Band 1: Status

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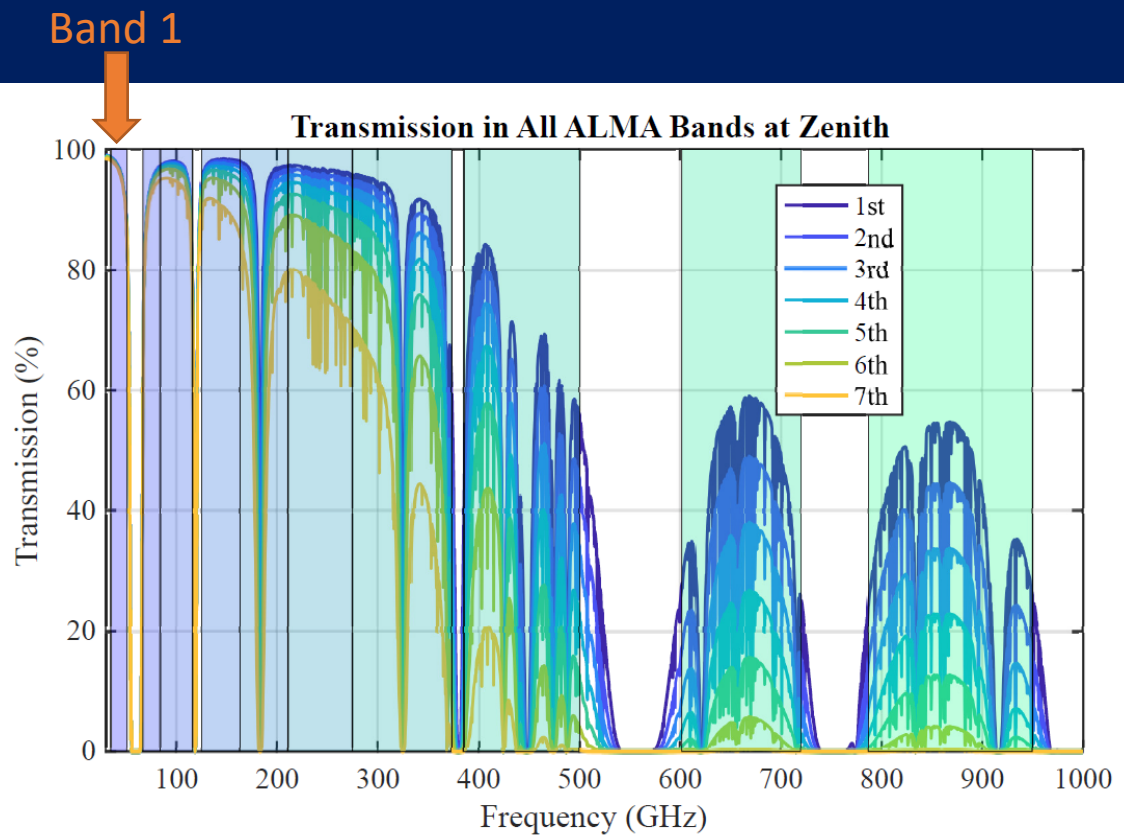
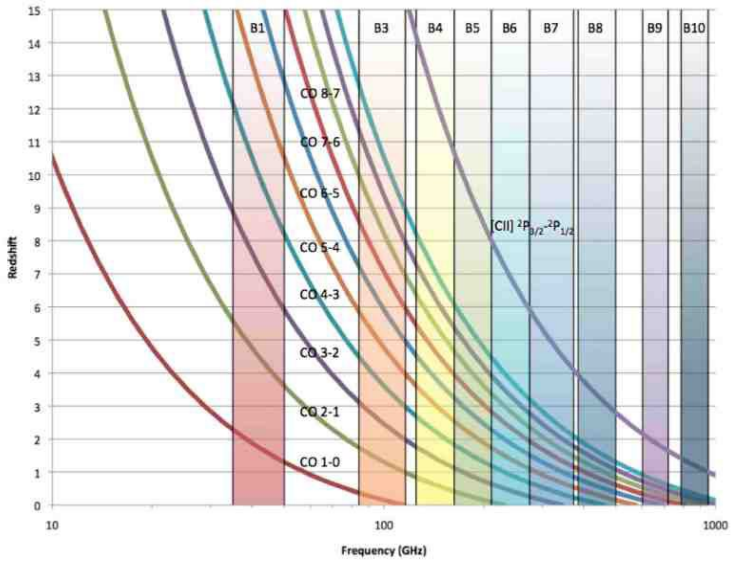
What's Band 1?

- The lowest frequency band covering 35-50 GHz.
- Ongoing EA Development Project.
- The Band 1 receivers are developed and tested by the ASIAA in Taiwan in collaboration with the NAOJ.
- After some delay due to the COVID-19, receiver shipment and integration to the ALMA antennas started in March 2021.
- ~30 antennas equipped with Band 1 receiver are on the site and under testing.



Band 1 Science

- Cold molecular ISM through important lines, such as SiO, CS, CH3OH, HDO, recombination lines, etc.
- Redshifted CO lines:
  - CO(1-0) at z=2, CO(2-1) at z=4-5, CO(3-2) at z=6-9
- Probing a large range of energy regime through F-F, synchrotron, dust emission.
- Dust grain growth from millimeter to centimeter-sized pebbles.
- S-Z effect, and more. See talks by Hsi-Wei and Jorge.
- ALMA Band 1 can provide comparable sensitivity to JVLA, and will have more chance of observations because of the site advantage.



Di Francesco+ 2013

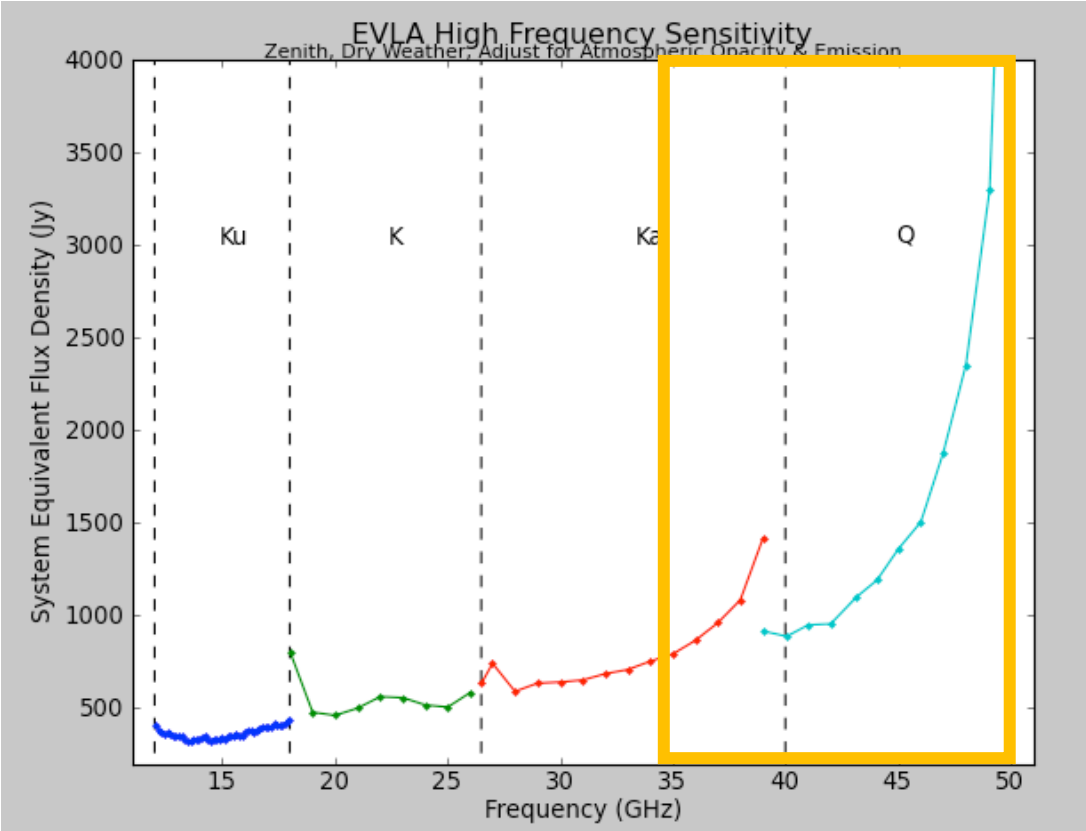
Condon 1992

Modified from original
- Scientific plot removed

JVLA vs. ALMA

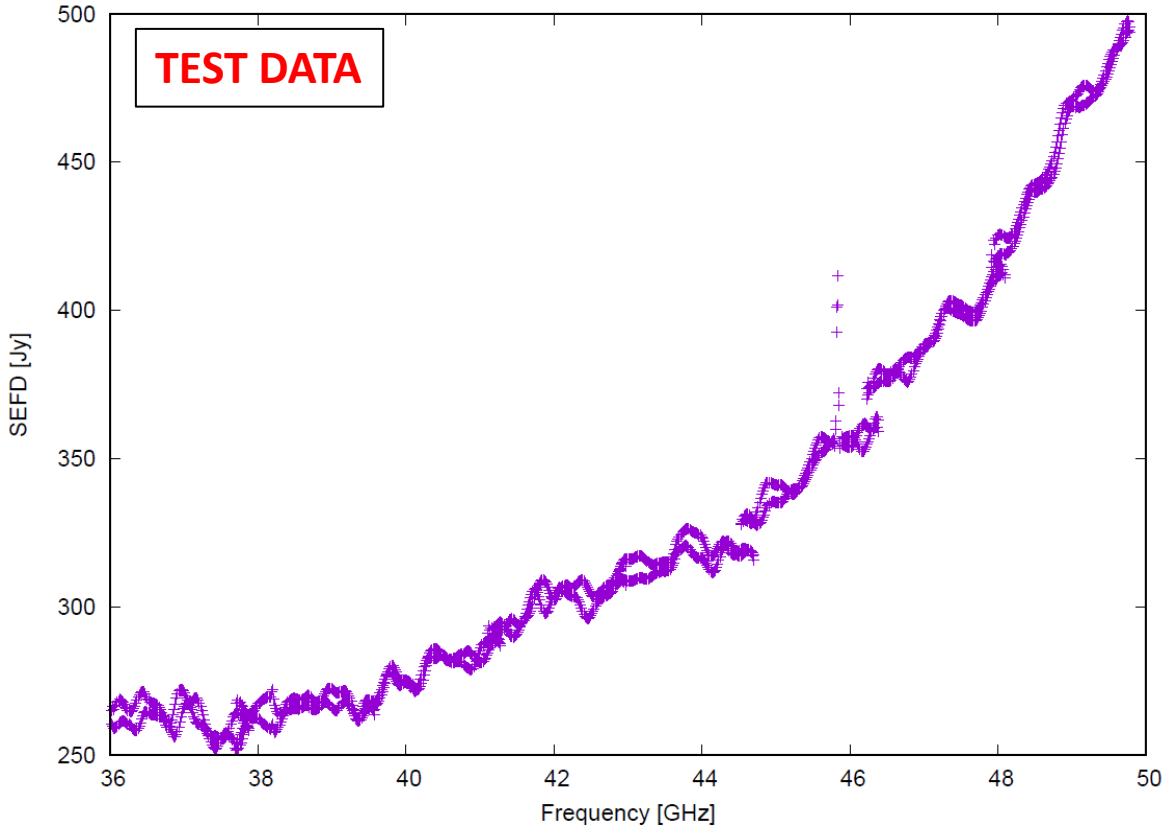
System Equivalent Flux Density (SEFD) = 5.62 Tsys/(antenna aperture efficiency)

JVLA



Credit: NRAO

ALMA



JVLA vs. ALMA

Di Francesco+ 2013

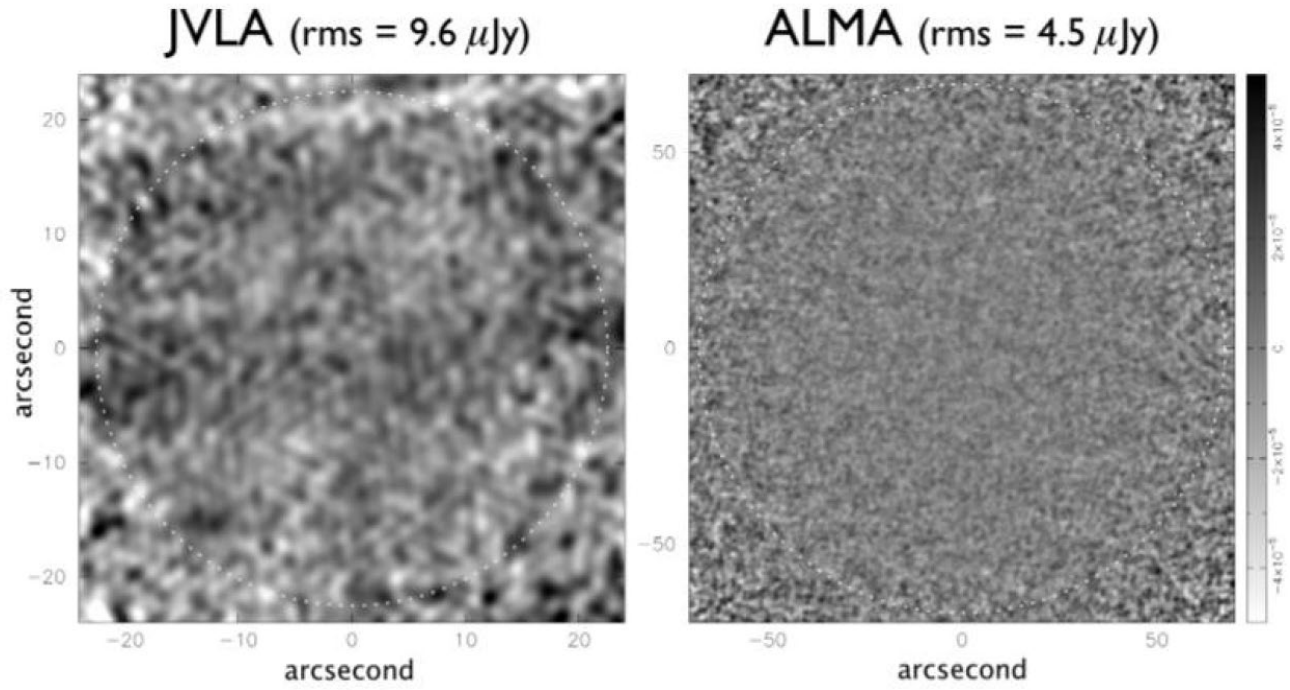


Fig. 7.— Images from JVLA and ALMA observations simulated with CASA. The observations were set toward a "blank" sky at 45 GHz with 8 GHz (continuum) bandwidth, with JVLA in its D-configuration while ALMA in its "12" configuration provided in CASA. Both array configurations give rise to a similar angular resolution of ∼1″.6 FWHM. The white dotted circles denote the corresponding primary beam sizes. There resulting 1 σ rms noise levels after 2 hours of on-source integration are 9.6 μJy and 4.5 μJy, respectively, for JVLA and ALMA, which are in general agreement with the estimated noise level shown in Table 2.

JVLA vs. ALMA

Di Francesco+ 2013

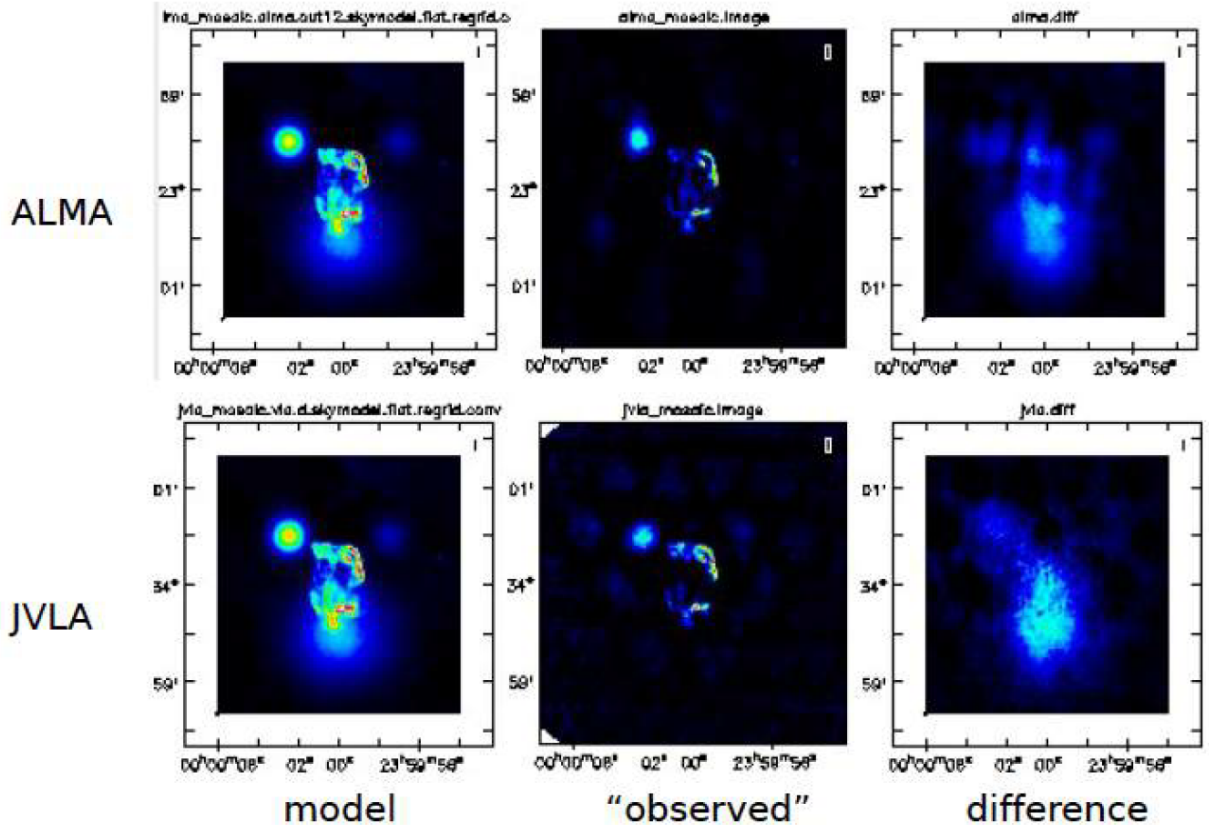


Fig. 9.— Images from CASA simulations of observations of extended 45 GHz emission with the JVLA and ALMA. The left-hand panels show the model image (a superposition of the G41.1-0.3.b template provided by the CASA guide with three extended Gaussian sources (two 18″ in size and one 48″ in size) convolved with the synthesized beams. The middle panels show the resulting images from the simulations. The right-hand panels show the difference between the model and observation images. Both simulated observations were executed with one hour of on-source time in total toward the zenith. The ALMA and JVLA are assumed to be in their "12" and "D" configurations (both provided in CASA), respectively, which resulted in similar synthesized beam sizes of 1.7″ × 1.7″. The achieved noise level by ALMA is around five times better than that by JVLA (i.e., 10 μJy beam^{-1} for ALMA vs. 50 μJy beam^{-1} for JVLA). Observation overheads (e.g., calibration scans) and phase decoherence due to site location were not included in the simulations, both of which will lead to greater degradation in the JVLA images.

Anticipated Band 1 Observing Modes in Cycle 10

Preliminary!!!

- 12m array only (no 7m/TP)
- Stokes I only (no Stokes Q/U/V)
- TDM (low spectral resolution), FDM (high spectral resolution), spectral scan, Mosaic/multiple pointing
- Band 1 PI observations will start when at least 41 antennas have been ready.
  - Expected timeline: March 2024
  - C1-C6 configurations will be visited.
- Band 1 VLBI/Phased array is TBD.

Angular resolution, MRS, FoV

Configuration		Frequency 40 GHz
C-1	Resolution	8.45
	MRS	71.25
C-2	Resolution	5.75
	MRS	56.50
C-3	Resolution	3.55
	MRS	40.50
C-4	Resolution	2.30
	MRS	28.00
C-5	Resolution	1.38
	MRS	16.75
C-6	Resolution	0.78
	MRS	10.28

Primary beam width / FoV = 145” at 40 GHz

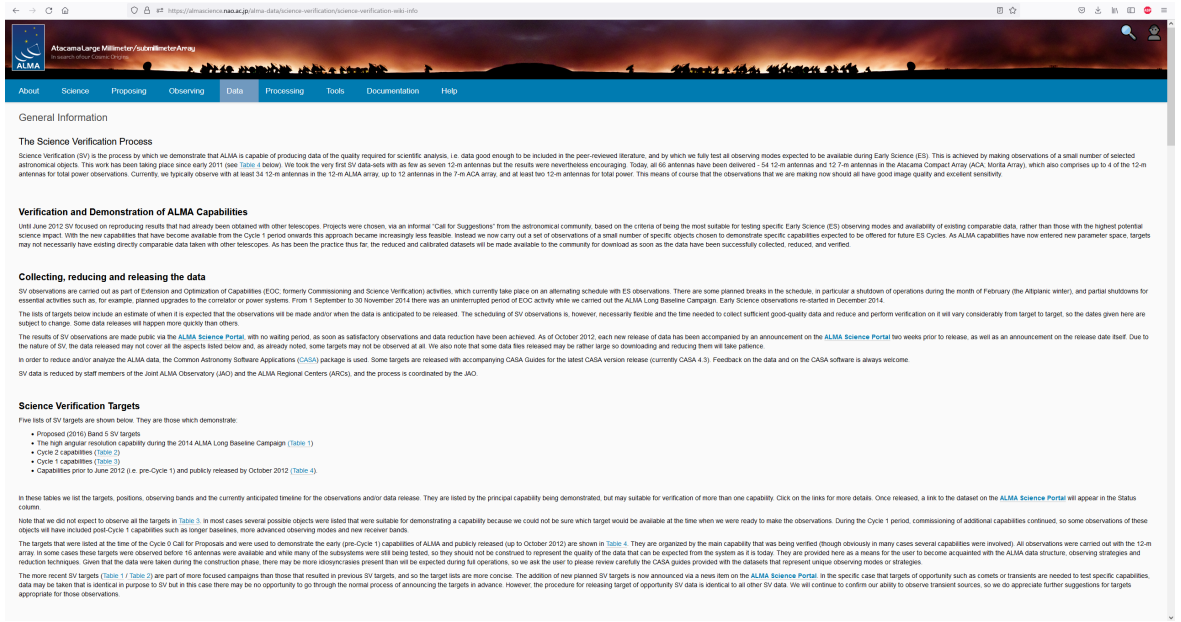
Notes for Proposers

- Fractional bandwidth of Band 1 ($\Delta\nu/\nu$) is largest in the ALMA bands.
  - Take notice on the difference in angular resolution/MRS/FoV between spectral windows. At most ~15% difference between spw0 and spw3 for 1.875GHz bandwidth.
- Flux calibration accuracy is TBD.
  - The main issue is that quasars (flux calibrators) show a curvature in their spectra and therefore simple extrapolation from higher bands with single power law will not work.
  - We are currently testing quasar flux monitoring in Band 1.
- Data processing
  - Pipeline processing by default.
  - Higher-order continuum fitting (**fitorder**>1 in **uvcontsub**) and imaging (**nterms**>2 in **tclean**) are not supported in the Cycle 10 Pipeline. Those data will be reduced by manual (particular for the curvy continuum by f-f + dust).

Science Verification

- SV campaign is being planned in 2023.
- Demonstration of continuum and spectral line observation capability in Band 1.
- The data will be public with data reduction/imaging script through the ALMA Science Portal.

Science Verification (ALMA Science Portal)



Atacama Large Millimeter/submillimeter Array

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General Information

The Science Verification Process

Science Verification (SV) is the process by which we demonstrate that ALMA is capable of producing data of the quality required for scientific analysis, i.e. data good enough to be included in the peer-reviewed literature, and by which we fully test all observing modes expected to be available during Early Science (ES). This is achieved by making observations of a small number of selected astronomical objects. This work has been taking place since early 2011 (see Table 4 below). We took the very first SV data-sets with as few as seven 12-m antennas but the results were nevertheless encouraging. Today, all 66 antennas have been delivered - 54 12-m antennas and 12 7-m antennas in the Atacama Compact Array (ACA, Morita Array), which also comprises up to 4 of the 12-m antennas for total power observations. Currently, we typically observe with at least 34 12-m antennas in the 12-m ALMA array, up to 12 antennas in the 7-m ACA array, and at least two 12-m antennas for total power. This means of course that the observations that we are making now should all have good image quality and excellent sensitivity.

Verification and Demonstration of ALMA Capabilities

Until June 2012 SV focused on reproducing results that had already been obtained with other telescopes. Projects were chosen, via an informal "Call for Suggestions" from the astronomical community, based on the criteria of being the most suitable for testing specific Early Science (ES) observing modes and availability of existing comparable data, rather than those with the highest potential science impact. With the new capabilities that have become available from the Cycle 1 period onwards this approach became increasingly less feasible. Instead we now carry out a set of observations of a small number of specific objects chosen to demonstrate specific capabilities expected to be offered for future ES Cycles. As ALMA capabilities have now entered new parameter space, targets may not necessarily have existing directly comparable data taken with other telescopes. As has been the practice thus far, the reduced and calibrated datasets will be made available to the community for download as soon as the data have been successfully collected, reduced, and verified.

Collecting, reducing and releasing the data

SV observations are carried out as part of Extension and Optimization of Capabilities (EOC; formerly Commissioning and Science Verification) activities, which currently take place on an alternating schedule with ES observations. There are some planned breaks in the schedule, in particular a shutdown of operations during the month of February (the Altiplanic winter), and partial shutdowns for essential activities such as, for example, planned upgrades to the correlator or power systems. From 1 September to 30 November 2014 there was an uninterrupted period of EOC activity while we carried out the ALMA Long Baseline Campaign. Early Science observations re-started in December 2014.

The lists of targets below include an estimate of when it is expected that the observations will be made and/or when the data is anticipated to be released. The scheduling of SV observations is, however, necessarily flexible and the time needed to collect sufficient good-quality data and reduce and perform verification on it will vary considerably from target to target, so the dates given here are subject to change. Some data releases will happen more quickly than others.

The results of SV observations are made public via the ALMA Science Portal, with no waiting period, as soon as satisfactory observations and data reduction have been achieved. As of October 2012, each new release of data has been accompanied by an announcement on the ALMA Science Portal two weeks prior to release, as well as an announcement on the release date itself. Due to the nature of SV, the data released may not cover all the aspects listed below and, as already noted, some targets may not be observed at all. We also note that some data files released may be rather large so downloading and reducing them will take patience.

In order to reduce and/or analyze the ALMA data, the Common Astronomy Software Applications (CASA) package is used. Some targets are released with accompanying CASA Guides for the latest CASA version release (currently CASA 4.3). Feedback on the data and on the CASA software is always welcome.

SV data is reduced by staff members of the Joint ALMA Observatory (JAO) and the ALMA Regional Centers (ARCs), and the process is coordinated by the JAO.

Science Verification Targets

Five lists of SV targets are shown below. They are those which demonstrate:

- Proposed (2016) Band 5 SV targets
- The high angular resolution capability during the 2014 ALMA Long Baseline Campaign (Table 1)
- Cycle 2 capabilities (Table 2)
- Cycle 1 capabilities (Table 3)
- Capabilities prior to June 2012 (i.e. pre-Cycle 1) and publicly released by October 2012 (Table 4)

In these tables we list the targets, positions, observing bands and the currently anticipated timeline for the observations and/or data release. They are listed by the principal capability being demonstrated, but may suitable for verification of more than one capability. Click on the links for more details. Once released, a link to the dataset on the ALMA Science Portal will appear in the Status column.

Note that we did not expect to observe all the targets in Table 3. In most cases several possible objects were listed that were suitable for demonstrating a capability because we could not be sure which target would be available at the time when we were ready to make the observations. During the Cycle 1 period, commissioning of additional capabilities continued, so some observations of these objects will have included post-Cycle 1 capabilities such as longer baselines, more advanced observing modes and new receiver bands.

The targets that were listed at the time of the Cycle 0 Call for Proposals and were used to demonstrate the early (pre-Cycle 1) capabilities of ALMA and publicly released (up to October 2012) are shown in Table 4. They are organized by the main capability that was being verified (though obviously in many cases several capabilities were involved). All observations were carried out with the 12-m array. In some cases these targets were observed before 16 antennas were available and while many of the subsystems were still being tested, so they should not be construed to represent the quality of the data that can be expected from the system as it is today. They are provided here as a means for the user to become acquainted with the ALMA data structure, observing strategies and reduction techniques. Given that the data were taken during the construction phase, there may be more idiosyncrasies present than will be expected during full operations, so we ask the user to please review carefully the CASA guides provided with the datasets that represent unique observing modes or strategies.

The more recent SV targets (Table 1 / Table 2) are part of more focused campaigns than those that resulted in previous SV targets, and so the target lists are more concise. The addition of new planned SV targets is now announced via a news item on the ALMA Science Portal. In the specific case that targets of opportunity such as comets or transients are needed to test specific capabilities, data may be taken that is identical in purpose to SV but in this case there may be no opportunity to go through the normal process of announcing the targets in advance. However, the procedure for releasing target of opportunity SV data is identical to all other SV data. We will continue to confirm our ability to observe transient sources, so we do appreciate further suggestions for targets appropriate for those observations.