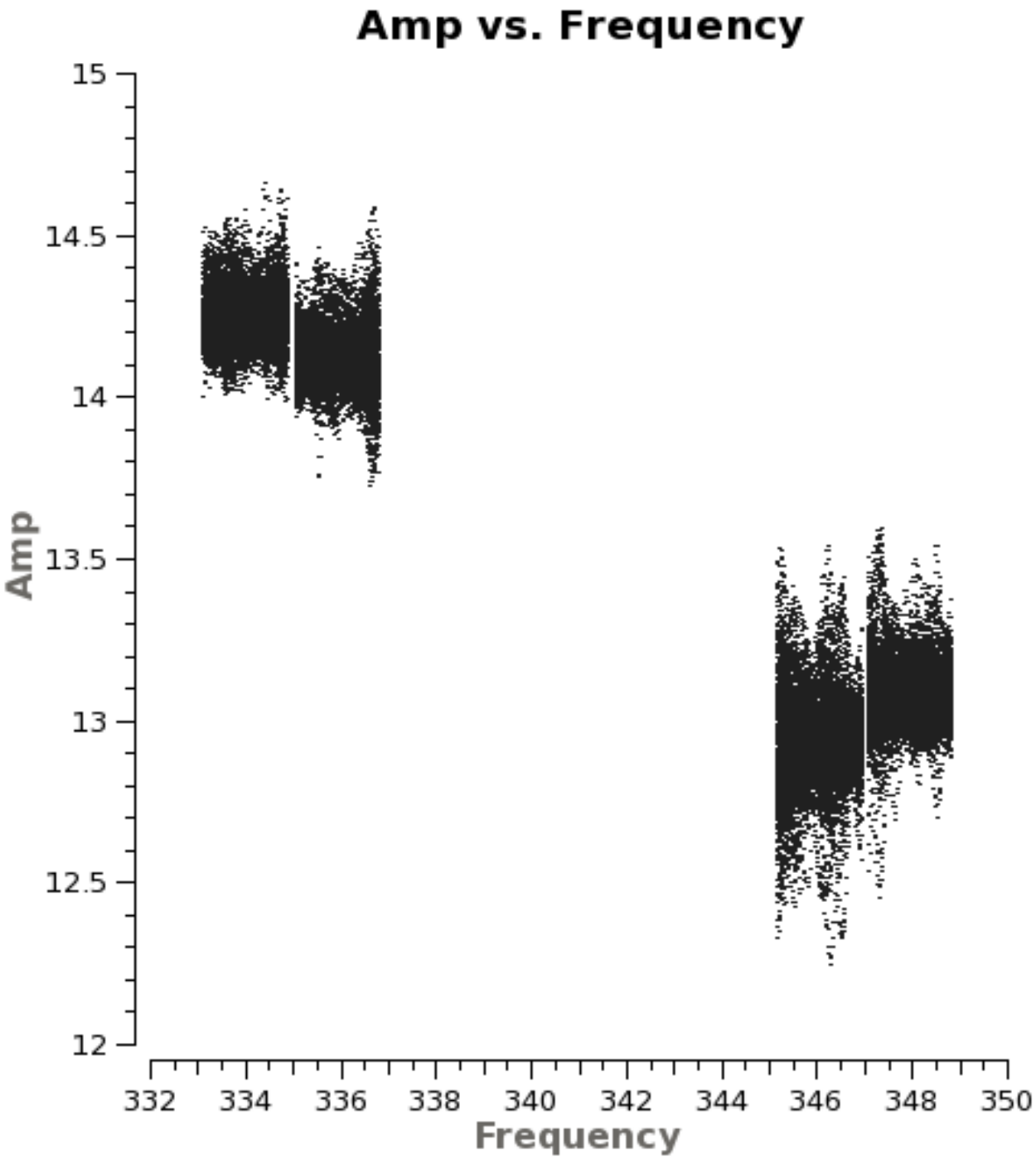


Figure 9: Amplitude versus frequency for 3c279, after calibration.

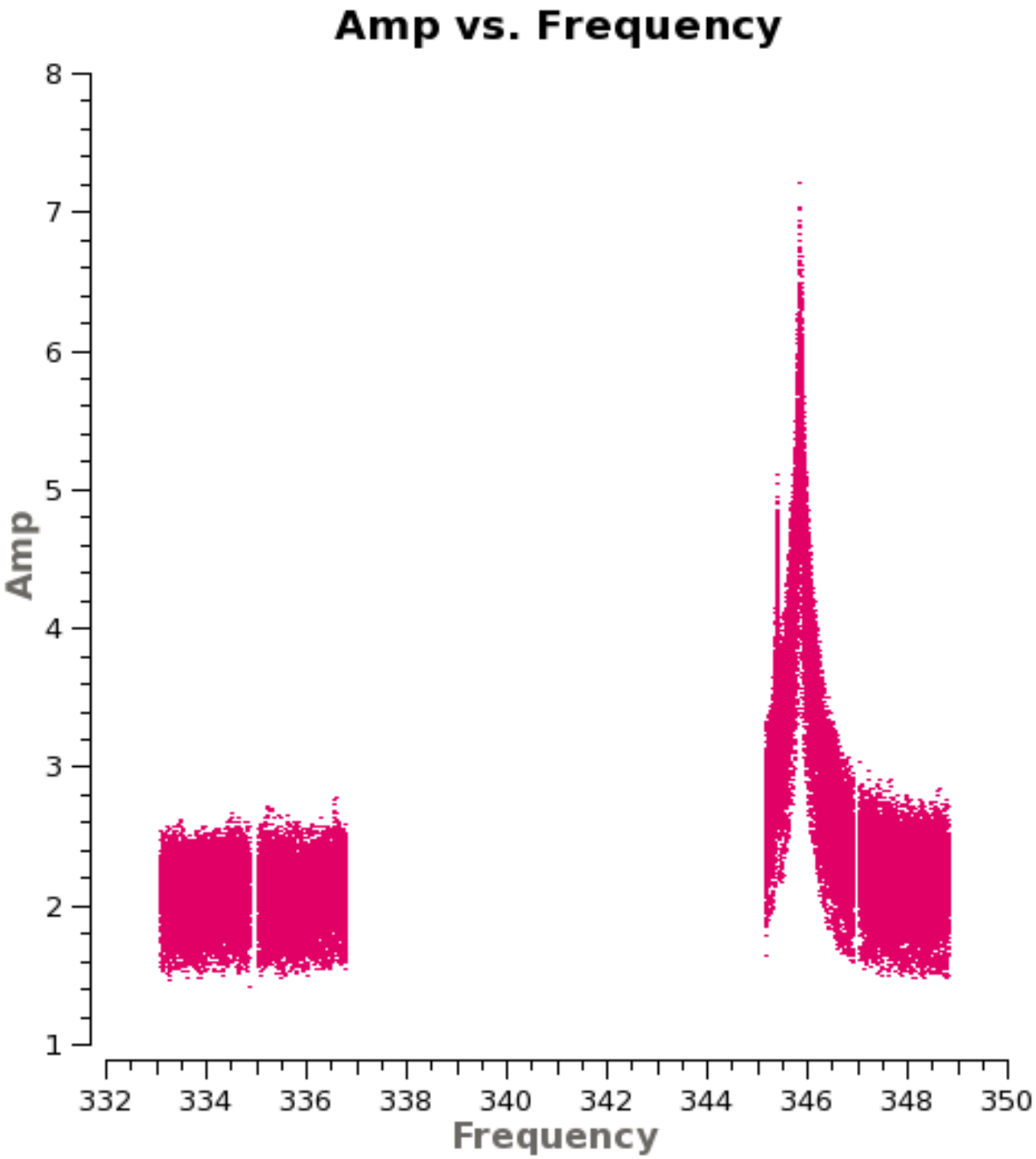


Figure 10: Amplitude versus frequency for Titan, after calibration.

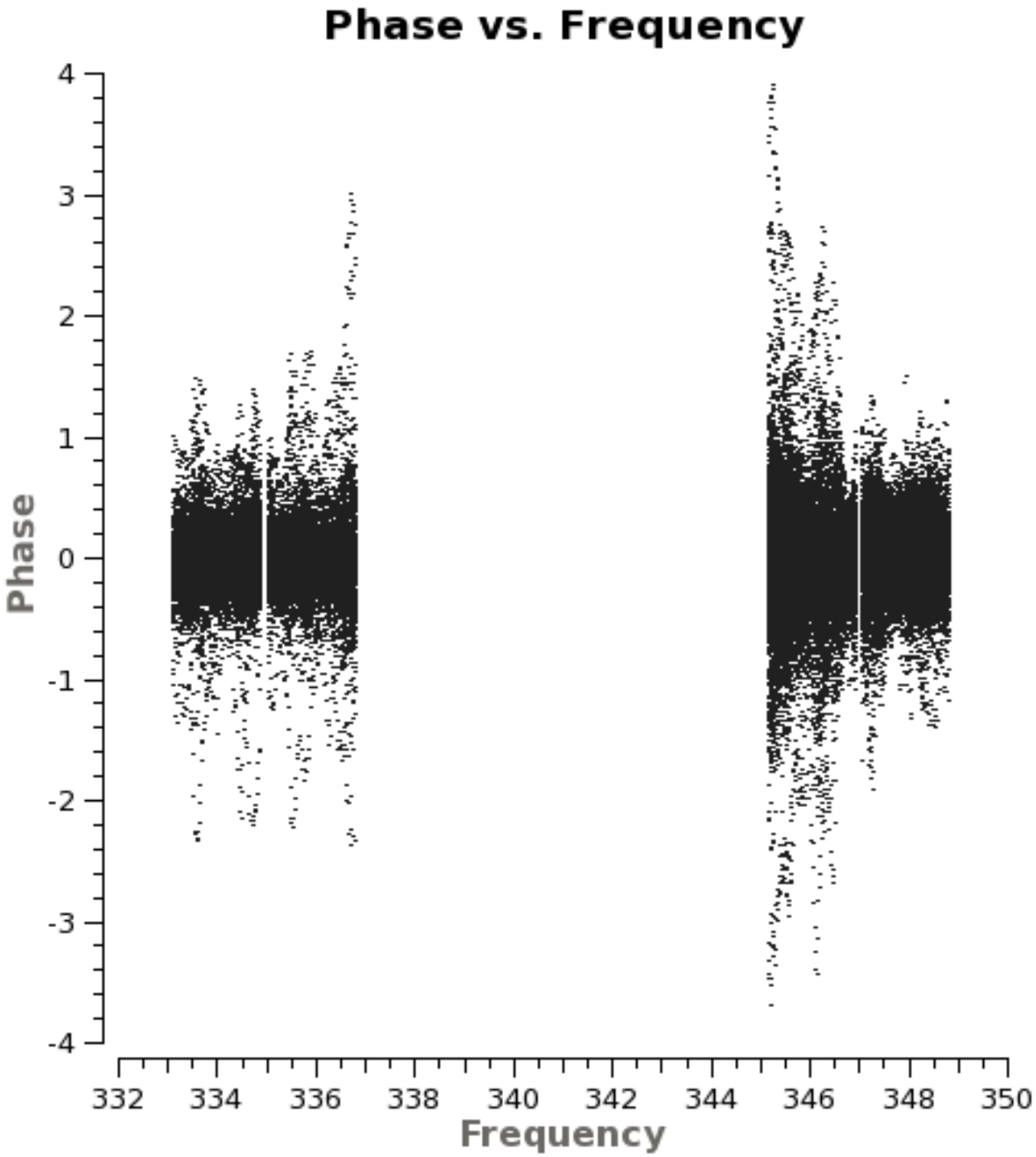


Figure 11: Phase versus frequency for 3c279, after calibration.

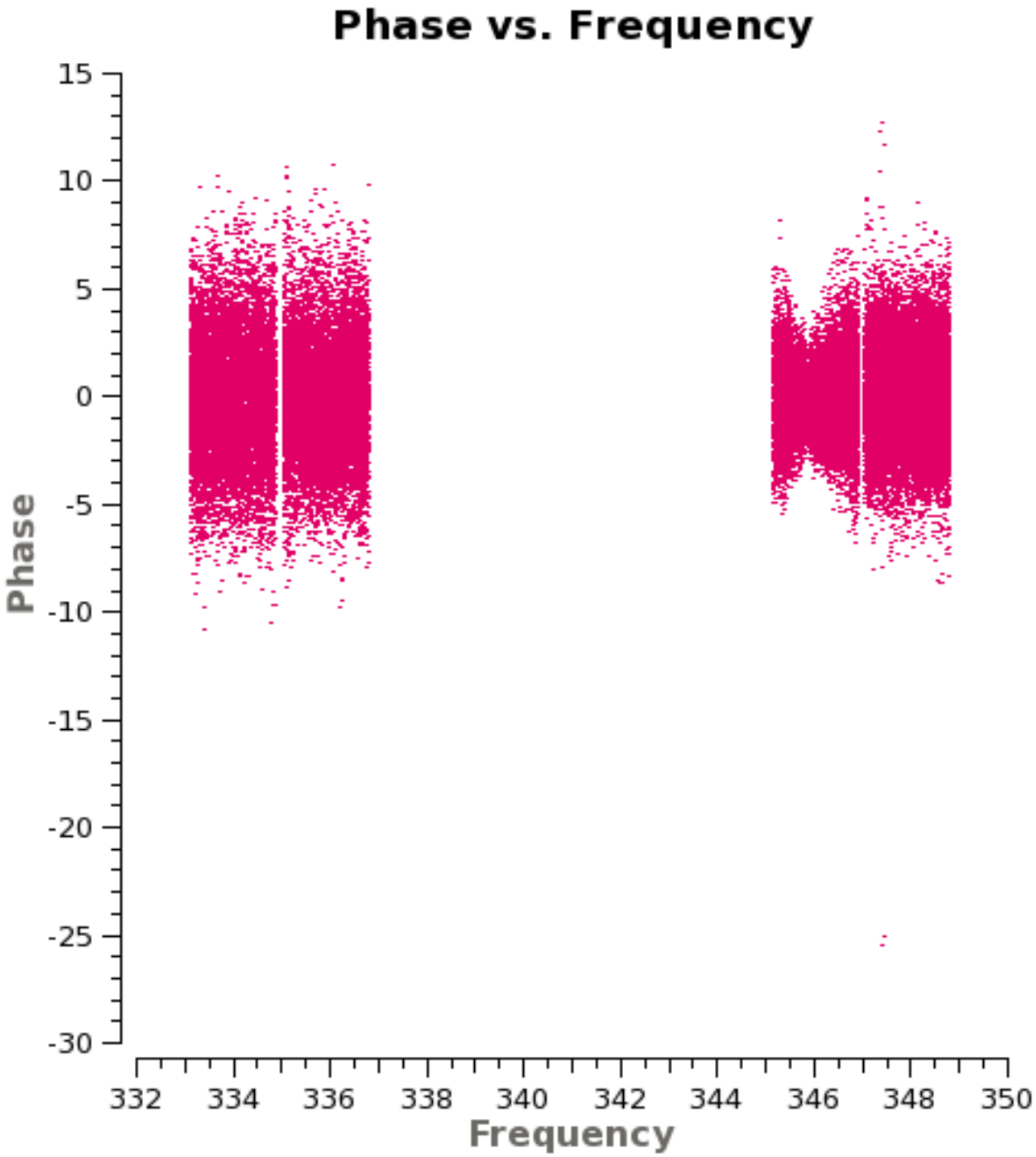


Figure 12: Phase versus frequency for Titan, after calibration.