ALMA Status and Progress towards Early Science

Leonardo Testi[1]
Richard Hills[2]
Robert Laing[1]
Stefano Stanghellini[1]
Wolfgang Wild[1]

[1] ESO
[2] Joint ALMA Observatory

We report on the status and progress of the ALMA project and the expected timeline and capabilities for Early Science. Over the past year, the progress on ALMA construction and on the commissioning activities has been huge. At the time of writing the observatory is progressing on the initial phases of science verification and preparing to open to external users to begin Early Science observations.

The year 2010 has seen extraordinary progress in the ALMA project. At the beginning of the year, with three fully equipped antennas working as an interferometer, Commissioning and Science Verification (CSV) activities officially started at the Array Operations Site (AOS) on the Chajnantor plateau at an elevation of 5000 metres (Testi, 2010). Under the leadership of Richard Hills and Alison Peck at the Joint ALMA Office, the CSV team has been steadily working to test and improve the performance of the whole ALMA system. This process has culminated in the production of the first ALMA test images in the second part of the year (see Figure 1 for an early example). At the time of writing the CSV team is working to obtain science demonstration data with the eight-antenna interferometer at the high site and is focusing on refining the calibration plan, in addition to continuing the commissioning activities on the equipment that is constantly being delivered.

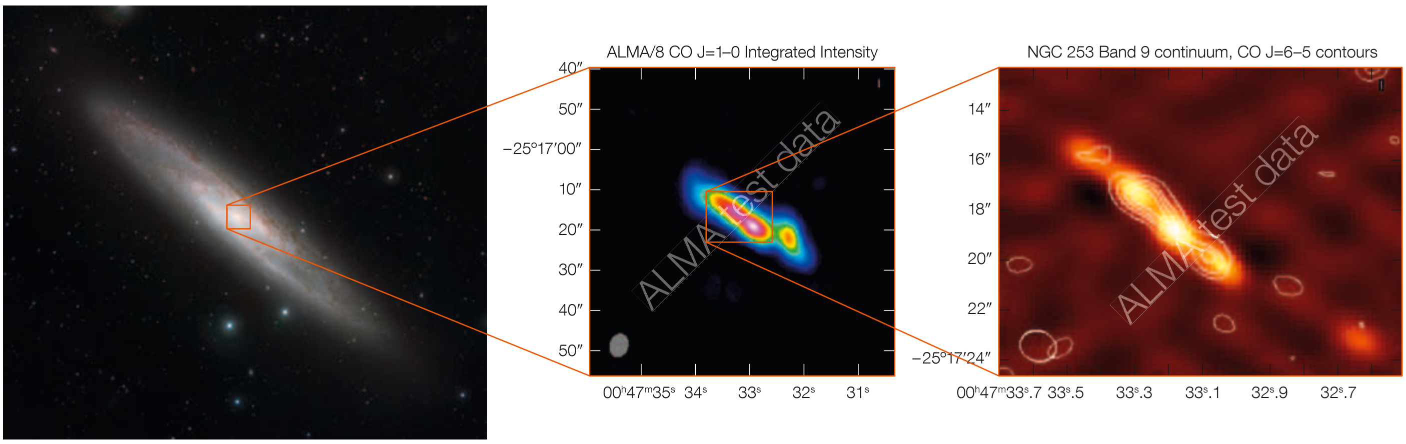
On the hardware construction side, there has been steady progress throughout the year thanks to the tremendous effort from the project teams in all regions and the work of the Assembly Integration and Verification group in Chile. In particular, focusing on deliverables from the European side, the ALMA front-end cartridges for Band 7 (275–373 GHz, produced at IRAM in France) and Band 9 (602–720 GHz, produced by NOVA in the Netherlands) as well as the water vapour radiometers (produced by the Swedish company Omnisys) are in a very advanced stage of production and more than half of the total number of units have been delivered to the project. The test data shown in Figure 2 were obtained with the Band 7 and Band 9 cartridges. Phase correction using the water vapour radiometers (see Nikolic et al., 2009) has been demonstrated as part of commissioning; this represents a key step towards validating the ALMA calibration strategy for high frequency and high angular resolution observations.

Naturally, the most visible pieces of hardware of the ALMA system are the antennas. ALMA has provisionally accepted fourteen antennas. Eight antennas are fully equipped and working as an interferometer at the high site (see the image on the Telescopes and Instrumentation section page, p. 4); the remainder are partly equipped and under test or in the process of being outfitted with ALMA front-end and back-end systems at the Operations Support Facility (OSF). Many more antennas are in various stages of assembly in the contractor camps at OSF. Among these are the first European antennas from the AEM consortium; five of these have been fully assembled at the time of writing (see Figure 3) and the first ones are undergoing performance tests and tuning with the goal of being delivered to the ALMA project in early 2011.

Initial results of the all-sky pointing tests have been excellent with the root mean square on pointing accuracy below 1 arcsecond (see Figure 4 for an example of a pointing run). The surface accuracy of the European antenna tested so far is also excellent. The panels are mounted and aligned in the assembly procedures to a good initial accuracy. Preliminary tests on the first antenna have shown that, following a partial initial cycle of holography measurements and panel adjustments, the surface can be brought within the ALMA specifications (see example in Figure 5). Testing of many aspects, such as the dependence of the antenna performance on environmental conditions and of the final figure and stability of the surface accuracy, are starting at the time of writing.

Figure 1. ALMA test data obtained in Bands 3 and 9 on the nearby star-forming galaxy NGC 253. The large image is a VISTA infrared image of NGC 253 (see ESO PR 1025). The data shown is the CO(1–0) integrated emission; at right the CO(6–5) integrated emission contours are overlaid on the 0.45 mm continuum emission.

Credit: ALMA CSV team



Credit: ALMA CSV team

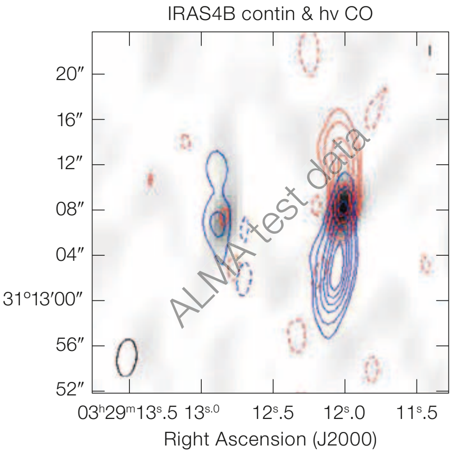


Figure 2. ALMA test data in Band 7 of the molecular outflow in the star-forming region NGC 1333. The red and blue contours show the high velocity CO(3–2) emission while the 0.85 mm continuum emission is shown as greyscale.

Credit: ESO/AEM consortium

Figure 3. The AEM antenna camp at the OSF. Five antennas are fully assembled while a sixth is inside the temporary shelter on the right ready for the installation of the main reflector assembly; parts of the seventh antenna are also being assembled.

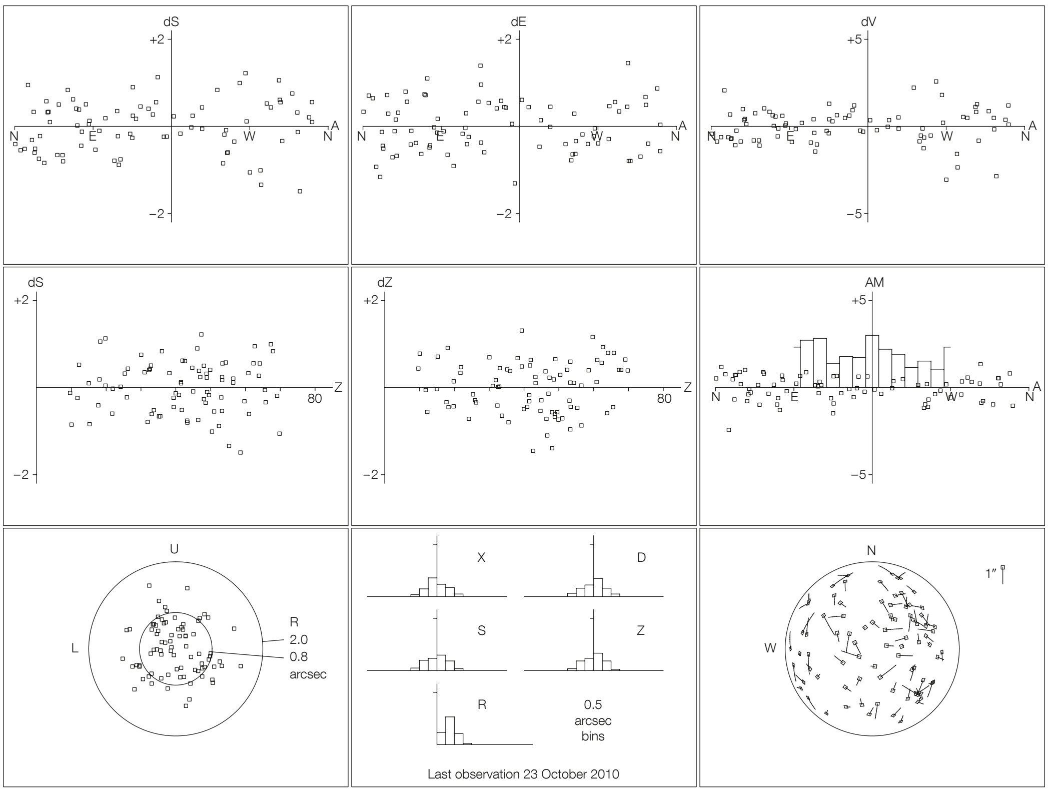
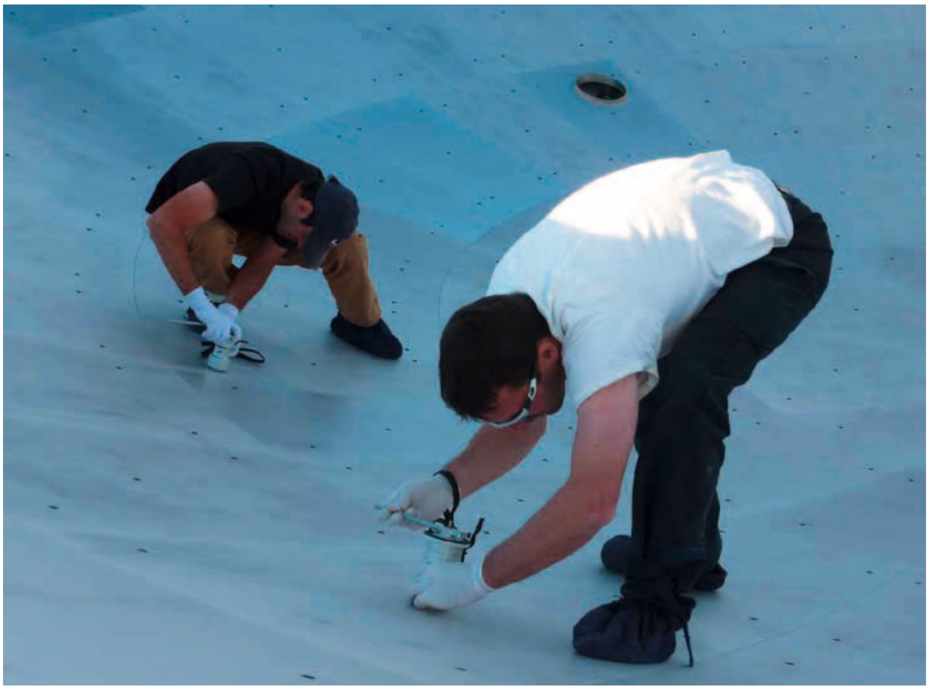


Figure 4. Example of all-sky optical pointing session for the first AEM antenna. The top panels show the pointing errors as a function of azimuth and elevation of the observed stars. The bottom right circular diagram shows the position of the observed stars on the sky. The bottom left circular panel shows the pointing error distribution, which in this case corresponds to an all sky rms accuracy of 0.8 arcseconds.



Credit: ESO/AEM consortium

Figure 5. Adjusting panels on the AEM antennas using the manual panel adjuster tools. Note that this operation can be performed walking on the reflector surface when the antenna is stowed; the hole on the dish surface to the rear of the image is used for the optical pointing telescope.

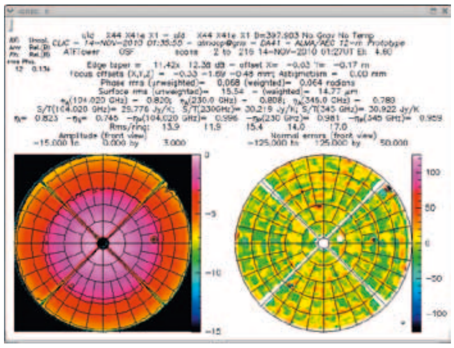


Figure 6. Example results of a holography run after tuning the position of approximately half of the panels on the AEM dish. In this particular case the surface was found to be set to approximately 15 μm rms.

During the autumn of 2010, the ALMA project has been going through a series of external reviews that have focused on the progress and current results of the CSV activities and the readiness for operations, culminating in the ALMA Annual External Review. These reviews scrutinised all the aspects of the ALMA project and provided advice to the ALMA Director and the ALMA Board on the status and progress of ALMA construction. The main focus of the reviews has been to assess the readiness of ALMA for Early Science. The conclusion of the reviews is that hardware delivery, system verification and commissioning, as well as the deployment of all the procedures for the start of science operations, are all progressing at the pace required to start Early Science observations in the second half of 2011. Nevertheless, the opening of the observatory to external users will result in additional challenges to meet the standards expected for ALMA data and run science operations at the same time as construction and commissioning. For these reasons the ALMA science advisory committees have all recommended that the main focus remains on the full ALMA construction and operations and that the Early Science capabilities are focused on a limited set of well-tested modes.

The announcement of opportunity for Early Science observations will be released in the first quarter of 2011 with the deadline for proposal submission before the summer. The precise capabilities that will be available for Early Science will be announced as part of the call for proposals, but it is likely that the array will be offered in two compact configurations of 16 antennas (with the maximum baseline likely to be of the order of 250 metres). The limited instantaneous coverage of the *uv*-plane will imply that most projects will require Earth rotation synthesis to achieve good imaging capabilities during Early Science. The available observing modes will be limited to single field interferometry using Bands 3, 6, 7 or 9 (84–116 GHz, 211–275 GHz, 275–373 GHz, 602–720 GHz, respectively), full polarisation capabilities and a range of single spectral resolution correlator modes. During the first year of operations, scientific observations will be limited to a fraction of the total available time, not exceeding 30 %, as the first priority of the project will be to work on completing and commissioning the full ALMA system.

A series of workshops, schools and tutorials have been and are being organised to prepare European astronomers for ALMA. The European ALMA Regional Centre (ARC) and its nodes located in several European countries have put in place a strong effort to support the community uptake of Early Science. On 6 and 7 April 2011, the European ARC will organise a tutorial at ESO Headquarters in Garching focused on the use of the ALMA software for Early Science (see the full announcement on page 49). In particular, the tutorials will focus on the use of the ALMA observing tool, which will be used by ALMA users for the preparation of observing proposals and to set up the approved projects for observation at the telescope.

References

Nikolic, B. et al. 2009, The Messenger, 131, 14
Testi, L. 2010, The Messenger, 139, 52