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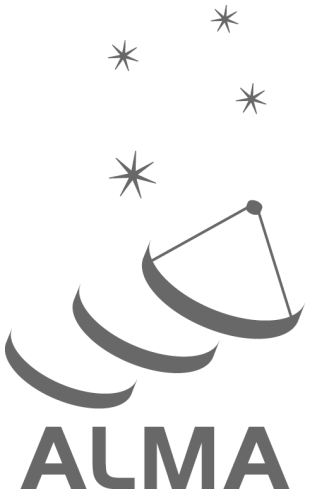
Guide to the European ALMA Regional Centre

European ARC and ARC nodes, edited by Martin Zwaan



www.almascience.org

ALMA, an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile.

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 directed to the appropriate ALMA Regional Center at ESO, NAOJ or NRAO.

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Contributors

This document was written by the European ARC at ESO and the European ARC nodes

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Purpose of this document

The purpose of this document is to help users finding their away around the European ALMA Regional Centre (ARC). The main message is that the European ARC is the 'one stop shop' for all European ALMA users. Our goal is to explain how the ARC structure works and how it can help users at the different stages of their ALMA observing project.

ALMA in a nutshell

The Atacama Large Millimetre/submillimetre Array (ALMA) is expected to be the leading observatory at millimetre and submillimetre wavelengths in the coming decades. ALMA is a global collaboration involving East Asia, Europe, North America and the host country Chile. When completed, ALMA will comprise at least 66 high precision antennas equipped with receiver and digital electronics systems to observe in the frequency range from 30 GHz to 1 THz and angular resolutions as high as 6 milliarcsec. Using a fully dynamic scheduling system and innovative calibration strategies, the ALMA system will allow to make the best use of the atmospheric conditions on the Chajnantor plateau at 5000 m altitude in the Atacama desert. ESO is leading the European contribution to the ALMA project on behalf of its member states.

Early Science will be the first opportunity for the users to propose science projects with ALMA. In this initial call, only reduced (but still substantial) capabilities will be offered: 16 antennas for interferometry, four frequency bands and a limited range of baselines. The capabilities of ALMA will gradually improve during Early Science operations and we currently expect that the ALMA baseline project will be completed and in Full Science Operations by 2013.

More information on the ALMA project can be found on the ESO ALMA webpages at www.eso.org/sci/facilities/alma

Organization of European ARC structure

The ALMA Regional Centre (ARC) structure in Europe supports the science use of ALMA by the European user community. The ARC forms the interface between the ALMA observatory and the user community throughout the lifetime of a project, i.e., from proposal preparation to data analysis. In Europe, the services to the community are provided by a distributed network with a central, coordinating node at the ESO headquarters in Garching, and ARC nodes at Manchester, Leiden, Bonn, Onsala, Grenoble, Bologna, and Ondrejov.

The primary aim of the ARC structure in Europe is the maximize ALMA's scientific return for European users. The ARC structure is staffed with scientists, most of whom are experienced (sub)millimeter interferometrists. The staff at the ESO ARC and the ARC nodes work together to provide optimal support to users along the complete trajectory from proposal preparation, choosing which observing modes, preparation of phase II material (the so-called 'scheduling blocks' or SBs), delivery of the calibrated science products to the users, and, if required, additional data reduction. Furthermore, the ARC can give advice regarding observing strategies and can help with ALMA archival research. The ARC network organizes tutorials and workshops throughout Europe to train users in proposal preparation and data reduction.

The central point of contact for ALMA users is the ALMA help desk, which is available to all registered users from the ***ALMA User Portal***. There is one Helpdesk for all global ALMA users, but queries from European users will be primarily addressed by the European ARC, either by scientists in Garching or by staff in one of the ARC nodes.

For all ALMA questions: use the ALMA Helpdesk to contact the ARC. The Helpdesk is available through the User Portal.

Role of the central ARC and the ARC nodes

The central ARC in Garching and the ARC nodes distributed throughout Europe work together to provide optimal support to European ALMA users. It is however important to realize that the tasks that the central ARC and the nodes fulfill are very different. The most important differentiation is that all face-to-face support is happening exclusively at the ARC nodes. This face-to-face support is recognized as one of the core functions of the ALMA project.

To provide some background information, we briefly describe here the different tasks of the central ARC and the ARC nodes. We stress, however, that the typical ALMA user does not need to know the details of the task division between the central ARC and the nodes.

All initial contacts between the user and the ARC structure happen through the ALMA Helpdesk. The ARC staff may answer the user's question immediately, refer to documentation, or forward the query to an expert within the ARC network. The ARC may advise that face-to-face help is required, or the users may indicate themselves that they need face-to-face support.

When we restrict ourselves only to the tasks that are of direct relevance to ALMA users, the main tasks of the central ARC are:

- Phase I operations, implying the distribution of the call for proposals to prospective European ALMA users, and support to them during proposal preparation. We also provide assistance in coordinating the refereeing process and in assessing the technical feasibility of the proposals.
- Phase II operations, which includes assisting users with the preparation of the technical details required to schedule and execute the proposed observations, and validation of Phase II material.
- Data product support: delivery of the final raw and pipeline-reduced data to the PIs.
- Archive operations: The ESO ARC node holds a complete synchronized copy of the ALMA archive.
- Staffing the ALMA Helpdesk.
- Community development and outreach.

The relevant tasks of the ARC nodes are:

- Face-to-face user support with proposal preparation.
- Face-to-face help with data reduction, including also expert support in data processing for specialized observing techniques.
- Help in archival research, including assistance to users of the ALMA archive in identifying and using the data products suitable for their scientific projects.
- Community development and outreach.

The following section describes in more detail what kind of support can be expected throughout the lifetime of an ALMA project.

How the ARC can help with your ALMA observing project

For each scheduling period, a Call for Proposals for ALMA will be issued. The ESO ARC will distribute this call among the European user community by email and make it available on the ESO ALMA web pages: www.eso.org/sci/facilities/alma. The call provides information about the available capabilities and necessary information for the submission of electronic proposals. Initially, the call for proposals will go out once per year, but this frequency will change to twice yearly when ALMA is in full operation.

The ALMA User Portal

All ALMA users need to register to the ALMA User Portal, which is accessible through the ESO ALMA web pages. This User Portal is a single sign-on gateway to the various tools described below, the Helpdesk, the ALMA Science Archive, and other relevant information.

*To submit a proposal, download ALMA software, or gain access to the Helpdesk, you will need to register with the **ALMA User Portal** (http://almascience.org/).*

Proposal preparation

The Phase I material of the proposals must be prepared with the ALMA Observing Tool (OT), which allows the users to provide a scientific and technical justification, target specification, time-on-target plus overhead specification, sensitivity and integration time estimation, atmospheric conditions requirements (e.g. transparency and atmospheric conditions), etc. This tool is available from the ALMA User Portal and from the ESO ARC webpages.

The ALMA Observing Tool is available for downloading from the ALMA User Portal. Need help? Use the Helpdesk to contact the ARC.

In addition, there is the online ALMA simulator, hosted at the UK node. This online tool allows users to upload an image and 'observe' it with ALMA at different frequencies, bandwidths, configuration, integration times and weather conditions. The results are images as ALMA would produce them, together with point spread functions and maps of the uv-coverage. This information can help users in planning their ALMA observations. This tool, the Observation Support Tool (OST), is available from http://almaost.jb.man.ac.uk/.

More experienced users may want to use simulation capabilities included in the CASA data reduction package, which allows for more flexibility.

At ESO, ARC staff assist users with the preparation of their Phase I material. This assistance covers technical help with the Observing Tool, help with the ALMA exposure time calculator and simulator, but also involves consultation regarding observing strategy.

Users may choose to visit an ARC node for face-to-face support during proposal preparation.

Need help with proposal submission? Use the Helpdesk. Need face-to-face help for preparing a complicated proposal? Use the Helpdesk to coordinate a visit to an ARC node.

After proposal submission

After the submission deadline, all proposals are ranked by the Proposal Review Committee (PRC), who makes a recommendation to the ALMA director on the scheduling of ALMA projects for the coming period. Note that there is only one international proposal review committee for all ALMA proposals.

Users with newly approved observing projects are notified by email and invited to complete the observation preparation phase, known as Phase II. At this time, users shall provide all additional information not supplied during Phase I required to schedule and execute individual observations. This information shall be submitted using the same tool that is used for the preparation of Phase I material: the ALMA Observing Tool (OT), provided by the Joint ALMA Office (JAO) in Chile, and available to users through the User Portal. The ARC staff shall again be the primary interface between the users and the Joint ALMA Observatory during this observation preparation phase. The result of this phase is the creation of Scheduling Blocks (SBs) which are required to execute observations. The SB is the smallest (indivisible) unit in ALMA observing that can be scheduled independently. The SB contains a full description of how the science target and the calibration targets are to be observed, and sets of SBs can be combined with a description for the post processing of the data, ultimately resulting in an image.

Support with preparation of Scheduling Blocks (SBs)

A Phase II completion deadline is established for each scheduling cycle and this deadline is communicated to all users with approved programs. It is important to adhere to this deadline as all projects with incomplete Phase II submission at the deadline will not be executed.

All submitted SBs are verified by ARC staff. If problems are found, users are notified and asked to revise their material. Until such problems are resolved, user-provided observations will not be scheduled for execution. Note that the problems can be technical (i.e. user used the OT incorrectly or the OT produced bad results) or operational (i.e. the ARC review reveals a better way to execute the program). Once all Phase II material is found to be correct, it will be certified and released to ALMA operations in Chile for scheduling and possible execution.

Users are allowed to modify their observing projects after this point only after seeking and receiving approval from the ARC, which can be contacted through the Helpdesk.

Scheduling Blocks that are submitted in time and verified by the ARC staff can be executed at any time without further intervention from users or ESO ARC staff. If a problem is found at run-time, execution of the SB and all associated SBs (i.e., the whole project) is halted. The ESO ARC then works with the user to fix the problem. Once the problem is resolved, the SBs are re-released for scheduling.

Need help with Scheduling Block preparation? Contact the ARC through the Helpdesk. Need face-to-face help for preparing Scheduling Blocks? Use the Helpdesk to coordinate a visit to an ARC node.

The ARC nodes can provide additional help to users in preparing their Phase II material. Users may choose to visit one of the ARC nodes and work with expert staff members to create their Scheduling Blocks.

Tracking your project

There is an online Project Tracker available to follow the status of an ALMA observing project and its scheduling blocks after the project is accepted and scheduled for observing. This tracking can be done by the principal investigator, co-investigators and observatory staff. The project tracker allows the PI and co-Is to search for their active projects and get an overview of the scheduling blocks that have been observed or are still in the queue, and which ones need additional work, etc. When problems arise during the execution of scheduling blocks, users are notified by email, and problems are logged in the Project Tracker as well.

Follow project progress with the Project Tracker tool, which is available through the User Portal.

After data have been taken

ALMA observing projects are dynamically scheduled, taking into account the weather conditions, the configuration of the array, the proposal ranking and possibly other constraints. Short projects may be observed within one day, whereas others may take several weeks or months to complete. After the observations for a project have been completed, users are notified by email.

All data pass through a multi-tier quality assurance (QA) scheme before they are released to the user. ALMA data sets can vary enormously in size, depending on correlator settings, averaging times and total integration time. Data size may range from many TB for lengthy projects to tens of GB for the shortest observations. Depending on the data volume, users can download the data from the ALMA archive over the internet, or may request to receive the data on hard disk drives.

The ALMA Science Archive is available through the User Portal.

It is important to realize that all ALMA data are kept in the archive. That is, the ALMA archive is not just a repository of 'old data', but all requests for data of recently observed programs are also handled through this archive. This ALMA Science Archive is accessible through the User Portal.

The data reduction pipeline

When a block of data for a particular program has been observed, the ALMA data reduction pipeline is activated. This pipeline runs on dedicated machines in Chile and uses a heuristics system to edit, calibrate and image automatically data taken with the standard observing modes. The pipeline heuristics have captured the reduction knowledge of experienced radio interferometer users and incorporated it into the reduction scheme. The output of the data reduction pipeline is stored in the ALMA Science Archive and is subject to a final Quality Assurance test before the reduced data are made available to the user. The Project Tracker can be used to explore which parts of your observing program have been fully pipeline processed.

Please note that during Early Science the pipeline will still be under development. The data processing will be done using a combination of the pipeline and by-hand analysis using CASA.

Data reduction support

The data reduction pipeline produces high quality science products for most standard observing modes. Expert hands-on help with data reduction may be required however, especially when more complicated observing techniques are used. The ARC is the primary contact point for users who need assistance with the data reduction. ARC staff provide basic data analysis support, ranging from simple advice, to provision of appropriate data analysis documents and products, to detailed assistance for users who require it.

It should be understood that the ESO ARC's responsibility lies primarily at assuring that the reduced data from all standard ALMA observing modes meet the requirements as set by the approved observing proposal and those specified by the Quality Assurance procedure.

Basic data reduction support: use the Helpdesk. Advanced data reduction support: visit an ARC node (use the Helpdesk to coordinate a visit)

The ARC nodes can provide further assistance to all users who require it. A likely scenario may be the following: The ALMA data reduction pipeline has processed your data and produced a high quality data cube that is publication ready for many purposes. To reach your specific science goals however, you may need images with higher spatial resolution or higher sensitivity. The ARC nodes can help you to reprocess the data, using different weighting schemes in the imaging stage. Another user may need higher dynamic range image cubes and can work with an ARC node to apply self-calibration to the data. For the use of nonstandard analysis techniques and the utilization of the advanced algorithms and software developed by one of the nodes, ALMA users can also travel to an ARC node, where the best possible support can be provided.

Visitors to the ARC nodes are guaranteed use of the most recent version of the CASA package. For any first line CASA support, please visit the CASA Guides website at casaguides.nrao.edu.

Additional help from the European ARC

Archive research support

A complete, synchronized mirror of the ALMA archive is kept at ESO and is a valuable resource for data mining. Assistance for archive research would encourage broader approaches to scientific investigations. Scientists in the ARCs enable archive research by providing support for astronomers accessing the ALMA science archive. The ALMA Science Archive is available through the User Portal.

To ensure that the archive (and ALMA) is exploited to its full potential, ARC nodes provide support for users wishing to make visits for the purpose of exploiting the archive. If the data to be analyzed are known before the visit is made, then it should of course be established at that point if the data's proprietary period has expired (normally 12 months after completion of the observing project).

Basic archive research support: use the Helpdesk. Advanced archive exploitation support: visit an ARC node (use the Helpdesk to coordinate a visit)

Prospective ALMA users are likely to want to consult the Archive when planning observations as well as for data mining. The ARC nodes can help users extract information effectively (such as potential calibration source properties, or whether there are public domain data meeting the required criteria) as well as assist with analysis of archive data, as for any other project.

Users may want to contribute advanced data products back to the archive; such requests for ingestion are coordinated by ESO.

Need training?

The European ARC structure regularly organizes workshops and tutorials related to ALMA. Dedicated CASA data reduction tutorials are organized throughout Europe, as well as sessions introducing the ALMA Observing Tool and more general workshops introducing ALMA capabilities. The ESO ALMA webpages give a listing of all scheduled activities and the European ARC email list is used to disseminate this information.

Need information on upcoming ALMA related tutorials and workshops? Check the ESO ALMA webpages and sign up to the European ARC email exploder.

General questions

For any general questions related to. e.g., the capabilities of A LMA, the availability of certain observing modes, or anything else, please also use the Helpdesk.

Any questions related to ALMA: use the Helpdesk

How to organize a face-to-face visit

As stated before, the preferred route to obtaining any type of support is through the ALMA Helpdesk. The user may indicate that they require face-to-face support or an ARC scientist may suggest that face-to-face help is desirable. In the Helpdesk ticket, give as much information as possible on the purpose of the visit and the proposed node and dates. In case the user has already contacted an ARC node about face-to-face support, a Helpdesk ticket should still be created by the user or the node staff to keep a centralized schedule of ARC node visits.

User visits are usually made to a local node as national funding bodies normally expect this. If the user and the ARC (node) staff decide that specialist support can only be (or better) provided at another node, this can be organized.

Requests for face-to-face support should be made through the Helpdesk. Together with the staff at the ESO ARC and the ARC nodes, it is decided which node the user should visit and on which dates. Support staff at this node are responsible for arranging the details of the visit. Each visitor is assigned a single member of staff for support purposes and can expect that this support person will be able to respond as quickly as possible to their requests for help, within reason.

Prior to a visit, the user's data are downloaded from the Archive and made ready for their arrival. Computer facilities at the ARC node are made available. If users have any special needs or plan to work on their private laptop computer, this should be discussed with the ARC node before arrival. Laptop use is in principle not encouraged considering the expected sizes of the ALMA data files.

It should be noted that ARC node staff need specific permission from the user to access their data in the ALMA Science Archive. ARC nodes provide facilities for the user to copy data onto a hard disk drive or (size permitting) DVD. Before a user travels to an ARC node, they discuss with the node staff which media are supported and whether the user should bring appropriate storage devices. Nodes can also support ftp of data providing the link at the user's home institute is fast enough.

ARC nodes keep a copy of the data the user has been working on for at least a few weeks after the end of the user's visit. That way, if there are post-visit questions, the ARC nodes can look directly at the data, making it much easier to understand any problems users may have.

After a visit, the user is invited to submit feedback on the service received and whether the goals of the visit were met. This is done via a web form on the ESO ARC web pages.

Resources for visits

It is foreseen that most users apply for funding from their local agencies for support to travel to one of the ARC nodes. Some ARC nodes have access to funds for visiting scientists. Please check the details in the next section, or visit the ARC node web pages.

The ARC nodes

This section provides more information on the type of support the different nodes can provide. Users are encouraged to visit the individual ARC node web pages to obtain the most up-to-date information. Most ARC nodes also maintain email lists that are used to inform their local communities about activities and region-specific news items.

The Italian node in Bologna

The Italian ARC node is located at the at the Istituto di Radioastronomia in Bologna. Once ALMA is operational, the Italian ARC-node will employ one staff member and four postdocs that dedicate 50% of their time to face-to-face support of visitors and other ALMA-related tasks. The ARC occupies an open-plan office, where desks are available for up to two or three visitors simultaneously. Each visitor is assigned a desktop computer, with which they can connect to a dedicated server through a high-speed optical fibre connection (10 Gbit/sec). Connecting personal computers to the server is also possible. A dedicated system manager is present at the ARC node to solve any computer/software-related problems. A total of 14 TB of disk space is available for data storage and -elaboration.

Visit the Italian ARC node at www.alma.inaf.it

Apart from general face-to-face help, the Italian ARC offers support for two specialized areas of observations: mosaicking and polarimetry. Their expertise furthermore includes handling of large data sets and GRID-technology. They also offer general scientific support concerning mm-astronomy and interferometry.

No funding for visitors (travel, lodging) is available.

The Dutch node in Leiden: Allegro

Allegro, the ARC node in the Netherlands, is located at Leiden Observatory. The node's duties are distributed over two staff members and two postdocs.

Allegro provides general face-to-face support. Allegro also offers expert advice on high-frequency observing (roughly speaking bands 8, 9, and 10) including proposal planning, setup of observations and calibration strategies, reduction techniques, and data analysis. In addition, Allegro offers help in using radio-techniques for wide-field imaging, and hosts a large suite of data analysis tools that can be consulted on-line or in person.

Visit the Dutch ARC node at www.alma-allegro.nl

The German node in Bonn/Bochum/Cologne

The German ARC node was established as one initiative of the Research Association for Interferometry in North Rhine-Westphalia and is a collaboration between the astronomical institutes at the universities of Bonn, Cologne and Bochum. The node is physically located at the Argelander Institute for Astronomy in Bonn. The ARC support is provided by a total of two permanent staff and three postdocs.

The ARC node provides a dedicated visitors room equipped with workstations that can access all the necessary data and software for ALMA data reduction, help with proposals, and ALMA archive research. A total of three visitors can be accommodated simultaneously and the visitor office is located next to a dedicated parent-children office.

Visit the German ARC node at www.astro.uni-bonn.de/ARC

In addition to the face-to-face support, the German node offers support in three specialty areas: advanced data analysis and modeling, polarimetry and astrometry. The advanced analysis includes work with the Cologne Database for Molecular Spectroscopy and a number of in-house developed tools.

The IRAM node in Grenoble

IRAM is an international institute funded by Germany, France, and Spain. The institute is operating the 30-m Pico-Veleta telescope and the Plateau de Bure interferometer. The face-to-face support is organized using the same procedures and infrastructures as for the Plateau de Bure. A computer room dedicated to data reduction is available and each project is assigned a local contact. A total of six staff are associated with the IRAM node.

The IRAM ARC node provides a good opportunity to use synergies between the IRAM instruments and ALMA, as, e.g., an access to the full sky or to large-scale surveys with the 30-m. In addition to general face-to-face support, specific domains of expertise at IRAM include the calibration of (sub)millimeter interferometric data or wide-field imaging and the inclusion of short-spacings.

Funding is available for travel and accommodation, with the usual IRAM rules: one mission/one person per project. Funding is however limited to astronomers affiliated to one of the IRAM funding agencies.

Visit the IRAM ARC node at www.iram.fr/IRAMFR/ARC

The Nordic node in Onsala

The Nordic ARC node's main mission is to support ALMA users in Denmark, Finland, Sweden and other Nordic and Baltic countries. The node is physically located at Onsala Space Observatory (OSO) near Gothenburg, Sweden. OSO is the Swedish National facility for Radio Astronomy and is hosted by Chalmers University of Technology. OSO has a long history in mm/submm astronomy and presently runs the 20 m single dish telescope at Onsala and is a partner in the APEX submillimetre single dish telescope at the ALMA site in Chile.

Visit the Nordic ARC node at www.chalmers.se/rss/oso-en/observations/alma-regional-centre

The ARC node has high capacity data links for downloading archive data and high performance computer facilities to support ALMA data reduction. There is ample dormitory and guest room accommodation on site to support data reduction visits and small workshops. ARC node support is spread over six staff members, four of whom are permanent employees, plus a postdoc and a student. The permanent staff include experienced millimetre wave observers, specialists in interferometry algorithm development and computer support personnel.

The node is active in community outreach to promote ALMA in the Nordic countries. The node also organises meetings for the whole Nordic community to explain the science that can be done with ALMA and train users to plan, submit, and reduce ALMA projects. As well as giving general face-to-face support, the node has expertise in the areas of astrometry, robust phase self-calibration, multi-frequency synthesis, deconvolution algorithms and polarisation. In collaboration with academic staff at Chalmers, there is also extensive scientific expertise on-site in the areas of radiative transfer and astrochemistry.

The UK node in Manchester

The UK ARC node is centrally located at the University of Manchester and conveniently placed for all national and international transport links. A dedicated suite of offices and workstations is provided in a new building which houses the Jodrell Bank Centre for Astrophysics. Six ARC staff (plus IT and administrative support) divide their time between face-to-face user support and related research and development. Facilities for visiting astronomers at the Manchester ARC node include a large dedicated room with ample desk space, which can also be used for small meetings/tutorials. Staff members can provide guidance for installation of the basic software on a user's laptop, as well as high-capacity dedicated machines if more powerful data reduction facilities are required. The node has very fast internet links (enhanced through Manchester participation in real-time VLBI) for communication with the ESO-based ALMA Archive.

Visit the UK ARC node at www.alma.ac.uk

The UK ARC node draws on local and national expertise to offer specialised assistance in a number of areas:

- Interferometry skills, in particular advanced calibration, especially for extended array configurations (high resolution), wide-band high-sensitivity continuum imaging (multi-frequency synthesis), mosaicing and wide-field imaging (including combining ALMA configurations to improve image fidelity), and polarimetry.
- Multi-instrument research, in particular comparing data from different telescopes, combining ALMA and compatible data, and interoperability between CASA and AIPS.
- Data management, in particular data mining the ALMA Archive, development of pipelines and scripts for large projects, standards and documentation for data publication, and simulations.

UK PATT funding may be available for visits by eligible investigators based at a UK institute to reduce ALMA data (but this cannot be used prior to the acceptance of an observing project).

The Czech node in Ondrejov

The Czech node in is located at Ondrejov Observatory near Prague. The node has available an office for two visitors equipped with computers dedicated to ALMA. They can offer cheap accommodation in the guest rooms of the Astronomical Institute at Ondrejov. The node's duties are currently distributed over two staff members, four postdocs, and one technician.

Visit the Czech ARC node at www.asu.cas.cz/alma

The team is ready to provide support in preparation and submission of proposals to ALMA, with interpretation of observations, with some numerical modeling of the observed processes, and interstellar molecular line identification. The expertise areas of the Czech node are:

- Solar radio spectroscopy in dm-range, non-LTE radiative transfer, physics of the solar chromosphere, prominences and filaments, and solar flare plasma astrophysics.
- Galaxy evolution in clusters and groups, triggered star formation, protoplanetary disks, galactic center and AGNs.
- High resolution microwave laboratory spectroscopy of small molecules with a focus on hyperfine effects, spectroscopy of unstable transient molecular species, theoretical analyses of molecular energies, and transition (dipole) moment measurements.

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI) and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.