RSRO Report

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1. Test Observation

1.1. Slew in Different Azimuthal Direction

Symptom: Occasionally a few, and sometimes all, antennas slew in azimuth seemingly away from the targeted position.

Cause: Did not specify antenna wrap in OPT, and antennas were in a different wrap from OPT assumed.

Solution: Specify antenna wrap in OPT. However, my SBs can be executed in two different LST ranges with different wrap. It is not clear how to prepare SBs in this situation.

Figure 1 shows a part of the observational procedure of my second test observation (SB ID: 10738365). My observation started at UTC 9 (LST = 5 h) on Nov 6. The report from OPT was made at the same LST. After a few cycles, switching between my secondary calibrator and two targets, the antennas slewed to another nearby calibrator, $\sim 5^\circ$ away from my secondary calibrator. The OPT shows a slew time of ~ 20 s. However, in the observation the antennas slewed in a different azimuthal direction for $\sim 40^\circ$ (Figure 2), so there is no on-source time. The reason is that I did not specify the wrapping direction, and that the source was at Az $\sim 90^\circ$, where the antennas have to decide to slew in which direction. In the observation, the antennas are in a different wrap from that OPT assumed, so the OPT did not show warning about the antenna wrap. Such issue did not occur in my first test observation, which started at a different LST (= 23 h). The other problem is that my observation can be executed in two different LST ranges, before and after transit. The preferred wrap directions for the two LST ranges are different. Since observations are dynamically scheduled, I do not know the starting LST of my observation and hence the wrap direction. Currently Joan suggests I submit two scheduling blocks of two different LST ranges, and they will choose one to execute.

18	J0336+3218	J0336+3218	38.976GHz / 36.928GHz	05:26:05	00:00:12	CalBP, CalGain, Apply Ref. Ptg.	1.83	273.3d	67.1d	78.1d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:26:40	00:00:23		1.84	273.3d	67.0d	78.0d
19	L1448 IRS2E	L1448 IRS2E	38.976GHz / 36.928GHz	05:26:40	00:00:15	Apply Ref. Ptg.	2.02	271.0d	64.3d	74.5d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:28:05	00:01:10		2.04	271.2d	64.0d	74.5d
20	J0336+3218	J0336+3218	38.976GHz / 36.928GHz	05:28:05	00:00:15	CalBP, CalGain, Apply Ref. Ptg.	1.86	273.5d	66.7d	78.0d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:28:40	00:00:20		1.87	273.6d	66.5d	78.0d
21	Per-Bolo 58	Per-Bolo 58	38.976GHz / 36.928GHz	05:28:40	00:00:12	Apply Ref. Ptg.	1.99	272.4d	64.9d	76.0d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:30:05	00:01:13		2.01	272.6d	64.6d	76.0d
22	J0336+3218	J0336+3218	38.976GHz / 36.928GHz	05:30:05	00:00:12	CalBP, CalGain, Apply Ref. Ptg.	1.89	273.7d	66.2d	77.9d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:30:40	00:00:23		1.90	273.8d	66.1d	77.9d
23	L1448 IRS2E	L1448 IRS2E	38.976GHz / 36.928GHz	05:30:40	00:00:15	Apply Ref. Ptg.	2.09	271.5d	63.5d	74.5d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:32:05	00:01:10		2.11	271.7d	63.2d	74.4d
24	J0336+3218	J0336+3218	38.976GHz / 36.928GHz	05:32:05	00:00:15	CalBP, CalGain, Apply Ref. Ptg.	1.93	273.9d	65.8d	77.9d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:32:40	00:00:20		1.94	274.0d	65.7d	77.9d
	END LOOP	Target Loop								
⊟	LOOP	Test Cal								
25	J0329+2756	J0329+2756	38.976GHz / 36.928GHz	05:32:40	00:00:20	CalGain, Apply Ref. Ptg.	2.05	265.2d	63.1d	69.1d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:33:35	00:00:35		2.06	265.4d	62.9d	69.1d
26	J0336+3218	J0336+3218	38.976GHz / 36.928GHz	05:33:35	00:00:20	CalBP, CalGain, Apply Ref. Ptg.	1.95	274.1d	65.5d	77.8d
		(1) Ka band 8 GHz	34.88GHz / 32.832GHz	05:34:20	00:00:25		1.96	274.2d	65.4d	77.8d
	END LOOP	Test Cal								

Fig. 1.— A part of the observational procedure of my second test observation.

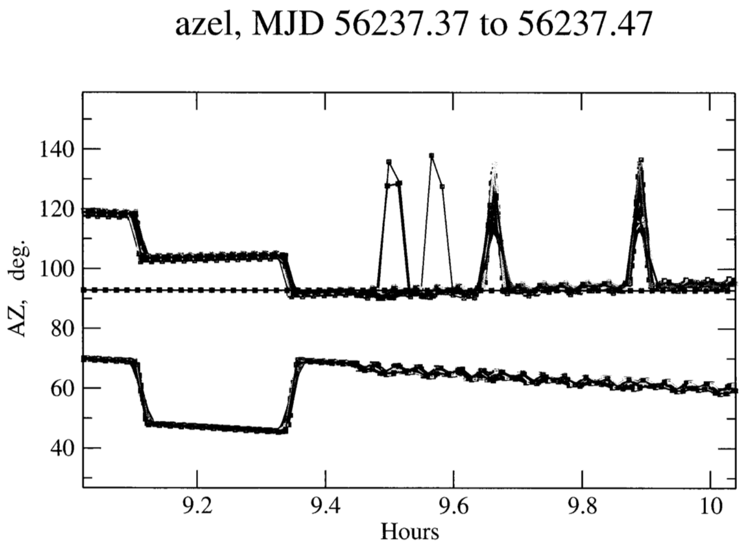

Fig. 2.— Antenna pointing, azimuthal direction (upper lines) and elevation (lower lines), during the test observation.

1.2. Phase Offset Between Two Calibrators

Symptom: Use one phase calibrator to calibrate the other. There is remaining phase offset.

Cause: Likely due to tropospheric phase variation.

Figure 3 shows the data of my first test observation (SB ID: 10716670), phase as a function of time (left column) and frequency (right column). The observation was done in Ka band. The API shows rms phase is 1.1° – 1.4°. In addition to the secondary calibrator, I observe one more nearby calibrator as a test calibrator, 3° away from the secondary calibrator. I used the secondary calibrator to calibrate the test calibrator. Figure 2 shows the calibrated results. There is clear phase offset between the two calibrators, and in some baselines the offset is $\sim 40°$. RCP and LCP show the same behavior. There is no clear slope in phase as a function of frequency, so the phase offset is unlikely due to delay error. In addition, there is no systemic change in the phase offset with the baseline lengths. If I do self-cal on the test calibrator, the offset is removed. The most recent baseline correction was made on 3 Oct, and this observation was conduct on 19 Oct. There is no update of baseline correction. In Claire's test data, which observed a test calibrator for a longer period, the phase of a test calibrator gradually changes between ± 50° as a function of time. Therefore, the phase offset is likely due to tropospheric phase variation.

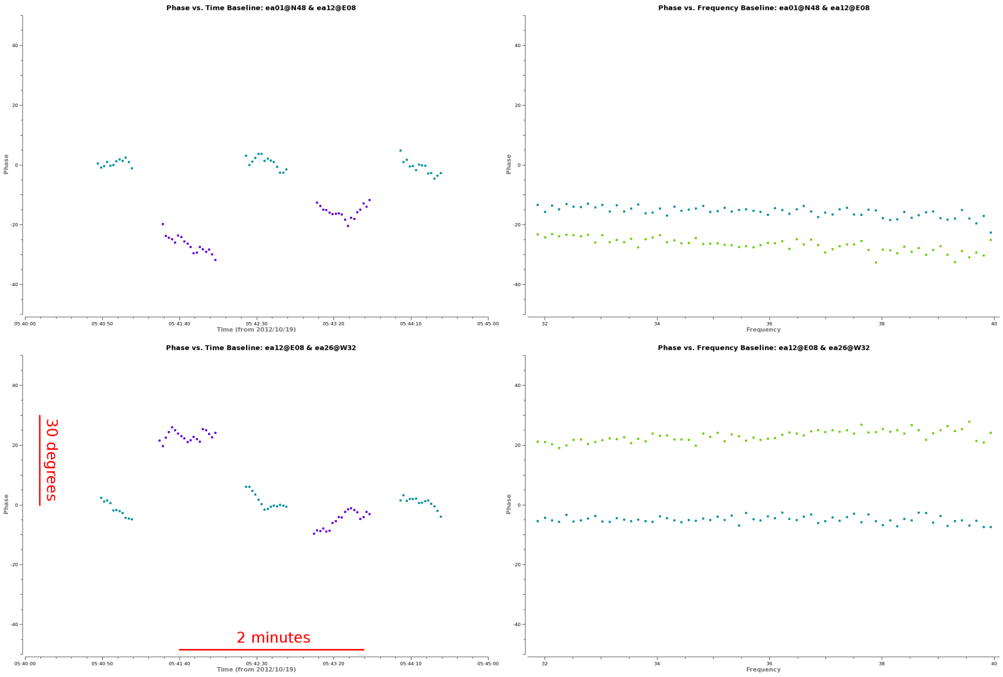

Fig. 3.— Left column: Phase of the secondary calibrator (blue) and the test calibrator (Purple) as a function of time, which is averaged over the 8 GHz bandwidth. Right column: Phase of the test calibrator as a function of frequency, which is averaged over one spectral window, and data points of two difference colors represents the data of two difference scans.

1.3. Different Trend of Phase Variation

Symptom: One sampler (B2D2) of the antenna 2 show different trend of phase variation from other three samplers of the antenna 2.

Cause: Could be malfunctioning.

Figure 4 shows the phase solution of the antenna 2 of my two test observations. One sampler (B2D2; red data points in Figure 4) in the antenna 2 shows different behavior of phase from other three samplers, indicating that this sampler is malfunctioning, but this sampler does not show amplitude lower than other samplers. No such problem was found in any other antenna

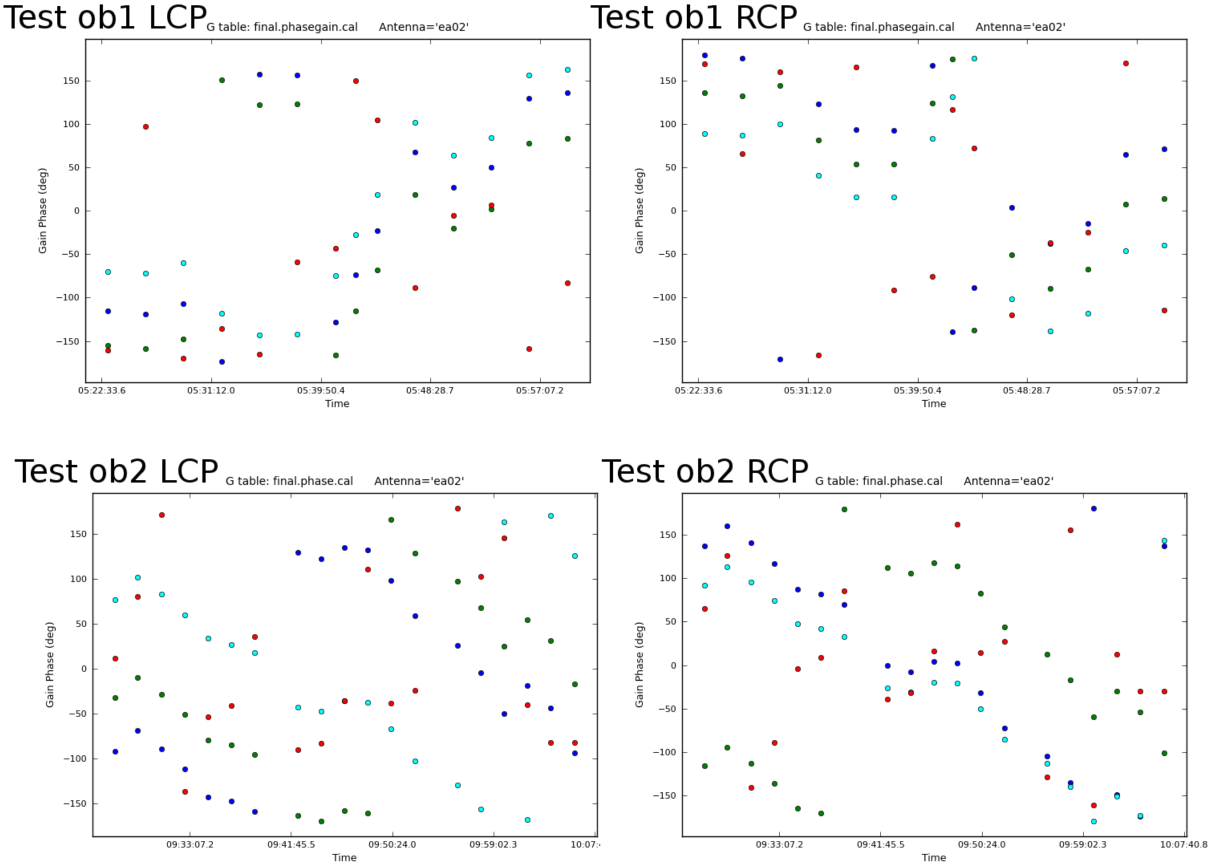

Fig. 4.— Phase solution as a function of time from two test observations (top and bottom panels). Left and right panels show the solution of LCP and RCP, respectively. Data points of different colors present the solutions of one spectral window from four different samplers.

1.4. Spikes in spectra

Figure 5 shows the spectrum of my target source, L1451-mm (flux ∼ 300 μJy at 36 GHz), of one baseline. There are several spikes in the spectrum, and spectra from several baselines have spikes at the same frequencies. I will check frequencies of these spikes.

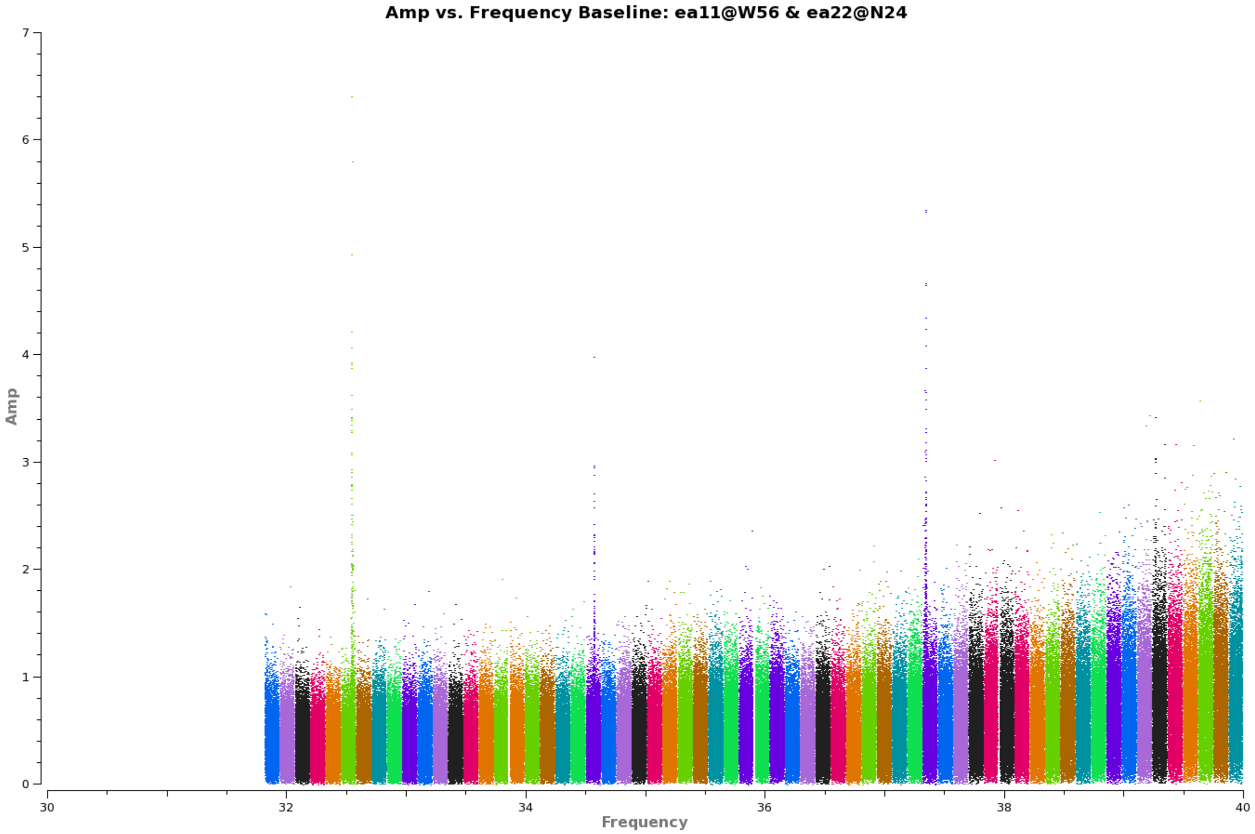

Fig. 5.— Spectrum of my target source, L1451-mm (flux ∼ 300 μJy at 36 GHz), of one baseline.

2. Data Reduction

2.1. Bad Sampler

Symptom: Some 3-bit samplers are more noisy than others mostly by a few tenth and few by one order of magnitude.

Solution:
1. Samplers more noisy by one order of magnitude may not have sufficient S/N to derive good solutions. Flagging may be needed.
2. For samplers more noisy by a few tenth, keeping the data and down weighting them (e.g., ”statwt” in CASA) can optimize S/N of images.

Figure 6 shows the performance of 3-bit samplers. There are some 3-bit samplers which are more noisy than others (the long tail of the distribution). The more noisy samplers can be identified by comparing bandpass among samplers. Figure 7 shows an example, which compares the bandpass of 3-bit and 8-bit samplers. More noisy samplers show lower amplitude than others. The same comparison can be also made between different 3-bit samplers by plotting bandpass of a secondary calibrator. The left panel in Figure 7 shows an example of the worst case; that 3-bit sampler is more noisy by more than one order of magnitude. The right panel in Figure 7 shows an example of a typical case; about 20% – 50% of 3-bit samplers are more noisy by a few tenth. In the data I have reduced, the data of those worst samplers are automatically flagged during data reduction, because there is no sufficient S/N to derive solutions (per spw gain or per channel bandpass). However, I have not yet tried to derive solutions with average over multiple spectral windows or channels. Some data of those worst samplers can have sufficient S/N to get solutions, and the solutions do not look good (large scattering). Flagging may be needed. An easy way to identify these bad samplers is to reduce data without initial flagging and then compare amplitude gain of a secondary calibrator among samplers in different antennas at the same frequency. If spectral windows of a certain sampler are mostly flagged during the calibration or many of them have much lower gain, that sampler may need to be flagged. For those 3-bit samplers which are more noisy by a few tenths than others, keeping the data of these sightly bad samplers and down weighting them (e.g., ”statwt”), can optimize S/N.

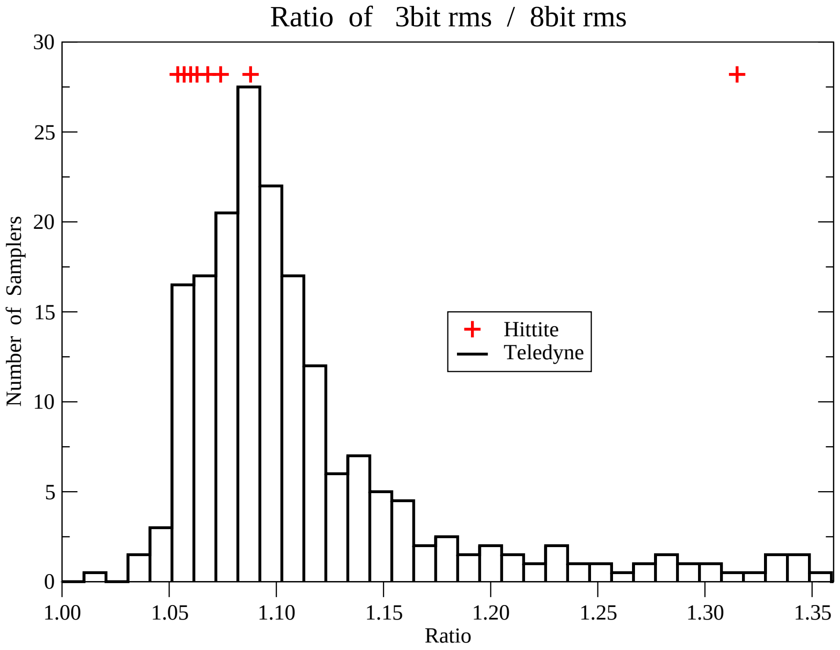

Fig. 6.— Ratio of rms noise of 3-bit to 8-bit samplers.

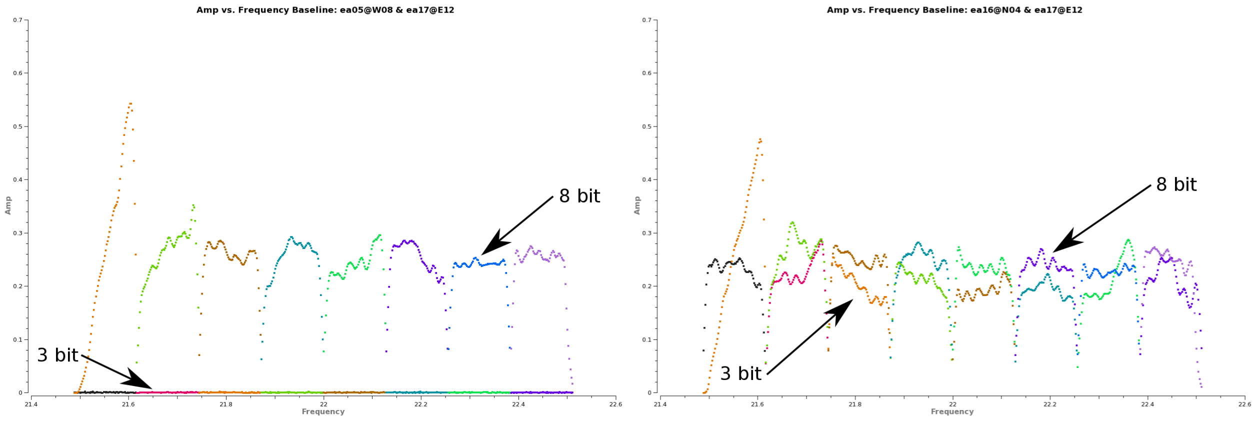

Fig. 7.— Amplitude of 3-bit and 8-bit samplers as a function of frequency of two different baselines. The 8-bit sampler shows higher amplitude than the 3-bit sampler.

2.2. Statwt

Test Result: Weights calculated by ”statwt” are correlated with rms noise of data.

The purpose of this test is to check whether weights calculated by the CASA task ”statwt” can reflect rms noise of data or not. Figure 8 compares weights calculated by ”statwt” (bottom panel) and rms noise calculated by Vivek (top panel). The rms noise is calculated for single visibility with a 2 MHz bandwidth and 4 s integration. The antenna 17 was adopted as a reference antenna. The bottom panel show 1/weight ($\propto \sigma^2$) of one spectral window at the same frequency of each sampler. Note that the weights calculated by ”statwt” is per integration (= 4 s). In order to show a general behavior, the weights shown in Figure 8 are averaged over one scan, and there is no large variation of weights over one scan in these data. Figure 8 shows that 1/weight is correlated with rms noise except for the antenna 18. The weights shown in Figure 8 are normalized, and their original values are $\sim 1/\sigma^2$.

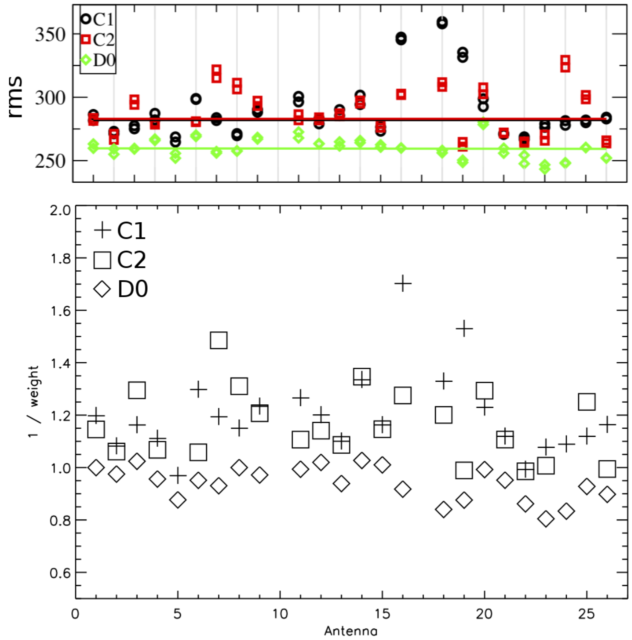

Fig. 8.— Top panel: rms noise (mJy) of three different samplers. Bottom panel: 1/weight of the data from the three sampler.

3. Results of Test Observation

Test Result:
1. The image of the test calibrator, which is calibrated by the secondary calibrator, is a point source.
2. The noise of the image of my target source is 40% higher than the theoretic noise level. After applying "statwt", the theoretical noise level is achieved.

Figure 9 shows the dirty and clean maps of the test calibrator in my test observation in the Ka band. The data of the test calibrator was calibrated by the secondary calibration. Although there are phase errors (Figure 3), the clean map show a point source as reported by "imfit". The data of the antenna 2 did not be included because the inconsistent phase variation of the samplers (Figure 4).

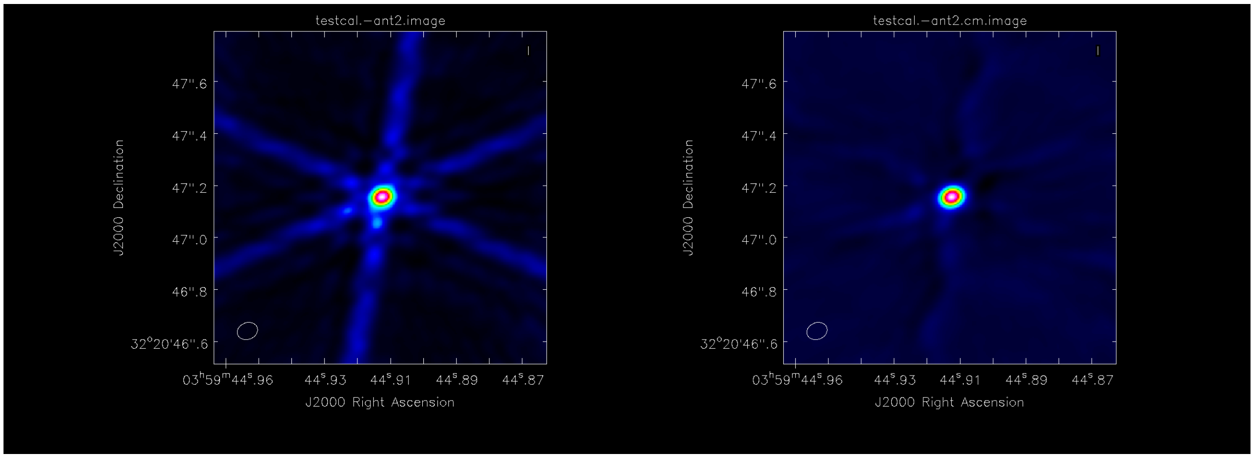

Fig. 9.— Dirty (left) and clean (right) maps of the test calibrator in the test observation, which is calibrated by the secondary calibrator.

Figure 10 shows the clean map of my target source, L1451-mm. L1451-mm is a candidate first core, which represents the evolutionary stage in transition from prestellar dense cores to protostars. We have computed synthetic images and SEDs of first cores, and first cores have a diameter of 5 to 10 AU (i.e., few tens of milliarcsecond) and a flux of few tens to few hundreds of μJy at 40 GHz. The observation was in night time (local time $\sim$ 23:00), and the API shows rms phase was $1.1^\circ - 1.4^\circ$. L1451-mm was integrated for 26 minutes in the Ka band. The theoretical noise calculated by VLA exposure calculator is 9.7 μJy. The noise in the map is $\sim$ 14 μJy without applying "statwt". With applying "statwt", the noise is $\sim$ 10 μJy. As reported by "imfit", the integrated flux of the source is $\sim$ 335 μJy, and the de-convolved size is $\sim$ 70 milliarcsecond. Our test observation show that with current 3-bit instruments we are able to achieve theoretical noise with applying weights, even though not all the samplers were well performed during the observation.

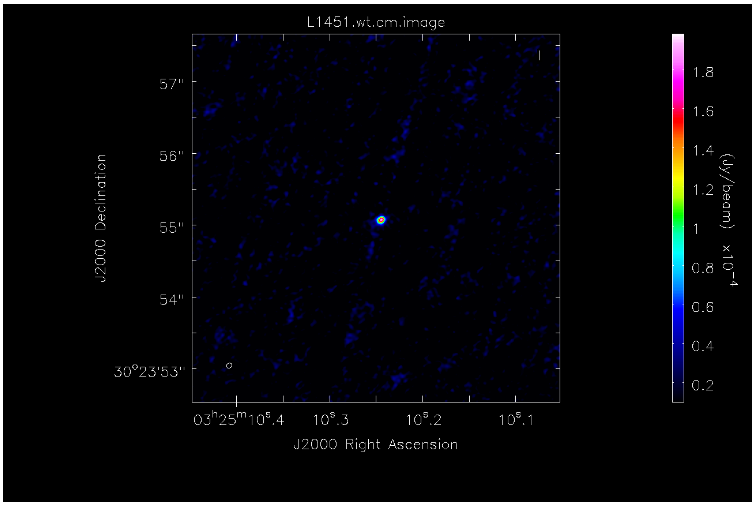

Fig. 10.— Clean map of my target source, L1451-mm.