Preparing for ALMA Cycle 6

Columbia University
March 30, 2018
Statia Cook, ALMA Ambassador

Overview

Workshops like this:

- are community events sponsored by the North American ALMA Regional Center
- are happening across the country right now!
- are hosted by local postdocs trained by NRAO (to ease the logistics of NRAO staff running multiple serial Community Days)

Goals:

- To support creation of (great) ALMA proposals
- To create centers of expertise, expand user base, and encourage collaborations
- To connect users with resources

Introductions

Me:

- Statia Cook
- Columbia Science Fellow and Planetary Scientist
- ALMA science: Detect and map trace molecules in planetary atmospheres

My goal today:

- To strengthen our local radio astronomy network!

Workshop Agenda

- 9:30 a.m.: Welcome/Introductions
- 9:45 a.m.: **ALMA Overview and Introduction to Capabilities**
- 10:30 a.m.: **Science Highlights**
- 11:15 a.m.: Coffee Break
- 11:30 a.m.**: Interferometry Basics** - *What you need to know to propose to ALMA*
- 12:15 p.m.: Lunch (proposal ideas and collaborations?)
- 1:15 p.m.: **Proposal Preparation**
- 2:00 p.m.: **ALMA Observing Tool** *intro and hands on session*
- 3:15 p.m.: Coffee Break
- 3:45 p.m.: **Simulations and Imaging with CASA** *intro and hands on session*
- 5:15 p.m.: Close

WiFi Available

Two Options:

1) Eduroam: secure and encrypted wireless network access to visitors from participating institutions

2) Columbia University: open network

Software to Download

If you haven't downloaded in advance, you will need both to participate in the afternoon hands-on time!

1) ALMA OT

https://almascience.nrao.edu/proposing/observing-tool

Download the webstart version (will automatically download the most recent version each time you open it)

2) CASA

https://casa.nrao.edu/casa_obtaining.shtml

Download most recent version 5.1.2

Where Can I Get Help After This Workshop?

ALMA Helpdesk	Questions answered within 48 hours (around the clock staffing in the week leading up to the proposal deadline) https://help.almascience.org
Student Observing Support	Up to $35k to support undergraduate or graduate student involvement in successful ALMA proposals https://science.nrao.edu/opportunities/student-programs/sos
Page Charges	Support available upon request for authors from US institutions reporting ALMA/VLA results https://library.nrao.edu/pubsup.shtml
Face-to-face Visits	NRAO covers travel expenses for up to 2 people from 2 teams per week to get support for data reduction, proposal preparation, etc. at the NAASC https://science.nrao.edu/facilities/alma/visitors-shortterm

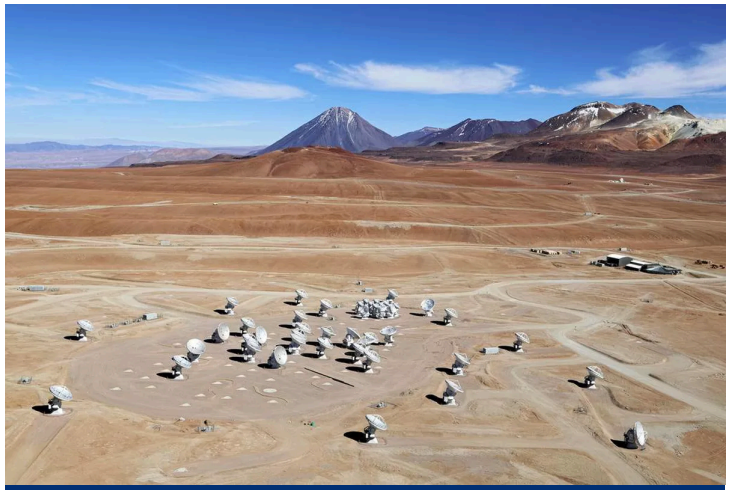
***All of today's talks will be available online for reference after this workshop**

ALMA Overview and Capabilities

This talk:

- Brief Introduction to NRAO
- Introduction to ALMA
- Latest Capabilities of ALMA
- ALMA Cycle 6 Timeline

NRAO: One Observatory, Two World Class Facilities



ALMA
Atacama Large Millimeter/ submillimeter Array

VLA
Karl G. Jansky Very Large Array

*Other Affiliated Telescopes and Observatories include the Green Bank Observatory (http://greenbankobservatory.org/) and the Long Baseline Observatory (https://www.lbo.us/)

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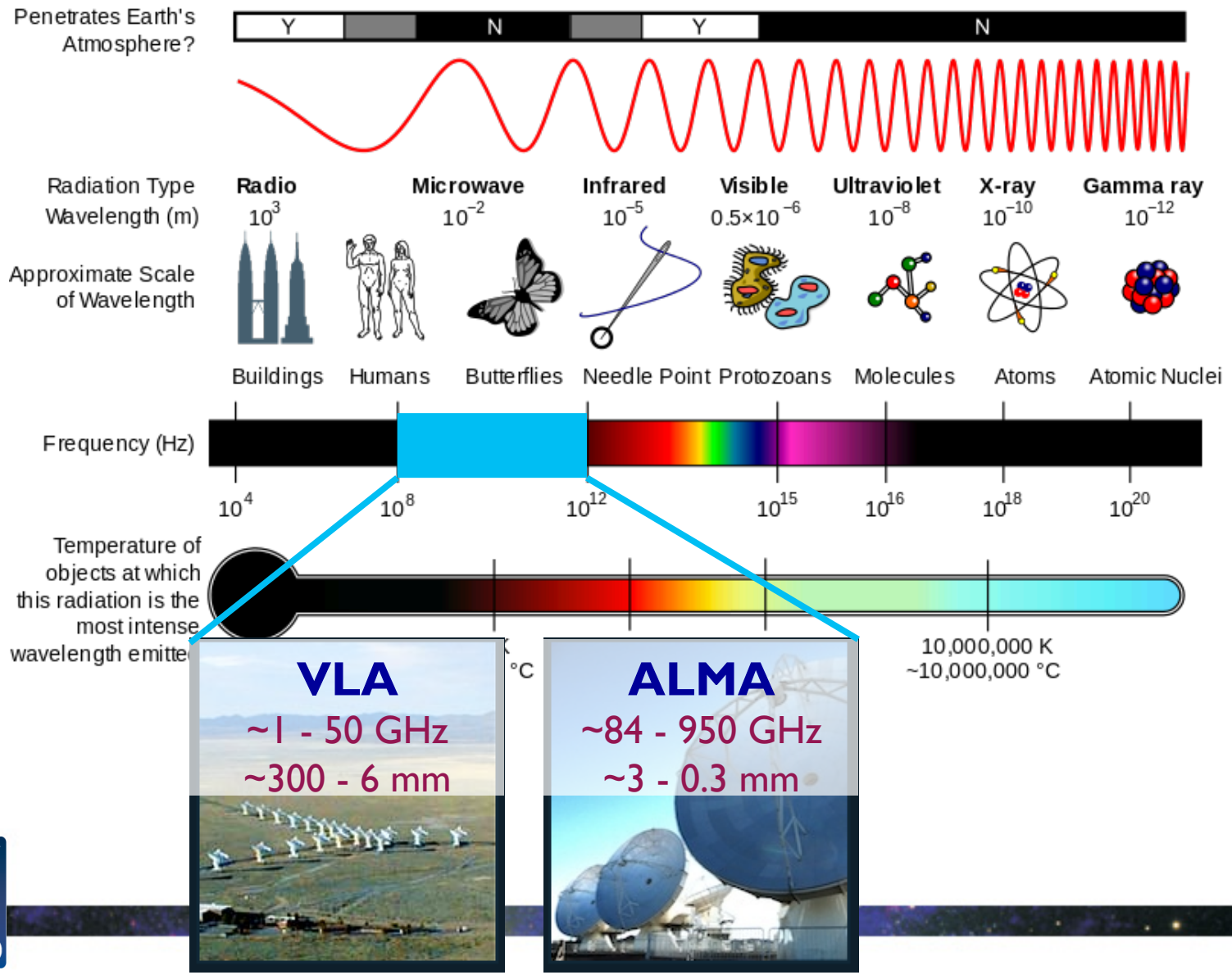
What Are Radio Wavelengths?



What Can We Observe in the Radio?

Sun	coronal mass ejections, magnetic field activity
Solar System	atmospheres, astrometry, composition, KBOs
Star-Forming Regions	dust and gas environment, kinematics (infall, outflows, jets), protoplanetary disks, cores, chemistry, feedback
Exoplanets	direct imaging, gaps in disks, kinematics
Pulsars	neutron star physics, pulse morphology, gravity, ISM probe
Galactic Structure	spiral arms, bars, global atomic/molecular gas properties
Nearby Galaxies	molecular/atomic gas content and kinematics, dynamics of galaxies at high resolution, (obscured) star formation, gas properties
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
Cosmology	H_0 measurement, SZE

more on science later!

What Is ALMA?

A global partnership between North America, Europe, and East Asia to deliver a revolutionary millimeter/ submillimeter telescope array (in collaboration with Chile)

Provides unprecedented imaging and spectroscopic capabilities at millimeter wavelengths

ALMA by the Numbers:

Elevation = 5000 m

Number of Antennas = 66

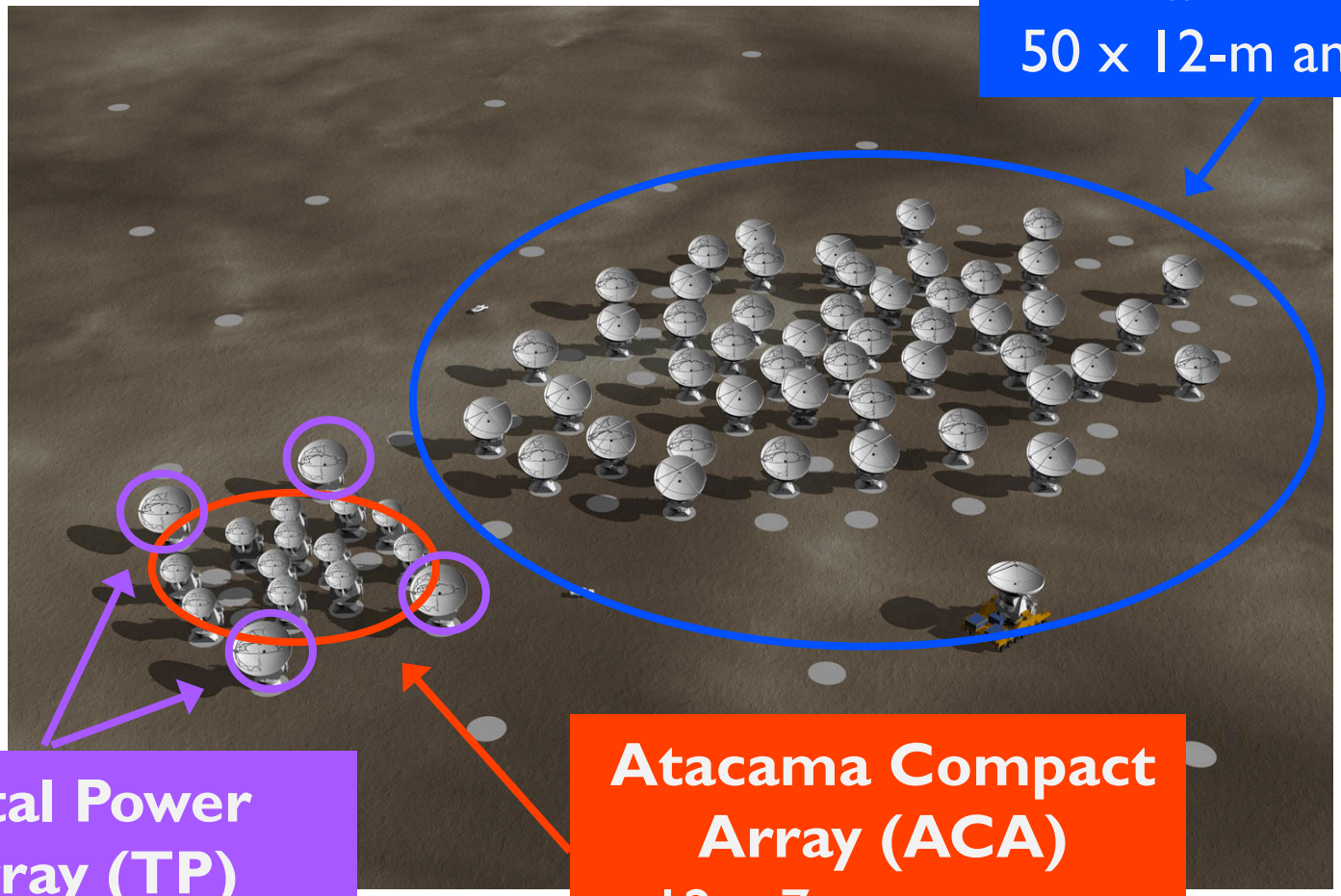
Baselines = 150 m to >16 km

Antenna Locations = 192

Wavelengths = 0.32 – 8.5 mm

Best Resolution = 0.015″ (at 300 GHz)

Array Configurations



Main Array
50 x 12-m antennas

Total Power Array (TP)
4 x 12-m antennas

Atacama Compact Array (ACA)
12 x 7-m antennas

**TP + ACA = Morita Array*

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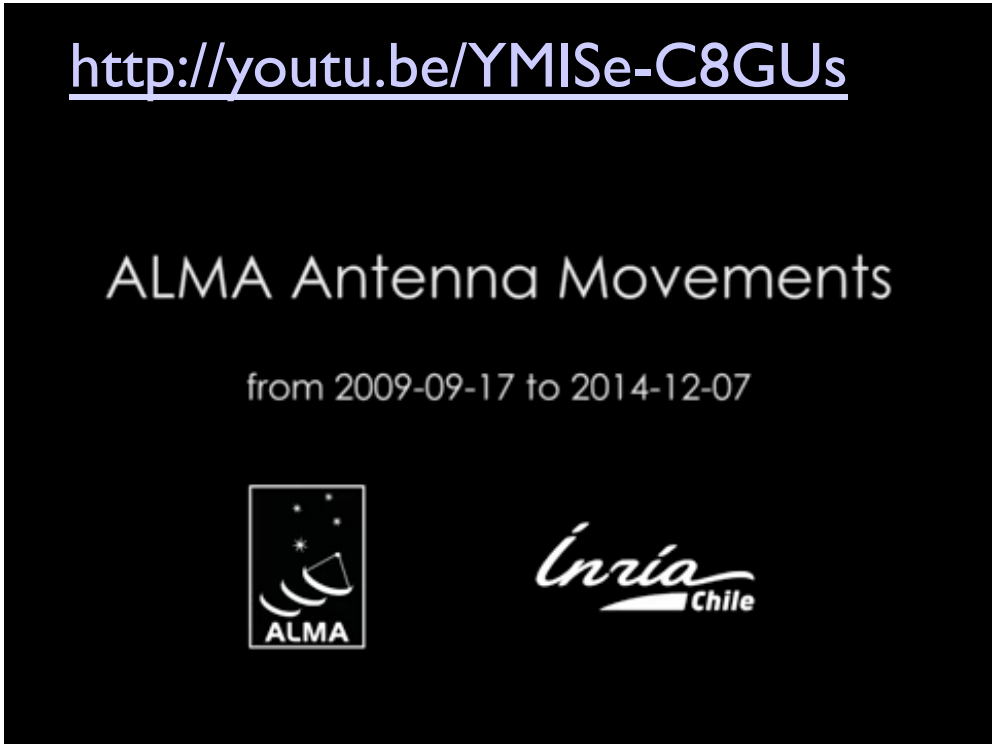
Array Configurations



A 'NYC-Centric' View of ALMA Configurations…

Most compact configuration = width of CU south lawn

Most extended = here to southern tip of Manhattan

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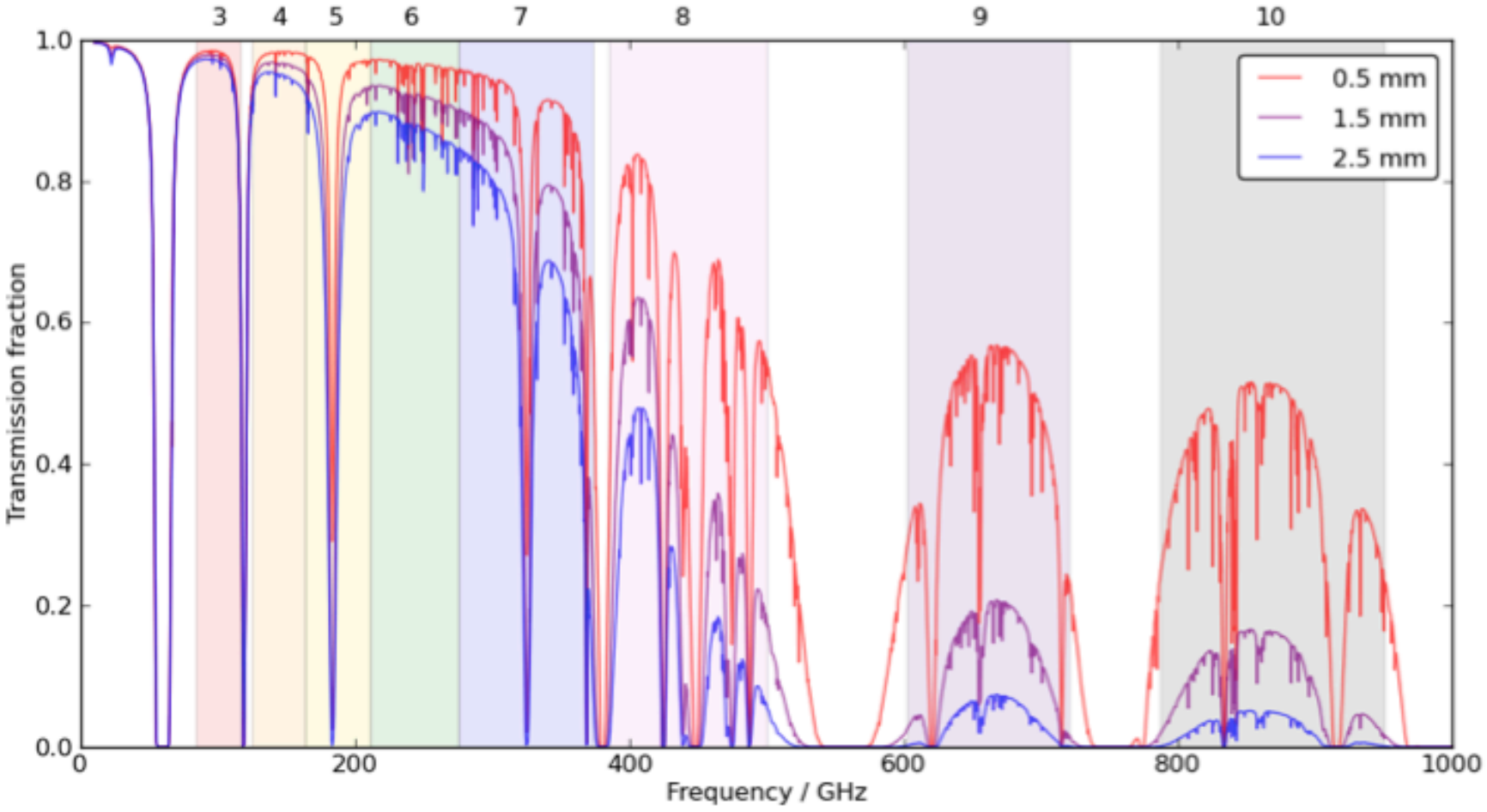
- Angular resolution down to 0.015” (at 300 GHz)
- Spectral bands from 84 to 950 GHz (3 mm to 320 μm)
- State-of-the-art low-noise, wide-band receivers (8 GHz bandwidth)
- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities including circular*
- Estimated 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 past/current mm interferometers

Spectral Coverage: ~0.32-8.5mm, spanning 10 atmospheric windows



ALMA is a telescope for all astronomers

- ALMA data is delivered to you in a reduced format, including the calibration scripts, imaging scripts and first-order data products
- A large team of NRAO experts is available for all your questions through the helpdesk
- Many tutorials and step-by-step instructions available online

Reminder: NAASC Sources of Support

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ALMA Ambassadors	You too can become an ALMA Ambassador! https://science.nrao.edu/facilities/alma/ambassadors-program

ALMA Cycle 6 Capabilities

NRAO NSF Associated Universities, Inc.

ALMA Development

- Early Science (2011-2015): Cycles 0-3
  - Continuous construction of antennas/receivers
  - Limited # hours available
  - Construction ended September 2014

- **Steady State (2015-2019): Cycles 4-6**
  - Testing and developing new capabilities

- Full Science (2019+): Cycle 7+
  - Everything in steady state, plus additional targeted deliverables such as: Bands 1 and 2, Band 7 in most extended array, Total Power continuum, circular polarization mosaicking, …

Overview of ALMA Capabilities in Cycle 6

Number of Antennas

12-m Array	7-m Array	12-m TP
43 (50)	10 (12)	3 (4)

Receiver Bands and 12-m Array Configurations

Band:	3	4	5	6	7	8	9	10
Wavelength (mm):	3.1	2.1	1.6	1.3	0.87	0.74	0.44	0.35
Frequency (GHz):	100	150	183	230	345	460	650	870
Max Baseline (km):	16	16	16	16	8.5	3.6	3.6	3.6
Max Resolution ("):	0.042	0.028	0.021	0.018	0.028	0.046	0.033	0.024

For future reference, see Appendix A of the ALMA Proposer's Guide available at: https://almascience.nrao.edu/documents-and-tools

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Overview of ALMA Capabilities

Available Observing Time

	12-m Array	7-m Array	12-m TP
Time (hours):	4000*	3000	3000

* Includes DDT, Cycle 5 carryover and resubmissions)

Spectral Line, Continuum, and Mosaic Observations

- **Spectral line and continuum:** 12-m Array and the 7-m Array, All Bands
- **Single pointing:** 12-m Array, 7-m Array, All Bands
- **Mosaics:** 12-m Array, 7-m Array, Band 3-9
- **TP spectral line (no continuum):** Bands 3-8

Polarization

- Single pointing, on axis, full (including circular) polarization for both continuum and full-spectral-resolution in Band 3, 4, 5, 6, and 7 offered for 12-m Array
- Minimum detectable degree of circular polarization = 1.8% of peak flux
- Only for on-axis sources with an angular size <10% of FWHM primary beam

New Observing Modes for Cycle 6

Circular Polarization Observations

- for Bands 3, 4, 5, 6 and 7 only

Time Simultaneous Observations

- between the 12-m and 7-m Arrays

Band 8 Observations are a Standard Observing Mode*

- Stand-alone ACA observations are allowed

Band 6 IF Extension

- The Band 6 IF bandwidth has increased by 0.5 GHz to enable **simultaneous** observations of ^{12}CO, ^{13}CO and C^{18}O with broader spectral windows.

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Standard vs. non-standard modes

Around 20% of the time is available for "non-standard modes" in Cycle 6

May not be reduced with standard data reduction pipeline

Non-Standard Observing Modes include:

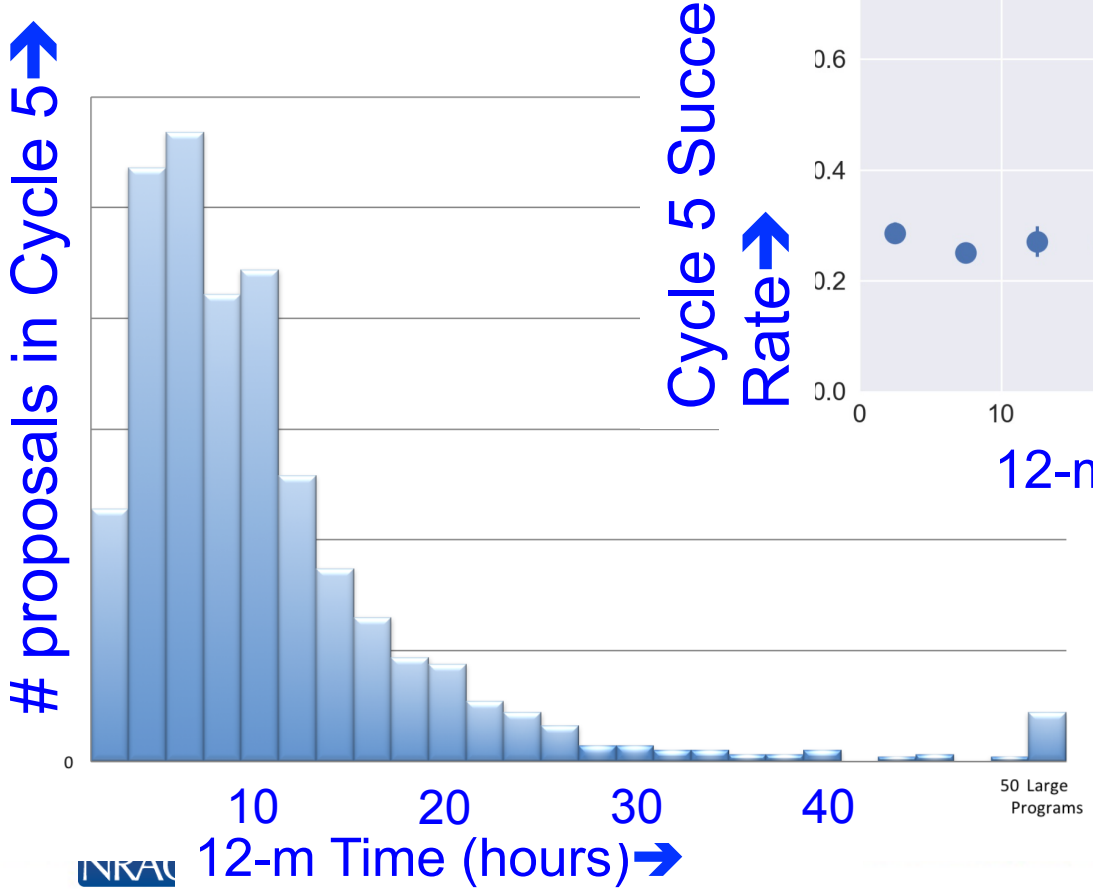
- Bands 9 and 10 observations
- Band 7 observations with maximum baselines > 5 km
- All polarization observations
- Spectral scans
- Bandwidth switching projects (having less than 1 GHz aggregate bandwidths over all spectral windows)
- Solar observations
- VLBI observations
- Non-standard calibrations (user-defined calibrations selected in the OT)
- Astrometric Observations

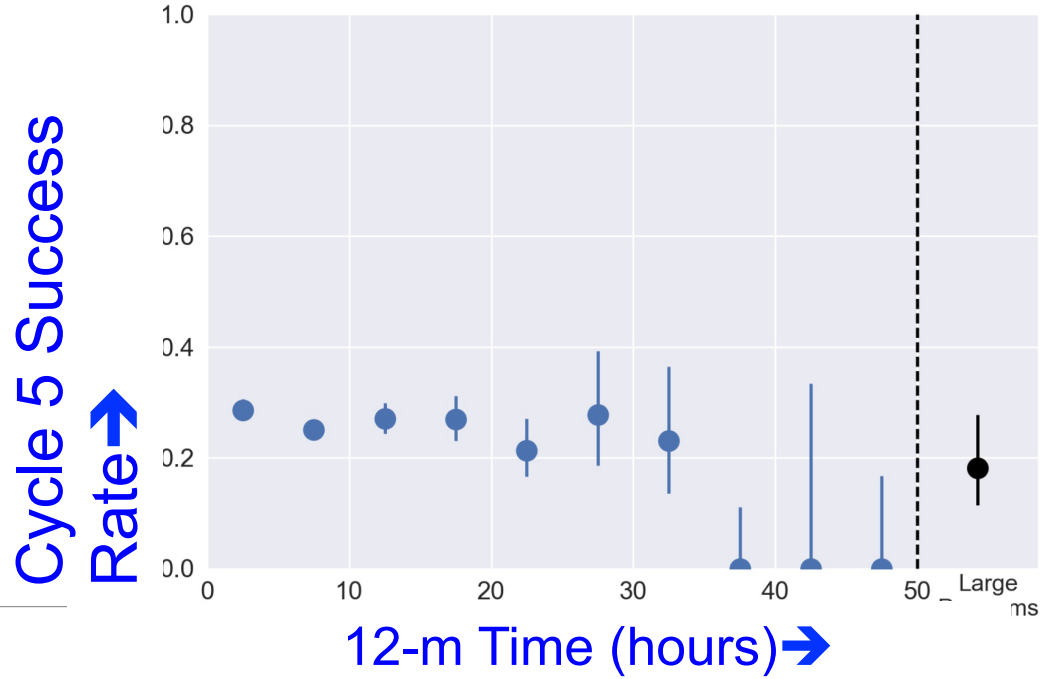
Cycle 6 Observing Time

- 4000 hours expected for PI programs 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

Cycle 6 Observing: Total Time Considerations

- "Medium-sized" proposals of about 10-25 hours encouraged!





Cycle 6 Array Configuration Schedule

Start date	Configuration	Longest baseline	LST for best observing conditions
2018 October 1	C43-6	2.5 km	~ 22h – 10h
2018 October 15	C43-5	1.4 km	~ 0h – 12h
2018 November 25	C43-4	0.78 km	~ 2h – 14h
2018 December 15	C43-3	0.50 km	~ 4h – 15h
2019 January 5	C43-2	0.31 km	~ 5h – 16h
2019 January 20	C43-1	0.16 km	~ 6h – 17h
2019 February 1-28	No observations due to February shutdown		
2019 March 1	C43-1	0.16 km	~ 8h – 21h
2019 March 15	C43-2	0.31 km	~ 8h – 22h
2019 April 1	C43-3	0.50 km	~ 9h – 23h
2019 April 15	C43-4	0.78 km	~ 10h – 0h
2019 May 1-31	No observations due to major antenna relocation		
2019 June 1	C43-10	16.2 km	~ 13h – 3h
2019 June 20	C43-9	13.9 km	~ 14h – 5h
2019 July 10	C43-8	8.5 km	~ 16h – 6h
2019 August 1	C43-7	3.6 km	~ 18h – 8h
2019 September 5	C43-6	2.5 km	~ 20h – 9h

No PI observing

Best Weather

Compact configurations

Extended configurations

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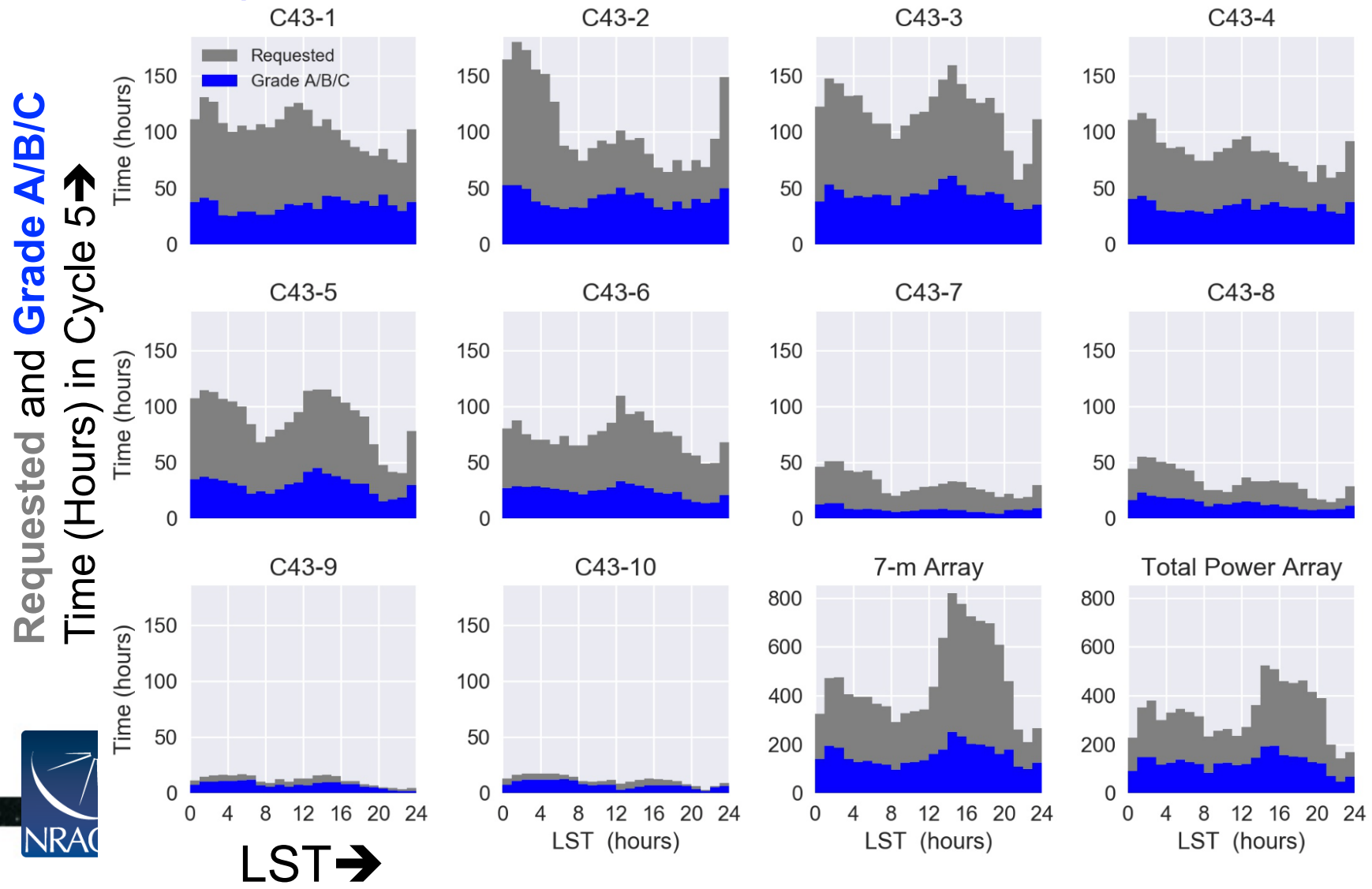
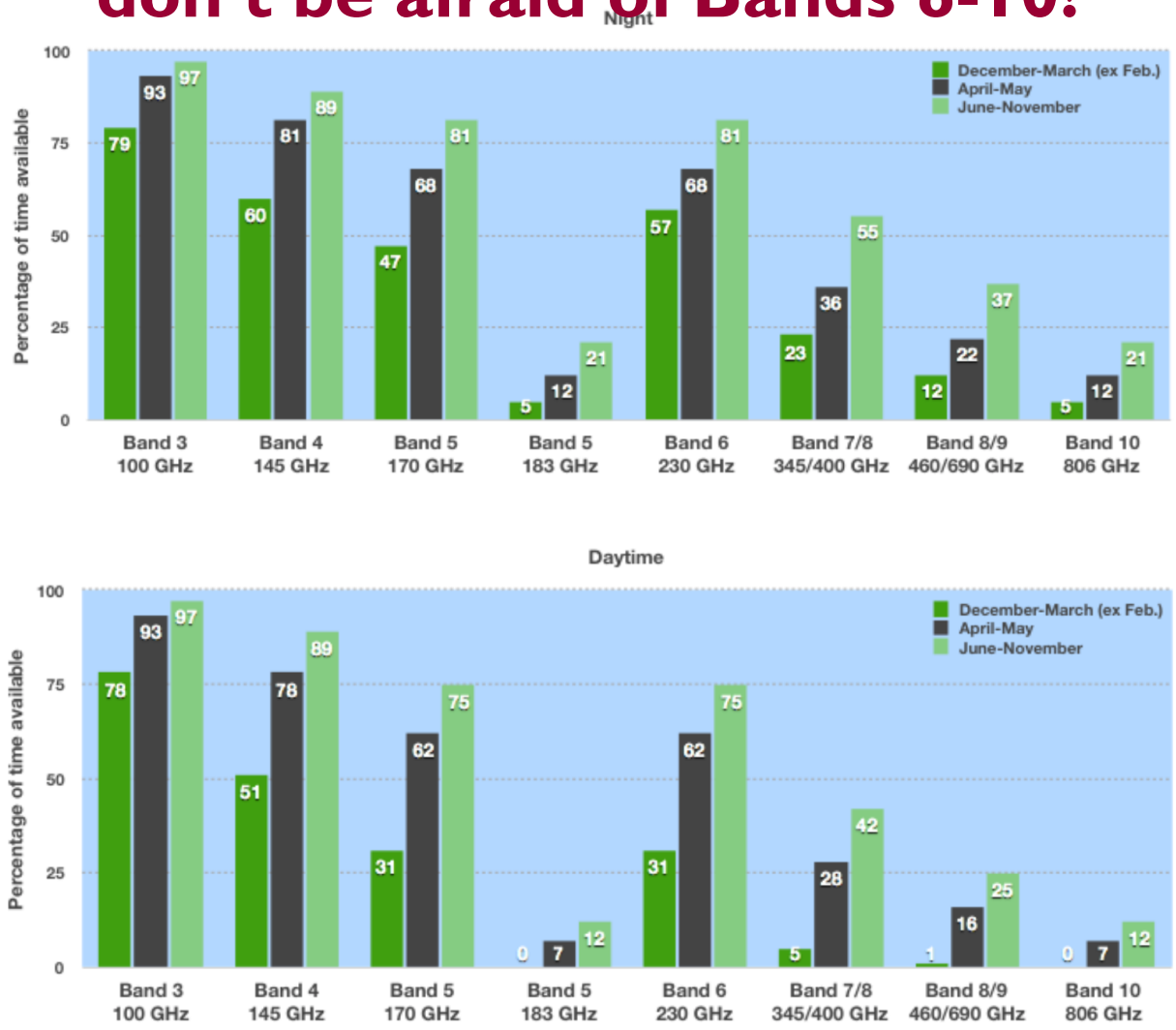
LST and Array Configuration Considerations

- Some LST ranges are in greater demand
- Consider extended configurations
- ACA-only observations STRONGLY ENCOURAGED



Longer λ's (lower bands) easier to observe BUT don't be afraid of Bands 8-10!

% time with good enough weather



Band→

The ALMA Cycle 6 Timeline

Date	Milestone
20 March 2018 (15:00UT)	Release of Cycle 6 Call for Proposals, Observing Tool & supporting documents and Opening of the Archive for proposal submission
19 April 2018 (15:00 UT)	Proposal submission deadline
End of July 2018	Announcement of the outcome of the Proposal Review Process
10 September 2018	Submission of Phase 2 by PIs
October 2018	Start of ALMA Cycle 6 Science Observations
September 2019	End of ALMA Cycle 6

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