Antennas

50x12m-Array
12x7m-Array
4 12m-TP Array
Longest baseline: 16 km
Completed in 2013

What is Interferometry?

In contrast to direct imaging, e.g. with a CCD camera on an optical telescope, an interferometer samples the power spectrum of the sky brightness distribution; this is equivalent to measuring the Fourier transform of the sky. In a single integration (typically a few seconds or less), each pair of antennas, called a baseline, samples a single point in this power spectrum, at a position in Fourier space related to the distance between the pair of antennas and the position angle of the baseline vector. Antennas which are close together (short baselines) sample large-scale angular structure, while long baselines sample very small-scale angular structure. By combining these data, called visibilities, over a large number of baselines (the uv-plane average), the Fourier plane is sampled, which can then be inverted (a Fourier transform) to reconstruct an image. The reconstructed image quality is very sensitive to the uv-coverage — how completely the raw visibility data covers the range of real angular scales on the sky. Even a few minutes of observations with the 43 12 m antennas (903 baselines) available in Cycle 5 provides good coverage. During longer observations, more of the uv-plane is filled in by the rotation and foreshortening of baselines as the Earth rotates on its axis. Antennas are periodically moved (reconfigured) to provide a wide range of array configurations with different baseline lengths; observations with different configurations may be combined to improve the uv-coverage. Furthermore, to recover very large-scale structure, the short spacings gap in the uv-coverage can be filled in by adding ACA observations. For more detailed descriptions of these terms, see the Glossary starting on page 31.
The ALMA front end can accommodate up to 10 receiver bands covering most of the wavelength range from 10 to 0.3 mm (30–950 GHz). Each receiver band is designed to cover a tuning range which is approximately tailored to the atmospheric transmission windows. These windows and the tuning ranges are outlined in Figure 4.1. In Cycle 5, Bands 3, 4, 5, 6, 7, 8, 9, and 10 are available (see available frequency and wavelength ranges for these bands in Table 4.1). The receivers are described in more detail in the following sections as well as in the references listed in Table 4.2.
Executive Summary

The ALMA Director, on behalf of the Joint ALMA Observatory (JAO) and the partner organizations in East Asia, Europe, and North America, is pleased to announce the ALMA Cycle 5 Call for Proposals (CfP) for scientific observations to be scheduled from October 2017 to September 2018.

It is anticipated that 4000 hours of the 12-m Array time and 3000 hours of the Atacama Compact Array (ACA) time, also known as the Morita Array, will be available for successful proposals from Principal Investigators (PIs) in Cycle 5.

Proposals must be prepared and submitted using the ALMA Observing Tool (OT), which is available for download from the ALMA Science Portal (www.almascience.org). Proposals will be assessed by competitive peer review by a single international review committee.

ALMA Cycle 5 proposal submission will open at 15:00 UT on Tuesday, 21 March 2017. The Cycle 5 proposal submission deadline is 15:00 UT on Thursday, 20 April 2017.

Table 1 summarizes these and other important milestones for Cycle 5.

ALMA provides continuum and spectral line capabilities for wavelengths from 0.32 mm to 3.6 mm, and angular resolutions from 0.018" to 3.4" on the 12-m Array. Cycle 5 will bring to ALMA several new observational capabilities, including full polarization observations in Band 4, baselines out to 16 km and simultaneous observations between the 12-m and 7-m Arrays. Starting in March 2018, also as part of Cycle 5, ALMA will offer observations in Band 5 (proposals for the latter observations are due at the regular Cycle 5 submission deadline).

This Proposer's Guide provides an overview of significant changes made in both the technical capabilities and observing strategies for Cycle 5 (Section 2), an overview of the ALMA organization (Section 3), the types of proposals offered in Cycle 5 (Section 4), information on proposal planning (Section 5) and submission (Section 6), an overview of the offered technical capabilities (Appendix A), and guidelines for writing a Technical Justification (TJ, Appendix B).

Table 1: The ALMA Cycle 5 timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 March 2017 (15:00UT)</td>
<td>Release of Cycle 5 Call for Proposals, Observing Tool &amp; supporting documents and opening of the Archive for proposal submission</td>
</tr>
<tr>
<td>20 April 2017 (15:00 UT)</td>
<td>Proposal submission deadline</td>
</tr>
<tr>
<td>End of July 2017</td>
<td>Announcement of the outcome of the proposal review process</td>
</tr>
<tr>
<td>August-September 2017</td>
<td>Submission of Phase 2 Scheduling Blocks</td>
</tr>
<tr>
<td>October 2017</td>
<td>Start of ALMA Cycle 5 Science Observations</td>
</tr>
<tr>
<td>September 2018</td>
<td>End of ALMA Cycle 5</td>
</tr>
</tbody>
</table>
New capability in C5

• Band 4 polarization
• Band 5 observation from March 2018
Proposal Types

• Regular Proposals
  – < 50 hr for 12-m Array, < 150 hr for ACA
• ToO Proposals
• Large Proposals
  – > 50 hr of 12-m and > 150 hr for ACA
  – standard observation mode
• mm-VLBI Proposals
  – GMVA at 3mm (Band 3)
  – NRAO/EHT at 1.3mm (Band 6)
  – March/April, 2018 (compact configuration)
• DDT (Director Discretionary Time) Proposals
Time available for C5 and Regional Share

- Total observation time
  - 4000 hours for 12m Array
  - 3000 hours for ACA Array
  - 20% for non-standard, 5% for Large, 5% for VLBI, 5% for DDT

- Regional Share
  - 22.5% for EA
  - 33.75% for EU
  - 33.75% for NA
  - 10% for Chile
Number of Antennas

• > 43 (40 for C4) antennas in the 12-m array
• Ten 7-m antennas and three 12-m antennas (single-dish observation) in the ACA
Receiver Bands

- Bands 3, 4, 5 (new), 6, 7, 8, 9, 10
  (3.0, 2.0, 1.6, 1.3, 0.85, 0.65, 0.45, 0.35 mm)
12-m Array configuration

- Maximum baselines between 0.161 km to 16.2 (12.6 km for C4)
- Maximum baselines of 1.4 km for Band
- Maximum baselines of 3.6 km for Bands 8,9,10
- Maximum baselines of 8.5 km (6.8 km for C4) for Band 7
- Maximum baselines of 16.2 km (12.6 km for C4) for Bands 3,4,6
- Antenna configuration files for 12-m and 7-m arrays (useful for CASA simulator) are available, https://almascience.org/documents-and-tools/cycle5/alma-configuration-files
Spectral line, Continuum and Mosaic Observations

- Spectral line and continuum observations with the 12-m and 7-m arrays in all Bands
- Single field interferometry (all bands) and mosaics (Bands 3 to 9) with 12-m and 7-m arrays.
- Single-dish spectral line observations in Bands from 3 to 8
Polarization

- Single pointing, on-axis, full (linear) polarization capabilities for continuum and full spectral resolution observations in Bands 3, 4, 5, 6, 7 on the 12-m Array
Standard vs. non-standard

- Standard observations are calibrated with the ALMA data reduction pipeline but non-standard observations require manual calibration by ARC staff
Non-standard observation mode

- Bands 8, 9 and 10 observations
- Band 7 observations with maximum baselines > 5 km
- All full polarization observations
- Spectral Scans
- Bandwidth switching projects
- Solar observation
- VLBI observations
- Non-standard calibrations
- Astrometric observations
Scheduling Priority

• Weather condition
• Angular resolution and LAS
• Target elevation and other practical constrains
• C4A, C5A, C5B, C5C
Figure 2. The percentage of time when the PWV is below the observing thresholds adopted for the various ALMA bands for an elevation of 60 degrees. The data were obtained with the APEX weather station between 2007 and 2016. Results are shown for night time (top) and daytime (bottom) observations.
Figure 3. Fraction of time that the PWV falls below a given value along the year. The percentages shown indicate the fraction of time that the PWV is under the PWV value indicated on the y-axis. For example, in January, 75% of the PWV measurements are under 6 mm, while in June 75% of the PWV measurements fall below 1.8 mm. The data were obtained with the APEX weather station between 2007 and 2016. The horizontal dashed lines show the observing thresholds adopted for the various ALMA bands for an elevation of 60 degrees.

Proposers do not need to anticipate weather conditions when writing their proposals. The Observatory will schedule the observations during appropriate weather conditions.

5.3.3 Angular resolution
In Cycle 5, PIs will be allowed to enter a range of angular resolution for a given SG in the OT. The range should be justified in the proposal and be scientifically meaningful (Section 6.2). In practice, if the PIs enter their sensitivity request in flux density units (e.g. Jy), the OT will assign to a given SG any number of configurations that fulfil the angular resolution range requested by the PI taking into account the observing efficiency. If the execution of a SG is time-wise significantly more efficient in a subset of the allowed configurations, only that subset will be considered. This choice is reflected in the OT, which will only display the configurations that the Observatory will consider for scheduling the SG.

PIs aiming to obtain high quality images of complicated structures may enter their sensitivity request in temperature units. The time estimate in these cases will correspond to the time needed to achieve the surface brightness requested in the finest angular resolution specified. This should not prevent PIs from entering a
## Configuration schedule for 12m

<table>
<thead>
<tr>
<th>Start date</th>
<th>Configuration</th>
<th>Longest baseline(^1)</th>
<th>LST for best observing conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017 October 1</td>
<td>C43-7</td>
<td>3.6 km</td>
<td>~ 21h – 10h</td>
</tr>
<tr>
<td>2017 October 5</td>
<td>C43-8</td>
<td>8.5 km</td>
<td>~ 22h – 11h</td>
</tr>
<tr>
<td>2017 October 25</td>
<td>C43-9</td>
<td>13.9 km</td>
<td>~ 23h – 12h</td>
</tr>
<tr>
<td>2017 November 10</td>
<td>C43-10</td>
<td>16.2 km</td>
<td>~ 1h – 13h</td>
</tr>
<tr>
<td>2017 December 1-18</td>
<td><strong>No observations due to large antenna reconfiguration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017 December 19</td>
<td>C43-6</td>
<td>2.5 km</td>
<td>~ 4h – 15h</td>
</tr>
<tr>
<td>2018 January 10</td>
<td>C43-5</td>
<td>1.4 km</td>
<td>~ 5h – 17h</td>
</tr>
<tr>
<td>2018 February 1-28</td>
<td><strong>No observations due to February shutdown</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 March 1</td>
<td>C43-4</td>
<td>0.78 km</td>
<td>~ 8h – 21h</td>
</tr>
<tr>
<td>2018 March 30</td>
<td>C43-3</td>
<td>0.50 km</td>
<td>~ 10h – 0h</td>
</tr>
<tr>
<td>2018 May 15</td>
<td>C43-2</td>
<td>0.31 km</td>
<td>~ 12h – 3h</td>
</tr>
<tr>
<td>2018 June 15</td>
<td>C43-1</td>
<td>0.16 km</td>
<td>~ 14h – 5h</td>
</tr>
<tr>
<td>2018 July 15</td>
<td>C43-2</td>
<td>0.31 km</td>
<td>~ 17h – 7h</td>
</tr>
<tr>
<td>2018 August 15</td>
<td>C43-3</td>
<td>0.50 km</td>
<td>~ 18h – 8h</td>
</tr>
<tr>
<td>2018 August 30</td>
<td>C43-4</td>
<td>0.78 km</td>
<td>~ 19h – 9h</td>
</tr>
<tr>
<td>2018 September 15</td>
<td>C43-5</td>
<td>1.4 km</td>
<td>~ 20h – 10h</td>
</tr>
</tbody>
</table>
Figure 4. Effective observing time available per configuration for executing PI projects.

As an example, up to 10 hours may be allocated to Large Programme systems in configuration C43-1 at LST = 0 h. The total number of hours excludes time spent on observatory calibration, maintenance, reconfigurations, and other activities. The fraction of that time available for Large Programme and high frequency observations is also indicated. The configuration schedule and, consequently, the total number of hours available per configuration may change as a result of proposal pressure (see text). The data files containing these histograms are available here.

5.3.5 Observing pressure as a function of Right Ascension

Figure 5 shows the Right Ascension (RA) distribution of Cycle 4 requested proposals, colored by requested array. The highest demand for observations is in the 2-6 h and 12-19 h RA ranges, with low demand in the 7-9 h and 22-1 h RA ranges. Earlier cycles had similar distributions. Proposals in less subscribed RA ranges will have a higher probability of execution.

From Cycle 5 on, the range of angular resolutions provided by PIs (Section 5.3.3) will have a direct impact in the observing pressure per configuration. Proposals that specify a broad range of acceptable angular resolutions (i.e., several acceptable configurations) will increase the likelihood that the proposal can be scheduled and executed. However, PIs should only request the range of angular resolutions that is acceptable for their science goals, as this will be evaluated during the proposal review process.

In addition, the observing pressure per configuration, estimated via simulations of the full cycle taking into account the APRC ranks and historical weather patterns, may change during the building of the observing queue (Section 6.5.3) by adjusting the configuration schedule (Section 5.3.4).
Obs. Pressure as a function of RA

Figure 5: Distribution of requested 12-m Array time for the Cycle 4 proposals as a function of Right Ascension and coded by array.

5.4.1 Checking for duplications

To ensure the most efficient use of ALMA, duplicate observations of the same location on the sky with similar observing parameters (frequency, angular resolution, coverage, and sensitivity) are not permitted unless scientifically justified. Archival data should be used whenever possible to accomplish the science goals of a proposed investigation. Observations are considered duplicates if the conditions indicated in Appendix A of the Users’ Policies are met.

Proposers are responsible for checking their proposed observations against the Archive and the list of Cycle 4 accepted programmes provided by the ALMA to avoid duplicate observations. Proposers will not be penalized for proposing duplications of previous cycle observations if they had no way to know about them by the release of the Call for Proposals. See the Duplications link on the Science Portal for information on checking for duplications.

The proposal cover sheet contains a section where PIs can justify proposed duplicate observations. PIs are also advised to justify their proposed observations in cases where they are similar to previously executed or accepted programmes but are not formal duplicates. The ALMA Review Panels (ARPs) will determine if the requested duplicate observation is scientifically justified.
Duplication check

- Duplications of the same location on the sky with similar observing parameters (frequency, angular resolution, coverage, and sensitivity) are not permitted unless scientifically justified.
  - Archive
  - List of ongoing observations (excel sheet)
  - https://almascience.nao.ac.jp/proposing/duplications
Proposal preparation and submission

• Science justification uploaded as a PDF file into OT
  – Includes S/N, range of angular resolution, source size, source sample size
  – figures, tables, references: 10-point font
• ALMA OT
  – includes self-contained technical justification without figures
• The PDF: 4 pages, 12-point font, < 20 MB.
  [http://almascience.org/proposing/proposal-template](http://almascience.org/proposing/proposal-template)
To do list for a Cycle 5 proposal

• Read two documents
  • https://almascience.nao.ac.jp/proposing/call-for-proposals
    – ALMA Cycle 5 Proposer’s Guide
    – Observing with ALMA – A Primer (Cycle 5)
• Register yourself at the Science Portal, now
  – https://asa.alma.cl/UserRegistration/newAccount.jsp
• Download the ALMA OT software
• Prepare a proposal in advance. Science is the most important factor for a successful proposal.