ALMA Community Day at UF

Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Very Long Baseline Array

NRAO

Schedule

09:00-09:30: Welcome and Introduction to NRAO Facilities

09:30-10:15: ALMA Overview and Capabilities

10:15-10:45: Interferometry Basics (Part 1)

10:45-11:15: **Coffee Break**

11:15-11:45: Interferometry Basics (Part 2)

11:45-12:15: Cycle 7 Proposal Preparation

12:15-13:45: **Lunch**

13:45-14:15: The ALMA Observing Tool

14:15-14:45: Observing Tool **hands-on**

14:45-15:00: Using the ALMA Archive

15:00-15:30: CASA Imaging and Simulations

15:30-15:45: Concluding discussion (including additional NAASC resources), final Q&A

Goals for Today

- ALMA Capabilities
  - Cycle 7 changes
- Basics of Interferometry
- Proposal preparation
  - Observing Tool
  - Observing strategies (LST/weather, ALMA array configurations)
  - Using the archive

What will not be covered

- Selection/identification of molecules relevant for specific science projects
- Details of imaging and analysis of delivered/archival ALMA observations
  - But if there's interest, possible follow-up workshop for this

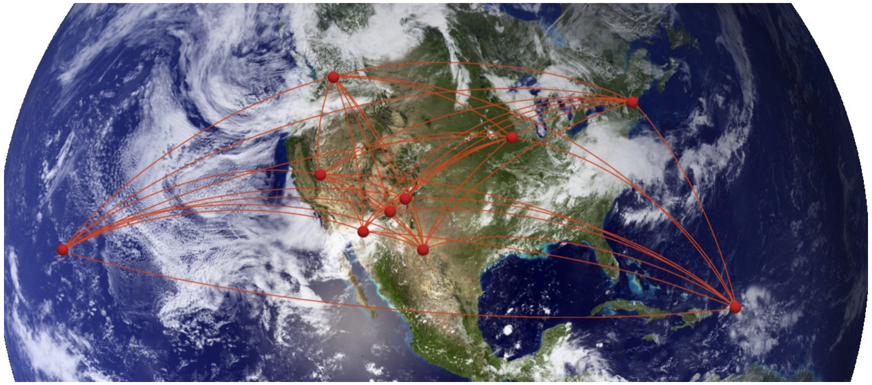
Logistics

- Morning coffee & lunch will be the in the Informatics lobby
- Restrooms are down the hall and to the right (follow signs)

Acknowledgements

- NRAO / North American ALMA Science Center:
  - Organizational help
  - Lunch
- UF Informatics Institute
  - Space
  - Coffee

National Radio Astronomy Observatory



George C. Privon

Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Very Long Baseline Array

Associated Universities, Inc.

NSF

NRAO

NRAO:
One Observatory, Three World Class Facilities

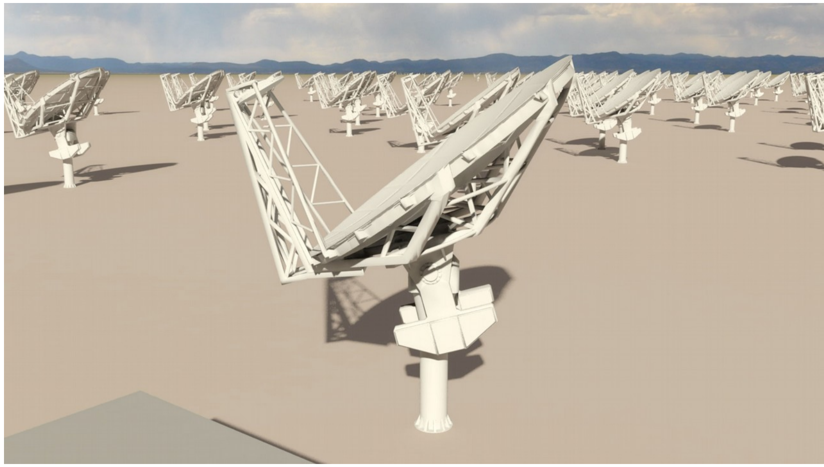
Other Affiliated Telescopes and Observatories include the Green Bank Observatory (http://greenbankobservatory.org/). The VLBA was incorporated back into NRAO last year.

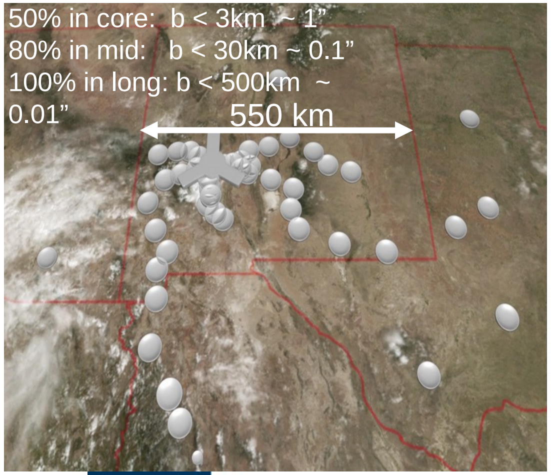
NRAO:
One Observatory, Three Facilities

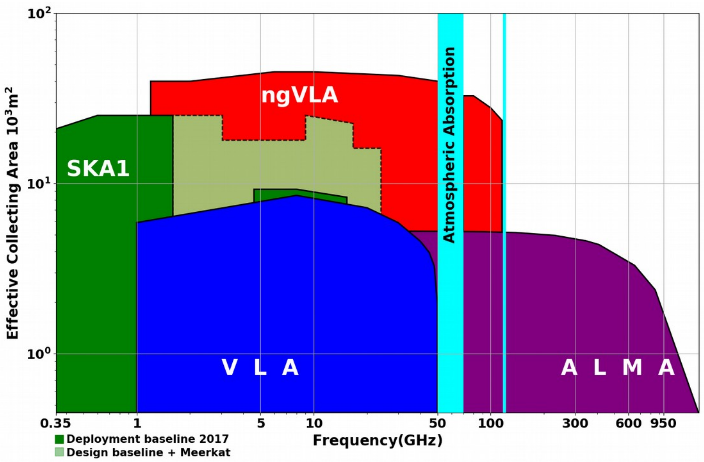
Atacama Large Millimeter/submillimeter Array:
a 66-antenna array in Chile

A next-generation Very Large Array (ngVLA)

- Scientific Frontier: ***Thermal imaging at milli-arcsec resolution***
- Sensitivity/Resolution Goal:
  - ***10x effective collecting area & resolution of JVLA/ALMA***
- Frequency range: ***1.2 –116 GHz***
- Located in Southwest U.S. (NM+TX) & MX, centered on VLA
- Baseline design under active development
- Low technical risk (reasonable step beyond state of the art)







Complementary suite from meter to submm arrays for the mid-21st century

- **< 0.3cm:** ALMA 2030
- **0.3 to 3cm: ngVLA**
- **> 3cm:** SKA

https://science.nrao.edu/futures/ngvla

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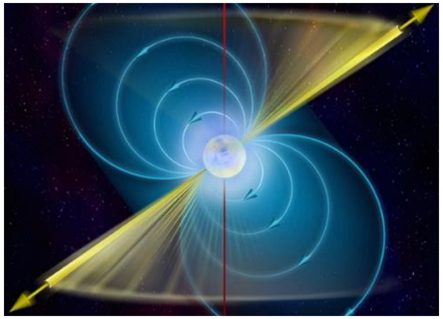
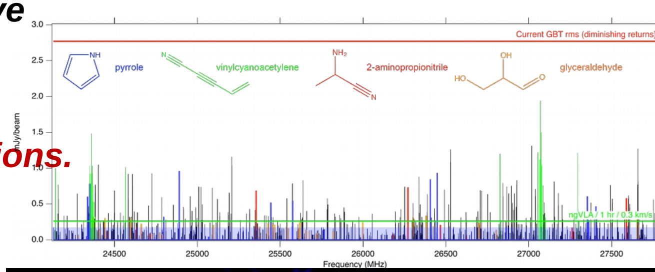
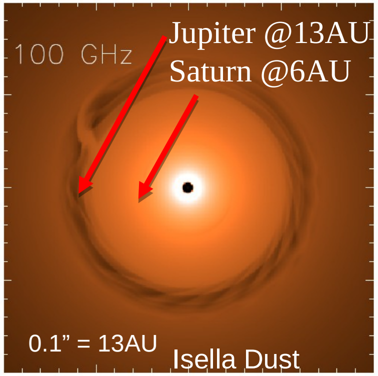
ngVLA Key Science Mission
(ngVLA memo #19)

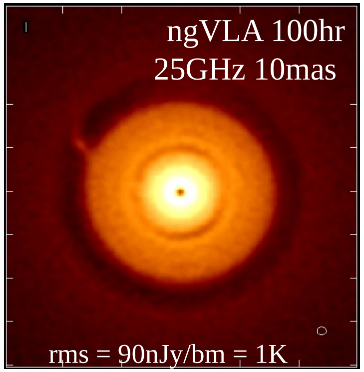
- ***Unveiling the Formation of Solar System Analogues***
- ***Probing the Initial Conditions for Planetary Systems and Life with Astrochemistry***
- ***Charting the Assembly, Structure, and Evolution of Galaxies Over Cosmic Time***
- ***Using Pulsars in the Galactic Center as Fundamental Tests of Gravity***
- ***Understanding the Formation and Evolution of Stellar and Supermassive BH's in the Era of Multi-Messenger Astronomy***

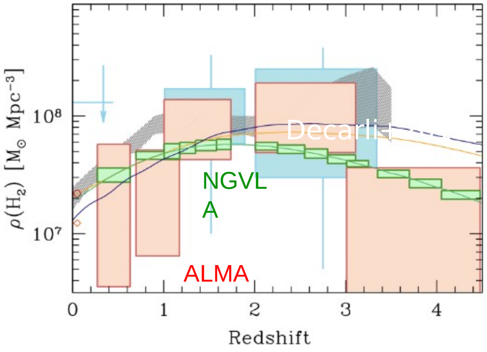


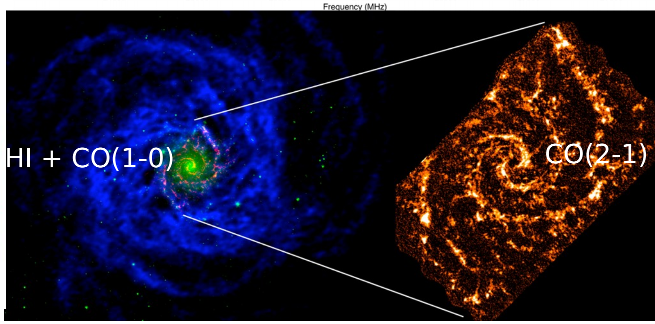


Highly synergistic with next-generation ground-based OIR and NASA missions.





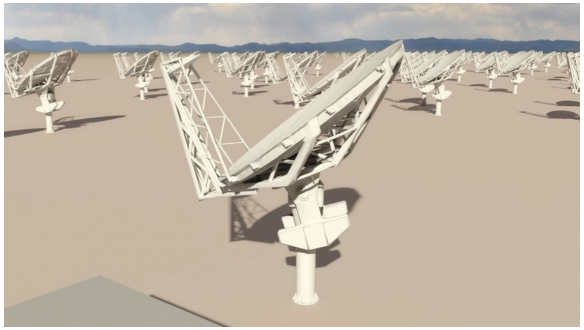




Current Reference Design Specifications
(ngVLA Memo #17)

- 214 18m offset Gregorian (feed-low) Antennas
  - Supported by internal cost-performance analysis
- Fixed antenna locations across NM, TX, MX
  - ~1000 km baselines being explored
- 1.2 – 50.5 GHz; 70 – 116 GHz
  - Single-pixel feeds
  - 6 feeds / 2 dewar package
- 19 6m short spacing array + 4 18m in TP mode to fill in (*u, v*) hole

- Continuum Sensitivity: ~0.1uJy/bm @ 1cm, 10mas, 10hr => T_B ~ 1.75K
- Line sensitivity: ~21.5uJy/bm @ 1cm, 10 km/s, 1”, 10hr => T_B ~ 35mK



Receiver Configuration

Band #	Dewar	f_L GHz	f_M GHz	f_H GHz	f_H: f_L	BW GHz
1	A	1.2	2.35	3.5	2.91	2.3
2	B	3.5	7.90	12.3	3.51	8.8
3	B	12.3	16.4	20.5	1.67	8.2
4	B	20.5	27.3	34.0	1.66	13.5
5	B	30.5	40.5	50.5	1.66	20.0
6	B	70.0	93.0	116	1.66	46.0

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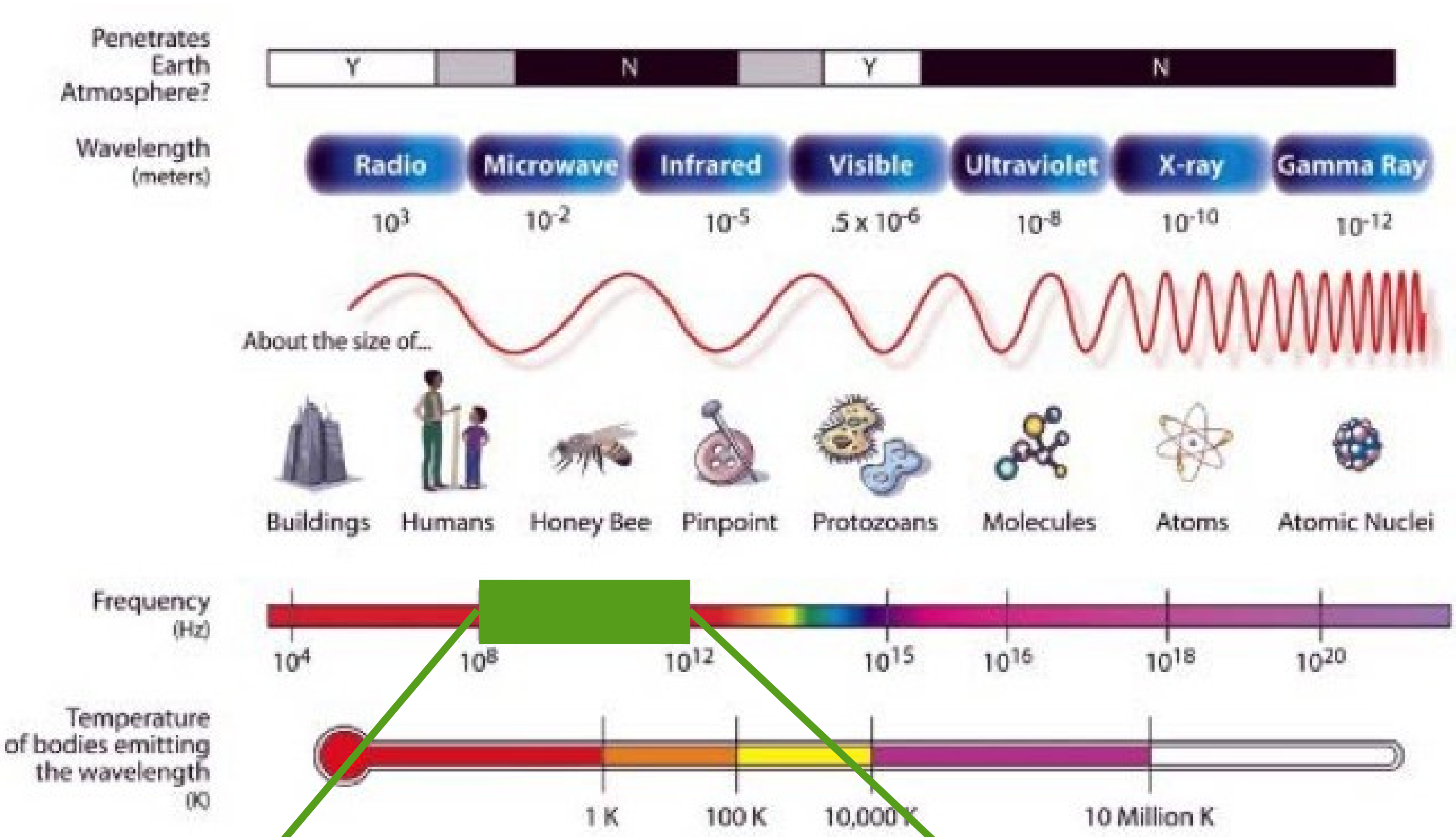

Penetrates Earth Atmosphere?
Y
N
Y
N
Wavelength (meters)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma Ray
10^3
10^-2
10^-5
.5 x 10^-6
10^-8
10^-10
10^-12
About the size of...
Buildings
Humans
Honey Bee
Pinpoint
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10^4
10^8
10^12
10^15
10^16
10^18
10^20
Temperature of bodies emitting the wavelength (K)
1 K
100 K
10,000 K
10 Million K


VLA
~1 - 50 GHz
~300 - 6 mm


ALMA
~84 - 950 GHz
~3 - 0.3 mm

Broad Science Topics with NRAO Telescopes

- Sun – coronal mass ejections, magnetic field activity
- Solar system, KBOs – atmospheres, astrometry, composition
- Star-forming regions – dust and gas environment, kinematics (infall, outflows, jets), proto-planetary disks, cores, chemistry, feedback, and natal cloud / star interactions
- Exoplanets – direct imaging, gaps in disks, kinematics
- Pulsars – neutron star physics, pulse morphology, gravity, ISM probe
- Galactic structure – spiral arms, bars, global atomic and molecular gas properties
- Nearby galaxies – molecular / atomic gas content and kinematics, dynamics of galaxies at high resolution, star formation, obscured SF, gas flow
- Galaxy groups and clusters – atomic and molecular gas across systems, star formation efficiency, kinematics, dynamical mass measurements
- Black holes – mass measurements, kinematics
- High redshift galaxies – extragalactic background light, source counts, star formation history and efficiency, evolution of gas content (atomic and molecular)
- Cosmology – H_0 measurement, SZE

What is ALMA?

A global partnership to deliver a revolutionary millimeter/submillimeter telescope array (in collaboration with Chile)

- North America
- Europe
- East Asia

66 reconfigurable, high precision antennas

λ ~ 0.32 – 8.5mm. Array configurations between 150 meters and >16 kilometers: 192 possible antenna locations:

- Main Array: 50 x 12m antennas
- Total Power Array: 4 x 12m antennas
- Atacama Compact Array (ACA): 12 x 7m antennas
- TP + ACA (Morita Array)

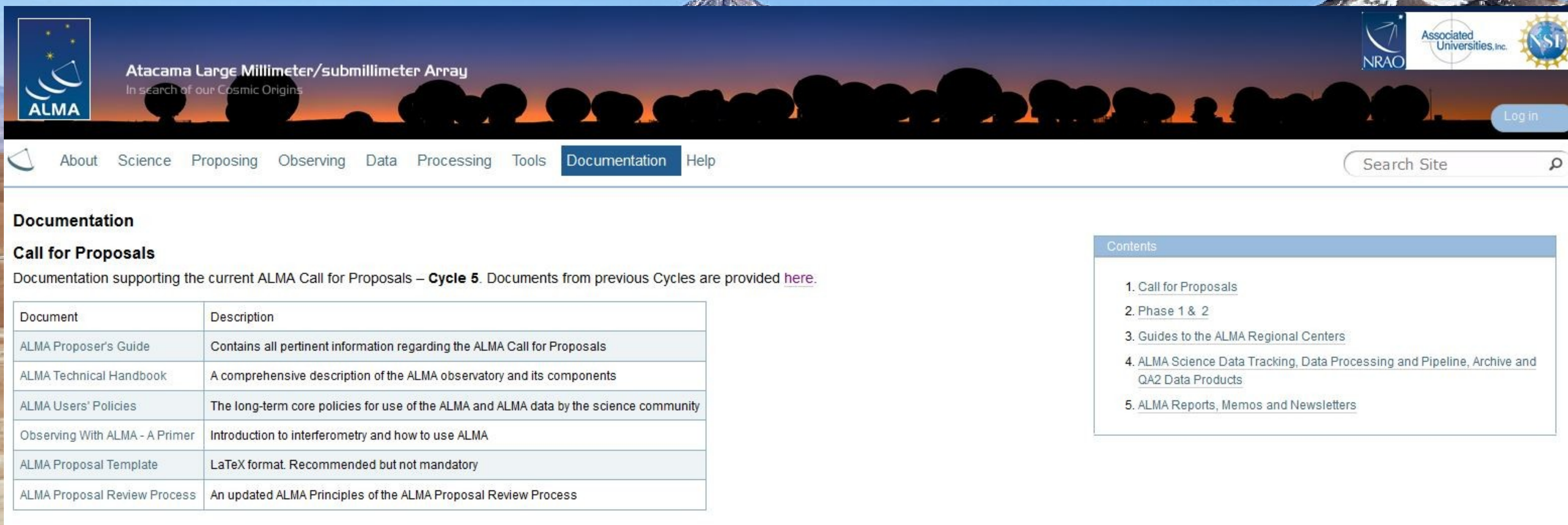
Array Operations Site is located at 5000m elevation in the Chilean Andes

Provides unprecedented imaging* & spectroscopic capabilities at mm/submm λ

What is ALMA?

Array configurations between 150 meters and >16 kilometers: 192 possible antenna locations:

http://youtu.be/YMISe-C8GUs


Atacama Large Millimeter/submillimeter Array

In search of our Cosmic Origins

About | Science | Proposing | Observing | Data | Processing | Tools | Documentation | Help

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Documentation

Call for Proposals

Documentation supporting the current ALMA Call for Proposals – **Cycle 5**. Documents from previous Cycles are provided here.

Document	Description
ALMA Proposer's Guide	Contains all pertinent information regarding the ALMA Call for Proposals
ALMA Technical Handbook	A comprehensive description of the ALMA observatory and its components
ALMA Users' Policies	The long-term core policies for use of the ALMA and ALMA data by the science community
Observing With ALMA - A Primer	Introduction to interferometry and how to use ALMA
ALMA Proposal Template	LaTeX format. Recommended but not mandatory
ALMA Proposal Review Process	An updated ALMA Principles of the ALMA Proposal Review Process

Contents

ALMA is a telescope for *all* astronomers

ALMA in a Nutshell…

- Angular resolution down to 0.015” (at 300 GHz)
- Sensitive, precision imaging 84 to 950 GHz (3 mm to 320 µm)
- State-of-the-art low-noise, wide-band receivers* (8 GHz bandwidth)
- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities including circular.
- Estimated 1 TB/day data rate
- All science data archived
- Pipeline processing

ALMA is 10-100 times more sensitive and has 10-100 times better angular resolution than current mm interferometers*

*With 90 Degree Walsh Switching in Bands 9 and 10, this gives 16 GHz of instantaneous bandwidth.

In either case, this is using the Time Division Mode (TDM) modes.

ALMA Current Status

- Construction Project ended in September 2014
- Routine science observing has been done out to **greater than 16 km baselines (C43-10)** thanks to the highly successful Long Baseline Campaigns in 2014 and 2015
- **All 66 antennas accepted**
  - Currently all 66 antennas are at the high site (AOS), of which ~47 on average (up to max ~66) are being used for Cycle 6 observations
  - Some construction and verification items remain to be finished (e.g., wide-field polarization; various observing modes)
- The ACA (Atacama Compact Array) or Morita Array – up to 12x7m antennas and 4x12m antennas for TP observations – is currently being used for Cycle 6 observations
- More on Capabilities later… however, first on to science!

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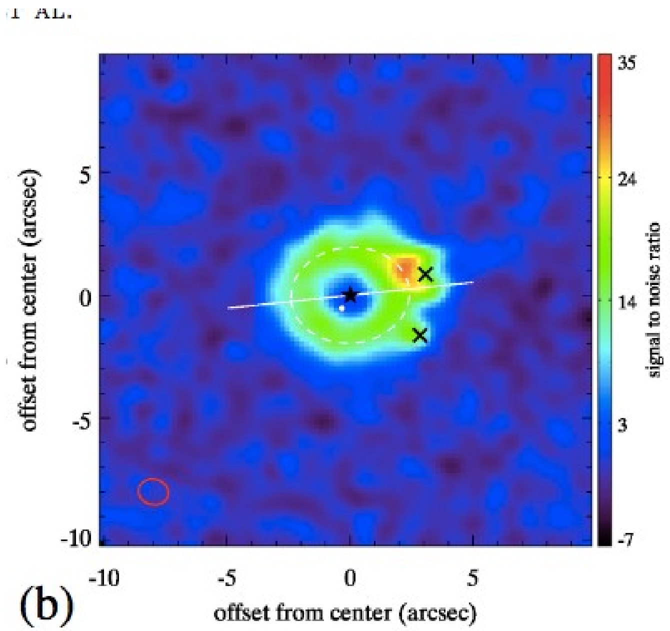
Science Highlight (1)

ALMA Images First Kuiper Belt Analogue Around Sun-like Star

- HD 95086 is a 1.6 M_{sun} A star about 17 Myr years old, 83.8 pc from the Sun
- HD 95086 hosts a directly-imaged ~4M_{Jup} planet about 57 AU from the star
- ALMA has imaged a debris disk outside the planetary orbit
  - The disk is inclined 30°
  - The disk extends from an inner radius ~100 AU to an outer radius ~320 AU.
  - A bright source near the edge of the ring is almost certainly a background galaxy.
  - A second planet may shepherd the inner edge of the cold disk, could be 0.2-1.5 M_{jup}



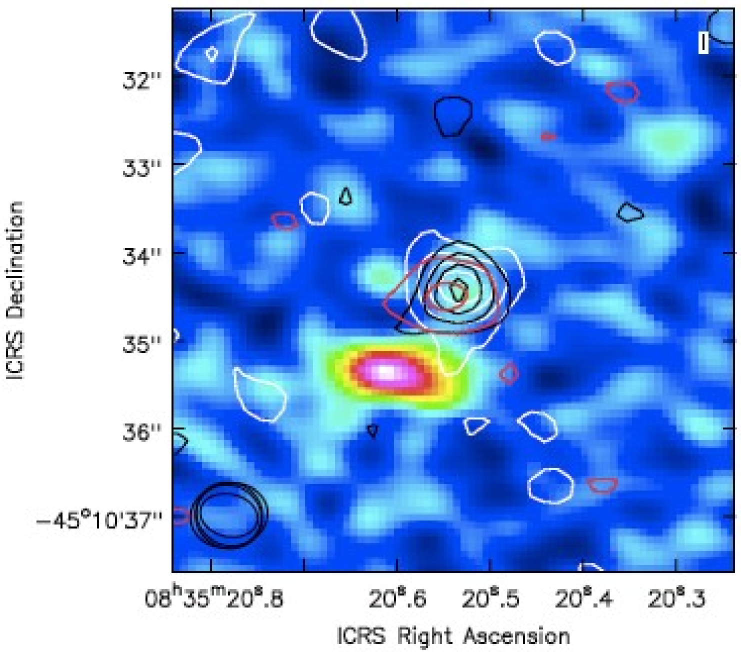
ALMA 1.3mm image of the Kuiper Belt analog disk around HD 95086 (black star). The optically imaged planet is represented by a white dot. The sources to the W are likely background galaxies, subtracted in this image. Disk major axis is white line.

Su+ 2017 arXiv 1709.10129

Science Highlight (2)

ALMA Images Vela Pulsar

- ALMA Development Study results on pulsar observations will appear soon.
  - Successful measurement of pulsar profiles were achieved on Vela
- Detections in non-time resolved mode were made on Vela, SgrA* magnetar, and Crab pulsar.
  - Vela pulsar was detected in ALMA Bands 3, 4, 6 and 7 (see B7 image)
  - Extended structure seen in B7 may be a counter-jet protruding from the pulsar



Vela Pulsar, ALMA B3,4,6 (contours) on B7 image; an extended structure, preliminarily detected in ground-based observations, may be a counter-jet protruding from the pulsar. (Mignani+, 2017)

Science Highlight (V)

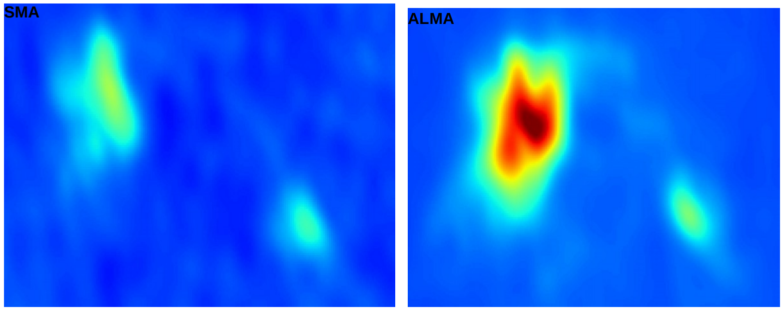
ALMA Catches, Characterizes Massive Star Outburst

Recent outbursts in YSOs show similar features:

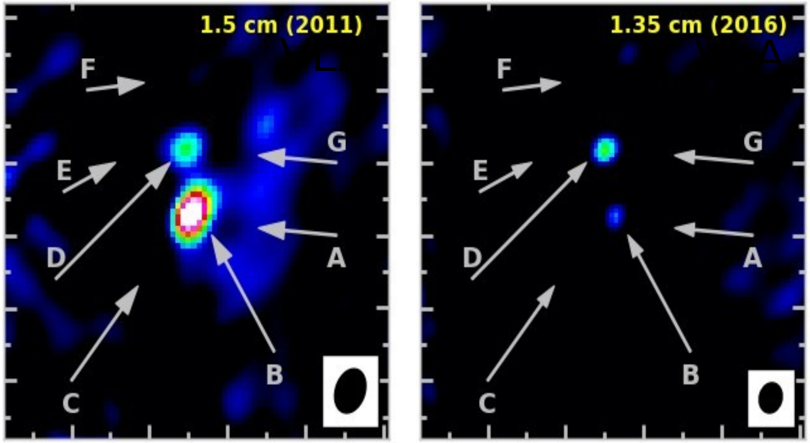
- Factors of 6-70x increase in L
- Sustained for many years (ongoing)

NGC6334I-MM1 dust continuum outburst is accompanied by:

- Dimming of the HCHII region by a factor of 4: suppression of UV photons
- Candidate compact disk/outflow system: disk traced by hot SO_2, outflow traced by $C^{34}S$ and 6 cm jet direction, and maser flare
- **Consistent with a B4 ZAMS star accreting >= 0.1$M_\odot$ in a short period. Understanding the details requires further monitoring and modeling**



Pre-outburst Post-outburst

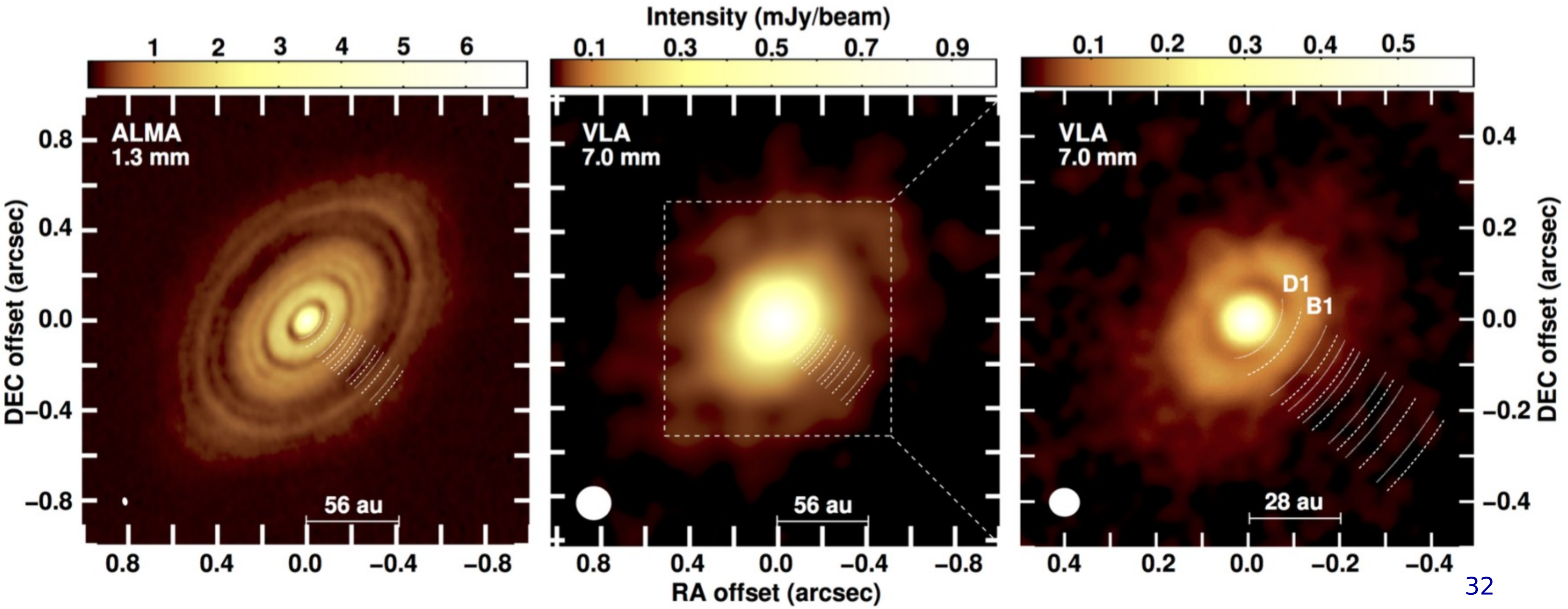


ALMA Science Highlights: Protoplanetary Disks

Protoplanetary Disks: With ALMA and VLA

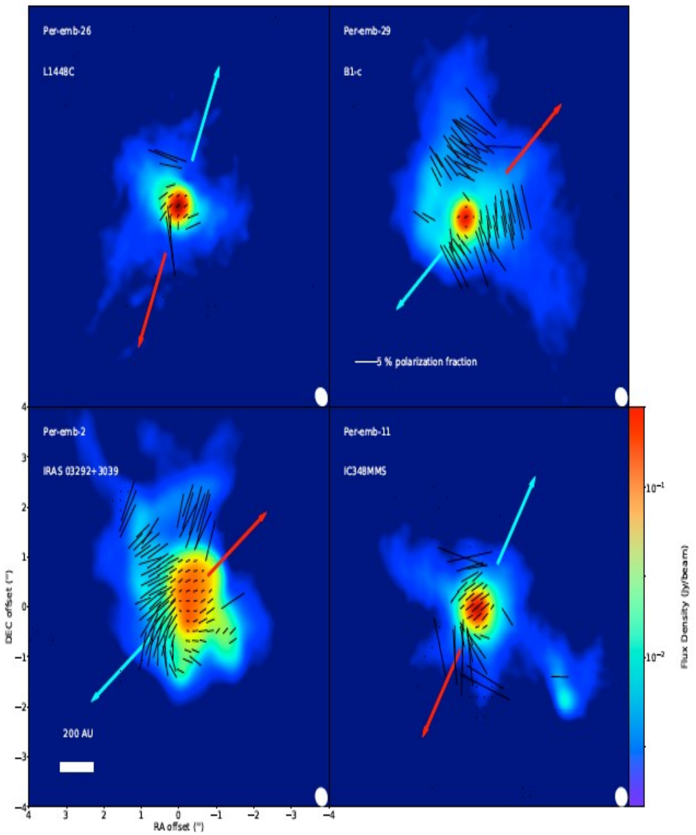
- Emission from inner regions of HL Tau still optically thick at ALMA wavelengths
- VLA can image the disk at comparable resolution to ALMA at 7mm where emission is optically thin
- Combination of ALMA+VLA helps differentiate between formation theories with info on grain growth, fragmentation, and formation of dense clumps: suggest HL Tau disk is in very early stage of planet formation with planets not yet in the gaps but set for future formation in the bright rings

Carrasco-González et al. 2016



ALMA Science Highlights: Polarization in protostars

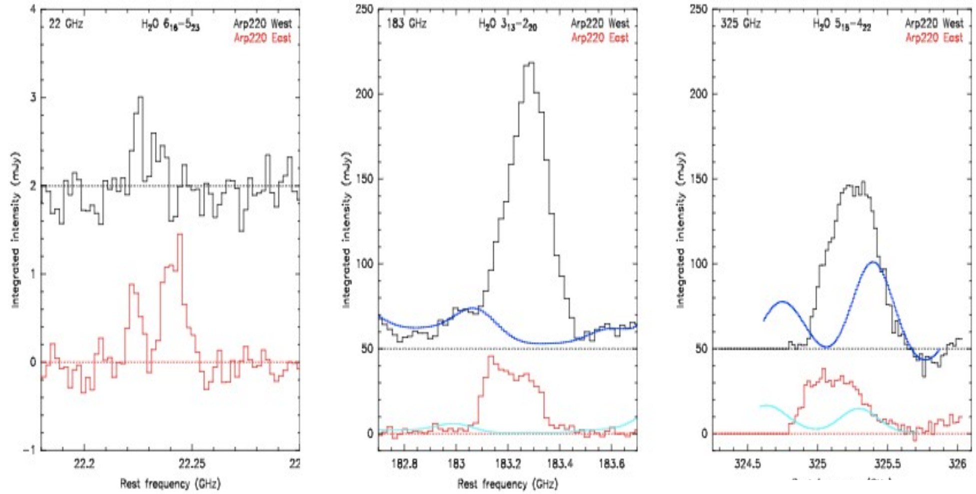
- Cox et al (arXiv:1802.00449) measured polarization in ten protostars in Perseus
  - ~100 AU scale, all show extended polarized continuum
  - Signatures intricate; three disks show signs of dust scattering origin
  - Envelopes typically more highly polarized; probably magnetically aligned grain origin



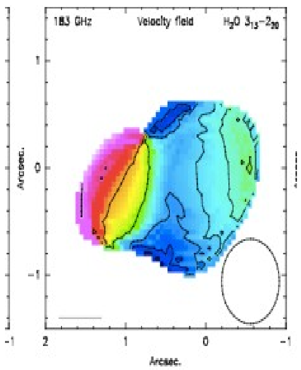
'Envelope' Sources
Color: Dust continuum at 870 μm
Black: non-rotated polarization
Outflow: red/blue arrows

ALMA Science Highlights: Water Emission

Water emission in Arp 220 West (black) and East (red) at 22, 183 and 325 GHz.



- ALMA observed water lines at 183 (B5) and 325 GHz (B7) in windows opaque at lower sites towards Arp 220
- Abundant water seen, probably thermal, arising in star-forming clouds
- Opens spectral windows on water in lower excitation regions



V_{rot} image

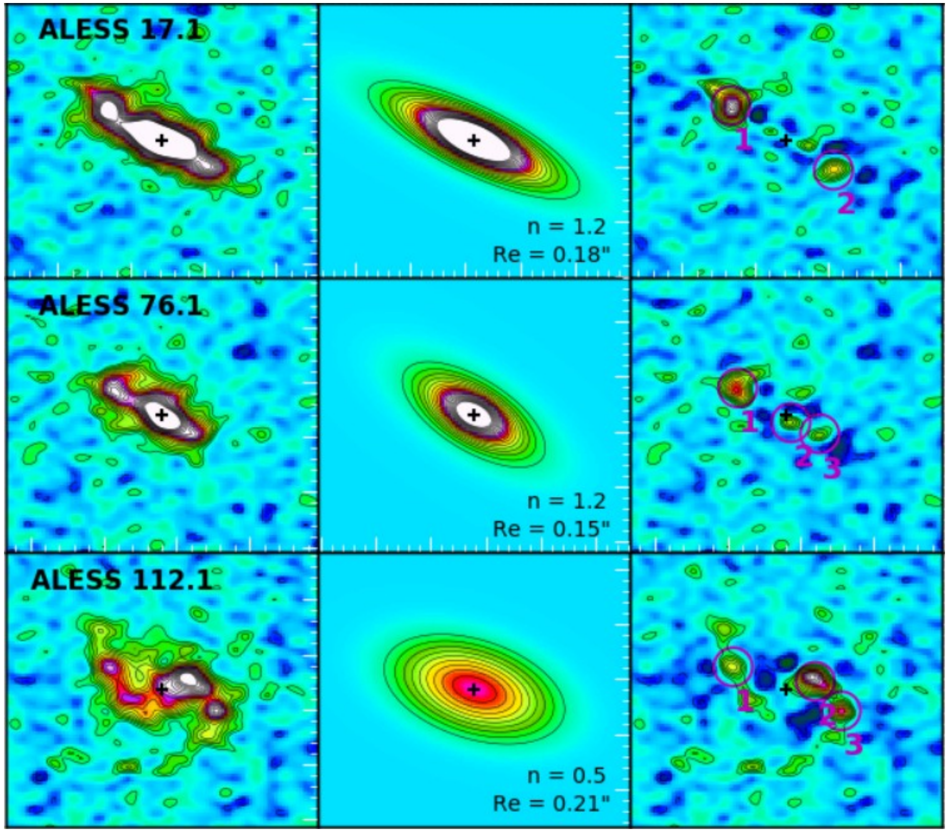
(S. König et al. 2016)

ALMA Science Highlights: Bars in SMGs

Hodge et al. (2018) show 0.07” imaging (500pc) for z=1.5-4.8 SMGs

Spiral structure, rings, and bars on similar physical scales as low-z galaxies

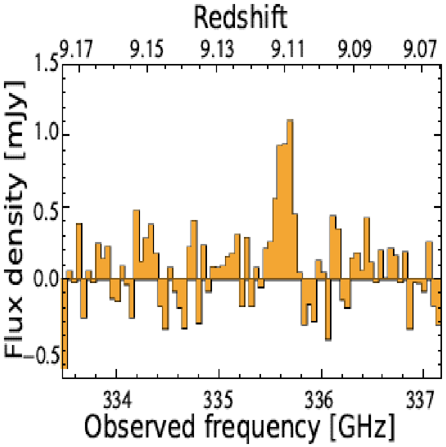
Angular momentum loss from these bars could provide long-term fuel for SMGs

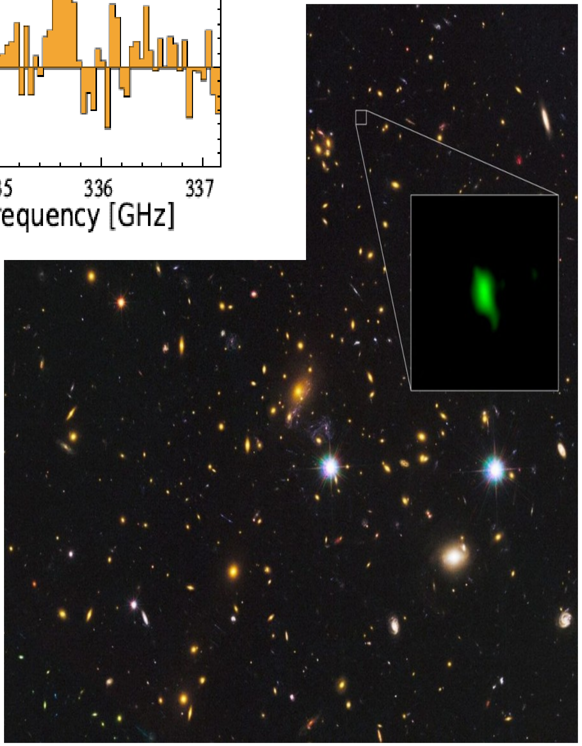


Left: ALMA 870micron continuum
Middle: GALFIT best fit
Right: Residual structure

ALMA Science Highlights: High-z Oxygen

- Redshift z=9.1096 for [O III] in MACS1149-JD1; universe was only 500 million years old.
  - Lensed; coincident with the rest-frame UV continuum emission detected by HST
  - Confirmed by 4sig VLT Lyα observations
- Suggests star formation ongoing there for ~250myr.
  - Spatially resolved; no continuum
  - Suggests stars fed chemical complexity early in the history of the Universe
  - z ~ 15.4 thus represents the logical epoch of formation of MACS1149-JD1





(Hashimoto+ Nature 2018)

ALMA Cycle 7 Capabilities

ALMA in Cycle 7

In Cycle 7 we continue to operate as what is been defined as "Steady State Operations"

New Observing Modes for Cycle 7:

Long baseline (up to 16.2km) in B7.

- For the first time, B7 will be available out to 16.2 km as a standard mode if a suitable calibrator is found within 5 degrees. If not, it will be a non-standard mode.
- **NOTE**: There will be NO C-9 or C-10 in Cycle 8! If you want/need those longest baselines, request them for Cycle 7 or wait until Cycle 9

Improved Spectral Scan Mode.

- The Spectral Scan observing mode has been refined and it is now 25% faster and will be offered as a standard observing mode.

Band 7 Solar Observations.

- Band 7 continuum observations will be available for Solar observing. This will also include the full continuum single-dish map of the sun (always available for Solar).

Relaxed restrictions on data rates.

- Previous restrictions on observing modes set from the ALMA data rate have been largely removed. Users should no longer be limited by data rate restrictions or warnings when proposing.

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ALMA Capabilities

The Cycle 7 capabilities are fully described in Appendix A of the ALMA Proposers Guide available at:

(https://almascience.nrao.edu/documents-and-tools)

In summary:

Number of antennas

- At least forty-three (43) antennas in the 12-m Array
- At least ten (10) 7-m antennas (for short baselines) and three (3) 12-m antennas (for making single-dish maps) in the ACA

Receiver bands

- Receiver Bands 3, 4, 5, 6, 7, 8, 9, and 10 (wavelengths of about 3.1, 2.1, 1.6, 1.3, 0.87, 0.74, 0.44, and 0.32 mm, respectively)

12-m Array Configurations

- Bands 8, 9, 10: Maximum baselines between 0.15 km and 3.6 km
- Bands 3, 4, 5, 6, and 7: Maximum baselines between 0.15 km and 16.2 km
- Files containing representative antenna configurations for the 12-m and 7-m arrays suitable for Common Astronomy Software Applications (CASA) simulations are available from the ALMA Science portal (http://almascience.org/documents-and-tools/cycle5/alma-configuration-files)

ALMA Capabilities

Spectral line, continuum, and mosaic observations

- Spectral line and continuum observations with the 12-m Array and the 7-m Array in all bands
- Single field *interferometry* (all bands) and mosaics (Bands 3 to 9) with the 12-m Array and the 7-m Array
- *Single-dish* spectral line observations in Bands 3 to 8

Polarization

- Single pointing, on axis, full (including circular) polarization for both continuum and full-spectral-resolution observations in Band 3, 4, 5, 6, and 7 are offered on the 12-m Array. The minimum detectable degree of circular polarization, defined as three times the systematic calibration uncertainty, is currently 1.8% of the peak flux for both TDM and FDM observations. Circular polarization will be offered only for sources that are on-axis with an angular size less than 10% of the FWHM primary beam.

Observing Time:

- 4300 hours for successful proposals of PI programs expected on the 12m Array (includes DDT, Cycle 4 Carryover and resubmissions)
- 3750 hours available on the ACA*
- 3750 hours available on the Total Power Array*
    - ~750 Hours of ACA time will be available through the Supplemental Call in mid-Cycle 7.

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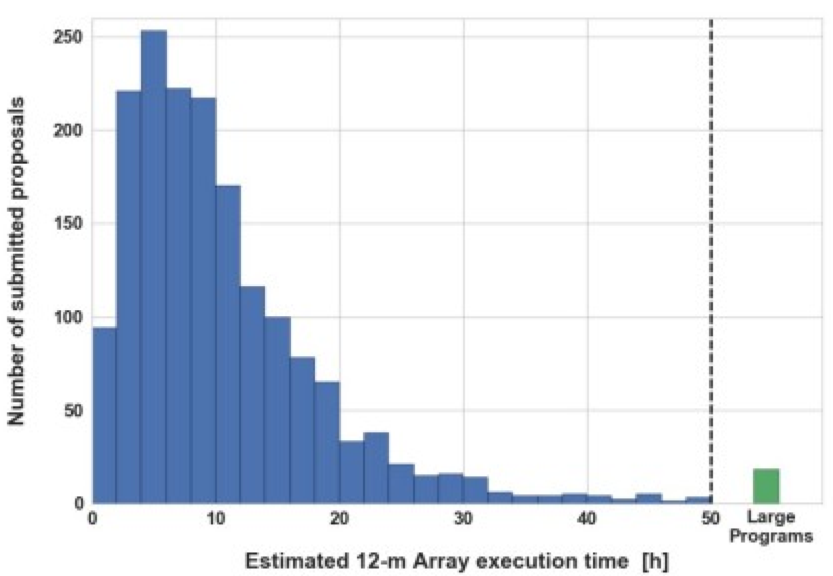
ALMA Capabilities

Observing Time:

- Strongly encourage ACA-only observations in a wide range of science and large observing times.
- Also encourage “medium size” 12m proposals of about 10-30 hours



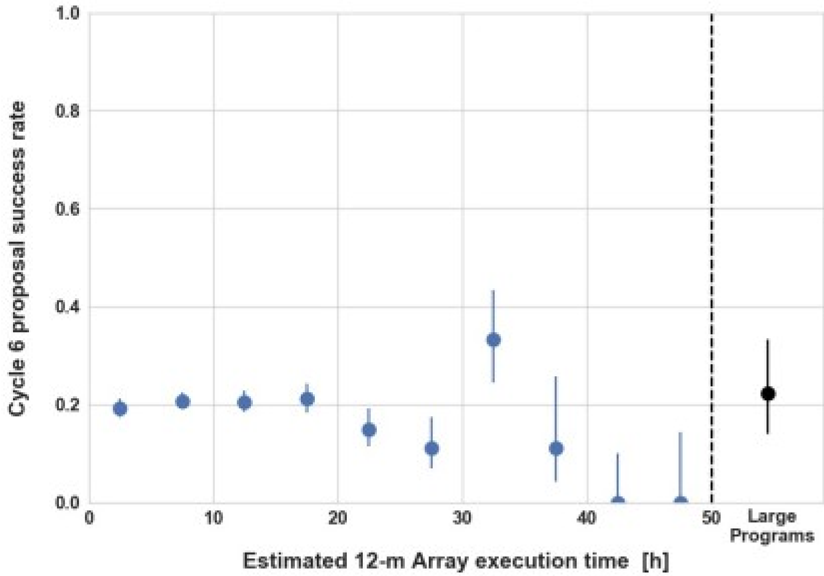


Figure 1: (Left) Number of proposals submitted as a function of the 12-m Array execution time in Cycle 6. (Right) The fraction of proposals (with 1sigma confidence intervals) that are assigned priority Grade A or B as a function of the estimated 12-m Array time.

ALMA Capabilities

ACA Supplemental Call:

- In Cycle 7, ALMA will offer a stand-alone ACA Supplemental Call for Proposals.
- It is anticipated that the Supplemental Call will be issued on 3 September 2019 with a proposal deadline on 1 October 2019.
- A minimum of 750 h of observing time on the ACA will be allocated through the Supplemental Call for observations between January 2020 and September 2020.
- Proposals may be submitted that use the 7-m Array only or the 7-m Array plus the Total Power array and with the same technical capabilities offered for the ACA in the Main Call.
- The prioritization of ACA observations in Cycle 7 will be as follows: proposals which require ACA time (in combination with the 12-m Array or stand-alone ACA observations only) will only be eligible for "A" or "B" priority in the Main Call; in the Supplemental Call, stand-alone ACA proposals accepted to the scheduling queue will be all given priority "C".
- Proposals submitted to the Supplemental Call will be peer reviewed through a distributed system.
- More information about the supplemental call can be found at: https://almascience.nrao.edu/proposing/7m-array-supplemental-call

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ALMA Capabilities

Standard vs Non-Standard modes:

In Cycle 7 around 20% of the time will be used for non-standard modes.

This fraction will get smaller as we go into Full Operation and the amount of new capabilities decreases.

The fraction of time available for testing of new capabilities in Cycle 7 is ~10%

Non-Standard Observing Modes include:

- Band 7 observations with baselines longer than 5 km if the phase calibrator is expected to be further than 5 degrees from the science target (the Observing Tool used for proposal submission will assess the availability of suitable phase calibrators and will issue a warning in such a case)
- Bands 9 and 10 observations
- All polarization observations
- Bandwidth switching projects (having less than 1 GHz aggregate bandwidths over all spectral windows)
- Solar observations
- VLBI observations
- Non-standard calibrations (user-defined calibrations selected in the OT)
- Astrometric Observations

ALMA Capabilities

Full ALMA Operations (All Cycle 7 Capabilities plus):

Receiver bands:

- Include Bands 1 and 2

Baselines:

- All bands out to 16 km. Some may never be considered a standard mode

Standard vs Non-Standard modes:

- Fraction of non-standard modes should decrease to about 10%

Observing Time:

- Up to 4500 hours+ for successful proposals of PI programs expected on the 12m Array (includes DDT, Cycle 7+ Carryover and resubmissions)

Observing Modes:

- Wide field polarization capabilities (12m + 7m arrays)
- Full operations include full Stoke plus circular polarization at all observing bands including mosaics and Total Power

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ALMA Timelines and Milestones

Cycle 7

Date	Milestone
19 March 2019 (15:00UT)	Release of Cycle 7 Call for Proposals, Observing Tool & supporting documents and Opening of the Archive for proposal submission
17 April 2019 (15:00 UT; **11:00 EDT**)	Proposal submission deadline
End of July 2019	Announcement of the outcome of the Proposal Review Process
05 September 2019	Deadline for Submission of Phase 2 by PIs
October 2019	Start of ALMA Cycle 7 Science Observations
September 2020	End of ALMA Cycle 7

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ALMA Timelines and Milestones

Cycle 7 Supplemental Call

Date	Milestone
03 September 2019	Call for Proposals and Supplemental Call submission server opened
01 October 2019	Deadline to submit Supplemental Call proposals
15 October 2019	Proposals released to reviewers
22 October 2019	Deadline for reviewer to report conflicts of interest on proposal review assignments
12 November 2019	Deadline to submit reviews and ranks
Early December 2020	Notification emails sent to PIs
January 2020	Successful Supplemental Call proposals enter the observing queue

ALMA Array Configuration Schedule (Cycle 7)

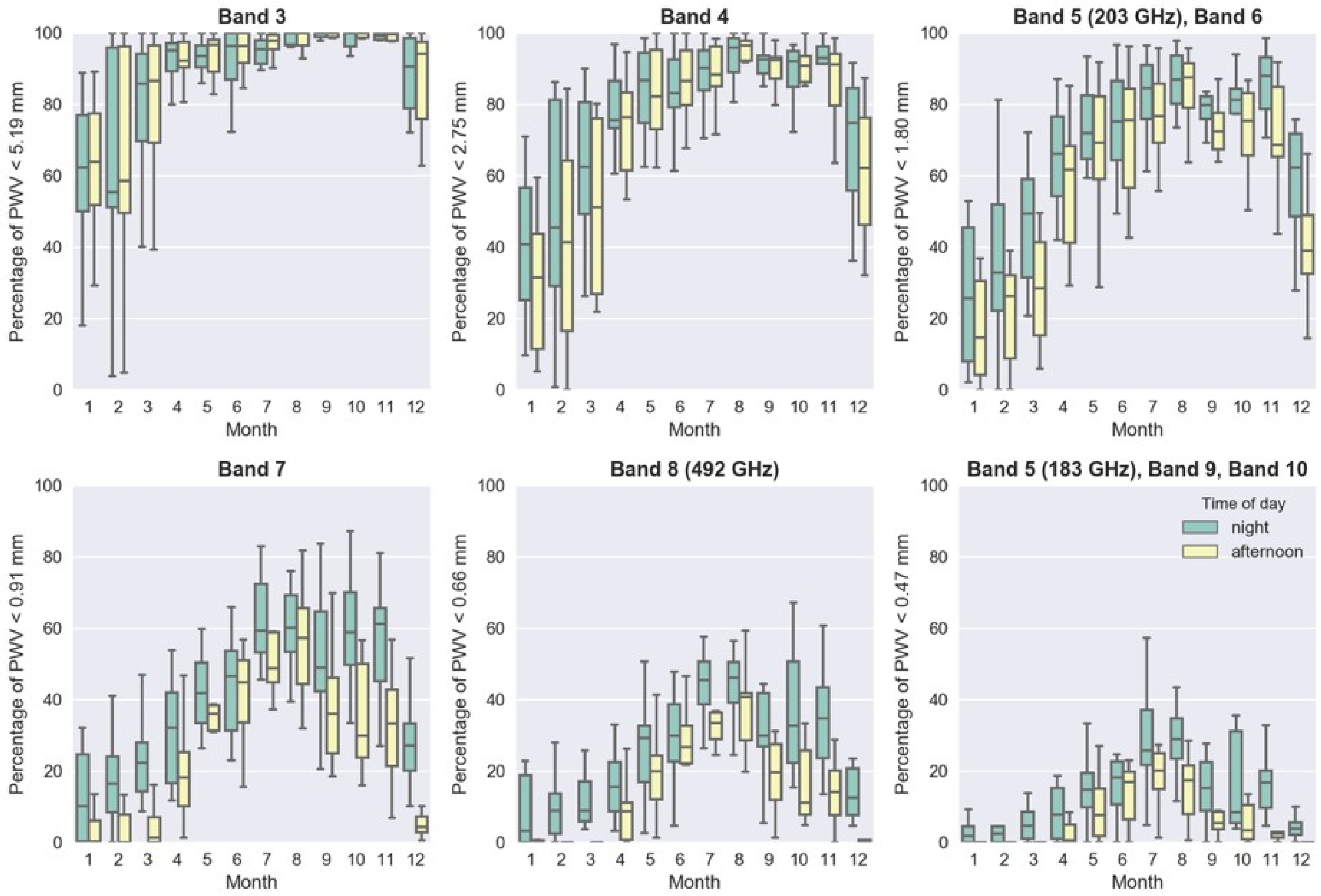
For Cycle 7, the long baseline array configurations will be in the southern hemisphere winter in order to accommodate high spatial resolution observation. The array configuration schedule will cycle every couple years to accommodate the range of LST.

The long term configuration schedule is available off the ALMA Science Portal at:

NOTE: No PI observing takes place in Feb!

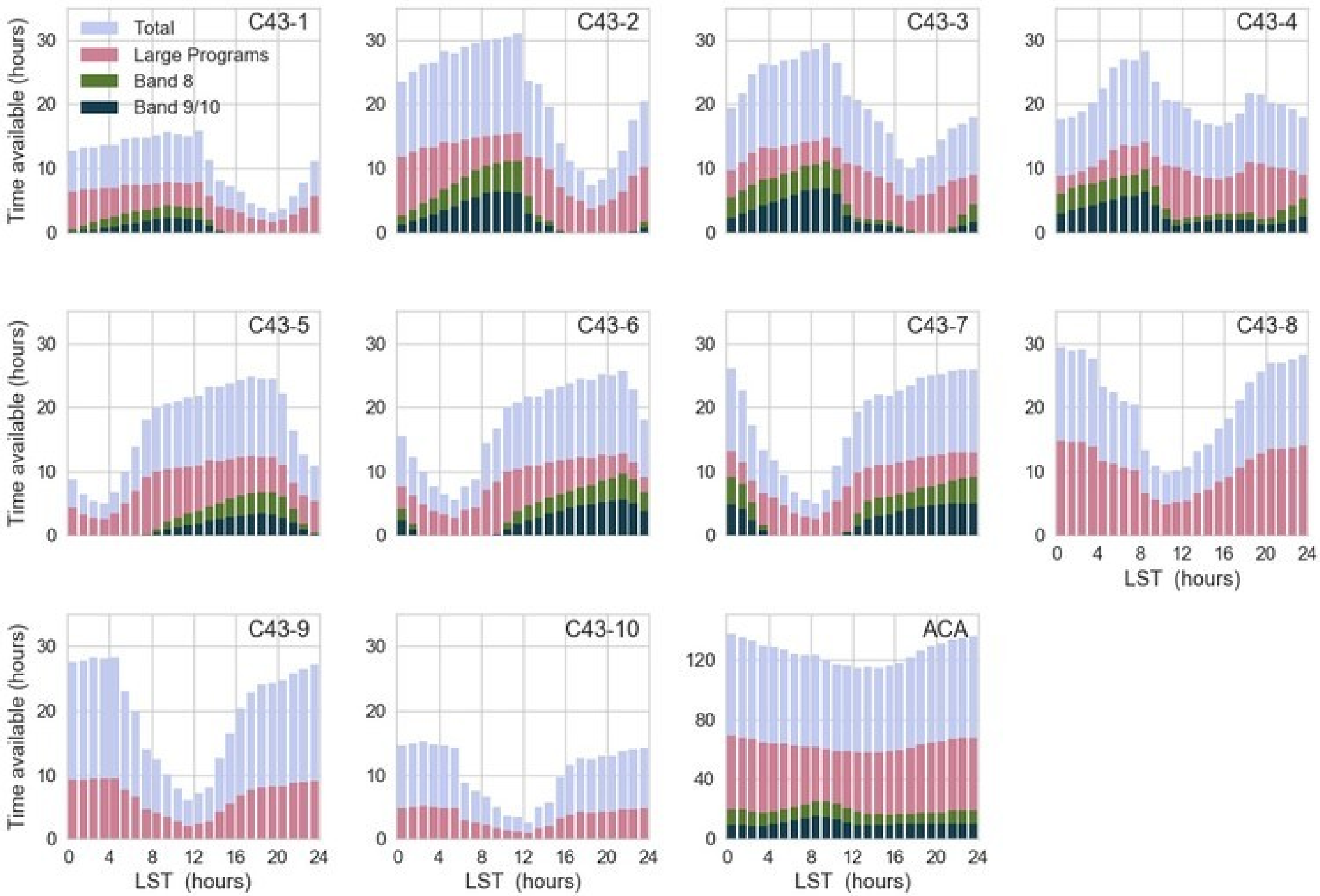
Start date	Configuration	Longest baseline	LST for best observing conditions
2019 Oct 1	C-4	0.78 km	~ 22h – 10h
2019 Oct 20	C-3	0.50 km	~ 23h – 11h
2019 Nov 10	C-2	0.31 km	~ 1h – 13h
2019 Nov 30	C-1	0.16 km	~ 2h – 14h
2019 Dec 20	C-2	0.31 km	~ 4h – 15h
2020 Jan 10	C-3	0.50 km	~ 5h – 17h
2020 Feb 1-28	No observations due to February Maintenance		
2020 Mar 1	C-4	0.78 km	~ 8h – 21h
2020 Mar 20	C-5	1.4 km	~ 9h – 23h
2020 Apr 20	C-6	2.5 km	~ 11h – 1h
2020 May 20	C-7	3.6 km	~ 13h – 3h
2020 Jun 20	C-8	8.5 km	~ 15h – 5h
2020 July11	C-9	13.9 km	~ 16h – 6h
2020 Jul 30	C-10	16.2 km	~ 17h – 7h
2020 Aug 20	C-9	13.9 km	~ 19h – 8h
2020 Sept 10	C-8	8.5 km	~ 20h – 9h

ALMA Observing Strategies (Cycle 6)



Box and whisker plots of the percentage of time that the precipitable water vapor (PWV) is less than the thresholds adopted for the various ALMA bands versus the month of the year. Results are shown for both night time (green) and mid-afternoon (yellow), and assume a source elevation of 60 degrees. The horizontal line within a box indicates the median, the boundaries of a box indicate the 25th- and 75th -percentile of the distribution, and the whiskers indicate the highest and lowest values of the distribution. The PWV measurements were obtained by the APEX weather stations between 2007 and 2017.

ALMA Observing Strategies (Cycle 7)



Effective observing time available per configuration for executing PI projects. As an example, up to 30 hours are expected to be available in C43-2 at LST=10 h for all observations and up to 15 h may be allocated to Large Programmes. The total number of hours excludes time spent on observatory calibration, maintenance, reconfigurations, and other activities. The fraction of that time available for Large Programmes (pink) and high frequency observations (green and dark blue) is also indicated. The configuration schedule and, consequently, the total number of hours available per configuration may change as a result of proposal pressure. The data files containing these histograms are available here.

NAASC Sources of Support

- **ALMA Helpdesk:** User support is a priority so questions are usually answered within 48 hours (with around the clock staffing in the week leading up to the proposal deadline) - https://help.almascience.org
- **Student Observing Support:** Successful ALMA proposals will be invited to apply for up to $35k to support undergraduate or graduate student involvement - https://science.nrao.edu/opportunities/student-programs/sos
- **Page Charges:** Upon request NRAO covers page charges for authors at US institutions when reporting results from ALMA/VLA - https://library.nrao.edu/pubsup.shtml
- **Face-to-face Visitor Support:** Upon request NRAO will cover the travel expenses of up to 2 people from 2 teams per week to come to the NAASC to get support for data reduction, proposal preparation, etc… We also have long term visitor support as well - https://science.nrao.edu/facilities/alma/visitors-shortterm
- **ALMA Ambassadors:** You too can become an ALMA Ambassador. For program eligibility visit - https://science.nrao.edu/facilities/alma/ambassadors-program

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