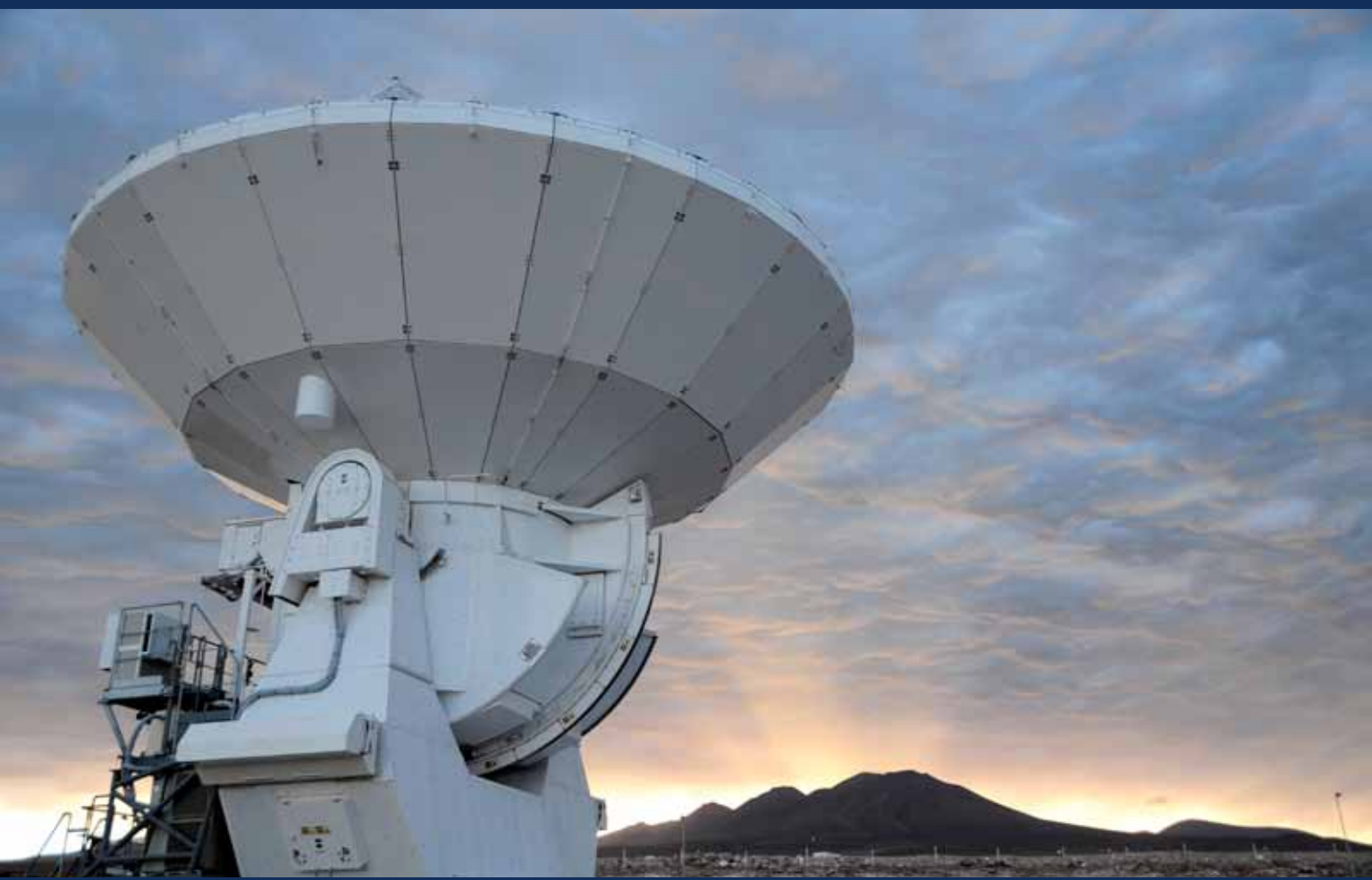
ALMA

SEARCHING THE COSMOS



www.almaobservatory.org

SEARCHING THE COSMOS

Outgoing Director, Thijs de Graauw, discusses the history behind the Atacama Large Millimeter/sub-millimeter Array (ALMA) and the significant enhances it is helping bring to the scientific community, both in Chile and throughout the world

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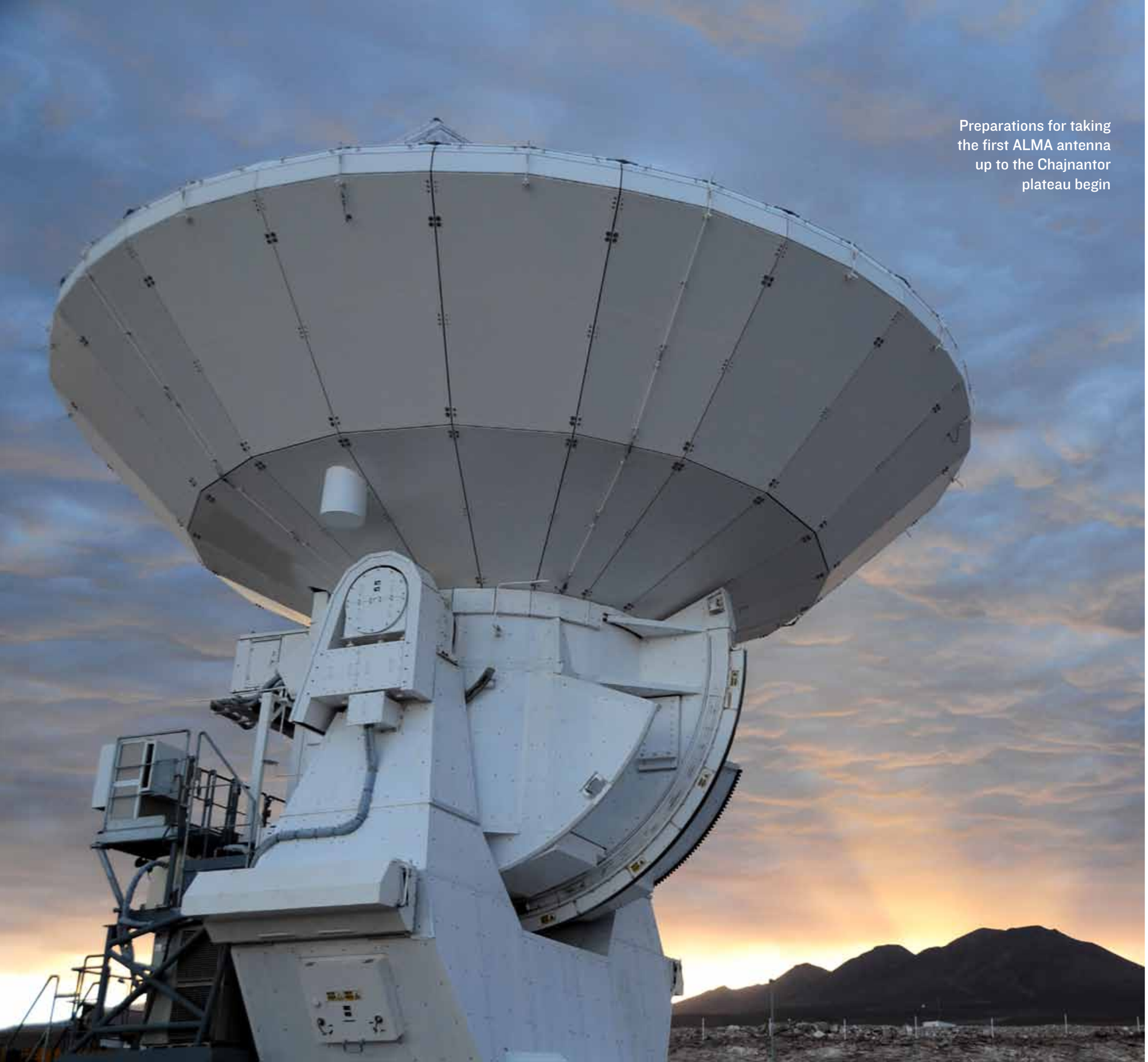
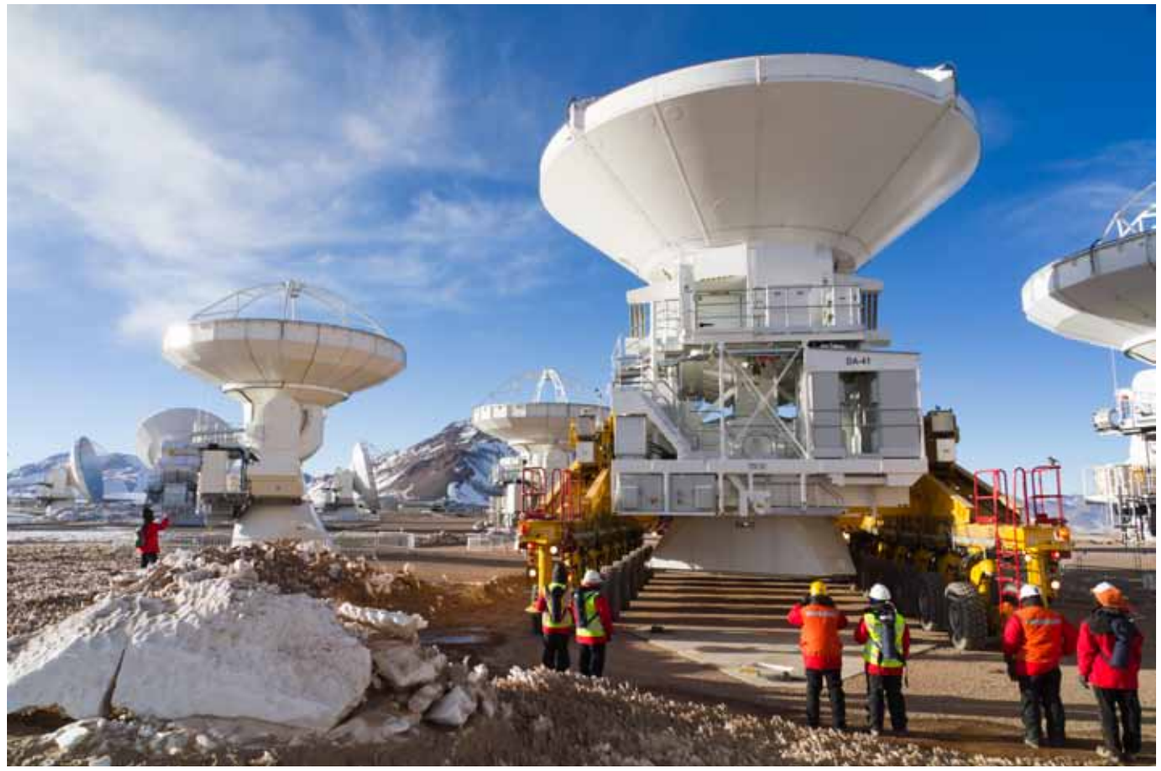


Preparations for taking the first ALMA antenna up to the Chajnantor plateau begin

No matter what corner of the planet you inhabit we all share the same amazement and wonder of the stars and planets above us. It is this wonder that has driven scientists and astronomers to try to gain an increasingly detailed understanding of the universe. In order to do so these experts strive to collect as much data and information as possible and one of the major ways of doing this is through the observations of the electromagnetic spectrum radiated by celestial sources.

"Among the most profound mysteries in astronomy are the origins of things such as galaxies, stars, planets, and the molecules that seed life," explains Atacama Large Millimeter/sub-millimeter Array (ALMA) outgoing director, Thijs de Graauw. "What ALMA does is observe light emitted by cool-temperature objects in space. This permits us to unravel profound mysteries about the formation of planets and the appearance of complex molecules, including organic molecules."

The birth of ALMA dates back to the 1980s when large size millimeter/submillimeter arrays of radio telescopes were studied by astronomers in Europe (LSA), North America (MMA) and Japan (LMSA), and different possible observatories were discussed. In the 1980s and early 1990s space observatories discovered strong submillimeter molecular emission from galaxies and it became obvious that the ambitious investigations to understand these objects could hardly be realised by only one of the proposed array telescopes and a merger into a single large



CREDIT: ALMA (ESO/NAOJ/NRAO), S. ROSSI (ESO)

European ALMA antennas

array would be necessary. The discussions and deliberations on merging the three projects took place in the nineties.

Consequently, a first memorandum was signed in 1999 by the North American community, represented through the National Science Foundation (NSF), and the European community, represented through European Organization for Astronomical Research in the Southern Hemisphere (ESO), followed in 2002 by an agreement between them to construct ALMA on a plateau in Chile.

Thereafter, Japan, through the National Astronomical Observatory of Japan (NAOJ), worked with the other partners

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to define and formulate its participation in the ALMA project. An official, trilateral agreement between ESO, the NSF, and the National Institutes for Natural Sciences (NINS, Japan) concerning the construction of the enhanced Atacama Large Millimeter/submillimeter Array was signed in September 2004. “With the inclusion of the Asian partners,” de Graauw continues, “ALMA has become a truly global astronomical facility, involving scientists from four different continents.”

At its simplest, ALMA is a radio telescope made up of an ensemble of 66 antennas, some seven metres and some 12 metres in diameter, that work in unison with the surface of the ALMA interferometer totalling more than 6,500 square metres, which is approximately equivalent to a football field. The sheer size and scope of the project makes it possible for ALMA to detect very faint radiation in space. Despite the harsh conditions, the ALMA antennas were installed at an altitude of 5,000 metres in an exceptional area for astronomical observation. The high altitude and lack of moisture prevents water in the atmosphere from absorbing the radio waves, which would normally hinder observation from Earth.

“As one can imagine,” de Graauw highlights,” to make images from millimeter-wavelength light gathered by multiple antennas, we need absolutely colossal computing power. The signals coming from each pair of antennas must be

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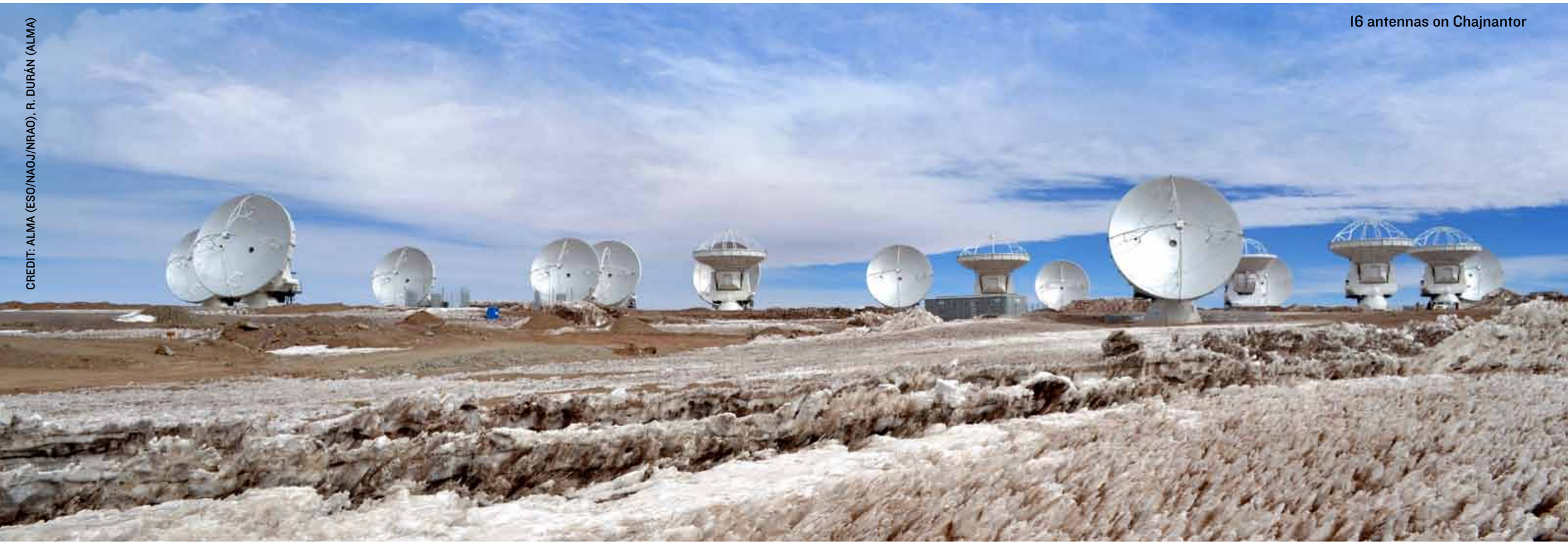


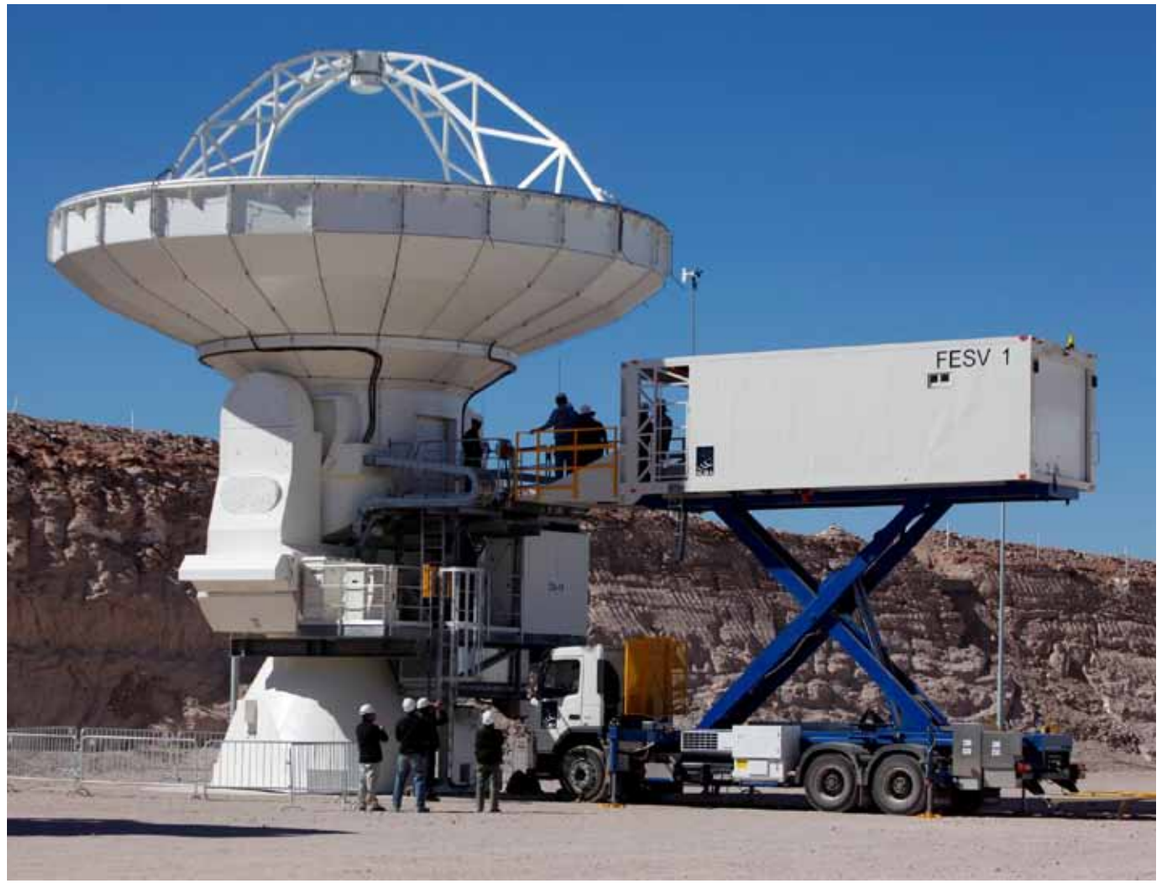
CREDIT: ALMA (ESO/NAOJ/NRAO), R. DUNCAN FARRÁN (ALMA)

16 antennas on Chajnantor

PHYSIK INSTRUMENTE

For 50 of its antennas, the ALMA obervatory uses high-precision Hexapods from PI. They align the sub-reflectors to the large main reflectors of the radio telescopes to compensate for external impacts. PI uses its technological knowledge and long-term experience in micro and nanopositioning technology for providing highest positioning performance in extreme ambient conditions. The Hexapod systems with six degrees of freedom in motion are installed behind the sub-reflectors and allow for 6D positioning with resolution in the submicrometer and arcsecond range. The positioning system's parallel kinematics structure is considerably more compact and stiffer than serially stacked multi-axis systems and leads to a very high resonant frequency. Since only a single platform is actuated, the moved mass is significantly smaller. This results in improved dynamics with considerably faster response. For the Hexapods in the ALMA antennas, PI developed and manufactured highly stiff and robust joints. The Hexapods can ad-just the position of the sub-reflectors precisely to several millimeters.The digital controller's components for position control of the Hexapods have been adapted to reduced atmospheric pressure. With this high-performance digital control technology, that combines incremental position sensors and optical reference sensors in the Hexapod's individual struts, PI provides a high-resolution measurement and control system for the ALMA observatory.

www.pi.ws



CREDIT: ALMA (ESO/NAOJ/NRAO), CARLOS PADILLA (NRAO/AUI/NSF)

The Front End Service Vehicle in its raised position servicing the receiver cabin

mathematically compared billions of times every second. It would take approximately three million domestic laptops to carry out the same quantity of operations per second as the ALMA correlator."

Scientists from around the world are already competing for ALMA's observing time. The first cycle of observations, known as Cycle 0, was launched at the end of September 2011. An impressive 919 project proposals were submitted by the worldwide science community, representing an unprecedented level of demand for a ground-based or space telescope. Those astronomers who obtain observing time have exclusive access to their collected data for one year, after which the data becomes public in a vast library. "As with the great telescopes that have gone before it," de Graauw

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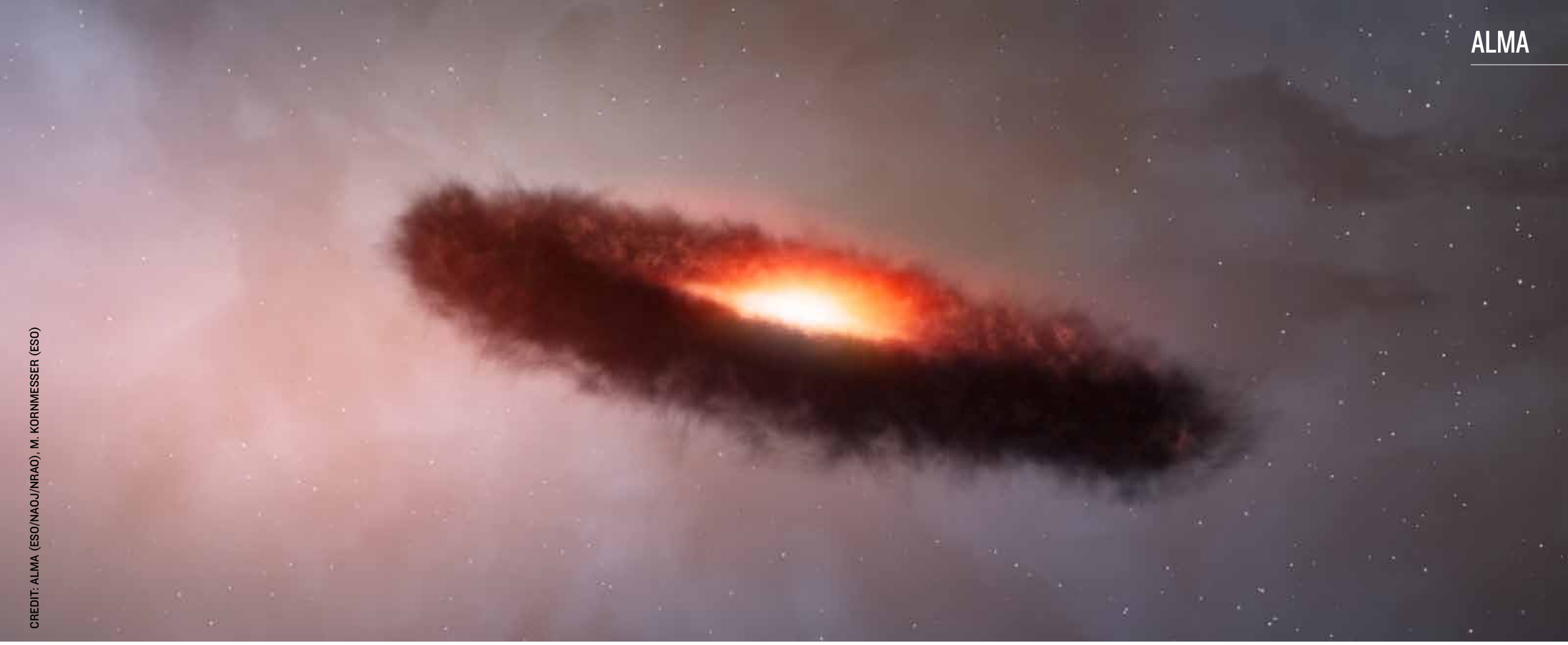
Antennas make up the ALMA project



CREDIT: ALMA (ESO/NAOJ/NRAO), M. KORNMESSER (ESO)

Artist's impression of the disc of dust and gas around a brown dwarf

> "AS WITH THE GREAT TELESCOPES THAT HAVE GONE BEFORE IT ALMA WILL ENABLE US TO SEE ASPECTS OF THE UNIVERSE WHOSE EXISTENCE WE HAVEN'T EVEN SUSPECTED"

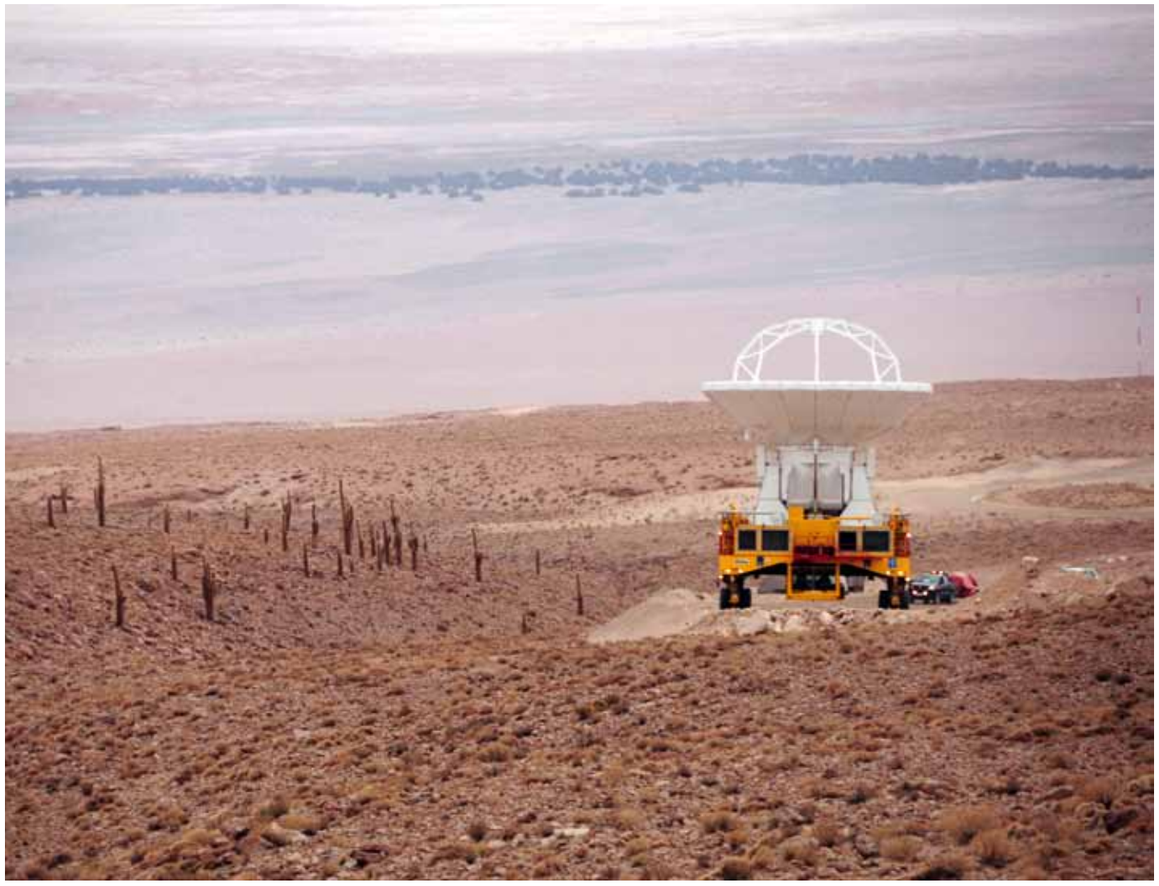
enthuses, "ALMA will enable us to see aspects of the universe whose existence we haven't even suspected."

On a much more localised scale the ALMA project is also contributing directly towards Chile's development as a centre for astronomy. Indeed the construction and operation of the observatory has been identified as one of the most significant factors in the growing encouragement of training specialised human resources, promoting innovations in engineering and software development, in helping to improve the country's telecommunications infrastructure, and supporting the social and economic development of ALMA's local and regional communities.

"Our relationship with the Chilean community and government has been excellent both at the national and regional levels," de Graauw says. "We have found collaboration and communication to be fluid at the ministerial level as well as with regional authorities through the Intendente – the equivalent of a regional governor - and local authorities, through the mayor and town council of San Pedro de Atacama and the Toconao indigenous community."

Since 2003 ALMA has contributed towards the development of astronomy in Chile through the ALMA-CONICYT Fund, allocated annually to promote human resources, instrumentation, teaching, outreach and fellowships. This fund will apportion close to $700,000 in 2013.

On a regional scale ALMA contributes



The transporter, now carrying the antenna, leaves the OSF and reaches an altitude of 3,000 meters

annually to the ALMA Region II Fund, also since 2003. The Fund promotes productive and social-economic development in the Antofagasta Region, supporting local initiatives through a public call for proposals. This year, over $300,000 dollars will be allocated. Locally, ALMA supports a programme to improve education in science and English at the Toconao public school. ALMA has given training, selected and funded teachers, and built infrastructure to allow these programmes to take root. The said programmes have helped to raise test-scores for Toconao students in national standardized tests, and have been well received by teachers, parents and local authorities. Currently, there are conversations with the Municipality of San Pedro de Atacama and

5,000

Metres above sea level. Altidude of the ALMA project

CREDIT: NRAO/AUI/NSF, CARLOS PADILLA
ACKNOWLEDGEMENT: GENERAL DYNAMICS C4 SYSTEMS

Aerial view of the ALMA Operations Center

other strategic partners with the intention of replicating Toconao's successful experience to other schools in the district.

More broadly, Chile benefits from the creation of jobs at ALMA, where over 80 percent of the staff is locally hired. Many of the positions require advanced technical and professional qualifications, so valuable training and workplace learning take place at the observatory. In the long run, ALMA is contributing to the positioning of Chile as the undisputed astronomical capital of the world.

"ALMA is in the business of collecting unique astronomical data for investigations of the universe at millimetre and submillimeter wavelengths," de Graauw says, "and in this wavelength range ALMA is the biggest observatory on the planet. Looking ahead there is an advanced plan to build a very large radio astronomy telescope based on similar techniques but at much lower frequencies and therefore per unit much easier and cheaper. The diameter of this telescope will be much larger as will be the total radiation collecting area, but the operating frequencies are much lower. The total collecting area is to be equivalent to one square kilometre. Therefore the name of the project is SKA, Square Kilometre Array. It is in the planning phase and the budget has not yet been allocated but precursor projects are already operating." BE

For more information about ALMA visit: www.almaobservatory.org

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