The European ALMA Regional Centre: User Support for European Astronomers

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What will happen when ALMA is operational? How can an astronomer apply to get observing time with ALMA? What happens when their proposal is approved? Will they be able to process the data, obtain high-quality science products and extract their science from it? Sooner or later each astronomer interested in ALMA science will ask herself or himself these questions. The aim of this article is to describe how the process of proposing for observing time, subsequent execution of the observations, obtaining and processing of the data is going to take place in the ALMA epoch.

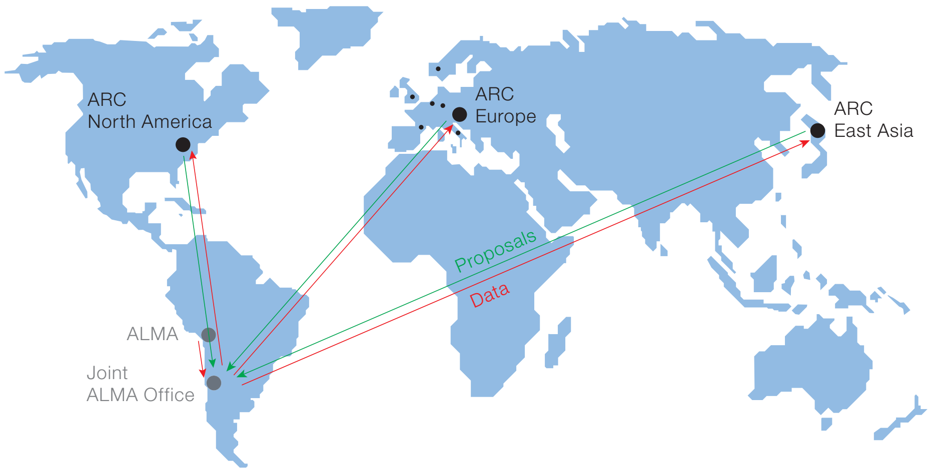
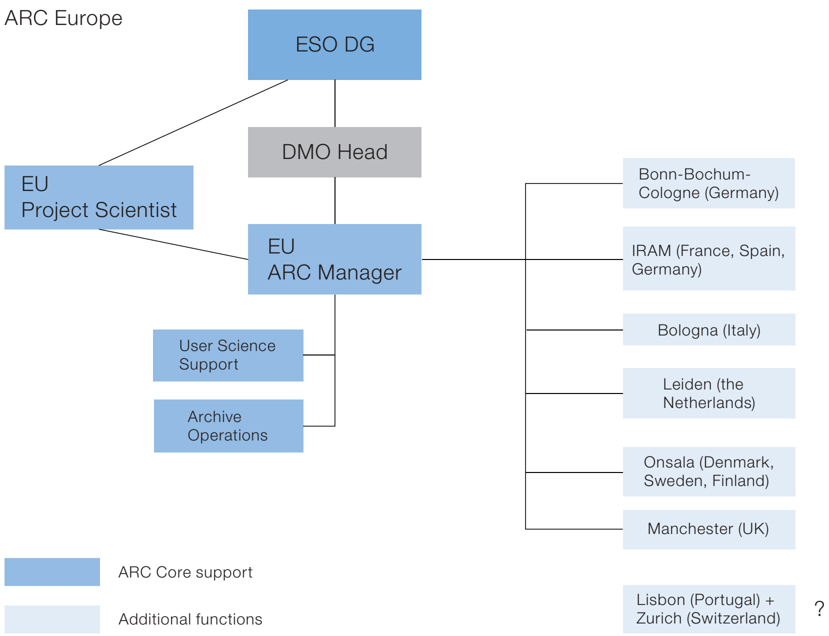


Figure 1 (above): Proposals/Observing files are sent from the ARCs to the Joint ALMA Observatory (JAO) in Santiago (Chile). Data are sent from the JAO to ARCs by reverse route, with complete archives of all data at all four sites.

Figure 2 (below): A schematic sketch of the EU ARC structure, with the ESO central node and the satellite nodes in Europe: Bologna (Italy), Bonn-Bochum-Cologne (Germany), Grenoble (IRAM, France), Leiden (the Netherlands), Manchester (UK), and Onsala (Sweden, Denmark, Finland).



From an astronomer's perspective, the basic principles on which the ALMA science operations are based are the following: *every astronomer, including novices to aperture synthesis techniques, should be able to use ALMA; ALMA observations will be carried out in service mode and will be dynamically scheduled to optimally match the weather conditions and array configuration; the calibration shall be reliable and self-consistent, so that data from the archive can be retrieved and reprocessed at any moment; data will be made public in a timely fashion.*

The interface between ALMA and the user communities is formed by the ALMA Regional Centres (ARCs), currently being established in Europe, the US and East Asia. For European users, the European ALMA Regional Centre (EU ARC) is being set up as a cluster of nodes located throughout Europe, with the main centre at the ESO headquarters in Garching. This main centre is part of ESO's Data Management Operations Division (DMO) and serves as the access portal to ALMA for the European user community. In synergy with the distributed network of ARC nodes, the centre's aim is to optimise ALMA's science output and to fully exploit this unique and powerful facility.

The EU ARC will be the point of contact for European ALMA users from the moment of proposal submission to the actual distribution of calibrated data and subsequent analysis. The core of the ARC activities will consist of running a help-desk for the proposal submission and submission of observing programmes, the delivery of data to principal investigators, the maintenance and refinement of the ALMA data archive, and the feedback to the data reduction pipeline and the off-line reduction software systems that surround it. The relationship between the user, the ARC, and the Joint ALMA Observatory (JAO) in Chile, is schematically shown in Figure 1. A sketch of the EU ARC structure is shown in Figure 2. Potential ALMA users may find it interesting to check from time to time the newly set-up EU ARC web page, where more details on the EU ARC tasks will continuously be added (*http://www.eso.org/projects/alma/ARC/*).

Indeed, for day-to-day operations, the three ARCs spread over three continents form an integral part of the overall ALMA operations. The ARC staff serve their regional communities, but also provide products to the entire ALMA observatory, such as improved pipeline heuristics or observing tools. Science staff from the ARCs rotate through Chilean operations, providing the necessary close ties among the sites, and keeping the ARC staff familiar with the realities of observatory operations.

Moreover, fundamental to ALMA's success in Europe are the enhanced services provided by the network of ARC nodes. These are required to fully realise the transformational nature of ALMA and to maximise the scientific return for the European community. Fostering community development and guiding the future evolution of ALMA use are among the nodes' primary tasks. The nodes will provide face-to-face help and additional support, beyond what are called *the ARC core functions*, such as advanced user support for special projects and refinement in the data-reduction process. To achieve these goals, the nodes will conduct a programme of fellowships, user grants, student and postdoctoral programmes, as well as promote the organisation of workshops and schools and any other support facilities for users. The sponsoring of workshops, schools, and events that stimulate the scientific activities around ALMA is very important for ALMA's visibility within the European programmes of education and public outreach.

What does a user have to do to submit an ALMA observing proposal?

Once the Joint ALMA Office (JAO) issues calls for proposals, an astronomer wishing to apply for observing time will have to register on the ALMA web page. After registration, the user will make use of the ALMA Observing tool (AOT) to prepare a proposal. The AOT is a java application and is essentially a complete software package enabling one to construct a so-called *Observing Project*. This Observing Project is the top item that any user will work on and consists of two parts: a *Phase I Observing Proposal* with emphasis on the scientific justification of the proposed observations and containing a minimal amount of technical information required to check the feasibility of the proposal, and a *Phase II Observing Programme* submitted only if observing time has been granted. The JAO, with assistance from the ARCs, coordinates the refereeing process. If European astronomers need help with the preparation of their Observing Project, they have to address themselves to the EU ARC, which provides documentation, proposal preparation and submission help. In case the users require face-to-face help, they will be directed to their national or geographically closest ARC node, unless it is a highly specialised issue, which can better be addressed at one of the other nodes.

The EU ARC also helps with the planning of the observations of proposals that successfully pass the scientific and technical evaluation of the time allocation committee. With the use of the AOT the user needs to specify the technical details that control how the observations are to be carried out. The user creates a number of scheduling blocks (SBs) that contain all information necessary to execute a single observation. A scheduling block essentially consists of low-level observation commands to be submitted to the observing queue and will typically take 30 to 60 minutes to execute. It can be thought of as the smallest unit that can be scheduled independently, reminiscent of the VLT observation block (OB). It is self-contained and usually provides scientifically meaningful data as well as a full description of how the science target and the calibration targets are to be observed. Sets of SBs can be combined with a description for the post-processing of the data, ultimately resulting in an image or a data cube.

The AOT provides two different 'Views' that can be used to define an Observing Project: a 'Science View' and a 'System View'. In the Science View, inputs should be provided that relate directly to the science goal, such as the area to be observed for each target, the required sensitivity and frequencies. The amount of technical detail in this view is minimal. Therefore, this view is useful for all astronomers, including those with little experience in aperture synthesis interferometry, to create full Observing Projects using standard observing modes. For more experienced users who desire more control over the telescope configuration, the AOT provides a 'System View'. In this view, more detailed specifications of each Scheduling Block can be given, such as the frequency setting of the local oscillator, the upper and lower side bands, the correlator parameters and the selection of base-bands and sub-band sets within each base-band. This view can also be used by experienced observers and observatory staff to develop and test new observing modes. Figures 3 and 4 show screen shots of the AOT's Visual Spectral Editor and the Visual Spatial Editor.

In accordance with the statement at the beginning of this article, it is foreseen that for most ALMA projects the Science View provides sufficient detailed information to fully specify the observations. The required SBs will be constructed by the system and the user will only be bothered with system parameters when this is absolutely necessary. All material produced in this phase will be verified by ARC staff, after which it will be certified and released to ALMA operations for scheduling and execution.

What does a user have to do to obtain ALMA data?

In the ALMA era, users will not travel to Chajnantor to carry out the observations. Instead, observations will be dynamically scheduled, depending on weather conditions and the array configuration. Observations will be carried out 24 hours per day. Some projects may require only a single configuration, whereas others may need observations using multiple configurations combined with the ACA (Atacama Compact Array, a Japanese contribution) and total power observations. Such a project may need several months to complete.

Before ALMA data reach the PIs, the data will pass through a multi-tier quality assurance programme. This programme is a combination of on-site duty astronomer checks, a quick-look analysis, system performance checks and feedback from ARC staff. After this stage, the data proceed to the data-reduction pipeline and

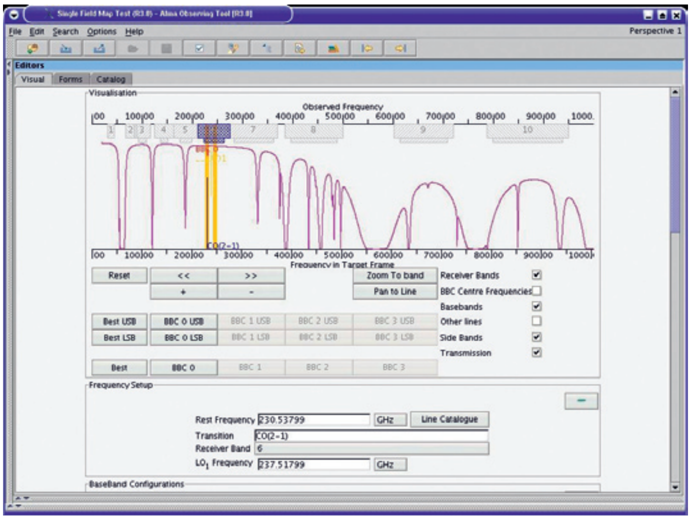


Figure 3: A typical display produced by the ALMA Observing Tool (AOT) using the Visual Spectral Editor. The graphics show the ALMA receiver bands and the user-selected positions for the base-bands and side-bands. Also, the atmospheric transmission curve is displayed.

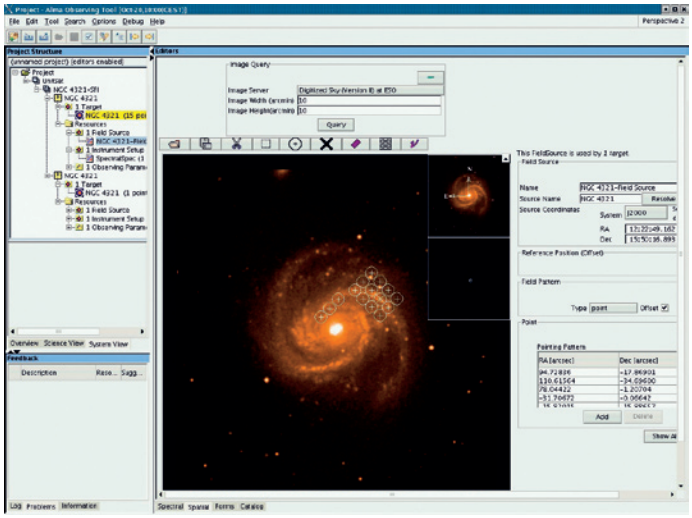


Figure 4: Display of the Visual Spatial Editor of the ALMA Observing Tool for an example single-field interferometry observation of NGC 4321. In the Editors pane the figure shows the image of NGC 4321 as it was retrieved from the ESO image server. The small circles represent the pointing positions for this target observation; the radius shows the size of the primary beam at the observing frequency. On the left the project structure in the System View is visible; on the right is the Field Source form with the Pointing Pattern table of the telescope pointings.

are delivered to the archive. PIs will be notified immediately after their science data become available. The items made available to the PIs are the pipeline products (fully calibrated images or data cubes and calibrated u-v data), raw u-v plane source and calibration data, and off-line data processing software including user support.

It is essential to the success of ALMA that astronomers inexperienced in aperture synthesis imaging techniques are able to obtain science-ready images and data cubes from their ALMA projects. The data-reduction pipeline will therefore produce high-quality science products for most standard observing modes. However, expert hands-on help will be required in many cases, especially when more complicated observing techniques are used. The first point of contact for data reduction help is the ARC main node in Garching, where users can address their questions by telephone or e-mail to a help-desk. Face-to-face help for specialised topics will be available from the nodes spread out over Europe. Specialised topics that come to mind are for instance high dynamic range imaging, multi-frequency synthesis, mosaicing, high-frequency imaging, self-calibration, advanced data analysis, etc.

The off-line pipeline data-reduction software package responsible for generating science ready data products is CASA (Common Astronomy Software Applications), a C++ code based on aips++ libraries. CASA has recently gone through major changes to optimise its use for ALMA data reduction. One of the most significant modifications is the creation of a completely re-designed python interface. Over the last few years, a series of user tests have been carried out to test the functionality of the data-reduction software and to ensure that the development is adequate for ALMA needs. The tests have concentrated on many data-reduction issues, and essentially covered the full end-to-end process from raw data sets to fully calibrated data cubes. The results from the tests have been very positive and promising, all testers were able to edit, calibrate and image the test data sets.

Concluding remarks

Although full ALMA operations will start in 2012, pre-operation activities have already started. The ARCs are organising the support system, testing the software, writing cookbooks and manuals and preparing the commissioning and science verification phase, which will be starting in 2009. The first call for proposals for Early Science will be issued in early 2010 and the ARCs must be functioning at full speed before that date.

The international community can provide inputs into the ALMA project and operation through their representatives in the ALMA Science Advisory Committee (ASAC) and the European community through the European ALMA Science Advisory Committee (ESAC). Links to these committees can be found in *http://www.eso.org/projects/alma/administration/committees/*.


Photo: H. Bohn, ESO

Sunset on Paranal. Unit Telescope 1 (Antu) preparing for observations and three Auxiliary Telescopes of VLTI undergoing tests.