Capabilities for ALMA Cycle 0

1 Antennas

All proposers should assume that observations in Cycle 0 will utilize sixteen fully operational antennas.

It may be that, due to problems with the equipment or other reasons, the number of antennas available will sometimes be less than 16. In that case the ALMA support staff will endeavor to carry out observations that they believe will not be seriously affected having a slightly smaller number of antennas. The integration times or UV coverage might be increased to compensate where that is practical.

2 Receivers

Bands 3, 6, 7 and 9 will be available on all antennas. For all bands both linear polarizations of the astronomical signals are received and processed separately.

The receivers are based on SIS mixers and there are two types - dual-sideband (2SB), where the upper and lower sidebands are separated in the receiver and then processed separately, and double-sideband (DSB), where the sidebands are super-imposed coming out of the receiver but are separated in later processing.

The frequency ranges and receiver types are shown in Table 1.

Band	Lower frequency [GHz]	Upper frequency [GHz]	Type
3	84	116	2SB
6	211	275	2SB
7	275	373	2SB
9	602	720	DSB

Table 1. Properties of ALMA Cycle 0 Receiver Bands

These are the nominal frequency ranges for continuum observations. Observations of spectral lines that are within about 0.2 GHz of a band edge are not possible at present.

Water Vapor Radiometers will also be available on all antennas. Correction for phase errors due to fluctuations in atmospheric water vapor will be applied when it improves the coherence.

3 Array Configurations

There will be two array configurations available for Cycle 0: Compact and Extended. The Compact configuration is designed to have high brightness-temperature sensitivity and should be used for observations where extended structure is important. The Extended configuration has higher angular resolution and is more suited for the study of objects with higher surface brightness features. These configurations correspond to the following baselines:

- Compact Configuration:
  - Minimum baselines: ~18m
  - Maximum baselines: ~125m
- Extended Configuration:
  - Minimum baselines: ~36m
  - Maximum baselines: ~400m

The Cycle 0 antenna configuration files (Cyc0_comp.cfg and Cyc0_ext.cfg) can be used when simulating ALMA Cycle 0 observations with the CASA Simulator. These configuration files are already incorporated in the web-based Observation Support Tool.

The Notices of Intent for Cycle 0 indicate roughly equal levels of demand for the compact and extended array configurations offered.

The schedule that is currently foreseen for the compact and extended configurations offered for Early Science Cycle 0 is as follows:

- 30 September - 30 November 2011: Extended configuration
- 1 December 2011 - 30 January 2012: Compact configuration
- 1 February - 29 February 2012: Science shutdown over altiplanic winter
- 1 March - 30 April 2012: Compact configuration
- 1 May - 30 June: Extended configuration

This schedule takes into account scientific, engineering and operational factors. It will allow observations in all Right Ascensions for each configuration, and as a result PIs preparing Cycle 0 proposals need not be overly concerned about RA availability.

Prospective PIs are asked to note that this schedule is indicative only, and that Early Science Cycle 0 observing is being offered on a "Best Efforts" basis. The dates and even the approach may be adjusted as necessary, particularly if required to maintain progress towards the completion of the full ALMA observatory.

The properties of the two offered configurations are summarized in Table 2.

Band	Frequency [GHz]	Angular Resolution [“]	Maximum Scale [“]	T_{bc} [mK]	Flux [mJy]	T_{bl} [K]	Field of View [“]
Properties of the Compact Configuration (baselines of ~18 m to ~125 m)							
3	100	5.3	21	0.65	0.14	0.030	62
6	230	2.3	9	1.0	0.20	0.029	27
7	345	1.55	6	1.8	0.37	0.043	18
9	675	0.80	3	15	3.2	0.27	9
Properties of the Extended Configuration (baselines of ~36 m to ~400 m)							
3	100	1.56	10.5	7.6	0.14	0.35	62
6	230	0.68	4.5	11	0.20	0.34	27
7	345	0.45	3.0	20	0.37	0.50	18
9	675	0.23	1.5	175	3.2	3.1	9

Table 2. Properties of ALMA Cycle 0 Array Configurations

In Table 2:

- It is important to note that all these figures are estimates based on simulations and modeling together with test data on individual sub-systems. It has not yet been possible to confirm these figures by testing at system level and until this has been done there remains some uncertainty, especially on the sensitivity values.
- "Angular Resolution" is the FWHM of the synthesized "dirty" beam for a source in the declination range 0° to -40° (outside this range of declination the beam will become somewhat elongated in the North-South direction).
- "Maximum Scale" is the largest angular scale that can be observed effectively. If the objects contain smoothly varying structures that are larger than this in both dimensions, those components will be "resolved out". This is the well known "missing flux" problem intrinsic to interferometry. The limit is taken to be 0.6 × (wavelength/min_baseline), but this is only a guideline. The ALMA Compact Array (ACA) and single-dish observing modes, which will be used to measure these larger scales in the future, are not available for Cycle 0.
- "T_{bc}" is the five-sigma continuum brightness-temperature sensitivity in milli-Kelvin for a 1-hour observation using the full bandwidth (i.e. 7.5 GHz per polarization) in dual polarization mode.
- "Flux" is the five-sigma flux sensitivity in milli-Janskys per beam again for 1-hour of observing with the full continuum bandwidth in dual polarization mode.
- "T_{bl}" is the three-sigma spectral-line brightness-temperature sensitivity in Kelvin for a 4-hour observation with a 1 km/s spectral resolution in dual polarization mode.
- "Field Of View" is the nominal field of view for single-field interferometry. It is taken to be 1.2 × (wavelength/dish diameter) and is therefore close to the FWHM of the primary beam.

4 Correlator Capabilities

The correlator provides a set of spectral "windows" which can be used simultaneously.

For Cycle 0, up to four simultaneous spectral windows are available. The spectral windows must all have the same bandwidth and resolution.

4.1. Polarization

The correlator can process both polarizations or all the resources can be used to analyze a single polarization.

When a Dual Polarization setup is used, separate spectra are obtained for each linear polarization of the input signal. This will give two largely independent estimates of the source spectrum that can be combined to improve sensitivity.

In Single Polarization mode, only a single input polarization ("pol-X") is analyzed. For a given resolution, this provides $\sqrt{2}$ poorer sensitivity than the Dual Polarization case, but one can use either a factor two more bandwidth for the same spectral resolution or a factor of two better spectral resolution for the same bandwidth. Single polarization should therefore be used in cases where having a large number of spectral channels is more important than having the best sensitivity.

4.2. Bandwidth and Resolution

The correlator operates in two main modes - Time Division Mode (TDM) or Frequency Division Mode (FDM).

TDM provides modest frequency resolution and produces a relatively compact data set. It should be used for continuum observations or for spectral line observations that do not require high spectral resolution.

FDM gives high spectral resolution and produces much larger data sets. It should be used for observations of spectral lines in all sources except those with very wide lines. Six FDM set-ups will be available with different bandwidths and resolutions as set out in Table 3.

4.3. Overview

The correlator modes offered for Cycle 0 are summarized in Table 3.

Bandwidth (MHz)	**Channel Spacing (MHz)**	**Number of Channels**	**Correlator Mode**
Correlator Mode properties for Dual Polarization			
2000	15.6	128	TDM
58.6	0.0153	3840	FDM
117	0.0305	3840	FDM
234	0.061	3840	FDM
469	0.122	3840	FDM
938	0.244	3840	FDM
1875	0.488	3840	FDM
Correlator Mode properties for Single Polarization			
2000	7.8	256	TDM
58.6	0.0076	7680	FDM
117	0.0153	7680	FDM
234	0.0305	7680	FDM
469	0.061	7680	FDM
938	0.122	7680	FDM
1875	0.244	7680	FDM

Table 3. Properties of ALMA Cycle 0 Correlator Modes

Notes for Table 3:

- These are the figures for each spectral window and, in the case of dual polarization, for each polarization.
- The "Bandwidth" given here is width of the spectrum processed by the digital correlator. The usable bandwidth is limited to about 1875 MHz by the anti-aliasing filter, which is ahead of the digitizer in the signal path.
- The "Channel Spacing" is the separation between data points in the output spectrum. The spectral resolution - i.e. the FWHM of the spectral response function - is larger than this by a factor that depends on the "window function" that is applied to the data in order to control the ringing in the spectrum. For the default function - the "Hanning" window - this factor is 2, i.e. the effective spectral resolution will be twice the channel spacing given in Table 3.

5 Observational Modes

Two observational modes are offered in Cycle 0: single field interferometry and pointed mosaics.

5.1. Single field interferometry

Single field Interferometry is the standard observing mode in which the antennas track a single pointing position. Observations of phase and amplitude calibrators are included as part of the observing sequence. In addition to objects with fixed RA and Dec, moving targets (including the planets, their major moons, asteroids and comets) can be observed. Observations of the Sun will, however, not be supported in Cycle 0.

5.2. Pointed mosaics

When observing pointed mosaics, the antennas cycle around a series of pointing positions and the interferometric data are combined in post-processing to produce a "mosaic" image. The spatial resolution and largest angular scale will be about the same as for a single field interferometry, i.e. as given in Table 2 and Table 3, but the mosaic image will cover a larger area. In rough terms, the field of view will be increased by a factor equal to the number of pointing positions divided by four. Since the observing time is split between the different pointing positions, the time required to reach a given sensitivity scales with the size of the field of view. There are also some overheads associated with changing the pointing positions that cause a further loss of sensitivity. In Cycle 0 this additional loss is expect to amount to about 10% for 25 points and 20% for 50 points. Mosaics with larger than 50 pointing positions will not be supported in Cycle 0.

The OT will provide the capability to set up suitable patterns of pointing positions.

6 Calibration

Phase calibration is essential for all interferometric observations. It is accomplished by observing suitable sources - i.e. objects that have very small angular sizes and accurately known positions. Positional accuracy of better than $1/10^{th}$ of a synthesized beam-width should be possible on sufficiently bright objects.

Absolute amplitude calibration will be based on observations of objects of known flux, principally solar system objects. It is expected that the accuracy of the absolute amplitude calibration relative to these objects will be better than 5% for Band 3. Calibration in the higher frequency bands is likely to be less accurate. The goals are: better than 10% in bands 6 and 7, and better than 20% in band 9.

The ALMA Observatory has adopted a set of strategies to achieve good calibration of the data. Requests for changes in these strategies will only be granted in exceptional circumstances and must be fully justified by the requester. Some flexibility exists in choosing the actual calibrator sources. The default option is automatic calibrator selection by the system. If users opt for providing their own calibrators, justification will be needed. This may result in decreased observing efficiency and/or calibration accuracy.