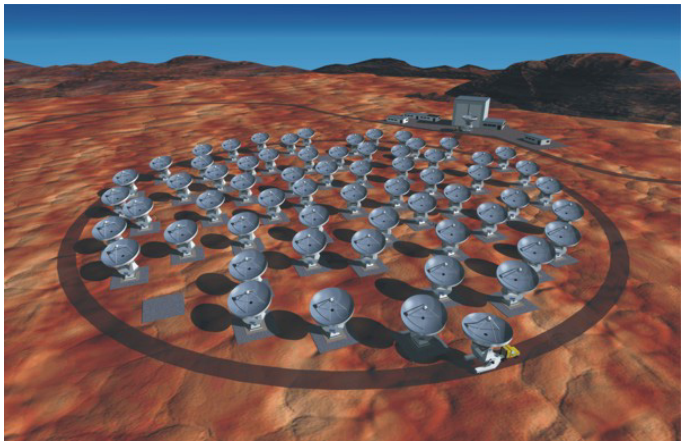
National Radio Astronomy Observatory

# Background Information
# Atacama Large Millimeter Array

## ALMA: Imaging the Light from Cosmic Dawn

The Atacama Large Millimeter Array (ALMA) will be one of astronomy's most powerful telescopes -- providing unprecedented imaging capabilities and sensitivity many orders of magnitude greater than anything of its kind today.

ALMA will be an array of 64 radio antennas that will work together as one telescope to study millimeter- and submillimeter-wavelength light from space. These wavelengths, which crosses the critical boundary between infrared and microwave radiation, hold the key to understanding such processes as planet and star formation, the formation of early galaxies and galaxy clusters, and the formation of organic and other molecules in space.



An international partnership funds and operates ALMA. The North American participation is administered principally through the U.S. National Science Foundation's National Radio Astronomy Observatory (NRAO); the European participation is administered primarily through the European Southern Observatory (ESO).

## What is Millimeter Wavelength Astronomy?

Astronomers learn about objects in space by studying the energy emitted by those objects. Our Sun and the other stars throughout the Universe emit visible light. But, these objects also emit other kinds of energy, such as X-rays, infrared radiation, and radio waves. Other objects emit very little or no visible light, yet are strong sources of other wavelengths of electromagnetic radiation.

Most of the energy in the Universe is present in the millimeter portion of the spectrum. This energy comes from the cold dust and gas that fills interstellar and even intergalactic space. It also comes from distant galaxies and galaxy clusters that formed many billions of years ago at the edges of the known universe.

With ALMA, astronomers will have access to this remarkable portion of the spectrum.

Current observatories simply do not have anywhere near the necessary sensitivity and resolution to unlock the secrets that abundant millimeter wavelength "light" can reveal. It will take the

unparalleled power of ALMA to fully study this energy and better understand the nature of the universe.

## ALMA's Unique Capabilities

ALMA's ability to detect remarkably faint millimeter wavelength emission and to create high-resolution images of the source of that emission, give it capabilities not found in any other astronomical instrument. ALMA will therefore be able to study phenomenon previously out of reach to astronomers and astrophysicists. These capabilities include studying:

- The age of the universe, its size and structure;

- The formation of galaxies (like the Milky Way) at the earliest times in cosmic history;

- New planets forming around young stars in our Galaxy;

- The birth of new stars in spinning clouds of gas and dust; and,

- Interstellar clouds of gas and dust that are the nurseries of complex molecules and even organic chemicals that form the building blocks of life.

## How Will ALMA Work?

All of ALMA's 64 antennas will work in concert, taking quick "snap shots" or long-term exposures of astronomical objects and large portions of the sky. Cosmic millimeter waves from these objects will be reflected up from the surface of each dish to the subreflector above the dish's center. From there they will be guided down into highly sensitive receivers operating at just a few degrees above Absolute Zero. There the signals will be amplified many millions of times, digitized, and then sent along underground fiber-optic cables to a large signal processor in the control building.

This specialized computer, called a correlator - running at 16,000 million-million operations per second - will combine all of the data from the 64 antennas to make images of remarkable quality.

## Who Will Use the Telescope?

Scientists from all over the world will use ALMA. They will compete for observing time by submitting proposals, which will be judged by a group of their peers on the basis of scientific merit.

## Building ALMA

ALMA is an international collaboration. Partners from North America include the United States (National Science Foundation, through its NRAO facility operated by Associated Universities, Inc.) and the Canadian National Research Council. European partners include the European Southern Observatory, the Centre National de al Recherche Scientifique (France), the Max-Planck Gesellschaft (Germany), the Netherlads Foundation for Research in Astronomy, the Netherlands Onderzoewkschool Voor Astronomie, the United Kingdom Particle Physics and

Astronomy Research Council, the Ofincina de Ciencia y Technologia/Instituto Geografico Nacional (Spain) and the Swedish Natural Science Research Council

Chile, as the host nation for ALMA, will participate in the project through its presence on the ALMA Board, and other ALMA committees, and by making available the superb astronomical site in the Atacama Altiplano.

## The Extraordinary ALMA Site

Since atmospheric water vapor absorbs millimeter waves, ALMA will need to be constructed in a very dry area, preferable at a very high altitude.

Extensive tests showed that the sky above the Atacama Desert of Chile has the unsurpassed clarity and stability essential for ALMA. That is why ALMA will be built there at 16,500 feet elevation (5,000 meters) in the Chilean Andes.

## Timeline for ALMA

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| June 1998: | Phase 1 (Research and Development) |
| June 1999: | European/American Memorandum of Understanding |
| January 2002: | North American Prototype Antenna Testing at VLA Site |
| July 2003: | European Prototype Antenna Testing at VLA Site |
| 2004: | Tests of the Prototype System |
| 2007: | Initial scientific operation of the partial array |
| 2011: | Final construction of the array |

## The European Southern Observatory

The European Southern Observatory is an intergovernmental, European organization for astronomical research. It has ten member countries. ESO operates astronomical observatories in Chile and has its headquarters in Garching, near Munich, Germany.

## The National Radio Astronomy Observatory

The National Radio Astronomy Observatory is a National Science Foundation facility operated by Associated Universities, Inc. created to design, build, and maintain state-of-the-art radio astronomy facilities for use by scientists around the world. The NRAO operates other renowned radio telescopes in West Virginia, New Mexico, and across the United States.