ALMA Newsletter

June 2009

ALMA

Introduction

“Dear ALMA newsletter recipients,

I am pleased to introduce the second issue of our newsletter. First of all, I would like to thank all of you for the very nice comments and feedbacks we received after our first issue.

In the following, we give the up to date information about activities in Chile, both at the ALMA site and in Santiago. The most exciting recent development has been the interferometric measurement of Mars, done at the Operations Support Facility (OSF). This result is proof that the antennas, receivers, local oscillators, software and correlator are functioning well together. Although there was a similar result at the Antenna Test Facility in Socorro, New Mexico, this is a major step forward since all of the components used in the recent test are final designs or close to it. Again, I would like to congratulate all the people all over the world who have made this milestone possible !

Additional progress at OSF has many components, which we invite you to discover in this issue. At the Chajnantor site, the Array Operations Site building has received its final modifications and series production of antenna foundations is underway. All of this is a crucial contribution to the prerequisites for Early Science.

A new feature, starting in this issue, is a section titled “ALMA In Depth”. This series of articles will present an account of features that contribute to the unique capabilities of the ALMA instrument. This series starts with receivers, and will continue with other parts of the system in future issues.

Enjoy ALMA’s universe !”

Thijs de Graauw, ALMA Director

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.

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Two antennas linked pointing at Mars, Image courtesy of Lewis Knee (ALMA)

Focus on...

Successful static interferometry at ALMA's Operations Support Facility (OSF)

We reached a major milestone on April 30 when two ALMA antennas were linked as an integrated system to observe an astronomical object for the first time. This milestone achievement, technically termed "First Fringes", came at ALMA's Operations Support Facility (OSF), 2,900 metres above sea level. "This is another important step forward for ALMA since it proves that the various hardware components work well together. The efforts of all the staff involved in this first antenna integration show the strength of our global collaboration and give much confidence that we can reach full operations with ALMA as one great astronomical observatory," ALMA Director Thijs de Graauw said.

Faint radio waves naturally emitted by the planet Mars were collected by the two 12-metre diameter ALMA antennas (one delivered by North America, the other by Japan), then processed by state of the art electronics to turn the two antennas into a single, high-resolution telescope system, called an interferometer.

Such pairs of antennas are the basic building blocks of imaging systems that enable radio telescopes to deliver images that approach or even exceed the resolving power of visible light telescopes, such as the Hubble Space Telescope. In such a system, each antenna is combined electronically with every other antenna to form a multitude of antenna pairs. Each pair contributes unique information that is used to build a highly-detailed image of the astronomical object under observation.

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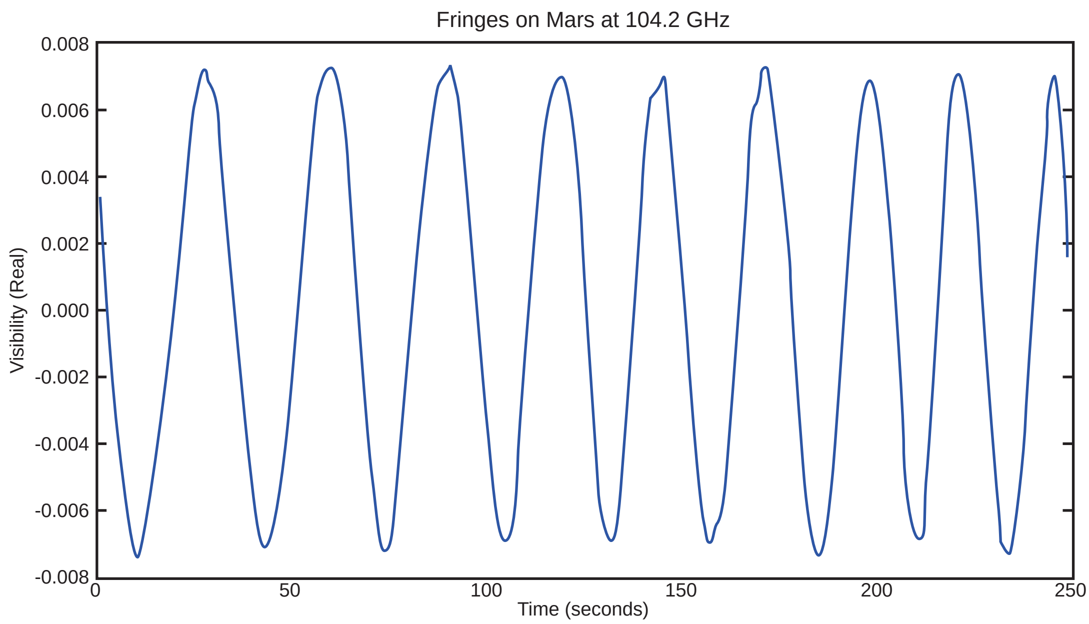
Focus on...

This graph shows a plot of a single channel of the combined output of the two antennas in a correlator as a function of time, when observing Mars. The “wave” appearance of the signal is caused by the motion of Mars.



When completed early in the next decade, ALMA’s 66 antennas will provide over a thousand such antenna pairings, with the maximum distances between some antennas exceeding 14 kilometres. This will enable ALMA to see with a sharpness surpassing that of the best space telescopes. The antennas will operate at an altitude of 5,000 metres, high above the OSF, in one of the best locations on Earth for millimetre-wavelength astronomy, the Chajnantor Plateau in Chile’s Atacama Desert.

The successful Mars observation was conducted at an observing frequency of 104.2 GHz. Astronomers measured the distinctive varying “fringes” detected by the interferometer as the planet moved across the sky. With software upgrades expected in June, the fringes will be predicted and adjusted for planetary motion.

“This can only be achieved with the accurate synchronization of the antennas and the electronic equipment to a precision much better than one millionth of a millionth of a second between equipment. In full operation, these will be located many kilometres apart. The extreme environment where the ALMA observatory is located - with its strong winds, high altitude and wide range of temperatures - just adds to the complexity of the observatory and to the fascinating engineering challenges we face”, comments ALMA Project Engineer Richard Murowinski.

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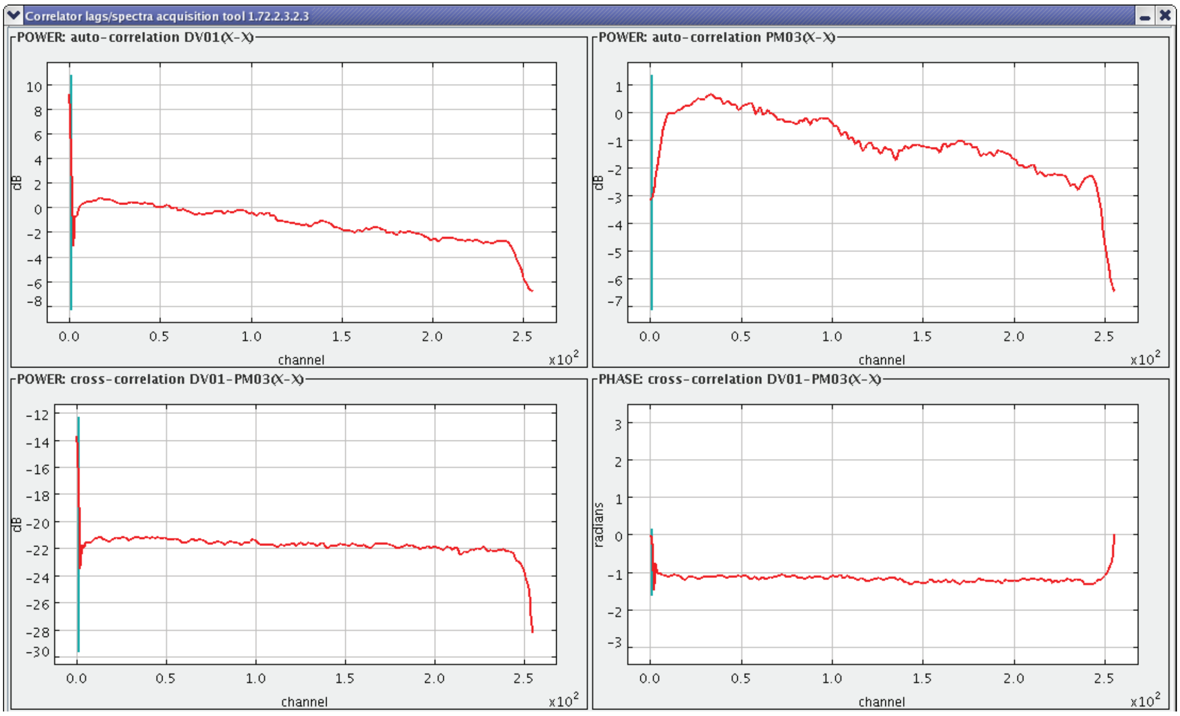
Focus on...

ALMA will provide astronomers with the world's most advanced tool for exploring the universe at millimetre and submillimetre wavelengths. It will detect fainter objects and be able to produce much higher-quality images at these wavelengths than any previous telescope system. Scientists are eager to use this transformational capability to study galaxies that formed in the early universe, to learn long-sought details about how stars are born, and to trace the motion of gas and dust as it whirls toward the surface of newly-formed stars and planets.

"We are on target to do the first interferometry tests at the 5,000-metre high-altitude site by the end of this year, and by the end of 2011 we plan to have at least 16 antennas working together as a single giant telescope," de Graauw said.

Here is a screenshot of the full correlator output for a single one-second integration. The top two windows are the spectral shapes of signals from the two individual antennas. The bottom panels are the phase (right) and cross-correlated power (left). The sensitivity of an interferometer to various spatial scales in the sky is determined by the separation of the 2 antennas. This experiment detected slightly below one percent of the total signal from Mars, since the planet has a large size, so it is quite well resolved on this baseline (the length of the baseline was 71.8 meters). When all antennas are available for full science operations, many more antenna pairs of different separations would result in much more signal being received from all astronomical sources, so this successful test is a very good indication of the exciting science to come. Particularly encouraging are the flatness phase and amplitude as a function of frequency.



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Progress at the ALMA site

Here is a short synopsis regarding the recent progress of the site construction work:

Array Operations Site (AOS)

The Technical Building (TB) at the AOS, at 5,000 metres, houses the two correlators. It is ready to be formally accepted by the project.

The Transporter shelter is also finished and is undergoing ALMA acceptance procedures.

Two areas are under construction. The area containing the central cluster of antenna foundations (the most compact configuration for the 12-meter antennas) is excavated and antenna foundations are under construction with a delivery planned for late 2010 (see more detailed article about the construction of the antenna foundations below). At the Atacama Compact Array (ACA) site, the plan requires 22 antenna foundations, and these are already finished.

Requests for bids from construction companies for building the power and communication infrastructure connecting the antenna stations with the AOS-TB have been received and are being evaluated. The awarding of the road construction, and power and fiber optics distribution is expected to happen in late June 2009.

Meanwhile, there is work under way for one foundation close to the AOS Technical Building. This will be fully operational in early July 2009. The access road is already built, and the power and communications fiber optics to it are under construction.

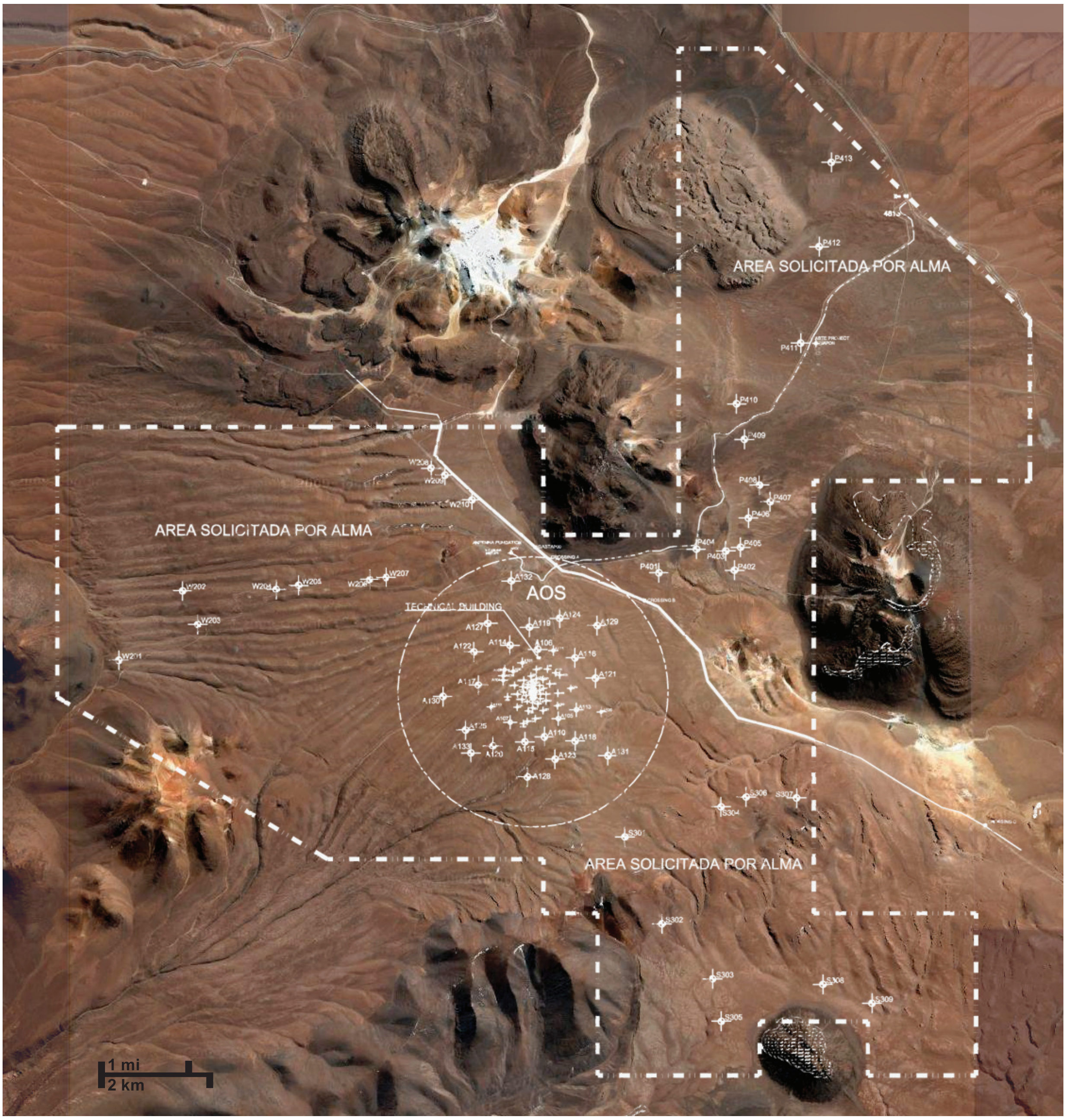
General view of the Atacama Compact Array (ACA) with all the foundations almost completed.

Progress at the ALMA site

Array Operations Site (AOS)

More about the construction of the foundations.

Shown below are the locations of the antenna foundations on Chajnantor Plateau, at 5,000 metres above sea level. These were determined by optimization calculations carried out for the Science Integrated Product Team (IPT) by John Conway (Onsala Space Observatory, Chalmers University) and Mark Holdaway (NRAO). These antenna positions provide the most complete information for observations of astronomical sources at a range of locations on the sky. The construction of the foundations (hereafter "antenna stations") closely follows the optimized positions, subject to local conditions. If conditions are too difficult, a shift of a few metres may be required. This will not affect imaging quality.



Google Maps 2009

Progress at the ALMA site

1. This figure shows a comparison of the perimeters of the smaller triangle-like stations and larger circular stations. For the circular station design, the excavated volume is 54 cubic metres. This larger foundation will be so massive that it will be stable without the need for anchors to solid rock. The depth of the excavation is 1.7 metres; this is extended down to rock that can bear the weight of the ALMA antennas. The rock on Chajnantor is composed of volcanic ash slowly compressed over long periods of time. If the soil is firm, the sides of the cavity can be vertical, and then the concrete is poured up to the soil walls. If the soil is looser, the sides must be sloped, and forms must be used to provide the support for the concrete.

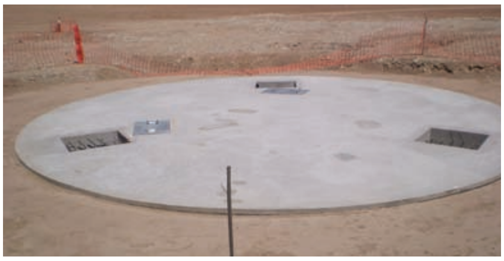
2. Workmen checking the floor of the foundation, to ensure that no cracks are present. The forms for pouring the first leveling layer of lean concrete (i.e. concrete with a smaller amount of cement) are in place. At this stage, a geologist verifies visually that the rock has sufficient weight bearing capacity. A record of all of these activities is kept for each station. In addition to concrete, the stations will be anchored to the rock. For this, around the perimeter the locations of rock anchors will be painted on the floor to ensure that the anchors will not coincide with cracks. If cracks are found these are filled in with grout (cement and water) which acts as a sealant. There is a step in the floor at the rear; this was caused by movement after a volcanic eruption. This will also be treated with grout. Then lean concrete will be poured into the excavation. The concrete must harden at a temperature of higher than 5 degrees Celsius.

3. A later stage of the pouring. The lean concrete (shown being poured at the back of this picture) is being leveled. The station is covered to provide a higher temperature while the concrete hardens, the so-called curing process. The red cylinder in the lower right is a heater used to provide warmth during the concrete curing process. During the entire time, the temperature is constantly monitored.

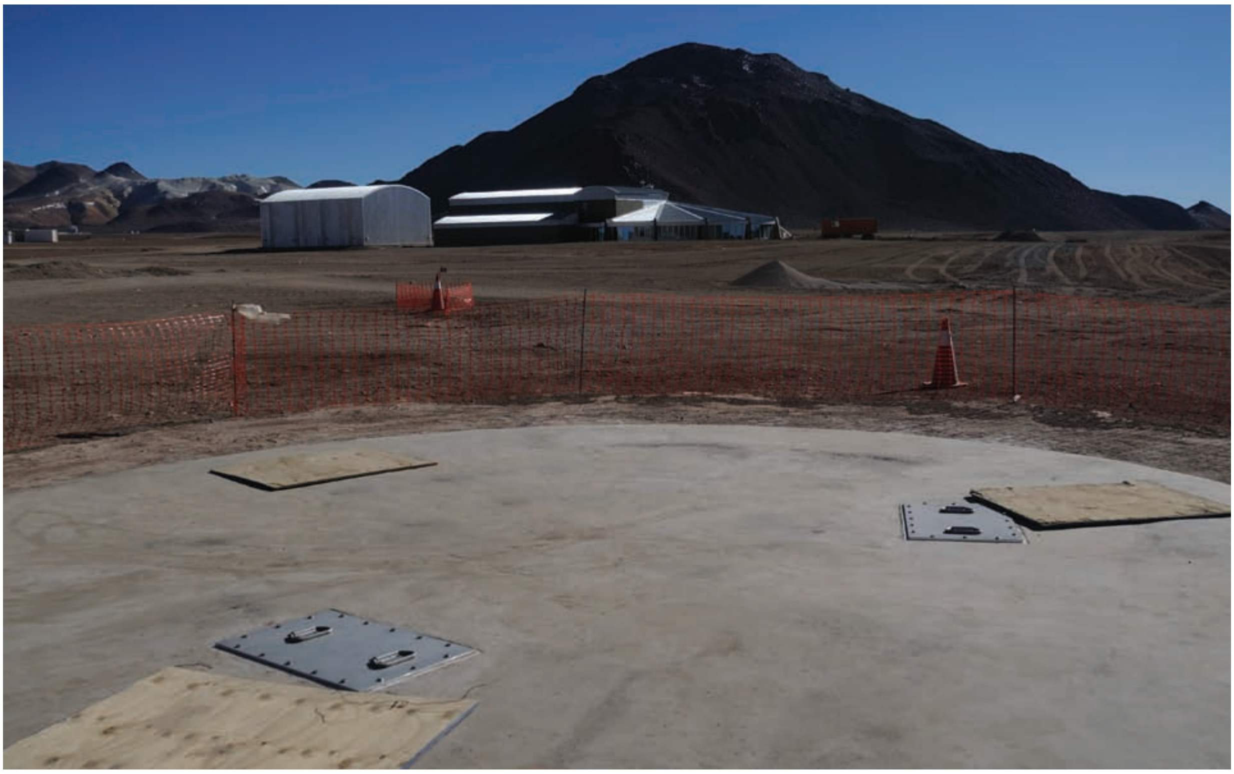
Progress at the ALMA site

4. Preparations for pouring the upper level of concrete. This is to be denser structural concrete (type G-250) with a reinforcing cage (lean concrete does not require this cage). The red tube in the middle of the station is a conduit for signal and power cables. The level is used to ensure that the construction is as close to horizontal as possible.

5. Workmen finishing the concrete surface. This is a final finish, since on top of this there will be additional, rather thin, layers. The uppermost thin layers of concrete are sloped to allow run-off after rain or snow. The space around the antenna station must be filled with soil. This is a more massive type station.



6. Station after the concrete work was finished. The next steps are to mount inserts in the three openings. These inserts will ensure that the antenna is accurately placed on the station and also provide a strong and solid connection between station and antenna. The two covered openings are for the power and signal transmission vaults.



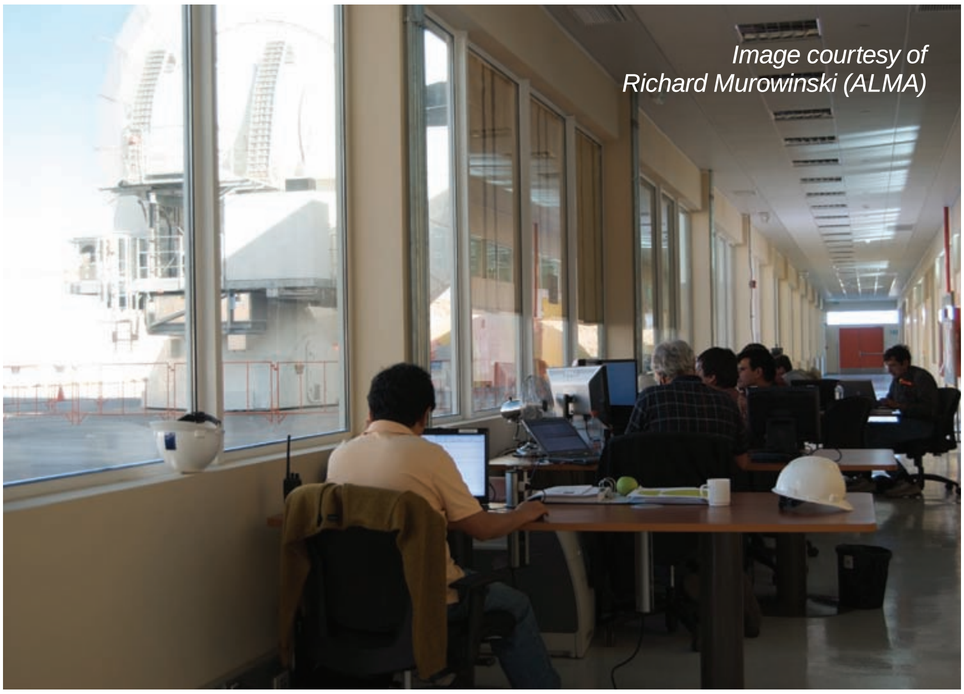
Completed pad with the AOS Technical Building and the Chajnantor mountain in the background

Progress at the ALMA site

Operations Support Facility (OSF)

The Operations Support Facility contains a collection of buildings at a 2.9 km elevation. At this site, the staff has sleeping quarters, a cafeteria and a large Technical Facility (TF) building. In addition, there are three Site Erection Facilities (SEFs) for the antenna suppliers. The TF building now houses the activities for Assembly/Integration/ Verification (AIV), which includes antenna testing by the ALMA staff, and Commissioning and Science Verification (CSV). When ALMA begins science operations, the TF building will house the ALMA control center and a visitor center. The ALMA Site IPT is now starting the final phase of this activity with the goal of allowing the OSF-TF to reach a fully operational stage.

The activities in the TF are a detailed outfitting of the computer room and a rearrangement of space to accommodate a large conference room. In the rear of the TF is the control center for the antenna tests carried out by the AIV team. Here the main change will be a subdivision that needs to be done to locate the necessary electronics, including the Central Local Oscillator (CLO) and 2-antenna correlator area. In another part of the building containing the warehouse and the machine shops there will be the addition of extra surface to allow the extension of the electric sub-station and the modification of the entrances for the shops area.



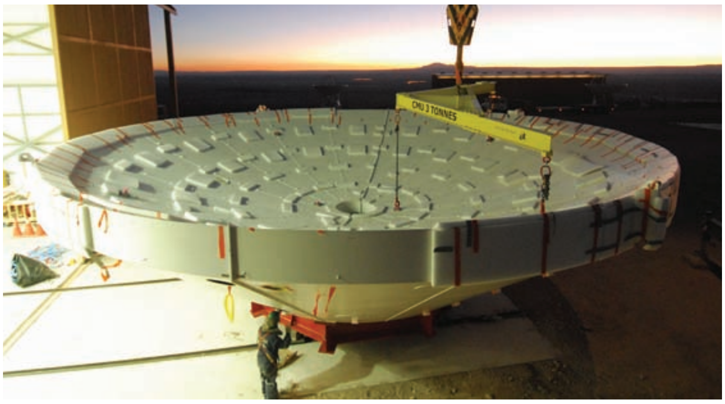
Science, Engineering and Operations staff at work together in a temporary AIV antenna control area

For the computer room, there will be erection of seismic support racks and then fine tuning of air conditioning. In the CLO/correlator room there will be installation of additional cooling and electric power. In addition, seismic support racks will be purchased and installed. The conference room will be equipped with complete audio-visual facilities for meetings held at the OSF.

At the Transporter Shed, plans for the layouts are being finalized. The design for the administration area is in the definition phase with discussions involving an architectural firm.

Progress at the ALMA site

The first parts of the European antennas crossing the Atacama Desert on their way to the OSF. In the background, the Andes mountains.



This photo was taken at the OSF. The 1st backup structure covered with protective foams is mounted on the integration jig foreseen for panel integration, prior to be moved inside the European Antenna Consortium BUS integration building.

The preliminary steps for assembly of the European Antenna Consortium antennas at the Site Erection Facility (SEF). In this view, a crane is lifting the lower part of the antenna, containing the elevation drive system. The SEFs for each antenna supplier are located close to but below the OSF building. On the right are two Mitsubishi Electric Company (MELCO) 12-meter antennas.

Antennas

Arrival first European antennas at the OSF.

Within the last two months, all of the parts needed to assemble the first European Antenna Consortium antenna have arrived at the OSF as well as parts of the second European antenna. The second steel structure has been inspected and is scheduled to leave Europe this month. A substantial number of parts for the third antenna are also being shipped and are expected to arrive at the OSF shortly thereafter.

For the assembly of the European antenna number one, the plan is to begin in June. The procedures for the assembly are now being verified and final preparation of the facilities for the European Antenna Consortium assembly at the OSF is ongoing.

In Europe, the pace of the European Antenna Consortium production activity has reached the expected level. Thus, production capacity is not an issue. The most critical parts of the first antennas are in hand. These include the carbon fiber Back Up Structures (BUSes) and receiver cabins. Three steel structures for the antennas are in the integration phase in Europe beyond the first two and at least six others are ready for starting factory integration. The production of the eight BUSes and of the receiver cabin of antenna number 11 has started. A total of 11 sets of panels have also been produced. In the very near future the challenge will shift from the production in Europe to the assembly and commissioning phase in Chile, which will require extensive organizational efforts to ensure the planned rate of delivery.

Progress at the ALMA site

Antennas

ALMA accepts its third antenna


Image courtesy of Nick Emerson (NRAO)

On April 29, 2009, ALMA accepted its third antenna, which is the second ALMA production antenna designed and built by Vertex for the North American partners of the project. An ALMA transporter moved this antenna to one of the foundations at the nearby OSF, and antenna outfitting began immediately. This antenna will be equipped with the Front End recently delivered from the European Front End Integration Center at Rutherford Appleton Labs. At the Vertex Site Erection Facility, the acceptance of the second antenna allowed completed antenna No 6 to be moved to an outside location for eventual sky testing. Its brethren No 3 and No 5 are also outside the building for testing. Meanwhile, the tenth antenna arrived, to be erected in the space within the building vacated by No 6.

Antenna Tests at the OSF

An important ALMA milestone is to achieve phase closure with three antennas at the 5 km high site at the end of 2009. In preparation for meeting this milestone, there must first be a series of tests of the individual antennas at the OSF-TF. These started in early 2009 and are proceeding well. Interspersed with these tests are investigations of the performance of the entire system, including interferometry between two antennas. This latter investigation resulted in the first interferometric measurements of an astronomical source to be obtained at the OSF.

Of the three antennas that will be used in the phase closure test at the AOS, two are from Vertex and one from Mitsubishi Electric Company (MELCO). These antennas are conditionally accepted by ALMA, so one goal of the ALMA team is to reproduce the results obtained by the antenna vendors during their testing. These antennas are equipped with engineering front ends with receiver bands 3, 6, 7 and 9. Because of limits set by atmospheric conditions, receiver band 9 will probably only be used efficiently at the 5 km high site, but measurements at the OSF are being carried out for the other three receiver bands. Included in the tests by the ALMA team are: (1) investigations of the absolute all sky pointing (specified to be 2 arc second RMS); (2) offset pointing (spec. 0.6 arc seconds RMS); (3) accuracy of the surfaces (spec. 25 micrometres RMS); (4) details of the shapes of the beams; and (5) the efficiencies. Thus far, the tests have concentrated on 1-2-3, and 4-5 are just now beginning.

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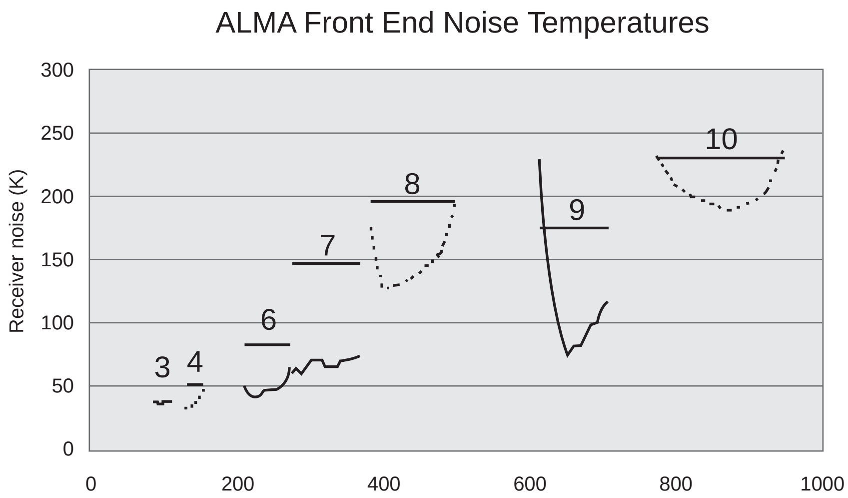
ALMA In Depth

The ALMA Receivers, at the leading-edge of technology

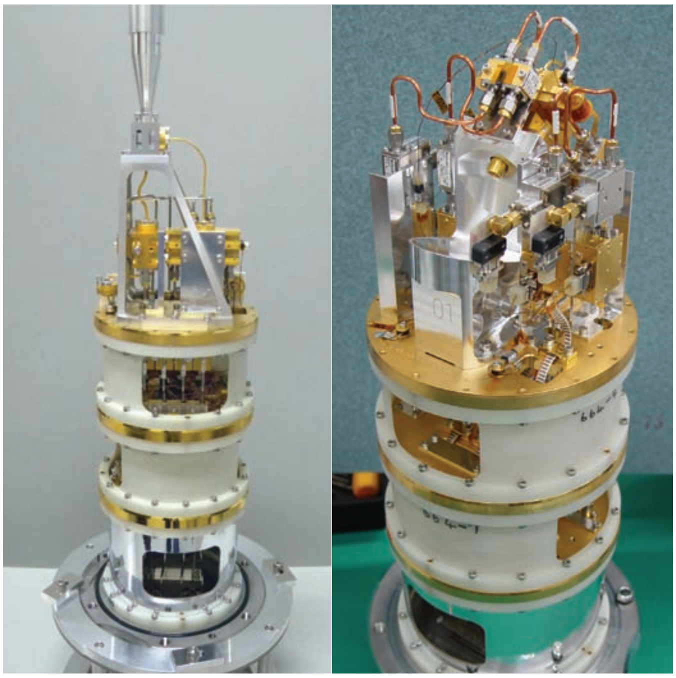
There are three essential items that contribute to the superior sensitivity of ALMA. These There are three essential items that contribute to the superior sensitivity of ALMA. These are: (1) the high, dry site; (2) the large collecting area: and (3) the receiver system. The ALMA project has devoted a great deal to maximize the sensitivity contribution from the first two items. These include the Chajnantor site and the collecting area provided by 66 antennas that allow operation to 1 THz. In the following, we give a short update on the status of the receivers. In the optical and near infrared (near IR) wavelength range, the sensitivity of astronomical detector systems has improved by about a factor of 25 since the 1960s. The sensitivity of millimetre and sub-millimetre astronomical receivers has improved by at least this factor over the same time. In the last few years, receiver sensitivity has improved by another factor of two to four, due to the ALMA development program.



Noise temperatures for the ALMA Receiver Bands, on the vertical axis plotted against receiver frequency, on the horizontal axis. The solid horizontal lines mark the specifications for ALMA receiver Bands 3, 4, 6, 7, 9 and 10 (Band 7 is not labeled). The dashed lines under Band 4, 8 and 10 indicate the present status which is in the development phase. The solid irregular lines under Bands 6, 7 and 9 show the present status of laboratory measurements of the receiver noise temperatures for these Bands. In wavelength these ALMA receivers cover a range from 3.5 millimeters to 0.3 millimeters. (adapted from a plot made by J. Webber, NRAO). Not shown on this plot are Receiver Band 5 (at about 180 GHz), which will be installed on six antennas, and Bands 1 (about 30 GHz) and 2 (about 80 GHz), which will be installed at a later time.

The optical and near IR detectors convert the incident radiation to electrical current in an efficient way. The millimetre and submillimetre (mm/sub-mm) receivers must fulfill a number of additional requirements beyond those that apply to the optical and near IR detectors. That is, the mm/sub-mm receivers must also preserve additional properties of the incident radiation. The most important of these additional properties is the relative arrival time of this radiation at each antenna. This relative arrival time is referred to as the phase of the signal. In addition, the polarization properties must be accurately recorded. All of this must be done without corrupting the properties of the radiation, or adding more than a small amount of noise power. To accomplish this, the incident radiation is shifted to a longer wavelength (lower frequency) in the first element of the receiver. Then the power level of the radiation is increased by an enormous factor (roughly a million-million times). The signal is converted to digital form at this point. This output is transferred to the central correlator in the Array Operations Site (AOS), where the astronomical radiation is processed further to produce images.

ALMA in-depth



Two different ALMA Front Ends. Band 4 (on the left) operates from 125 to 163 GHz and is designed and built by NAOJ in Japan. Band 8 (on the right), also built by NAOJ, is designed to operate at much higher frequencies (385 to 500 GHz), which reflects in the different design.

The noise added by radio astronomy receivers is measured in temperature units, Kelvin. This is universally used as a measure of power for a unit bandwidth. Thus above 200 GHz in the plot, the smooth horizontal line at about 70 Kelvin is the ALMA specification, while the uneven line starting at about 50 Kelvin is the actual measured receiver performance. It is interesting to compare the receiver noise with noise from the earth's atmosphere. The ideal situation is for a receiver mounted on a lossless antenna outside the earth's atmosphere. We can calculate the noise added to an earth-bound receiver to reach such an ideal. For an ALMA antenna on a very dry site at an elevation of 5 km, the earth's atmosphere would add 10 Kelvin to the noise of a Band 6 receiver. In this situation, the atmosphere adds about 20% to the measured noise of the Band 6 ALMA receiver. Thus, the sensitivity of millimetre receivers, such as Band 6, could still be improved somewhat but for submillimetre receivers, such as Band 9, the earth's atmosphere adds a substantial amount of noise to the receiver contribution. Thus, ALMA receivers are close to ideal systems, especially in the submillimetre wavelength range where the earth's atmosphere contributes more noise.

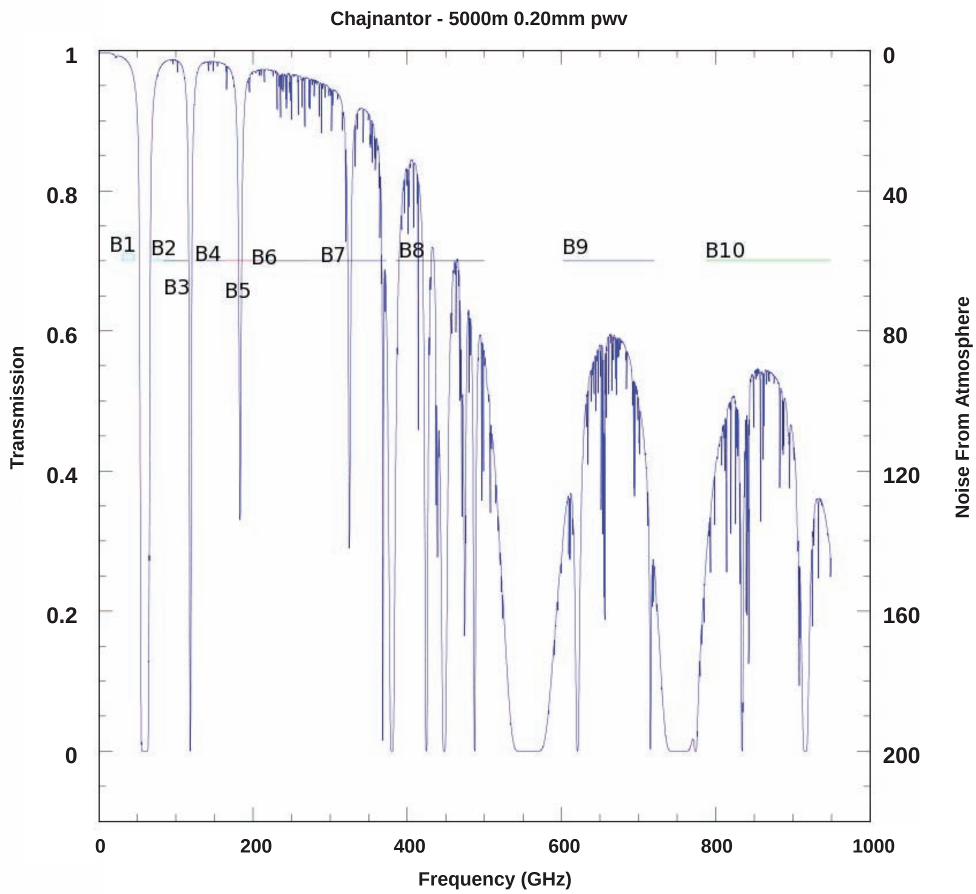
ALMA Band	Frequency Range (GHz)	Receiver Noise over 80% of the RF band	Temperature (K) at any RF Frequency	To be produced by [1]	Receiver Technology
1	31-45	17	26	tbd	HEMT
2	67-90	30	47	tbd	HEMT
3	84-116	37	60	HIA	SIS
4	125-163	51	82	NAOJ	SIS
5*	163-211	65	105	OSO	SIS
6	211-275	83	136	NRAO	SIS
7	275-373	147	219	IRAM	SIS
8	385-500	196	292	NAOJ	SIS
9	602-720	175	261	NOVA	SIS
10	787-950	230	344	NAOJ	SIS

This table gives an overview of the receiver plans for ALMA. The two lowest frequency receiver bands are in the planning stage. The Front Ends for these are High Electron Mobility Transistors (HEMT's), which are cooled to improve the receiver noise performance.

[1]tbd: to be decided; IRAM: Institut de Radio Astronomie Millimétrique (Grenoble, France); HIA: Herzberg Institute of Astrophysics (Victoria, Canada); NAOJ: National Astronomical Observatory of Japan (Mitaka, Japan); NOVA: Nederlandse Onderzoekschool voor Astronomie (Groningen, the Netherlands); NRAO: National Radio Astronomy Observatory (Charlottesville, USA); OSO: Onsala Space Observatory/Chalmers University (Onsala, Sweden); * EU FP6 receivers from Onsala.

ALMA in-depth

It is worthwhile to present some of the principles needed to achieve the receiver noise temperatures of ALMA receivers. First, the receivers are superconducting devices, so-called Superconducting-Insulating-Superconducting (SIS) devices. The SIS device is cooled to 4 degrees above absolute zero. The principle is that a flow of electrical current is hindered by the insulating layer. For a given receiver setting, the current will flow when the astronomical signal shines on the device. The SIS device has three useful properties: (1) converting light from the sky to electrical current; (2) by combining the frequency of the incoming astronomical signal with the one generated at the AOS building, converting the sky frequency to a much lower frequency; and (3) adding a minimum amount of noise to the astronomical signal. A specific example can be given for Band 7. The astronomical frequency could be between 275 and 373 GHz (0.87 millimetres). If the astronomical signal of interest is at 345 GHz, this will be converted to 8 GHz (about 3 centimetres wavelength) with the signal properties such as amplitude, phase and sense of polarization preserved. The signal is then amplified. At each antenna, the signal plus noise from the front end and sky, is passed to the back end where it is amplified, digitized and then transmitted to the AOS building. Here it is processed further. After being combined with the outputs of the other ALMA antennas, these data can be used to produce an image.



On the left vertical axis is the transmission of the earth's atmosphere, on the right axis is the noise contributed by the earth's atmosphere. This plot is for the ALMA site, at an elevation of 5 km. The total amount of water vapor above the site is 0.25 mm. This is a very small amount of water vapor, so the effect of the earth's atmosphere on receiver noise is a minimum.

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Who's who

The Assembly, Integration, Verification (AIV) Team

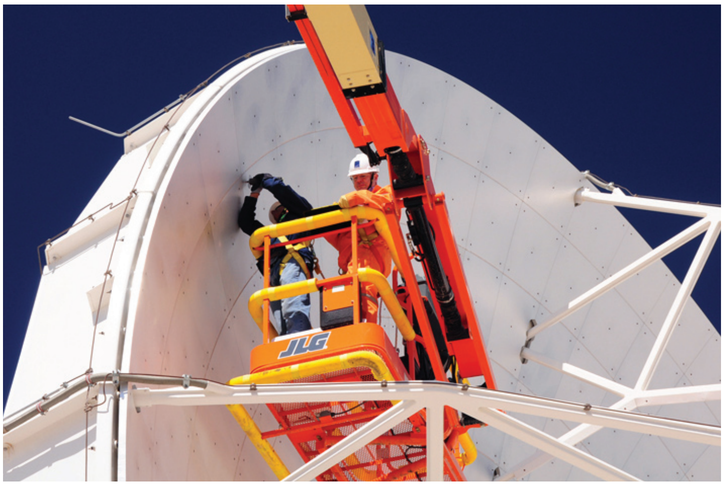
Assembly, Integration, and Verification (AIV) is the process by which the software and hardware deliveries from the distributed ALMA partners (North America, South America, Europe, and East Asia) are assembled and integrated into a working system, and the initial technical capabilities tested to insure that they will meet the observatories exacting requirements for science.

Because of its central role in the construction of the observatory, AIV must coordinate closely with each of the delivering IPT (Integrated Product Team) groups (Antenna, Front End, Back End, Correlator, Computing, Site) as well as each of the Executives (ESO, NAOJ, NRAO). The AIV group is led by Joe McMullin. It is composed of a core of engineers and technicians (electrical, mechanical, RF) and supported by scientists, software engineers and administration/documentation specialists. Currently AIV is composed of roughly 30 engineers/technicians, eight computing staff and five scientists, complemented by additional contributions from the Commissioning and Science Verification (CSV), Department of Science Operations (DSO) and Department of Technical Services (DTS) staff.

Image courtesy of Lewis Knee (ALMA)

Who's who

The AIV process is composed of four key stages; the first three take place at the OSF (Operations Support Facility) and the fourth at the AOS (Array Operations Site) at 5,000 metres:


Holography campaign: panels adjustment on an antenna

1) Antenna verification: During this stage the basic antenna control is tested, as well as the pointing and tracking characteristics and overall surface quality (all of which impact the sensitivity of the overall instrument).

2) Electronics integration: During this stage, the core electro-mechanical systems are integrated into the antenna and tested. These include the Front End, the Back End including the digital transmission system, square law detector and output to the correlator. In addition, there is the amplitude calibration device and the water vapor radiometre which will provide corrections for phase fluctuations. The calibration devices are designed to enhance receiver stability. In addition to detailed tests of parts of the receiver, there are also higher level investigations of the integrity of the signal path connectivity. That is, does the entire electronics system perform as required by the specifications?

3) Single Dish Characterization: During this stage the complete single dish system - namely, antenna plus receiver - is explored through radiometric pointing, focus and beam characterization, and calibration of the system amplitudes over the four ALMA frequency bands, under the conditions of operation on site. These include tests of the data acquisition for different observing modes.

4) Observing Site verification: During this stage there will be a repeat of aspects of the previous three test stages made at 2.9 km elevation. In addition there will be careful monitoring and testing of the electronic systems to confirm normal operation under the harsh environmental conditions of the Array Operations Site at 5 km elevation. The final part of these tests incorporates the antennas into an interferometric array.

The AIV activities will continue throughout the construction of the observatory. AIV begins with the acceptance of the first antenna and concludes with the receipt of the final antenna system (number 66). The immediate focus of AIV at present is the delivery of three verified and calibrated antenna systems to the AOS for the start of Commissioning and Science Verification. This part of the AIV activity should be completed by the end of this year.

Job opportunities

ALMA will be building up its scientific staff over the next few years. Specific positions will be advertised as they become available.

The Joint ALMA Observatory (JAO) is seeking

Test Scientists

for the ALMA Assembly, Integration and Verification.

Purpose and Scope of the Position: ALMA is opening positions for Test Scientists to participate in system tests during the Assembly, Integration and Verification processes.

The successful candidates will be part of the team responsible for ensuring that appropriate testing has been accomplished to verify that the system requirements have been met. These positions will develop qualification tests, analyze test results and approve reports. They support routine tests on antennas, such as holographic measurement and optical pointing, by performing data analysis, developing automated control and reduction scripts, and training operators, engineers and technicians. They also develop and execute tests to characterize integrated interferometric system behavior, including radiometric pointing, antenna and beam characterization, surface shape change with elevation, path delay, phase stability, bandpass stability changes, etc.

During array commissioning, Test Scientists will work with the engineering staff to develop tests and provide the analysis needed to help resolve problems with system performance. They will also work with the commissioning team to define tests needed to validate the system.

Test Scientists are expected and encouraged to conduct active astronomical research programs.

Qualifications: Applicants for this position have to fulfill the following requirements:

- An advanced degree in engineering, physics or astronomy at the Doctoral level;
- At least 3 years of observational experience with radio astronomy; observing techniques and data reduction
- Experience in techniques used in radio astronomy observations;
- Willingness to travel to the ALMA sites near San Pedro de Atacama and abroad.

In addition to the above criteria, the successful candidates will meet the following requirements:

- Experience in software development for astronomical applications (C++, Python);
- Experience with and understanding of microwave and digital systems;
- Experience with and understanding of aperture synthesis arrays;
- Experience in working in a team environment;
- Working knowledge of or willingness to learn Spanish;
- High level of communication and negotiation in English.

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Job opportunities

Due to the frequent travel requirements and work at high altitudes, a successful high altitude medical check is a necessary condition of employment for this position.

Duty station: The positions are based in Santiago de Chile and will require frequent travelling to the ALMA Operational Support Facility near San Pedro the Atacama.

Starting date: As soon as possible.

Contract: These are International Staff positions that are hired as term appointments, which are needed during the construction period that is scheduled to be accomplished in 2012. There is a possibility for Test Scientists to be transferred to the observatory science operations team during or on completion of their term appointment.

Remuneration: ALMA international staff will be recruited as employees of either ESO or AUI/NRAO. Both ESO and AUI/NRAO offer attractive remuneration packages including a competitive salary, comprehensive social benefits and provide financial support in relocating families. Furthermore, an expatriation allowance as well as some other allowances may be added.

Review of applications will begin on 14 July 2009; however applications will be accepted until the position is filled.

The NRAO/ESO are equal opportunity employers. The post is equally open to suitably qualified female and male applicants.

For more information about the way to apply to this position, please see the web pages at (through NRAO), (through ESO)

ALMA Fellowships

With ALMA becoming operational in a few years, ESO offers ALMA Fellowships to complement its regular fellowship programme. Applications by young astronomers with expertise in mm/sub-mm astronomy are encouraged. ESO offers several ALMA fellowship positions to be taken in the European ARC nodes - funded by the Marie-Curie COFUND Programme of the European Community - to complement its regular fellowship programme. For more information, application forms and deadlines:

http://www.eso.org/sci/activities/ESOfellowship.html
http://cordis.europa.eu/fp7/people/cofund_en.html

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More information on ALMA and contact details can be found on the ALMA homepage www.almaobservatory.org

Regional newsletters:
http://www.eso.org/sci/facilities/alma/newsletter/2008/

http://www.nrao.edu/news/newsletters/

http://www.nro.nao.ac.jp/alma/E

Upcoming events

XXVII[th] International Astronomical Union (IAU) General Assembly

Date: 3 to 14 August. Location: Rio de Janeiro.

More information: http://www.astronomy2009.com.br/

* **Visiting ALMA before or after the IAU General Assembly**

We have realised that quite a few colleagues may be thinking of adding a visit to ALMA into their travel itineraries when they come to South America for the IAU in Rio. We are naturally keen to show off the Project but we are concerned that we will not be able to cope with visitors showing up at random times. We would therefore ask that people plan their trips so that they make the visit to the ALMA site on either Friday the 31st July and the Monday 17th of August.

Note: ALMA is located near San Pedro de Atacama and the nearest airport is Calama, which is about 2 hours flight north of Santiago.

More information: Any enquiries and questions, please contact
Claudia Reyes: creyes@alma.cl

The Fourth North American ALMA Science Center Conference (NAASC): Assembly, Gas Content and Star Formation History of Galaxies

A major goal of this meeting is to highlight the capabilities of ALMA, and its synergy with the EVLA, Herschel, JWST, etc., in driving transformational science in these key areas in the next decade.

Dates: 21 to 24 September. Location: Charlottesville, Virginia, USA.

More information: http://www.nrao.edu/meetings/galaxies09/

ESO-MPE-MPA-USM 2009 Joint Workshop: From circumstellar disks to planetary systems

The goals of the workshop will be to review the status of the field and to discuss transformational programs that will be made possible with the upcoming facilities, and especially by the combined use of the ESO present and future facilities. To achieve this, the workshop will bring together the communities working with ground based infrared large telescopes and interferometers, with space observatories and millimeter interferometers as well as theorists.

Dates: 3 to 6 November. Location: Garching, Germany.

More information: http://www.eso.org/sci/meetings/disks2009