An Introduction to the ALMA Observing Tool

How to turn that great idea into an ALMA proposal...

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An Introduction to the ALMA Observing Tool

How to turn that great idea into an ALMA proposal...

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With thanks to Arielle Moullet & Harvey Liszt
What is ALMA?

- A global partnership to deliver a revolutionary millimeter/submillimeter telescope array by North America, Europe, East Asia, in collaboration with Chile
- 66 reconfigurable, high precision antennas
- $\lambda \sim 0.32 - 8.5\text{mm}$
- Array configurations between 150 meters and >16 kilometers:
  - Main Array: 50 x 12m antennas
  - Total Power Array: 4 x 12m antennas
  - Atacama Compact Array (ACA): 12 x 7m antennas
  - TP + ACA (Morita Array)
- Array Operations Site is located at 5000m elevation in the Chilean Andes
- Provides unprecedented imaging* & spectroscopic capabilities at mm/submm $\lambda$
ALMA in a Nutshell...

- Angular resolution down to 0.015” (at 300 GHz)
- Sensitive, precision imaging 84 to 950 GHz (3 mm to 320 µm)
- State-of-the-art low-noise, wide-band receivers* (8 GHz bandwidth)
- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities including circular.
- Estimated 1 TB/day data rate
- All science data archived
- Pipeline processing
ALMA Current Status

- Construction Project ended in September 2014
- Science observing has been out to > **16 km baselines (C43–10)** thanks to the highly successful Long Baseline Campaigns in 2014 and 2015
- **All 66 antennas accepted**
  - Currently all 66 antennas are at the high site (AOS), of which ~47 on average (up to max ~54) are being used for Cycle 5 observations
  - Some construction and verification items remain to be finished (e.g., wide-field polarization; various observing modes)
- The ACA (Atacama Compact Array) or Morita Array – up to 12x7m antennas and 4x12m antennas for TP observations
  - currently being used for Cycle 5 observations
The Cycle 6 capabilities are fully described in Appendix A of the ALMA Proposers Guide available at: https://almascience.nrao.edu/documents-and-tools

In summary:

- **Number of antennas**
  - At least forty-three (43) antennas in the 12-m Array
  - At least ten (10) 7-m antennas (for short baselines) and three (3) 12-m antennas (for making single-dish maps) in the ACA

- **Receiver bands**
  - Receiver Bands 3, 4, 5, 6, 7, 8, 9, and 10 (wavelengths of about 3.1, 2.1, 1.6, 1.3, 0.87, 0.74, 0.44, and 0.35 mm, respectively)

- **12-m Array Configurations**
  - Maximum baselines for the antenna configurations between 0.15 km and 16 km
  - Maximum baselines of 3.6 km for Bands 8, 9 and 10
  - Maximum baselines of 8.5 km for Band 7
  - Maximum baselines of 16 km for Bands 3, 4, 5 and 6
ALMA Capabilities

- **Spectral line, continuum, and mosaic observations**
  - Spectral line and continuum observations with the 12-m Array and the 7-m Array in all bands
  - Single field interferometry (all bands) and mosaics (Bands 3 to 9) with the 12-m Array and the 7-m Array
  - Single-dish spectral line observations in Bands 3 to 8

- **Polarization**
  - Single pointing, on axis, full (including circular) polarization for both continuum and full-spectral-resolution observations in Band 3, 4, 5, 6, and 7 are offered on the 12-m Array. (min polarization percentage of 1.8% of the peak flux for circular polarization; only for sources that are on-axis with an angular size less than 10% of the FWHM primary beam).

- **Observing Time:**
  - 4000 hours for successful proposals of PI programs expected on the 12m Array (includes DDT, Cycle 4 Carryover and resubmissions)
  - 3000 hours available on the ACA
  - 3000 hours available on the Total Power Array
Proposal Checklist

- Read relevant documentation (CfP Guide, Primer, etc.)
- Create an ALMA account by registering at the Science Portal (almascience.org)
- Download the Observing Tool (OT) & related guides
- Prepare the Science Case
  - Note the new capabilities for the current cycle!
- Prepare Science Goals (sources, frequency & correlator setup, integration times) within the OT
- Make use of the Helpdesk & the Knowledgebase
Cycle 6 Documentation & Timeline

- Call for Proposals
- Proposer’s Guide
- ALMA Primer
- OT Guide
- ALMA Tech Handbook
- Timeline for Cycle 6
  - Mar. 20 – Call for Proposals
  - Apr. 19 – Proposal Deadline
  - End July – Results to PIs
  - Aug. 2018 – PIs submit SBs
  - Oct. 2018 – Start of Cycle 6
  - Sept. 2019 – End of Cycle 6

ALMA, an international astronomy facility, is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.
Proposal Checklist

- Read relevant documentation (CfP Guide, Primer, etc.)
- Create an ALMA account by registering at the Science Portal (almascience.org)
- Download the Observing Tool (OT) & related guides
- **Prepare the Science Case**
  - Note the new capabilities for the current cycle!
- Prepare Science Goals (sources, frequency & correlator setup, integration times) within the OT
- Make use of the Helpdesk & the Knowledgebase
Before you start the OT...

From your science case:

- **Source(s):**
  - single pointings or mosaics?
  - what angular resolution do you need?
  - what is the largest angular size of your source(s)?

- **Spectral configuration:**
  - continuum or spectral lines?
  - frequency: which band?

- **Are you doing polarization?**
  - what is the expected polarization fraction?

- **Sensitivity:**
  - what rms do you need to achieve your science goals?
  - over what bandwidth? i.e., 3 km/s, or 1.875 GHz, etc.
The configuration schedule may determine when an object will be observed.

In Cycle 6, for example:

- C43–1,2 January, March
- C43–3,4 December, April
- C43–5 October only
- C43–8..10 June, July

Some combinations of object + configuration may not be available for night-time observing.
Box and whisker plots of the percentage of time that the precipitable water vapor (PWV) is less than the thresholds adopted for the various ALMA bands versus the month of the year. Results are shown for both night time (green) and mid-afternoon (yellow), and assume a source elevation of 60 degrees. The horizontal line within a box indicates the median, the boundaries of a box indicate the 25th- and 75th-percentile of the distribution, and the whiskers indicate the highest and lowest values of the distribution. The PWV measurements were obtained by the APEX weather stations between 2007 and 2017.
From your science case:

• Source(s):
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  - what angular resolution do you need?

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On to the Observing Tool!
Downloading the ALMA OT

https://almascience.nrao.edu

Observing Tool
The ALMA Observing Tool (OT) is a Java application used for the preparation and submission of ALMA Phase 1 (observing proposal) and Phase 2 (telescope runfiles for accepted proposals) materials. It is also used for preparing and submitting Director’s Discretionary Time (DDT) proposals. The current Cycle 6 release of the OT is configured for the present capabilities of ALMA as described in the Cycle 6 Call For Proposals. Note that in order to submit proposals you will have to register with the ALMA Science Portal beforehand.

Note that preparation of Cycle 5 DDT proposals needs to be done using the Cycle 5 version of the Observing Tool. This version of the OT can be found in the DDT page, or the Phase 2 menu.

Download & Installation
The OT will run on most common operating systems, as long as a 64-bit version of Java 8 is installed (see the troubleshooting page if you are experiencing Java problems). The ALMA OT is available in two flavours: Web Start and tarball.

The Web Start application is the recommended way of using the OT. It has the advantage that the OT is automatically downloaded and installed on your computer and it will also automatically detect and install updates. There are some issues with Web Start, particularly that it does not work with the Open JDK versions of Java such as the “Iced Tea” flavour common on many modern Linux installations. The Oracle variant of Java should therefore be installed instead. If this is not possible, then the tarball installation of the OT is available.

The tarball version must be installed manually and will not automatically update itself, however there should be no installation issues. For Linux users, we also provide a download complete with a recommended version of the Java Runtime Environment. Please use this if you have any problems running the OT tarball with your default Java.

Documentation
Extensive documentation is available to help you understand and use the OT.

- If you are a novice OT user you should start with the User Manual.
- Audio-visual illustrations of different aspects of the OT can be found in the OT video tutorials. These are recommended for novices and advanced users alike.
- More in-depth information on the OT can be found in the User Manual, while concise explanations of all fields and menu items in the OT are given in the Reference Manual. These two documents are also available within the OT under the Help menu.

Troubleshooting
If you have problems with the installation and/or startup of the OT, please see the troubleshooting page. A list of currently known bugs, their status and possible workarounds can be found on the regularly updated known OT Issues page. A further source of information is the OT section of the ALMA Helpdesk Knowledgebase - this contains a number of articles that deal with frequently-asked questions. After exploring these resources, if confusion over some aspect of the OT remains, or if a previously unidentified bug has been uncovered, please file a Helpdesk ticket.
OT Video Tutorials

The OT video tutorials provide an audio-visual demonstration of different aspects of proposal preparation in the OT. Novice users should start with the first video and work their way down, while more experienced users may want to jump straight to one of the specialised videos.

OT Video Tutorial 1: Useful to Know

This video will help you get started with the OT and introduce you to some handy tips and tricks. Topics covered include navigating the OT, using the help function, the template library, time estimation, validation, opening & submitting projects including re-submissions, and the concept of non-standard modes. Note: this video is from Cycle 4, some things have changed slightly in Cycle 5. In particular, time constraints can now also include simultaneous 12-m and 7-m observations, and re-submissions are no longer defined by the user. Also, the time estimate interface has changed a bit.
When the ALMA OT starts

First you see this

Then you see this

- Create a new proposal
- Create a new DDT proposal
- Open an existing project from disk
- Retrieve a project from the ALMA science archive

Do not show this message again
Creating a new proposal

- Load the standard templates that are distributed with the OT
- Create a new proposal from scratch (regular or DDT)
- Open a previous proposal (regular or DDT) as a new proposal
- Click here to load a project (perhaps an old one of yours) from disk as a template
Next: Add science goals

Use templates or start from scratch! Drag the one you’d like to modify, from here up to the Proposal folder. (actual templates will be different from this illustration)

Hint: you can also drag&drop or copy&paste elements between Science Goals in your project
Before you start the OT...

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- **Are you doing polarization?**
  - What is the expected polarization fraction?

- **Sensitivity:**
  - what rms do you need to achieve your science goals?
  - over what bandwidth? i.e., 3 km/s, or 1.875 GHz, etc.
Set your targets: Field Setup

When you resolve a name check all returned info

Source name, position, proper motion, velocity, velocity rest frame.

Rectangular mosaic or 1/more offset pointings?

The expected source properties are used with the spectral setup, desired angular resolution, rms, to set the S/N, dynamic range and overall project viability.
Set your targets: Mosaics

The Spatial tab gives a graphical visualization of the Field Setup.

Select a background image from an online image server.

When you click on this node you will land on the visualizer tab.
Setting up the mosaic in the Field Setup

Define the length, width and position angle of the region to mosaic. Default is to separate the field centers by about 48% of the primary beam (the Nyquist rate). HPBW for the 12m antennas are $1.13\lambda/D$.

Estimated number of 7m Array pointings

No more than 150 12m Array pointings.
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• Are you doing polarization?
  - What is the expected polarization fraction?

• Sensitivity:
  - what rms do you need to achieve your science goals?
  - over what bandwidth? i.e., 3 km/s, or 1.875 GHz, etc.
When you click on this node you will land on the visualizer tab.
Adding spectral windows

This option will call up a version of the spectral line picker. Windows added this way retain line id and other info from the splatalog.

Frequencies may also be entered by hand.
Using the spectral line catalog

Filters can be used to narrow the search

Select a line from the list

<table>
<thead>
<tr>
<th>Transition Filter</th>
<th>Description</th>
<th>Rest Frequency</th>
<th>Sky Frequency</th>
<th>Upper-state Energy</th>
<th>Lovas Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
<td>113.172 GHz</td>
<td>113.172 GHz</td>
<td>634.675 K</td>
<td>0.01</td>
</tr>
<tr>
<td>CO v=2 1-0</td>
<td>Carbon Monoxide</td>
<td>114.222 GHz</td>
<td>114.222 GHz</td>
<td>3089.154 K</td>
<td>0.02</td>
</tr>
<tr>
<td>CO v=0 1-0</td>
<td>Carbon Monoxide</td>
<td>115.271 GHz</td>
<td>115.271 GHz</td>
<td>5.532 K</td>
<td>0.02</td>
</tr>
<tr>
<td>CO v=2 2-1</td>
<td>Carbon Monoxide</td>
<td>226.34 GHz</td>
<td>226.34 GHz</td>
<td>6145.538 K</td>
<td>0.02</td>
</tr>
<tr>
<td>CO v=1 1-0</td>
<td>Carbon Monoxide</td>
<td>228.439 GHz</td>
<td>228.439 GHz</td>
<td>3100.118 K</td>
<td>0.03</td>
</tr>
<tr>
<td>CO v=0 2-1</td>
<td>Carbon Monoxide</td>
<td>230.538 GHz</td>
<td>230.538 GHz</td>
<td>16.596 K</td>
<td>0.03</td>
</tr>
<tr>
<td>CO+ J=2-1, F=3/2-1/2</td>
<td>Carbon Monoxide</td>
<td>235.79 GHz</td>
<td>235.79 GHz</td>
<td>70.02 K</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Sky Frequency (GHz)

Min: 313 GHz, Max: 950 GHz
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- **Sensitivity:**
  - what rms do you need to achieve your science goals?
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Control and Performance defines the required angular resolution, sensitivity, largest angular scale, etc.
Time-constrained observing

- Entering Time Constrained observations – Dates, Epochs or Monitoring
- Justification or additional information
- A file format is defined in the help to import a list of time constraints
Science Goal time estimates

Click the time estimate to see how much time you need and get a breakdown by array and on-source vs. overhead for the 12m synthesis.
Science Goal time estimates

This project needs 12m + 7m synthesis owing to the combination of angular resolution and largest angular scale.

Click the time estimate to see how much time you need and get a breakdown by array and on-source vs. overhead for the 12m synthesis.
View the project time summary

Total and Calibration Times

<table>
<thead>
<tr>
<th>Science Goal</th>
<th>12-m Ext.</th>
<th>12-m Compact</th>
<th>12-m Ext. + Compact</th>
<th>ACA 7-m</th>
<th>ACA TP</th>
<th>Overall</th>
<th>Non-standard Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSXiiRA16a1</td>
<td>51.12 min</td>
<td>24.75 min</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>51.12 min</td>
<td>24.75 min</td>
</tr>
<tr>
<td>MSXiiRA16a2</td>
<td>51.12 min</td>
<td>24.75 min</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>51.12 min</td>
<td>24.75 min</td>
</tr>
<tr>
<td>MSXiiRA16a3</td>
<td>51.97 min</td>
<td>24.75 min</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>51.97 min</td>
<td>24.75 min</td>
</tr>
<tr>
<td>MSXiiRA16a4</td>
<td>51.12 min</td>
<td>24.75 min</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>51.12 min</td>
<td>24.75 min</td>
</tr>
<tr>
<td>MSXiiRA16b1</td>
<td>1.29 h</td>
<td>29.95 min</td>
<td>1.29 h</td>
<td>29.95 min</td>
<td>-</td>
<td>1.29 h</td>
<td>29.95 min</td>
</tr>
<tr>
<td>MSXiiRA16b2</td>
<td>1.29 h</td>
<td>29.95 min</td>
<td>1.29 h</td>
<td>29.95 min</td>
<td>-</td>
<td>1.29 h</td>
<td>29.95 min</td>
</tr>
<tr>
<td>Overall</td>
<td>6.01 h</td>
<td>2.65 h</td>
<td>6.01 h</td>
<td>2.65 h</td>
<td>-</td>
<td>6.01 h</td>
<td>2.65 h</td>
</tr>
</tbody>
</table>

Data Volumes and Data Rates

<table>
<thead>
<tr>
<th>Science Goal</th>
<th>Data Volume</th>
<th>Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-m</td>
<td>ACA 7-m</td>
</tr>
<tr>
<td>MSXiiRA16a1</td>
<td>54.85 GB</td>
<td>-</td>
</tr>
<tr>
<td>MSXiiRA16a2</td>
<td>54.85 GB</td>
<td>-</td>
</tr>
<tr>
<td>MSXiiRA16a3</td>
<td>55.77 GB</td>
<td>-</td>
</tr>
<tr>
<td>MSXiiRA16a4</td>
<td>54.85 GB</td>
<td>-</td>
</tr>
<tr>
<td>MSXiiRA16b1</td>
<td>83.35 GB</td>
<td>-</td>
</tr>
<tr>
<td>MSXiiRA16b2</td>
<td>83.35 GB</td>
<td>-</td>
</tr>
<tr>
<td>Overall</td>
<td>387.01 GB</td>
<td>-</td>
</tr>
</tbody>
</table>
There are separate standard sections for Sensitivity, Imaging and Correlator and another may appear to allow you to justify some of the parameter choices you may have made.

Each requires its own 50+ word justification.

Each standard section comes with a summary of the requested input information to detail the different technical aspects of your program.
Click here to make sure that your project can be validated by the OT. If it doesn’t validate the archive will reject it.

When you are satisfied that your proposal is complete, click here to submit your proposal to the archive.
Science Highlights - Possible Disk Truncation in Ophiuchus Brown Dwarfs

The sensitivity, resolution and the wavelength coverage of ALMA makes it an ideal tool for studying the properties of the cold outer disks of young stars and low mass objects. Such observations can aid us in understanding the formation of their central objects and their likelihood of ultimately hosting planets. In a recent Astronomy & Astrophysics paper, Dr. Testi and his collaborators made use of ALMA Band 7 to observe an unbiased sample of spectroscopically confirmed Ophiuchus brown dwarfs with infrared excesses.
I could use a hand...

Have no fear, the ALMA Helpdesk is here...
The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC), and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI), and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction and operation of ALMA.