ALMA Project Update

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ALMA Project Outline



- Outline of the Construction project
- Cycle 2 Progress
- Commissioning
- Cycles 3 and 4
- ALMA Development

https://almascience.eso.org/news/alma-status-report-november-2014







What is ALMA?



ALMA antennas



Antennas provided by three different vendors

- Vertex (North America)
- AEM consortium (Europe)
- Melco (Japan)
- Same specifications for all antennas
- Currently almost all antennas at the 5000m site, typically a couple require maintenance.







ALMA Frequency Bands



Atmospheric transmission at Chajnantor





ALMA Frequency Bands



ALMA Band	Frequency Range (GHz)	Receiver Noise (K) over 80% of the RF band	Temperature (K) at any RF Frequency	To be produced by	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*	162 - 211	65	105	NOVA/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

* Six Band 5 units produced under FP6 funding



End of Construction



- Official end of ALMA Construction September 2014
- Infrastructure (power, roads) much more stable
- Leftovers (EU)
 - ALMA Residence (ESO FC and Council approved contract)
 - AOS Surveillance System
 - Fixes: ACD gearboxes, DC vacuum feed through connector,
 - AEM antenna warranty actions (HVAC, Hexapod upgrades)
 - Continue to monitor performance





ALMA Science Operations Centres











ALMA Data Flow







NAASC: North America ALMA Science Center



The North American **ARC** is headquartered at NRAO-Charlottesville and is a partnership between the US, Canada (7.25%), and Taiwan

The NAASC is a combination of the NA ARC and US funded Full Science Support at NRAO. Canada NA ARC support provided by NRC Herzberg





NAASC is a Full Support Center for NA ALMA Community

- Proposals
- Observing scripts
- Data archive and reduction
- Training and Workshops
- Development programs & studies
- Value-added tools (simalma, Splatalogue)
- Student & Postdoc programs
- Publication support (page charges, press releases)
- EPO & outreach programs



East Asian ARC





EA-ARC non-core functionalities:
Science operation of ASTE and Mopra telescopes
Data filler to CASA (Nobeyama 45m, ASTE)
Development of joint archive of ALMA, Nobeyama 45m, ASTE
Laboratory molecular line database (Toyama), http://www.sci.u-toyama.ac.jp/phys/4ken/atlas/
VO—collaboration with JVO group (NAOJ) Portal for FITS images of ALMA Public data, SV data 3D FITS image viewer "Vissage" http://jvo.nao.ac.jp/download/Vissage/





ALMA observations



- ➤ Cycle 0
 - o started on 30 Sept 2011
 - 917 proposals, European 399 (43.5%)
- Cycle 1
 - started on 1 Dec 2012 and delayed until 31 May 2014 + carry overs (333h)
 - o total 1108, European 481 (43%)
- Cycle 2
 - o Started June 1 2014
 - o total 1383, European 562 (41%)

Pressure factors (highest priority projects)

- Cycle 1: Europe: 9.1 (global ALMA: 5.7)
- Cycle 2: Europe: 4.9 (global ALMA: 3.9)



Publications



154 refereed papers as of October 20



57% of all refereed ALMA publications use data from EU Exec 40% of all refereed ALMA publications have EU PI



Usage of the ALMA archive









Observing Progress

- Cycle 2 proposals
 - 170 hr Cycle 2 A, 333 hr Cycle 1 A, 1530 hr Cycle 2 B (estimated)
- Cycle 2 June 3 Sept 1
 - 370 hr 12m array successfully executed (33%)
 - 360 hr 7m array successfully executed (37%)
- Remaining Cycle 1 + 2 (A+B)
 - 1670 hr 12m array
 - Dec 1 Sept 30 (including 2 month engineering shutdown)
 - Requires an increase in observing efficiency to ~50%

Pipeline accepted and in use for interferometric data calibration September 2014





Commissioning: Long Baselines

- Sept 1 Nov 30
 - Baselines to >15 km in Band 3
 - Bands 3 10
 - On-line WVR correction; improved delay model; faster switching cycle
 - Very promising results
- Science verification targets
 - Juno Band 6 continuum
 - Mira Band 3 and 6, SiO, continuum
 - HL Tau Bands 3, 6, 7, Continuum, CO
 - 3C138, Bands 3 and 6, continuum, linear polarization
 - SDP8.1, Bands 4, 6, 7, CO, H₂O, continuum
 - Public data release ~end Jan 2015





15km Band 3 / 7 km Band 10











Band 6 continuum 0.035 arcsec FWHM





Juno, Band 6



0.04 x 0.03 arcsec = 60 x 45 km at Juno



Commissioning: recent and forthcoming activities 1

- High-frequency Campaign
 - Band-to-band transfer (3-9, 6-9, 6-10)
 - Phase stability tests and metrics
 - Uranus, Neptune, 3C454.3 in Band 10
- High-precision ephemerides (Pluto/Charon)
- Bandwidth transfer and bandpass stability
- Linear polarization
- Total power linearity (4-bit only)









Uranus at 860 GHz



Pluto+Charon Band 7 Ephemeris tracking

3C286 linear polarization





Commissioning: recent and forthcoming activities 2

- Fast scanning (total power, including solar)
- ALMA Phasing Project
 - H maser installed; now default frequency standard
 - First quadrant of correlator phased successfully
- Solar commissioning campaign
 - Mixer detuning (Pavel Yagoubov)
 - Campaign December
- Subarrays
 - 4 subarrays/8 antennas each used simultaneously in November





Cycle 3 Anticipated capabilities



- At least thirty-six 12-m antennas in the main array, and ten 7-m antennas (for short baselines) and two 12-m antennas (for making single-dish maps) in the Atacama Compact Array (ACA)
- Receiver bands 3, 4, 6, 7, 8, 9, & 10 (wavelengths of about 3.1, 2.1, 1.3, 0.87, 0.74, 0.44, and 0.35 mm)
- Baselines up to 2 km for Bands 8, 9 and 10
- Baselines up to 5 km for Band 7
- Baselines up to 10 km for Bands 3, 4, & 6
- Both single field interferometry and mosaics
- Spectral-line observations with all Arrays and continuum observations with the 12-m Array and the 7-m Array.
- Polarization (on-axis, continuum in Band 3, 6 and 7, no ACA, no mosaics, no spectral line, no circular polarization)
- Mixed correlator modes (both high and low frequency resolution in the same observation)



Cycle 3: time line



- Pre-announcement: Dec 8 2014
- Call for Proposals/Archive open: March 24 2015
- Submission deadline: April 23 2015
- Observations start: October 1 2015
- One-year cycles from now on





Cycle 4 Priorities

- Solar
- ALMA Phasing Project
- On-the-fly interferometry
- Robustness improvements
- 90° phase switching for better sideband separation
- Band 9 and 10 total power spectral line
- Continuum total power (fast scanning)
- Efficiency (e.g. multiple calibrator intents; dynamic time adjustment)
- Large programmes (>50 hr). Fully tested capabilities only.



ALMA Development: near/mid-term strategy



- Complete ALMA as it is currently specified
 - Full polarization, long baselines, total power, solar, efficient calibration,
- Restore lost capability
 - Bands 1, 2, 5; VLBI, data rate, ...
- Develop new ideas and technologies
 - Wideband receivers; focal-plane arrays; higher IF bandwidth; sideband separation at high frequencies;
- Vision for ALMA in the 2020's ("ALMA 2030")
 - Development programme has suffered from a lack of direction, so individual regions have acted unilaterally
 - Science priorities
 - Landscape (complementary facilities)
 - Development pathways
 - Process led by Programme Scientists, ASAC



Current Development Projects 1

- Band 5 (167-211 GHz) full production
 - [CII] in the EoR
 - Water in the local Universe
 - Deployment by 2017
 - NOVA, GARD















- ALMA Phasing Project
 - Phase up 50 antennas to give 84m equivalent aperture
 - VLBI at 230GHz (345GHz)
 - Event Horizon Telescope Collaboration, led by MIT
 - Image Event Horizon of the Galactic Centre black hole and the formation of the jet in M87
 - Goal: open access mmVLBI Network







Current Development Projects 3

- Band 1 (35-52 GHz)
 - ASIAA, NRAO, NAOJ, HIA, U Chile
 - Prototype under construction; full production anticipated
- Ongoing smaller projects
- ESO Studies
 - mmVLBI operations model
 - solar
 - improved cryo-cooler
 - digitizer upgrade
 - wideband 67-113 GHz receiver design
 - line identification/optimization/radiative transfer code in CASA





ESO-ALMA Community days

Garching 13-15 April 2015

http://www.eso.org/sci/meetings/2015/Alma 2015.html

- ESO-ESA workshop
 - Herschel and ALMA Archive research
 - Garching 15-17 April 2014

http://www.eso.org/sci/meetings/2015/AlmaHerschel2015.html



