

CASA Regression Tests Use Cases

Doc #:
Date: 2010-03-11
Status: development
Page: 1 of 29

CASA Regression Tests Use Cases

Doc number

Version: 1.1

Status: Development

2010-03-11

Prepared By:		
Name and Signature	Organisation	Date
Sandra Castro Ed Fomalont Gustaaf Van Moorsel	ESO NRAO NRAO	2010-03-11



CASA Regression Tests Use Cases

Doc #:
Date: 2010-03-11
Status: development
Page: 2 of 29

Change Record

Version	Date	Affected Section	Change Request #	Remarks
1.0	2009-12-22	All		Initial version
1.1	2010-03-11	All		Removed UC06 and renumbered others

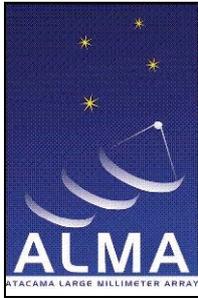


Table of Contents:

<u>INTRODUCTION:</u>	5
<u>UC-00: NARROW FIELD IMAGING OF POINT SOURCES</u>	6
Description:	6
Performance:	6
Pre-conditions:	7
Basic Course:	7
Alternate Course:	7
Post-conditions:	7
<u>UC-01: NARROW FIELD IMAGING OF EXTENDED SOURCES WITH SINGLE POLARIZATION</u>	8
Description:	8
Performance:	8
Pre-conditions:	8
Basic Course:	9
Alternate Course:	9
Post-conditions:	9
<u>UC-02: NARROW FIELD IMAGING OF TWO VLA CONFIGURATIONS ON VERY EXTENDED SOURCES WITH FULL POLARIZATION</u>	10
Description:	10
Performance:	11
Pre-conditions:	11
Basic Course:	11
Alternate Course:	12
Post-conditions:	12
<u>UC-03: MOSAICING SMALL ANGULAR-SIZE SOURCES WITH DUAL POLARIZATION</u>	14
Description:	14
Performance:	15
Pre-conditions:	15
Basic Course:	15
Post-conditions:	16
<u>UC-04: HI LINE DATA OF A SPIRAL GALAXY WITH DUAL POLARIZATION</u>	17
Description:	17
Performance:	17
Pre-conditions:	17
Basic course:	17
Alternate course:	19
Post-conditions:	19
<u>UC-05: PRIMARY BEAM ROTATION EFFECTS USING WIDE-FIELD POLARIMETRY</u>	20
Description:	20



Performance:	20
Pre-conditions:	20
Basic course:	20
Alternate course:	21
Post-conditions:	21

UC-06: WIDE-FIELD IMAGING WITH OUTLIERS CHECK **22**

Description:	22
Performance:	22
Pre-conditions:	23
Basic course:	23
Alternate course:	23
Post-conditions:	23

UC-07: SINGLE AND MULTI-SCALE IMAGING OF 3C219 **24**

Description:	24
Performance:	24
Pre-conditions:	24
Basic course:	24
Alternate course:	25
Post-conditions:	25

UC-08: MOSAIC OF NGC 4826 **26**

Description:	26
Performance:	27
Pre-conditions:	27
Basic course:	27
Alternate course:	28
Post-conditions:	28

UC-9: FRINGING - TBD **29**

Description:	29
Performance:	29
Pre-conditions:	29
Basic course:	29
Alternate course:	29
Post-conditions:	29

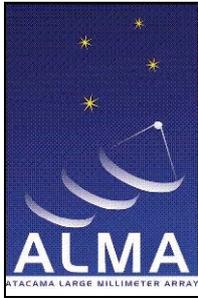


Introduction:

This document describes the current use cases in the CASA regression tests suite version 3.0. The use cases try to cover many typical ALMA and EVLA science cases and observation modes, using VLA and simulated data. The tests described here are end-to-end tests, showing the steps to reduce the data described in each specific case. Unit tests that deal with single CASA tasks and tools will be described in a separate document.

Throughout the text, some conventions are adopted to highlight the procedures. CASA task names or tools are written in underlined italic (e.g. *clean*) and if necessary, some parameters for the task are shown. The parameters are written in italic (e.g. *mode=*). Not all parameters of a task are shown, but only the most relevant or the ones denoting special cases. In every use case, the parameters are specific for the data set being presented in the case.

The performance of each use case describes the wall clock time necessary to run the regression test without any interaction from the user. The computer system used for all performance measures is a 64 bits PC running Red Hat Linux 4. It has a single core Intel Xeon processor of 2.66 GHz CPU and 2 Gb of RAM memory.



UC-00: Narrow field imaging of point sources

Description:

This use case describes the steps to work on a narrow-field data with discrete sources. The set contains simulated data taken from the U-V coverage for VLA B-configuration data of 3C219. The source data were replaced by a visibility associated with discrete sources. One source pair is a point double, the other is a displaced core-halo. Gaussian noise of 0.3 Jy has been added to each UV-point, resulting in a map rms of 0.33 mJy.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	1	8447.6	25000	25000	8447.6	RR RL LR LL
1	1	8497.6	25000	25000	8497.6	RR RL LR LL

Field	Name	RA	Dec	Epoch	Description
0	3C219	09:17:50.42	+45.51.40.40	B1950	source

Model data used in clean

ID	Size	RA	Dec
0	1024,1024	09:21:08.367	45.38.54.328
1	128,128	09:21:36.977	45.36.24.328

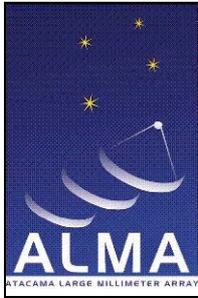
Initial estimates of component parameters for double point sources

Peak	XPIX	YPIX	BMAJ	BMIN	BPA	FIXP
Stokes I						
0.3	212	664	0.65''	0.65''	0.0°	abp
0.3	212	664	0.65''	0.65''	0.0°	abp
Stokes U						
-0.01	212	664	0.65''	0.65''	0.0°	abp
0.04	212	664	0.65''	0.65''	0.0°	abp

Performance:

Non-interactive execution time is estimated to be:

Execution time: 300 s

**Pre-conditions:**

- 1) Data is previously imported into a CASA measurement set (MS).
- 2) Data is previously calibrated.
- 3) CASA 3.0 or later is installed in the system.
- 4) Data is available in the current directory.

Basic Course:

- 1) Run *clean* on all Stokes parameters, which will produce two images according to the sources described in the file *model_data*. Task *clean*, *stokes=IQUV*, *outerfile=model_data*, *niter=2000*, *threshold=0.8* mJy, *mask=input_mask*, *imagermode=csclean*, *restoringbeam=[0.65,0.65,0.0deg]*.
- 2) Make separate images in each Stoke. Task *immath*, *expr=IM0*, *stokes=I*, then change the *stokes* successively to Q, U, V and run the task for each one of them.
- 3) Repeat the above step for the second image.
- 4) Fit one or more Gaussian components to the images. This task runs in each image created in steps 2 and 3. First, for point sources. Task *imfit*, *box=63,54,74,64*, *stokes=I*. Change the *stokes* successively for the other components.
- 5) Fit Gaussian components to the extended source. Task *imfit*, *box=231,367,252,391*, *stokes=I*. Change the *stokes* successively for the other components.
- 6) Fit Gaussian components to the point double sources. Task *imfit*, *stokes=I*, *box=203,657,221,671*. Change the *stokes* successively for the other components.

Alternate Course:**Post-conditions:**

- 1) Integrated flux of point source I, second image should be about 1.0 Jy, nearly unresolved.
- 2) Integrated flux of point source Q, second image should be about 0.1 Jy, nearly unresolved.
- 3) Integrated flux of point source U, second image should be about -0.08 Jy, nearly unresolved.
- 4) Integrated flux of point source V, second image is pure noise.
- 5) Integrated flux of extended source I, first image should be about 0.5 Jy, size 1.5" x 0.5" in position angle of 30°.
- 6) Integrated flux of point double sources, first image should be 0.2 and 0.4 Jy.



UC-01: Narrow field imaging of extended sources with single polarization

Description:

This case uses a VLA data set from the HII region NGC 7538. Six fields are observed using an array of 27 antennas with two spectral windows and two single polarization setups across 63 channels.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	63	23691.4682	97.65625	6152.34375	23694.4955	RR
1	63	23719.6063	97.65625	6152.34375	23722.6336	LL

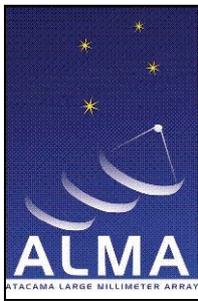
Field	Name	RA	Dec	Epoch	Description
0	1328+307	13:28:49.65	+30.45.58.64	B1950	phase calibrator
1	2229+695	22:29:11.65	+69.31.02.64	B1950	flux calibrator
2	NGC7538C	23:11:53.58	+61.10.54.10	B1950	source
3	NGC7538D	23:11:35.07	+61.10.39.70	B1950	continuum, line source
4	NGC7538E	23:11:25.98	+61.11.06.10	B1950	source
5	NGC7538F	23:11:27.11	+61.12.13.30	B1950	source

Performance:

Non-interactive execution time is estimated to be:
Execution time: 406.99 s

Pre-conditions:

- 1) CASA 3.0 or later is installed in the system.
- 2) Data is available in the current directory.



Basic Course:

- 1) Import VLA data into a CASA measurement set. Task: *importvla*, *bandname* = K, *frequencytol* = 10000000.0.
- 2) Automatic flagging of bad data. Flags all autocorrelation data in the measurement set automatically. Task: *flagautocorr*.
- 3) Get a list of the data set objects and properties. Task *listobs*.
- 4) Fill the model column for flux density calibrators. For this particular data set we use the flux density of 1328+307 in field 0. Task: *setjy*.
- 5) Determine temporal gains from calibrator observations. In this case we use fields 0 and 1, which are 1328+307 and 2229+695 and reference antenna VA19. Task: *gaincal*.
- 6) Calculate a bandpass calibration solution using the calibrator from field 0. Task: *bandpass*.
- 7) Bootstrap the flux density scale from standard calibrators. After running *gaincal* on standard flux density calibrators and other calibrators with unknown flux densities, *fluxscale* will determine the flux density of the unknown calibrators that are most consistent with the standard calibrator antenna gains. In this case we use 1328+307 as the reference. Task *fluxscale*, *reference*=1328+307, *transfer*=2229+695.
- 8) Apply calibration solutions to raw data. We apply to fields 1 through 5. Task *applycal*.
- 9) Split the measurement set in five tables for the flux calibrator, continuum source, mf, continuum, line data and bandpass calibrator. Task *split*.
- 10) Deconvolve the images from each split table. Run the task once for each split table and save a new image. Task *clean*, *mode*=channel, *psfmode*=hogbom.

Alternate Course:

- 1) Run *clean* to create images for the calibrators.

Post-conditions:

- 1) Two images are available as a result of the deconvolution processes; continuum and line source images. Expected values are: calibration maximum amplitude 2.41347932816; source maximum amplitude 18.3368988037; image maximum 0.262860178947; image RMS 0.0127357998863.
- 2) Regression tests pass if the absolute difference between the new values and the reference values, divided by the reference values is smaller than 0.05.



UC-02: Narrow field imaging of two VLA configurations on very extended sources with full polarization

Description:

This end-to-end test describes the data reduction of VLA B- and C-configurations of continuum polarimetry data at 5 GHz with full polarization.

The science target is 3C129, a radio galaxy and the calibrators are: a) 0420+417, observed alternately with 3C129, b) 0518+165 (3C138), for flux density/poln p.a., c) 0134+329 (3C48), for flux density/poln p.a.. The observing modes are: two 50 MHz continuum (single channel) sub-bands at 4585.1 and 4885.1 MHz and full polarization: RR, RL, LR, LL.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	1	4885.1	50000	50000	4885.1	RR RL LL LR
1	1	4585.1	50000	50000	4585.1	RR RL LL LR

B-configuration

Field	Name	RA	Dec	Epoch	Description
0	2345-167	23:45:27.68	-16:47:52.60	B1950	flux calibrator
1	A2597	23:22:43.70	-12:23:56.00	B1950	other source
2	0420+417	04:20:27.93	+41:43:08.04	B1950	bandpass calibrator
3	3C129	04:45:31.69	+44:55:19.95	B1950	extended source
4	0518+165	05:18:16.53	+16:35:26.90	B1950	phase calibrator
5	0134+329	01:34:49.83	+32:54:20.52	B1950	phase calibrator

C-configuration

Field	Name	RA	Dec	Epoch	Description
0	0134+329	01:34:49.83	+32:54:20.52	B1950	phase calibrator
1	0420+417	04:20:27.93	+41:43:08.04	B1950	bandpass calibrator
2	0518+165	05:18:16.53	+16:35:26.90	B1950	phase calibrator
3	3C129	04:45:31.69	+44:55:19.95	B1950	extended source

**Performance:**

Non-interactive execution time is estimated to be:

Execution time: 2353.10 s

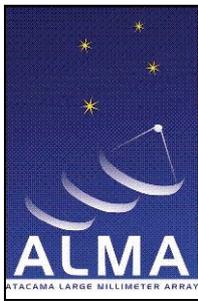
Pre-conditions:

- 1) CASA 3.0 or later is installed in the system.
- 2) Data is available in the current directory.

Basic Course:

For each of the two VLA configurations B and C, the steps are:

- 1) Import VLA data into CASA measurement set. Task *importvla*, *bandname* = C, *evlabands* = F.
- 2) Get information about the sources, fields, etc. Task *listobs*.
- 3) Set the flux density calibrator total intensity models. In this specific case the sources are resolved, so we use model images provided by the VLA. For field 0518+165 we use the model image 3C138_C.im and for field 0134+329 we use model 3C48_C.im. Task *setjy*.
- 4) Plot the data to identify and mark the bad regions. Task *plotms*.
- 5) Solve for gain on calibrators. Reference antenna is VA12 and parallactic angle calibration is applied on the fly. Chosen fields are 0420+417, 0518+165 and 0134+329. Task *gaincal*, *parang*=True, *refant*=VA12.
- 6) Scale gain solution from 0420+417 according to flux density calibrators. The references are 0518+165 and 0134+329. Task *fluxscale*.
- 7) Plot the rescaled table created in previous step and examine the solutions. Note that the gain amplitudes are now constant. Task *plotcal*.
- 8) Solve for instrumental polarization (D term) on 0420+417 and also for source polarization. We use the gain table (from step 5) instead of the flux table because the model is still 1.0 Jy. Task *polcal*.
- 9) Set full polarization model for 0518+165, once for each spectral window. Task *setjy* is executed first with *spw*=0, and using flux densities I=3.688, Q=0.380, U=-0.153, and V=0.0. Then with *spw*=1 using flux densities I=3.862, Q=0.397, U=-0.161, and V=0.0.
- 10) Solve for polarization position angle (X term) on 0518+165. We now use as gain tables the flux table (step 6) and the instrumental polarization table (step 8). Gain fields are 0518+165 and 0420+417. Task *polcal*, *poltype*=X.



- 11) Apply calibration solutions to raw data keeping the parallactic angle as true. Task applycal.
- 12) Deconvolve the source image by applying different PSF algorithms to compare the results.
 - a) a simple clean using Hogbom as the PSF mode. This will clean the IQUV planes consecutively;
 - b) clean using PSF mode Cotton-Schwab;

NOTE: Run the same steps above on the C configuration data. When finished, continue with the following steps for imaging the combination of the B and C configurations.

- 13) Extract the data from B and C data sets. Task split.
- 14) Combine the two extracted sets into one. Task concat.
- 15) Deconvolve the joint data. Task clean using either one of the following:
 - a) *psf* = hogbom, *threshold* = 0.08 mJy; this will clean the IQUV planes consecutively.
 - b) *psf* = clark and *imagermode* = csclean, *threshold* = 0.16 mJy, which will do a joint IQUV deconvolution.
- 16) Extract I, Q, U and V images with task immath.
- 17) Form polarization intensity and angle also with immath.
- 18) Create a complex linear polarization for display.

Alternate Course:

- 1) Flag bad data manually after identifying the bad regions on a plot. Task flagdata, *mode*=manualflag.
- 2) Run clean with different weights.
- 3) Another variation is to set up clean boxes around the emission using the parameter *mask*:
[992, 988, 1172,1139], [1029,1053,1212,1222]
[1029,1081,1299,1222], [1065,1158,1397,1409]
[1237,1153,1612,1583]
- 4) Deconvolve the calibrators as an optional step. Task clean.

Post-conditions:

- 1) An image of the two B and C configurations is available as a result of the deconvolution process.
- 2) Analyze the images for the following questions:
 - a) Do calibrator polarizations come out correctly?
 - b) Is the structure of the calibrator as expected?
 - c) Is the image of 3C129 good?



CASA Regression Tests Use Cases

Doc #:
Date: 2010-03-11
Status: development
Page: 13 of 29

- 3) The non-interactive clean from step 15 can give S/N ratio of about 850. By using custom boxes and cleaning deeper, it should be possible to reach a dynamic range of over 1000.



UC-03: Mosaicing small angular-size sources with dual polarization

Description:

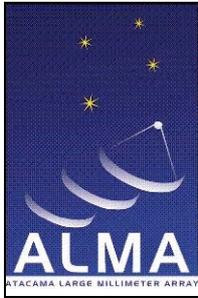
The data set is a VLA SiO Mosaic of a YSO in NGC 1333 consisting of 10 source fields in an almost linear array oriented SE-NW. Two spectral windows are centered on red and blue-shifted emission peaks. The central field is also observed in two spectral windows centered on red and blue-shifted emission peaks.

The NGC 1333 mosaic was observed on 2 separate days: 2 May 2003 and 8 May 2003. The quality of the second data set is significantly worse and does not add much to the image. Observations are of shocked SiO (1-0) emission in a bipolar outflow (~ 43 GHz, VLA Q band receivers). There is no detectable continuum emission in this data. There are two overlapping spectral windows with starting frequencies of 43.4197 GHz and 43.4224 GHz. No tipping scans were done during this observation so we cannot do an opacity correction during the gain calibration. 16 fields were observed with the following setup.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	63	43416.2392	97.65652	6250	43419.2666	RR LL
1	63	43418.9887	97.65652	6250	43422.0161	RR LL

Field	Name	RA	Dec	Epoch	Description
0	0336+323_1	03:36:30.10	+32:18:29.34	J2000	flux calibrator
1	03289+31146	03:28:55.40	+31:14:35.28	J2000	source
2	03290+31145	03:28:57.57	+31:14:29.35	J2000	source
3	03290+31144	03:28:59.74	+31:14:23.42	J2000	source
4	03290+31143	03:29:01.92	+31:14:17.49	J2000	source
5	03291+31142	03:29:04.09	+31:14:11.57	J2000	source
6	0336+323_2	03:36:30.10	+32:18:29.34	J2000	flux calibrator
7	03289+31146	03:28:55.40	+31:14:35.28	J2000	source
8	03289+31147	03:28:53.22	+31:14:41.20	J2000	source
9	03289+31148	03:28:51.05	+31:14:47.13	J2000	source
10	03288+31149	03:28:48.87	+31:14:53.05	J2000	source
11	03288+31150	03:28:46.70	+31:14:58.98	J2000	source
12	0542+498_1	05:42:36.13	+49:51:07.23	J2000	flux calibrator
13	0542+498_2	05:42:36.13	+49:51:07.23	J2000	flux calibrator
14	0319+415_1	03:19:48.16	+41:30:42.10	J2000	bandpass calibrator
15	0319+415_2	03:19:48.16	+41:30:42.10	J2000	bandpass calibrator

**Performance:**

Non-interactive execution time is estimated to be:

Execution time: 3224.50 s

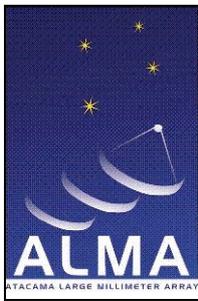
Pre-conditions:

- 1) CASA 3.0 or later is installed in the system.
- 2) Data is available in the current directory.

Basic Course:

For each observing day, the steps are:

- 1) Import data from FITS into CASA measurement set. Task *importuvfits*.
- 2) Get information about the sources, fields, etc. Task *listobs*.
- 3) Flag the bad data. Information on bad data can come from different sources: observation log, test report, etc. Here we get the information from a test report. We flag data with antenna ID 8; flag all data whose amplitude are not in a certain range; flag bad data in a time range and flag all antenna 14 and 15 data in the stated time range. Task *flagdata*, *mode=manualflag*:
- 4) Set the fluxes of the primary calibrators, namely fields 0542+498_1 and 0542+498_2. Task *setjy*, *modimage=modelim*
- 5) Solve for gain calibration using fields 0, 12 and 14. The reference antenna is VA27. Task *gaincal*, *field = 0,12,14*.
- 6) Solve for gain calibration using fields 6, 13 and 15. Task *gaincal*, *field = 6,13,15*.
- 7) Calculate a bandpass calibration solution using field 0 and the gain table from step 5. Task *bandpass*, *field=0*, *spw=0*.
- 8) Calculate bandpass again for field 6 using gain table from step 6. Task *bandpass*, *field=6*, *spw=1*.
- 9) Bootstrap the flux scale. Transfer the flux density from flux calibrator to gain calibrators. In the first step we use 0542+498_1 as the reference and 0336+323_1 and 0319+415_1 as the fields with unknown flux densities. Task *fluxscale*.
- 10) In the second bootstrap, the reference is 0542+498_2 and the transfer fields are 0336+323_2 and 0319+415_2. Task *fluxscale*.
- 11) Apply the calibration solutions from first calibrator using tables from steps 7 and 9. Task *applycal*, *field=0~5*, *spw=0*, *gainfield=0*.
- 12) Apply the calibration solutions from second calibrator using tables from steps 8 and 10. Task *applycal*, *field=6~11*, *spw=1*, *gainfield=6*.
- 13) Split out the corrected data of the source (choose CORRECTED_DATA column). Task *split*, *field=1~5,7~11*, *spw=0;1:0~62*.



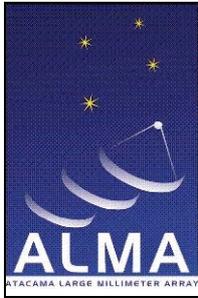
- 14) Split out the first calibrator. Task *split*, *field=0*, *spw=0:0~62*.
- 15) Split out the second calibrator. Task *split*, *field=6*, *spw=1:0~62*.

NOTE: Run the above steps on the second data set from 8 May 03. Once finished, continue with the following steps.

- 16) Merge the two split measurement sets into one output data set. Use the MS created in step 13 of each observing data set. Task *concat*, *freqtol=10MHz*, *dirtol=1arcsec*.
- 17) Imaging using mosaic. There are 63 channels in each spectral window with about 30 channels of overlap, therefore there are about 96 total independent channels. The task will figure out how the windows overlap and will place them properly on the grid. Set the total mosaic size with *nx*, *ny*; starting with the third channel (2), make 18 channels with 5-channel averaging. The mosaic phase centre is in field 0. Use both spectral windows. Main parameters of task *clean*, *imsize=[800,800]*, *niter=1*, *field=0~9*, *spw=0~1*, *imagermode=mosaic*, *ftmachine=mosaic*.
- 18) Calculate moments from the image. We compute four moments, which are: i) integrated value of the red spectrum; ii) integrated value of the blue spectrum; iii) integrated value of both windows and iv) intensity weighted coordinate of both windows. Task *immoments*.

Post-conditions:

- 1) A mosaic image is available as a result of the deconvolution process.
- 2) Statistical values are expected to be (for averaged channels): a) 2 May set: field 0 calibration maximum amplitude 4.427; field 6 calibration maximum amplitude 3.978; source maximum amplitude 3.091; b) 8 May set: field 0 calibration maximum amplitude 5.988; field 6 calibration maximum amplitude 7.232; source maximum amplitude 8.823; c) 0th moment image maximum 0.7339; 0th moment image rms 0.07303.
- 3) Regression tests pass if the absolute difference between the new values and the reference values, divided by the reference values is smaller than 0.05.



UC-04: HI Line data of a spiral galaxy with dual polarization

Description:

This use case refers to one day of observing spanning four VLA archive files of the spiral galaxy NGC 2403. The data set have observations of 5 fields with one spectral window and one polarization setup, taken with an array of 27 antennas.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	127	1481.25202	24.41	3100.57563	1419.79008	RR LL

Field	Name	RA	Dec	Epoch	Description
0	NGC2403	07:36:54.50	+65.35.20.00	J2000	source
1	0137+331	01:37:41.29	+33.09.35.13	J2000	flux calibrator
2	0841+708	08:41:24.36	+70.53.42.17	J2000	flux calibrator
3	0542+498	05:42:36.13	+49.51.07.23	J2000	flux calibrator
4	1331+305	13:31:08.28	+30.30.32.96	J2000	flux calibrator

Performance:

Non-interactive execution time is estimated to be:

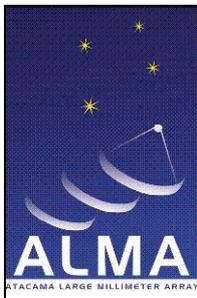
Execution time: 4312 s

Pre-conditions:

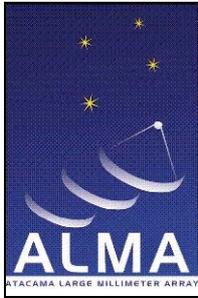
- 1) CASA 3.0 or later is installed in the system.
- 2) Data is available in the current directory.

Basic course:

- 1) Import VLA data into CASA measurement set. Task *importvla*.
- 2) Get information about the sources, fields, etc. Task *listobs*.
- 3) Plot calibrator data (fields 1 through 4) and check if flagging is necessary. In this case no flagging is needed. We plot the average over all channels, except for the edge channels. Task *plotms*.



- 4) Plot the source visibilities (field 0), one correlator at a time. RR correlator shows one bad time interval. Click “Mark”, draw a rectangle around the bad data and click “Flag” to flag the bad data. We plot the average over all channels, except for the edge channels. Task *plotms*.
- 5) Do the same for the LL correlator. One bad point is visible in the upper right corner, which needs to be flagged. Task *plotms*.
- 6) Fill the model column for flux density calibrators. Fields 1, 3 and 4 contain the flux/bandpass calibrators. Task *setjy*, *spw=0:5~112*, we ignore the edge channels.
- 7) Create user-defined table containing antenna gain solutions, once for each calibrator (fields 1, 2, 3 and 4) since uv ranges are different. Task *gaincal*, use *append=False* for the first run. Then, repeat with *append=True* to have all solutions in only one table.
- 8) Bootstrap the flux of the phase calibrator 0841+708 using the flux/bandpass calibrators in fields 1, 3 and 4. Task *fluxscale*, *transfer=2*.
- 9) Calculate a bandpass calibration solution. Task *bandpass*, *field=1,3~4*.
- 10) Apply calibrations created in steps 8 and 9 to source data. They will be written into the CORRECTED_DATA column. Task *applycal*, *gainfield=1,4*.
- 11) Plot a few channels to check for unflagged bad data. In this particular case, use channel 50. We also see that antenna 0 (LL) is bad throughout the whole observation. Task *plotms*, *spw=0:50*, *correlation=''*, *width=1*.
- 12) Flag bad data manually. Task *flagdata*:
 - a) *mode=manualflag*, *spw=0*, *timerange=03:52:44~03:52:46*, *correlation=RR*.
 - b) *mode=manualflag*, *spw=0*, *timerange=''*, *correlation=LL*, *antenna=0*.
- 13) Plot data again and check if additional flagging is needed. Check one or more individual channels instead of averaging over them. This shows that additional flagging is necessary. Make sure to apply flags seen in one channel to all channels. Tasks *plotms*, *extendflag=True*, *extendchan=all*.
- 14) Repeat step 11 and verify if all necessary flagging has been done.
- 15) Split the source data only (field 0). Task *split*, *field=0*.
- 16) Fit a continuum using line-free regions on both ends of the spectrum and subtract it from the data. Earlier inspection of the data shows where to find the line-free channels. Task *uvcontsub*, *field=0*, *fitspw=0:21~30;92~111*.
- 17) Make a “dirty image” without any cleaning. We image only channel 32, which is line-free and has not been used to calculate the continuum in step 13. This will provide us with an estimate of the rms noise of channels with line emission. Task *clean*, *niter=0*, *nchan=1*, *start=32*, *field=0*, *spw=0*.
- 18) Determine the rms in channel 32. Task *imstat*.
- 19) Image and clean all channels. The threshold here is set to 2 times the rms calculated in step 17. Task *clean*, *niter=100000*, *threshold=1.2*.
- 20) Determine useful statistics on image. Specifically, we are interested in the maximum and sigma values in off-source boxes and rms of line-free channels (in this case they are 0 through 3). Task *imstat*.
- 21) Make a total HI map. We calculate the 0th moment (total HI map) and the 1st moment (velocity field) of the image. For better results, we use the rms calculated for line-



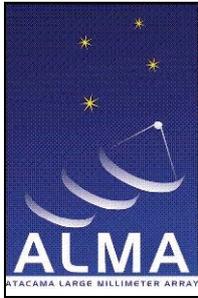
free channels in step 17. This will exclude pixels falling in this interval as given by the $\text{cutoff}=3*\text{rms}$ (in Jy). Task *immoments*, *chans=4~56*, *excludepix = [-100, cutoff]*.
22) Visualize the two moments. Task *viewer*.

Alternate course:

- 1) Instead of flagging bad data interactively, use “Locate” in *plotms* to determine which baselines and/or antennas need flagging and over which time range. Task *flagdata*, *mode=manualflag*, setting *antenna* and *timerange* as needed.
- 2) Calibration solutions can be visualized using the task *plotcal*.
- 3) After step 19, it is recommended to verify the header of the image using *imhead*, and check the axis order (RA, DEC, Stokes, Frequency). This information is useful when selecting a subset of the image cube.

Post-conditions:

- 1) Plot the bandpass calibration data from step 9 and note the galactic absorption in the first two fields. Only field 4 is free of absorption. Task *plotcal*, *xaxis=chan*, *yaxis=amp*, *antenna=25*, *iteration=field*, *field=1,3~4*.
- 2) One final image is available as a result of the deconvolution process in step 19.
- 3) Canonical values are listed as: dirty image rms 0.000588262734707; clean image maximum 0.0231359191239; clean image off-source rms 0.000533470036927; clean image off-line rms 0.000515150649237; clean 0th moment maximum 0.551860868931; clean 0th moment rms 0.0878139138222; clean 1st moment median 129.940628 (in BARY).
- 4) Regression tests pass if the differences between new and canonical values are inside a given tolerance of about 0.1.



UC-05: Primary beam rotation effects using wide-field polarimetry

Description:

This use case refers to the data set of the edge-on galaxy IC 2233, taken with the VLA array of 28 antennas. The data set has one spectral window and one polarization setup in 86 channels. Only one field is present in the data set.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	86	1416.8847	24.4140	099.6095	1417.91009	RR LL

Field	Name	RA	Dec	Epoch	Description
0	IC2233	08:13:58.80	+45.49.36.30	J2000	source

As opposed to most of the other use cases in this document, the basic course followed here uses CASA tools instead of tasks.

Performance:

Non-interactive execution time is estimated to be:
Execution time: 5727 s

Pre-conditions:

- 1) Data is previously calibrated.
- 2) CASA version 3.0 or later is available in the system.
- 3) Data is available in the current directory.

Basic course:

- 1) Create a CASA measurement set from a UV FITS file. Tool *im.fromfits*.



- 2) Open and select visibilities for subsequent processing. Tools *im.open* and *im.selectvis* with *nchan=11*. We avoid channels that contain lines and problems with Gibbs ringing effects.
- 3) Set the image parameters for subsequent processing. Tool *im.defineimage*, *nx=2048*, *ny=2048*.
- 4) Set general options for further processing. Tool *im.setoptions*, using the parameters *cache=4*nx*ny*, *pastep=360.0*, *ftmachine=pbwproject*; this parameter sets the Fourier transform machine to use.
- 5) Calculate a deconvolved image. Tool *im.clean*, *algorithm=cs*, *niter=6000*.

Alternate course:

- 1) Import the UV FITS file into a CASA measurement set. Task *importuvfits*.
- 2) Deconvolve the image for all channels. Task *clean*, TBD.

Post-conditions:

- 1) Display the images created in both courses and compare the differences.
- 2) Reference statistical values are: Stokes I peak 0.86264914 Jy/beam; Stokes I rms 0.00138987 Jy/beam; Stokes I peak position [942,1130,0,0] pixels; Stokes V peak 0.0006167 Jy/beam; Stokes V rms $5.06523975 \times 10^{-5}$ Jy/beam; stokes V peak position [1415,1008,1,0] pixels.
- 3) Regression tests pass if the absolute difference between new and reference values is smaller than 10^{-5} ;



UC-06: Wide-field imaging with outliers check

Description:

This use case shows the procedure to create a wide-field image from five different pointings. The data comes from VLA continuum data, L-band in A-configuration with 27 antennas, which was put together with a wide-field model with added Gaussian noise. There is only one field and the data has already been calibrated.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	1	1464.9	50000	50000	1464.9	RR RL LR LL
1	1	1385.1	50000	50000	1385.1	RR RL LR LL

Field	Name	RA	Dec	Epoch	Description
0	WR125	19:28:15.57	+19.33.25.10	J2000	source

Outliers table containing five pointings

ID	size	RA	Dec
0	128,128	19:28:13.448	19:33:45.10
1	128,128	19:27:26.046	19:26:45.10
2	128,128	19:28:36.794	19:41:45.10
3	128,128	19:31:12.444	19:26:45.10
4	128,128	19:28:19.461	19:31:45.10

Performance:

Non-interactive execution time is estimated to be:

Execution time: 1400 s



Pre-conditions:

- 1) Data is previously calibrated
- 2) CASA 3.0 or later is installed in the system.
- 3) Data is available in the current directory.

Basic course:

- 1) Import UV FITS data into CASA measurement set. Task *importuvfits*.
- 2) Get information about the sources, fields, etc. Task *listobs*.
- 3) Create a wide-field image with a size that is sufficient to cover all the outliers. Task *clean* using: *gridmode=widefield*, *outlierfile=outliers.txt*, containing outliers names, sizes and centers, *wprojplanes=* reasonable value (minimum is 16; see cookbook), *imsize=4096*, *weighting=briggs*, *niter=500*.

Alternate course:

- 1) Create five images, one for each pointing given in the outliers file. One can compare the five images with the wide-field image created in step 3. Task *clean*, *outlierfile=outliers.txt*, *imsize=128*, *gridmode=""*.

Post-conditions:

- 1) One wide-field image is available as a result of the deconvolution process. If alternate course is taken, five images are created after running *clean*.
- 2) TBD regression test values.



UC-07: Single and multi-scale imaging of 3C219

Description:

This use case refers to the VLA data of the radio galaxy 3C219, taken with an array of 26 antennas in D configuration, with 2 spectral windows, one channel and one polarization setup. The data has been previously calibrated.

Summary of observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	1	8435.1	50000	50000	8435.1	RR RL LR LL
1	1	8435.1	50000	50000	8435.1	RR RL LR LL

Field	Name	RA	Dec	Epoch	Description
0	0917+449	09:17:41.91	+44.54.39.62	B1950	flux calibrator
1	3C219	09:17:50.42	+45.51.40.40	B1950	source
2	3C219NE	09:17:53.50	+45.52.33.00	B1950	source
3	3C219SW	09:17:47.70	+45.51.08.00	B1950	source
4	1328+307	13:28:49.65	+30.45.58.64	B1950	phase calibrator

Performance:

Non-interactive execution time is estimated to be:

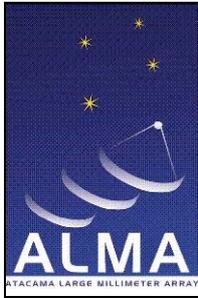
Execution time: 300 s

Pre-conditions:

- 1) Data is previously calibrated.
- 2) CASA 3.0 or later is installed in the system.
- 3) Data is available in the current directory.

Basic course:

- 1) Import UV FITS data into CASA measurement set. Task *importuvfits*.
- 2) Get information about the sources, fields, etc. Task *listobs*.



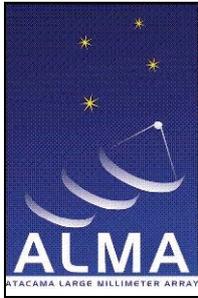
- 3) Change data equinox to J2000. Task *fixvis*.
- 4) Create image of one field using single scale. Task *clean*, *niter*=4000, *field*=1.
- 5) Mosaic of 3 fields using single scale. Task *clean*, *imagermode*=mosaic, *niter*=4000, *field*=1,2,3.

Alternate course:

- 1) Create image of one field using multi-scale. Task *clean*, *multiscale*=[0,5,15], *niter*=4000, *field*=1.
- 2) Mosaic of 3 fields using multi-scale. Task *clean*, *multiscale*=[0,5,15], *imagermode*=mosaic, *niter*=4000, *field*=1,2,3.
- 3) Use multi-scale *clean* with larger beams and compare.

Post-conditions:

- 1) The mosaic mode in *clean* gives better results than the default mode. The use of single and multi-scale do not change much the results for this data set. In this case, choose single-scale as multi-scale cleaning is currently slower.
- 2) If multi-scale is used with larger beams, does it give better results?
- 3) TBD regression tests values.



UC-08: Mosaic of NGC 4826

Description:

This use case refers to the VLA data of the spiral galaxy NGC 4826 from the BIMA Survey of Nearby Galaxies (BIMA SONG). The data consist of two observing nights of three fields including calibrators and source (fields 2-8) with 5 and 6 spectral windows, respectively.

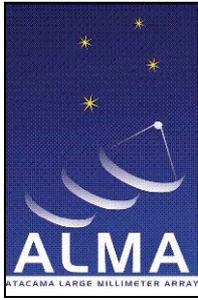
Summary of 1st night observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	1	115219.429	800000.072	800000.072	115271.2	YY
1	64	114950.382	1562.5	100000	115271.2	YY
2	64	115040.397	1562.5	100000	115271.2	YY
3	64	115130.137	1562.5	100000	115271.2	YY
4	64	115220.153	1562.5	100000	115271.2	YY

Summary of 2nd night observed data

Spw	Channels	Ch1 (MHz)	Channel Width (kHz)	Tot BW (kHz)	Ref (MHz)	Corrs
0	1	115138.579	400000.006	400000.006	115271.2	YY
1	1	115217.017	800000.072	800000.072	115271.2	YY
2	64	114950.387	1562.5	100000	115271.2	YY
3	64	115040.402	1562.5	100000	115271.2	YY
4	64	115130.143	1562.5	100000	115271.2	YY
5	64	115220.157	1562.5	100000	115271.2	YY

Field	Name	RA	Dec	Epoch	Description
0	3C273-F0	12:29:06.69	+02.03.08.59	J2000	flux calibrator
1	1230+123-F0	13:10:28.66	+32.20.43.78	J2000	calibrator 1 st night
	1310+323-F0	12:30:49.42	+12.23.28.04		calibrator 2 nd night
2	NGC4826-F0	12:56:44.24	+21.41.05.10	J2000	source
3	NGC4826-F1	12:56:41.08	+21.41.05.10	J2000	source
4	NGC4826-F2	12:56:42.66	+21.41.43.20	J2000	source
5	NGC4826-F3	12:56:45.81	+21.41.43.20	J2000	source
6	NGC4826-F4	12:56:47.39	+21.41.05.10	J2000	source
7	NGC4826-F5	12:56:45.81	+21.40.27.00	J2000	source
8	NGC4826-F6	12:56:42.66	+21.40.27.00	J2000	source

**Performance:**

Non-interactive execution time is estimated to be:

Execution time: 1002.47 s

Pre-conditions:

- 1) Data is previously imported into a CASA measurement set.
- 2) CASA 3.0 or later is installed in the system.
- 3) Data is available in the current directory.

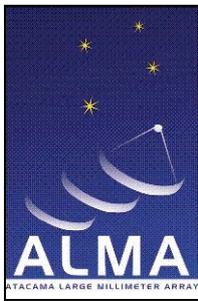
Basic course:

NOTE: Steps for first observing night.

- 1) Reinitialize the calibration for this visibility data set. Task *clearcal*.
- 2) Get information about the sources, fields, etc. Task *listobs*.
- 3) Set the flux density of the calibrator to 23 Jy. Task *setjy*, *field=0*, *fluxdensity = [23.0,0.,0.,0.]*.
- 4) Flag bad data non-interactively. Task *flagdata*, *mode=manualflag*, *clipexpr=ABS YY*, *clipminmax=[0.0,80.0]*, *clipoutside=True*.
- 5) Solve for gain calibration. Task *gaincal*, *field=0,1*, *refant=ANT5*, *solint=inf*, *minsnr=2.0*.
- 6) Transfer the flux density scale. Task *fluxscale*, *reference = 3C273-F0*, *transfer = 1230+123-F0*.
- 7) Correct the calibrator and target source data. Task *applycal*, *spw= 0*, *field=1*. For the source, *applycal*, *field=2~8*.
- 8) Split the calibrator and source data into separate MS. Task *split*.
- 9) Image the calibrator. Task *clean*, *field=0*, *spw=0*, *threshold=10.*, *ftmachine=ft*, *niter=100*, *stokes=I*.
- 10) Image the target source mosaic. Task *clean*, *imsize = [256,256]*, *spw=0,1,2*, *field=0,1,2,3,4,5,6*, *ftmachine = mosaic*, *imagermode = mosaic*, *scaletype = SAULT*, *niter = 300*, *pbcor = False*, *minpb=0.01*, *cyclefactor=0.01*.
- 11) Export the image to a FITS image. Task *exportfits*.

NOTE: Steps for second night.

- 12) Reinitialize the calibration for this visibility data set. Task *clearcal*.
- 13) Get information about the sources, fields, etc. Task *listobs*.
- 14) Set the flux density of the calibrator to 23 Jy. Task *setjy*, *field=0*, *fluxdensity = [23.0,0.,0.,0.]*.



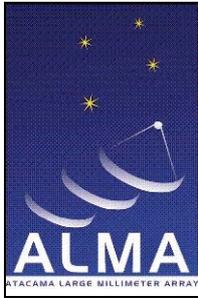
- 15) Flag bad data non-interactively. Task *flagdata*, *mode=manualflag*, *spw=2~5:0;1;62*.
- 16) Solve for gain calibration. Task *gaincal*, *field=0,1*, *refant=ANT5*, *solint=inf*, *minsnr=2.0*.
- 17) Transfer the flux density scale. Task *fluxscale*, *reference = 3C273-F0*, *transfer = 1310+323-F0*.
- 18) Correct the calibrator and target source data. Task *applycal*, *spw= 1*, *field=1*. For the source, *applycal*, *field=2~8*, *spw=2~5*, use *spwmap* to apply gain solutions derived from *spw1* to all *spwd*, *spwmap=[1]*.
- 19) Split the calibrator and source data into separate MS. Task *split*.
- 20) Do an extra flagging on the split source MS. Task *flagdata*, *clipexpr = ABS I*, *clipminmax = [0.0,0.0]*, *clipoutside = True*, *antenna = 5*, *unflag = False*, *timerange = 1998/04/16/09:42:39.0~1998/04/16/10:24:46.0*.
- 21) Image the calibrator. Task *clean*, *field=0*, *spw=0*, *threshold=10.*, *ftmachine=ft*, *niter=100*, *stokes=I*.
- 22) Image the target source mosaic. Task *clean*, *imsize = [256,256]*, *nchan=30*, *start=47*, *width=4*, *spw=0~2*, *field=0~6*, *ftmachine = mosaic*, *imagermode = mosaic*, *scaletype = SAULT*, *cyclefactor=3*, *niter = 300*.
- 23) Export the image to a FITS image. Task *exportfits*.
- 24) Concatenate both source visibility sets into a single MS. Task *concat*, *frequol = 50 MHz*.
- 25) Image the combined visibility set. Task *clean*, *nchan=30*, *start=46*, *width=4*, *spw=0~2*, *field=0~6*, *imsize=[256,256]*, *imagermode=mosaic*, *ftmachine=mosaic*, *niter=500*, *scaletype=SAULT*, *cyclefactor=3*.
- 26) Calculate moments from the image. 0th moment with tool *ia.open*, *ia.moments*, *moments=0*, *axis=3*, *includepix=[0.070,1000.0]*, *mask=indexin(3,[3:24])*.
- 27) Calculate the 1st moment from the image. Tool *ia.moment*, *moments=1*, *axis=3*, *includepix=[0.007,1000.0]*, *mask=indexin(3,[3:24])*; *ia.close*.
- 28) Export the combined image to a FITS image. Task *exportfits*.

Alternate course:

- 1) Run *clean* in steps 10, 22 and 25 with parameter *ftmachine=ft* for a more traditional image plane mosaicing.

Post-conditions:

- 1) The following are reference statistical values for calibrators and images: a) mean amplitude of 1st night calibrator 10.51; b) mean amplitude of 1st night source 111.52; c) mean amplitude of 2nd night calibrator 4.3269; d) mean amplitude of 2nd night source 156.992; e) maximum amplitude of mosaic image 168.18; f) mosaic image rms 11.77.
- 2) Tests pass if the absolute difference between reference values and new values, divided by the reference values is smaller than 0.08.



UC-10: Fringing - TBD

Description:

Performance:

Non-interactive execution time is estimated to be:

Execution time:

Pre-conditions:

- 1) CASA 3.0 or later is installed in the system.
- 2) Data is available in the current directory.

Basic course:

- 1) Import UV FITS data into CASA measurement set. Task *importuvfits*.

Alternate course:

Post-conditions: