ALMA Community Day
University of Wyoming

George C. Privon

Logistics

- Slides will be made available online after the workshop. (under “Program” tab on left side of Community Day website)
- For questions, use “Raise Hand” in Zoom (available via the “participants” menu) or speak up
- Please install the ALMA Observing Tool for the afternoon hands-on session:
  https://almascience.nrao.edu/proposing/observing-tool

Community Day Goals

1) Describe ALMA capabilities for Cycle 8

2) Guidance for preparing and submitting proposals
   - Technical proposal details
   - Specifying an observing program in the ALMA Observing Tool (the "OT")
   - Querying the ALMA archive

3) Basics of radio interferometry and aperture synthesis
   - Emphasis on considerations for proposal preparation

Schedule

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

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

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

10:45-11:15: [Break]

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

11:45-12:15: Cycle 8 Proposal Preparation

12:15-13:45: [Lunch break]

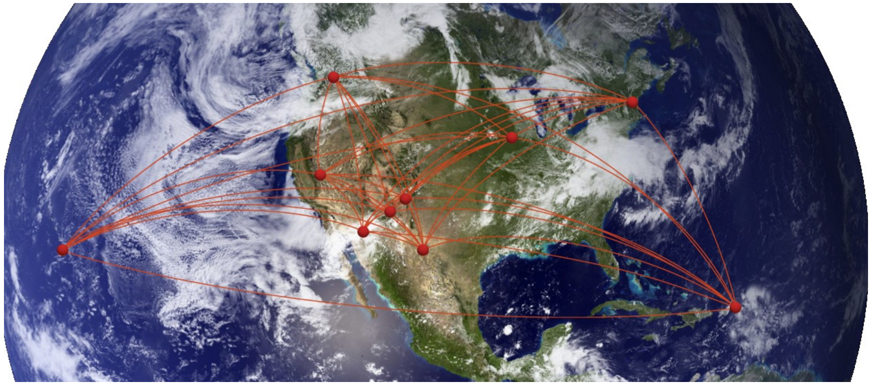
13:45-14:15: The ALMA Observing Tool

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

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

15:00-15:15: Concluding discussion, NAASC resources, final Q&A

National Radio Astronomy Observatory



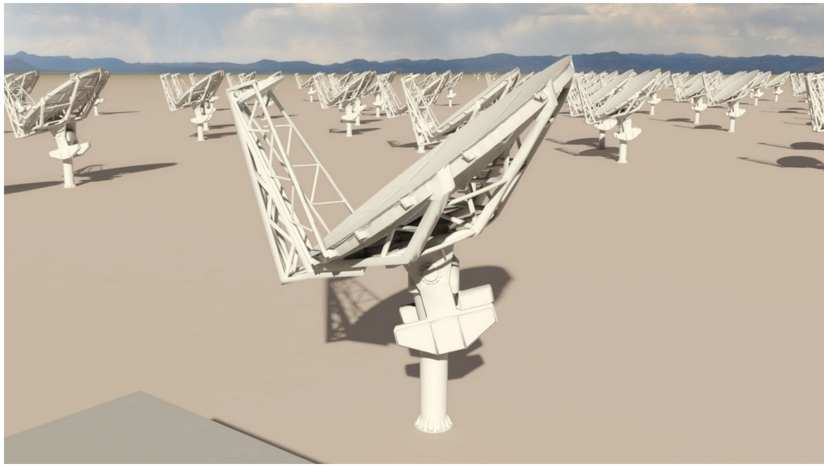
Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Very Long Baseline Array

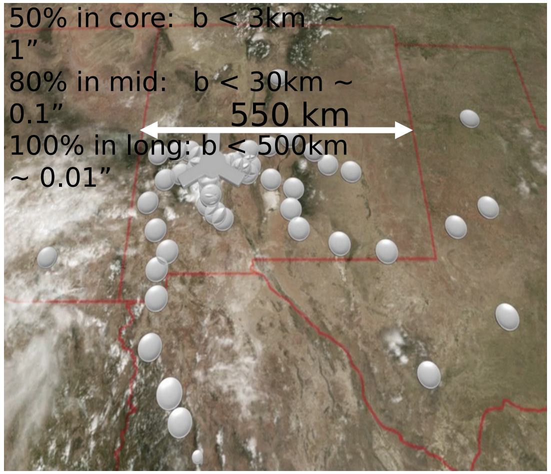
NRAO:
One Observatory, Three World Class Facilities

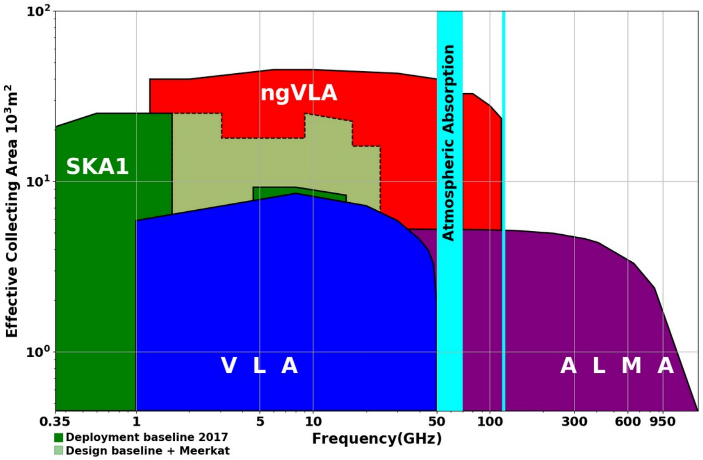
Other Affiliated Telescopes and Observatories include the Green Bank Observatory (http://greenbankobservatory.org/). The VLBA was incorporated back into NRAO last year.

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)







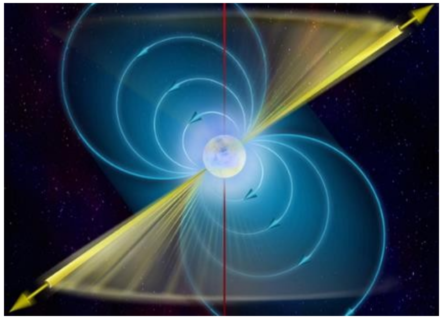
Complementary suite of arrays from meter to submm for the mid-21st century:

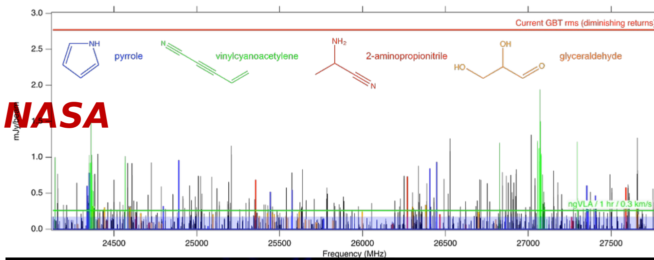
- **< 0.3cm:** ALMA 2030
- **0.3 to 3cm: ngVLA**
- **> 3cm:** SKA

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

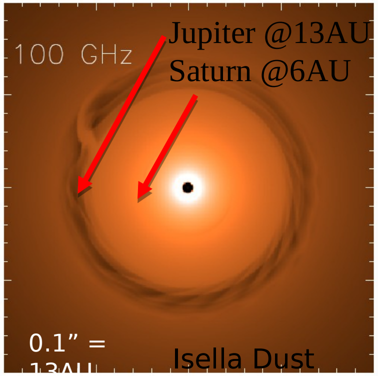
ngVLA Key Science Mission
(ngVLA memo #19)

- ***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***

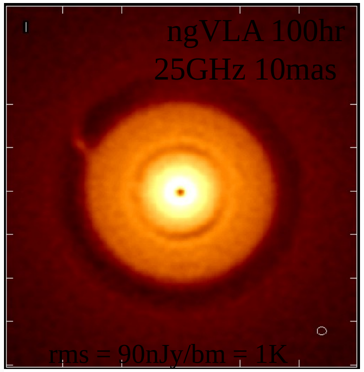


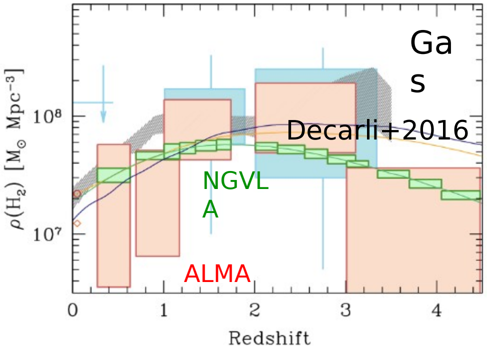


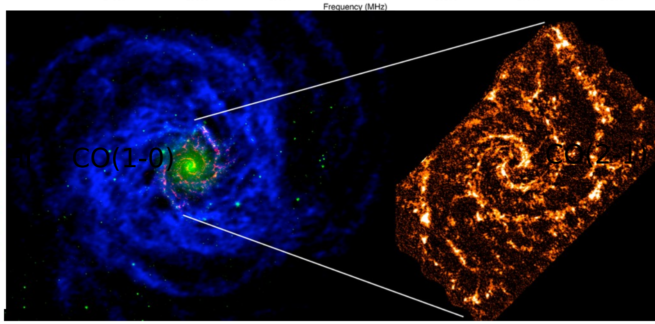
Highly synergistic with next-generation ground-based OIR and NASA missions.



Isella Dust Model

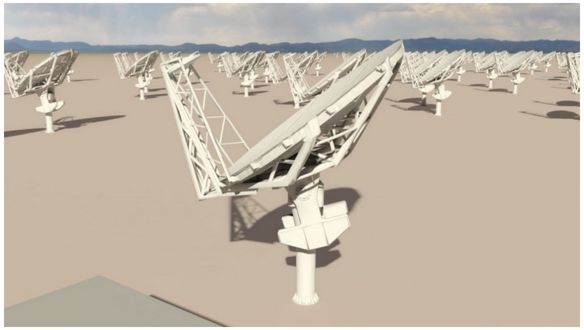






Current Reference Design Specifications

(ngVLA Memo #17)

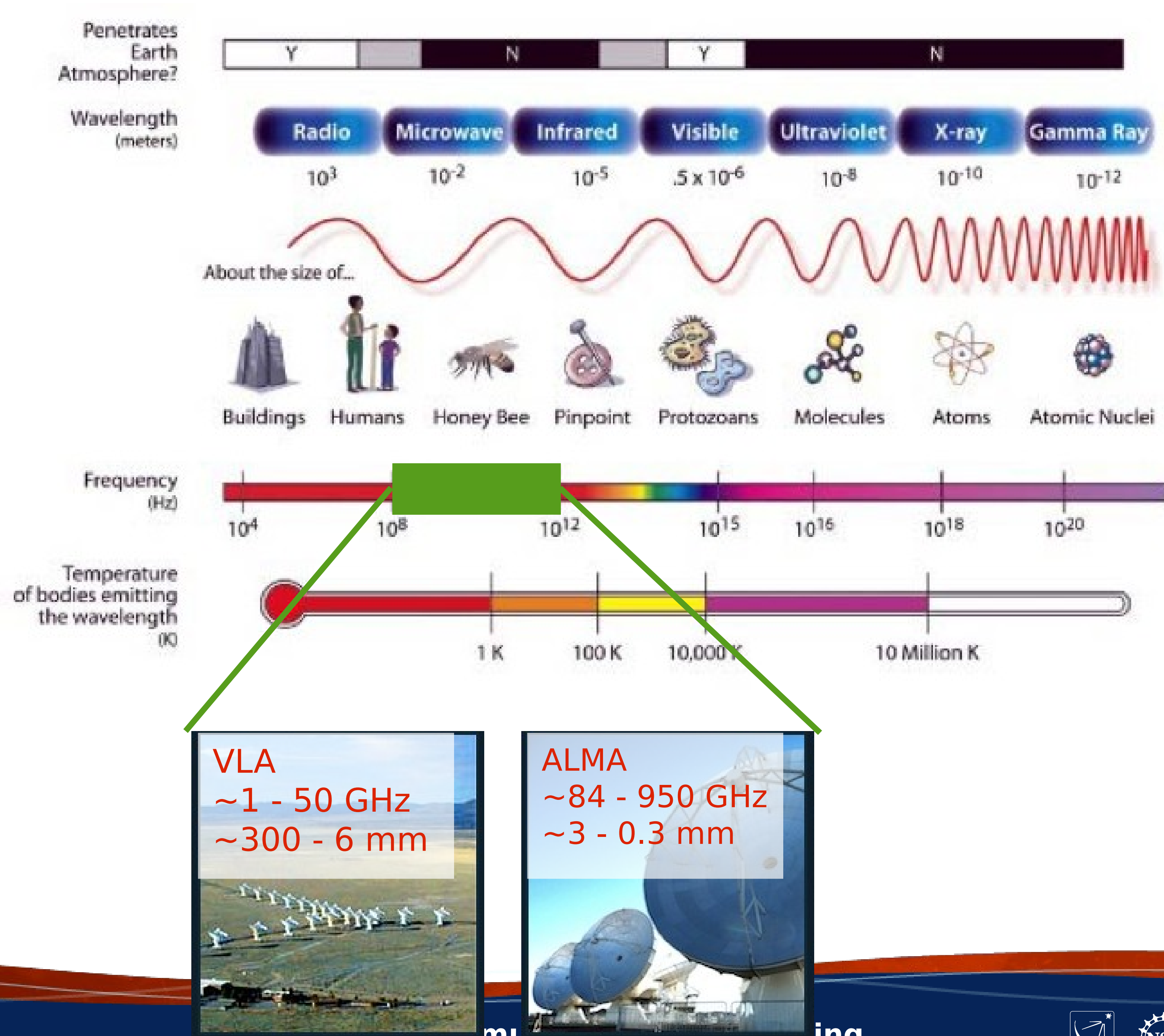


- 214 18m offset Gregorian (feed-low) Antennas
  - Supported by internal cost-performance analysis
- Fixed antenna locations across NM, TX, MX
  - ~1000 km baselines being explored
- 1.2 – 50.5 GHz; 70 – 116 GHz
  - Single-pixel feeds
  - 6 feeds / 2 dewar package
- 19 6m short spacing array + 4 18m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



Penetrates Earth Atmosphere?
Y
N
Y
N
Wavelength (meters)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma Ray
10^3
10^{-2}
10^{-5}
$.5 \times 10^{-6}$
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

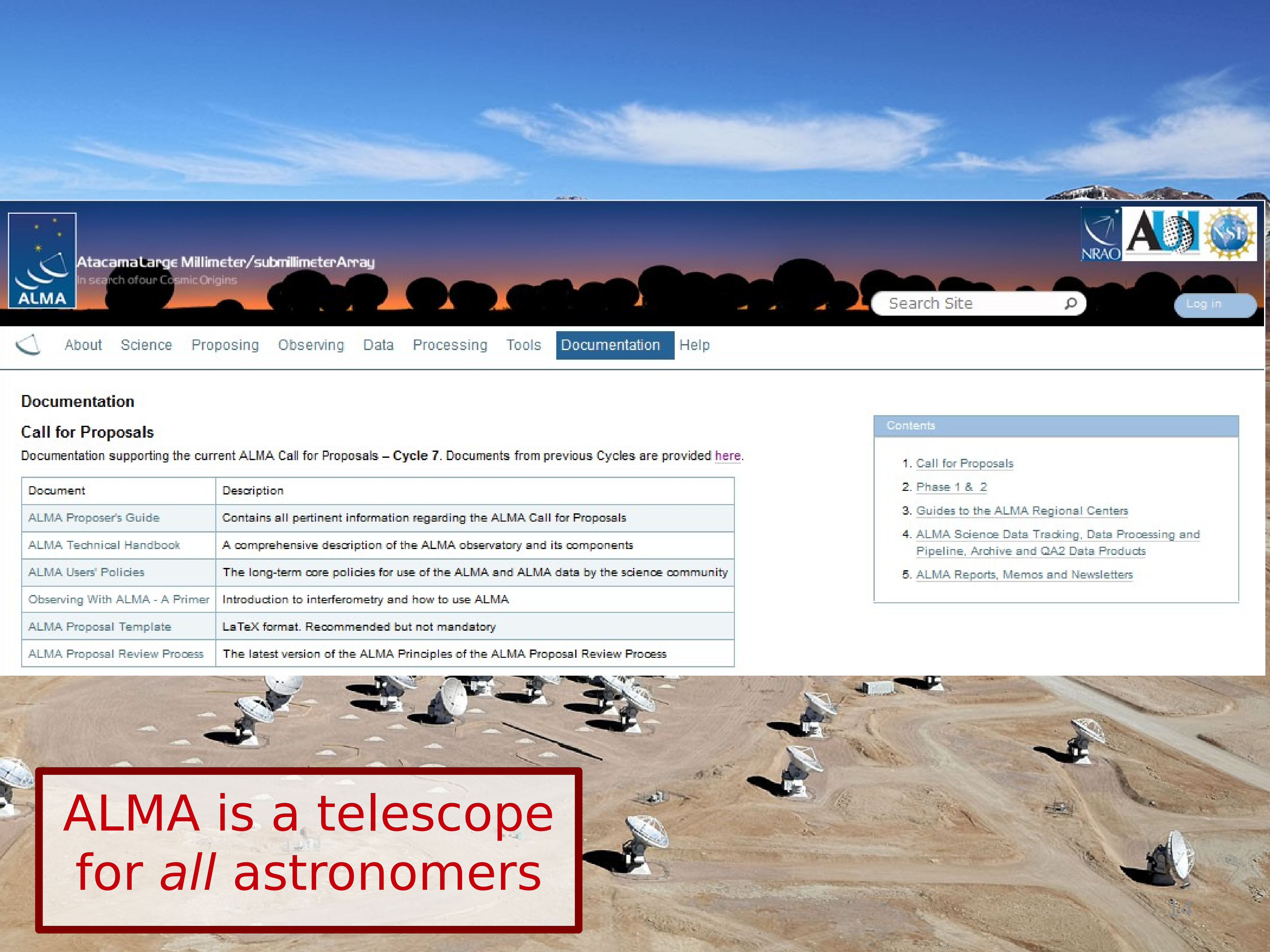
λ ~ 0.32 – 8.5mm. Array configurations between 150 meters and >16 kilometers, with 192 possible antenna locations.
  - Main Array: 50 x 12m antennas
  - Total Power Array: 4 x 12m antennas
  - Atacama Compact Array (ACA): 12 x 7m antennas
  - TP + ACA (Morita Array)

- 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 with 192 possible antenna locations:

- http://youtu.be/YMISe-C8GUs



Atacama Large Millimeter/submillimeter Array
In search of our Cosmic Origins
ALMA
NRAO AUI NSF

Search Site
Log in

About Science Proposing Observing Data Processing Tools Documentation Help

Documentation

Call for Proposals

Documentation supporting the current ALMA Call for Proposals – **Cycle 7**. 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	The latest version of the 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.

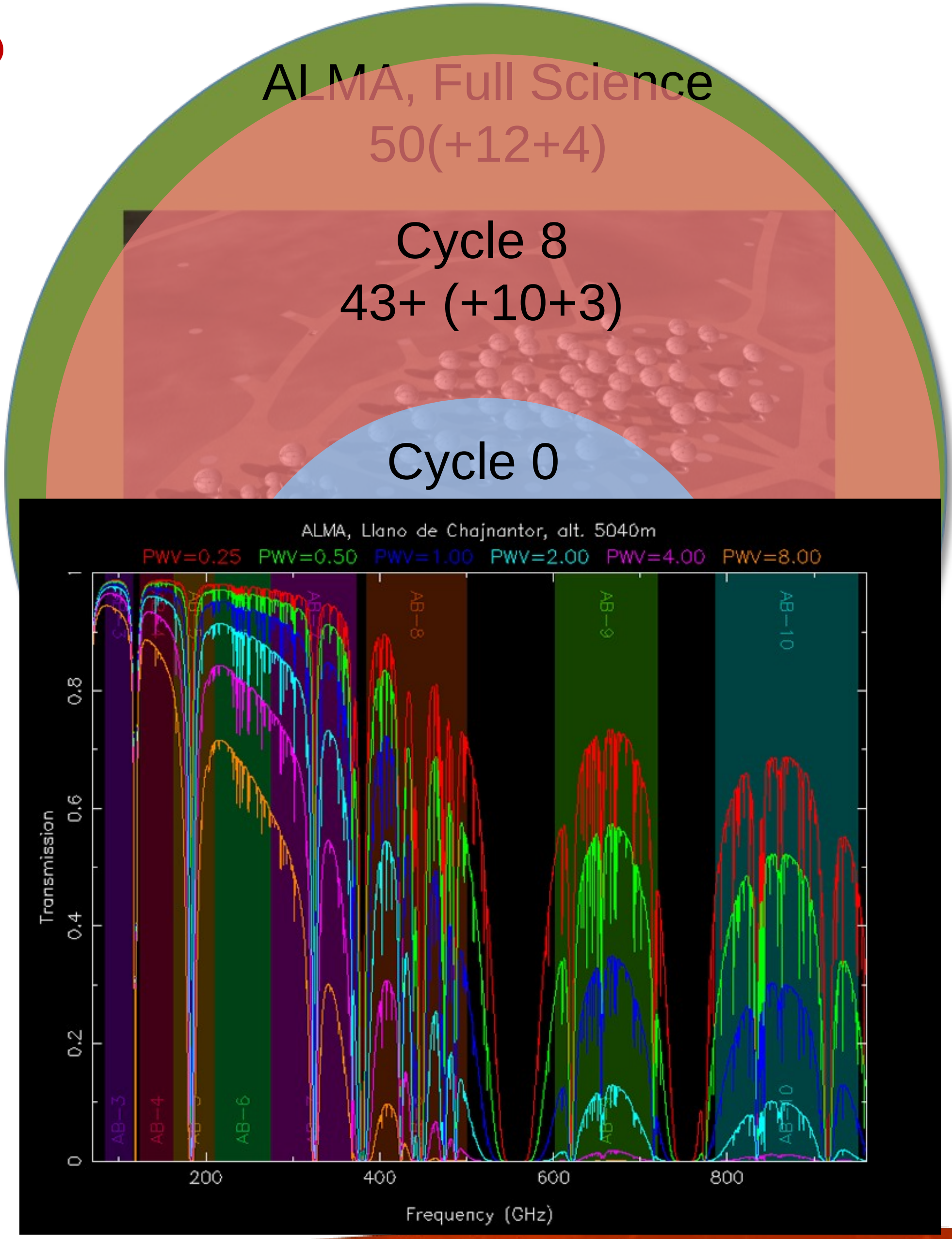
What is ALMA?

Collecting Area

Not only sensitivity but the collecting area (1.6 acres or 6600+ m2) + huge number of baselines provides excellent image fidelity

Spectral Coverage -

Covers ten atmospheric windows with 50% or more transmission above 35 GHz
https://almascience.nrao.edu/proposing/about-alma/atmosphere-model

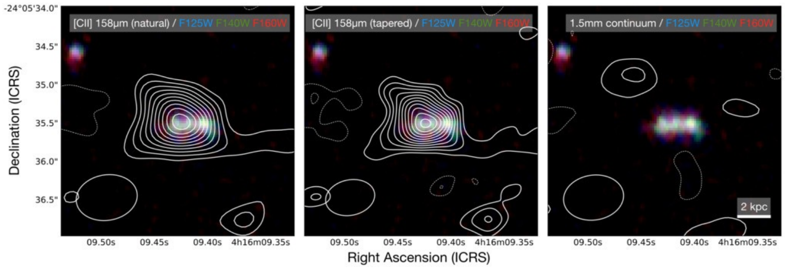


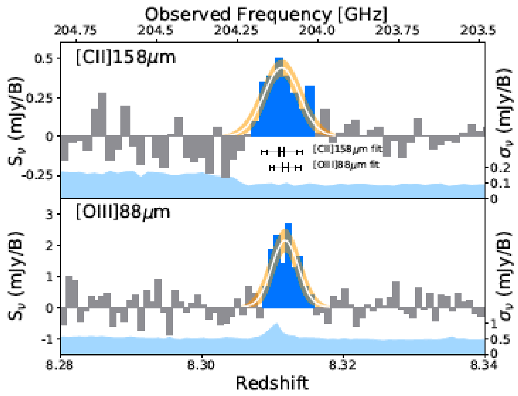
ALMA Current Status

- Construction Project ended in September 2014
- Routine science observing has been 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 7 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 7 observations
- More on Capabilities later… however, first on to science!

[CII] and warm dust continuum in a z = 8.31 Lyman break galaxy

- ALMA detection of [CII] 157.7 micron emission from the Lyman break galaxy (LBG) MACS0416_Y1 at z = 8.3113
- Luminosity ratio of [OIII] 88 / [CII] is 9.31 +/- 2.6,
  - indicative of hard interstellar radiation fields and/or a low covering fraction of photo-dissociation regions.
  - The emission of [CII] is co-spatial with the 850 micron dust emission (90 micron rest-frame),
  - Peak [CII] emission does not agree with the peak [OIII] emission, suggesting that the lines originate from different conditions in the interstellar medium.
- No detected continuum emission at 1.5 mm (160 micron rest-frame)
  - Warm dust temperature (T > 80 K), and/or steep dust-emissivity index (β > 2), compared to galaxy-wide dust emission found at lower redshifts (typically T ~30 – 50 K, β ~ 1 – 2).
- If such temperatures are common, this would reduce the required dust mass and relax the dust production problem at the highest redshifts.



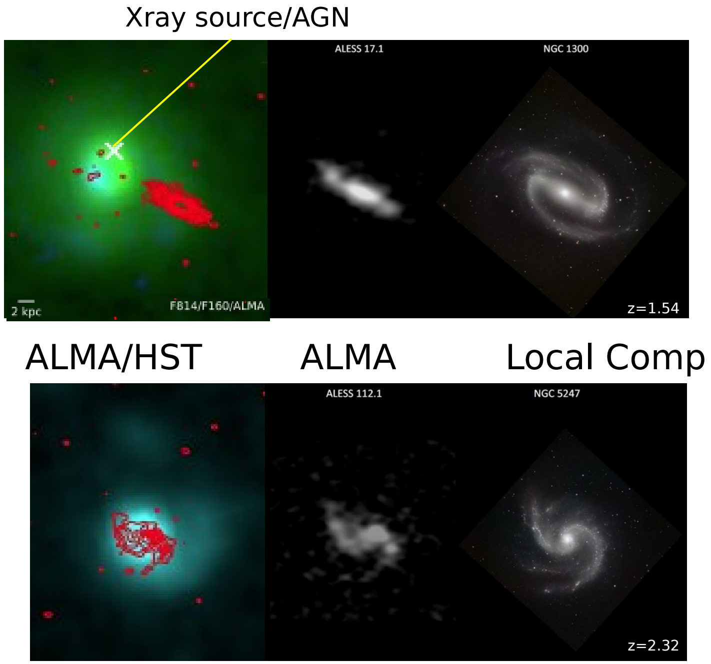


T. Bakx, Y. Tamura, T. Hashimoto, et. al. arxiv: 2001.02812

ALMA Images Nascent Galaxy Structure

ALMA 0.07” (0.5kpc) imaging of rest-frame FIR emission from 6 SMGs at z~1.5 < z < 4.9

- Robust sub-kpc structure on underlying exponential disks (FWHM ~few kpc)
- Often poor correlation with HST: ALMA seeing heavily dust-obscured cores only
- Structures suggest spiral arms, edge-on nuclear emission (bars)



Hodge+ 2019, ApJ, 876, 130

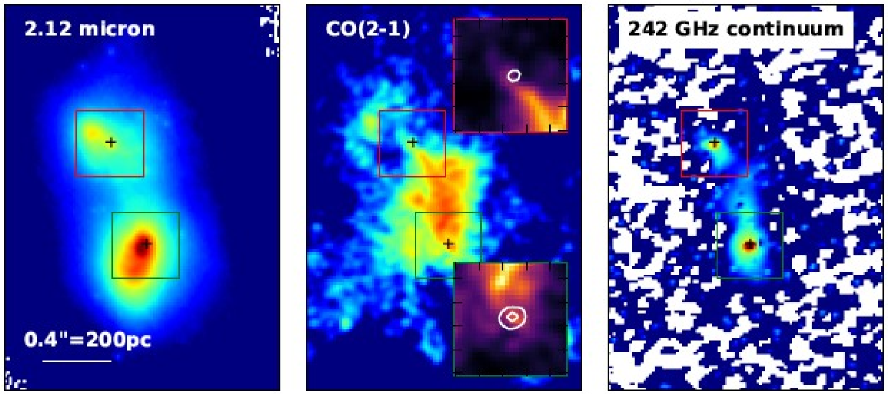
How Much ‘Black Hole’ Mass is Molecular?

How to Fuel an AGN: Mapping Circumnuclear Gas in NGC6240 with ALMA

Medling, Privon, Barcos-Muñoz+ 2019 arXiv 1910:12967

- Significant molecular gas mass contaminates dynamical black hole mass measurements; an important discovery showing a critical need for high resolution observations of molecular gas such as these with Band 6 at 30x60pc resolution. Up to 90% of the inferred mass in the southern nuclear region is molecular!
- In the south nucleus, and in the sum of the two, these corrections are sufficient to reduce the implied black hole masses to within the scatter of black hole scaling relations.
- dynamical black hole mass measurements must resolve this small scale – or correct for the gas mass present – to measure accurate black hole masses. The two black holes in this work show different levels of correction, with gas masses making up 5%-11% of the original black hole mass measurement in the north and 6%-89% in the south black hole.
- The amount of gas near a quiescent black hole could be minimal compared to that around a gas-rich obscured AGN like NGC 6240; this variability must be characterized before statistical corrections can be made to other black hole mass measurements.

FUEL FOR NGC 6240’S BLACK HOLES 3



Left : Keck NIRC2 K-band image of NGC 6240, highlighting the two nuclei (Max et al. 2005).
Center: ALMA Band 6 moment 0 maps of CO(2-1) integrated over 1200 km s^{-1}. Insets: nuclear regions in a different color scale for clarity, with continuum contours from right panel overlaid. Images are rescaled in each panel to show structure; details in Notes.
Right : Rest frequency 242 GHz continuum contours from the same dataset peak at the locations of the two AGN. Note that the millimeter continuum lines up with the kinematic centers of the K-band disks and not the photocenters, due to the large amount of dust present between the two nuclei that attenuates half of each disk even in the near-infrared.

New Understanding of Galactic Star formation

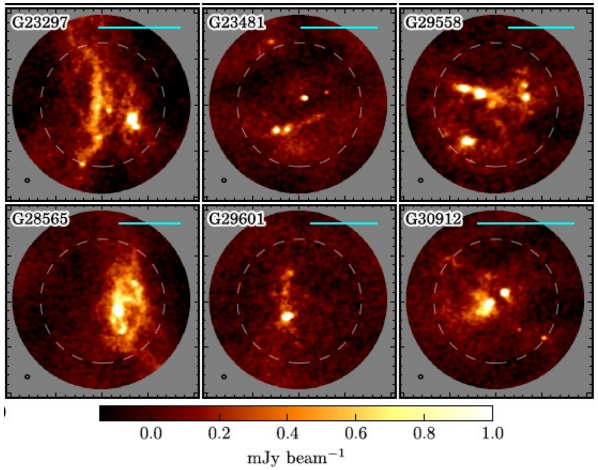
Low Mass Young Stellar Objects in Ophiuchus

1.3 mm ALMA dust continuum images with polarization E-vectors at 0.25" = 35 au resolution

14/37 detected at current sensitivity

Majority consistent with dust self-scattering in optically thick disks rather than magnetic fields

Sadavoy et al. 2019, ApJS, 245, 2



Significant fragmentation at an early stage in massive starless clump candidates suggest hierarchical fragmentation process

Svoboda et al. 2019, ApJ, 886, 36

Brown Dwarf Protoplanetary Disks

E. Sanchis, L. Testi, A. Natta, C. F. Manara, B. Ercolano, T. Preibisch, T. Henning, S. Facchini, A. Miotello, I. de Gregorio-Monsalvo, C. Lopez, K. Mužić, *I. Pascucci*, A Santamaría-Miranda, A. Scholz, M. Tazzari, S. van Terwisga, *J. P. Williams*

- New 890 µm continuum ***ALMA*** observations of 5 brown dwarfs (BDs) with infrared excess in Lupus, in combination with 4 BDs previously observed, allowed us to study the mm properties of the full known BD disk population of this nearby star-forming region.
  - 5 out of the 9 BD disks show dust emission.
  - BD disks are extremely compact--only one source is marginally resolved.
  - These BDs have low estimated accretion rates, and assuming that the mm-continuum emission is a reliable proxy for the total disk mass, disk dust masses are very low.
- This suggests that either BD systems are unable to form planets, or, more likely, rocky planetary cores are formed within the first Myr
- Examples of low mass objects—brown dwarfs—show that even in nearby Lupus, ALMA's sensitivity and resolution are scarcely adequate.

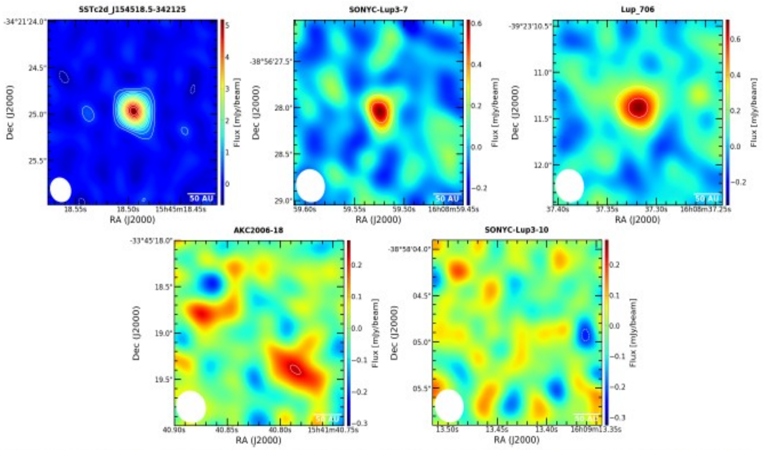
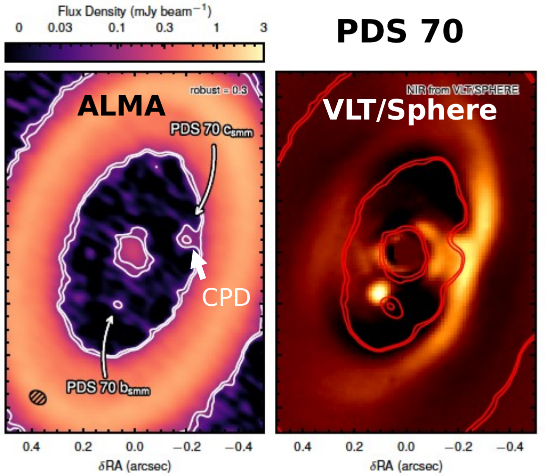


Fig. 2. Dust continuum images at 890 μm of the Lupus BDs disks survey from ALMA Band 7 observations. The beam size FWHM is $0.27'' \times 0.24''$ for the J154518.5-342125 map (robust parameter of -1), and $0.36'' \times 0.33''$ for the rest of the maps (robustness $= +0.5$). The average beam position angle is $PA = 28^\circ$. The contours are drawn at increasing (or decreasing) 3σ intervals as solid (dashed) lines.

ALMA Observes Planet Formation in Protoplanetary Disks

PDS 70 is a 5 Myr old low mass (0.76M_{Sun}) T Tauri star at 110 pc

- arXiv:1906.06308: Isella et al.
- Surrounded by dust rings at 74 and 10 AU
- In the inter-ring gap, it harbors two VLT-detected Jovian mass planets, b and c
- ALMA image of closer-in, PDS70b, shows dust trailing it
- The image also shows a **circumplanetary disk (CPD) around PDS70c**, with M_{dust}~.002 to .004 M_{Earth}

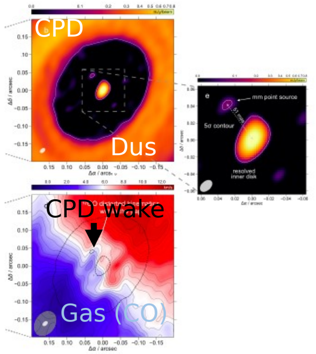


(L) ALMA image showing rings of dust and a gap, which contains two planets. (R) Near-IR image from VLT/Sphere

HD 100546 is 4.8 Myr old Be star (~2.2M_{Sun})
103 pc distant

- arXiv:1906.06305: Perez et al. and 1906.06302: Casassus & Perez
- Surrounded by asymmetric dust ring at 20-40 AU
  - Within the gap at 7.8 AU lies a candidate CPD of dust mass 1 M_{Moon}
  - The feature coincides with a localized CO gas velocity kink and a Doppler-flip signature expected along the spiral wakes
- **Observations like these are pushing the limits of ALMA's current spectral line sensitivity**

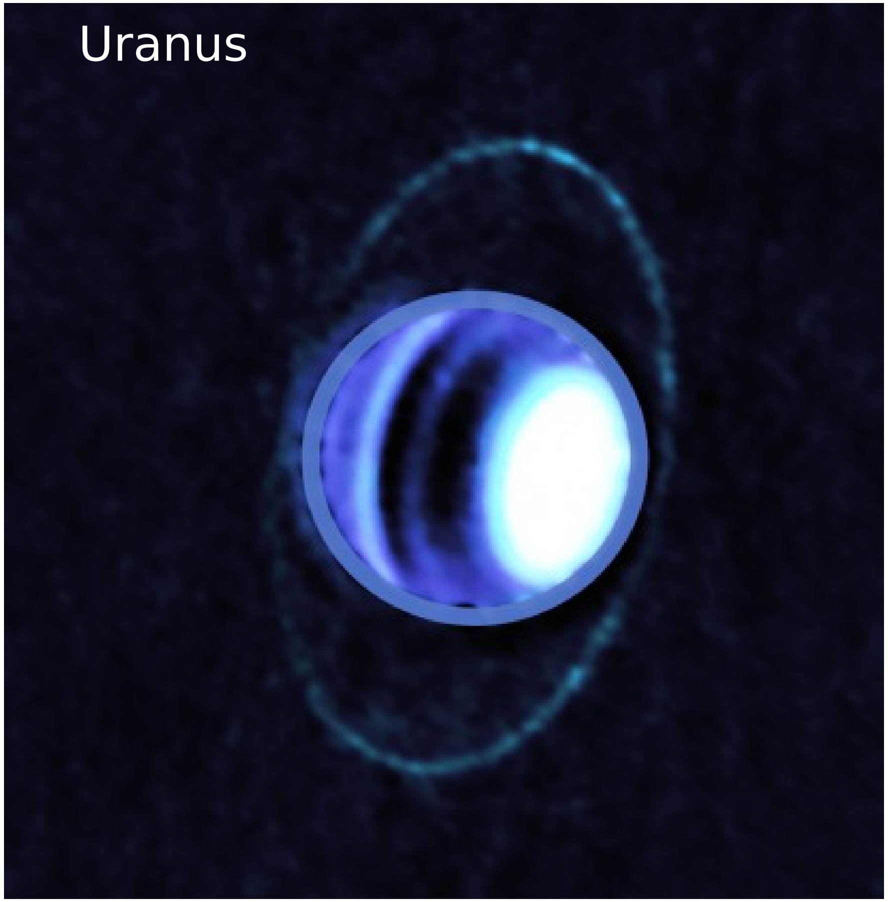
HD100546



(L) Dust (greyscale) and (R) CO velocity anomaly (color) suggest a perturbation ('wake')

Extraordinary ALMA Images of Our Own Backyard

- Thermal emission from the Uranus **ε** ring shows micron-sized dust is not present in the ring system.
- Confirms the hypothesis, proposed based on radio occultation results (Gresh et al. 1989), that the main rings are composed of centimeter-sized or larger particles
- Temperature of rings: 77+-2K
- The other main rings are visible in a radial (azimuthally-averaged) profile at millimeter wavelengths.

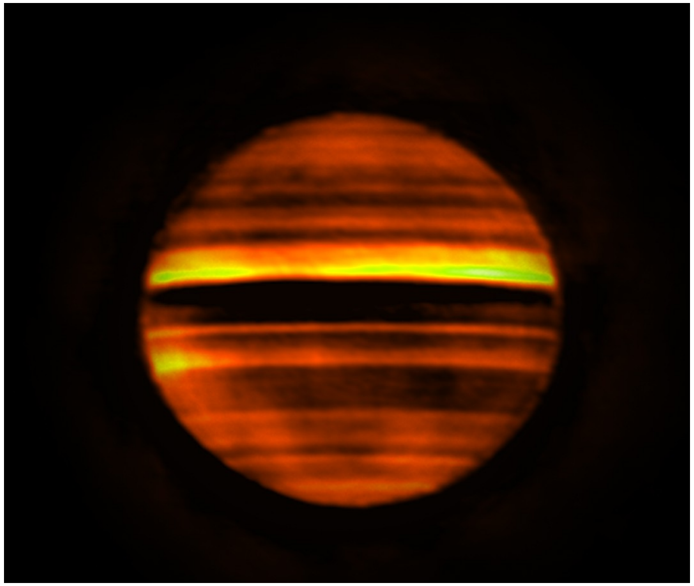


arxiv:1905.12566: Molter et al.

ALMA Millimeter Wavelength Images of Jupiter

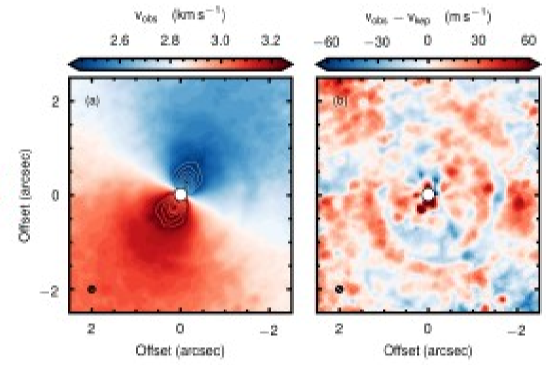
de Pater+ arXiv:1907.11820

- Jupiter at 1.3mm (mosaic of 17 pointings)
  - NH_3 dominates opacity, so the image can provide its 3 dimensional distribution
  - High brightness indicates lower NH_3 abundance
  - Dark areas indicate higher atmospheric opacity
- Imaged days after an outbreak in the South Equatorial Belt
  - Favored model: Eruptions triggered by energetic plumes via moist convection at base of water cloud, bringing up NH_3.



Kinematic Detection of Planets in Formation

- Goal: find planets during formation, embedded in disk
  - High angular resolution optically using extreme adaptive optics seeking thermal or line (Hα) emission
  - High angular emission in the (sub)millimeter using ALMA, seeking circumplanetary disks, sensitive down to $0.03M_{lunar}$
  - Gas kinematic perturbations from embedded protoplanets (e.g. spiral wakes), producing orbital clearing or perturbed gas rotational velocity, seen in some sources
- Definitive identification would come through direct imaging of wake spiral pattern
  - May occur throughout the entire disk (visible to ALMA, or in NIR to JWST or ELTs)
  - Pattern is larger, allowing more distant or lower resolution detection; sensitivity still needed
- Example: TW Hya, nearest (60pc) disk: ALMA 6.6 hr, $^{12}CO(3\text{-}2)$ achieved 8au resolution revealed azimuthal structure, hinting at planet-driven features.



TW Hya at 8au resolution (Huang+18) l) $^{12}CO(3\text{-}2)$ r) residual with bulk Keplerian motion removed. Note hints of planet-driven features

ALMA Cycle 8 Capabilities

Cycle 7/8 Important Information (COVID-19)

- Cycle 8 deadline delayed to at least 19 May 2020 (1500 UT)
  https://almascience.nrao.edu/news/delay-of-the-cycle-8-proposal-submission-deadline
  - An update will be given by 21 April 2020

- Cycle 7 observations currently suspended
  https://almascience.nrao.edu/news/alma-cycle-7-observations-suspended-due-to-covid-19
  - Science portal will be updated when observations resume
  - Data processing and archives still operational
  - “Virtual face-to-face” visits only
    https://science.nrao.edu/facilities/alma/visitors-shortterm

- [All dates in presentation should be considered tentative, pending further developments]

ALMA in Cycle 8

In Cycle 8 we continue to operate as what is been defined as "Steady State Operations"*

- **In Cycle 8, the following technical capabilities will be available for the first time:**
  - Solar observations in Band 5
  - VLBI observations of faint science targets (correlated flux density <500 mJy within an unresolved core on ALMA baselines up to 1 km). These observations will be done in passive phasing mode, where it is recommended to have a bright calibrator within 5 deg of the science target.
  - High-frequency observations (Bands 9 and 10) with the stand-alone 7-m Array
  - Mosaicking of continuum linear polarization observations (Bands 3 to 7)
  - Spectral scans with the 7-m Array

ALMA Capabilities

- **The Cycle 8 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**
    - Maximum baselines for the antenna configurations will vary from 0.16 km to 8.5 km. Configurations C-9 and C-10 will not be offered in Cycle 8.
    - Maximum baselines of 3.6 km for Bands 8, 9 and 10
    - Maximum baselines of 8.5 km for Bands 3 to 7
    - 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/cycle8/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, linear and circular polarization for both continuum and full-spectral-resolution observations in Bands 3, 4, 5, 6, and 7 on the 12-m Array.
  - Linear polarization imaging of a compact source on-axis in both continuum and full spectral resolution modes is feasible at the level of 0.1% (3 sigma) fractional polarization for the very brightest calibrators, and 0.2% (3 sigma) level for a typical observation.
  - The minimum detectable degree of circular polarization is 1.8% of the peak flux for both continuum and full spectral resolution observations. (NOTE that Zeeman observations have not been fully commissioned and should be discouraged from proposing.)
  - Mosaicking of continuum linear polarization observations (Bands 3 to 7).
- **Observing Time:**
  - 4300 hours for successful proposals of PI programs expected on the 12m Array (includes DDT, Cycle 4 Carryover and resubmissions)
  - 3000 hours available on the ACA*
  - 3000 hours available on the Total Power Array*
    - ~2500? Hours of ACA time will be available through the Supplemental Call in mid-Cycle 8.

ALMA Capabilities

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

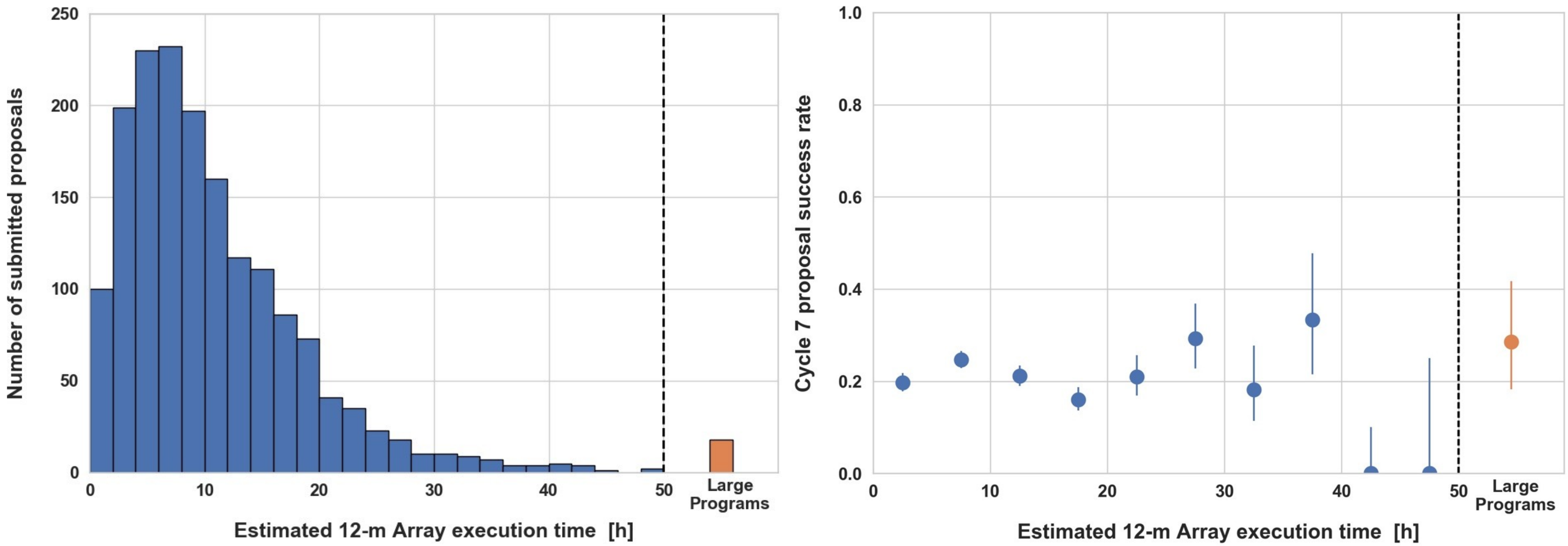


Figure 1: (Left) Number of proposals submitted as a function of the 12-m Array execution time in Cycle 7. (Right) The fraction of proposals (with 1sigma confidence intervals) that are assigned priority Grade A or B as a function of the estimated 12-m Array time.

ALMA Capabilities

ACA Supplemental Call:

- In Cycle 8, ALMA will offer a stand-alone ACA Supplemental Call for Proposals.
- The Supplemental Call will open on 15 September 2020 and the proposal deadline will be on 8 October 2020.
- Observations from the Supplemental Call will be scheduled from January 2021 to September 2021.
- The anticipated amount of time available will be announced in the Call. While stand-alone ACA proposals accepted from the Main Call may be assigned priority "A", "B", or "C", all accepted proposals from the Supplemental Call will be assigned priority "C".
- Proposals submitted to the Supplemental Call will be peer reviewed through a distributed system, in which the PI of each submitted proposal, or a designee from among the co-Is, will be responsible for reviewing ten other proposals submitted in the same call.
    - Summary from the Cycle 7 Supplemental Call process can be found at: https://almascience.nrao.edu/news/results-of-the-aca-standalone-cycle-7-supplemental-call
- More information about the supplemental call can be found at: https://almascience.nrao.edu/proposing/7m-array-supplemental-call

ALMA Capabilities – NEW!!!

Dual-Anonymous Proposal Review

- Proposals in Cycle 8 will implement a dual-anonymous process for proposal reviews. While proposers will still enter their names and affiliations in the Observing Tool, their identities will be concealed from the reviewers.
- **It will be the responsibility of the investigators to write their proposals such that anonymity is preserved.**
- Guidelines on how to prepare such proposals is available now in an ALMA Science Porta news item and, later, in the CfP - https://almascience.nrao.edu/news/items-for-planning-cycle-8-proposals

ALMA Capabilities

Standard vs Non-Standard modes??? GONE!

- Unlike in previous cycles, there will no longer be a distinction between standard and non-standard modes so… there is no more 20% cap on the time request for non-standard modes!!!
- Proposal types in Cycle 8 will include Regular, Very Long Baseline Interferometry (VLBI), Target of Opportunity, and Large Program. VLBI proposals work in concert with the Global mm-VLBI Array (GMVA) or the Event Horizon Telescope (EHT).
- GMVA programs must also submit a proposal to the GMVA by its 1 February 2020 deadline. Additional information about proposing with ALMA using the GMVA was made available in the GMVA Call for Proposals in early January 2020.

However, Large Program Observing Modes will STILL be restricted. They cannot include:

- 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 8 Capabilities plus):

- **Receiver bands**:
  - Include Bands 1 and 2
    - Band 1 summary report from 2019 June - https://zenodo.org/record/3240351. Full ALMA Band 1 Science Case: http://arxiv.org/abs/1310.1604
    - Band 2 summary report from 2019 June - https://zenodo.org/record/3240407
- **Baselines:**
  - All observing bands out to 16 km. Same may never be considered a standard mode
- **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:**
  - Full operations include full Stoke plus circular polarization at all observing bands including mosaics and Total Power

ALMA Timelines and Milestones

The ALMA Cycle 8 Timeline

Date	Milestone
17 March 2020 (15:00UT)	Release of Cycle 8 Call for Proposals, Observing Tool & supporting documents and Opening of the Archive for proposal submission
19 May 2020 (15:00 UT)	(Earliest possible) Proposal submission deadline
(TBD)	Announcement of the outcome of the Proposal Review Process
(TBD)	Deadline for Submission of Phase 2 by PIs
October 2020	Start of ALMA Cycle 8 Science Observations
September 2021	End of ALMA Cycle 8

ALMA Timelines and Milestones

The ALMA Cycle 8 Supplemental Call Timeline

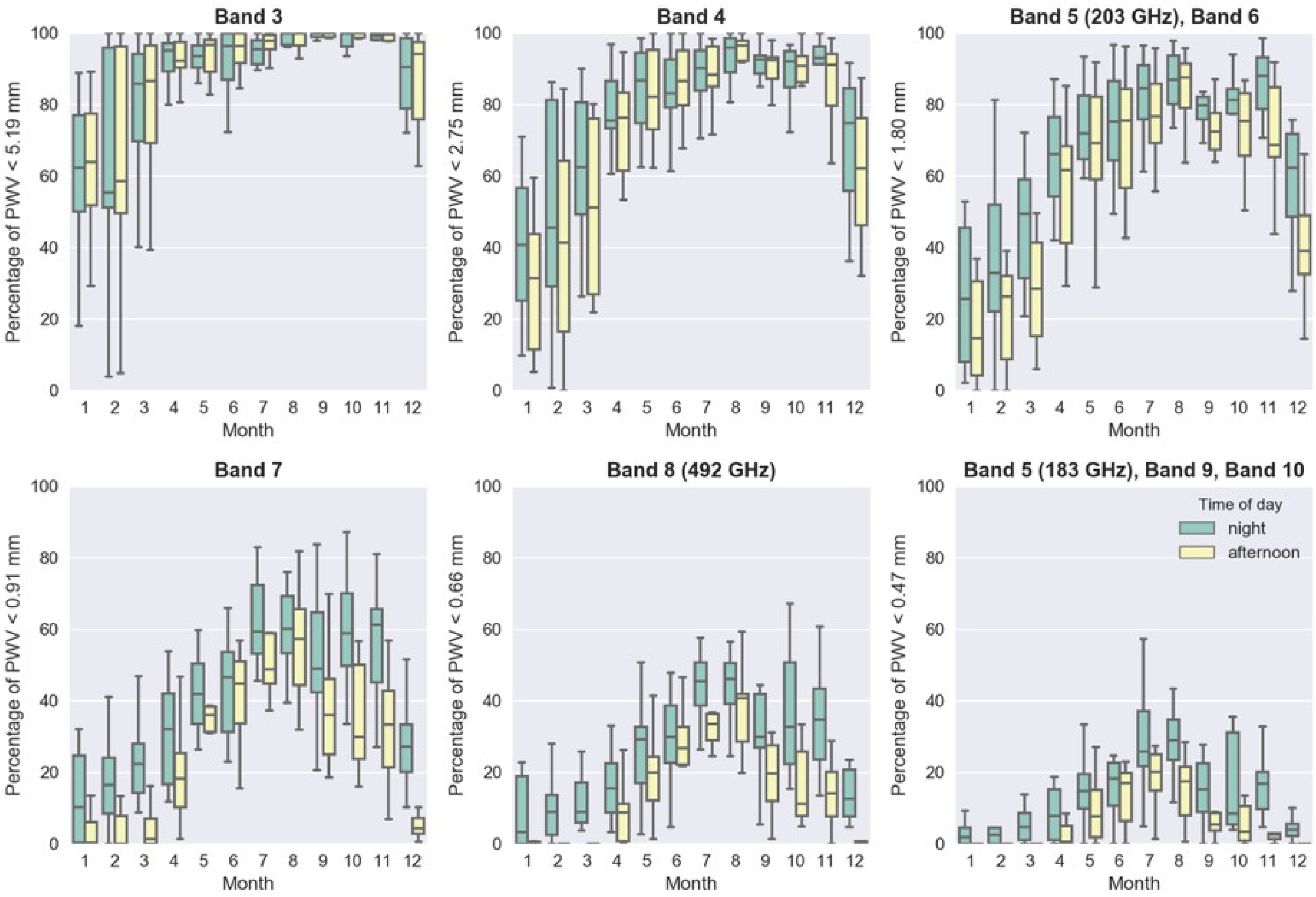
Timeline TBD, but call will be released on or after 15 September 2020.

ALMA Array Configuration Schedule (Cycle 8)

- Antenna configurations for the main 12-m array will use a new nomenclature in Cycle 8.
  - Configurations will be called C-1, C-2, and so on up to C-10, with C-1 having similar characteristics to the C43-1 configuration of Cycle 7, and likewise for the others.
  - Cycle 8 will NOT include the two longest baseline 12-m array configurations, C-9 and C-10.
- Maximum baselines in Cycle 8 will therefore be 8.5 km in configuration C-8.
- Configurations C-9 and C-10 with maximum baselines of 13.9 km and 16.2 km, respectively, will again be available in Cycle 9.
- **NOTE: No PI observing takes place in Feb!**
- The forward-looking configuration schedule (through Cycle 9) can be found at: https://almascience.nrao.edu/observing/observing-configuration-schedule/long-term-configuration-schedule

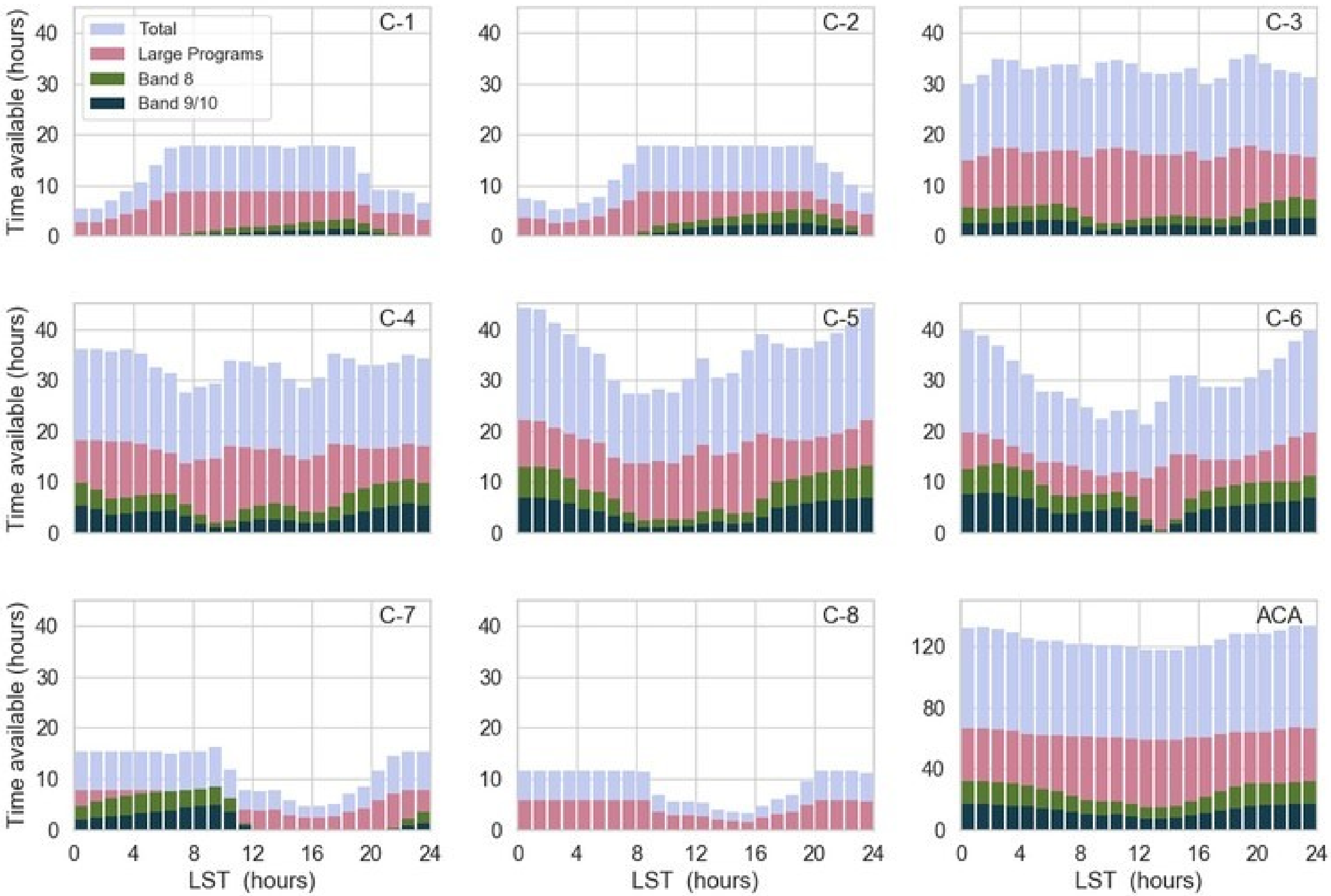
Start date	Configuration	Longest baseline	LST for best observing conditions
2020 October 1	C-8	8.5 km	~ 22h – 10h
2020 October 20	C-7	3.6 km	~ 23h – 11h
2020 November 10	C-6	2.5 km	~ 1h – 13h
2020 December 01	C-5	1.4 km	~ 2h – 14h
2020 December 20	C-4	0.78 km	~ 4h – 15h
2021 January 10	C-3	0.50 km	~ 5h – 17h
2021 February 1-28	No observations due to February Maintenance		
2021 March 1	C-1	0.16 km	~ 8h – 21h
2021 March 26	C-2	0.31 km	~ 9h – 23h
2021 April 20	C-3	0.50 km	~ 11h – 1h
2021 May 10	C-4	0.78 km	~ 13h – 3h
2021 May 31	C-5	1.4 km	~ 15h – 5h
2021 June 23	C-6	2.5 km	~ 16h – 6h
2021 July 28	C-5	1.4 km	~ 17h – 7h
2021 August 18	C-4	0.78 km	~ 19h – 8h
2021 September 10	C-3	0.5 km	~ 20h – 9h

ALMA Observing Strategies (Cycle 8)



- 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 8)



- Effective observing time available per configuration for executing PI projects. As an example, up to 36 hours are expected to be available in C-4 at LST=00 h for all observations and up to 18 h may be allocated to Large Programs. The total number of hours excludes time spent on observatory calibration, maintenance, reconfigurations, and other activities. The time available for Large Programs is shown in pink and time for high-frequency observations in green and dark blue. The configuration schedule and, consequently, the total number of hours available per configuration may change in response to 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
- **NAASC Financial Support for Workshop/Conferences:** The NAASC invites scientists to apply for funding in support of upcoming conferences and workshops. - https://science.nrao.edu/facilities/alma/community1/NAASC-Conference-and-Workshop-Support
- **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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