ALMA

Science & Technology Facilities Council
UK Astronomy Technology Centre

The Atacama Large Millimetre Array, will be the largest and most sensitive telescope in the world at millimetre and submillimetre wavelengths (10mm-350μm). It will consist of at least 54 twelve-metre diameter antennas, and 12 seven-metre diameter complementary dishes. It will be built on the plains of Chajnantor, at 5000m above sea level in the Atacama Desert, Chile, one of the driest places on Earth.

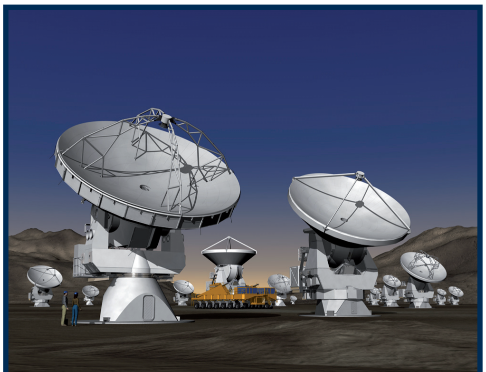
International Collaboration

ALMA is being built by a large international consortium including the USA and Canada (led by the National Radio Astronomical Observatory), 10 European countries (led by the European Southern Observatory) and Japan and Taiwan (led by the National Astronomical Observatory of Japan). The UK is participating in a number of areas in this challenging and complex project.

ALMA will begin operations with a small number of antennas in 2011, and reach its full potential with the completion of all antennas in 2013.

ALMA Science

ALMA will provide a millimetre/submillimetre counterpart to the world's major optical and infrared facilities such as the HST and VLT. Because submillimetre wavelengths are almost completely unhindered by obscuring dust, ALMA should be capable of seeing star-forming galaxies throughout the entire Universe, star-forming regions across our Galaxy, and planet forming regions in our solar neighbourhood. ALMA will represent a jump of two orders of magnitude in sensitivity and angular resolution so it will undoubtedly produce a major step in astrophysics, comparable to that provided by the HST. It will revolutionise the study of the origins of planets, stars and galaxies. But as with all major advances in telescopes, serendipity will play a role, and it is difficult to predict what new discoveries will be made and exactly where the biggest impact will lie.



Artist's impression of ALMA
Credit: ESO

ALMA Specifications

The ALMA antennas can be moved around on pads spread over the desert floor, effectively giving the telescope a "zoom" capability. At its largest, ALMA will be 14 kilometres across, allowing the telescope to observe fine-scale details of astronomical objects. Complementing this by using the 7 metre antennas in a "compact array" ALMA will be able to study the large-scale structures of these same objects.

The combination of the characteristics of the ALMA site: high, dry, large and flat, and the maximum antenna separation will mean that it will be possible to achieve 10 milli-arcsecond resolution, 10 times that of the Hubble Space Telescope.

ALMA will generate over 1200, and perhaps as many as 2016 individual antenna pairs ("baselines") during the observations. To handle this enormous amount of data, it relies on a very powerful, specialized computer (a "correlator"), which will perform 16 million billion (1.6 x 10^16) operations per second.

The ALMA site at Chajnantor

UK ATC Expertise

The UK ATC is leading the development of the ALMA Observing Tool, in collaboration with developers from ESO and NAOJ. This is software which will form the astronomer's primary interface with ALMA: an easy to use tool that will enable observers not experienced in submillimetre aperture synthesis to create observing programmes that meet their science goals, while also supporting the needs of experienced observers.

The UK ATC is also playing a significant role in developing the software that will convert the complex data to the form of images and spectra suitable for scientific analysis.

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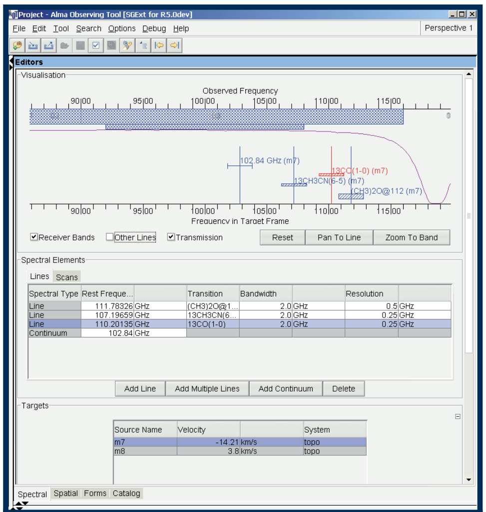


Frequency selection: Molecular transitions, in which the observer is interested and atmospheric transmission are shown in both graphic and table form. There is also a table showing which sources are to be observed.

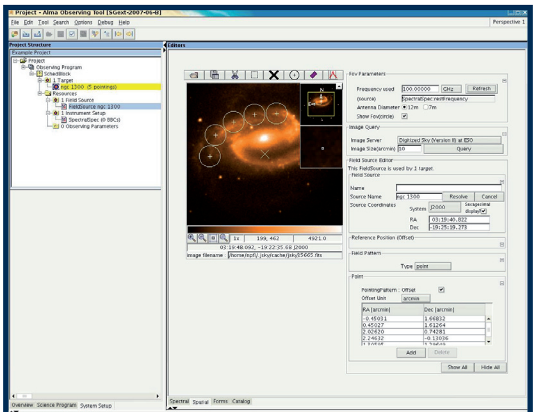
ALMA Observation Preparation

Due to its complexity and inhospitable location, ALMA will be almost exclusively operated in service mode. Aims for the telescope include ease of use for observers new to sub-millimetre interferometry as well as ability for “black-belt” users to push ALMA to its limits (and indeed to extend those limits). These apparently contradictory requirements provide the UK ATC led Observation Preparation team with exciting challenges in the design of the ALMA Observing Tool – astronomers’ principle interface with the telescope throughout both proposal submission and observation preparation.

To meet these requirements, the Observing Tool (OT) supports multiple views of an observing project. The Science View consists of a series of Science Goals each of which is expressed purely in terms of scientific intent – specifying which source to observe, which frequency and the desired signal-to-noise ratio. The System View describes the detailed telescope setup required for an observation in terms of Sched Blocks – the atomic unit of operation of ALMA. The OT handles translation from Science Goals to Sched Blocks. Ease of use is another key aim for the OT, and to this end not only are graphical tools provided for specifying the target on the sky, which parts of the spectrum to observe and (for the advanced user) how to set up the ALMA Correlator, but also spectral line and image catalogues can be referenced to assist these processes. Additionally, an exposure time calculator is available to provide an estimate of how long a given observation will take. Modern ergonomics evaluation techniques have been used to design workflows to guide users through the steps required to set up an observation, and these will further ease the process.

Whilst we make it as simple as possible to define an ALMA observation that is correct, an extra level of safety is provided by built-in verification tools which not only highlight problems, but also suggest solutions.

Although ostensibly a straightforward task, producing an observation for ALMA is a complex feat. The ALMA Observing Tool draws on many technologies and techniques to simplify this, allowing the astronomer full access to the considerable power of the telescope without being overwhelming.



Target selection: In this case one spiral arm of galaxy NGC 1300. The image was retrieved by the tool from the Digital Sky catalogue at ESO. Each white circle denotes a single pointing of the telescope.

ALMA Heuristics

The UK ATC is also taking part in the development of reduction ‘heuristics’ to handle data from ALMA. At mm and sub-mm wavelengths the effects of the Earth’s atmosphere are likely to significantly corrupt the astronomical data. Therefore, the system must be able to correct bad data where possible, or flag it up where not. It must be able to generate the required data products automatically, whilst logging enough information to allow observers to trace and verify the reduction process. Lastly, the reduction ‘engine’ must be flexible in use and easy to develop further in the light of experience from the working telescope.

The UK ATC’s part in the work so far has been to develop the user interface and a framework for the reduction steps, and to develop algorithms to detect bad data. The latter is done by applying statistical tests to a range of ‘views’ of the complex dataset; some problems are subtle and only show up strongly in one ‘view’, for example in the calibration results for the antennas.