Atacama
Large
Millimeter /
submillimeter
Array

Band 4 & 8 Imaging Verification Test Report: 30 May 2014

ALMA Technical Note Number: 3

Status: FINAL

Prepared by:	**Organization:**	**Date:**
Takahashi Satoko	JAO/NAOJ	30 May 2014

Band 4 Imaging Verification Report (Xf8c)

Reporter: Satoko Takahashi

ver.1: 2014-04-08

ver.2: 2014-04-15

ver.3: 2014-05-30

Abstract:

Band 4 verification data was obtained toward quasars (J1908-2941 and J1923-210) and blank sky using 22 usable antennas. Images from all the four BBs were successfully obtained and their fluxes and position are consistent within the expected measurements errors. The measured rms noise levels on the blank sky were consistent within factor of 1.6 compared to those expected from the ALMA sensitivity calculator. This can be explained by considering Tsys variations (both by time as well as by antennas) during the observations.

Observations & Data Reduction:

The observation was made on 2014-03-15 using fifteen 12m antennas and seven 7m antennas with the BL correlator (described below). The PWV during the observations was around 0.37mm. Elevation of the observed sources was between 59 and 75°(Figure 1). The detailed scheduling block information is as follows, and the observed field and spectral settings are listed in Table 1 and Table 2, respectively.

12m antennas used:

DA43, DA55, DA59, DA60, DA61, DA64, DV01, DV10, DV14, DV16, DV17, DV18, DV20, DV22, and PM04

7m antennas used:

CM01, CM02, CM03, CM06, CM09, CM11, and CM12

* Note that antennas include “operational”, “science”, and “engineering” status.

Scheduling block information:

Project name: Performance Regression V2.4 (Version 2.4)

Project Code: 0000.0.00133.CSV

SchedBlock BL-B4-RA 19h Correct

PI: dgunawan; ExecBlock: uid://A002/X7cbdcd/X8fc

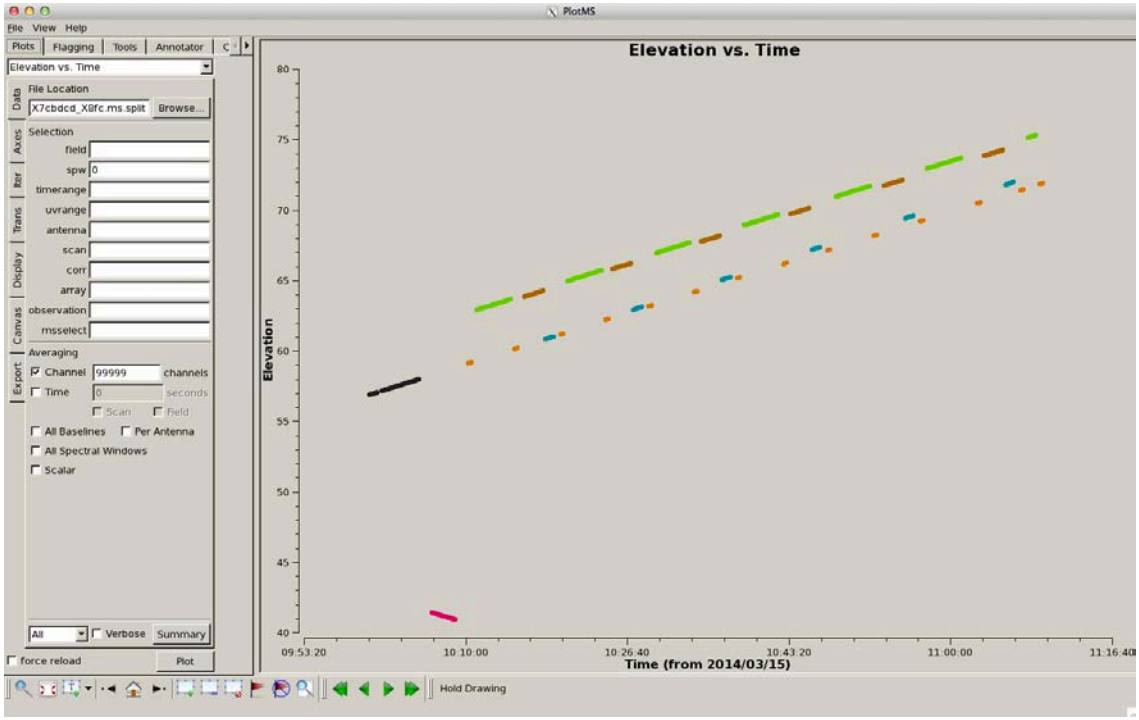
Table 1: Observed fields

Name	R.A. (J2000)	Dec. (J2000)	Separation from 3c279	Total Integration time [s]	Note
J1924-2914	19:24:51.055940	-29:14:30.12110	—	278	Bandpass calibrator
Ceres	14:14:05.155622	+01:30:03.30257	—	145	Amplitude calibrator
J1921-293	19:24:51.056000	-29:14:30.12100	—	339	Gain calibrator
Blank sky	19:08:29.400000	-28:42:18.40000	4.1 degree	1288	Target
J1908-2942	19:08:29.400000	-29:42:18.40000	4.1 degree	689	Target
J1923-219-offset	1(;23:32.190000	-21:04:28.33300	8.2 degree	327	Target

Table 2: Spectral settings

BB	SPW	# channels	Center Freq. [GHz]	Ch. Width [kHz]	Toal BW [MHz]
1	0	128	149.007813	15625	20000
2	1	3840	149.062744	488.281	1875
3	2,3,4,5	960, 960, 960, 690	150.468994, 150.000244, 149.531494, 149.062744	488.281, 488.281, 488.281, 488.281	468.75, 468.75, 468.75, 468.75
4	6,7,8,9,10,11	240, 240, 480, 960, 960, 960	150.410278, 150.351685, 150.234497, 150.000122, 149.765747, 149.5313722	244.141, 244.141, 244.141, 244.141, 244.141, 244.141	58.593, 58.593, 117.1875, 234.375, 234.375, 234.375

Figure 1: Elevation plots. Each color shows the different field: black (J1924-2914), pink (Ceres), orange (J1921-293), green (Blank sky), brown (J1908-294), and blue (J1923-219-offset).

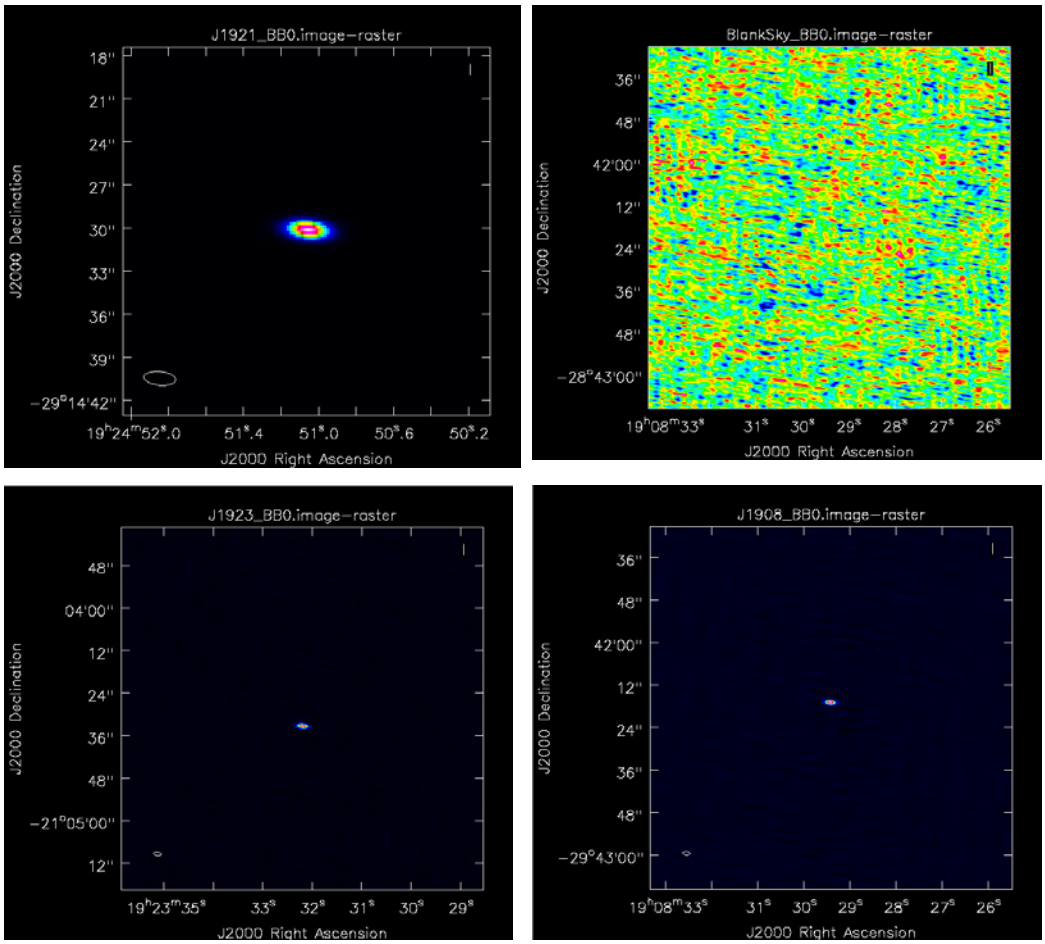


CASA version 4.2.0 (r28322) + the standard Cycle I data reduction procedure (i.e., Eric's script) was used for the data reduction. Baseline correction was applied based on the baseline measurements carried out on March 16. Due to ICT-1770 (Scans start 1-3 seconds before antenna arrives on source), the first scan of each sequence was flagged using "quack" option in a task ***flagdata***. The used reduction script (uid___A002_X7cbdcd_X8fc.ms.scriptForCalibration.py) and CLEAN commands (Imaging-X8fc.txt) are attached in this JIRA ticket.

Results:

The positions and peak flux of sources were estimated by elliptical Gaussian fitting using ***imfit*** and rms noises were measured using ***imstat***. The images and summary of the image properties are posted as Figure 2 and Table 3.

*BB1:



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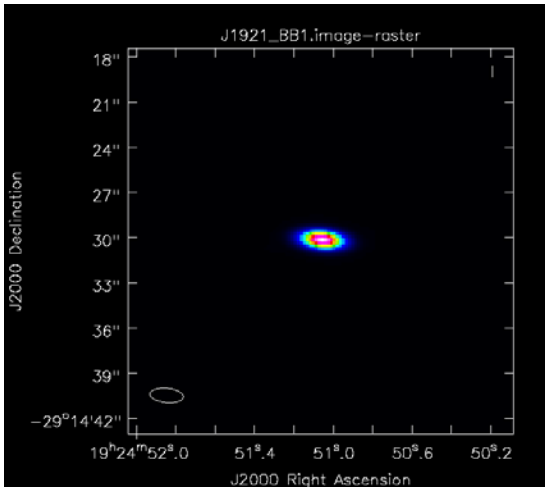
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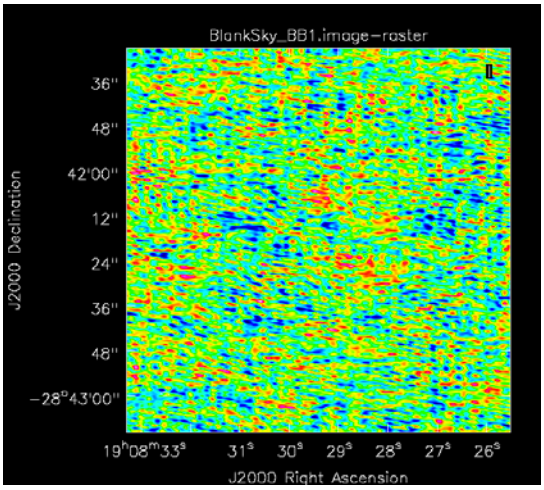
J2000 Right Ascension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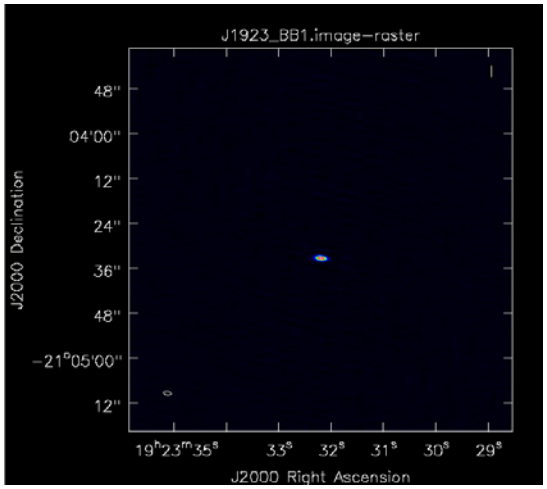
J2000 Right Ascension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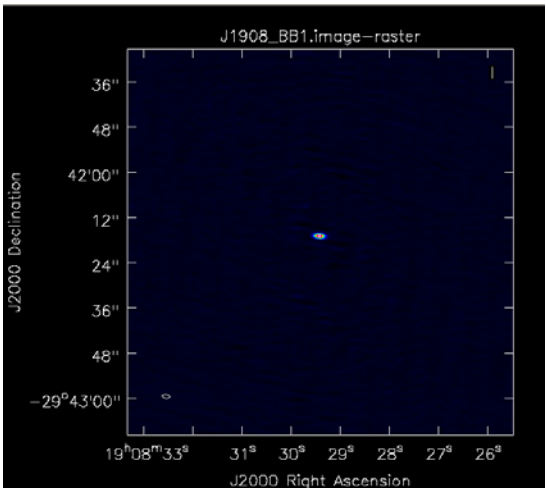
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J2000 Right Ascension

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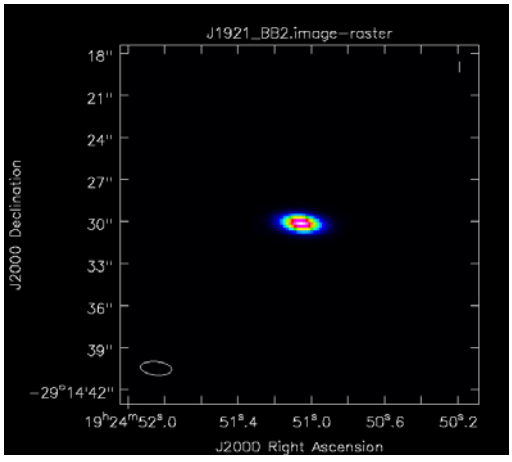
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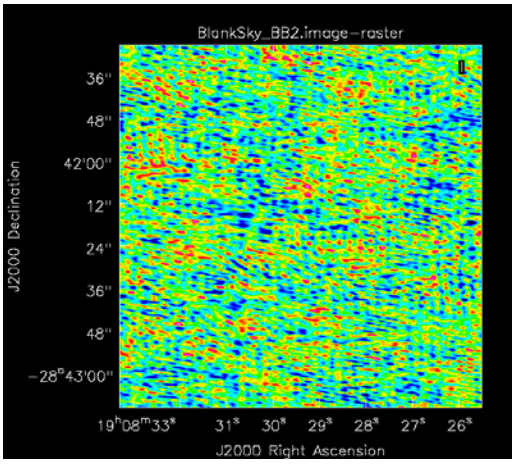
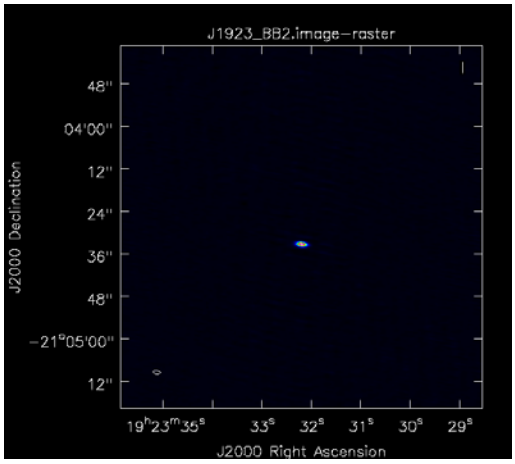
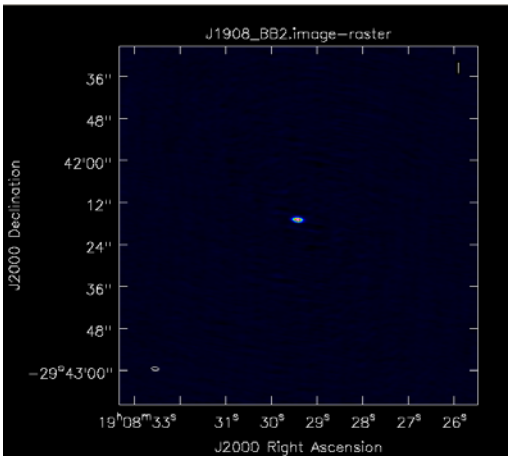
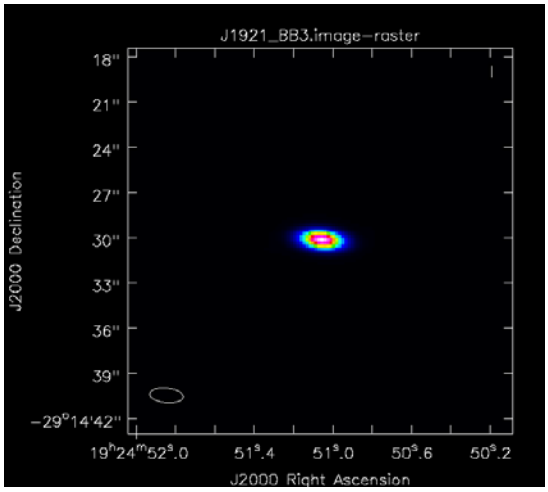
J2000 Declination
J2000 Right Ascension

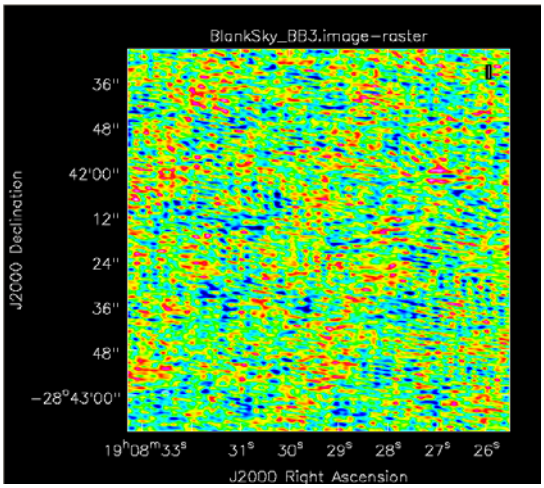

BlankSky_BB2.image-raster
J2000 Declination
J2000 Right Ascension

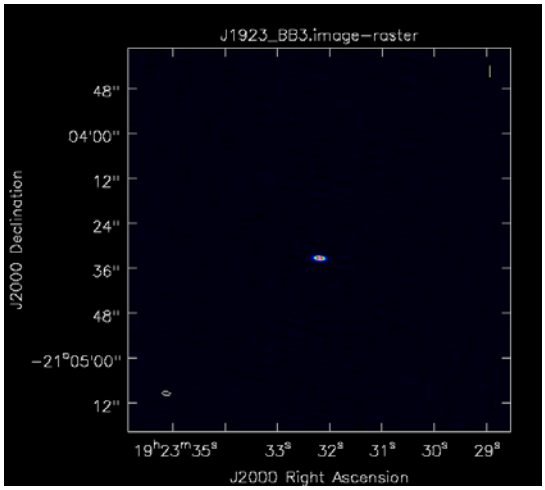




*BB4







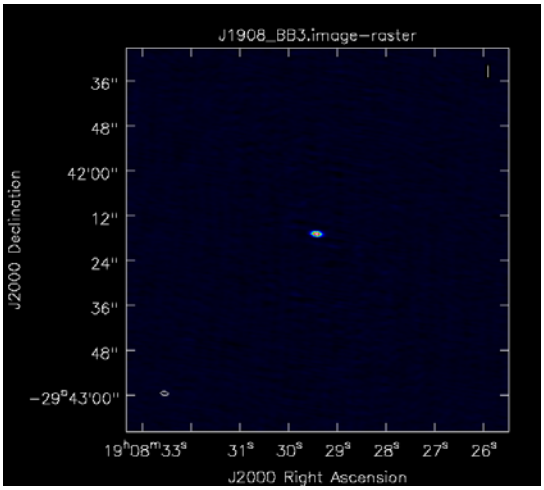


Figure 2: The images obtained from the experiments. J1921-293 (phase calibrator), blank sky, J1923-219, which offsets from the phase center, J1908-2942 (fainter QSO). Image toward J1921-293 was zoomed in.

Table 3: Image properties

BB1

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)	error	rms	Dynamic range
	(hh:mm:ss; dd:mm:ss)+/-(arcsec, arcsec)	(arcsec)	(Jy)	(Jy)	(Jy)	
J1921-293	(19:24:51.055998, -029.14.30.120999)+/- (0.000493, 0.000214)	(-0.001476, +0.005303)	4.4012	+/- 0.0022	1.07E-03	4113
Blank sky	--	—	—	—	8.55E-05	—
J1908-2942	(19:08:29.42703, -029.42.16.95405)+/- (0.000870, 0.000382)	(-0.094500, -0.000003)	5.37E-02	+/- 0.00043	2.01E-04	267
J1923-210 (offset)	(19:23:32.19203, -021.04.33.35435)+/- (0.000856, 0.000361)	(+0.032976, -0.000006)	1.86E+00	+/- 0.014	3.98E-03	466

BB2

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)		rms	Dynamic range
J1921-293	(19:24:51.055995, -029.14.30.121032)+/- (0.000444, 0.000193)	(-0.001476, +0.005303)	4.4016	+/- 0.0018	1.06E-03	4152
Blank sky	--	—	—	—	8.94E-05	—
J1908-2942	(19:08:29.42689, -029.42.16.95367)+/- (0.000851, 0.000373)	(-0.097488, -0.000003)	5.39E-02	+/- 0.00042	1.95E-04	276
J1923-210 (offset)	(19:23:32.19194, -021.04.33.35447)+/- (0.00830, 0.00350)	(+0.031500, -0.000006)	1.86E+00	+/- 0.013	3.97E-03	467

BB3

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)		rms	Dynamic range
J1921-293	(19:24:51.055994, -029.14.30.121012)+/- (0.000462, 0.000201)	(-0.001476, +0.005303)	4.3992	+/- 0.0018	1.14E-03	3859
Blank sky	--	—	—	—	8.53E-05	—
J1908-2942	(19:08:29.42717, -029.42.16.95323)+/- (0.000904, 0.000396)	(-0.092988, -0.000003)	5.37E-02	+/- 0.00044	2.01E-04	267
J1923-210 (offset)	(19:23:32.19191, -021.04.33.35452)+/- (0.00851, 0.00359)	(+0.031500, -0.000006)	1.85E+00	+/- 0.014	3.90E-03	475

BB4

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)		rms	Dynamic range
J1921-293	(19:24:51.056001, -029.14.30.121015)+/- (0.000505, 0.000225)	(0.000000, +0.005303)	4.4105	+/- 0.0020	1.18E-03	3738
Blank sky	--	—	—	—	1.32E-04	—
J1908-2942	(19:08:29.42707, -029.42.16.95299)+/- (0.000943, 0.000424)	(-0.094500, -0.000003)	5.40E-02	+/- 0.00047	2.42E-04	223
J1923-210 (offset)	(19:23:32.19196, -021.04.33.35510)+/- (0.00824, 0.00356)	(+0031500, -0.000006)	1.86E+00	+/- 0.013	4.02E-03	463

- **Flux scaling:** Derived absolute flux value of J1921-293 using the primary flux calibrator, Ceres, is ~4.4 Jy. The value is consistent with an expected flux of 4.2 Jy, which was derived from an independent measurement at Band 3, which is 5.63 Jy, performed on 2014-04-03, assuming with the spectral index of -0.71 (The spectral index was estimated from the grid survey results in Band 7 (performed on 2014-03-24) and Band 3).
- **Positions:** The positional offsets between the apriori positions and measured positions of observing targets (J908-2942 and J1923-210) listed in Table 3. The positional differences in the right ascension are several times larger than those expected from the positional offsets such as originated to (i) the fitting error (~10^{-3} arcsec), (ii) the positional accuracies determined by source S/N ($\sigma \sim (1/2\pi)*(\theta/S/N) \sim$ several x 10^{-3} arcsec), and (iii) the positional error caused by the baseline error ($\Delta\theta = (\Delta\lambda/\lambda) \times \theta$ x d/360~ a few times 10^{-3} arcsec). Here, we adopted that the baseline error of 0.2mm, which is retrieved from a system verification report #154 by Sugimoto-san. Nonetheless, the target position are still consistent within ~0.1". The offset corresponds to 4.5 % of the synthesized beam size. This could be explained by the systematic phase offset could be caused by the baseline error (which can be slightly different from the one we assumed from

the Sugminoto-san's report) as well as the phase offset originate to the troposphere structure (which is not easy to quantitatively estimate). This much of the positional offset is within our expectation (normally the positional offset of 5-10% of the beam size be seen in the ALMA experiments). Interestingly, the offsets measured in the declination direction (order of 10^{-6} arcsec) were smaller than those expected from the accuracies of positional determination (orders of 10^{-3} arcsec, meaning that there is positional offset is zero..). One possibility could be explain this is that, again, unknown baseline error or atmospheric effect could cancel out the positional error.

Noise estimations: Adopting the mean measured T_{sys} during observations of ~50 K and the integration on-source time of 1288 sec, the theoretical noise level is estimated to be ~0.054 mJy/beam from the ALMA sensitivity calculator with 2GHz bandwidth (scaling with antenna surface area as well as the system temperature). The measured rms noise levels for BB1, BB2, BB3 (for the ~2GHz bandwidth), and BB4 (for the ~1GHz bandwidth) are 0.086, 0.089, 0.085, and 0.132 mJy/beam, respectively. These values are consistent within factors of ~1.6 compared to those expected from the theoretical values. This can be explained by considering Tsys variations (both by time as well as by antennas) during the observations.

Conclusions:

A performance evaluation data set in Band 4 was analyzed. The calibrated data showed that the positional accuracies coincide within ~0.1" compared to the apriori positions, which is within expectation. The rms noise levels in a blank sky field measured in all the four BBs are factor of ~1.6 higher than those expected from the ALMA sensitivity calculator. This slightly higher value may be explained by the Tsys value variations during the experiment.

Band 8 Imaging Verification Report (X5ab)

Reporter: Satoko Takahashi

Ver2. (2014-04-08)

* Modified part are written in the orange color

Abstract:

Band 8 verification data was obtained toward quasars (J1239-103 and 3c273) and blank sky with 20 usable antennas. Images from all the four BBs were successfully obtained and their fluxes and position are consistent within the expected measurements errors. The rms noise level on the blank sky images were measured to be 0.34 mJy/beam, which is more or less agreed (within 30%) with those estimated from the ALMA sensitivity calculator adopting with the similar observing conditions (and without considering Tsys variation during the observations).

Observations & Data Reduction:

The observation was made on 2014-03-15 using fourteen 12m antennas and seven 7m antennas as described below with the BL correlator. The PWV during the observations was around 0.35mm. Elevation of the observed sources was between 35 and 60°(Table 1). The detailed scheduling block information is as follows, and the observed field and spectral settings are listed in Table 1 and Table 2, respectively.

12m antennas used:

DA43, DA55, DA59, DA61, DA64, DV01, DV10, (DV14), DV16, DV17, DV18, DV20, DV22, and PM04

7m antennas used:

CM01, CM02, CM03, CM06, CM09, CM11, and CM12

* Note that antennas include “operational”, “science”, and “engineering” status.

Scheduling block information:

Project name: Performance Regression V2.4 (Version 2.4)

Project Code: 0000.0.00133.CSV

SchedBlock BL-B8-RA 12h Correct

PI: dgunawan, ExecBlock: uid://A002/X7cbdcd/X5ab

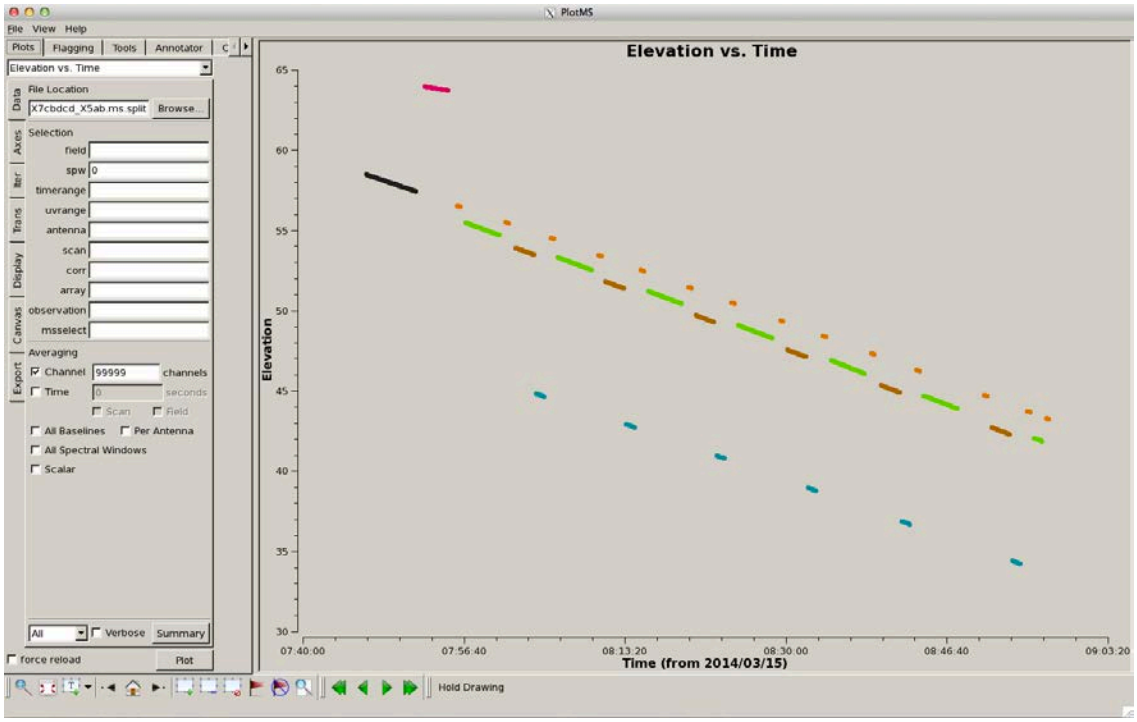
Table 1: Observed fields

Field	Name	R.A. (J2000)	Dec. (J2000)	Separation from 3c279	Total Integration time [s]	Note
0	J1256-0547 (3c279)	12:56:11.167000	-05:47:21.52500	—	296	Bandpass calibrator
1	Ceres	14:14:07.352235	+01:29:40.86814	—	145	Amplitude calibrator
2	3c279	12:56:11.167000	-05:47:21.52500	—	97	Gain calibrator
3	Blank Sky	12:39:43.061000	-11:23:28.69300	6.9 degree	1288	Target
4	J1239-103	12:39:43.061000	-10.23.28.69300	6.2 degree	115	Target
5	3c273	12:29:06.700000	-02:03:13.39800	10.4 degree	327	Target

Table 2: Spectral settings (revised)

BB	SPW	# channels	Center Freq. [GHz]	Ch. Width [kHz]	Toal BW [MHz]
1	0	128	409.007813	15625	20000
2	1	3840	409.062744	488.281	1875
3	2,3,4,5	960, 960, 960, 690	410.468994, 410.000244, 409.531494, 409.062744	488.281, 488.281, 488.281, 488.281	468.75, 468.75, 468.75, 468.75
4	6,7,8,9,10,11	240, 240, 480, 960, 960, 960	410.410278, 410.351685, 410.234497, 410.000122, 409.765747, 409.531372	244.141, 244.141, 244.141, 244.141, 244.141, 244.141	58.593, 58.593, 117.1875, 234.375, 234.375, 234.375

Figure 1: Elevation plots. Each color shows the different field: black (J1256-0547/3c279), pink (Ceres), orange (3c279), green (Blank sky), brown (J1239-103), and blue (3c273).



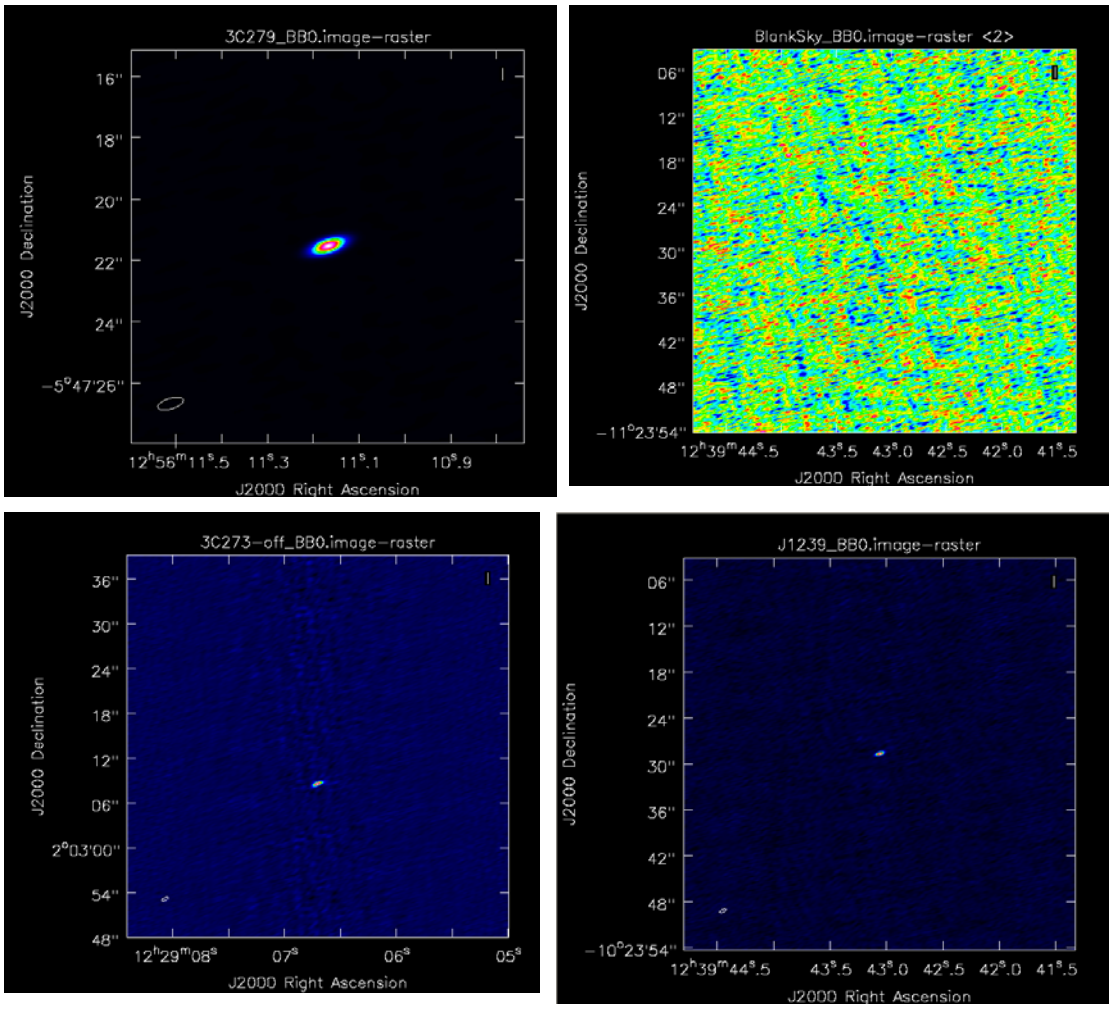
CASA version 4.2.0 (r28322) + the standard Cycle I data reduction procedure (i.e., Eric's script) was used for the data reduction. Baseline correction was applied based on the baseline measurements carried out on March 16. WVR data were not properly obtained on DV14 (PRTSPR-3847), so the data associated with DV14 was flagged out.

Moreover, due to ICT-1770 (Scans start 1-3 seconds before antenna arrives on source), the first scan of each sequence was flagged using “quack” option in a task ***flagdata***. The used reduction script (uid___A002_X7cbdcd_X5ab.ms.scriptForCalibration.py) and CLEAN commands (Imaging-X5ab.txt) are attached in this JIRA ticket.

Results:

The positions and peak flux of sources were estimated by elliptical Gaussian fitting using ***imfit*** and rms noises were measured using ***imstat***. The images and summary of the image properties are posted as Figure 2 and Table 3.

*BB1:



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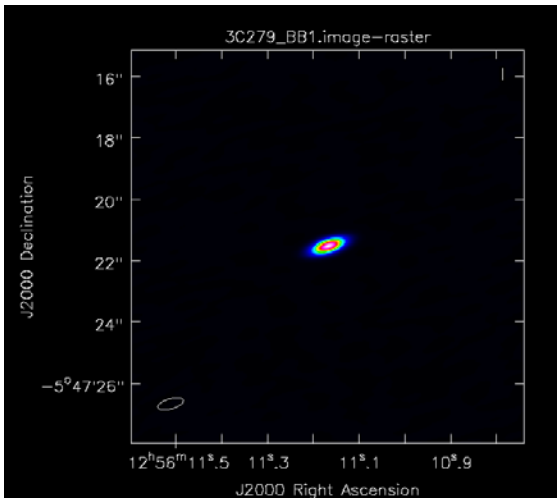
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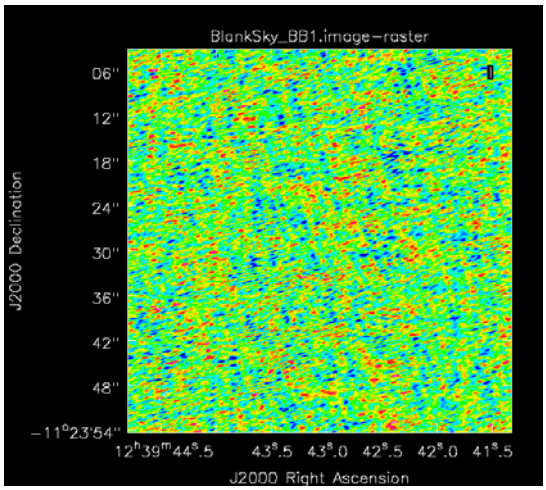
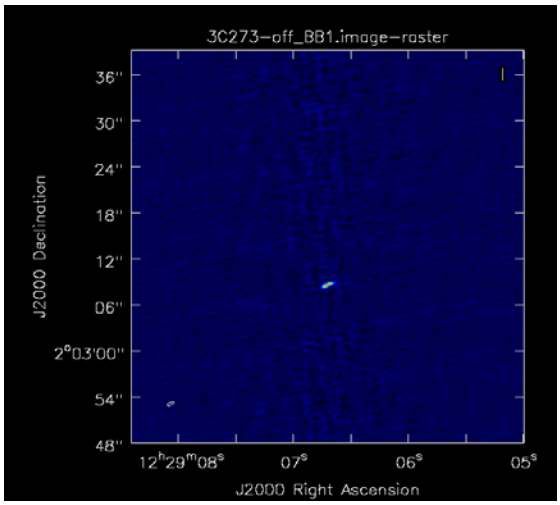
J2000 Declination
J2000 Right Ascension


BlankSky_BB1.image-raster
J2000 Declination
J2000 Right Ascension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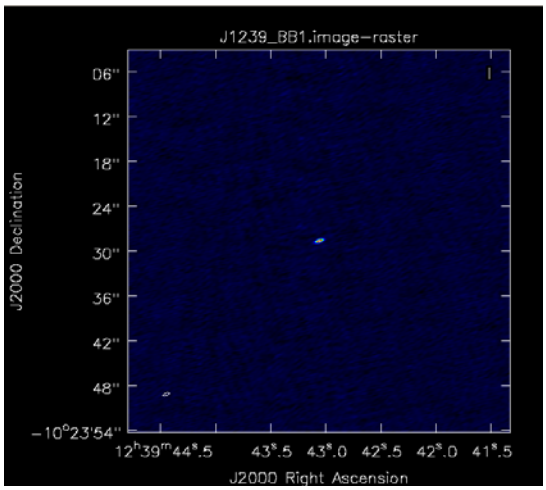
J2000 Right Ascension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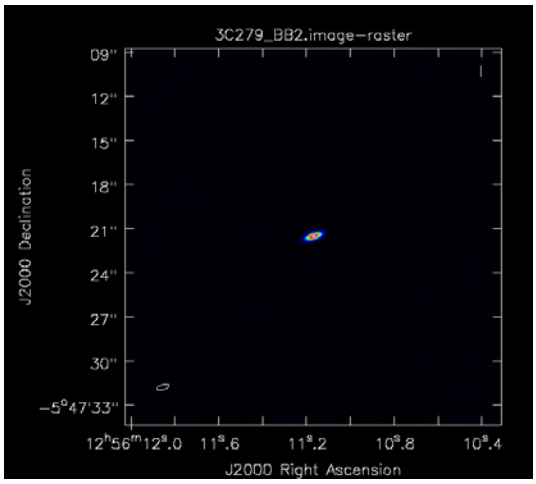
J2000 Right Ascension

*BB3: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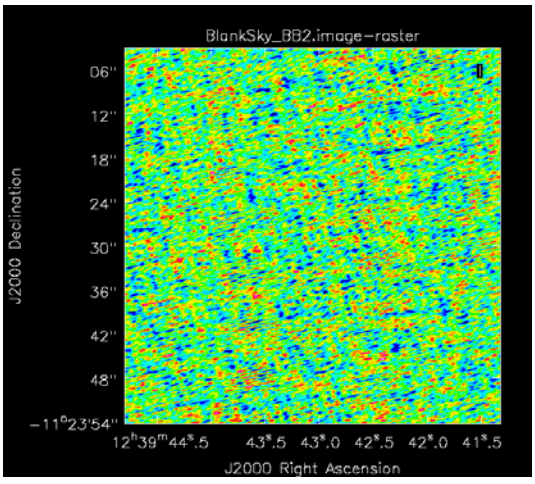
J2000 Declination
J2000 Right Ascension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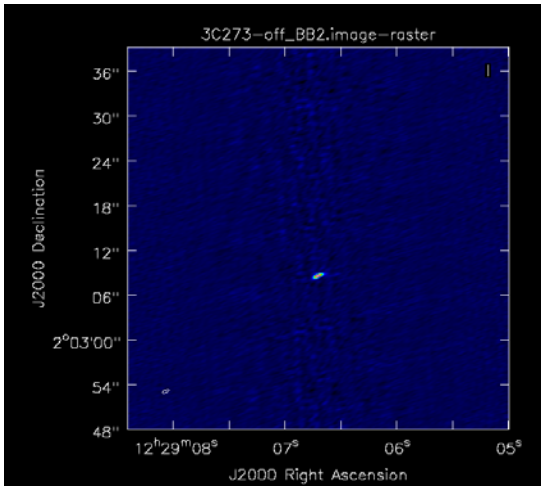
J2000 Declination
J2000 Right Ascension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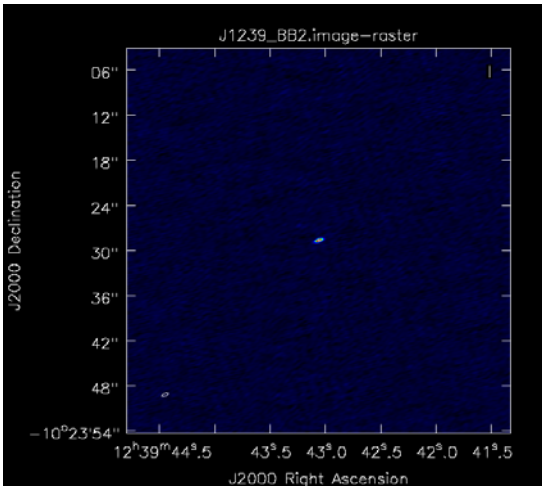
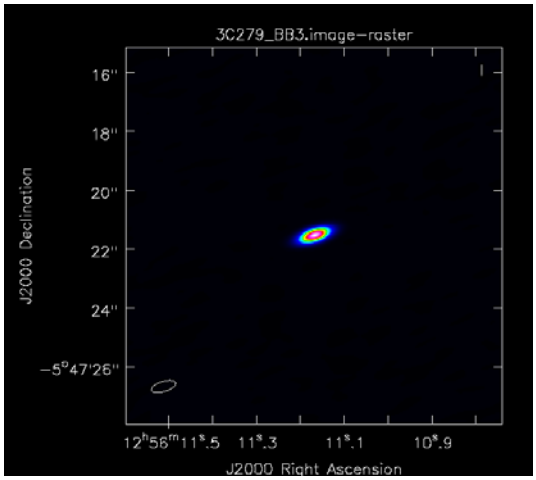
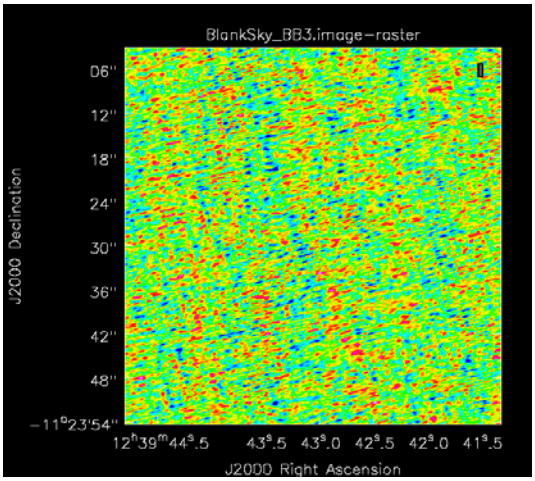
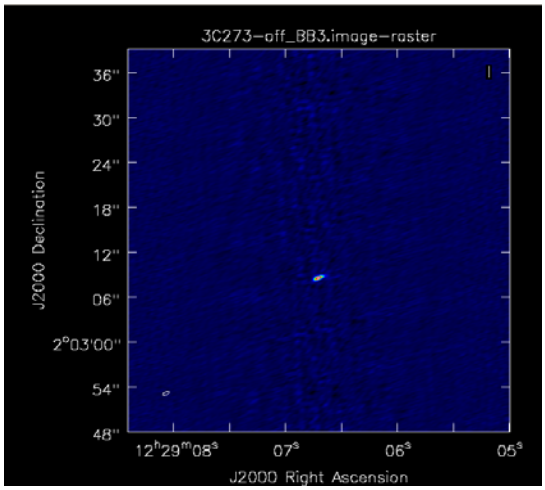
J2000 Declination
J2000 Right Ascension


J1239_BB2.image-raster
J2000 Declination
J2000 Right Ascension

BB4:


3C279_BB3.image-raster
J2000 Declination
J2000 Right Ascension


BlankSky_BB3.image-raster
J2000 Declination
J2000 Right Ascension


3C273-off_BB3.image-raster
J2000 Declination
J2000 Right Ascension

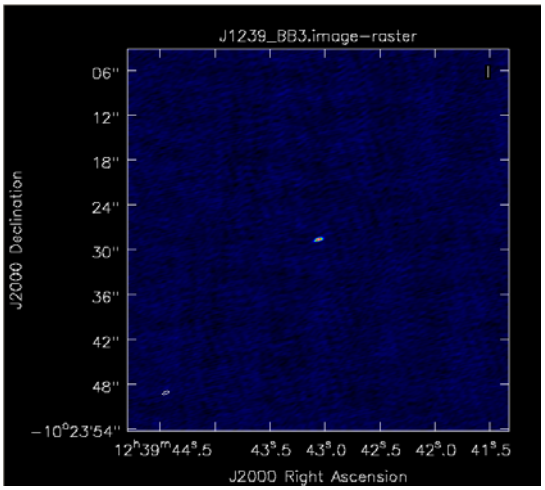

J1239_BB3.image-raster
J2000 Declination
J2000 Right Ascension

Figure 2: The images obtained from the experiment. 3c279 (phase calibrator), blank sky, 3c273, which offsets from the phase center, J1239-103 (fainter QSO). Image toward 3c279 was zoomed in.

Table 3: Image properties

BB1

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)	error	rms	Dynamic range
3C279	(12:56:11.167003, -05.47.21.525044)+/- (0.000369, 0.000184)	(0.000000, 0.000000)	6.614	+/- 0.0059	0.002182396	3030.614059
Blank sky	--	—	--	—	0.000338447	—
J1239-103	(12:39:43.06067, -10.23.28.66855)+/- (0.00340, 0.00172)	(-0.005976, 0.033948)	0.05771	+/- 0.00046	0.000643624	89.6641796
3C273_off	(12:29:06.70482, -02.03.08.54770)+/- (0.01322, 0.00691)	(0.072000, -0.050292)	1.152	+/- 0.033	0.01412443	81.56081343

BB2

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)		rms	Dynamic range
3C279	(12:56:11.167003, -05.47.21.525047)+/- (0.000322, 0.000159)	(0.000000, 0.000000)	6.6211	+/- 0.0051	0.002190955	3022.015514
Blank sky	--	—	--	—	0.000338853	—
J1239-103	(12:39:43.06054, -10.23.28.66954)+/- (0.00384, 0.00193)	(-0.007488, +0.032976)	0.05778	+/- 0.00052	0.000619561	93.25965745
3C273_off	(12:29:06.70481, -02.03.08.54782)+/- (0.01321, 0.00693)	(+0.072000, -0.050184)	1.153	+/- 0.033	0.01410601	81.73820946

BB3

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)		rms	Dynamic range
3C279	(12:56:11.167002, -05.47.21.525031)+/- (0.000364, 0.000180)	(0.000000, 0.000000)	6.5931	+/- 0.0058	0.002278911	2893.092359
Blank sky	--	—	--	—	0.000334891	—
J1239-103	(12:39:43.06040, -10.23.28.66941)+/- (0.00364, 0.00183)	(-0.009000, +0.032976)	0.577	+/- 0.00049	0.000613756	940.1127027
3C273_off	(12:29:06.70482, -02.03.08.54787)+/- (0.01317, 0.00686)	(+0.072000, -0.050076)	1.147	+/- 0.032	0.015239	75.267406

BB4

Name	Derived position and fitting accuracy	Offset from the actual position	Peak (imfit)		rms	Dynamic range
3C279	(12:56:11.166999, -05.47.21.525035)+/- (0.000341, 0.000171)	(-0.001512, 0.000000)	6.6294	+/- 0.0055	0.002415788	2744.197752
Blank sky	--	—	--	—	0.000548402	—
J1239-103	(12:39:43.06015, -10.23.28.66522)+/- (0.00427, 0.00218)	(-0.013500, +0.036972)	0.5748	+/- 0.00057	0.000884112	650.1439467
3C273_off	(12:29:06.70488, -02.03.08.54718)+/- (0.01320, 0.00692)	(+0.072000, -0.050796)	1.154	+/- 0.033	0.01472921	78.34771858

- **Flux scaling:** Derived absolute flux value of 3C279 using the primary flux calibrator, Ceres, is ~6.6 Jy. The value is consistent with an expected flux of 6.7 Jy, which was derived from an independent measurement at Band 7, which is 7.48 Jy, performed on 2014-03-20, adopting the spectral index of -0.65 (The spectral index was derived from the grid survey results in Band 3 (performed on 2014-04-03) and Band 7).
- **Positions:** The positional offsets between the actual position and measured position for observing targets (J1239-103 and 3c273) listed in Table 3 are consistent within the same orders of the positional uncertainties originated to the fitting errors and positional accuracies determined by source S/N, which is ($\sigma \sim (1/2\pi)*(\theta/S/N)$).
- **Noise estimations:** Adopting the mean measured T_{sys} during observations of ~200 K, and the integration on-source time of 1288 sec, the theoretical noise level is estimated to be 0.26 mJy/beam from the sensitivity calculator. The measured

rms noise levels from the observed data on the blank sky are ~0.34 mJy/beam for BB1, 2, 3 (with the ~2GHz bandwidth), and 0.55 mJy/beam for BB4 (with the ~1GHz bandwidth), respectively. The measured values show factor of ~1.3 higher values than those expected from the sensitivity calculator. However, the estimation does not consider the Tsys variation during the observations.

Conclusions:

A performance regression data set in Band 8 was analyzed. The calibrated data showed that the positional accuracies are within expected uncertainties. The rms noise levels in a blank sky field are more or less consistent with the theoretically expected values.