ALMA Basics and Cycle 9 Capabilities

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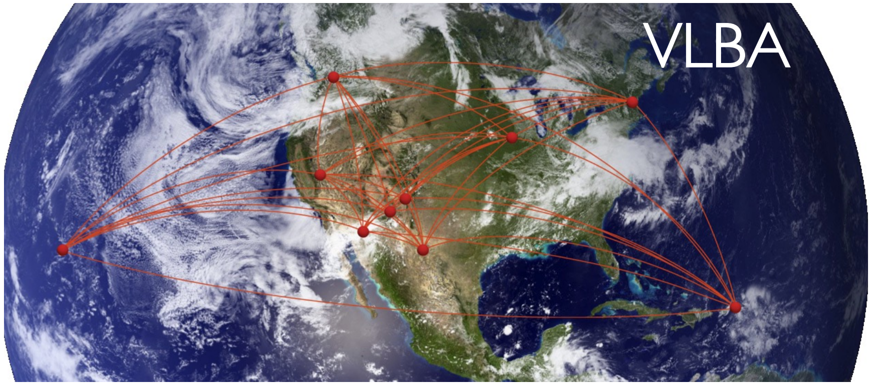
NRAO NSF AUI

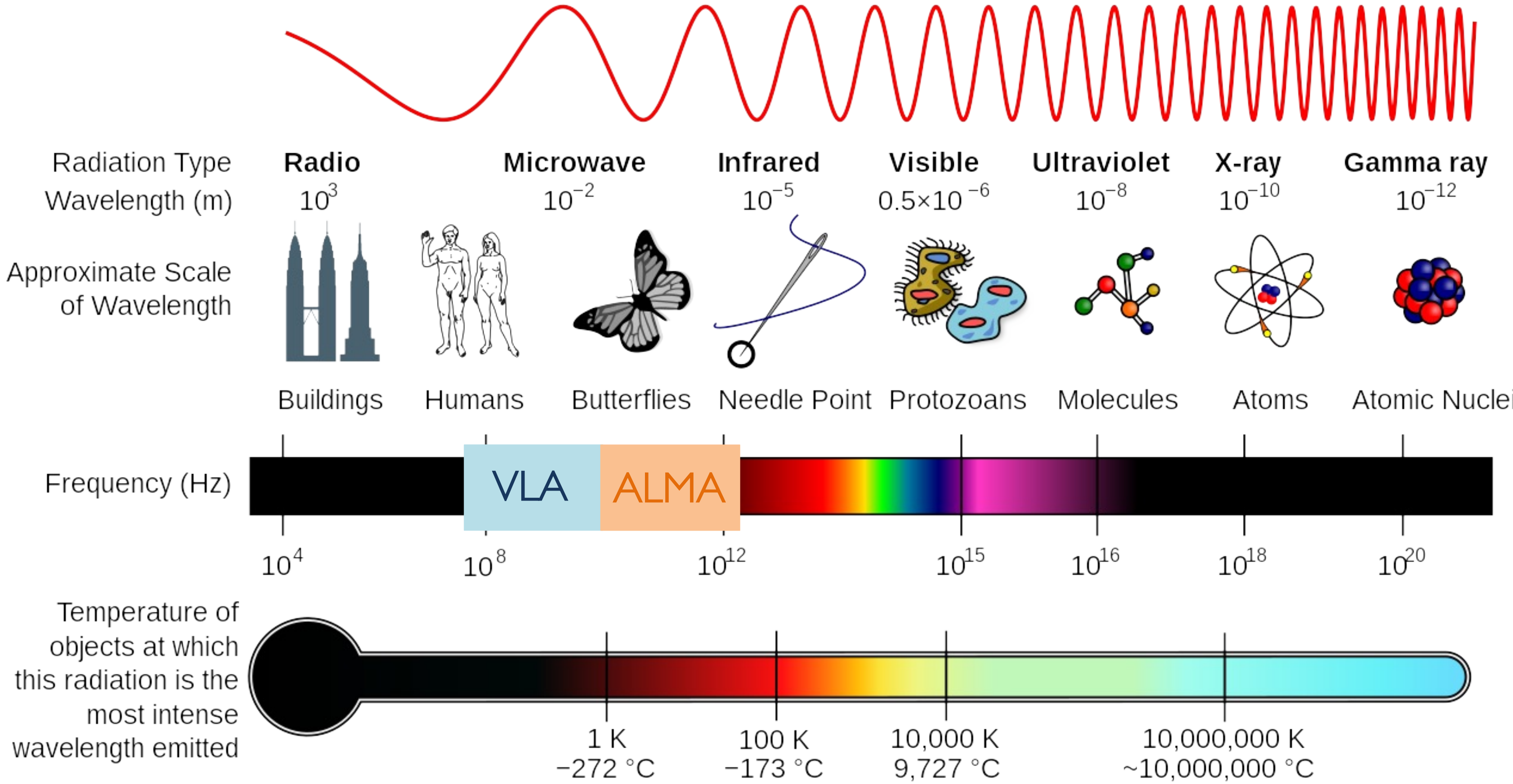
National Radio Astronomy Observatory



Atacama Large Millimeter/submillimeter Array (ALMA)

Karl G. Jansky Very Large Array (VLA)

Very Long Baseline Array (VLBA)


Radiation Type
Wavelength (m)
Radio
10^{3}
Microwave
10^{-2}
Infrared
10^{-5}
Visible
0.5×10^{-6}
Ultraviolet
10^{-8}
X-ray
10^{-10}
Gamma ray
10^{-12}
Approximate Scale of Wavelength
Buildings
Humans
Butterflies
Needle Point
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
VLA
ALMA
10^{4}
10^{8}
10^{12}
10^{15}
10^{16}
10^{18}
10^{20}
Temperature of objects at which this radiation is the most intense wavelength emitted
1 K
−272 °C
100 K
−173 °C
10,000 K
9,727 °C
10,000,000 K
~10,000,000 °C


VLA
1 – 50 GHz
300 – 6 mm


ALMA
84 – 950 GHz
3 – 0.3 mm

Broad science topics with ALMA (and NRAO telescopes)

Sun – coronal mass ejections, magnetic field activity

Solar system, KBOs – atmospheres, astrometry, composition

Star-forming regions – dust and gas environment, kinematics (in-fall, outflows, jets), protoplanetary 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 of North America, Europe, East Asia, and Chile

66 reconfigurable, high precision antennas with array configurations between 150 m and >16 km: 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

Located at 5000 m elevation in Chilean Andes

Provides unprecedented imaging & spectroscopic capabilities at mm/submm wavelengths

What is ALMA?

Angular Resolution

ALMA is an interferometer, which means that the angular resolutions goes as wavelength / largest baseline

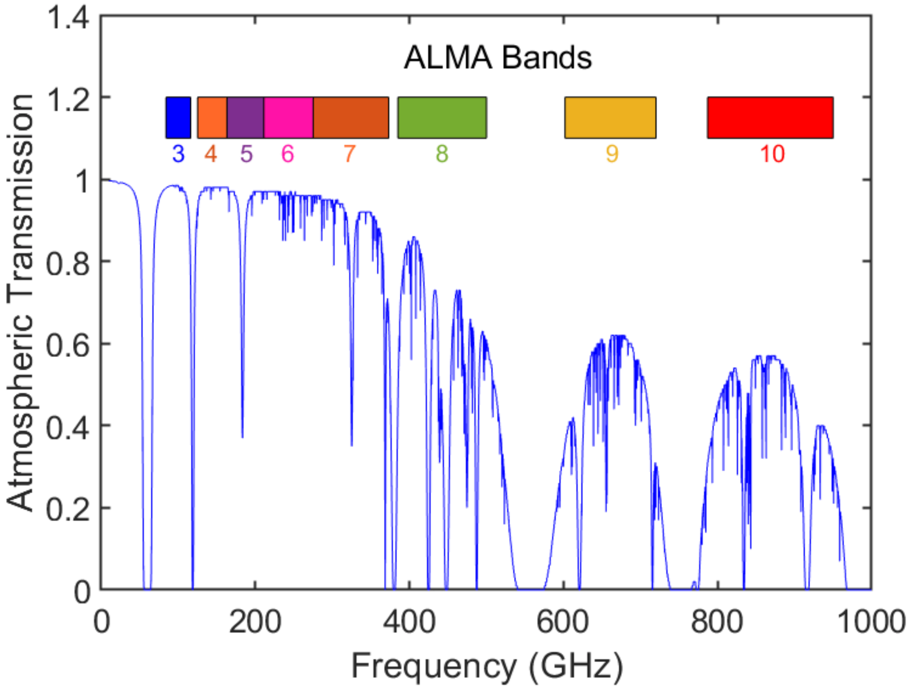
Collecting Area

Not only sensitivity but the collecting area (1.6 acres or 6600+ m^2) & large number of baselines provides excellent image fidelity

Spectral Coverage

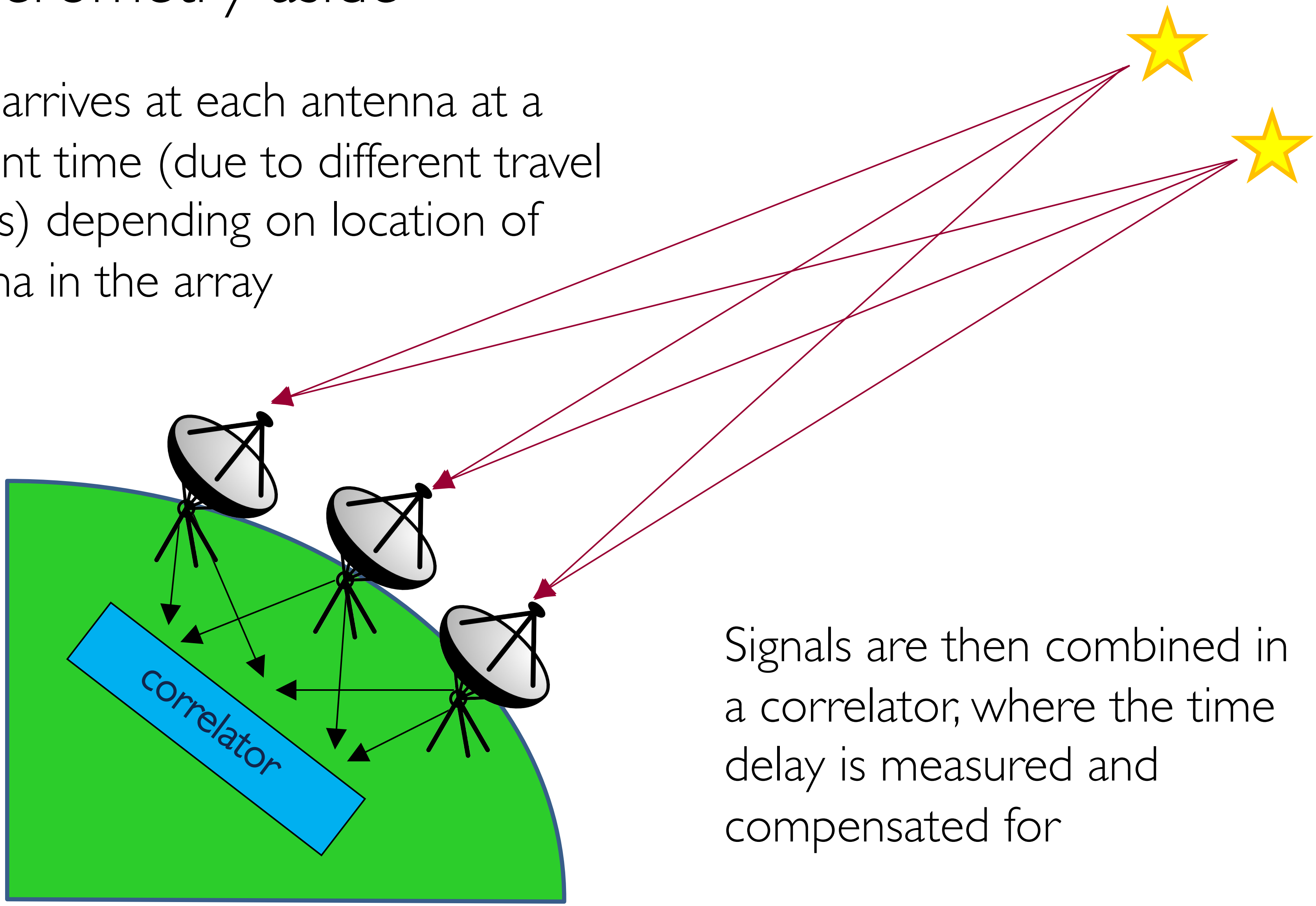
Atmospheric windows with >50% transmission above 35 GHz

54 (12-m) + 12 (7-m) antennas



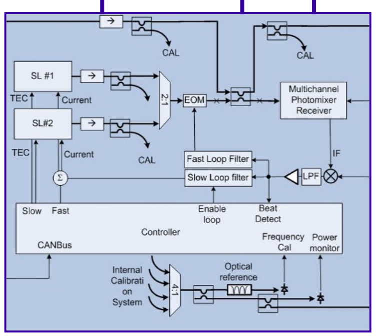
Interferometry aside

Signal arrives at each antenna at a different time (due to different travel lengths) depending on location of antenna in the array



Signals are then combined in a correlator, where the time delay is measured and compensated for

Correlator details



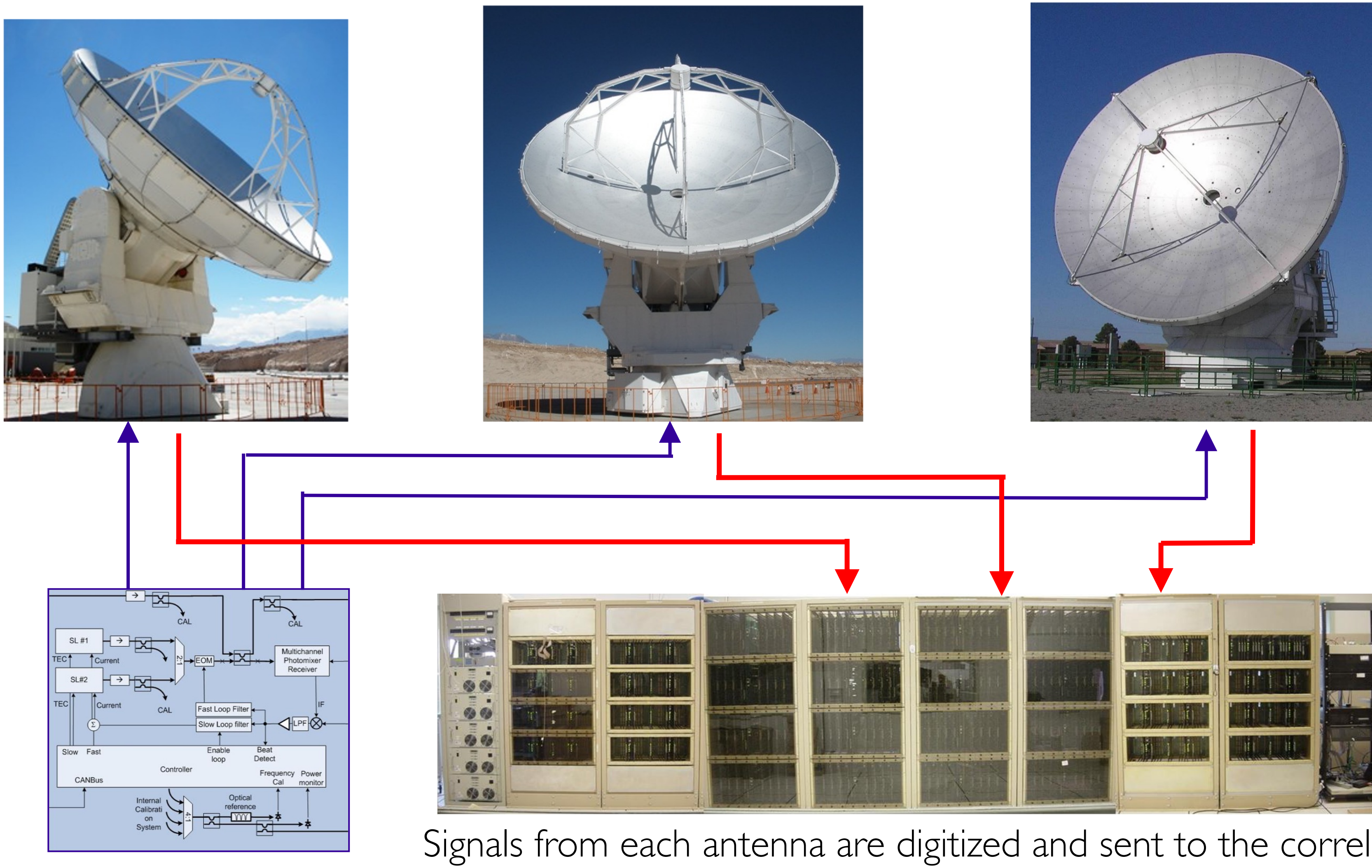
To measure arrival times, we need accurate clocks

At Band 10, one wavelength error = 1 picosecond = 10^{-12} s (!!)

Need ≪1 wavelength timing precision, so each antenna has an on-board clock with high sampling rates

Once determined, the reference time is distributed to all antennas

Correlator details



Signals from each antenna are digitized and sent to the correlator
For ~50 antennas, data rate is 600 GB/sec

Angular scales of an interferometry

Angular resolution of an array :

$\sim \lambda / B_{max}$ (B_{max} = longest baseline)

Maximum angular scale:

$\sim \lambda / B_{min}$ (B_{min} = shortest distance between antennas)

Field of view (FOV):

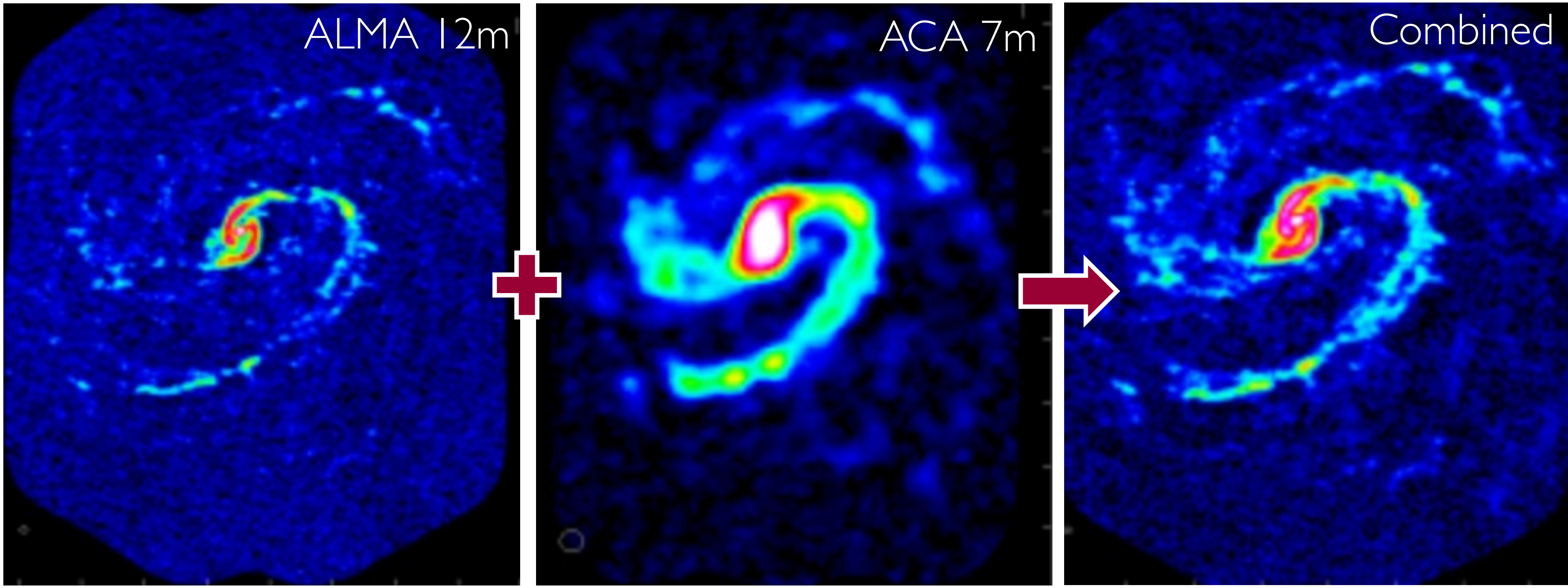
$\sim \lambda / D$ (D = antenna diameter)

*Sources more extended than the FOV can be observed using multiple pointing centers in a mosaic

An interferometer is sensitive to a range of angular sizes:

$$\lambda / B_{max} < \theta < \lambda / B_{min}$$

Characteristic angular scales: M100



ALMA 12m shows smaller spatial scales (denser / clumpier emission)

ACA 7m data shows larger spatial scales (diffuse / extended emission)

To get both — you need a combined image!

Angular scales – a proposal tip!

Interferometers act as spatial filters - shorter baselines are sensitive to larger targets

Spatial scales larger than the smallest baseline cannot be imaged

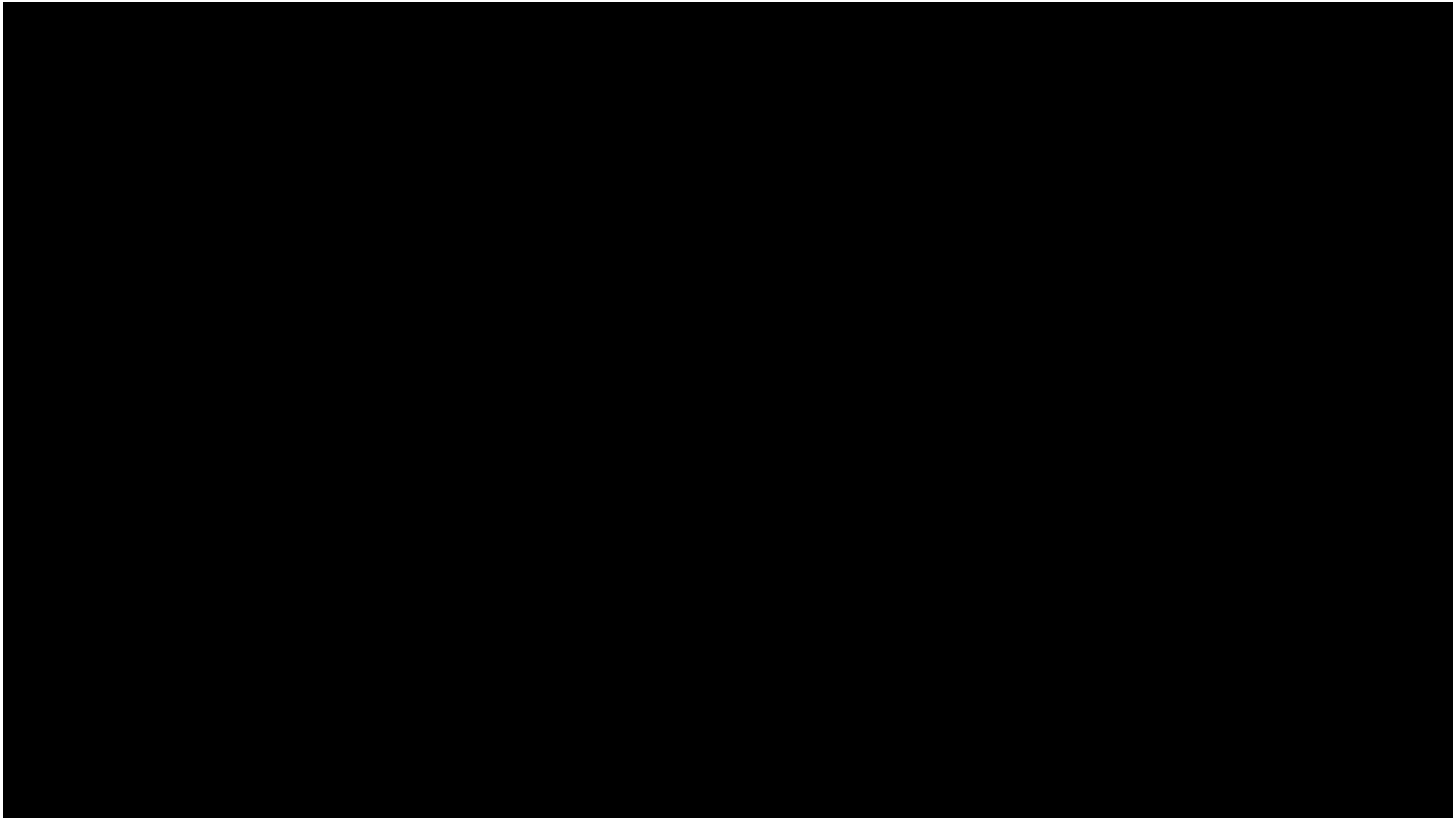
Spatial scales smaller than the largest baseline cannot be resolved

Table A-1: Angular Resolutions (AR) and Maximum Recoverable Scales (MRS) for the Cycle 9 configurations

Config	Lmax		Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Band 9	Band 10
	Lmin		100 GHz	150 GHz	185 GHz	230 GHz	345 GHz	460 GHz	650 GHz	870 GHz
7-m	45 m	AR	12.5”	8.35”	6.77”	5.45”	3.63”	2.72”	1.93”	1.44”
	9 m	MRS	66.7”	44.5”	36.1”	29.0”	19.3”	14.5”	10.3”	7.67”
C-1	161 m	AR	3.38”	2.25”	1.83”	1.47”	0.98”	0.74”	0.52”	0.39”
	15 m	MRS	28.5”	19.0”	15.4”	12.4”	8.25”	6.19”	4.38”	3.27”
C-2	314 m	AR	2.30”	1.53”	1.24”	1.00”	0.67”	0.50”	0.35”	0.26”
	15 m	MRS	22.6”	15.0”	12.2”	9.81”	6.54”	4.90”	3.47”	2.59”
C-3	500 m	AR	1.42”	0.94”	0.77”	0.62”	0.41”	0.31”	0.22”	0.16”
	15 m	MRS	16.2”	10.8”	8.73”	7.02”	4.68”	3.51”	2.48”	1.86”
C-4	784 m	AR	0.92”	0.61”	0.50”	0.40”	0.27”	0.20”	0.14”	0.11”
	15 m	MRS	11.2”	7.50”	6.08”	4.89”	3.26”	2.44”	1.73”	1.29”
C-5	1.4 km	AR	0.55”	0.36”	0.30”	0.24”	0.16”	0.12”	0.084”	0.063”
	15 m	MRS	6.70”	4.47”	3.62”	2.91”	1.94”	1.46”	1.03”	0.77”
C-6	2.5 km	AR	0.31”	0.20”	0.17”	0.13”	0.089”	0.067”	0.047”	0.035”
	15 m	MRS	4.11”	2.74”	2.22”	1.78”	1.19”	0.89”	0.63”	0.47”
C-7	3.6 km	AR	0.21”	0.14”	0.11”	0.092”	0.061”	0.046”	0.033”	0.024”
	64 m	MRS	2.58”	1.72”	1.40”	1.12”	0.75”	0.56”	0.40”	0.30”
C-8	8.5 km	AR	0.096”	0.064”	0.052”	0.042”	0.028”	0.021”	0.015”	0.011”
	110 m	MRS	1.42”	0.95”	0.77”	0.62”	0.41”	0.31”	0.22”	0.16”
C-9	13.9 km	AR	0.057”	0.038”	0.031”	0.025”	0.017”	0.012”	0.0088”	N/A
	368 m	MRS	0.81”	0.54”	0.44”	0.35”	0.24”	0.18”	0.13”	
C-10	16.2 km	AR	0.042”	0.028”	0.023”	0.018”	0.012”	0.0091”	N/A	N/A
	244 m	MRS	0.50”	0.33”	0.27”	0.22”	0.14”	0.11”		

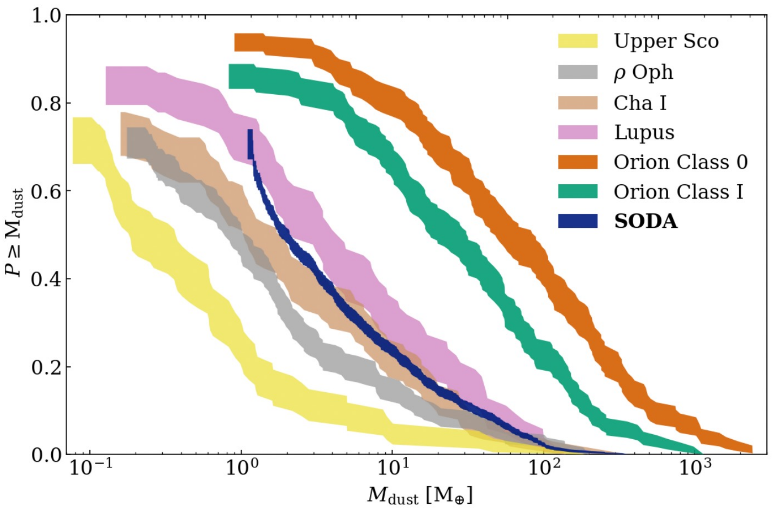
From ALMA Cycle 9 Proposer’s Guide

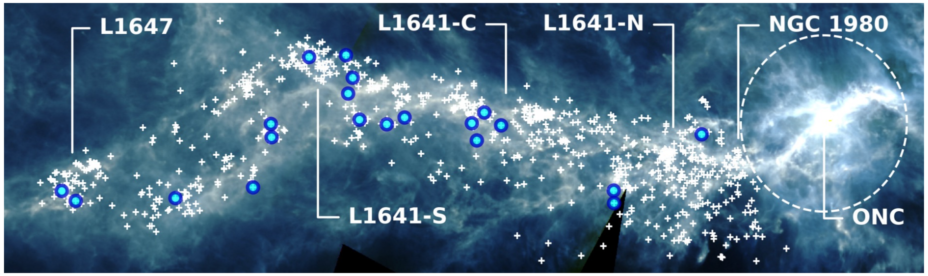
Array configurations between 150 m and >16 km and 192 possible antenna locations



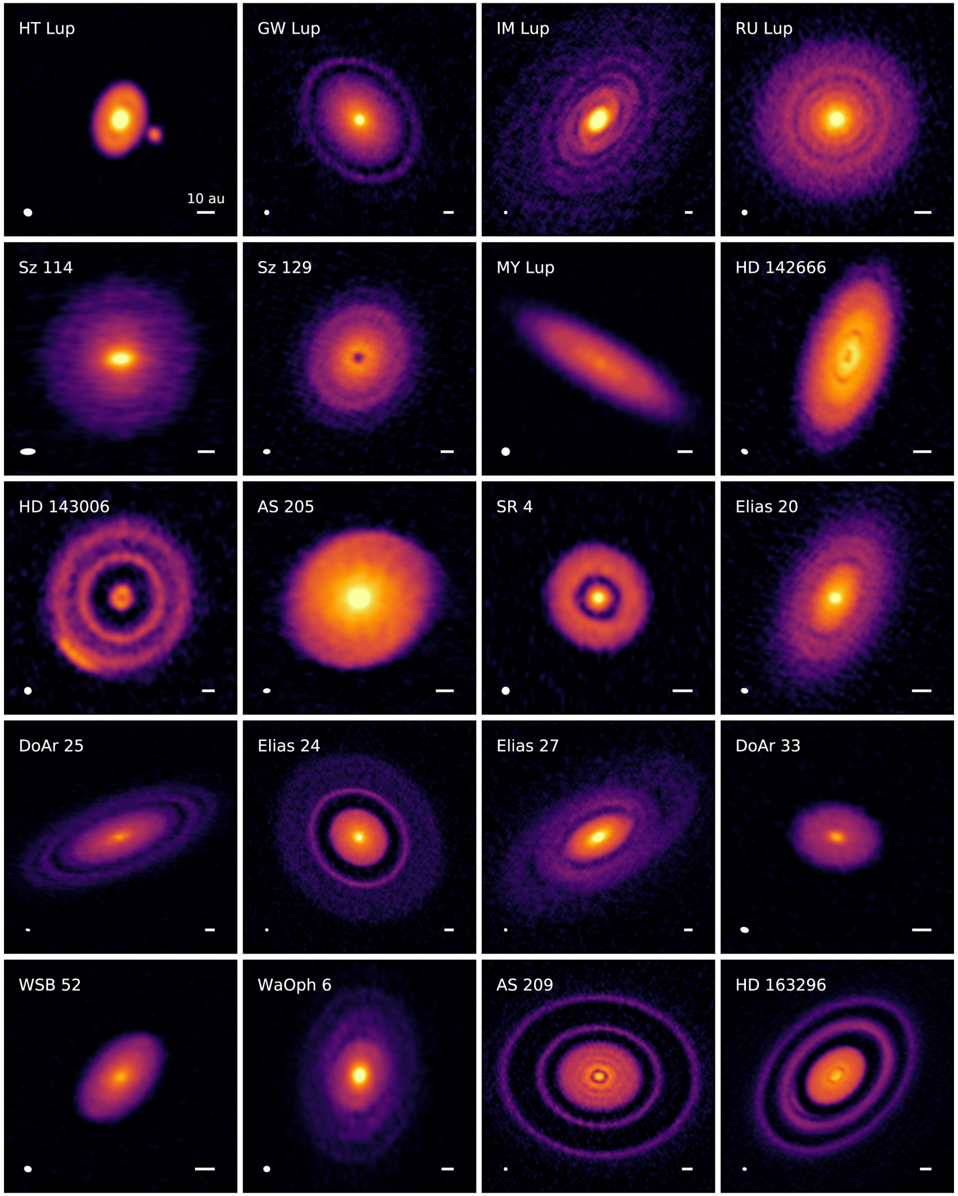
Imaging highlights: dust in protoplanetary disks

ALMA has enabled studies of disk demographics to highly detailed views of substructure in individual disks





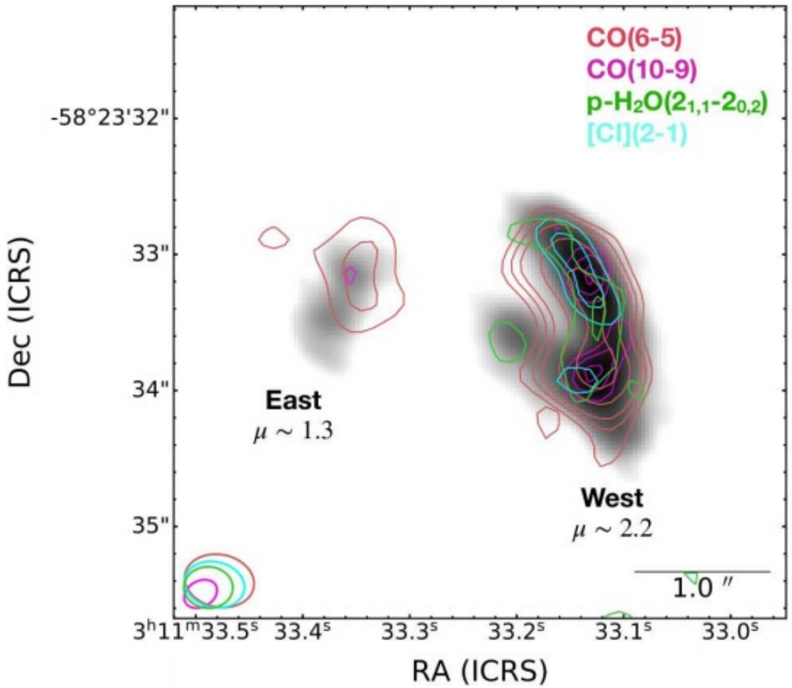
SODA, van Terwisga+22



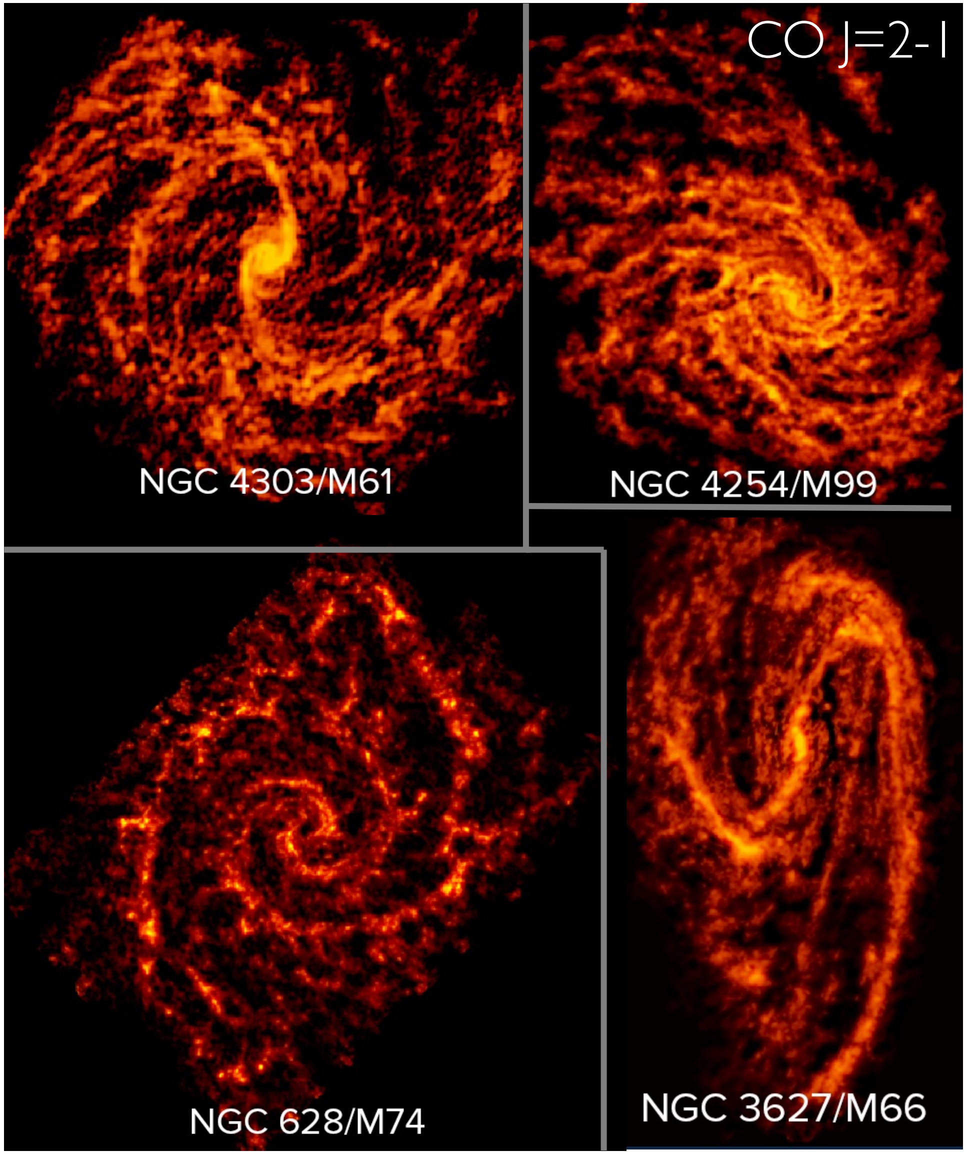
DSHARP, Andrews+18, Huang+18

Imaging highlights: gas in galaxies

ALMA can study nearby galaxies in molecular line emission in detail and detect gas in high-z sources



Gas in dusty star-forming galaxy at z~7
Jarugula+21

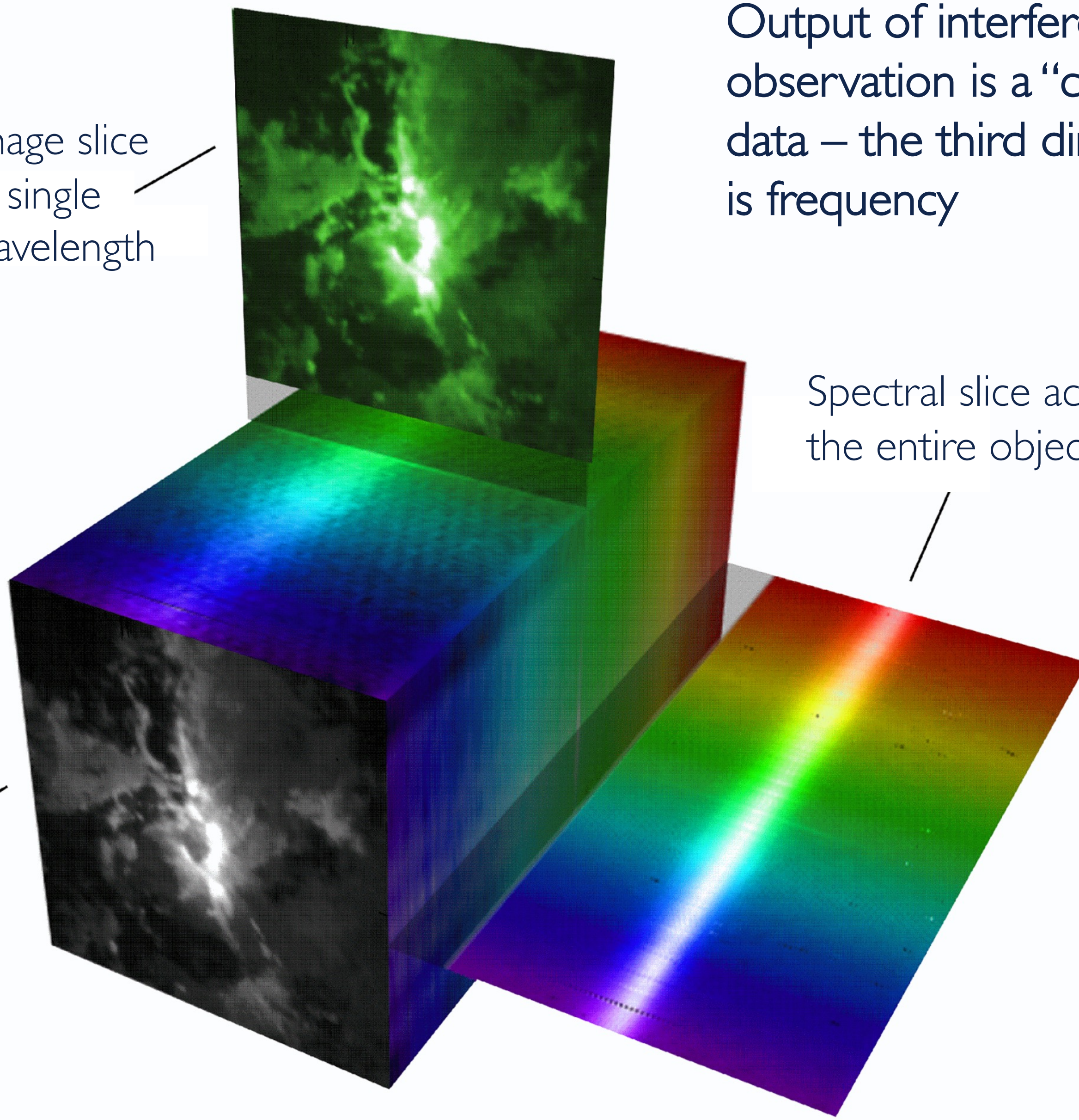


PHANGS, Leroy+21

Not only imaging, but 3D info in spectra

Output of interferometric observation is a "cube" of data – the third dimension is frequency

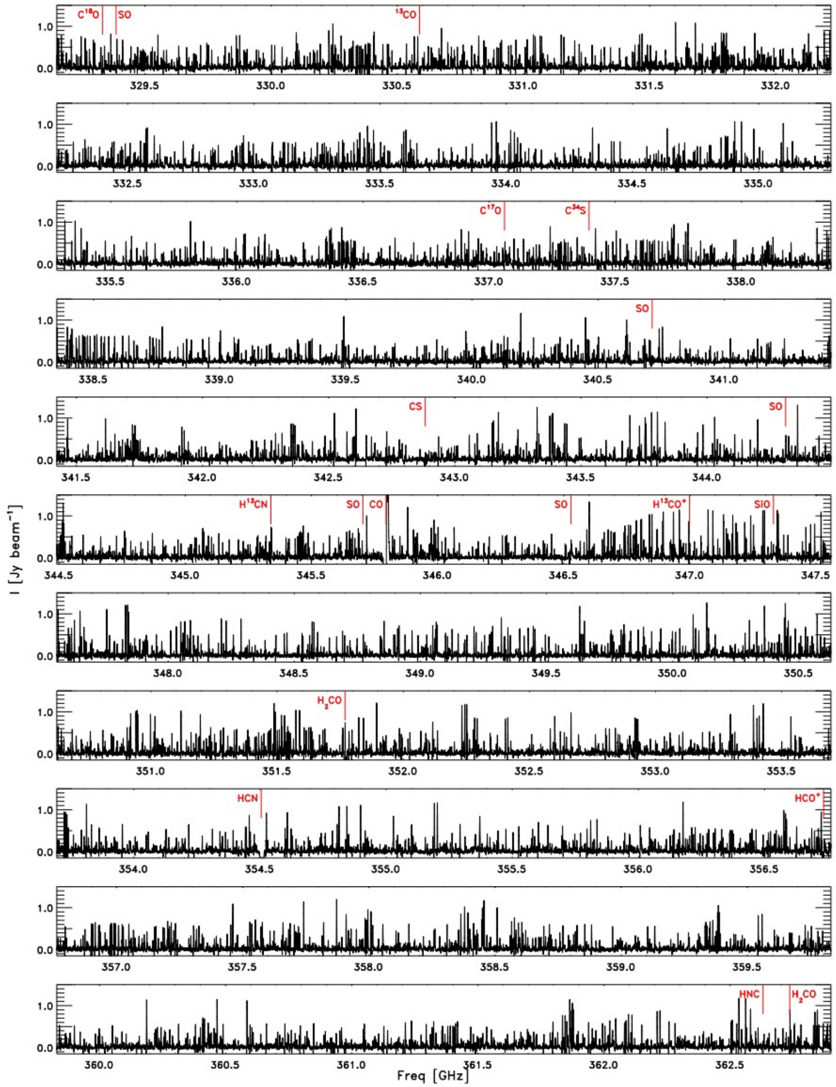
Image slice at single wavelength



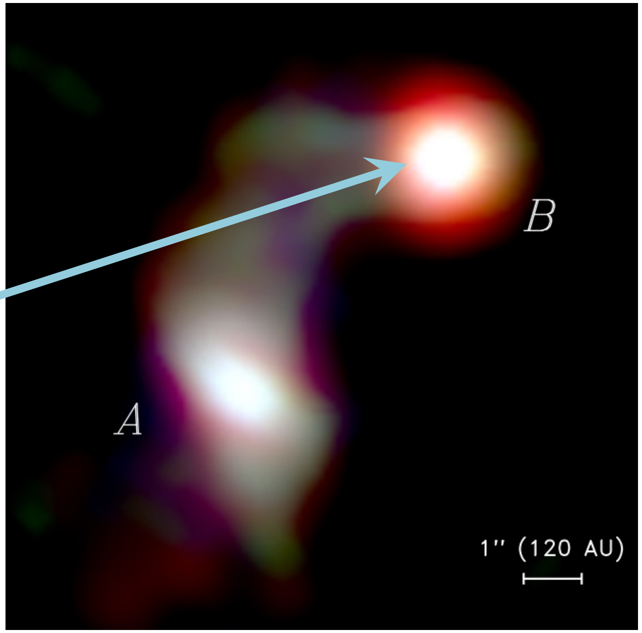
Spectral slice across the entire object

Object seen in combined light

Often most interesting science is in 3rd dimension



Young Low Mass Stars: IRAS 16293

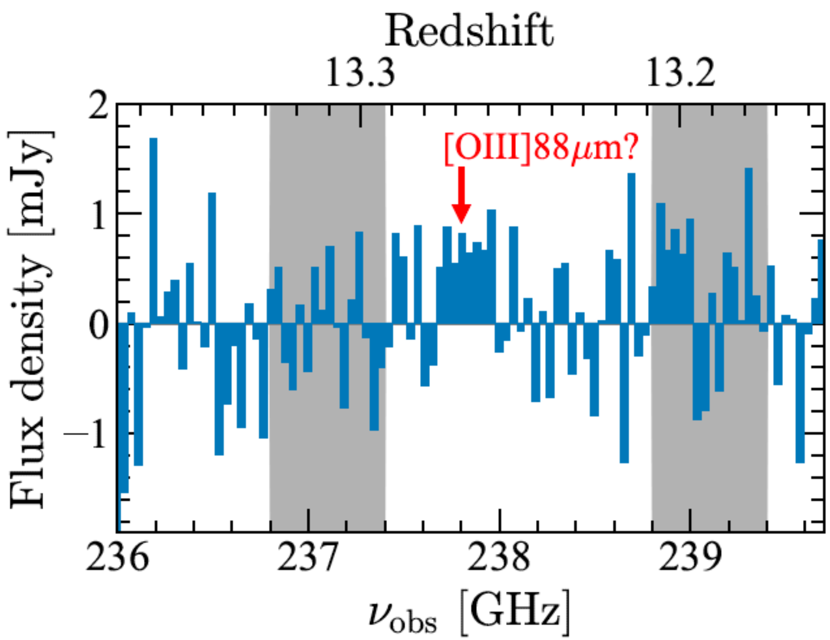


PILS, Jørgensen+16

High degree of chemical complexity, including lines from complex organic molecules

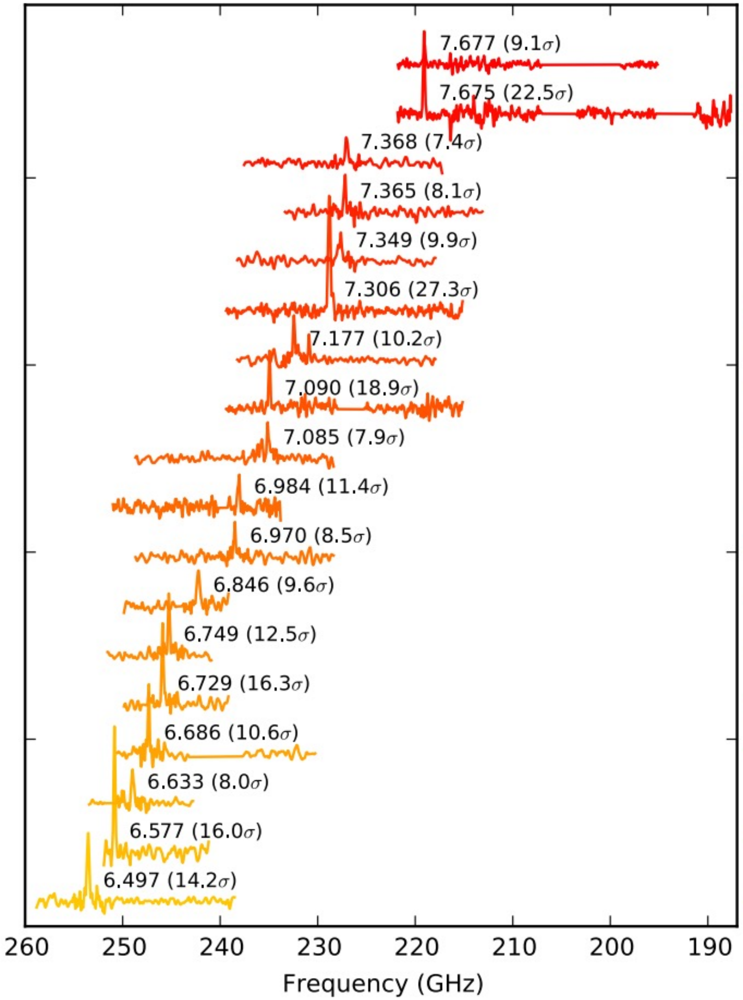
Often most interesting science is in 3rd dimension

Lines are detectable in high redshift sources and upcoming upgrades will only improve similar searches



tentative [O III] 88 μm line at z = 13.27
Harikane+21

UV-bright galaxies which emit [C II] strongly

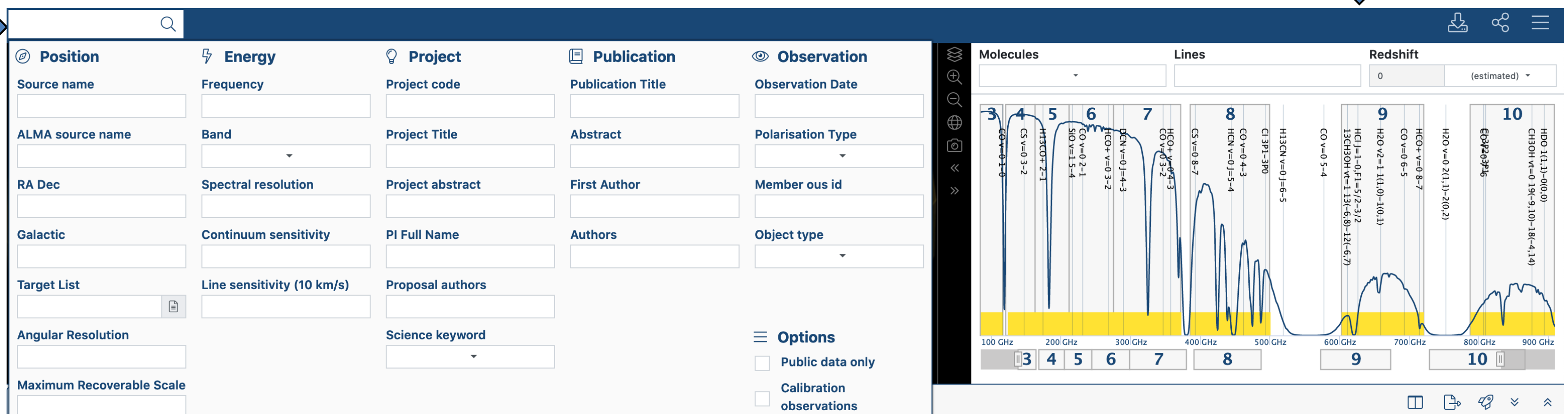


REBELS, Bouwens+21

ALMA hosts an extensive archive of previous observations!

Filter columns based on target, publication, etc.

Spectral window viewer

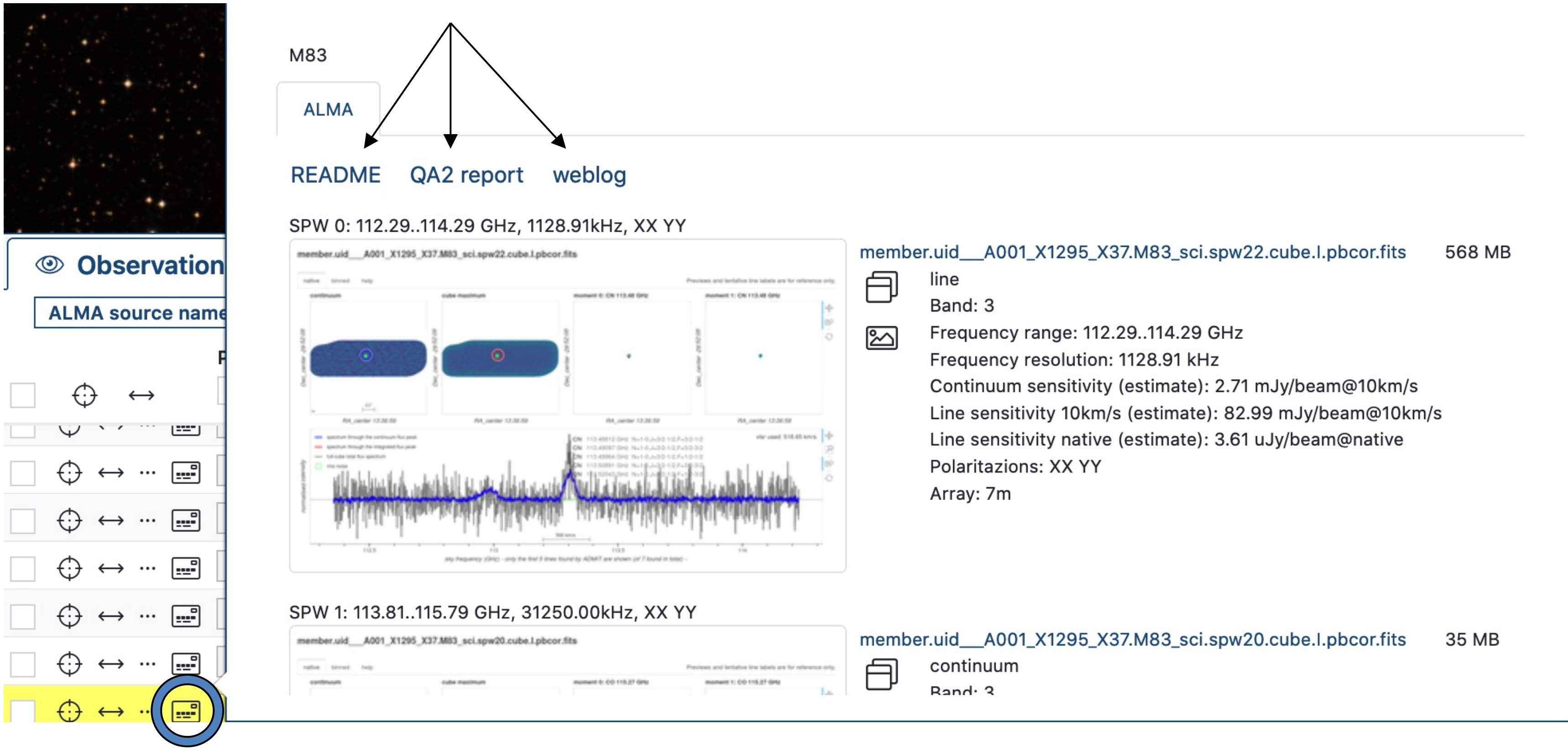


List of programs

Project code	ALMA source name	Ra (h:m:s)	Dec (d:m:s)	Band	Cont. sens. (mJy/beam)	Frequency support	↑ Release date	Publications	Ang. res. (arcsec)	Min. vel. res. (km/s)	Array	Mosaic	Max. reco. scale (arcsec)	FOV (arcsec)	Scientific category	Science keywo
2018.1.01205.L	IRAS_15398-3359	15:43:02.242	-34:09:06.805	6	0.0532	216.08..234.73GHz	0012-01-20	2	1.204	0.183	12m		22.473	25.833	ISM and star formation	Low-mass star f
2011.0.00191.S	Fomalhaut b	22:57:38.685	-29:37:12.616	7	0.1181	343.08..358.84GHz	2012-12-06	2	1.021	0.816	12m		14.433	16.592	Disks and planet forma...	Debris disks, Ex
2011.0.00101.S	GRB021004	00:26:54.680	+18:55:41.600	7	0.1136	337.01..353.00GHz	2012-12-06	2	1.322	26.541	12m		14.682	16.878	Active galaxies	Starburst galaxi
2011.0.00131.S	R Scl	01:26:58.079	-32:32:36.424	7	0.9115	330.25..346.11GHz	2012-12-06	5	1.241	0.846	12m	mosaic	14.979	62.007	Stars and stellar evolut...	Asymptotic Giar
2011.0.00397.S	J035448.24-33082...	03:54:48.240	-33:08:27.200	7	0.4848	337.03..353.01GHz	2012-12-20	3	1.372	26.541	12m		10.183	16.877	Active galaxies	Active Galactic
2011.0.00397.S	J041754.10-281655.9	04:17:54.100	-28:16:55.900	7	0.4848	337.02..353.01GHz	2012-12-20	3	1.400	26.541	12m		10.521	16.877	Active galaxies	Active Galactic
2011.0.00397.S	J063027.81-212058...	06:30:27.810	-21:20:58.600	7	0.5346	337.01..352.99GHz	2012-12-20	3	1.279	26.541	12m		8.285	16.878	Active galaxies	Active Galactic
2011.0.00397.S	J061200.23-06220...	06:12:00.230	-06:22:09.600	7	0.5346	337.00..352.99GHz	2012-12-20	3	1.303	26.541	12m		8.828	16.878	Active galaxies	Active Galactic

Often including quick-look images and spectra

Click on links for direct download of files



Hover over for quick look

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

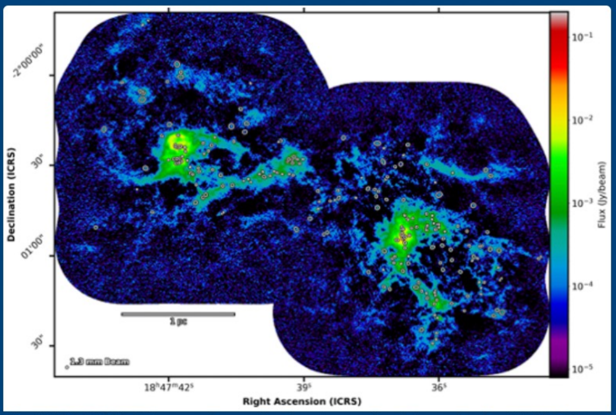
ALMA is 10-100 times more sensitive and has 10-100 times better angular resolution than current mm interferometers

Atacama Large Millimeter/submillimeter Array
In search of our Cosmic Origins

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

Science Highlight

Top-heavy Core Mass function revealed by ALMA-IMF: a challenge to the IMF universality



The W43-MM2&MM3 protocluster cloud, as imaged at 1.3 mm by the ALMA 12 m array. White ellipses outline the size of the 208 compact cores of few thousand AU size extracted by the core extraction algorithm getsf.

The ALMA-IMF Large Program aims to answer the longstanding question on whether the Initial Mass Function (IMF) inherits its shape from its core content, and more precisely the Core Mass Function (CMF). To do that, ALMA-IMF has targeted and imaged 15 high-mass star-forming regions in the nearby Milky Way (d ≤ 6 kpc). In a recently accepted paper (Pouteau et al.,2022), the team has used high-resolution, ~ 0.5 arcsec, Band 6 (1.3 mm) and Band 3 (3 mm) data to detect and extract ~200 peaked cloud structures of few thousand AU, called cores, in the W43-MM2&MM3 protocluster cloud (see figure). The authors find that, unlike what was found for several decades, the CMF of this cloud - qualified as mini-starburst - is top-heavy, i.e. it has an excess of high-mass cores compared to low and...

More...

Observatory News

ALMA Cycle 9 Call for Proposals is Now OPEN!
Mar 24, 2022

ALMA Science Archive previews
Feb 14, 2022

QA0+ results now available from SnooPI
Jan 31, 2022

ALMA Cycle 9 Pre-Announcement
Dec 15, 2021

ALMA Science Archive object-type search, text-based similarity search and Jupyter Notebooks
Dec 14, 2021

More...

NRAO Events

18th Synthesis Imaging Workshop
May 18, 2022

The VLA Sky Survey in the Multiwavelength Spotlight
Sep 07, 2022

AAS: NRAO Town Hall
Dec 31, 2022

AAS: ALMA Special Session: ALMA Status & Plans for Increased Capability
Dec 31, 2022

AAS: ngVLA Special Session: Chemical Probes of Astrophysical Systems
Dec 31, 2022

More...

ALMA Status

Configuration Sche

Refereed publicatio
Last observed sourc
Current configuratio

More...

The ALMA Science Portal is a one-stop source for information and tools aimed at the scientific community as a whole, including proposers, archive researcher funding agencies.

Quick Links

ALMA Basics	Cycle 9 Call for Proposals
ALMA Science	Cycle 9 Proposer's Guide
ALMA Primer	Proposing Guidance

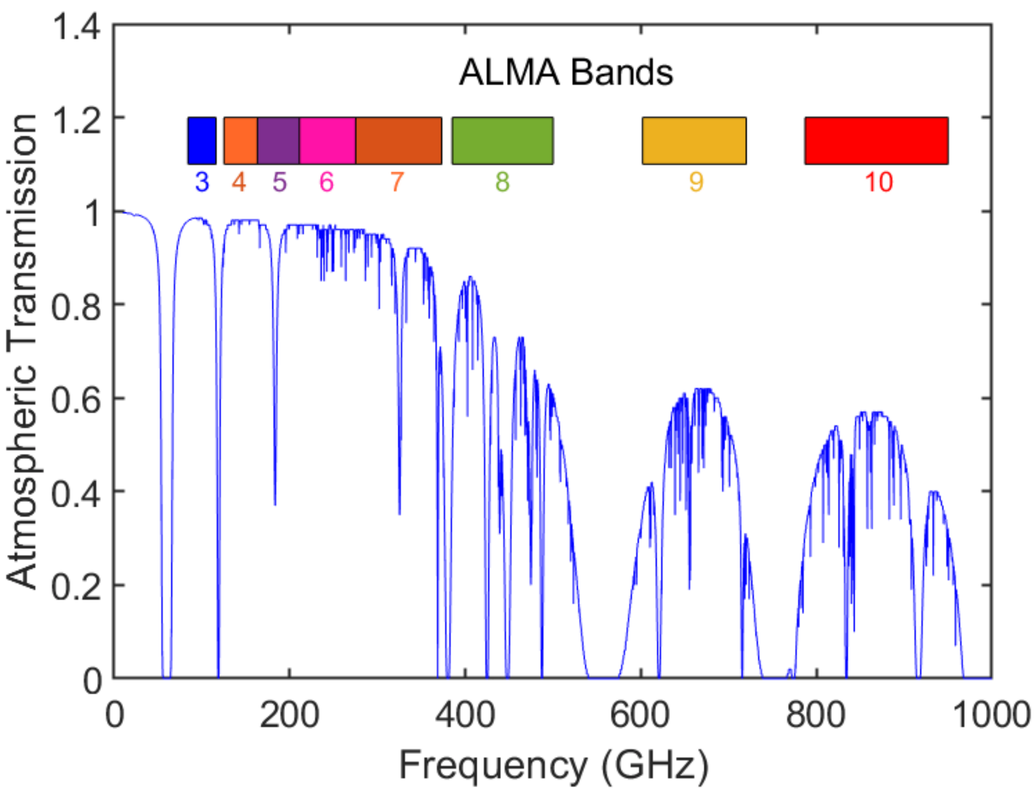
ALMA is a telescope for *all* astronomers

You do not need to be an expert to propose!

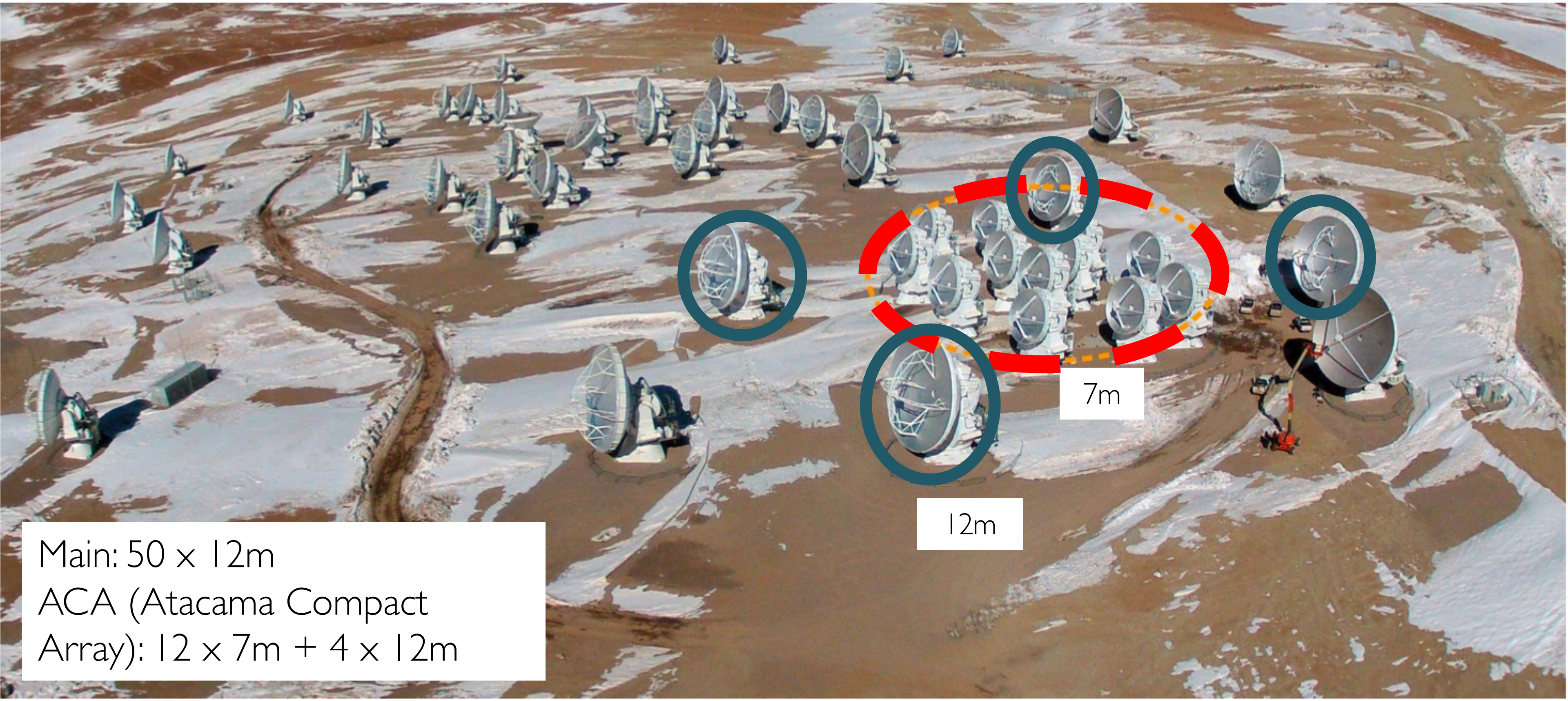
ALMA Cycle 9 Capabilities

ALMA frequency bands

Band	Frequency (wavelength)
3	84-116 GHz (2.59-3.57mm)
4	125-163 GHz (1.84-2.40mm)
5	158-211 GHz (1.42-1.90mm)
6	211-275 GHz (1.09-1.42mm)
7	275-373 GHz (0.80-1.09mm)
8	385-500 GHz (0.60-0.78mm)
9	602-720 GHz (0.42-0.50mm)
10	787-950 GHz (0.32-0.38mm)



ALMA array configurations



ALMA array configuration (Cycle 9)

Config	Min-max baseline	Angular resolution at l=3mm	Maximum recoverable scale at l=3mm
7m	9-45m	12.5''	66.7''
C-1	15-161m	3.38''	28.5''
C-2	15-314m	2.30''	22.6''
C-3	15-500m	1.42''	16.2''
C-4	15-784m	0.92''	11.2''
C-5	15-1400m	0.55''	6.70''
C-6	15-2500m	0.31''	4.11''
C-7	64-3600m	0.21''	2.58''
C-8	110-8500m	0.096''	1.42''
C-9	368-13900m	0.057''	0.81''
C-10	244-16200m	0.042''	0.50''

- Maximum baselines in Cycle 9 will be 16.2 km in configuration C-10.
- Configurations C-9 and C-10 with maximum baselines of 13.9 km and 16.2 km, respectively, will NOT again be available until Cycle 11.

ALMA timelines and milestones

Cycle 9 Timeline

Date	Milestone
24 March 2022	Release of Cycle 9 Call for Proposals, Observing Tool, and supporting documents, and opening of the Archive for proposal submission
21 April 2022 (15:00 UT)	Proposal submission deadline for Cycle 9 Call for Proposals
1 June 2022 (15:00 UT)	Deadline to submit reviews for the distributed peer review system
August 2022	Announcement of the outcome of the proposal review process
1 October 2022	Start of ALMA Cycle 9 Science Observations
30 September 2023	End of ALMA Cycle 9

ALMA array configuration schedule (Cycle 9)

NOTE: No PI observing takes place in Feb!

The forward-looking configuration schedule (through Cycle 11) can be found at:

https://almascience.nrao.edu/observing/observing-configuration-schedule/long-term-configuration-schedule

Start date	Config	Longest baseline	LST: Best conditions
1-Oct-22	C-3	0.50	22-10
20-Oct-22	C-2	0.31	23-11
10-Nov-22	C-1	0.16	1-13
30-Nov-22	C-2	0.31	2-14
20-Dec-22	C-3	0.50	4-15
10-Jan-23	C-4	0.78	5-17
1-Feb-23	No observations due to maintenance		
1-Mar-23	C-4	0.78	8-21
20-Mar-23	C-5	1.4	9-23
20-Apr-23	C-6	2.5	11-1
20-May-23	C-7	3.6	13-3
20-Jun-23	C-8	8.5	14-5
11-Jul-23	C-9	13.9	16-6
30-Jul-23	C-10	16.2	17-7
20-Aug-23	C-9	13.9	19-8
10-Sep-23	C-8	8.5	20-9

ALMA capabilities

The Cycle 9 capabilities are fully described in Appendix A of the ALMA Proposers Guide available at https://almascience.nrao.edu/documents-and-tools.

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

- 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)

ALMA capabilities

12-m Array Configurations

- Cycle 9 includes configurations C-1 through C-10.
- Maximum baselines between 0.16 km and 16.2 km depending on array configuration and subject to the following restrictions:
  - The maximum possible baseline for Bands 3, 4, 5, 6, 7, and 8 is 16.2 km (C-10).
  - The maximum possible baseline for Band 9 is 13.9 km (C-9).
  - The maximum possible baseline for Band 10 is 8.5 km (C-8).
- 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/cycle9/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

ALMA Capabilities

Polarization

- Single-pointing, on-axis, full linear and circular polarization for both continuum and full spectral resolution observations in Bands 3 to 7 on the 12-m Array. The field of view of linear and circular polarization observations is limited to the inner one third and the inner one tenth of the primary beam, respectively.
- Mosaicking of continuum linear polarization observations (Bands 3 to 7).
- – Linear polarization near on-axis imaging in continuum and full spectral resolution modes at the 0.1% (3s) fractional polarization level with the very brightest calibrators and 0.2% (3s) level for a typical observation
- – Minimum detectable circular polarization: 1.8% of peak flux for both continuum & full spectral resolution observations
- – Single pointing on-axis linear polarization in Bands 3-7 with the standalone ACA (ACA + 12m pol not available)
- Up to a total of 75 hours of full polarization observations of a single field with the 7-m Array in stand-alone mode at the Main Call only (Bands 3 to 7).
    - Note that combined 7-m Array and 12-m Array polarization observations are not supported this cycle.

ALMA capabilities – NEW!!

In Cycle 9, the following technical capabilities will be available for the first time:

- Fast Regional Mapping (FRM) for Solar Total Power observations. The size of the field of view for Solar Total Power observations can be changed by PI.
- Spectral line Very Long Baseline Interferometry (VLBI). This capability is offered in Band 3 only, in conjunction with the Global Millimeter VLBI Array (GMVA). - need to submit the same proposal to ALMA and GMVA
- Submillimeter VLBI. A continuum VLBI capability will be offered for the first time in Band 7 (0.87 mm) in conjunction with the Event Horizon Telescope (EHT). – No need to submit the same proposal to EHT
- Longer baseline high-frequency observations: Band 8 up to C-10, Band 9 up to C-9, and Band 10 up to C-8. The band-to-band (B2B) calibration mode may be triggered for long baseline high frequency observations in order to find a suitably close and strong calibrator. Some science targets, particularly at the highest frequencies and longest baselines, may NOT BE POSSIBLE even with B2B (see Appendix 9.6 of the PG).
    - The total time allocated to projects requiring band-to-band calibration techniques may be limited to 45 hours. For more information about band-to-band calibration see Section 4.2 of this document or Section 10.5.3 of the Technical Handbook.

ALMA capabilities – NEW!!

Band-to-Band calibration

- For observations in Band 7 and higher, observations requiring C-8 to C-10 may require Band-to-Band (B2B) calibration in order to find a nearby and sufficiently bright phase calibrator to ensure phase calibration quality. The ALMA Observing Tool will automatically check the availability of suitable phase calibrators during proposal validation and will automatically trigger the B2B mode where required.
- B2B observations are subject to the availability of suitable calibrators as checked by the ALMA-OT. Some science targets, particularly at the highest frequencies and longest baselines, may not be possible even with B2B. See Chapter 10 of the Technical Handbook.

A maximum of 45 hours of Cycle 9 observing time will be available for observations requiring the B2B calibration mode.

ALMA capabilities

Observing Time:

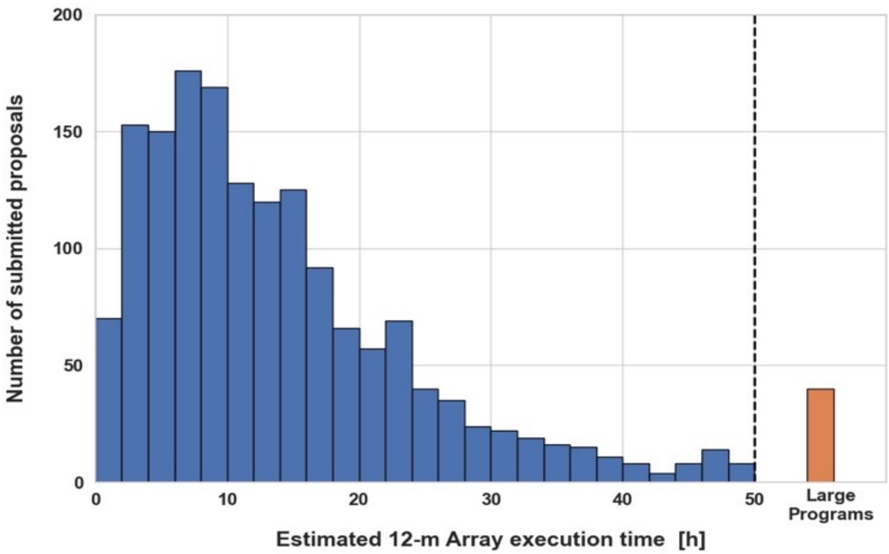
- 4300 hours on the 12-m Array and 4300 hours on the Atacama Compact Array (ACA), also known as the Morita Array, for successful proposals in Cycle 9 (includes DDT, Cycle 8 Carryover and resubmissions)
- Cycle 9 is not expected to include a Supplemental CfP for stand-alone ACA observations. The community is encouraged to submit ACA projects in the LST range of 20h to 10h for the April 2022 deadline.

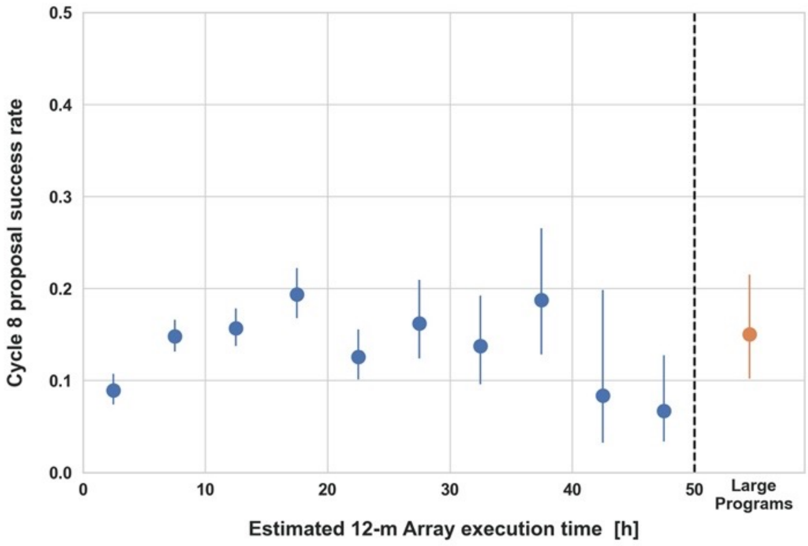
Observing Time (other notes):

- Proposals requesting more than 25 hours on the 12-m Array, including Large Programs, will have priority to fill at least 10% of the observing queue (see Section 1.4 of the PG).
- There is no longer a cap on the total time that can be allocated to Large Programs.
- However, Large Programs will not be allowed to exceed 50% of the available time for a given LST range in any of the Cycle 9 configurations.

ALMA capabilities

- But ALMA doesn't accept long proposals. I have a better chance of submitting a shorter proposal because it will be accepted, right?!?!?
- WRONG!!!





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:

NOT PLANNED FOR CYCLE 9!!!

- In Cycle 8, 2021 ALMA will offer a stand-alone ACA Supplemental Call for Proposals.
- The Supplemental Call will open on 08 September 2021 and the proposal deadline will be on 06 October 2021.
- Observations from the Supplemental Call will be scheduled from January 2022 to September 2022.
- 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".
- More information about the supplemental call can be found at: https://almascience.nrao.edu/proposing/7m-array-supplemental-call

ALMA capabilities

Standard vs Non-Standard modes??? (STILL) 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 9 will include Regular, Very Long Baseline Interferometry (VLBI), Phased Array, Target of Opportunity, and Large Programs. 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 2022 deadline. Additional information about proposing with ALMA using the GMVA was made available in the GMVA Call for Proposals in early January 2022.

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

- Time Critical or ToO, Full Polarization, Solar, VLBI or Phased Array, Astrometric Observations
- Non-standard calibrations (user-defined calibrations selected in the OT) or Band-to-Band calibrations
- Bandwidth switching projects (having less than 1 GHz aggregate bandwidths over all spectral windows)
- NOTE: Contact your local ARC for support NOW to help with preparing your large programs. The ARCs have both proposal preparation and data processing support available for your large programs. Review the documentation off the science portal on how to prepare "value added" data products.

ALMA capabilities in the future

Full ALMA Operations (All Cycle 9 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.

Observing Time:

- Up to 4500 hours+ for successful proposals of PI programs expected on the 12m Array (includes DDT, Cycle 8+ Carryover and resubmissions)

Observing Modes:

- Full operations include full Stoke plus circular polarization at all observing bands including mosaics and Total Power

WARNING!!!!

THERE IS NO SUCH THING AS A "LATE" PROPOSAL

"My internet is down…"

"My proposal won't validate…"

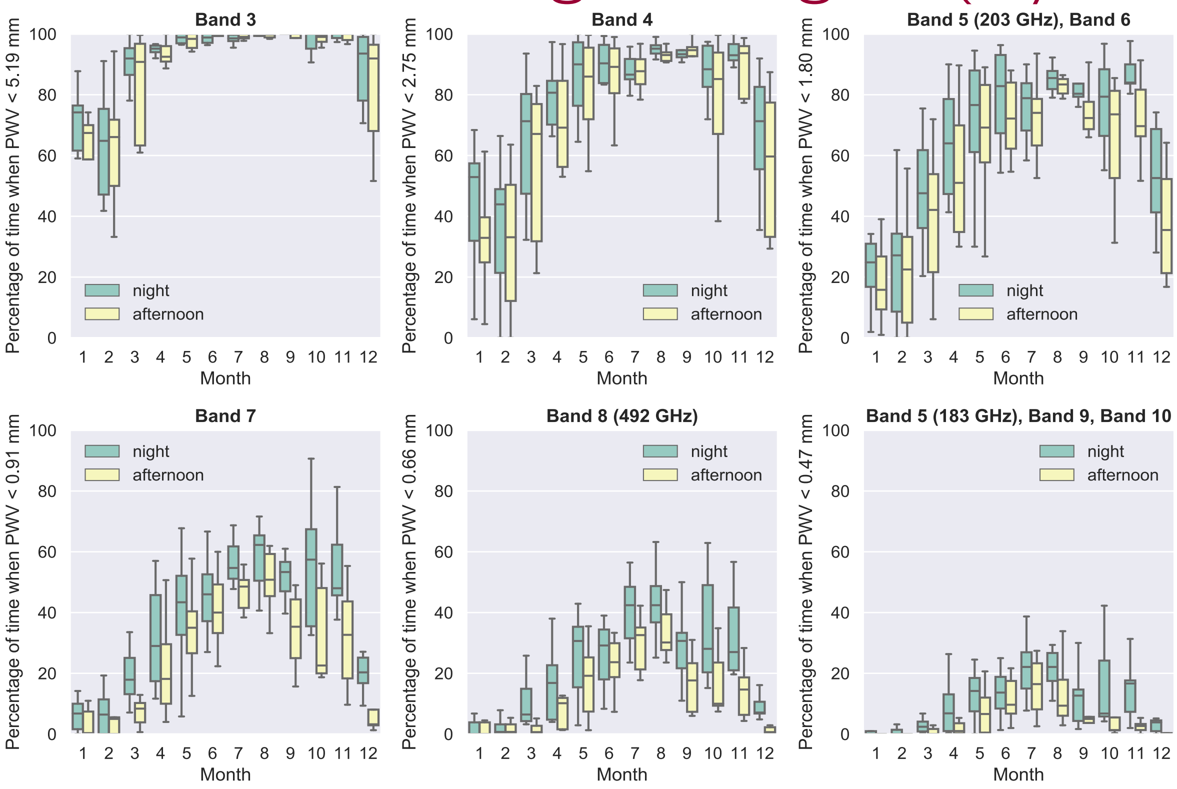
"My power went out…"

"I thought the time was 16UT not 15UT…"

"My dog at my proposal…"

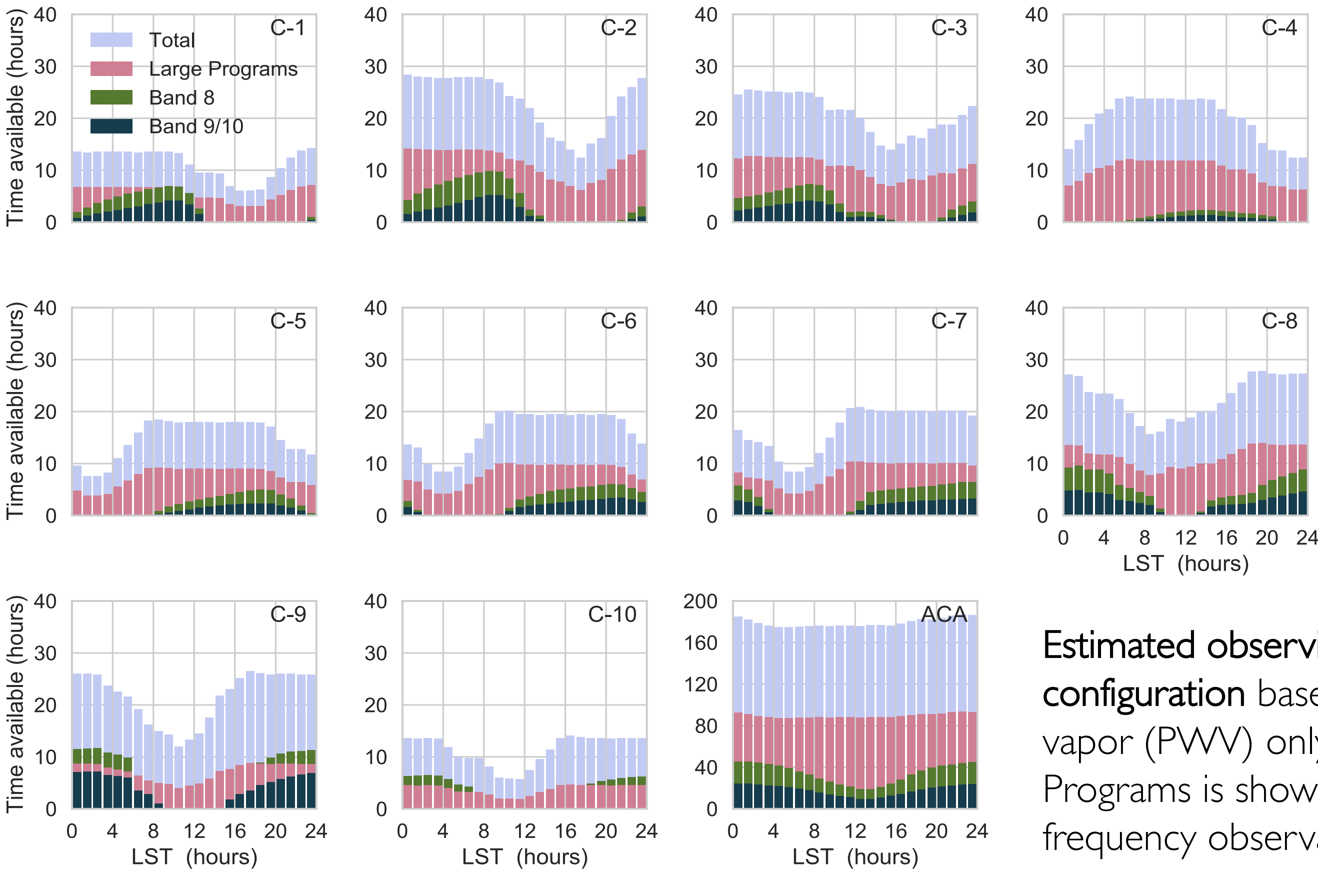
There is no excuse for a late proposal UNLESS the Observatory grants an extension.

ALMA observing strategies (Cycle 9)



The percentage of time when the PWV is below the observing thresholds adopted for the various ALMA bands for night-time (green) and afternoon (yellow) and for an elevation of 60 degrees. The horizontal line within the box indicates the median. Boundaries of the box indicate the 25th- and 75th-percentile, and the whiskers indicate the highest and lowest values of the results. The data were obtained with the APEX weather station, ALMA measurements, and weather forecast data between September 2010 and February 2019.

ALMA observing strategies (Cycle 9)



Estimated observing time available per configuration based on precipitable water vapor (PWV) only. The time available for Large Programs is shown in pink and time for high-frequency observations in green and dark blue.

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.
  - Also can ask for a "NAASC Chat" through the f2f department which is more than a ticket but less than a full virtual f2f visit!

- **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

NAASC sources of 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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