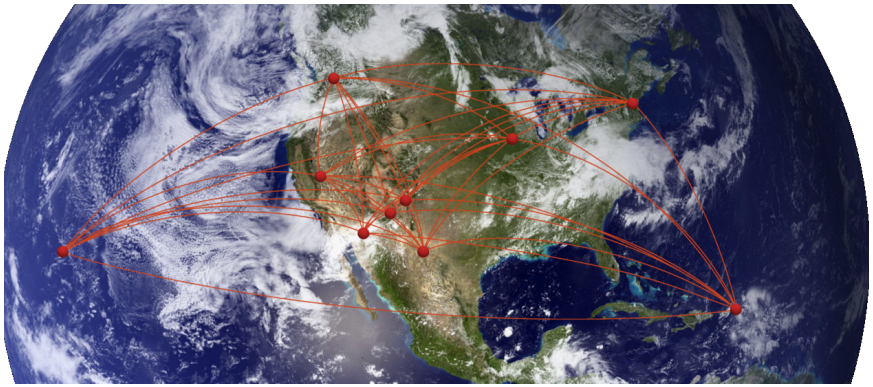
NRAO/ALMA overview & capabilities



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

Amy Sardone

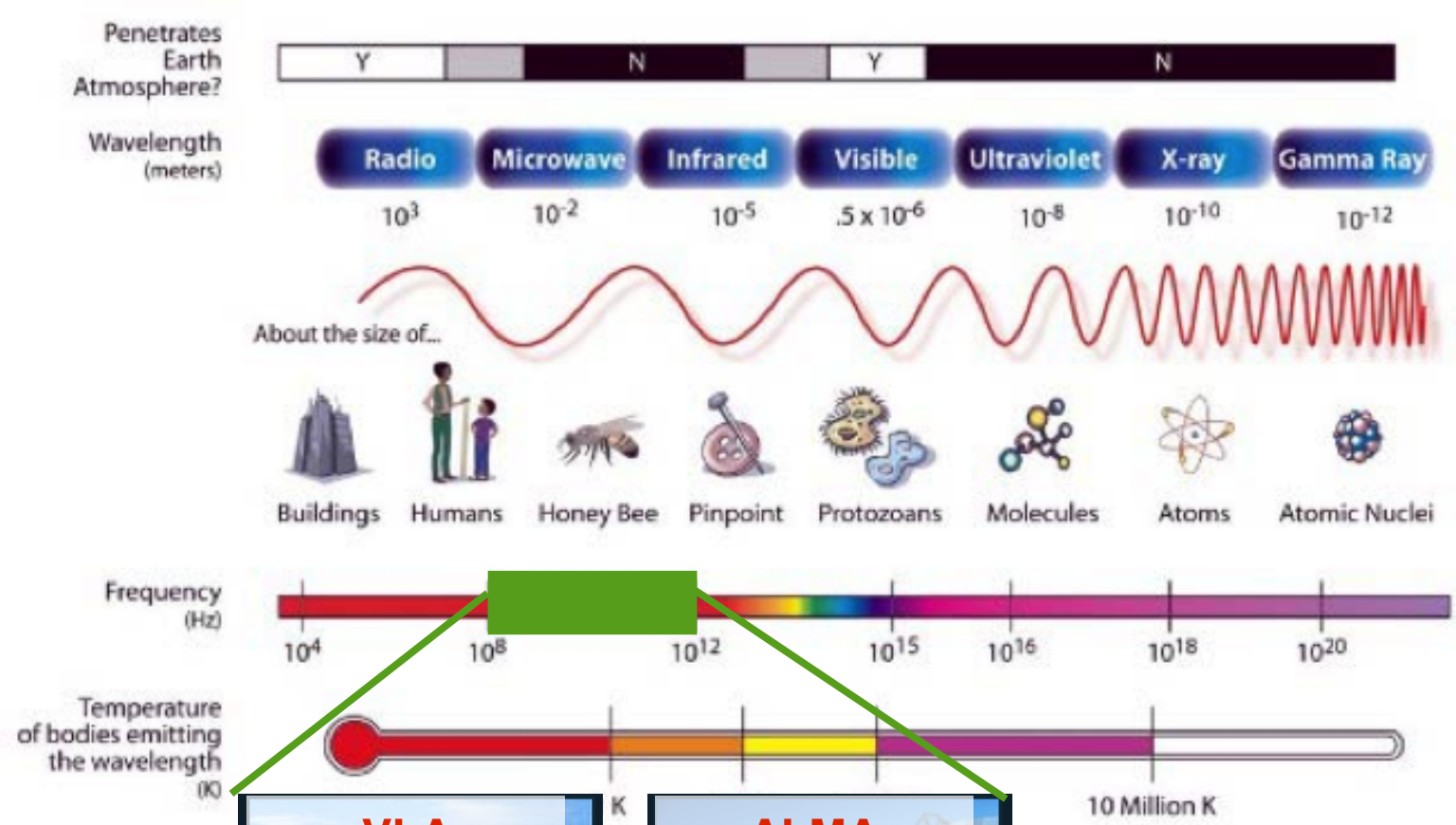
NRAO: One Observatory, Three World Class Facilities

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

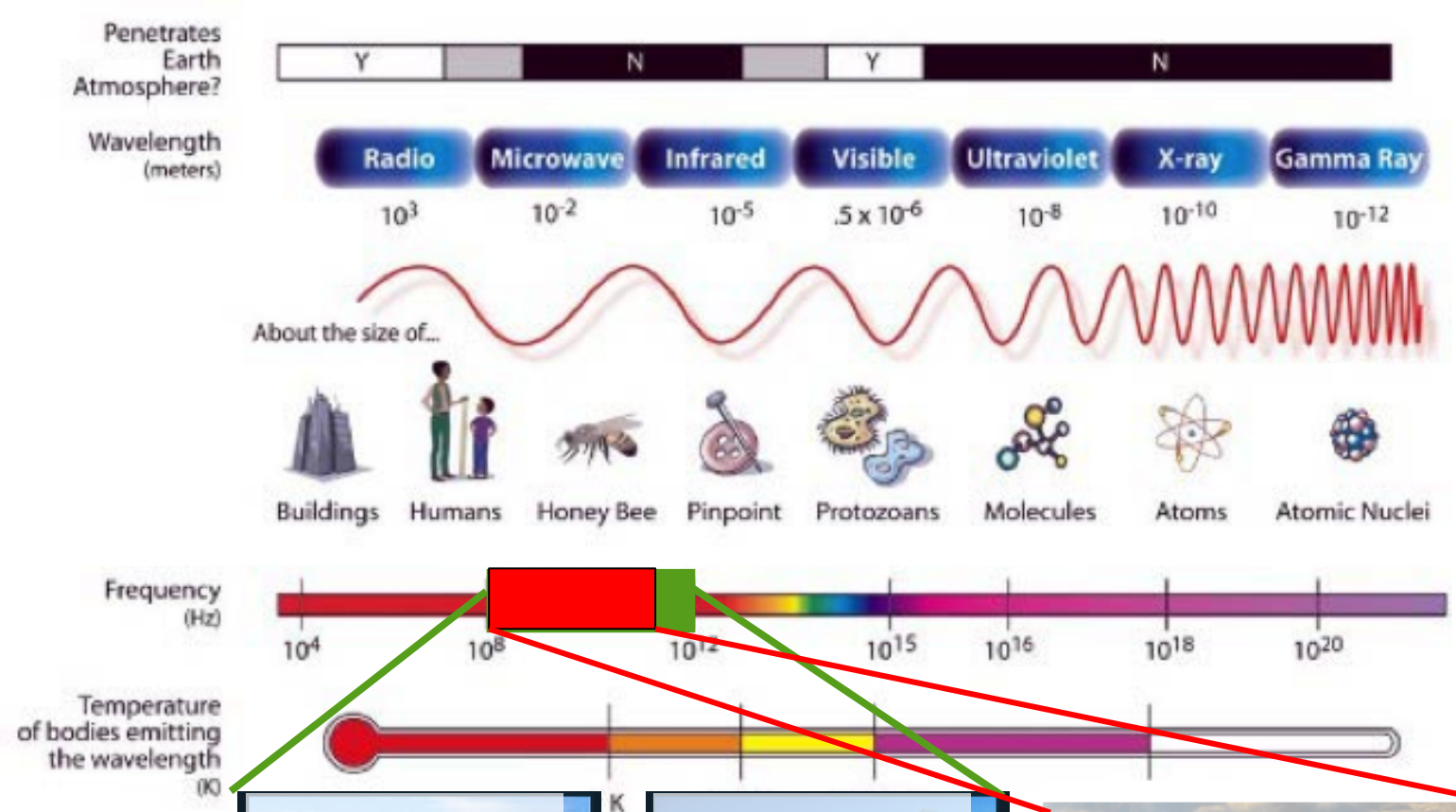
NRAO: One Observatory, Three World Class Facilities

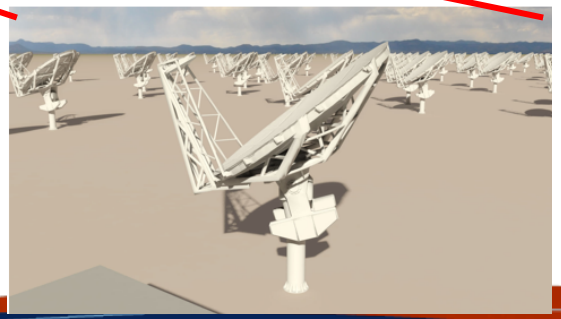
Atacama Large Millimeter/submillimeter Array: a 66-antenna array in Chile

What Are Radio Wavelengths?



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

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

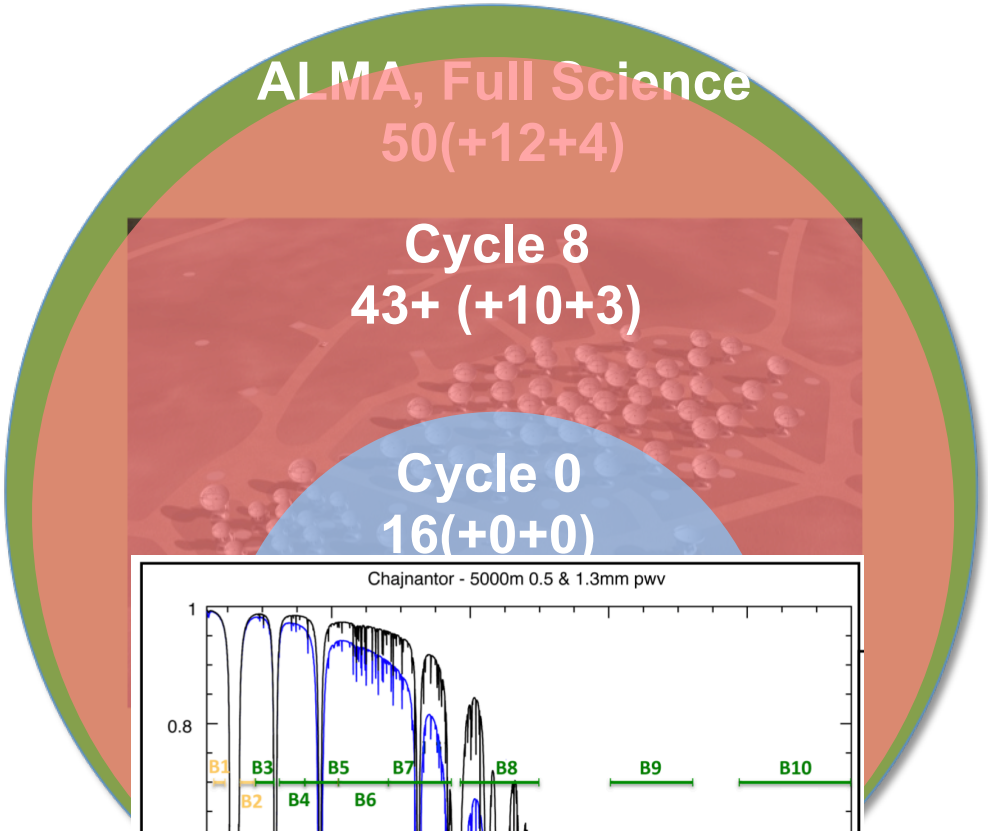
Antenna Locations = 192

Wavelengths = 0.32 – 8.5 mm

Best Resolution = 0.015" (at 300 GHz)

Collecting Area

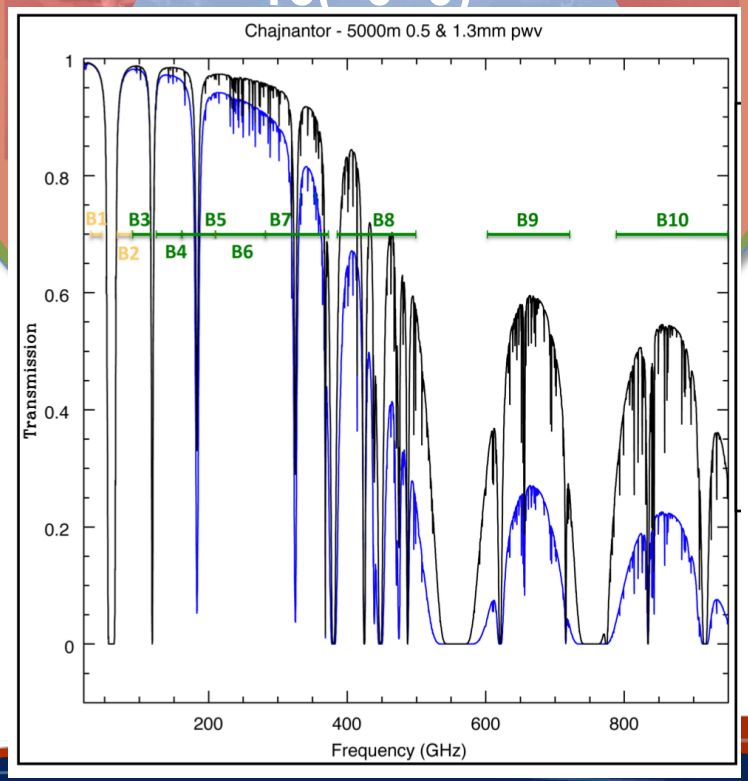
Not only sensitivity but the collecting area (1.6 acres or 6600+ m2) + huge number of baselines provides excellent image fidelity



Spectral Coverage -

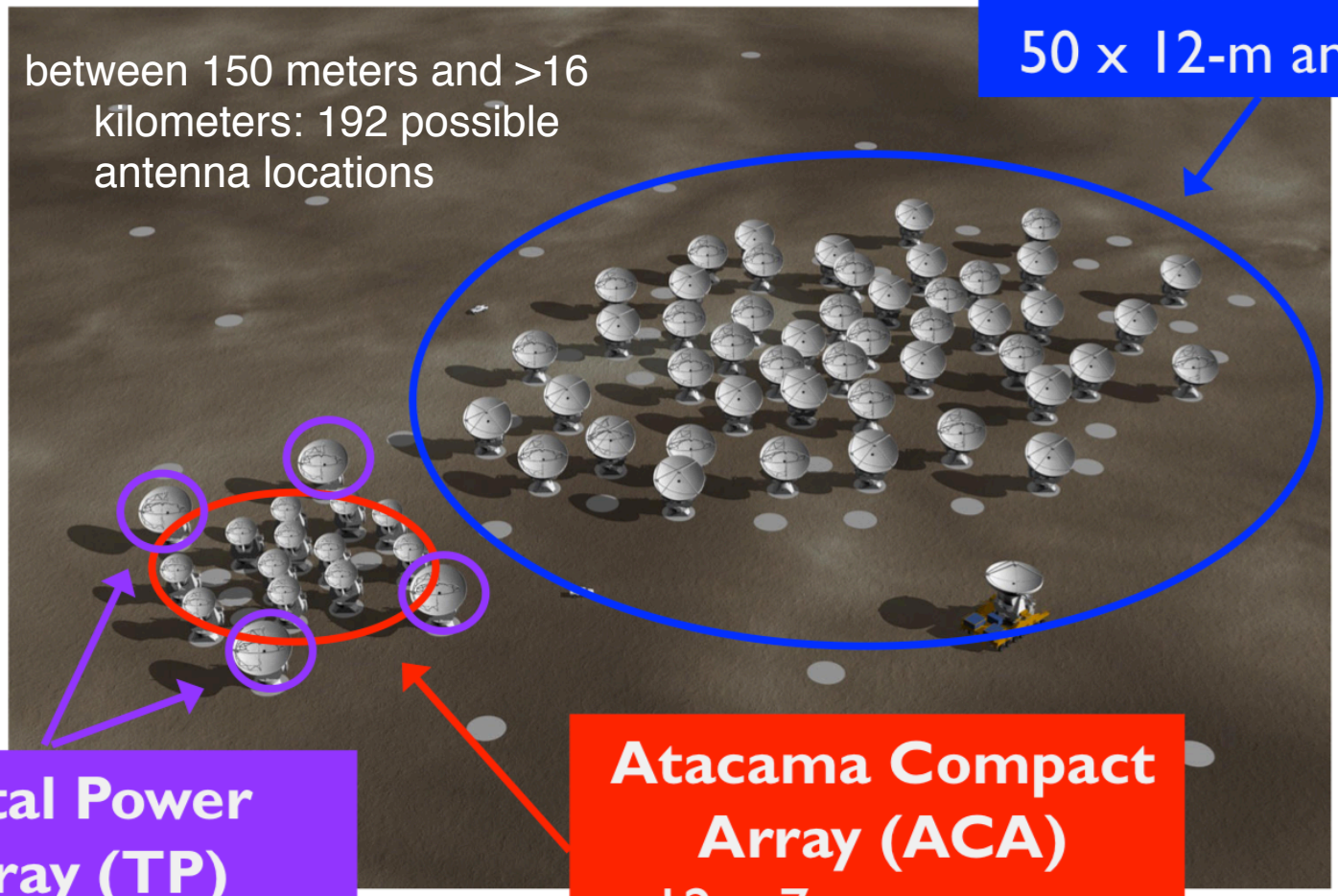
Covers ten atmospheric windows with 50% or more transmission above 35 GHz

https://almascience.nrao.edu/proposing/about-alma/atmosphere-model



transparency of the atmosphere above the ALMA site as a function of frequency

Array Configurations



*TP + ACA = Morita Array

NRAO

ALMA in a Nutshell...

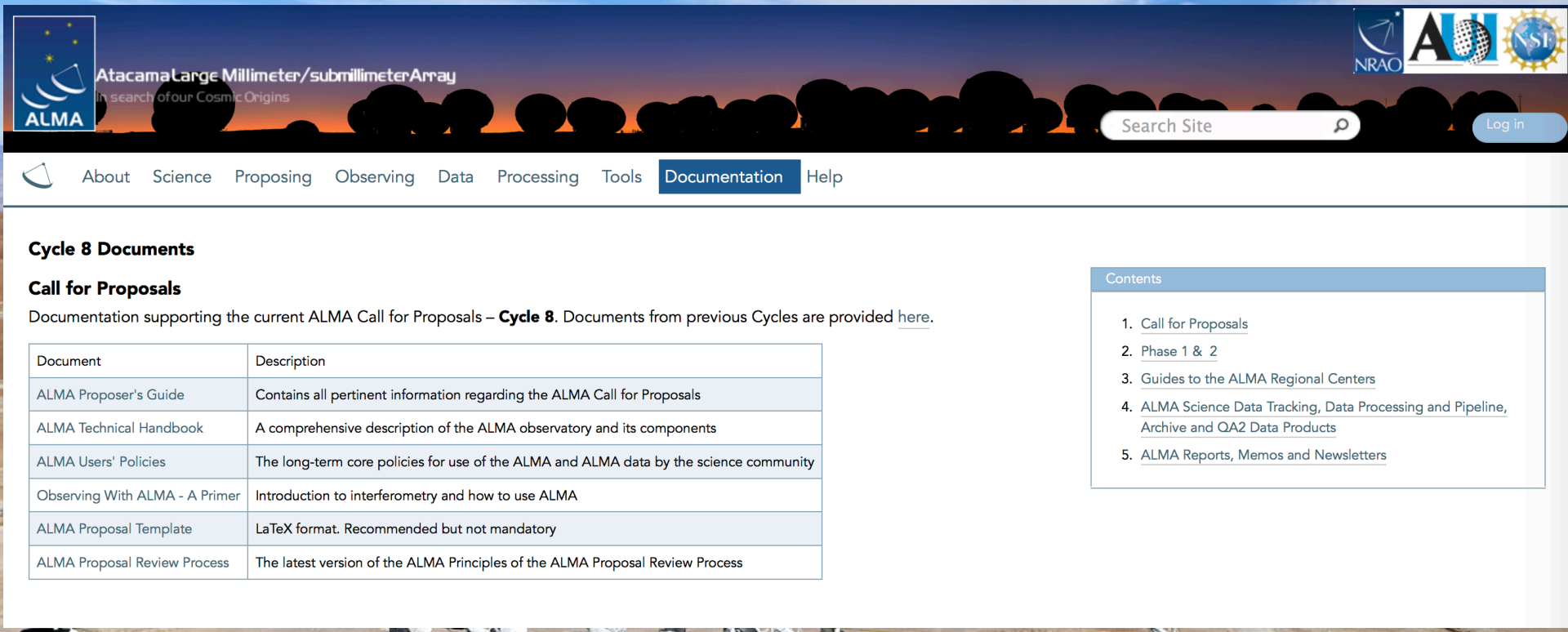
- Angular resolution down to 0.015” (at 300 GHz)
- Sensitive, precision imaging 84 to 950 GHz (3 mm to 320 μm)
- State-of-the-art low-noise, wide-band receivers* (8 GHz bandwidth)
- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities including circular.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

ALMA is *several* times more sensitive and has *several* times better angular resolution than current mm interferometers

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 8 observations

www.almascience.org



ALMA is a telescope for *all* astronomers

ALMA Cycle 8 Capabilities

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 ***notional*** 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 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
  - Observations using the 12-m array operating as a single dish for pulsar science

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 7 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.

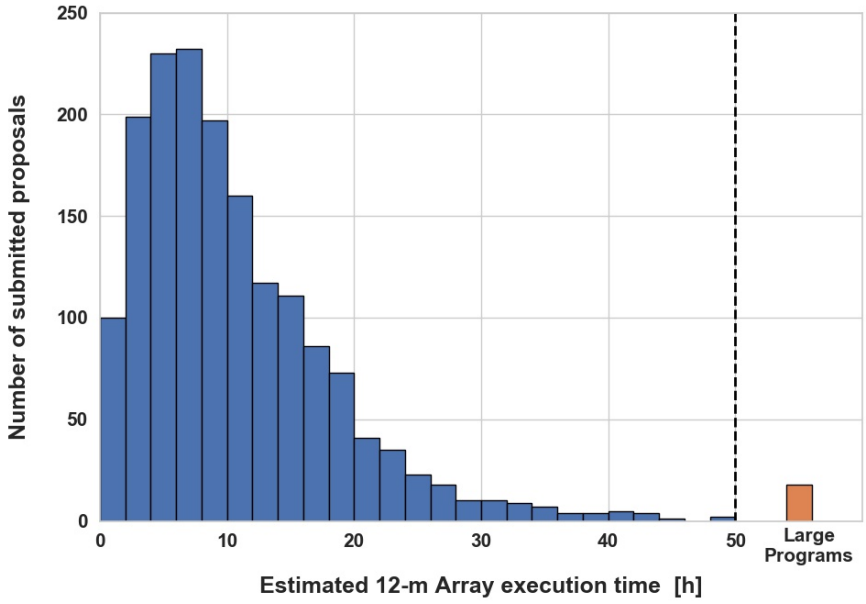
ALMA Capabilities

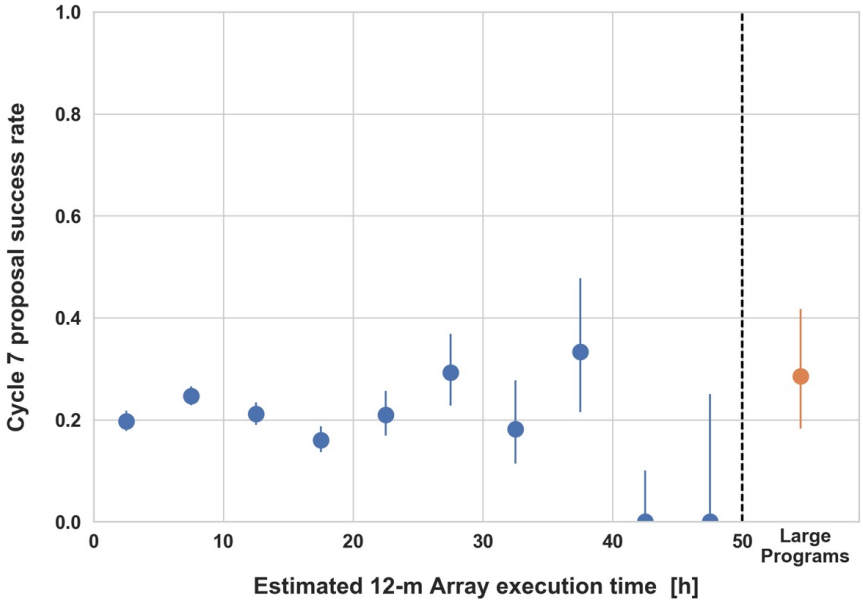
ACA Supplemental Call:

- 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

- **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





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 Portal 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:

- Time-critical ToO
- Full polarization observations
- Solar observations
- VLBI observations
- Pulsar mode
- 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 Main Call 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
15 April 2020 (15:00 UT)	Proposal submission deadline
End of July 2020	Announcement of the outcome of the Proposal Review Process
09 September 2020	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

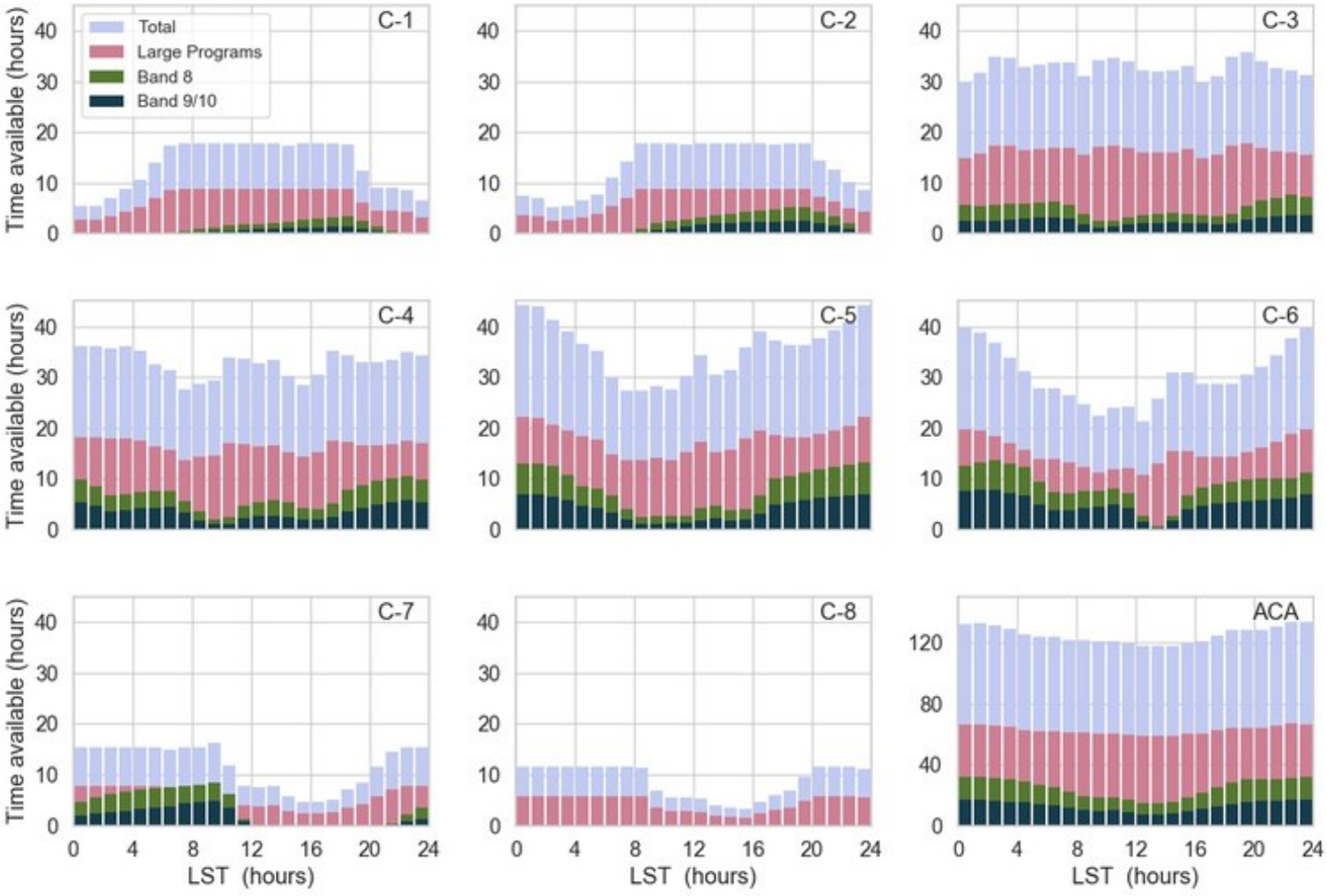
Date	Milestone
15 September 2020 (15:00 UT)	Call for Proposals and Supplemental Call submission server opened
08 October 2020 (15:00 UT)	Deadline to submit Supplemental Call proposals
22 October 2020	Proposals released to reviewers
29 October 2020 (15:00 UT)	Deadline for reviewer to report conflicts of interest on proposal review assignments
19 November 2020 (15:00 UT)	Deadline to submit reviews and ranks
Early December 2020	Notification emails sent to PIs
January 2021	Successful Supplemental Call proposals enter the observing queue

ALMA Array Configuration Schedule (Cycle 8)

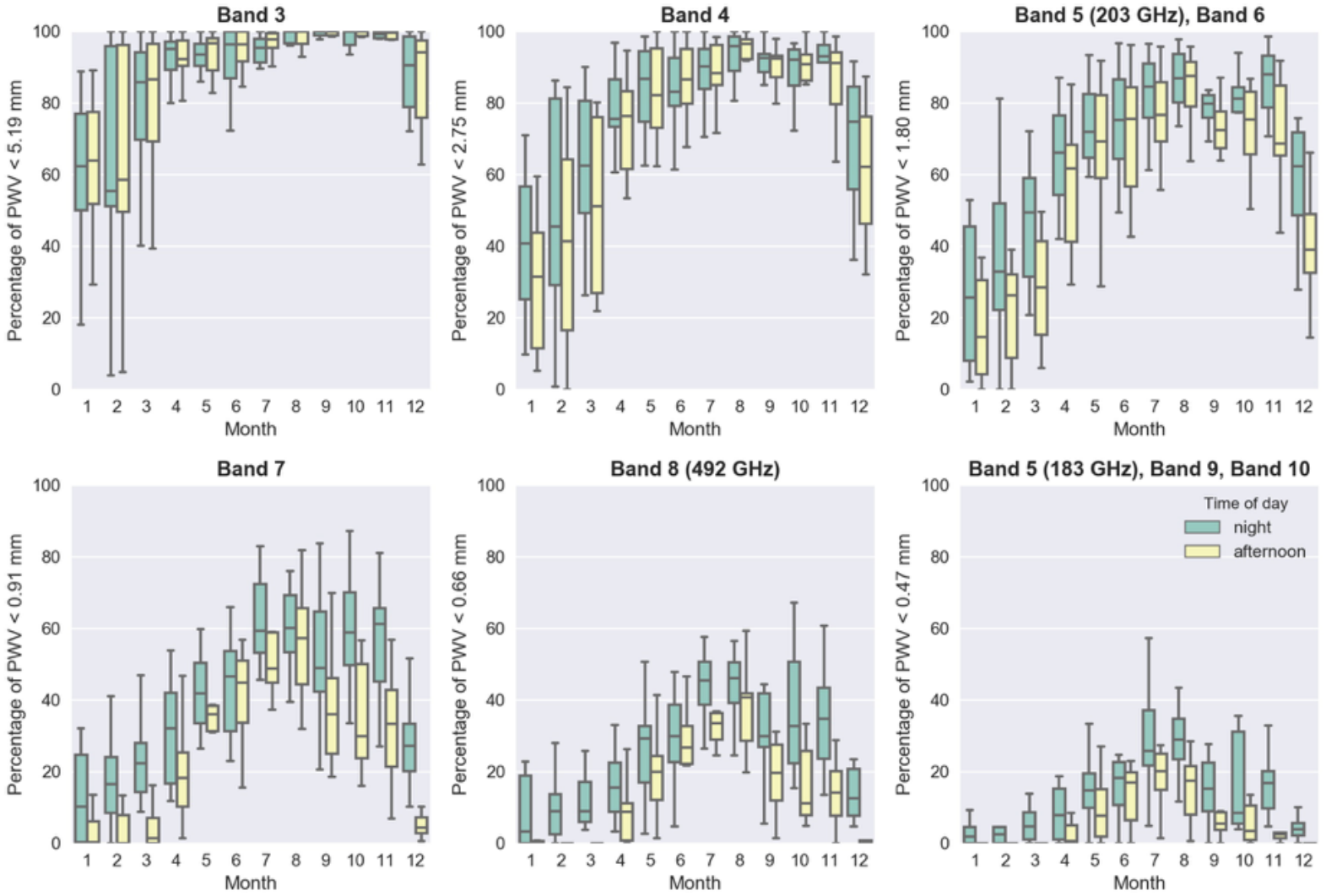
- Antenna configurations for the main 12-m array will use a new nomenclature in Cycle 8.
  - Configurations will be called C-1, C-2, and so on up to C-10, with C-1 having similar characteristics to the C43-1 configuration of Cycle 7, and likewise for the others.
  - Cycle 8 will NOT include the two longest 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)



ALMA Observing Strategies (Cycle 8)



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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