User Support:

ALMA Cycle 3 Proposer's Guide and Capabilities

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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.

User Support:

For further information or to comment on this document, please contact your regional Helpdesk through the ALMA User Portal at **www.almascience.org**. Helpdesk tickets will be redirected automatically to the nearest ALMA Regional Centre at ESO, NAOJ or NRAO.

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1 Introduction

The Joint ALMA Observatory (JAO) invites proposals for Cycle 3 Early Science observations of the Atacama Large Millimeter/submillimeter (ALMA). Cycle 3 operations will include standard and non-standard modes (see below), with only non-standard mode observations being conducted on a best-effort basis, while standard modes will no longer be subject to SUCH limitations. ALMA has entered into a phase where PI-science observations dominate activities while continued improvements and developments are also explored.

In Early Science Cycle 3, ALMA will have the following capabilities: thirty-six 12-m antennas for interferometric observations, the Atacama Compact Array (ACA, also known as the Morita Array) including ten 7-m antennas for interferometric observations (7-m Array) and two 12-m antennas for single-dish observations (Total Power Array), receiver bands 3, 4, 6, 7, 8, 9 and 10 (wavelengths of about 3.1, 2.1, 1.3, 0.87, 0.74, 0.44 and 0.35 mm, respectively), array configurations with maximum baselines ranging from ~160 m to ~10 km (but not for all receiver bands), single-field imaging and mosaics of up to 150 pointings, polarization capabilities, and a set of correlator modes that will allow both continuum and spectral line observations simultaneously. Solar observations will not be available in Cycle 3. Projects requiring detection of extended emission may need ACA observations.

ALMA Early Science Cycle 3 is expected to span 12 months, beginning October 1, 2015. It is anticipated that about 2100 hours of array time will be available for projects with grades A and B. Up to 20% of proposals may be assigned a grade of **A,** qualifying them for carry-over to Cycle 4 if they are not fully completed by the end of Cycle 3.

Users of any professional background, nationality or affiliation may submit a proposal in response to the ALMA Early Science Cycle 3 Call for Proposals. Proposals will be assessed by peer review, and ranked on the basis of scientific merit and potential contribution to the advancement of scientific knowledge. High-frequency observations (upper Band 7 and Bands 8–10) will be harder to schedule than low-frequency observations (Bands 3, 4 and 6) due to fewer available hours of favorable weather conditions.

Standard observing modes are those that have been used in previous Cycles and for which the data can be reduced by the pipeline. Non-standard modes are observing modes that are less well characterized, or for which the data need to be processed by ALMA staff. Up to 25% of the total observing time will be assigned to such projects (see Section 5.3 and Appendix A)

ALMA staff will conduct quality assurance (QA) on ALMA data, and will provide processed data products through the respective ALMA Regional Centres (ARCs). Principal Investigators and observing teams may need to invest their own time and expertise to ensure that the data products are of the appropriate quality and to re-reduce the raw data if the quality is unsatisfactory. This may include the need to visit the relevant ARC or ARC node to get help and to assist with quality assurance and potential data re-reduction.

2 Invitation for submission of ALMA Cycle 3 proposals

JAO invites users of any professional background, nationality or affiliation to submit proposals for Cycle 3 Early Science observations with ALMA. Successful projects will be scheduled between October 1, 2015 and September 30, 2016.

Proposals for ALMA are prepared and submitted using the ALMA Observing Tool (hereafter OT; Section 4.2.2). The OT is available for download from the ALMA Science Portal (*www.almascience.org*). ALMA Cycle 3 proposal submission will open at:

15:00 UT on March 24, 2015

The Cycle 3 proposal submission deadline is:

15:00 UT on April 23, 2015

Table 1 summarizes the important dates and milestones of Cycle 3. ALMA reserves the right to alter the given dates, should it become necessary to do so.

Table 1: The ALMA Cycle 3 timeline

Date	Milestone
24 March 2015	Release of Cycle 3 Call for Proposals, Observing Tool & supporting documents
24 March 2015	Opening of the Archive for proposal submission
23 April 2015 (15:00 UT)	Proposal submission deadline
August 2015	Announcement of the outcome of the Proposal Review Process
1 October 2015	Start of ALMA Cycle 3 Science Observations
30 September 2016	End of ALMA Cycle 3

3 Overview

3.1 ALMA

ALMA, an international astronomy facility, is a partnership of the European Organisation for Astronomical Research in the Southern Hemisphere (ESO), the U.S. National Science Foundation (NSF) and the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Republic of Chile. ALMA is funded by ESO on behalf of its Member States, by NSF in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and by NINS in cooperation with the Academia Sinica (AS) in Taiwan and the Korea Astronomy and Space Science Institute (KASI). ALMA construction and operations are led by ESO on behalf of its Member States; by the National Radio Astronomy Observatory (NRAO), managed by Associated Universities, Inc. (AUI), on behalf of North America; and by the National Astronomical Observatory of Japan (NAOJ) on behalf of East Asia. JAO provides the unified leadership and management of the construction, commissioning and operation of ALMA.

3.2 The ALMA telescope on Chajnantor

ALMA is composed of 66 high-precision antennas. Fifty of these antennas are 12-meter dishes in the 12-m Array, used for sensitive, high-resolution imaging. These are complemented by the ACA composed of twelve closely spaced 7-meter antennas (7-m Array), and four 12-meter antennas for single-dish observations (Total Power Array), to enhance wide-field imaging. At full operational capability, the wavelengths covered by ALMA will range from 0.32 mm to 3.6 mm (frequency coverage of 84 GHz to 950 GHz).

The Array is located on the Chajnantor plain of the Chilean Andes, a site that offers the exceptionally dry and clear sky conditions required to operate at millimeter and submillimeter wavelengths. The ALMA antennas, weather stations, the two correlators and their computer interfaces, Local Oscillator generation hardware, timekeeping hardware, and the related Array Real-Time Machine computer are all located at the 5000-meter site referred to as the Array Operations Site (AOS). This site is connected via Gigabit fiber links to the Operation Support Facility (OSF), located at an altitude of 2900 meters, not far from the town of San Pedro de Atacama. Science operations are conducted from the OSF and coordinated from the JAO Central Office in Santiago.

A detailed description of the ALMA technical characteristics is found in the ALMA Technical Handbook.

ALMA is located at **latitude = –23.029°**, **longitude = –67.755°**. Targets as far north as declination +40°, corresponding to a maximum source elevation at Chajnantor of ~25°, can in principle be observed from the ALMA site, but shadowing by adjacent antennas becomes an increasing problem at low elevations. The imaging capability, as well as the time on source, will necessarily be limited for such northern sources, especially at the higher frequencies.

3.3 The Joint ALMA Observatory and the ALMA Regional Centres

The JAO is responsible for the overall leadership and management of construction and operations of ALMA in Chile. The Santiago Central Office (SCO) houses the Director's Office and its associated functional units, as well as astronomers, technicians and administrative staff. The SCO also hosts the ALMA main archive (referred to in the rest of this document as the Archive). The JAO solicits proposals to observe with ALMA through Calls for Proposals and organizes the peer review of the proposals by science experts. In addition, the JAO schedules all science observations and places the data in the electronically accessible ALMA Archive.

The three ALMA regional partners (Executives) maintain the ARCs within their respective region. The ARCs provide the interface between the ALMA project and its user communities. The ARCs are responsible for user support, mainly in the areas of proposal preparation, observation preparation, acquisition of data through the Archive, data reduction, data analysis, delivery of data, visitor support and workshops/schools. Each ARC operates an archive that is a mirror of the SCO main archive. Browsing and data mining are done through the ARC mirror archives.

The East Asian ARC (EA ARC) is based at the National Astronomical Observatory of Japan (NAOJ) headquarters in Tokyo. It is operated in collaboration with Academia Sinica Institute of Astronomy (ASIAA) and Astrophysics (ASIAA) in Taiwan and Korea Astronomy and Space Science Institute (KASI) in Korea and supports the astronomy communities of Japan, Taiwan and Republic of Korea.

European researchers are supported by the European ARC (EU ARC). It is organized as a coordinated network of scientific support nodes distributed across Europe. The EU ARC is located at ESO Headquarters in Garching bei München (Germany), where also many of the core ARC activities take place. Face-to-face support and additional services are provided by seven regional nodes and one centre of expertise. The regional nodes are currently: Bonn-Cologne (Germany), Bologna (Italy), Onsala (Sweden), IRAM, Grenoble (France), Allegro, Leiden (The Netherlands), Manchester (United Kingdom) and Ondřejov (Czech Republic). The centre of expertise is located in Lisbon (Portugal).

The North American ARC (NA ARC) is contained within the North American ALMA Science Center (NAASC), based at NRAO headquarters in Charlottesville, VA, USA. It is operated in collaboration with the National Research Council of Canada (Canada) and Academia Sinica Institute of Astronomy and Astrophysics (Taiwan), and supports the astronomical communities of North America and Taiwan.

3.4 ALMA Proposal Eligibility

Registered users of any professional background, nationality or affiliation may submit ALMA proposals. Each proposal must identify a single individual who will serve as Principal Investigator (PI). The PI will act as the official contact between ALMA and the proposing team for all correspondence related to the proposal. By submitting a proposal, the PI takes full responsibility for its contents, in particular with regard to the names of the Co-Investigators (Co-Is) and the agreement to act according to the ALMA policies and rules, including the conditions specified in the present Proposer's Guide and the ALMA Users Policies. He/she also acknowledges and accepts the limitations of the capabilities and the operational restrictions spelled out in the other documents listed in Section 4.2. The PI will be responsible for the scientific and administrative conduct of the project. Proposals shall be submitted only by the PI, not by Co-Is. There is no limit to the number of Co-Is who may appear on a proposal.

The main guiding principle in the assignment of observing priorities is to optimize the scientific impact of ALMA. Observing priority assignment will be based on scientific merit, taking into account the expected availability of resources while attempting to ensure that each region receives its share of the time, that is:

- 22.5% for East Asia (EA);
- 33.75% for Europe (EU);
- 33.75% for North America (NA);
- 10% for Chile.

The distribution of observing time across regions will be based on the actual execution time of the 12-m Array observations. Successful projects will have their observing time assigned to the region of the PI, which is defined as the region to which the organization that employs the PI belongs, or as the region of residence for unaffiliated PIs (see Users Policies for details).

New for Cycle 3: Additional rules apply for qualification to use the Chilean share of the time: see http://www.das.uchile.cl/das_alma_crc.html. Note that they include the timely submission of supporting documentation to the ALMA Chilean Review Committee.

ALMA proposals may also be submitted by PIs whose affiliation does not lie within any ALMA Executive's region. Such proposals are referred to as "Open Skies" proposals.

ALMA policies prohibit multiple submissions of the same proposal using different Executive affiliations. If such proposals are detected, the first submitted version will be considered and the remaining proposals ignored.

4 Tools, Documentation, Support

4.1 The ALMA Science Portal

The ALMA Science Portal is the primary access point for science users to ALMA. It is intended to provide a gateway to all ALMA resources, documents and tools relevant to users for proposal preparation, proposal assessment, project tracking, project data access and data retrieval, as well as access to the ALMA Helpdesk (see Section 4.3).

Any user has access to:

- User registration;
- The Call for Proposals and related documents and tools;
- Download of the Observing Tool (OT);
- Helpdesk "knowledgebase" articles listing solutions to common questions and problems;
- Archive access to non-proprietary data;
- All official ALMA user documentation and some software tools, including the ALMA Sensitivity Calculator, observing simulators, the ALMA spectral line database Splatalogue, etc.

In addition, registered users may:

- Submit or be Co-I on ALMA proposals;
- Manage their user profile;
- Access the Project Tracker to monitor the status of the user's scheduled observing projects and sign-up to receive automatic email notifications of certain project state transitions;
- Submit Helpdesk tickets;
- Access their proprietary data through the science archive and delegate their data rights to other ALMA users.

To ensure full-time availability, there are three instances of the Science Portal, one at each ARC. Users may access any of them via a common entry point, at *www.almascience.org.*

The Science Portal also includes links to the local ARC webpages from which users can access local information and specific services of each ARC, such as local visitor and student programs, schools, workshops, and outreach materials and activities.

4.2 Documentation

The following documents are relevant for submission of Cycle 3 proposals. All of them can be accessed via the ALMA Science Portal (www.almascience.org/*).*

4.2.1 The Call for Proposals

The **ALMA Cycle 3 Call for Proposals** is published on the Science Portal. It contains a short description of the ALMA capabilities, deadlines and limitations specific to Cycle 3. Full details are available in the documents accompanying the Call for Proposals, which are briefly described below.

The **ALMA Cycle 3 Proposer's Guide** (this document) presents the overall directions and guidelines for proposers, with an overview of the proposal review procedures, of the Cycle 3 capabilities, and of the array scheduling.

The **ALMA Users' Policies** document which contains a complete description of the applicable users' policies. The long-term core policies for usage of ALMA and of ALMA data by the ALMA user community are presented.

The **ALMA Cycle 3 Technical Handbook** describes the more technical aspects of ALMA during Cycle 3, including receiver characteristics, array configurations, available observing modes and correlator setups, and the basis of the OT time estimates.

The **Learn More link** offers users succinct summaries of the successive steps involved in the preparation and submission of an ALMA observing proposal. It is designed to help users to find the relevant documents and sources of additional information in each step easily.

4.2.2 The Observing Tool Documentation

The ALMA OT is the proposal preparation and submission (Phase 1) software application; the OT is also used for observation preparation (Phase 2). The OT documentation provides all the basic information required to complete the steps of proposal preparation and submission. It includes:

- The **OT Phase 1 Quickstart Guide**: A guide to proposal preparation for the novice ALMA OT user. It provides an overview of the necessary steps to create an ALMA Observing Proposal.
- The **OT Video Tutorials**: A visual demonstration of proposal preparation and submission with the OT.
- The **OT User Manual**: This manual is intended for all ALMA users, from novices to experienced users. It provides comprehensive information about how to create valid Phase 1 proposals and Phase 2 programs for observing astronomical objects. It is also included as part of the "Help" documentation within the OT application itself.
- The **OT Reference Manual**: This manual provides a more concise explanation for all the fields and menu items in the OT. It is also included as part of the "Help" documentation within the OT application itself.
- The **OT trouble-shooting page** lists OT installation requirements and workarounds for common installation problems.
- The **known OT issues page** lists currently known bugs, their status and possible workarounds. This page may be updated during the proposal submission period, so if you experience problems with the OT please check here first.

4.2.3 The ALMA Regional Centre Guides

The ARC Guides contain user support details specific to each ALMA regional partner. They are:

- The **East-Asian ARC Guide**;
- The **European ARC Guide**;
- The **North American ARC Guide**.

4.2.4 Proposal preparation utilities

There are two tools to help users to produce simulated images of simple or user-provided science targets.

The first is integrated into **CASA** (Common Astronomy Software Applications), the offline data reduction and analysis tool for ALMA data. CASA includes the tasks "simobserve" and "simanalyze", which generate simulated ALMA data and make images from the simulations. An additional CASA task, "simalma", simplifies the process of combining data from multiple arrays. These CASA tools require configuration files that specify the outlay of ALMA antennas. Files for representative Cycle 3 configurations are available at the Science Portal. A guide for simulating ALMA observations with CASA is available at *http://casaguides.nrao.edu/index.php?title=Guide_To_simulating_ALMA_Data*. Additional information on CASA, including hardware requirements and download instructions, is available at *http://casa.nrao.edu*.

The second tool for simulating ALMA observations is the **ALMA Observation Support Tool** (OST). The OST uses a simplified web interface to help users generate ALMA simulations. Users submit jobs to the OST and are notified by email when the simulations are completed. The OST is also described at *http://casaguides.nrao.edu/index.php?title=Guide_To_simulating_ALMA_Data*, and full documentation is available at *http://almaost.jb.man.ac.uk/help*.

Splatalogue is a database containing frequencies of atomic and molecular transitions emitting in the radio through submillimeter wavelength range. This database is used by the ALMA OT for spectral line selection. To learn more about it, see the Splatalogue QuickStart Guide on the Science Portal.

Atmospheric Transmission at Chajnantor can be reviewed with the atmosphere-model tool, which allows the user to model the atmospheric transmission as a function of frequency and amount of precipitable water vapour. The output is a plot of the transmission fraction as a function of frequency. Up to six different water vapour contents can be selected.

4.2.5 Other documents

Observing with ALMA: A Primer for Early Science is a brief introduction to ALMA observing, to (sub)millimeter terminology, and to interferometric techniques, which should prove useful for investigators who are new to radio astronomy. Several example science projects illustrating the Cycle 3 capabilities are also provided.

The **ALMA Memo Series** and **ALMA Technical Notes Series** include technical reports regarding various aspects of the ALMA project development and construction.

4.3 The ALMA Helpdesk

The ALMA Helpdesk is accessed from the ALMA Science Portal or directly at *http://help.almascience.org*. Submitted tickets are directed to support staff at one of the ARCs, who are available to answer any question relating to ALMA, including ALMA policies, capabilities, documentation, proposal preparation, the OT, Splatalogue, CASA, etc. Users may also request information on workshops, tutorials, or about visiting an ARC or ARC node for assistance with data reduction and analysis. Users must be registered at the ALMA Science Portal to submit a Helpdesk ticket. As a rule, ALMA staff aims to answer Helpdesk tickets within two working days.

The Helpdesk includes a "knowledgebase feature", which is a database of answered questions or "articles" on all aspects of ALMA and is also available to unauthenticated users. Users can search the knowledgebase to find answers to common queries without submitting a Helpdesk ticket. Knowledgebase articles which match their query are automatically suggested to users as they type.

5 Cycle 3 general information and policies

5.1 Introduction and policies

Cycle 3 will have a duration of 12 months. It is anticipated to start on October 1, 2015 and finish on September 30, 2016.

The ALMA capabilities during Cycle 3 will be limited compared to those of the completed array. About 2100 hours of 12-m Array time are available for Cycle 3. They will be allocated to the A- and B-grade approved Cycle 3 projects and the A-grade projects transferred from Cycle 2. Science observations will be executed by ALMA operations staff, taking into account (in rough order of priority): the weather conditions, the configuration of the array, target elevation and other practical constraints, the projects' assigned priority group, and executive balance. All other things being equal, the project with the highest scientific rank will be observed, and A-grade projects carried over from Cycle 2 will be given priority over Cycle 3 grade B projects.

Cycle 3 non-standard mode observations will be conducted on a best effort basis. The standard observing modes will be pipeline-calibrated and imaged, and their quality will be guaranteed by the Observatory.

ALMA staff will conduct quality assurance on ALMA data, and will provide processed data products through the respective ARCs. Experience in radio (in particular, millimeter) interferometry, though not considered by the review panels, will be an advantage in working with ALMA data products, particularly for projects that include non-standard modes. PIs and observing teams should anticipate the need to invest their own time and expertise to assure the quality of the provided data products and to re-reduce the raw data if the quality of the data products is not satisfactory. This may include the need to visit the relevant ARC or ARC node to get help and to assist with quality assurance and potential data re-reduction.

5.2 Scheduling Considerations

Cycle 3 observations will be continuously scheduled during nighttime in 16h shifts and during part of the week also during day-time (for Bands 3-6), interrupted by periods of engineering and execution of tasks associated with optimization and further development of the Array.

Apart from time-constrained observations, there are other aspects of a proposed observation that will affect when it may be scheduled. The first of these is the requested observing band, and the second is the requested resolution. Considerations that PIs should be aware of are given below.

5.2.1 Observing Band considerations

The atmosphere above Chajnantor is one of the best in the world for ground-based observation in the (sub)millimeter wavelength range (Evans et al 2002, ALMA Memo No. 471, available from the ALMA Memo Series). However, both the opacity (primarily determined by the amount of Precipitable Water Vapour – PWV) and the phase stability of the atmosphere limit when ALMA can be used at certain frequencies, in particular in the higher-frequency bands and at frequencies near water absorption lines. Both transmission and phase stability follow a yearly cycle (late southern winter is best – see Figures 2 and 4 of Memo 471) and a diurnal cycle (late night and early morning are best – see Figures 3 and 5 of Memo 471). In addition to the transmission and phase stability criteria, low wind speeds and night, or early morning, observing times are required for optimum observing conditions.

These cycles are illustrated in Figure 1, which shows the fraction of the year when the PWV is below 1 mm. Red and blue colors represent low and high probability of good weather, respectively. Regular weather patterns are subject to both short (daily weather patterns) and longer cycles (years; the El Niño Southern Oscillation may be important). During parts of the year, such as a large fraction of the Altiplanic winter[1] season (January-March), it may be difficult to carry out submillimeter observations. For this reason, a yearly extended maintenance and upgrade period is scheduled each February, during which no science observations are scheduled.

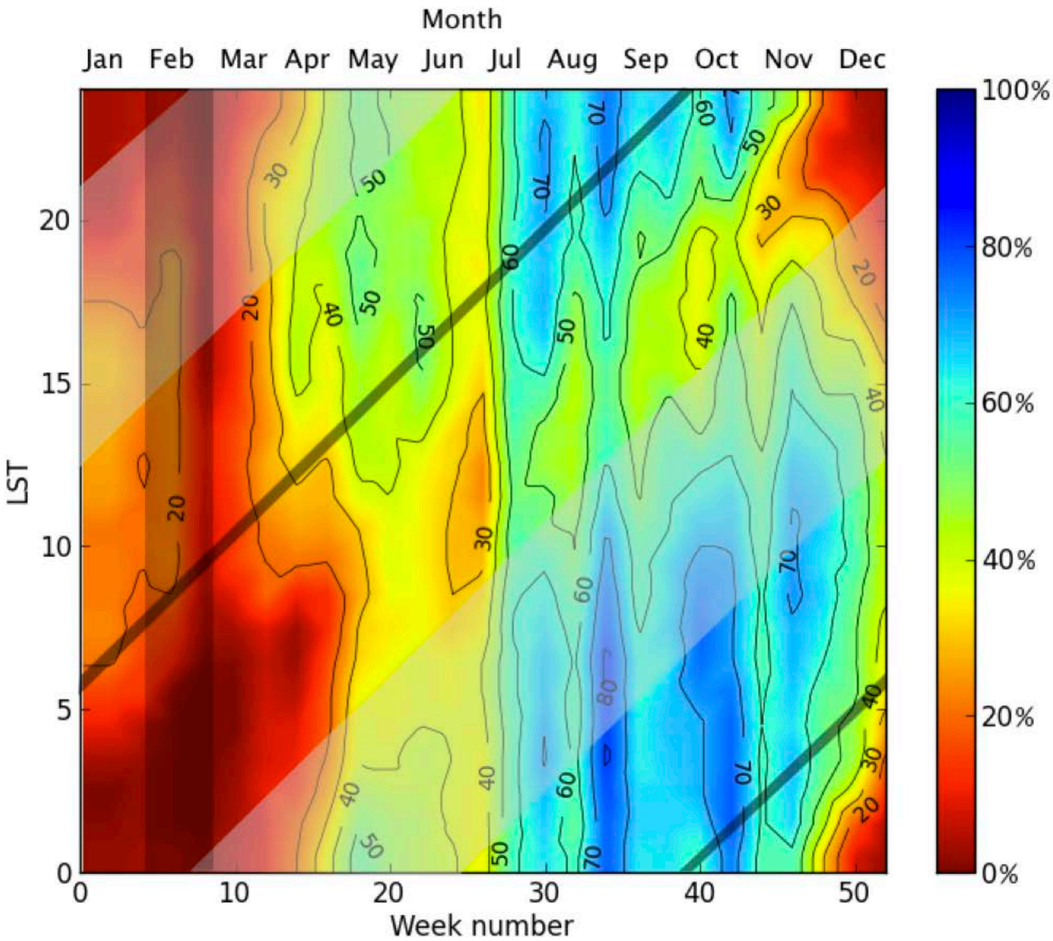

Figure 1. The percentage of time when the Precipitable Water Vapour (PWV) is below 1 mm as a function of Local Sidereal Time (LST) and week number beginning with January 1. Red identifies epochs with very little time available at low PWV and therefore less suitable for high frequency observing, while blue corresponds to epochs with a large fraction of time available at low PWV. The data were obtained with the APEX radiometer over the years 2007-2011 (5 years). The diagonal thin dark grey lines show local midnight, and the diagonal thick light grey bands show the ALMA engineering time, which normally is unavailable for Early Science observations. The vertical dark grey band shows the February period devoted to annual maintenance and upgrades.

Table 2 gives the fraction of time in Cycle 3 that is expected to be useful for observing in each band, given the limitations above, excluding complete shutdowns due to excessive wind and to precipitation. This table provides an indication of the limited amount of observing time at the higher frequencies that can be allocated in Cycle 3. However, it should be pointed out that there are large variations within each

[1] During southern summer, the high-pressure system over the Pacific Ocean weakens and moves southwards, allowing warm humid air from the Amazons to flow over the Andes into northern Chile, causing rain and occasionally snow to fall on the usually dry Altiplano: this phenomenon is known as Altiplanic winter.

band. For example, it is as difficult to conduct observations in the upper Band 7 wavelength range as in Bands 8–10 wavelength range[2].

Table 2: Estimated maximum fraction of observing time suitable for observations in each band in Cycle 3

ALMA Band	Band 3	Band 4	Band 6	Band 7	Band 8	Band 9	Band 10
Fraction of time	100%	90%	70%	40%	20%	10%	10%

Notes for Table 2: Times exclude total weather shutdowns. These estimates are based on 1998-2011 atmospheric transmission statistics from the ALMA Site Characterization and Monitoring program and APEX radiometer in combination with the ALMA Cycle 0 experience from October 2011 to March 2012.

Because of these factors, the actual time to reach a given signal to noise on a target depends on the prevailing conditions when the project is observed. The ALMA OT is designed so that investigators request a given sensitivity to reach a particular Science Goal (see Appendix A). The OT calculates an estimated execution time to reach the specified sensitivity, based on the radiometer equation, anticipated calibration overheads, the nominal Cycle 3 capabilities (number of antennas, etc.) and default observing conditions (see documentation for the ALMA Sensitivity Calculation in Section 9.2 of the **ALMA Cycle 3 Technical Handbook**). Proposers do not need to anticipate weather conditions when writing their proposals. The Observatory will strive to schedule the observations during appropriate weather conditions.

5.2.2 Configuration Schedule for the 12-m Array

During Cycle 3, the 12-m Array will be arranged in 8 different configurations (see the Technical Handbook, chapter 7). Investigators request a specific target angular resolution and largest angular scale for each science goal. This angular resolution is mapped to one of the 12-m Array configurations that are planned for Cycle 3 (see Table 7.1 in the Technical Handbook). The scheduling software will prioritize scheduling of the science goal when the array is in the best matching configuration, although a slightly more compact or extended configuration may be allowed within the angular resolution tolerances adopted for Cycle 3.

Cycle 3 will start on 2015 October 1st in the most extended configuration (C36-8) and on average there will be a new configuration per month. As mentioned in Section 5.2.1, observations will not be scheduled in February due to the bad weather conditions during the Altiplanic winter. The configuration schedule is given in Table 3, and minor modifications to the 2016 Cycle 3 schedule may be done as a result of the proposal pressure depending on the results of the proposal review process. The exact dates of re-configurations, in particular during southern winter time, may also depend on the weather situation.

In Cycle 4 the array configuration schedule will be done in such a way that compact configurations will be done in the southern winter time for favouring high-frequency observations, and the long baselines at different months compared to Cycle 3.

[2] To see how the atmospheric transmission varies with frequency, go to *http://almascience.org/documents-and-tools/overview/about-alma/atmosphere-model*.

This constitutes the tentative plans for configuration schedule in the coming cycles, i.e. every two cycles the best weather conditions at southern winter will interchange between long baselines (to benefit projects that need the highest resolutions) and most compact configurations (to benefit projects at higher frequencies). In this way different LST ranges for long baselines and high frequency projects will also be covered.

Projects unlikely to be scheduled (see Table 3 for details):

1. High frequency projects (band 7,8,9, and 10) around the Altiplanic winter (December-February) have a low chance to be observed even in the most compact configurations

2. High frequency projects (band 7,8,9, and 10) during day time are less likely to be observed due to the poorer atmospheric stability and higher system temperatures.

Table 3: 12-m Array Configuration Schedule for Cycle 3

Start Dates	Configuration	Night LST	Not recommended
2015 October 1	C36-8	~17h - 9h	High frequency projects especially during day time (LST ~10h-16h)
2015 November 10	C36-7	~19h - 11h	High frequency projects especially during day time (LST ~12h-18h)
2015 December 29 (Maintenance in February)	C36-1	~00h - 16h	High frequency projects any time , specially during day time (LST ~17h-23h)
2016 March 22	C36-2	~04h - 20h	High frequency projects day time (LST ~21h-03h)
2016 April 19	C36-3	~07h - 23h	High frequency projects day time (LST ~00h-06h)
2016 May 10	C36-4	~08h - 00h	High frequency projects day time (LST ~01h-07h)
2016 May 31	C36-5	~10h - 02h	High frequency projects day time (LST ~03h-09h)
2016 July 5	C36-6	~13h - 05h	High frequency projects especially during day time (LST ~06h-12h)
2016 August 30	C36-7	~16h - 08h	High frequency projects especially during day time (LST ~09h-15h)

Notes for Table 3: Dates include relocation time at the end of every configuration

5.3 Summary of Cycle 3 capabilities and limitations

The Cycle 3 capabilities are described in Appendix A. In summary they are:

- At least thirty-six 12-m antennas in the main array, and ten 7-m antennas (for short baselines) and two 12-m antennas (for making single-dish maps) in the ACA
- Receiver bands 3, 4, 6, 7, 8, 9, & 10 (wavelengths of about 3.1, 2.1, 1.3, 0.87, 0.74, 0.44, and 0.35 mm, respectively)
- Baselines up to 2 km for Bands 8, 9 and 10

- Baselines up to 5 km for Band 7
- Baselines up to 10 km for Bands 3, 4, & 6
- Both single field interferometry and mosaics
- Spectral-line observations with all Arrays and continuum observations with the 12-m Array and the 7-m Array. TP Array observations will be limited to spectral line observations in Bands 3 to 8.
- Polarization (on-axis, continuum in Band 3, 6 and 7, no ACA, no mosaics, no spectral line, no circular polarization)
- Mixed correlator modes (both high and low frequency resolution in the same observation)
- The maximum observing time per proposal, as estimated by the OT, is 100 hours.

ACA observations are only available to complement 12-m Array observations, and are restricted to projects requiring detection of extended emission.

The number of array elements available for science observing is less than the number available overall. This is due to, among other things, maintenance activity, especially during daytime observing. It is expected that the number of array elements available for use will grow over the course of the cycle.

Standard observing modes are those that have been used in previous Cycles and for which the data can be reduced by the pipeline. Non-standard modes are observing modes that are less well characterized, or for which the data need to be processed by ALMA staff. Up to 25% of the total observing time will be assigned to such projects. Non-standard modes are:

- Bands 8, 9 & 10 observations
- Long baselines (> 2km)
- Polarization
- Spectral Scans
- Spectral setups with only narrow band spectral windows (aggregate bandwidth < 934 MHz)
- User-defined calibrations

Due to this restriction, proposals with Science Goals that include non-standard modes that are given a science ranking that puts them outside the 25% time allocation for non-standard modes will be assigned a grade of C (see Appendix Section B1).

As much as one-third of the 12-m Array time will be available for observations that require both the 12-m Array and the ACA (which can be operated concurrently). This fraction is based on the expectation that 2100 hours of ACA will be available for Cycle 3 science observing, and the fact that for Cycle 3 the OT allocates four times as much time on the TP Array and two times as much on the 7-m Array as is needed for the corresponding 12-m Array observations (see Appendix C). Due to this restriction, proposals with Science Goals that include ACA observations that are given a science ranking that puts them above the 2100 hours allocated for ACA time will be assigned a grade of C (see Appendix Section B.1).

Observers cannot apply to use the ACA separately from the 12-m Array. The inclusion of ACA components (7-m Array and/or TP Array) is based on the user-specified Largest Angular Scale. The OT "Time Estimate" will indicate whether the 7-m Array and/or TP Array are necessary to meet the PI science goals and calculate the total time accordingly. The ACA time estimate is based on the TP Array time if TP observations are required, or on the 7-m Array time otherwise (see Appendix Section A.5). The 100-hour proposal limit applies to the sum of the 12-m Array time and of the ACA time. Observers who request an amount of observing time different from that estimated by the OT (see Appendix C) must still adhere to the 100 hour maximum.

For each Science Goal users will specify a desired angular resolution and the source Largest Angular Structure. Acceptable values span the ranges available from the Cycle 3 configurations (see Appendix A). For certain combinations of these parameters, a second 12-m Array configuration is required, increasing the required 12-m Array time of the Science Goal by 50%. The OT "Time Estimate" will indicate whether a second 12-m Array configuration is necessary to meet the PI science goals and calculate the total time accordingly.

Standard, Target of Opportunity (ToO) and Director Discretionary Time (DDT) Proposals will be accepted for Cycle 3 (see the ALMA Users' Policies for a detailed description of the proposal types). The estimated execution time for these proposals must not exceed 100 hours. The review process of Standard and ToO Proposals is described in Appendix B.

5.4 Proposal Type

5.4.1 Standard Proposals

Standard Proposals deal with observations that can be fully specified by the regular proposal submission deadline. They may include standard or non-standard modes. They may involve time critical, multiple epoch observations, and continuous monitoring of a target over a fixed time interval (rather than to achieve a given sensitivity), but their execution is restricted to the time slots reserved for Cycle 3 science observations. Time-critical observations requiring a time window smaller than 14 days will not be guaranteed, but may be attempted on a best effort basis. Whether or not such observations are technically feasible will be decided on a case-by-case basis. This should not prevent observations of recurring phenomena with predictable times (e.g. maximum elongations of planetary satellites), as long as their occurrences are spread over a sufficiently wide fraction of the Cycle 3 observing period and as long as the number of epochs that need to be observed remains relatively small with respect to the total number of suitable epochs across the Cycle (i.e., there are several possible time slots for each observation). Any special timing constraints (e.g. observations that once started need to be continued for a set amount of time or executed with a fixed cadence) must be fully justified.

5.4.2 ToO Proposals

ToO Proposals should be submitted to observe targets that can be anticipated but not specified in detail. Like Standard Proposals, these proposals must be submitted by the Cycle 3 proposal deadline. While the target list may be left unspecified, observing modes and sensitivity requests must be specified in detail for ToO observations. Associated with these observations there must be a clear indication of the number of triggers needed to reach the science goals of the proposal, what the trigger will be for the actual observation to be performed, and the necessary reaction time for scheduling the observation after it is triggered.

The observatory will attempt to observe ToO proposals during the 48 hours following their triggering. However, they will only be executed during the time reserved for Cycle 3 Science Observations, and as a rule, engineering activities and activities associated with the optimization and further development of the Array will not be interrupted to carry out ToO observations. Consequently, reaction times may be significantly longer if the triggering occurs shortly before or during a time reserved to engineering or other activities. PIs will trigger observations from accepted ToO Proposals through a web form available at the ALMA Science Portal.

5.4.3 DDT Proposals

DDT Proposals may be submitted at any time during Cycle 3, for execution during this cycle. To qualify for DDT usage, proposals must fulfill the conditions specified at http://almascience.org/proposing/ddt-proposals. Capabilities, time tolerance restriction and science assessment will be based on the same criteria as for Standard and ToO Proposals. DDT Proposals will be approved for execution by the ALMA Director, based on the advice of a Standing Review Committee, with members from the JAO and the four regions, appointed by the Executive Directors and Chile. In exceptional cases, the ALMA Director may approve projects that would benefit from a very rapid response, and inform the Standing Committee and science operations team of this decision within 24 hours. Further DDT policies are described in the Users' policies. In Cycle 3, a maximum of 5% of the total time available for observations may be dedicated to the execution of DDT projects. Note that these proposals must be prepared using the DDT option in the OT, and that for DDT proposals during Cycle 2 the Cycle 2 capabilities are offered and the Cycle 2 OT documentation should be used.

5.5 Science categories

Cycle 3 proposals will be assigned to one of five science categories:

1. Cosmology and the high redshift universe
2. Galaxies and galactic nuclei
3. ISM, star formation and astrochemistry
4. Circumstellar disks, exoplanets and the solar system
5. Stellar evolution and the Sun

Category information is used to distribute the proposals for review to the most qualified assessors. The proposers select the category to which their proposal is assigned, but this selection may be modified by the JAO if another category is judged to better describe the science of the proposal.

Cycle 3 proposers must further specify the area of investigation to which their project pertains by selecting in the OT at least one and at most two keywords from the list in Appendix F.

6 Proposal preparation and submission:

6.1 The Observing Tool

The ALMA Observing Tool (OT) is used for proposal preparation and submission ("Phase 1") and, in the event that the proposal is awarded time, for the detailed planning of the observations ("Phase 2"). The OT is a Java-based application that resides and runs on the user's computer and interacts with the ALMA Archive and other databases over the Internet. Only registered ALMA users are able to submit or be Co-Is on ALMA proposals.

An ALMA proposal consists of basic proposal information that is entered directly into the OT, a Science Justification uploaded to the OT as a PDF file, and one or more Science Goals. Science Goals contain the technical details of the proposed observations and must include a complete and coherent Technical Justification. The OT is designed to facilitate proposal preparation and includes a number of tools and checks to ensure submitted proposals conform to the Cycle 3 capabilities.

The following sections contain guidelines for the Science and Technical Justification parts of a proposal only. All other aspects of proposal preparation are explained in an extensive suite of OT documentation. ALMA novices are encouraged to start with the **OT Quickstart Guide** and the **video tutorials.**

6.2 General guidelines for writing a proposal

ALMA Cycle 3 proposals must be written in English and include the following sections:

1. Science case
2. Figures, tables and references (optional)
3. A brief statement on the likely potential for publicity (e.g. images, press releases etc.) arising from the proposed scientific observations.

These sections shall be submitted as a single PDF document. **The total length of this document is limited to 4 pages** (A4 or US Letter format), **with a font size no smaller than 12 points**. Proposers are free to adjust the length of the various proposal sections within this overall length limit. The recommended breakdown is 2 pages for the science case and 2 pages for figures, tables, references and publicity statement. Figures and tables may be interleaved with the science case, so that e.g. figures appear close to the location in the text where references are made to them. Although the Technical Justification for each Science Goal is entered in the OT, any figure required for it still needs to be placed in the Science Justification PDF document. Users are encouraged to use the LaTeX template developed by ALMA for preparation of their proposals.

A file size limit of 20 MB will be enforced at submission. Accordingly, extremely large or complex figures may not be acceptable. Proposals must be self-contained. Their assessment will be based solely on their explicit contents, and no external references whatsoever will be considered. Reference can be made to published papers (including astro-ph preprints), as per standard practice in the scientific literature. Consultation of those references should not, however, be required for understanding the proposal.

6.2.1 Science case

Each proposal must describe the astronomical importance of the proposed project and include a clear statement of its immediate observing goals. Additionally, it should explain how the expected intensity of the target source(s) was estimated and justify the Signal-to-Noise (S/N) ratio required to achieve the scientific objectives of the project as well as, when appropriate, the size of the target sample.

Proposers can simulate ALMA observations using different array components and configurations (see Section 4.2.4). Simulations are not required. However, if they are discussed in a proposal to justify any technical aspects of an observation, their results (i.e., images and simulation details) should be included in the science case and referenced in the relevant Technical Justification.Proposers should keep in mind that the topical ALMA Review Panels span a wide range of scientific areas. Therefore, proposals should be written for an expert, but broad-based, astronomy audience.

6.2.2 Figures, tables, and references

Figures, tables, and references that support the science case and the Technical Justification may be included. Figure captions, tables and references may be listed in 10-point font and, together with the science case, they must fit within the overall 4-page length and 20 MB size limits of the PDF proposal.

6.2.3 Opportunities for public promotion of ALMA

Opportunities for public and media interest in ALMA science will be very important during Cycle 3. Proposers are requested to consider the potential media appeal of proposed observations, with regard to scientific content and/or the quality of the visuals that could be produced. Each proposal must include a brief statement on the likely potential for publicity arising from the proposed scientific observations. The statement must fit within the overall 4-page limit of the PDF proposal. This information will not be used in the assessment of the proposal, which will be based solely on scientific merit and technical feasibility.

In the event that a Cycle 3 proposal is successful and is selected for publicity activities, the ALMA Education and Public Outreach (EPO) team will work with the PI to develop materials for presentation to the media and the public (e.g. press releases), including support in the preparation of visuals if relevant. EPO may ask for cooperation on the scientific content and for the PI to be available for possible interviews. Furthermore, the PI will be asked to agree to inform the ALMA EPO team if he/she is planning a press release or similar media interaction (for example through the PI's own institution's press office). ALMA requests that PIs do this at the start of the process, to allow for sufficient time to assess the news story and provide assistance to PIs as appropriate. The contact e-mail address for all liaisons with the ALMA EPO team is *alma-epo-ipt@alma.cl*.

6.3 Technical justification

All proposals must contain a complete and coherent Technical Justification, which is entered directly into the OT in the Technical Justification (TJ) node of each Science Goal (SG). Note that any figures associated with the Technical Justification must still be included in the Science Justification PDF file, and clearly referenced in the TJ. Technical Assessors will normally not read the Science Case, therefore all the necessary information must be included in the TJ itself. **An incomplete or incomprehensible Technical Justification will lead to the rejection of the proposal on technical grounds.**

By design, each SG has its own Technical Justification, since the technical setup of the observations will often vary substantially from one SG to the next. If a Technical Justification is applicable to more than one SG you may simply copy and paste the entire TJ node between these SGs.

The TJ node contains three main sections: sensitivity, imaging and correlator configuration - corresponding to the main aspects that need to be addressed in order to assess the technical feasibility of any proposal. Each section includes at least one free-format text box that must be filled (50 characters minimum), as well as a number of parameters computed from the user input captured in that Science Goal. This information is designed to help with the writing of the Technical Justification, and will also highlight potentially problematic setups (blue text) if applicable. Please see the relevant sections in the OT Reference Manual (accessible by clicking the "**?**" symbols within the OT) for details. If the OT detects any technical choices that require an extra justification, appropriately labeled text boxes will appear in an additional "Choices to be justified" section.

Given that the information and the text boxes displayed in the TJ node are dependent on information provided elsewhere in the SG (including the Expected Source Properties entered in the Field Setup node), the rest of the Science Goal should be set up before filling in the Technical Justification. Specific guidelines on filling out the Technical Justification are given in Appendix C. Please also see the ALMA OT video tutorial 4: "The technical justification".

The ALMA project reserves the right to declare any type of observation that does not conform to the advertised capabilities technically infeasible. Users should be aware that observing modes that cannot be set up with the Cycle 3 OT will not be offered, and that any planned observations must be fully defined in terms of Science Goals.

If users have any questions about the Technical Justification, they should consult the ALMA Helpdesk. Additional considerations for ALMA Early Science observing are included in the ALMA Early Science Primer.

6.4 Proposal validation and submission

Once the proposal is validated within the OT, it can be submitted to the ALMA Archive. Note that the proposal can be resubmitted by the Principal Investigator as many times as needed before the proposal deadline. This does not apply for DDT proposals, for which the first submission is final. Resubmitted proposals overwrite previous versions.

Submission of Standard and ToO Proposals will be available from 15:00 UT on March 24, 2015.

The proposal submission deadline is firm. Proposals received after the deadline will not be considered. It is the PI's responsibility to convert the UT time of the proposal submission deadline to his/her local time zone.

Modifications of submitted proposals will not be permitted after the deadline. Co-Is can retrieve proposals from the Archive both before and after the deadline, but only the PI can submit (or resubmit) a proposal. To ensure that the load on the server does not affect its performance close to proposal submission deadline, users should refrain from unnecessarily retrieving proposals from the Archive between 0:00 and 15:00 UT on April 23, 2015.

If successfully submitted, a proposal receives a unique code adhering to a standard format. The format of the proposal code is as follows: YYYY.C.NNNNN.T. Here, "YYYY" denotes the year, "C" is the cycle ID, "NNNNN" is a five-digit running number and "T" denotes the proposal type. For example, the code 2015.1.00156.S indicates a Standard proposal which is the 156th ALMA proposal submitted for the regular cycle in 2015. To allow for later re-submission, *it is essential that, after submitting a proposal, users save a copy of it to their local disk, complete with the proposal submission code*.

To update a previously submitted proposal, users should modify that saved, post-submission copy, to ensure that the same submission code is used. *Attempts to update a previously submitted proposal using the local copy without a code should always be avoided, as this will result in a new (duplicate) submission that will be assigned a new code.*

Users wishing to create a new proposal based on a previous one as a template should make sure to take as starting point a local copy without a code, so as to avoid overwriting their original proposal in the Archive.

Cycle 3 DDT Proposals may be submitted throughout the Cycle, from 1 October 2015 to 30 September 2016. Like Standard and ToO Proposals, they must include a full science case and a detailed Technical Justification. DDT proposal submission is final; DDT proposals cannot be resubmitted.

A Helpdesk ticket should be submitted to withdraw a proposal after a code has been assigned.

6.5 Project completion and carry-overs

If not completed by the end of the cycle, Cycle 3 projects assigned priority flag A will be carried over to Cycle 4. All other projects, whether completed or not, will end at the conclusion of Cycle 3.

7 Data processing and data delivery

Each Science Goal consists of one or more ObsUnitSet (OUS), which includes one or more Scheduling Blocks (SB) that will be executed as many times as needed to reach the defined sensitivity. Once the requisite number of successful executions of an OUS has been obtained, the resulting data will be processed by ALMA staff. This involves calibration and flagging of the visibilities (mostly performed by the ALMA pipeline), and imaging enough of the data to validate that the calibration has been successful, that it has obtained the requested angular resolution and sensitivity (within cycle-specific tolerances), and contains no gross instrumental artifacts or calibration defects. The data are assessed using Observatory-defined metrics as part of the "Quality Assurance level 2" (QA2 – see Chapter 11 of the ALMA Technical Handbook).

Once the data are ready for delivery, the PI is notified by the ARC with which the PI is registered and the PI can download such data from the ALMA archive after authentication at the ALMA Science Portal. The data package will include at a minimum the processing log files, data processing script, QA2 report, a README file and the imaging products. Raw data are also available for download from the ALMA archive. Shipping of hard disks is available for data delivery in special cases.

By default, data obtained as part of an ALMA science program are subject to a proprietary period of 12 months, starting for each data package when the ARC sends the notification to the PI that the data are available.

Appendix A ALMA Cycle 3 capabilities

In the Observing Tool (OT) an observing proposal is specified in terms of Science Goals. A single Science Goal (SG) is constrained to include one set of observational parameters that apply to all sources included in that goal. This includes a single angular resolution, sensitivity, Largest Angular Scale (LAS), and receiver band. For Cycle 3, there is no restriction on the number of Science Goals per proposal.

A.1 Standard and non-standard modes

Cycle 3 will include the concept of standard and non-standard observing modes. Standard observing modes are those that have been used in previous Cycles and for which the data can be reduced by the CASA data reduction pipeline. Non-standard modes are observing modes that are less well characterized or for which the data need to be processed manually by ALMA staff. Up to 25% of the total observing time will be assigned to such projects. Non-standard modes are:

- Bands 8, 9 & 10 observations
- Long baselines (> 2km)
- Polarization
- Spectral Scans
- Spectral setups with only narrow band spectral windows (aggregate bandwidth < 934 MHz)
- Non-standard calibrations (user-defined calibrations selected in the OT)

A.2 Antennas

In Cycle 3 at least thirty-six 12-m antennas in the main array (hereafter the 12-m Array) will be offered. The ACA will have available at least ten 7-m antennas (for short baselines, hereafter the 7-m Array) and two 12-m antennas (for making single-dish maps, hereafter the Total Power or TP Array). The ACA is used for short baseline interferometry and single-dish observations, and will only be offered to complement observations with the 12-m Array, not as a stand-alone capability. The use of the TP Array is limited to spectral line observations (not continuum) in Bands 3, 4, 6, 7 and 8. Bands 9 and 10 are not available for any TP observations.

The number of antennas available may sometimes be less than the numbers given above due to unforeseen problems with the equipment, during array reconfigurations. ALMA support staff will endeavor to schedule observations that will not be seriously affected by having a slightly smaller number of antennas. The integration times or u-v coverage might also be increased to compensate whenever this is practical.

A.3 12-m Array Configurations

In Cycle 3 the antennas in the 12-m Array will be staged into distinct configurations intended to transition from the most compact (with maximum baselines of ~160 m) up to the most extended configuration (maximum baselines of ~10 km). Eight configurations have been defined to represent the possible distribution of 36 antennas over this range of maximum baselines: six configurations with maximum baselines from 160 m up to ~2 km, one configuration with a maximum baseline of ~5 km, and one configuration with a maximum baseline of ~10 km. Those configurations have been optimized for imaging, i.e. uv coverage and low side lobe response. The detailed properties of these configurations are given in Chapter 7 of the Cycle 3 Technical Handbook. Note that specific configurations cannot be requested by users. The scheduling software will prioritize scheduling of the science goal when the array is in the best matching configuration, although a slightly more compact or extended configuration may be allowed within the angular resolution tolerances adopted for Cycle 3.

The two most extended configurations (5 km and 10 km) will be offered alone, it will not be possible to combine them in the same Science Goal with another configuration, either from the 12-m Array or the ACA. Note that the maximum recoverable scales (MRS) for these configurations are limited, especially at high frequencies. Investigators may include additional Science Goals to request separate observations using the more compact 12-m Array configurations. Each SG must be separately justified, have its own performance goals (sensitivity and resolution), and will be processed, assessed, and delivered independently. Combination of observations from different Science Goals will be left to the investigators.

The six more compact configurations of the 12-m Array will be offered either alone, or in combination with another 12-m configuration and/or the 7-m Array and/or the TP Array. The OT will suggest the optimum combination. Please note that for the 12-meter array, shadowing becomes significant (> 5 %) in the most compact configuration for sources with declination lower than −75° or higher than +25°. For more details, see the Section 7.2 of the Technical Handbook.

For all observations, the relevant parameters used by the OT in deciding the required array components for the representative frequencies of a given project are (see Chapter 7 of the Technical Handbook for details): (1) the Maximum Recoverable Scale (MRS) that can be imaged without the need for the ACA (defined by the shortest baseline of the most compact 12-m Array configuration); (2) the coarsest angular resolution obtainable with the 12-m Array (defined by twice the resolution of the most compact 12-m Array configuration to avoid significant loss of sensitivity); and (3) the finest angular resolution obtainable (defined by the longest baseline of the most extended 12-m Array configuration). These quantities are given in Table A-1. Sources with a user-specified Largest Angular Scale (LAS) larger than the Maximum Recoverable Scale listed in this table will require the addition of ACA observations. Observations with a requested angular resolution either coarser or finer than the values listed in Table A-1 (scaled to the appropriate frequency) are not allowed. Values that are inconsistent with any Cycle 3 limitations for the above parameters will result in a warning or a validation error in the OT.

Table A-1: Maximum Recoverable Scale[1] and Coarsest and Finest Angular Resolutions[1] for the Cycle 3 12-m Array configurations

Frequency	Maximum Recoverable Scale without ACA[2,3]	Coarsest allowed angular resolution[2,3,4]	Finest achievable angular resolution[2,3,5]
(GHz)	(arcsec)	(arcsec)	(arcsec)
100	25.3	6.8	0.075
150	16.9	4.6	0.050
230	11.0	3.0	0.030
345	7.3	2.0	0.034
460	5.5	1.4	0.060
650	3.9	1.0	0.040
870	2.9	0.8	0.030

Notes for Table A-1:

1. See Chapter 7 of the Technical Handbook for relevant equations and detailed considerations.
2. Computation for source at zenith. For sources transiting at lower elevations, the North-South angular measures will increase proportional to 1/sin(ELEVATION).
3. All angular measures scale inversely with observed sky frequency.
4. Coarsest allowed angular resolution is twice the resolution of the most compact 12-m Array configuration (maximum baseline of 167 meters).
5. Finest achievable angular resolution is defined by the resolution of the most extended 12-m Array configuration (~10 km for Bands 3-6, ~5 km for Band 7 and ~2 km for Bands 8-10), assuming Briggs 0.5 weighting.

A.4 ACA

The ACA in Cycle 3 is composed of ten 7-m antennas for the 7-m Array and two 12-m antennas for the TP Array. One 7-m Array configuration will be offered in Cycle 3. For more on the ACA see Chapter 7 of the Cycle 3 Technical Handbook. Given the short baselines in the ACA configuration, sources with declinations less than −60° or greater than +20° are subject to significant shadowing

The TP Array is used to recover the most extended emission in order to have all angular scale information up to the size of the requested map areas. For Cycle 3, TP Array observations are included only if the LAS cannot be achieved with the 7-m array, and the TP Array can only be used for spectral line observations (not continuum) in Bands 3–8. No TP Array Band 9 and 10 observations are offered for this cycle. This means that angular scales greater than those listed in Table A-2 cannot be recovered for any observations in Band 9 and 10, or for continuum observations in any band.

Observations with the 12-m Array and the ACA will be conducted independently, and the data from the different arrays will be calibrated separately and can be combined during data reduction.

Table A-2: Maximum Recoverable Scales for ACA 7-m observations

Frequency (GHz)	Maximum Recoverable Scale[1,2] (arcsec)
100	42.8
150	28.5
230	18.6
345	12.4
460	9.3
650	6.6
870	4.9

Notes for Table A-2:

1. Computation for source at zenith. For sources transiting at lower elevations, the North-Source angular measures will increase proportional to 1/sin(ELEVATION).
2. All angular measures scale inversely with observed sky frequency.

A.5 Time estimates for multi-configuration observations

Images that require a high fidelity over a broad range of angular scales require observations taken with a continuous range of antenna baseline separations. The user-requested angular resolution (θ) determines the most extended 12-m configuration that is needed (up to the "finest allowed angular resolution" listed in Table A-1), and the user-requested sensitivity plus calibration requirements determine the amount of observing time needed in this configuration ($\Delta t_{extended}$). The user-provided LAS and angular resolution determines if multiple array components are needed, and this information is reported in the Science Goal "Time Estimate" in the OT. Interested users should refer to Chapter 7 of the Cycle 3 Technical Handbook for a table of the array combinations needed to recover various angular scale ranges.

For the purposes of proposal preparation, the time needed for the different array components (including calibrations), referenced to the time needed in the most extended 12-m configuration, has been defined as $4\Delta t_{extended}$ for the TP Array, $2\Delta t_{extended}$ for the 7-m Array and $0.5\Delta t_{extended}$ for a more compact 12-m Array configuration (if needed).

The **total** time required by a proposal is estimated in the OT by adding the expected observing times for both the 12-m Array and the ACA. For Cycle 3, this total time must be less than 100 hours. The additional time due to the ACA observations is not considered in the review of the proposal.

Table A-3 lists the total observing time estimates for the different array combination possibilities offered in Cycle 3. For this computation, the ACA time is the TP Array time if this array is used or otherwise the 7-m Array time, i.e. it is not the sum of the 7-m and TP Array time. There will be two project execution queues, one for the 12-m Array and one for the ACA. Therefore, the time available for Cycle 3 observations is about 2100 hours for the 12-m Array and the same for the ACA. The time accrued by a proposal using the 12-m Array and the ACA will be charged to the two queues separately, as per the time requirements estimated by the OT for each array.

Table A-3: Total Time multiplication factors for multi-array observations

Array Components needed (based on θ and LAS)	Total Time estimate
Single 12-m Array configuration	1.0 $\Delta t_{extended}$
Two 12-m Array configurations	1.5 $\Delta t_{extended}$
Single 12-m Array configuration and 7-m Array	3.0 $\Delta t_{extended}$
Two 12-m Array configurations and 7-m Array	3.5 $\Delta t_{extended}$
One 12-m Array configuration and 7-m Array and TP Array (spectral line, Bands<9)	5.0 $\Delta t_{extended}$
Two 12-m Array configurations and 7-m Array and TP Array (spectral line, Bands<9)	5.5 $\Delta t_{extended}$

Based on the LAS, the OT will advise whether the 7-m Array and/or TP Array is needed for a given project. Any setup needs to be explained in the Technical Justification.

A.6 Receivers

Bands 3, 4, 6, 7, 8, 9 and 10 will be available on all antennas. However, observations with Bands 8, 9 and 10 will only be offered for configurations with baselines up to ~ 2 km, Band 7 up to ~ 5 km, and Bands 3, 4 and 6 up to ~ 10 km (see Section A.3). For all bands, both linear parallel-hand polarizations of the astronomical signals (XX, YY) are received and processed separately (dual polarization).

There are two types of receivers: 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 may be separated in later processing.

Table A-4 summarises the properties of the receiver bands offered in Cycle 3, details can be found in the technical handbook.

Table A-4: Properties of ALMA Cycle 3 Receiver Bands

Band	Frequency range[1] (GHz)	Wavelength range (mm)	IF range	Type
3	84 – 116	3.6 – 2.6	4 – 8	2SB
4	125 – 163	2.4 – 1.8	4 – 8	2SB
6	211 – 275	1.4 – 1.1	5 – 10	2SB
7	275 – 373	1.1 – 0.8	4 – 8	2SB
8	385 – 500	0.78 – 0.60	4 – 8	2SB

9	602 – 720	0.50 – 0.42	4 – 12	DSB
10	787 – 950	0.38 – 0.32	4-12	DSB

Notes for Table A-4:

1. 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) in Frequency Division Mode (FDM, see Section A.6.1), because of the responses of the spectral edge filters implemented in the correlator. IF is the intermediate frequency.

Although up to three receiver bands will be available at any time, the capability to rapidly switch between them within the same Science Goal (except for the purposes of data calibration) is not offered in Cycle 3.

Water Vapour Radiometer (WVR) measurements to correct for errors due to fluctuations in atmospheric water vapour will be available for all 12-m antennas. No WVRs are installed in the ACA 7-m antennas and no WVR corrections will be applied to 7-m Array observations.

A.6.1 Band 9 and 10 considerations

For Band 9 and 10 observations, additional uncertainties will affect the data. Since the sidebands can be separated reliably only in interferometric observations, single-dish Band 9 and 10 observations with the TP Array will not be offered in Cycle 3. Also, owing to the complexity of the atmospheric absorption in Band 9 and 10, calibration will be compromised (this also applies to Band 8 and the high frequency end of Band 7). Band 9 and 10 ACA 7-m Array observations are more compromised than the corresponding 12-m Array observations, since the rapid atmospheric phase correction cannot be applied, and the smaller collecting area will limit the network of usable calibrators; in particular bright calibrators will be sparse at these high frequencies. All of these factors, together with the limited u-v coverage, will affect imaging at Band 9 and 10 during Cycle 3 and will in particular limit the achievable dynamic range with the ACA 7-m Array. Imaging dynamic ranges up to 50 are typical for these bands (see Appendix D for details).

No mosaics will be offered for Band 10 observations.

A.7 Spectral capabilities

A.7.1 Spectral windows, bandwidths and resolutions

The ALMA IF system provides up to four basebands (per parallel polarization) that can be independently placed within the two receiver sidebands. For 2SB receivers (Bands 3–8 – see Table A-4), the number of basebands that can be placed within a sideband is 0, 1, 2, 3, or 4, but user cannot select 3 basebands in one sideband and 1 in the other, but 3 and 0 are fine. For DSB receivers (Band 9), any number of basebands (up to 4) is acceptable.

The 12-m Array uses the 64-input Correlator, while the 7-m and TP Arrays use the 16-input ACA Correlator. Both correlators offer the same spectral set-ups. The 64-input Correlator operates in two main modes: **Time Division Mode (TDM)** and **Frequency Division Mode (FDM)**. TDM provides modest spectral resolution and produces a relatively compact data set. It is 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 is used for observations of spectral lines in all sources except when coarse spectral resolution is sufficient. Six correlator set-ups with different bandwidths and spectral resolutions are available (see Table A-5).

For each baseband, the correlator resources can be divided across a set of spectral “windows” (spw) that can be used simultaneously and positioned independently. For Cycle 3, up to four spectral windows per baseband are allowed. The correlator can be set to provide between 128 and 3840 channels within each spw, and the fraction of correlator resources that are assigned to each spw sets the number of channels and the bandwidth available within it. The sum of the correlator resources spread across all spectral windows must be less than or equal to one (4192 channels).

The data can be pre-smoothed in the correlator by averaging (or binning) spectral channels in powers of 2. This allows one to reduce the data rate without increasing the sampling integration time (see Chapter 4 of the Cycle 3 Technical Handbook for more information). In Cycle 3, the maximum data rate is 60 MB/s, with the expected average of 6 MB/s. Any spectral setup implying more than twice the expected average of 6 MB/s must be justified in the technical justification (Section 6.3).

Different correlator modes can be specified for each baseband, but all spws within a given baseband must use the same correlator mode. For example, a high-resolution FDM mode can be used for spectral line observations in one baseband (with up to 4 differently placed FDM spectral windows), while the other three basebands can be used for continuum observations using the low-resolution TDM mode. And while each spw within a baseband must use the same correlator mode, they can each be assigned a different fraction of the correlator resources and each use a different spectral averaging factor, providing a broad range of simultaneously observed spectral resolutions and bandwidths. Spectral windows can overlap in frequency, although the total continuum bandwidth for calculating the sensitivity is set by the total non-overlapped bandwidth.

Table A-5: Properties of ALMA Cycle 3 Correlator Modes, dual-polarization operation [1,2]

Bandwidth[(3)] (MHz)	Channel spacing[(4)] (MHz)	Spectral resolution (MHz)	Number of channels	Correlator mode[(5)]
2000[3]	15.6	31.2	128[3]	TDM
1875	0.488	0.976	3840	FDM
938	0.244	0.488	3840	FDM
469	0.122	0.244	3840	FDM
234	0.061	0.122	3840	FDM
117	0.0305	0.061	3840	FDM
58.6	0.0153	0.0305	3840	FDM

Notes for Table A-5:

1. These are the values for each spectral window and for each polarization, using the full correlator resources and no on-line spectral binning.
2. Single-polarization modes are also available, which gives twice the number of channels per spw, and half the channel spacing of the above table.
3. The "Bandwidth" given here is the width of the spectrum processed by the digital correlator. The usable bandwidth in all modes is limited to a maximum of about 1875 MHz by the anti-aliasing filter, which is ahead of the digitizer in the signal path. For TDM modes, the anti-aliasing filter also limits the total bandwidth to about 1875 MHz and the number of channels to about 120.
4. 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. See the Technical Handbook for full details.
5. Only for the 64-input Correlator

A.7.2 Polarization

For Cycle 3, on top of the dual polarizations (XX, YY) and single polarization modes (XX), observations to measure the full intrinsic polarization (XY, YX) of sources will also be offered for TDM observations in Bands 3, 6 and 7. Only linear polarization is an accepted observing mode. While PIs will receive data which will allow them to generate circular polarization data, the quality and/or accuracy of that data at this time is not assured, and such data should not be used for scientific purposes.

When a **Dual Polarization** setup is used, separate spectra are obtained for each linear parallel-hand 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 (XX) is analyzed. For a given resolution, this provide √2 worse 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.

Full Polarization measurements using only TDM mode will be offered in Cycle 3 for 12-m Array observations only in Bands 3, 6 and 7. This is a non-standard mode, limiting the total time available for such observations. Sources must be centred and have a user-specified largest angular structure that is less than one-third of the 12-m Array primary beam at the frequency of the planned observations. The expected minimum detectable degree of polarization is 0.1% for compact sources and 0.3% for extended sources. Observations shall be single-field, but measurements of individual sources within a 10-degree area on the sky are possible (one field per source; see below). Polarization is not offered in spectral scan mode. The frequency settings for continuum polarization measurements can be specified by the user, but the OT supplies default setups as detailed in Table A-6.

Table A-6: Default frequencies for Polarization Observations[1]

Band	SPW1 (GHz)	SPW2 (GHz)	LO1 (GHz)	SPW3 (GHz)	SPW4 (GHz)
3	90.5	92.5	97.5	102.5	104.5
6	224.0	226.0	233.0	240.0	242.0
7	336.5	338.5	343.5	348.5	350.5

Notes for Table A-6:

1. Fixed central frequencies for four TDM spectral windows, each of width 1.875 GHz, and the corresponding LO1 setting. Frequencies were chosen to optimize spectral performance, and they are centred in known low noise and low instrumental polarization tunings of the receivers.

It should be noted that full polarization observations require sufficient parallactic angle coverage for calibration (about 3 hours). Science Goals with properties that lead to a total observing time estimate that is less than 3 hours will have the time estimate set to 3 hours to ensure sufficient parallactic angle coverage is obtained.

A.8 Source restrictions

Source positions are designated by: 1) fixed RA and DEC; 2) RA and DEC at a specified epoch with a linear proper motion; 3) An ephemeris that is specified that gives the RA and DEC as a function of time. All positions should be in equinox J2000. Observations of the Sun, however, are not supported in Cycle 3.

In each Science Goal, sources are selected in one of two ways: by specifying a rectangular field, or by specifying individual positions, with or without offsets. Each involves some restrictions. The total number of positions in a Science Goal (SG) must be less than or equal to 150 and all must lie within 10 degrees of each other. Pointings with the ACA, if used, do not count against the 150 pointing Science Goal limit.

All the sources in a science goal must be defined by the same setup – either all as rectangular fields, or all as individual positions.

A.8.1 Rectangular field

A rectangular field (also referred to as a mosaic) is specified by a field centre, the length, width and orientation of the field, and a single spacing between the pointing centres. Observations are conducted using the “mosaic” observing mode. This repeatedly cycles through all the pointings in the mosaic so that the imaging characteristics across the map are similar.

It is now possible to create multiple sources inside a SG, each of which can have a differently sized rectangular field. The sources are subjected to the following restrictions:

1. They are not separated by more than 10 degrees on the sky;
2. They can be observed with one spectral setup (relative placement and properties of spectral windows);
3. They can be observed with no more than five separate frequency settings that all fall within the same receiver band;
4. The sum over all mosaic pointings is less than or equal to 150.

If ACA observations are requested as part of a mosaic, then a corresponding 7-m Array mosaic will also be observed. If these are spectral line observations, the full mosaic area can also be covered by the TP Array in the available bands using On-The-Fly mapping.

The OT will set up a uniform mosaic pattern based on a user-specified pointing separation, and will calculate the time to reach the required sensitivity considering any overlap. Non-Nyquist spatial samplings are allowed. Sparser samplings must be justified in the technical justification. Individual mosaics will not be combined during post-processing.

A.8.2 Individual pointings

If a user does not wish to specify a rectangular field, they may include in a single Science Goal a mixture of sources and offsets, provided that:

1. They are not separated by more than 10 degrees on the sky;
2. They can be observed with one spectral setup (relative placement and properties of spectral windows);
3. They can be observed with no more than five separate frequency settings that all fall within the same receiver band;
4. The sum over all sources, offsets, and frequency settings is less than or equal to 150.

For targets separated by more than 10 degrees, such as wide-area surveys, additional SGs may be added.

Offsets can be specified for any source within a Science Goal, but the 150 pointing limit applies. Sets of offsets are designated either as a “Custom Mosaic” or a “Pointing Pattern”. The pointing centre of a pointing in a custom mosaic must be within one antenna beamsize (primary beam) of the pointing centre of the nearest pointing to it. The interferometric data will be combined in post-processing to produce a single image. The latter are not observed as mosaics, do not have a separation constraint (apart from the 10-degree separation limit of a Science Goal), and will not be combined to produce a single image.

For offsets, the OT does not consider the effect of overlapping pointings; users must take this into account when specifying the required sensitivity.

If ACA observations are requested for the Science Goal, then the corresponding 7-m Array observations will be obtained for each source and the same pointings that were defined for the 12-m array will be used. If the TP array is also required, the 12-m offset pointings must have been defined as a custom mosaic. If not, each pointing must be placed into a separate field source i.e. multiple offset pointings are not allowed in this case.

A.8.3 Spectral scan mode

Proposers who wish to carry out spectral surveys or redshift searches can do so using the “Spectral Scan” option in the OT to automatically set up a set of contiguous spectral windows to cover a specified frequency range, provided that:

1. All targets are separated by less than 10 degrees on the sky;
2. Angular resolution and LAS are computed for the Representative Frequency of each SG;
3. No more than 5 frequency tunings are used, all in the same band;
4. Only one pointing per target (no mosaics or offsets allowed);
5. The sum, for all targets, of the number of separate tunings required does not exceed 150 (i.e., the maximum number of targets, for 5 tuning for all targets in a SG, is 30);
6. Only 12-m Array observations are required (the ACA is not offered for this mode).
7. No full polarization selected

Spectral scans are categorized as a non-standard mode, limiting the total time available for such observations

A.8.4 Science Goals with more than one tuning

Users can include up to five tunings in a single Science Goal. This enables spectral scans or observations of targets with different recessional velocities within the same SB. The current calibration scheme for ALMA is to make each SB self-contained in terms of calibration. Therefore, multi-tuning SGs result in bandpass, amplitude, and gain calibrators being observed for each tuning in the SB. For SBs that can be completed in a single execution, this is quite efficient. However, for SBs that require multiple executions, the available time for science targets in each execution is reduced, and the resulting SBs can be quite inefficient. Separating each tuning into its own Science Goal can lead to more efficient SBs and lower overall time estimates.

A.9 Calibration

The ALMA Observatory has adopted a set of strategies to achieve good calibration of the data (see Chapter 10 of the Cycle 3 Technical Handbook). 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 at observing time. If users opt for providing their own calibrators, justification will be needed. This may result in decreased observing efficiency and/or calibration accuracy.

A.9.1 Imaging dynamic range

The standard ALMA data reduction should be sufficient to produce images with dynamic ranges (peak continuum flux to map rms) up to ~100. Therefore images of bright sources may end up being dynamic range limited rather than sensitivity limited. This situation may be improved for some sources (e.g. by using self calibration), but this cannot be guaranteed.

The ACA and the compact configurations of the 12-m Array offer about the same imaging dynamic range. For the more extended configurations, or the higher frequency bands (Band 9 and 10) the maximum imaging dynamic range will be closer to 50.

For more information please see the Knowledgebase article *"What is meant by imaging dynamic range?"*.

A.9.2 Flux accuracy

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 Bands 3 and 4. Calibration in the higher frequency bands is likely to be less accurate. The goal is for it to be better than 10% in Bands 6 and 7. Calibration at Bands 8, 9 and 10 will be challenging even at the 20% level owing to the high atmospheric opacity.

A.9.3 Bandpass accuracy

The detailed shape of the spectral response of the arrays during observations depends on many factors. This shape particularly affects projects that intend to observe spectral features that cover a significant fraction of a spw, and/or study spectral features with small contrast with respect to a strong continuum. It has been determined that, for Cycle 3, projects that require spectral dynamic ranges (i.e., the desired signal-to-noise ratio per spectral resolution element), per observation execution, of up to 1000 for ALMA Bands 3, 4, and 6 and 500 for Bands 7, 8, 9 and 10 are feasible. Requests for higher accuracies may be the grounds for rejection of the proposal.

A.9.4 Total power calibration

The intensity calibration for single dish observations with the TP Array is made by using the Amplitude Calibration Device (ACD), which results in an intensity scale in terms of the corrected Rayleigh-Jeans antenna temperature T_A^* (K). To combine the TP data with the interferometric data the intensity scale is converted from K to Jy. The conversion factor is a function of the observed frequency, half-power beam width and aperture efficiency of the TP Array antennas. The latter two are derived from a single-dish calibration observation associated with the observations of the science targets. The overall accuracy for the total power calibration is about 5% at Band 3, 4, 6 and 7, increasing to 15% at Band 8.

A.9.5 Astrometry

For Cycle 3, users wishing to include additional check sources with known coordinates in order to get more accurate astrometric positions should select "user defined calibration" and add the desired astrometric reference sources as fixed phase calibrators. These will be changed to check sources during the Phase II process. The final observations will be run through the standard calibration; the PI will be responsible for calculating and applying the astrometric corrections. The approximate position accuracy for baselines longer than 1 km is less than 0.01".

A.10 ToO and time-constrained observations

Observations of ToO, monitoring and time-constrained projects will be offered in Cycle 3 with a few restrictions:

- Observations must be done in only one 12-m Array configuration; the ACA is not offered for time-constrained observations
- Time-critical observations requiring a time window smaller than 14 days will not be guaranteed, but may be attempted on a best-effort basis. Whether or not such observations are technically feasible will be decided on a case-by-case basis. In particular, observations with strict timing constraints but many possible time windows may be feasible.
- ToO projects that require observations within two weeks of contact with the ALMA observatory cannot be guaranteed to be executed.
- Proposals that require very good weather conditions for more than two hours continuously will be rejected on technical grounds. Observations with less stringent weather requirements are limited to three hours of continuous monitoring. The longest continuous observations allowed are 3 hours for Bands 3-7 and 2 hours for Bands 8-10.

Appendix B The ALMA Proposal Review Process

B.1 Description

ALMA proposals will be subject to peer review. The policies and procedures for this process are summarized below.

Standard and ToO proposals[3] will be reviewed by the ALMA Proposal Review Committee (APRC) and the ALMA Review Panels (ARP). There will be at least one ARP per science category, comprising experts in the range of scientific topics covered by this category. The primary criterion for selection of the ARP members (Science Assessors) will be scientific competence. ARP membership will ensure appropriate representation of the ALMA regions.

Proposals will be assessed on the basis of the overall scientific merit of the proposed investigation and its potential contribution to the advancement of scientific knowledge.

To keep the workload of the panels to a manageable level, science assessments will take place in two stages. For Stage 1 review, each proposal will be assigned to at least four members of one of the ARPs of its science category, who will each give it a score and provide a brief written assessment. The individual assessor's scores will be combined to compute a mean preliminary score, which will be used to build a Stage 1 ranked list of all proposals. The top ~70% will proceed to Stage 2, as well as any proposals for which the standard deviation of the individual Stage 1 scores exceeds a given threshold. The exact fraction of proposals that will proceed to Stage 2 may be adjusted according to the number of submitted proposals, so as to ensure that the workload of the panels at Stage 2 is kept to a manageable level and that as many proposals as possible undergo both stages of the scientific assessment.

All proposals will be subject to Technical Assessment by a selected group of JAO and ARC experts. Technical assessments will be performed in parallel with the Stage 1 scientific assessments, according to criteria reflecting the technical justification requirements described in Section 6.3.

All ARPs will meet face-to-face to discuss the proposals that proceed to Stage 2. Following its discussion, each proposal will be assigned a single, final ARP score by secret vote. It may be complemented by additional ARP recommendations such as when two or more proposals involve duplication of Science Goals (see Section B.2.2).

The APRC, consisting of the ARP Chairs, of a non-ARP member APRC Chair and of a Chilean representative, will meet face-to-face immediately after the ARP meetings to prepare a single ranked list of all proposals after reviewing all ARP recommendations. Particular attention will be paid to the recommendations for treatment of duplicated Science Goals. A fraction of the highest ranked proposals accounting for up to 20% of the available 12-m Array time will be assigned Grade A by the APRC. They will be eligible for carry-over to Cycle 4 if they cannot be completed by the end of Cycle 3. However, the APRC may issue recommendations to de-scope proposals that include both non-standard and standard Science goals, if the proposal ranking puts it over the 25% time allocation for non-standard observations. In particular, they may restrict their approval to those Science Goals that use standard observing modes. Whether such de-scoping should be applied or if the alternative of downgrading the whole proposal (see Section 5.3) should be preferred will be assessed on a scientific basis for each proposal for which it is relevant.

[3] For DDT Proposals, see http://www.almascience.org/proposing/ddt-proposals.

Based on the APRC recommendations, the JAO will assign execution priorities, for communication to proposers. Grades A and B will be assigned to the top-ranked proposals of each region until their cumulative execution time reaches the respective regional share of the available science time for the cycle, taking into account the technical feasibility of the proposals, the limitations on availability of specific configurations (e.g., ACA), and observability constraints. Selected proposals further down the ranking will be assigned Grade C. They will be used as “fillers” so as to optimize the distribution of the projects eligible for execution in the multi-dimensional observation parameter space, to ensure that the observing queue is populated at all times throughout the cycle, even when weather conditions are not optimal. Grade C projects will be added to the observing programme until the cumulative execution time for each region exceeds 1.5 times the regional share of the available science time. Grade C projects will be observed only if the conditions do not allow any of the Grade A or B projects to be executed. The remaining proposals will not be observed.

The final decision about proposal selection rests with the Directors Council. The JAO will prepare the final recommendation to the Directors Council, based on the APRC ranked list. After its approval by the Directors Council, the outcome of the Proposal Review Process will be communicated to the PIs of all valid submitted proposals. The notifications will include the following information:

- A statement of the ratio between the total amount of estimated time that would be required to carry out all submitted proposals and the anticipated available observing time over the cycle (that is, the array oversubscription factor);
- The overall ranking of the proposal, as one of the following options: first decile, second decile, 20-40% band, 40-70% band, or bottom 30% of the ranking;
- The eligibility of the proposal for execution and the probability of completion of the project, in the form of one of the following “priority flags”:
    - **A:** the proposal was assigned the highest priority of execution. If it is not completed by the end of Cycle 3, its execution will continue in Cycle 4.
    - **B:** the proposal was assigned the highest priority of execution. However it will not be carried over to future cycles, even if it is not completed by the end of Cycle 3.
    - **C:** the proposal is in the group of filler projects, which will be observed only if the conditions do not allow any higher priority project to be executed.
    - **U:** the proposal will not be scheduled. Phase 2 Scheduling Blocks will not be prepared for it (see Section Appendix D).
    - **I:** the proposal was rejected because it is deemed technically infeasible with the Cycle 3 capabilities.
    - **O:** the proposal will not be observed because of duplication with a higher-ranked project of the current cycle.
- A consensus report, that is, the feedback of the Science Assessors about the strengths and the weaknesses of the proposal;
- A technical feasibility note for those proposals that are affected by technical feasibility issues.

Note that priority flags A, B, C and U are assigned on the basis of proposal ranking, factoring in regional share constraints. Thus there is no simple, one-to-one match between the overall ranking of a proposal and its priority flag.

B.2 Proposal Review Process policies

B.2.1 Confidentiality

For proposals assigned priority flag A or B, the project code, the proposal title and abstract, the name and region of the PI, as well as the names of the Co-Is will be made public soon after PIs are informed of the outcome of the proposal review process. For A proposals metadata will be also made public. For grade C projects, the corresponding information will be made public as soon as its first data are archived.

The scientific and technical justifications of the proposals, as well as information about proposals that will not be scheduled or are infeasible, remain confidential.

Metadata of the observations, for example, the source positions, observation frequencies, and integration times, will be publicly available once the data of that observation are archived.

B.2.2 Duplication

A high-level principle of ALMA is that identical data should not be taken twice unless scientifically necessary. The term “Duplication” is used to refer to projects that may potentially replicate the data or results obtained in another proposal.

In Cycle 3, potential duplication of proposals may occur when more than one team applies to observe the same targets in the same observing mode (frequency, angular resolution, area, depth, etc). Duplications will be assessed at the Science Goal level; that is, a Science Goal will be considered a duplication of another Science Goal only if the observations are judged to be scientifically equivalent.

Observations are considered duplicates if the conditions spelled out in Section 5.2 of the Users Policies are met.

In case of potential duplications, the relevant proposals shall be directly compared with each other, so as to ensure that their relative ranks shall duly reflect their respective scientific merits. The science assessors will determine if the considered duplicate proposals are mutually exclusive or if it would be scientifically meaningful for more than one to be approved. The final verdict will be rendered by the APRC.

Observations obtained in previous Cycles (with the exception of Cycle 0) will constitute potential duplications for Cycle 3 proposals if the above conditions are fulfilled. Cycle 2 grade A projects and any Cycle 1 and 2 projects with data deliveries that occurred before the Cycle 3 proposal submission deadline will be considered for duplications. See the Duplications link on the Science Portal for information on checking for duplications.

The Science Justification of a Cycle 3 proposal involving partial or full duplication of Science Goals of an approved Cycle 1 or 2 project belonging to the same proposing group (either with highest priority or as filler) must include an explicit statement about the considered duplication(s). The proposers must specify if the duplicating observations need to be repeated in Cycle 3 even if they have been successfully completed by the end of Cycle 2. Such repetition, if deemed necessary, must be scientifically justified.

Appendix C Technical Justification Guidelines

The Technical Justification must be entered directly into the OT on a per-science goal basis. Below are some guidelines on issues to consider in the different sections. In general, please address all the parameters reported by the OT.

Sensitivity:

At the top of this section, the OT will display the sensitivity and S/N achieved for different bandwidths (bandwidth requested for sensitivity, aggregate bandwidth, a third of the line width) as appropriate for the spectral setup and the Expected Source Properties defined. You should justify the sensitivity and S/N for all parts of the spectrum that are of interest, e.g. for a spectral setup targeting a weak and a strong spectral line as well as the continuum you should discuss the S/N expected for each. Keep in mind that the fluxes in the Expected Source Properties should have been entered **per synthesized beam,** i.e. you may have to correct any available flux measurements for the fact that your source is spatially resolved by ALMA and the flux is distributed over several synthesized beams (see Knowledgebase articles *"How can I estimate the Peak Flux Density per synthesised beam using flux measurements in Jy or K from other observatories?"* and *"How do I convert flux measurements given in Jy km/s or K km/s into the peak flux density required by the OT?"* for more details on using fluxes/brightness temperatures from other facilities). Users should be aware that the sensitivity requested may not always be achievable in practice, e.g. when the field of view contains another, very bright source or the spectrum has very bright lines (i.e. dynamic range limited). S/N values smaller than three trigger a blue informative message and need to be fully justified; they may lead to a rejection of the proposal on technical grounds if no adequate explanation is given. For setups including spectral lines, another value to double-check is the ratio of the line width (entered in the Expected Source Properties) over the bandwidth used for sensitivity (from the Control & Performance editor), which is conveniently displayed by the OT. It is important to understand that the sensitivity requested will be achieved over a frequency bin corresponding to this bandwidth, **not** necessarily over every spectral resolution element. For spectral line measurements this value should normally be larger than 3 (or even higher if you want to measure the shape of the line profile). An informative message will appear if this is not the case, and you should pay attention to address this issue in the justification text (e.g. if the sensitivity requirement is driven by the continuum it may be acceptable to have a very low ratio).

The final parameter to be checked for observations measuring both line and continuum emission is the spectral dynamic range, defined as the continuum peak flux divided by the line RMS. Limits on the spectral dynamic ranges offered in Cycle 3 for the different ALMA bands are given in Appendix A (Section A.9.3); an informative message will appear if these are exceeded and the proposal may be rejected on technical grounds. The spectral dynamic range is important especially when trying to detect a weak line on top of a strong continuum, and high spectral dynamic ranges may require a better bandpass accuracy than possible with a standard calibration. If you require a high spectral dynamic range you should consider selecting "User-defined calibration" and requesting extra bandpass calibrations.

Imaging:

Here you should justify the angular resolution (AR) and largest angular scale (LAS) requested, which for convenience are reported back to you by the OT. Note that if the LAS is zero, the OT will assume your target is a point source that can be observed with any configuration yielding an AR better than that requested. For more complex source structures (especially those requiring multiple 12-m configurations or the ACA) you should carefully justify your choice of AR and LAS, if necessary including simulations.

You can easily see whether additional 12-m configurations and/or 7-m ACA and/or Total Power observations will be carried out by checking the time estimate or project time summary in the OT. The *uv*-coverage for Cycle 3 is such that even snapshot images will be able to produce good maps of most sources. In the rare instances this is not the case (e.g. a very complex but bright source), the OT's sensitivity-based time estimate can be overridden (see below). For single or non-overlapping offset pointings PIs should make sure that the source fits within the inner 1/3 of the primary beam (field of view), or alternatively discuss the effects of the sensitivity loss towards the beam edges.

You should also pay attention to the imaging dynamic range (see Appendix A, Section A.9.1) expected in the final image if attempting to detect a weak signal that falls in the same pointing as a much brighter source. Note that this is not something that can be captured automatically by the OT, since it has no knowledge of the flux structure of the field to be observed. See the Knowledgebase article *"What is meant by imaging dynamic range?"* for details.

Correlator Configuration:

For spectral line observations, the OT reports the number of (Hanning smoothed) spectral resolution elements per line width (taking into account any spectral averaging) and the width of the representative spectral window. If the spectral resolution is larger than 1/3 of the line width from the Expected Source Properties, an informative message will appear, and if not suitably justified this will lead to the rejection of the proposal on technical grounds. Note that the spectral resolution is not necessarily the same as the bandwidth for sensitivity! You should carefully justify the requested correlator setup and the placement of spectral windows in the free-format text box. In the case of multiple spectral lines and/or narrow spectral windows in particular you should double-check that the line profiles are fully covered by the spectral windows defined. For high frequency ALMA bands (band 7 and up) you should check whether any of your spectral windows are severely impacted by atmospheric absorption, and if necessary modify the representative frequency to be at the most restrictive part of the atmosphere you want to detect a line (this will impact the time estimate), and/or move around any continuum windows to avoid areas of bad transmission. For the double sideband receivers (Bands 9 and 10) you should be aware that the atmospheric transmission in the spectral window mirror impacts the sensitivity achieved in the spectral window (and therefore the time estimate), and you may want to modify the spectral setup accordingly.

Choices to be justified:

The OT will automatically catch a number of user choices that must be explicitly justified and if applicable bring up a text box that must be filled. These choices are

- High data rate: the maximum data rate acceptable for ALMA is 60 MB/s, with an expected average of 6 MB/s. If the chosen spectral setup implies a data rate that is higher than twice the expected average you will need to justify this. Note that the limit is reached quite easily if more than two FDM spectral windows are defined. The easiest way to lower the data rate is by using spectral averaging. A spectral averaging factor of 2 will halve the data rate, but only marginally lower the spectral resolution of your observations.
- Override of OT's sensitivity-based time estimate: you may want to override the OT's time estimate because you would like to monitor a source over a certain time range, or because you want to build up the u-v coverage to image a very complex source. The time entered refers to the 12-m array time, includes all calibrations and must be fully justified. Note that proposals that require very good weather conditions (corresponding to observations in Bands 8, 9, or 10 or in Band 7 around the 325 GHz atmospheric absorption feature) for more than two hours

continuously will be rejected on technical grounds. Observations with less stringent weather requirements are limited to three hours of continuous monitoring. Note that the PWV automatically assigned by the OT based on the representative frequency of your observations is definite; it is not possible to request specific weather conditions for your observations.

- Time-constrained observations: the OT allows you to specify two types of time-constrained observing: single visit and multiple visits. In the first case, one or more time windows are specified, but the observations will only be carried out once during any of these time windows. In the second case, the Science Goal is observed in each of the time windows specified. While ALMA does not guarantee time-constrained observations within a time window of less than two weeks, it may be possible to time a single visit to a much higher accuracy if a large enough number of time windows are specified. The technical feasibility of time-constrained observations will be decided on a case-by-case basis.
- User-defined calibration: the default system-defined calibration option ensures that your data are adequately calibrated in terms of flux scale, bandpass and relative antenna gains. Observations making use of the full polarisation capabilities of ALMA will also include the necessary calibrations by default. User-defined calibrations should be necessary only in the rarest of cases, e.g. if a very high spectral dynamic range is required it may be necessary to perform additional calibrations and/or use specific sources. Such requests must be explained and justified in detail at Phase 1.
- Low maximum elevation: sources at high declinations are difficult to schedule for observation and suffer from high atmospheric attenuation, especially at high frequencies. Therefore you should offer a detailed explanation of why these sources need to be observed (rather than sources at lower declination) and/or why the observations cannot be obtained with another facility.
- Single polarisation: this should only be used when the very highest spectral resolution is required, as the sensitivity achieved is lower than when using the default Dual polarisation. You should carefully justify why the high spectral resolution requested is required for your observations.
- Non-Nyquist sampling for rectangular mosaics (Imaging section): given the drop in sensitivity towards the primary beam edges, Nyquist sampling is required to yield mosaics with a uniform sensitivity coverage. However, when the area to be covered is very large and large-scale structures are not being observed it may be acceptable to use a sparser sampling.
- ACA choice overridden (Imaging section): if you override the OT's recommendation for ACA use you need to explain your reason for doing so, ideally including simulations.

In addition to the issues mentioned above, PIs should note that the following requests/mistakes will lead to proposal rejection on technical grounds:

- Underestimation of the required observing time by more than a factor of 2 due to mistakes in the input parameters
- Smoothing of the data to resolutions that are comparable to those of a 12-m single-dish telescope.
- Technical Justifications based on data unavailable at the time of writing the proposal

- Omission of ALMA simulations that are integral to the justification of the observing requirements (see Section 6.2.1).
- Target of Opportunity (ToO) proposals that do not give full details on the number of triggers needed to reach the science goals of the proposal, what the trigger will be, and the necessary reaction time for scheduling the observation after it is triggered.
- Observations that cannot be set up in the OT
- Observations that are not fully defined in terms of Science Goals at Phase 1

Appendix D Preparation & submission of observations: Phase 2 and Changes to Projects

D.1 Phase 2

Once a project has been approved for scheduling, the project passes into Phase 2. At this stage, the project is assigned an ALMA Contact Scientist at the associated ARC or ARC node. This Contact Scientist initiates contact with the PI, establishes a preparation timeline and subsequently acts as the primary channel of communication between the project PI and the ALMA Observatory as a whole.

An initial draft version of the observing instructions (i.e. the actual Scheduling Blocks, or SBs) is created by ALMA staff, based on the information originally submitted in the proposal. Any modifications to the submitted proposal mandated as a result of the proposal review process or necessitated by technical considerations are incorporated.

These draft SBs are then presented to the PI by the Contact Scientist. At this point, the Contact Scientist will explain the actual expected execution behavior of the SBs, and may provide additional explanatory material as appropriate. Any other details requiring further clarification or possible modification are also discussed at this juncture. Communication with the Contact Scientist happens through the ALMA Helpdesk. This ensures that all such discussions are well documented and completed in a timely manner.

Necessary changes to the project may also be implemented at this stage, at the discretion of the Contact Scientist, consisting only of minor changes that do not impact the science scope or increase the total execution time. Examples of these might include (i) a change in a target position that is no more than half the primary beam size, (ii) a change in the target frequency for spectral line observations that is no more than 20% of the width of the original spectral window specified (as long as no additional diagnostic spectral lines would be measured as a result of the change), and (iii) other trivial changes, such as changing the velocity reference frame from LSR to Heliocentric. Any change that is more significant than these examples must be filed through the Helpdesk as a fully justified formal change request (see Section D.2), and is generally discouraged. A helpdesk-filed change request should address how the requested change fits into the approved proposal science, and how it fits within one of the cases described below.

Once a final version of the Phase 2 program has been agreed to be ready for execution by both the Contact Scientist and the PI, the project is admitted to the ALMA observing queue to await actual execution at the telescope. PIs may track the status of their SBs through the Project Tracker (PT), accessible from the ALMA Science Portal.

D.2 Changes to submitted projects

Changes to a submitted project prior to the completion of the review process will not be permitted. Changes to a project accepted for admission to the ALMA observing queue, unless minor (see above), will not normally be permitted. However, should a PI wish to request a major change to a project (see examples below), this will be done via a standard change request form accessed from the Helpdesk. Such change requests must include a very clear description of the proposed change along with a clear, substantive justification for the change. All such change requests will be considered by the Observatory on a case-by-case basis. Approved changes will be implemented by ARC staff, in consultation with the PI.

PIs are requested to carefully check source coordinates, frequency and angular resolution settings and calibration needs and contact the Helpdesk or the relevant ARC/ARC node if they need support before submitting their proposal. Therefore, major change requests are only fully justified if additional information that may seriously affect the scientific case of the project has become available since the time of submission, when there is a demonstrable bona fide mistake, or when there is the potential for interesting scientific optimization (note that, as a general rule, optimizations of the observation strategy that do not increase the total execution time of a science goal and do not change the scope of the project are already suggested by the Contact Scientist and implemented on a best-effort basis during Phase 2 and should therefore not need a change request). Change requests leading to duplications against current or past ALMA proposals are not approved.

Examples of changes requests that need approval by the Observatory are (i) a significant change in the coordinates of a target, (ii) a change in bandwidth or spectral resolution, (iii) additional spectral window configurations or frequency ranges, (iv) a change in frequency that implies the observation of additional line transitions, (v) a change/increase in the mapping area or map resolution, (vi) a change of array (e.g. inclusion of the ACA), or (vii) addition of extra calibrators.

Major change requests are treated by the Change Request Standing Committee (CRSC), consisting of senior astronomers from the JAO and the ARCs, who submits their recommendations to the ALMA Director for approval. The major change requests are treated case-by-case and evaluated taking into account increase in science scope, change of observing time, change from a standard to a non-standard mode etc.

Appendix E Acronyms and abbreviations

ACA	Atacama Compact Array
ALMA	Atacama Large Millimeter/Submillimeter Array
AOS	Array Operations Site
APEX	ALMA Pathfinder EXperiment
ARC	ALMA Regional Centre
ARP	ALMA Review Panel
APRC	ALMA Proposal Review Committee
AR	Angular Resolution
ASIAA	Academia Sinica Institute of Astronomy and Astrophysics
AUI	Associated Universities, Inc.
CASA	Common Astronomy Software Applications
Co-I	Co-investigator
DDT	Director Discretionary Time
EA ARC	East Asian ALMA Regional Centre
EPO	Education and Public Outreach
ESO	European Southern Observatory
EU ARC	European ALMA Regional Centre
FDM	Frequency Division Mode
FOV	Field Of View
IF	Intermediate Frequency
KASI	Korea Astronomy and Space Science Institute
JAO	Joint ALMA Observatory
LAS	Largest Angular Structure
LST	Local Sidereal Time
MRS	Maximum Recoverable Scale
NA ARC	North American ALMA Regional Center
NAASC	North American ALMA Science Center
NAOJ	National Astronomical Observatory of Japan
NINS	National Institutes of Natural Sciences
NRAO	National Radio Astronomy Observatory
NRC	National Research Council of Canada
NSC	National Science Council of Taiwan
NSF	National Science Foundation
OSF	Operation Support Facility
OST	Observation Support Tool
OT	Observing Tool
PDF	Portable Document Format
PI	Principal Investigator
PWV	Precipitable Water Vapour
QA2	Quality Assurance Level 2
SB	Scheduling Block
SCO	Santiago Central Office
SG	Science Goal
Spw	Spectral window
TDM	Time Division Mode
TJ	Technical Justification
ToO	Target of Opportunity
TP	Total Power
WVR	Water Vapour Radiometer

Appendix F Science keywords

The list below presents for each science category the keywords that can be used in the OT to further specify the scientific area of the proposal. **Proposers must select at least one and at most two keywords.**

Category 1 – Cosmology and the high redshift universe

a. Lyman Alpha Emitters/Blobs (LAE/LAB)
b. Lyman Break Galaxies (LBG)
c. Starburst galaxies
d. Sub-mm Galaxies (SMG)
e. High-z Active Galactic Nuclei (AGN)
f. Gravitational lenses
g. Damped Lyman Alpha (DLA) systems
h. Cosmic Microwave Background (CMB)/Sunyaev-Zel'dovich Effect (SZE)
i. Galaxy structure & evolution
j. Gamma Ray Bursts (GRB)
k. Galaxy Clusters

Category 2 – Galaxies and galactic nuclei

a. Starbursts, star formation
b. Active Galactic Nuclei (AGN)/Quasars (QSO)
c. Spiral galaxies
d. Merging and interacting galaxies
e. Surveys of galaxies
f. Outflows, jets, feedback
g. Early-type galaxies
h. Galaxy groups and clusters
i. Galaxy chemistry
j. Galactic Centres/nuclei
k. Dwarf/metal-poor galaxies
l. Luminous and Ultra-Luminous Infra-Red Galaxies (LIRG & ULIRG)
m. Giant Molecular Clouds (GMC) properties

Category 3 – ISM, star formation and astrochemistry

a. Outflows, jets and ionized winds
b. High-mass star formation
c. Intermediate-mass star formation
d. Low-mass star formation
e. Pre-stellar cores, Infra-Red Dark Clouds (IRDC)
f. Astrochemistry
g. Inter-Stellar Medium (ISM)/Molecular clouds
h. Photon-Dominated Regions (PDR)/X-Ray Dominated Regions (XDR)
i. HII regions
j. Magellanic Clouds

Category 4 – Circumstellar disks, exoplanets and the solar system

a. Debris disks
b. Disks around low-mass stars
c. Disks around high-mass stars
d. Exoplanets
e. Solar system: Comets
f. Solar system: Planetary atmospheres
g. Solar system: Planetary surfaces
h. Solar system: Trans-Neptunian Objects (TNOs)
i. Solar system: Asteroids

Category 5 – Stellar evolution and the Sun

a. The Sun
b. Main sequence stars
c. Asymptotic Giant Branch (AGB) stars
d. Post-AGB stars
e. Hypergiants
f. Evolved stars: Shaping/physical structure
g. Evolved stars: Chemistry
h. Cataclysmic stars
i. Luminous Blue Variables (LBV)
j. White dwarfs
k. Brown dwarfs
l. Supernovae (SN) ejecta
m. Pulsars and neutron stars
n. Black holes
o. Transients

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